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Description Contains many functions useful for data analysis, high-level graphics, utility operations, functions for computing sample size and power, simulation, importing and annotating datasets, imputing missing values, advanced table making, variable clustering, character string manipulation, conversion of R objects to Typst, LaTeX, and html code, recoding variables, caching, simplified parallel computing, encrypting and decrypting data using a safe workflow, general moving window statistical estimation, and assistance in interpreting principal component analysis.

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`%nin%` *Find Matching (or Non-Matching) Elements*

Description

`%nin%` is a binary operator, which returns a logical vector indicating if there is a match or not for its left operand. A true vector element indicates no match in left operand, false indicates a match.

Usage

```
x %nin% table
```

Arguments

`x`	a vector (numeric, character, factor)
`table`	a vector (numeric, character, factor), matching the mode of `x`

Value

vector of logical values with length equal to length of x.

See Also

match %in%

Examples

```
c('a','b','c') %nin% c('a','b')
```

---

abs.error.pred *Indexes of Absolute Prediction Error for Linear Models*

Description

Computes the mean and median of various absolute errors related to ordinary multiple regression models. The mean and median absolute errors correspond to the mean square due to regression, error, and total. The absolute errors computed are derived from $\hat{Y}$ − median($\hat{Y}$), $\hat{Y} - Y$, and Y − median(Y). The function also computes ratios that correspond to R^2 and $1 - R^2$ (but these ratios do not add to 1.0); the R^2 measure is the ratio of mean or median absolute $\hat{Y}$ − median($\hat{Y}$) to the mean or median absolute Y − median(Y). The $1 - R^2$ or SSE/SST measure is the mean or median absolute $\hat{Y} - Y$ divided by the mean or median absolute $\hat{Y}$ − median(Y).

Usage

```
abs.error.pred(fit, lp=NULL, y=NULL)

## S3 method for class 'abs.error.pred'
print(x, ...)
```

Arguments

fit	a fit object typically from lm or ols that contains a y vector (i.e., you should have specified y=TRUE to the fitting function) unless the y argument is given to abs.error.pred. If you do not specify the lp argument, fit must contain fitted.values or linear.predictors. You must specify fit or both of lp and y.
lp	a vector of predicted values (Y hat above) if fit is not given
y	a vector of response variable values if fit (with y=TRUE in effect) is not given
x	an object created by abs.error.pred
...	unused

Value

a list of class abs.error.pred (used by print.abs.error.pred) containing two matrices: differences and ratios.

Author(s)

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References

Schemper M (2003): Stat in Med 22:2299-2308.

Tian L, Cai T, Goetghebeur E, Wei LJ (2007): Biometrika 94:297-311.

See Also

lm, ols, cor, validate.ols

Examples

```
set.seed(1)         # so can regenerate results
x1 <- rnorm(100)
x2 <- rnorm(100)
y  <- exp(x1+x2+rnorm(100))
f <- lm(log(y) ~ x1 + poly(x2,3), y=TRUE)
abs.error.pred(lp=exp(fitted(f)), y=y)
rm(x1,x2,y,f)
```

---

addggLayers *addggLayers*

Description

Add Spike Histograms and Extended Box Plots to ggplot

Usage

```
addggLayers(
  g,
  data,
  type = c("ebp", "spike"),
  ylim = layer_scales(g)$y$get_limits(),
  by = "variable",
  value = "value",
  frac = 0.065,
  mult = 1,
  facet = NULL,
  pos = c("bottom", "top"),
  showN = TRUE
)
```

Arguments

g	a ggplot object
data	data frame/table containing raw data
type	specifies either extended box plot or spike histogram. Both are horizontal so are showing the distribution of the x-axis variable.
ylim	y-axis limits to use for scaling the height of the added plots, if you don't want to use the limits that ggplot has stored
by	the name of a variable in data used to stratify raw data
value	name of x-variable
frac	fraction of y-axis range to devote to vertical aspect of the added plot
mult	fudge factor for scaling y aspect
facet	optional faceting variable
pos	position for added plot
showN	sete to FALSE to not show sample sizes

Details

For an example see this. Note that it was not possible to just create the layers needed to be added, as creating these particular layers in isolation resulted in a ggplot error.

Value

the original ggplot object with more layers added

Author(s)

Frank Harrell

See Also

spikecomp()

---

addMarginal *Add Marginal Observations*

Description

Given a data frame and the names of variable, doubles the data frame for each variable with a new category "All" by default, or by the value of label. A new variable .marginal. is added to the resulting data frame, with value "" if the observation is an original one, and with value equal to the names of the variable being marginalized (separated by commas) otherwise. If there is another stratification variable besides the one in ..., and that variable is nested inside the variable in ..., specify nested=variable name to have the value of that variable set fo label whenever marginal observations are created for .... See the state-city example below.

Usage

```
addMarginal(data, ..., label = "All", margloc=c('last', 'first'), nested)
```

Arguments

data	a data frame
...	a list of names of variables to marginalize
label	category name for added marginal observations
margloc	location for marginal category within factor variable specifying categories. Set to "first" to override the default - to put a category with value label as the first category.
nested	a single unquoted variable name if used

Examples

```
d <- expand.grid(sex=c('female', 'male'), country=c('US', 'Romania'),
                 reps=1:2)
addMarginal(d, sex, country)

# Example of nested variables
d <- data.frame(state=c('AL', 'AL', 'GA', 'GA', 'GA'),
                city=c('Mobile', 'Montgomery', 'Valdosto',
                       'Augusta', 'Atlanta'),
                x=1:5, stringsAsFactors=TRUE)
addMarginal(d, state, nested=city) # cite set to 'All' when state is
```

---

all.is.numeric *Check if All Elements in Character Vector are Numeric*

Description

Tests, without issuing warnings, whether all elements of a character vector are legal numeric values, or optionally converts the vector to a numeric vector. Leading and trailing blanks in x are ignored.

Usage

```
all.is.numeric(x, what = c("test", "vector", "nonnum"), extras=c('.','NA'))
```

Arguments

x	a character vector
what	specify what="vector" to return a numeric vector if it passes the test, or the original character vector otherwise, the default "test" to return FALSE if there are no non-missing non-extra values of x or there is at least one non-numeric value of x, or "nonnum" to return the vector of non-extra, non-NA, non-numeric values of x.
extras	a vector of character strings to count as numeric values, other than "".

Value

a logical value if what="test" or a vector otherwise

Author(s)

Frank Harrell

See Also

as.numeric

Examples

```
all.is.numeric(c('1','1.2','3'))
all.is.numeric(c('1','1.2','3a'))
all.is.numeric(c('1','1.2','3'),'vector')
all.is.numeric(c('1','1.2','3a'),'vector')
all.is.numeric(c('1','',' .'),'vector')
all.is.numeric(c('1', '1.2', '3a'), 'nonnum')
```

---

approxExtrap *Linear Extrapolation*

Description

Works in conjunction with the approx function to do linear extrapolation. approx in R does not support extrapolation at all, and it is buggy in S-Plus 6.

Usage

```
approxExtrap(x, y, xout, method = "linear", n = 50, rule = 2, f = 0,
             ties = "ordered", na.rm = FALSE)
```

Arguments

x, y, xout, method, n, rule, f	see approx
ties	applies only to R. See approx
na.rm	set to TRUE to remove NAs in x and y before proceeding

Details

Duplicates in x (and corresponding y elements) are removed before using approx.

Value

a vector the same length as xout

Author(s)

Frank Harrell

See Also

approx

Examples

```
approxExtrap(1:3,1:3,xout=c(0,4))
```

---

areg *Additive Regression with Optimal Transformations on Both Sides using Canonical Variates*

Description

Expands continuous variables into restricted cubic spline bases and categorical variables into dummy variables and fits a multivariate equation using canonical variates. This finds optimum transformations that maximize R^2. Optionally, the bootstrap is used to estimate the covariance matrix of both left- and right-hand-side transformation parameters, and to estimate the bias in the R^2 due to overfitting and compute the bootstrap optimism-corrected R^2. Cross-validation can also be used to get an unbiased estimate of R^2 but this is not as precise as the bootstrap estimate. The bootstrap and cross-validation may also used to get estimates of mean and median absolute error in predicted values on the original y scale. These two estimates are perhaps the best ones for gauging the accuracy of a flexible model, because it is difficult to compare R^2 under different y-transformations, and because R^2 allows for an out-of-sample recalibration (i.e., it only measures relative errors).

Note that uncertainty about the proper transformation of y causes an enormous amount of model uncertainty. When the transformation for y is estimated from the data a high variance in predicted values on the original y scale may result, especially if the true transformation is linear. Comparing bootstrap or cross-validated mean absolute errors with and without restricted the y transform to be linear (`ytype='l'`) may help the analyst choose the proper model complexity.

Usage

```
areg(x, y, xtype = NULL, ytype = NULL, nk = 4,
     B = 0, na.rm = TRUE, tolerance = NULL, crossval = NULL)

## S3 method for class 'areg'
print(x, digits=4, ...)

## S3 method for class 'areg'
plot(x, whichx = 1:ncol(x$x), ...)

## S3 method for class 'areg'
predict(object, x, type=c('lp','fitted','x'),
                      what=c('all','sample'), ...)
```

Arguments

x	A single predictor or a matrix of predictors. Categorical predictors are required to be coded as integers (as factor does internally). For predict, x is a data matrix with the same integer codes that were originally used for categorical variables.
y	a factor, categorical, character, or numeric response variable
xtype	a vector of one-letter character codes specifying how each predictor is to be modeled, in order of columns of x. The codes are "s" for smooth function (using restricted cubic splines), "l" for no transformation (linear), or "c" for categorical (to cause expansion into dummy variables). Default is "s" if nk > 0 and "l" if nk=0.
ytype	same coding as for xtype. Default is "s" for a numeric variable with more than two unique values, "l" for a binary numeric variable, and "c" for a factor, categorical, or character variable.
nk	number of knots, 0 for linear, or 3 or more. Default is 4 which will fit 3 parameters to continuous variables (one linear term and two nonlinear terms)
B	number of bootstrap resamples used to estimate covariance matrices of transformation parameters. Default is no bootstrapping.
na.rm	set to FALSE if you are sure that observations with NAs have already been removed
tolerance	singularity tolerance. List source code for lm.fit.qr.bare for details.
crossval	set to a positive integer k to compute k-fold cross-validated R-squared (square of first canonical correlation) and mean and median absolute error of predictions on the original scale
digits	number of digits to use in formatting for printing
object	an object created by areg
whichx	integer or character vector specifying which predictors are to have their transformations plotted (default is all). The y transformation is always plotted.
type	tells predict whether to obtain predicted untransformed y (type='lp', the default) or predicted y on the original scale (type='fitted'), or the design matrix for the right-hand side (type='x').
what	When the y-transform is non-monotonic you may specify what='sample' to predict to obtain a random sample of y values on the original scale instead of a matrix of all y-inverses. See inverseFunction.
...	arguments passed to the plot function.

Details

areg is a competitor of ace in the acepack package. Transformations from ace are seldom smooth enough and are often overfitted. With areg the complexity can be controlled with the nk parameter, and predicted values are easy to obtain because parametric functions are fitted.

If one side of the equation has a categorical variable with more than two categories and the other side has a continuous variable not assumed to act linearly, larger sample sizes are needed to reliably estimate transformations, as it is difficult to optimally score categorical variables to maximize R^2 against a simultaneously optimally transformed continuous variable.

Value

a list of class "areg" containing many objects

Author(s)

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References

Breiman and Friedman, Journal of the American Statistical Association (September, 1985).

See Also

cancor,ace, transcan

Examples

```
set.seed(1)

ns <- c(30,300,3000)
for(n in ns) {
  y <- sample(1:5, n, TRUE)
  x <- abs(y-3) + runif(n)
  par(mfrow=c(3,4))
  for(k in c(0,3:5)) {
    z <- areg(x, y, ytype='c', nk=k)
    plot(x, z$tx)
 title(paste('R2=',format(z$rsquared)))
    tapply(z$ty, y, range)
    a <- tapply(x,y,mean)
    b <- tapply(z$ty,y,mean)
    plot(a,b)
 abline(lsfit(a,b))
    # Should get same result to within linear transformation if reverse x and y
    w <- areg(y, x, xtype='c', nk=k)
    plot(z$ty, w$tx)
    title(paste('R2=',format(w$rsquared)))
    abline(lsfit(z$ty, w$tx))
 }
}

par(mfrow=c(2,2))
# Example where one category in y differs from others but only in variance of x
n <- 50
y <- sample(1:5,n,TRUE)
x <- rnorm(n)
x[y==1] <- rnorm(sum(y==1), 0, 5)
z <- areg(x,y,xtype='l',ytype='c')
```

```
z
plot(z)
z <- areg(x,y,ytype='c')
z
plot(z)

## Not run:
# Examine overfitting when true transformations are linear
par(mfrow=c(4,3))
for(n in c(200,2000)) {
  x <- rnorm(n); y <- rnorm(n) + x
    for(nk in c(0,3,5)) {
    z <- areg(x, y, nk=nk, crossval=10, B=100)
    print(z)
    plot(z)
    title(paste('n=',n))
  }
}
par(mfrow=c(1,1))

# Underfitting when true transformation is quadratic but overfitting
# when y is allowed to be transformed
set.seed(49)
n <- 200
x <- rnorm(n); y <- rnorm(n) + .5*x^2
#areg(x, y, nk=0, crossval=10, B=100)
#areg(x, y, nk=4, ytype='l', crossval=10, B=100)
z <- areg(x, y, nk=4) #, crossval=10, B=100)
z
# Plot x vs. predicted value on original scale.  Since y-transform is
# not monotonic, there are multiple y-inverses
xx <- seq(-3.5,3.5,length=1000)
yhat <- predict(z, xx, type='fitted')
plot(x, y, xlim=c(-3.5,3.5))
for(j in 1:ncol(yhat)) lines(xx, yhat[,j], col=j)
# Plot a random sample of possible y inverses
yhats <- predict(z, xx, type='fitted', what='sample')
points(xx, yhats, pch=2)

## End(Not run)

# True transformation of x1 is quadratic, y is linear
n <- 200
x1 <- rnorm(n); x2 <- rnorm(n); y <- rnorm(n) + x1^2
z <- areg(cbind(x1,x2),y,xtype=c('s','l'),nk=3)
par(mfrow=c(2,2))
plot(z)

# y transformation is inverse quadratic but areg gets the same answer by
# making x1 quadratic
n <- 5000
x1 <- rnorm(n); x2 <- rnorm(n); y <- (x1 + rnorm(n))^2
z <- areg(cbind(x1,x2),y,nk=5)
```

```
par(mfrow=c(2,2))
plot(z)

# Overfit 20 predictors when no true relationships exist
n <- 1000
x <- matrix(runif(n*20),n,20)
y <- rnorm(n)
z <- areg(x, y, nk=5)  # add crossval=4 to expose the problem

# Test predict function
n <- 50
x <- rnorm(n)
y <- rnorm(n) + x
g <- sample(1:3, n, TRUE)
z <- areg(cbind(x,g),y,xtype=c('s','c'))
range(predict(z, cbind(x,g)) - z$linear.predictors)
```

`aregImpute` *Multiple Imputation using Additive Regression, Bootstrapping, and Predictive Mean Matching*

Description

The `transcan` function creates flexible additive imputation models but provides only an approximation to true multiple imputation as the imputation models are fixed before all multiple imputations are drawn. This ignores variability caused by having to fit the imputation models. `aregImpute` takes all aspects of uncertainty in the imputations into account by using the bootstrap to approximate the process of drawing predicted values from a full Bayesian predictive distribution. Different bootstrap resamples are used for each of the multiple imputations, i.e., for the `i`th imputation of a sometimes missing variable, `i=1,2,... n.impute`, a flexible additive model is fitted on a sample with replacement from the original data and this model is used to predict all of the original missing and non-missing values for the target variable.

`areg` is used to fit the imputation models. By default, linearity is assumed for target variables (variables being imputed) and `nk=3` knots are assumed for continuous predictors transformed using restricted cubic splines. If `nk` is three or greater and `tlinear` is set to `FALSE`, `areg` simultaneously finds transformations of the target variable and of all of the predictors, to get a good fit assuming additivity, maximizing R^2, using the same canonical correlation method as `transcan`. Flexible transformations may be overridden for specific variables by specifying the identity transformation for them. When a categorical variable is being predicted, the flexible transformation is Fisher's optimum scoring method. Nonlinear transformations for continuous variables may be nonmonotonic. If `nk` is a vector, `areg`'s bootstrap and `crossval=10` options will be used to help find the optimum validating value of `nk` over values of that vector, at the last imputation iteration. For the imputations, the minimum value of `nk` is used.

Instead of defaulting to taking random draws from fitted imputation models using random residuals as is done by `transcan`, `aregImpute` by default uses predictive mean matching with optional weighted probability sampling of donors rather than using only the closest match. Predictive mean matching works for binary, categorical, and continuous variables without the need for iterative

maximum likelihood fitting for binary and categorical variables, and without the need for computing residuals or for curtailing imputed values to be in the range of actual data. Predictive mean matching is especially attractive when the variable being imputed is also being transformed automatically. Constraints may be placed on variables being imputed with predictive mean matching, e.g., a missing hospital discharge date may be required to be imputed from a donor observation whose discharge date is before the recipient subject's first post-discharge visit date. See Details below for more information about the algorithm. A `"regression"` method is also available that is similar to that used in `transcan`. This option should be used when mechanistic missingness requires the use of extrapolation during imputation.

A `print` method summarizes the results, and a `plot` method plots distributions of imputed values. Typically, `fit.mult.impute` will be called after `aregImpute`.

If a target variable is transformed nonlinearly (i.e., if `nk` is greater than zero and `tlinear` is set to `FALSE`) and the estimated target variable transformation is non-monotonic, imputed values are not unique. When `type='regression'`, a random choice of possible inverse values is made.

The `reformM` function provides two ways of recreating a formula to give to `aregImpute` by reordering the variables in the formula. This is a modified version of a function written by Yong Hao Pua. One can specify `nperm` to obtain a list of `nperm` randomly permuted variables. The list is converted to a single ordinary formula if `nperm=1`. If `nperm` is omitted, variables are sorted in descending order of the number of `NA`s. `reformM` also prints a recommended number of multiple imputations to use, which is a minimum of 5 and the percent of incomplete observations.

Usage

```
aregImpute(formula, data, subset, n.impute=5, group=NULL,
           nk=3, tlinear=TRUE, type=c('pmm','regression','normpmm'),
           pmmtype=1, match=c('weighted','closest','kclosest'),
           kclosest=3, fweighted=0.2,
           curtail=TRUE, constraint=NULL,
           boot.method=c('simple', 'approximate bayesian'),
           burnin=3, x=FALSE, pr=TRUE, plotTrans=FALSE, tolerance=NULL, B=75)
## S3 method for class 'aregImpute'
print(x, digits=3, ...)
## S3 method for class 'aregImpute'
plot(x, nclass=NULL, type=c('ecdf','hist'),
     datadensity=c("hist", "none", "rug", "density"),
     diagnostics=FALSE, maxn=10, ...)
reformM(formula, data, nperm)
```

Arguments

`formula`	an S model formula. You can specify restrictions for transformations of variables. The function automatically determines which variables are categorical (i.e., `factor`, `category`, or character vectors). Binary variables are automatically restricted to be linear. Force linear transformations of continuous variables by enclosing variables by the identify function (`I()`). It is recommended that `factor()` or `as.factor()` do not appear in the formula but instead variables be converted to factors as needed and stored in the data frame. That way imputations for factor variables (done using `impute.transcan` for example) will

be correct. Currently reformM does not handle variables that are enclosed in functions such as I().

x — an object created by aregImpute. For aregImpute, set x to TRUE to save the data matrix containing the final (number n.impute) imputations in the result. This is needed if you want to later do out-of-sample imputation. Categorical variables are coded as integers in this matrix.

data — input raw data

subset — These may be also be specified. You may not specify na.action as na.retain is always used.

n.impute — number of multiple imputations. n.impute=5 is frequently recommended but 10 or more doesn't hurt.

group — a character or factor variable the same length as the number of observations in data and containing no NAs. When group is present, causes a bootstrap sample of the observations corresponding to non-NAs of a target variable to have the same frequency distribution of group as the that in the non-NAs of the original sample. This can handle k-sample problems as well as lower the chance that a bootstrap sample will have a missing cell when the original cell frequency was low.

nk — number of knots to use for continuous variables. When both the target variable and the predictors are having optimum transformations estimated, there is more instability than with normal regression so the complexity of the model should decrease more sharply as the sample size decreases. Hence set nk to 0 (to force linearity for non-categorical variables) or 3 (minimum number of knots possible with a linear tail-restricted cubic spline) for small sample sizes. Simulated problems as in the examples section can assist in choosing nk. Set nk to a vector to get bootstrap-validated and 10-fold cross-validated R^2 and mean and median absolute prediction errors for imputing each sometimes-missing variable, with nk ranging over the given vector. The errors are on the original untransformed scale. The mean absolute error is the recommended basis for choosing the number of knots (or linearity).

tlinear — set to FALSE to allow a target variable (variable being imputed) to have a nonlinear left-hand-side transformation when nk is 3 or greater

type — The default is "pmm" for predictive mean matching, which is a more nonparametric approach that will work for categorical as well as continuous predictors. Alternatively, use "regression" when all variables that are sometimes missing are continuous and the missingness mechanism is such that entire intervals of population values are unobserved. See the Details section for more information. Another method, type="normpmm", only works when variables containing NAs are continuous and tlinear is TRUE (the default), meaning that the variable being imputed is not transformed when it is on the left hand model side. normpmm assumes that the imputation regression parameter estimates are multivariately normally distributed and that the residual variance has a scaled chi-squared distribution. For each imputation a random draw of the estimates is taken and a random draw from sigma is combined with those to get a random draw from the posterior predicted value distribution. Predictive mean matching is then done matching these predicted values from incomplete observations with predicted

values from complete potential donor observations, where the latter predictions are based on the imputation model least squares parameter estimates and not on random draws from the posterior. For the `plot` method, specify `type="hist"` to draw histograms of imputed values with rug plots at the top, or `type="ecdf"` (the default) to draw empirical CDFs with spike histograms at the bottom.

`pmmtype` type of matching to be used for predictive mean matching when `type="pmm"`. `pmmtype=2` means that predicted values for both target incomplete and complete observations come from a fit from the same bootstrap sample. `pmmtype=1`, the default, means that predicted values for complete observations are based on additive regression fits on original complete observations (using last imputations for non-target variables as with the other methds), and using fits on a bootstrap sample to get predicted values for missing target variables. See van Buuren (2012) section 3.4.2 where `pmmtype=1` is said to work much better when the number of variables is small. `pmmtype=3` means that complete observation predicted values come from a bootstrap sample fit whereas target incomplete observation predicted values come from a sample with replacement from the bootstrap fit (approximate Bayesian bootstrap).

`match` Defaults to `match="weighted"` to do weighted multinomial probability sampling using the tricube function (similar to lowess) as the weights. The argument of the tricube function is the absolute difference in transformed predicted values of all the donors and of the target predicted value, divided by a scaling factor. The scaling factor in the tricube function is `fweighted` times the mean absolute difference between the target predicted value and all the possible donor predicted values. Set `match="closest"` to find as the donor the observation having the closest predicted transformed value, even if that same donor is found repeatedly. Set `match="kclosest"` to use a slower implementation that finds, after jittering the complete case predicted values, the `kclosest` complete cases on the target variable being imputed, then takes a random sample of one of these `kclosest` cases.

`kclosest` see `match`

`fweighted` Smoothing parameter (multiple of mean absolute difference) used when `match="weighted"`, with a default value of 0.2. Set `fweighted` to a number between 0.02 and 0.2 to force the donor to have a predicted value closer to the target, and set `fweighted` to larger values (but seldom larger than 1.0) to allow donor values to be less tightly matched. See the examples below to learn how to study the relationship between `fweighted` and the standard deviation of multiple imputations within individuals.

`curtail` applies if `type='regression'`, causing imputed values to be curtailed at the observed range of the target variable. Set to `FALSE` to allow extrapolation outside the data range.

`constraint` for predictive mean matching `constraint` is a named list specifying R `expression()`s encoding constaints on which donor observations are allowed to be used, based on variables that are not missing, i.e., based on donor observations and/or recipient observations as long as the target variable being imputed is not used for the recipients. The expressions must evaluate to a logical vector with no `NA`s and whose length is the number of rows in the donor observations. The expressions

refer to donor observations by prefixing variable names by d$, and to a single recipient observation by prefixing variables names by r$.

boot.method — By default, simple boostrapping is used in which the target variable is predicted using a sample with replacement from the observations with non-missing target variable. Specify boot.method='approximate bayesian' to build the imputation models from a sample with replacement from a sample with replacement of the observations with non-missing targets. Preliminary simulations have shown this results in good confidence coverage of the final model parameters when type='regression' is used. Not implemented when group is used.

burnin — aregImpute does burnin + n.impute iterations of the entire modeling process. The first burnin imputations are discarded. More burn-in iteractions may be requied when multiple variables are missing on the same observations. When only one variable is missing, no burn-ins are needed and burnin is set to zero if unspecified.

pr — set to FALSE to suppress printing of iteration messages

plotTrans — set to TRUE to plot ace or avas transformations for each variable for each of the multiple imputations. This is useful for determining whether transformations are reasonable. If transformations are too noisy or have long flat sections (resulting in "lumps" in the distribution of imputed values), it may be advisable to place restrictions on the transformations (monotonicity or linearity).

tolerance — singularity criterion; list the source code in the lm.fit.qr.bare function for details

B — number of bootstrap resamples to use if nk is a vector

digits — number of digits for printing

nclass — number of bins to use in drawing histogram

datadensity — see Ecdf

diagnostics — Specify diagnostics=TRUE to draw plots of imputed values against sequential imputation numbers, separately for each missing observations and variable.

maxn — Maximum number of observations shown for diagnostics. Default is maxn=10, which limits the number of observations plotted to at most the first 10.

nperm — number of random formula permutations for reformM; omit to sort variables by descending missing count.

... — other arguments that are ignored

Details

The sequence of steps used by the aregImpute algorithm is the following.
(1) For each variable containing m NAs where m > 0, initialize the NAs to values from a random sample (without replacement if a sufficient number of non-missing values exist) of size m from the non-missing values.
(2) For burnin+n.impute iterations do the following steps. The first burnin iterations provide a burn-in, and imputations are saved only from the last n.impute iterations.
(3) For each variable containing any NAs, draw a sample with replacement from the observations in the entire dataset in which the current variable being imputed is non-missing. Fit a flexible additive model to predict this target variable while finding the optimum transformation of it (unless

the identity transformation is forced). Use this fitted flexible model to predict the target variable in all of the original observations. Impute each missing value of the target variable with the observed value whose predicted transformed value is closest to the predicted transformed value of the missing value (if `match="closest"` and `type="pmm"`), or use a draw from a multinomial distribution with probabilities derived from distance weights, if `match="weighted"` (the default).
(4) After these imputations are computed, use these random draw imputations the next time the curent target variable is used as a predictor of other sometimes-missing variables.

When `match="closest"`, predictive mean matching does not work well when fewer than 3 variables are used to predict the target variable, because many of the multiple imputations for an observation will be identical. In the extreme case of one right-hand-side variable and assuming that only monotonic transformations of left and right-side variables are allowed, every bootstrap resample will give predicted values of the target variable that are monotonically related to predicted values from every other bootstrap resample. The same is true for Bayesian predicted values. This causes predictive mean matching to always match on the same donor observation.

When the missingness mechanism for a variable is so systematic that the distribution of observed values is truncated, predictive mean matching does not work. It will only yield imputed values that are near observed values, so intervals in which no values are observed will not be populated by imputed values. For this case, the only hope is to make regression assumptions and use extrapolation. With `type="regression"`, `aregImpute` will use linear extrapolation to obtain a (hopefully) reasonable distribution of imputed values. The `"regression"` option causes `aregImpute` to impute missing values by adding a random sample of residuals (with replacement if there are more `NA`s than measured values) on the transformed scale of the target variable. After random residuals are added, predicted random draws are obtained on the original untransformed scale using reverse linear interpolation on the table of original and transformed target values (linear extrapolation when a random residual is large enough to put the random draw prediction outside the range of observed values). The bootstrap is used as with `type="pmm"` to factor in the uncertainty of the imputation model.

As model uncertainty is high when the transformation of a target variable is unknown, `tlinear` defaults to `TRUE` to limit the variance in predicted values when `nk` is positive.

Value

a list of class `"aregImpute"` containing the following elements:

`call`	the function call expression
`formula`	the formula specified to `aregImpute`
`match`	the `match` argument
`fweighted`	the `fweighted` argument
`n`	total number of observations in input dataset
`p`	number of variables
`na`	list of subscripts of observations for which values were originally missing
`nna`	named vector containing the numbers of missing values in the data
`type`	vector of types of transformations used for each variable (`"s"`,`"l"`,`"c"` for smooth spline, linear, or categorical with dummy variables)
`tlinear`	value of `tlinear` parameter
`nk`	number of knots used for smooth transformations

cat.levels	list containing character vectors specifying the levels of categorical variables
df	degrees of freedom (number of parameters estimated) for each variable
n.impute	number of multiple imputations per missing value
imputed	a list containing matrices of imputed values in the same format as those created by transcan. Categorical variables are coded using their integer codes. Variables having no missing values will have NULL matrices in the list.
x	if x is TRUE, the original data matrix with integer codes for categorical variables
rsq	for the last round of imputations, a vector containing the R-squares with which each sometimes-missing variable could be predicted from the others by ace or avas.

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References

van Buuren, Stef. Flexible Imputation of Missing Data. Chapman & Hall/CRC, Boca Raton FL, 2012.

Little R, An H. Robust likelihood-based analysis of multivariate data with missing values. Statistica Sinica 14:949-968, 2004.

van Buuren S, Brand JPL, Groothuis-Oudshoorn CGM, Rubin DB. Fully conditional specifications in multivariate imputation. J Stat Comp Sim 72:1049-1064, 2006.

de Groot JAH, Janssen KJM, Zwinderman AH, Moons KGM, Reitsma JB. Multiple imputation to correct for partial verification bias revisited. Stat Med 27:5880-5889, 2008.

Siddique J. Multiple imputation using an iterative hot-deck with distance-based donor selection. Stat Med 27:83-102, 2008.

White IR, Royston P, Wood AM. Multiple imputation using chained equations: Issues and guidance for practice. Stat Med 30:377-399, 2011.

Curnow E, Carpenter JR, Heron JE, et al: Multiple imputation of missing data under missing at random: compatible imputation models are not sufficient to avoid bias if they are mis-specified. J Clin Epi June 9, 2023. DOI:10.1016/j.jclinepi.2023.06.011.

See Also

fit.mult.impute, transcan, areg, naclus, naplot, mice, dotchart3, Ecdf, completer

Examples

```
# Check that aregImpute can almost exactly estimate missing values when
# there is a perfect nonlinear relationship between two variables
# Fit restricted cubic splines with 4 knots for x1 and x2, linear for x3
set.seed(3)
```

```
x1 <- rnorm(200)
x2 <- x1^2
x3 <- runif(200)
m <- 30
x2[1:m] <- NA
a <- aregImpute(~x1+x2+I(x3), n.impute=5, nk=4, match='closest')
a
matplot(x1[1:m]^2, a$imputed$x2)
abline(a=0, b=1, lty=2)

x1[1:m]^2
a$imputed$x2


# Multiple imputation and estimation of variances and covariances of
# regression coefficient estimates accounting for imputation
# Example 1: large sample size, much missing data, no overlap in
# NAs across variables
x1 <- factor(sample(c('a','b','c'),1000,TRUE))
x2 <- (x1=='b') + 3*(x1=='c') + rnorm(1000,0,2)
x3 <- rnorm(1000)
y  <- x2 + 1*(x1=='c') + .2*x3 + rnorm(1000,0,2)
orig.x1 <- x1[1:250]
orig.x2 <- x2[251:350]
x1[1:250] <- NA
x2[251:350] <- NA
d <- data.frame(x1,x2,x3,y, stringsAsFactors=TRUE)
# Find value of nk that yields best validating imputation models
# tlinear=FALSE means to not force the target variable to be linear
f <- aregImpute(~y + x1 + x2 + x3, nk=c(0,3:5), tlinear=FALSE,
                data=d, B=10) # normally B=75
f
# Try forcing target variable (x1, then x2) to be linear while allowing
# predictors to be nonlinear (could also say tlinear=TRUE)
f <- aregImpute(~y + x1 + x2 + x3, nk=c(0,3:5), data=d, B=10)
f

## Not run:
# Use 100 imputations to better check against individual true values
f <- aregImpute(~y + x1 + x2 + x3, n.impute=100, data=d)
f
par(mfrow=c(2,1))
plot(f)
modecat <- function(u) {
 tab <- table(u)
 as.numeric(names(tab)[tab==max(tab)][1])
}
table(orig.x1,apply(f$imputed$x1, 1, modecat))
par(mfrow=c(1,1))
plot(orig.x2, apply(f$imputed$x2, 1, mean))
fmi <- fit.mult.impute(y ~ x1 + x2 + x3, lm, f,
                       data=d)
sqrt(diag(vcov(fmi)))
```

```
fcc <- lm(y ~ x1 + x2 + x3)
summary(fcc)   # SEs are larger than from mult. imputation

## End(Not run)
## Not run:
# Example 2: Very discriminating imputation models,
# x1 and x2 have some NAs on the same rows, smaller n
set.seed(5)
x1 <- factor(sample(c('a','b','c'),100,TRUE))
x2 <- (x1=='b') + 3*(x1=='c') + rnorm(100,0,.4)
x3 <- rnorm(100)
y  <- x2 + 1*(x1=='c') + .2*x3 + rnorm(100,0,.4)
orig.x1 <- x1[1:20]
orig.x2 <- x2[18:23]
x1[1:20] <- NA
x2[18:23] <- NA
#x2[21:25] <- NA
d <- data.frame(x1,x2,x3,y, stringsAsFactors=TRUE)
n <- naclus(d)
plot(n); naplot(n)  # Show patterns of NAs
# 100 imputations to study them; normally use 5 or 10
f  <- aregImpute(~y + x1 + x2 + x3, n.impute=100, nk=0, data=d)
par(mfrow=c(2,3))
plot(f, diagnostics=TRUE, maxn=2)
# Note: diagnostics=TRUE makes graphs similar to those made by:
# r <- range(f$imputed$x2, orig.x2)
# for(i in 1:6) {  # use 1:2 to mimic maxn=2
#   plot(1:100, f$imputed$x2[i,], ylim=r,
#        ylab=paste("Imputations for Obs.",i))
#   abline(h=orig.x2[i],lty=2)
# }

table(orig.x1,apply(f$imputed$x1, 1, modecat))
par(mfrow=c(1,1))
plot(orig.x2, apply(f$imputed$x2, 1, mean))


fmi <- fit.mult.impute(y ~ x1 + x2, lm, f,
                       data=d)
sqrt(diag(vcov(fmi)))
fcc <- lm(y ~ x1 + x2)
summary(fcc)   # SEs are larger than from mult. imputation

## End(Not run)

## Not run:
# Study relationship between smoothing parameter for weighting function
# (multiplier of mean absolute distance of transformed predicted
# values, used in tricube weighting function) and standard deviation
# of multiple imputations.  SDs are computed from average variances
# across subjects.  match="closest" same as match="weighted" with
# small value of fweighted.
# This example also shows problems with predicted mean
```

```
# matching almost always giving the same imputed values when there is
# only one predictor (regression coefficients change over multiple
# imputations but predicted values are virtually 1-1 functions of each
# other)

set.seed(23)
x <- runif(200)
y <- x + runif(200, -.05, .05)
r <- resid(lsfit(x,y))
rmse <- sqrt(sum(r^2)/(200-2))   # sqrt of residual MSE

y[1:20] <- NA
d <- data.frame(x,y)
f <- aregImpute(~ x + y, n.impute=10, match='closest', data=d)
# As an aside here is how to create a completed dataset for imputation
# number 3 as fit.mult.impute would do automatically.  In this degenerate
# case changing 3 to 1-2,4-10 will not alter the results.
imputed <- impute.transcan(f, imputation=3, data=d, list.out=TRUE,
                           pr=FALSE, check=FALSE)
sd <- sqrt(mean(apply(f$imputed$y, 1, var)))

ss <- c(0, .01, .02, seq(.05, 1, length=20))
sds <- ss; sds[1] <- sd

for(i in 2:length(ss)) {
  f <- aregImpute(~ x + y, n.impute=10, fweighted=ss[i])
  sds[i] <- sqrt(mean(apply(f$imputed$y, 1, var)))
}

plot(ss, sds, xlab='Smoothing Parameter', ylab='SD of Imputed Values',
     type='b')
abline(v=.2,  lty=2)  # default value of fweighted
abline(h=rmse, lty=2)  # root MSE of residuals from linear regression

## End(Not run)

## Not run:
# Do a similar experiment for the Titanic dataset
getHdata(titanic3)
h <- lm(age ~ sex + pclass + survived, data=titanic3)
rmse <- summary(h)$sigma
set.seed(21)
f <- aregImpute(~ age + sex + pclass + survived, n.impute=10,
                data=titanic3, match='closest')
sd <- sqrt(mean(apply(f$imputed$age, 1, var)))

ss <- c(0, .01, .02, seq(.05, 1, length=20))
sds <- ss; sds[1] <- sd

for(i in 2:length(ss)) {
  f <- aregImpute(~ age + sex + pclass + survived, data=titanic3,
                  n.impute=10, fweighted=ss[i])
  sds[i] <- sqrt(mean(apply(f$imputed$age, 1, var)))
```

```
}

plot(ss, sds, xlab='Smoothing Parameter', ylab='SD of Imputed Values',
     type='b')
abline(v=.2,   lty=2)  # default value of fweighted
abline(h=rmse, lty=2)  # root MSE of residuals from linear regression

## End(Not run)


set.seed(2)
d <- data.frame(x1=runif(50), x2=c(rep(NA, 10), runif(40)),
                x3=c(runif(4), rep(NA, 11), runif(35)))
reformM(~ x1 + x2 + x3, data=d)
reformM(~ x1 + x2 + x3, data=d, nperm=2)
# Give result or one of the results as the first argument to aregImpute

# Constrain imputed values for two variables
# Require imputed values for x2 to be above 0.2
# Assume x1 is never missing and require imputed values for
# x3 to be less than the recipient's value of x1
a <- aregImpute(~ x1 + x2 + x3, data=d,
                constraint=list(x2 = expression(d$x2 > 0.2),
                                x3 = expression(d$x3 < r$x1)))
a
```

---

binconf *Confidence Intervals for Binomial Probabilities*

Description

Produces 1-alpha confidence intervals for binomial probabilities.

Usage

```
binconf(x, n, alpha=0.05,
        method=c("wilson","exact","asymptotic","all"),
        include.x=FALSE, include.n=FALSE, return.df=FALSE)
```

Arguments

x	vector containing the number of "successes" for binomial variates
n	vector containing the numbers of corresponding observations
alpha	probability of a type I error, so confidence coefficient = 1-alpha
method	character string specifing which method to use. The "all" method only works when x and n are length 1. The "exact" method uses the F distribution to compute exact (based on the binomial cdf) intervals; the "wilson" interval is score-test-based; and the "asymptotic" is the text-book, asymptotic normal interval. Following Agresti and Coull, the Wilson interval is to be preferred and so is the default.

include.x	logical flag to indicate whether x should be included in the returned matrix or data frame
include.n	logical flag to indicate whether n should be included in the returned matrix or data frame
return.df	logical flag to indicate that a data frame rather than a matrix be returned

Value

a matrix or data.frame containing the computed intervals and, optionally, x and n.

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References

A. Agresti and B.A. Coull, Approximate is better than "exact" for interval estimation of binomial proportions, *American Statistician,* **52**:119–126, 1998.

R.G. Newcombe, Logit confidence intervals and the inverse sinh transformation, *American Statistician,* **55**:200–202, 2001.

L.D. Brown, T.T. Cai and A. DasGupta, Interval estimation for a binomial proportion (with discussion), *Statistical Science,* **16**:101–133, 2001.

Examples

```
binconf(0:10,10,include.x=TRUE,include.n=TRUE)
binconf(46,50,method="all")
```

---

biVar *Bivariate Summaries Computed Separately by a Series of Predictors*

Description

biVar is a generic function that accepts a formula and usual data, subset, and na.action parameters plus a list statinfo that specifies a function of two variables to compute along with information about labeling results for printing and plotting. The function is called separately with each right hand side variable and the same left hand variable. The result is a matrix of bivariate statistics and the statinfo list that drives printing and plotting. The plot method draws a dot plot with x-axis values by default sorted in order of one of the statistics computed by the function.

spearman2 computes the square of Spearman's rho rank correlation and a generalization of it in which x can relate non-monotonically to y. This is done by computing the Spearman multiple rho-squared between (rank(x), rank(x)^2) and y. When x is categorical, a different kind of Spearman correlation used in the Kruskal-Wallis test is computed (and spearman2 can do the Kruskal-Wallis test). This is done by computing the ordinary multiple R^2 between k-1 dummy variables and rank(y), where x has k categories. x can also be a formula, in which case each predictor is correlated separately with y, using non-missing observations for that predictor. biVar is used to do the looping and bookkeeping. By default the plot shows the adjusted rho^2, using the same formula used for the ordinary adjusted R^2. The F test uses the unadjusted R2.

spearman computes Spearman's rho on non-missing values of two variables. spearman.test is a simple version of spearman2.default.

chiSquare is set up like spearman2 except it is intended for a categorical response variable. Separate Pearson chi-square tests are done for each predictor, with optional collapsing of infrequent categories. Numeric predictors having more than g levels are categorized into g quantile groups. chiSquare uses biVar.

Usage

```
biVar(formula, statinfo, data=NULL, subset=NULL,
      na.action=na.retain, exclude.imputed=TRUE, ...)

## S3 method for class 'biVar'
print(x, ...)

## S3 method for class 'biVar'
plot(x, what=info$defaultwhat,
                       sort.=TRUE, main, xlab,
                       vnames=c('names','labels'), ...)

spearman2(x, ...)

## Default S3 method:
spearman2(x, y, p=1, minlev=0, na.rm=TRUE, exclude.imputed=na.rm, ...)

## S3 method for class 'formula'
spearman2(formula, data=NULL,
          subset, na.action=na.retain, exclude.imputed=TRUE, ...)

spearman(x, y)

spearman.test(x, y, p=1)

chiSquare(formula, data=NULL, subset=NULL, na.action=na.retain,
          exclude.imputed=TRUE, ...)
```

Arguments

formula	a formula with a single left side variable

statinfo see spearman2.formula or chiSquare code

data, subset, na.action
the usual options for models. Default for na.action is to retain all values, NA or not, so that NAs can be deleted in only a pairwise fashion.

exclude.imputed
set to FALSE to include imputed values (created by impute) in the calculations.

... other arguments that are passed to the function used to compute the bivariate statistics or to dotchart3 for plot.

na.rm logical; delete NA values?

x a numeric matrix with at least 5 rows and at least 2 columns (if y is absent). For spearman2, the first argument may be a vector of any type, including character or factor. The first argument may also be a formula, in which case all predictors are correlated individually with the response variable. x may be a formula for spearman2 in which case spearman2.formula is invoked. Each predictor in the right hand side of the formula is separately correlated with the response variable. For print or plot, x is an object produced by biVar. For spearman and spearman.test x is a numeric vector, as is y. For chiSquare, x is a formula.

y a numeric vector

p for numeric variables, specifies the order of the Spearman rho^2 to use. The default is p=1 to compute the ordinary rho^2. Use p=2 to compute the quadratic rank generalization to allow non-monotonicity. p is ignored for categorical predictors.

minlev minimum relative frequency that a level of a categorical predictor should have before it is pooled with other categories (see combine.levels) in spearman2 and chiSquare (in which case it also applies to the response). The default, minlev=0 causes no pooling.

what specifies which statistic to plot. Possibilities include the column names that appear with the print method is used.

sort. set sort.=FALSE to suppress sorting variables by the statistic being plotted

main main title for plot. Default title shows the name of the response variable.

xlab x-axis label. Default constructed from what.

vnames set to "labels" to use variable labels in place of names for plotting. If a variable does not have a label the name is always used.

Details

Uses midranks in case of ties, as described by Hollander and Wolfe. P-values for Spearman, Wilcoxon, or Kruskal-Wallis tests are approximated by using the t or F distributions.

Value

spearman2.default (the function that is called for a single x, i.e., when there is no formula) returns a vector of statistics for the variable. biVar, spearman2.formula, and chiSquare return a matrix with rows corresponding to predictors.

Author(s)

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References

Hollander M. and Wolfe D.A. (1973). Nonparametric Statistical Methods. New York: Wiley.

Press WH, Flannery BP, Teukolsky SA, Vetterling, WT (1988): Numerical Recipes in C. Cambridge: Cambridge University Press.

See Also

combine.levels, varclus, dotchart3, impute, chisq.test, cut2.

Examples

```
x <- c(-2, -1, 0, 1, 2)
y <- c(4,   1, 0, 1, 4)
z <- c(1,   2, 3, 4, NA)
v <- c(1,   2, 3, 4, 5)

spearman2(x, y)
plot(spearman2(z ~ x + y + v, p=2))

f <- chiSquare(z ~ x + y + v)
f
```

---

bootkm *Bootstrap Kaplan-Meier Estimates*

Description

Bootstraps Kaplan-Meier estimate of the probability of survival to at least a fixed time (times variable) or the estimate of the q quantile of the survival distribution (e.g., median survival time, the default).

Usage

```
bootkm(S, q=0.5, B=500, times, pr=TRUE)
```

Arguments

S	a Surv object for possibly right-censored survival time
q	quantile of survival time, default is 0.5 for median
B	number of bootstrap repetitions (default=500)
times	time vector (currently only a scalar is allowed) at which to compute survival estimates. You may specify only one of q and times, and if times is specified q is ignored.
pr	set to FALSE to suppress printing the iteration number every 10 iterations

Details

bootkm uses Therneau's survfitKM function to efficiently compute Kaplan-Meier estimates.

Value

a vector containing B bootstrap estimates

Side Effects

updates .Random.seed, and, if pr=TRUE, prints progress of simulations

Author(s)

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References

Akritas MG (1986): Bootstrapping the Kaplan-Meier estimator. JASA 81:1032–1038.

See Also

survfit, Surv, Survival.cph, Quantile.cph

Examples

```
# Compute 0.95 nonparametric confidence interval for the difference in
# median survival time between females and males (two-sample problem)
set.seed(1)
library(survival)
S <- Surv(runif(200))      # no censoring
sex <- c(rep('female',100),rep('male',100))
med.female <- bootkm(S[sex=='female',], B=100) # normally B=500
med.male   <- bootkm(S[sex=='male',],   B=100)
describe(med.female-med.male)
quantile(med.female-med.male, c(.025,.975), na.rm=TRUE)
# na.rm needed because some bootstrap estimates of median survival
```

```
# time may be missing when a bootstrap sample did not include the
# longer survival times
```

---

bpower *Power and Sample Size for Two-Sample Binomial Test*

Description

Uses method of Fleiss, Tytun, and Ury (but without the continuity correction) to estimate the power (or the sample size to achieve a given power) of a two-sided test for the difference in two proportions. The two sample sizes are allowed to be unequal, but for `bsamsize` you must specify the fraction of observations in group 1. For power calculations, one probability (`p1`) must be given, and either the other probability (`p2`), an `odds.ratio`, or a `percent.reduction` must be given. For `bpower` or `bsamsize`, any or all of the arguments may be vectors, in which case they return a vector of powers or sample sizes. All vector arguments must have the same length.

Given `p1`, `p2`, `ballocation` uses the method of Brittain and Schlesselman to compute the optimal fraction of observations to be placed in group 1 that either (1) minimize the variance of the difference in two proportions, (2) minimize the variance of the ratio of the two proportions, (3) minimize the variance of the log odds ratio, or (4) maximize the power of the 2-tailed test for differences. For (4) the total sample size must be given, or the fraction optimizing the power is not returned. The fraction for (3) is one minus the fraction for (1).

`bpower.sim` estimates power by simulations, in minimal time. By using `bpower.sim` you can see that the formulas without any continuity correction are quite accurate, and that the power of a continuity-corrected test is significantly lower. That's why no continuity corrections are implemented here.

Usage

```
bpower(p1, p2, odds.ratio, percent.reduction,
       n, n1, n2, alpha=0.05)


bsamsize(p1, p2, fraction=.5, alpha=.05, power=.8)


ballocation(p1, p2, n, alpha=.05)


bpower.sim(p1, p2, odds.ratio, percent.reduction,
           n, n1, n2,
           alpha=0.05, nsim=10000)
```

Arguments

`p1`	population probability in the group 1
`p2`	probability for group 2

odds.ratio	odds ratio to detect
percent.reduction	percent reduction in risk to detect
n	total sample size over the two groups. If you omit this for ballocation, the fraction which optimizes power will not be returned.
n1	sample size in group 1
n2	sample size in group 2. bpower, if n is given, n1 and n2 are set to n/2.
alpha	type I assertion probability
fraction	fraction of observations in group 1
power	the desired probability of detecting a difference
nsim	number of simulations of binomial responses

Details

For bpower.sim, all arguments must be of length one.

Value

for bpower, the power estimate; for bsamsize, a vector containing the sample sizes in the two groups; for ballocation, a vector with 4 fractions of observations allocated to group 1, optimizing the four criteria mentioned above. For bpower.sim, a vector with three elements is returned, corresponding to the simulated power and its lower and upper 0.95 confidence limits.

AUTHOR

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References

Fleiss JL, Tytun A, Ury HK (1980): A simple approximation for calculating sample sizes for comparing independent proportions. Biometrics 36:343–6.

Brittain E, Schlesselman JJ (1982): Optimal allocation for the comparison of proportions. Biometrics 38:1003–9.

Gordon I, Watson R (1996): The myth of continuity-corrected sample size formulae. Biometrics 52:71–6.

See Also

samplesize.bin, chisq.test, binconf

Examples

```
bpower(.1, odds.ratio=.9, n=1000, alpha=c(.01,.05))
bpower.sim(.1, odds.ratio=.9, n=1000)
bsamsize(.1, .05, power=.95)
ballocation(.1, .5, n=100)


# Plot power vs. n for various odds ratios  (base prob.=.1)
n  <- seq(10, 1000, by=10)
OR <- seq(.2,.9,by=.1)
plot(0, 0, xlim=range(n), ylim=c(0,1), xlab="n", ylab="Power", type="n")
for(or in OR) {
  lines(n, bpower(.1, odds.ratio=or, n=n))
  text(350, bpower(.1, odds.ratio=or, n=350)-.02, format(or))
}


# Another way to plot the same curves, but letting labcurve do the
# work, including labeling each curve at points of maximum separation
pow <- lapply(OR, function(or,n)list(x=n,y=bpower(p1=.1,odds.ratio=or,n=n)),
              n=n)
names(pow) <- format(OR)
labcurve(pow, pl=TRUE, xlab='n', ylab='Power')


# Contour graph for various probabilities of outcome in the control
# group, fixing the odds ratio at .8 ([p2/(1-p2) / p1/(1-p1)] = .8)
# n is varied also
p1 <- seq(.01,.99,by=.01)
n  <- seq(100,5000,by=250)
pow <- outer(p1, n, function(p1,n) bpower(p1, n=n, odds.ratio=.8))
# This forms a length(p1)*length(n) matrix of power estimates
contour(p1, n, pow)
```

`bpplot` *Box-percentile plots*

Description

Produces side-by-side box-percentile plots from several vectors or a list of vectors.

Usage

```
bpplot(..., name=TRUE, main="Box-Percentile Plot",
       xlab="", ylab="", srtx=0, plotopts=NULL)
```

Arguments

`...`	vectors or lists containing numeric components (e.g., the output of `split`).

name	character vector of names for the groups. Default is TRUE to put names on the x-axis. Such names are taken from the data vectors or the names attribute of the first argument if it is a list. Set name to FALSE to suppress names. If a character vector is supplied the names in the vector are used to label the groups.
main	main title for the plot.
xlab	x axis label.
ylab	y axis label.
srtx	rotation angle for x-axis labels. Default is zero.
plotopts	a list of other parameters to send to plot

Value

There are no returned values

Side Effects

A plot is created on the current graphics device.

BACKGROUND

Box-percentile plots are similiar to boxplots, except box-percentile plots supply more information about the univariate distributions. At any height the width of the irregular "box" is proportional to the percentile of that height, up to the 50th percentile, and above the 50th percentile the width is proportional to 100 minus the percentile. Thus, the width at any given height is proportional to the percent of observations that are more extreme in that direction. As in boxplots, the median, 25th and 75th percentiles are marked with line segments across the box.

Author(s)

Jeffrey Banfield
<umsfjban@bill.oscs.montana.edu>
Modified by F. Harrell 30Jun97

References

Esty WW, Banfield J: The box-percentile plot. J Statistical Software 8 No. 17, 2003.

See Also

panel.bpplot, boxplot, Ecdf, bwplot

Examples

```
set.seed(1)
x1 <- rnorm(500)
x2 <- runif(500, -2, 2)
x3 <- abs(rnorm(500))-2
bpplot(x1, x2, x3)
g <- sample(1:2, 500, replace=TRUE)
```

```
bpplot(split(x2, g), name=c('Group 1','Group 2'))
rm(x1,x2,x3,g)
```

---

bystats *Statistics by Categories*

Description

For any number of cross-classification variables, bystats returns a matrix with the sample size, number missing y, and fun(non-missing y), with the cross-classifications designated by rows. Uses Harrell's modification of the interaction function to produce cross-classifications. The default fun is mean, and if y is binary, the mean is labeled as Fraction. There is a print method as well as a latex method for objects created by bystats. bystats2 handles the special case in which there are 2 classifcation variables, and places the first one in rows and the second in columns. The print method for bystats2 uses the print.char.matrix function to organize statistics for cells into boxes.

Usage

```
bystats(y, ..., fun, nmiss, subset)
## S3 method for class 'bystats'
print(x, ...)
## S3 method for class 'bystats'
latex(object, title, caption, rowlabel, ...)
bystats2(y, v, h, fun, nmiss, subset)
## S3 method for class 'bystats2'
print(x, abbreviate.dimnames=FALSE,
   prefix.width=max(nchar(dimnames(x)[[1]])), ...)
## S3 method for class 'bystats2'
latex(object, title, caption, rowlabel, ...)
```

Arguments

y	a binary, logical, or continuous variable or a matrix or data frame of such variables. If y is a data frame it is converted to a matrix. If y is a data frame or matrix, computations are done on subsets of the rows of y, and you should specify fun so as to be able to operate on the matrix. For matrix y, any column with a missing value causes the entire row to be considered missing, and the row is not passed to fun.
...	For bystats, one or more classifcation variables separated by commas. For print.bystats, options passed to print.default such as digits. For latex.bystats, and latex.bystats2, options passed to latex.default such as digits. If you pass cdec to latex.default, keep in mind that the first one or two positions (depending on nmiss) should have zeros since these correspond with frequency counts.
v	vertical variable for bystats2. Will be converted to factor.

h	horizontal variable for bystats2. Will be converted to factor.
fun	a function to compute on the non-missing y for a given subset. You must specify fun= in front of the function name or definition. fun may return a single number or a vector or matrix of any length. Matrix results are rolled out into a vector, with names preserved. When y is a matrix, a common fun is function(y) apply(y, 2, ff) where ff is the name of a function which operates on one column of y.
nmiss	A column containing a count of missing values is included if nmiss=TRUE or if there is at least one missing value.
subset	a vector of subscripts or logical values indicating the subset of data to analyze
abbreviate.dimnames	set to TRUE to abbreviate dimnames in output
prefix.width	see print.char.matrix
title	title to pass to latex.default. Default is the first word of the character string version of the first calling argument.
caption	caption to pass to latex.default. Default is the heading attribute from the object produced by bystats.
rowlabel	rowlabel to pass to latex.default. Default is the byvarnames attribute from the object produced by bystats. For bystats2 the default is "".
x	an object created by bystats or bystats2
object	an object created by bystats or bystats2

Value

for bystats, a matrix with row names equal to the classification labels and column names N, Missing, funlab, where funlab is determined from fun. A row is added to the end with the summary statistics computed on all observations combined. The class of this matrix is bystats. For bystats, returns a 3-dimensional array with the last dimension corresponding to statistics being computed. The class of the array is bystats2.

Side Effects

latex produces a .tex file.

Author(s)

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See Also

interaction, cut, cut2, latex, print.char.matrix, translate

Examples

```
## Not run:
bystats(sex==2, county, city)
bystats(death, race)
bystats(death, cut2(age,g=5), race)
bystats(cholesterol, cut2(age,g=4), sex, fun=median)
bystats(cholesterol, sex, fun=quantile)
bystats(cholesterol, sex, fun=function(x)c(Mean=mean(x),Median=median(x)))
latex(bystats(death,race,nmiss=FALSE,subset=sex=="female"), digits=2)
f <- function(y) c(Hazard=sum(y[,2])/sum(y[,1]))
# f() gets the hazard estimate for right-censored data from exponential dist.
bystats(cbind(d.time, death), race, sex, fun=f)
bystats(cbind(pressure, cholesterol), age.decile,
        fun=function(y) c(Median.pressure   =median(y[,1]),
                          Median.cholesterol=median(y[,2])))
y <- cbind(pressure, cholesterol)
bystats(y, age.decile,
        fun=function(y) apply(y, 2, median))   # same result as last one
bystats(y, age.decile, fun=function(y) apply(y, 2, quantile, c(.25,.75)))
# The last one computes separately the 0.25 and 0.75 quantiles of 2 vars.
latex(bystats2(death, race, sex, fun=table))

## End(Not run)
```

`capitalize` *capitalize the first letter of a string*

Description

Capitalizes the first letter of each element of the string vector.

Usage

```
capitalize(string)
```

Arguments

`string`	String to be capitalized

Value

Returns a vector of charaters with the first letter capitalized

Author(s)

Charles Dupont

Examples

```
capitalize(c("Hello", "bob", "daN"))
```

ciapower *Power of Interaction Test for Exponential Survival*

Description

Uses the method of Peterson and George to compute the power of an interaction test in a 2 x 2 setup in which all 4 distributions are exponential. This will be the same as the power of the Cox model test if assumptions hold. The test is 2-tailed. The duration of accrual is specified (constant accrual is assumed), as is the minimum follow-up time. The maximum follow-up time is then `accrual + tmin`. Treatment allocation is assumed to be 1:1.

Usage

```
ciapower(tref, n1, n2, m1c, m2c, r1, r2, accrual, tmin,
         alpha=0.05, pr=TRUE)
```

Arguments

`tref`	time at which mortalities estimated
`n1`	total sample size, stratum 1
`n2`	total sample size, stratum 2
`m1c`	tref-year mortality, stratum 1 control
`m2c`	tref-year mortality, stratum 2 control
`r1`	% reduction in `m1c` by intervention, stratum 1
`r2`	% reduction in `m2c` by intervention, stratum 2
`accrual`	duration of accrual period
`tmin`	minimum follow-up time
`alpha`	type I error probability
`pr`	set to `FALSE` to suppress printing of details

Value

power

Side Effects

prints

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References

Peterson B, George SL: Controlled Clinical Trials 14:511–522; 1993.

See Also

cpower, spower

Examples

```
# Find the power of a race x treatment test.  25% of patients will
# be non-white and the total sample size is 14000.
# Accrual is for 1.5 years and minimum follow-up is 5y.
# Reduction in 5-year mortality is 15% for whites, 0% or -5% for
# non-whites.  5-year mortality for control subjects if assumed to
# be 0.18 for whites, 0.23 for non-whites.
n <- 14000
for(nonwhite.reduction in c(0,-5)) {
  cat("\n\n\n% Reduction in 5-year mortality for non-whites:",
      nonwhite.reduction, "\n\n")
  pow <- ciapower(5,  .75*n, .25*n,  .18, .23,  15, nonwhite.reduction,
                  1.5, 5)
  cat("\n\nPower:",format(pow),"\n")
}
```

---

cnvrt.coords *Convert between the 5 different coordinate sytems on a graphical device*

Description

Takes a set of coordinates in any of the 5 coordinate systems (usr, plt, fig, dev, or tdev) and returns the same points in all 5 coordinate systems.

Usage

```
cnvrt.coords(x, y = NULL, input = c("usr", "plt", "fig", "dev","tdev"))
```

Arguments

x	Vector, Matrix, or list of x coordinates (or x and y coordinates), NA's allowed.
y	y coordinates (if x is a vector), NA's allowed.
input	Character scalar indicating the coordinate system of the input points.

Details

Every plot has 5 coordinate systems:

usr (User): the coordinate system of the data, this is shown by the tick marks and axis labels.

plt (Plot): Plot area, coordinates range from 0 to 1 with 0 corresponding to the x and y axes and 1 corresponding to the top and right of the plot area. Margins of the plot correspond to plot coordinates less than 0 or greater than 1.

fig (Figure): Figure area, coordinates range from 0 to 1 with 0 corresponding to the bottom and left edges of the figure (including margins, label areas) and 1 corresponds to the top and right edges. fig and dev coordinates will be identical if there is only 1 figure area on the device (layout, mfrow, or mfcol has not been used).

dev (Device): Device area, coordinates range from 0 to 1 with 0 corresponding to the bottom and left of the device region within the outer margins and 1 is the top and right of the region withing the outer margins. If the outer margins are all set to 0 then tdev and dev should be identical.

tdev (Total Device): Total Device area, coordinates range from 0 to 1 with 0 corresponding to the bottom and left edges of the device (piece of paper, window on screen) and 1 corresponds to the top and right edges.

Value

A list with 5 components, each component is a list with vectors named x and y. The 5 sublists are:

`usr`	The coordinates of the input points in usr (User) coordinates.
`plt`	The coordinates of the input points in plt (Plot) coordinates.
`fig`	The coordinates of the input points in fig (Figure) coordinates.
`dev`	The coordinates of the input points in dev (Device) coordinates.
`tdev`	The coordinates of the input points in tdev (Total Device) coordinates.

Note

You must provide both x and y, but one of them may be `NA`.

This function is becoming depricated with the new functions `grconvertX` and `grconvertY` in R version 2.7.0 and beyond. These new functions use the correct coordinate system names and have more coordinate systems available, you should start using them instead.

Author(s)

Greg Snow <greg.snow@imail.org>

See Also

`par` specifically 'usr','plt', and 'fig'. Also 'xpd' for plotting outside of the plotting region and 'mfrow' and 'mfcol' for multi figure plotting. `subplot`, `grconvertX` and `grconvertY` in R2.7.0 and later

Examples

```
old.par <- par(no.readonly=TRUE)

par(mfrow=c(2,2),xpd=NA)

# generate some sample data
tmp.x <- rnorm(25, 10, 2)
tmp.y <- rnorm(25, 50, 10)
tmp.z <- rnorm(25, 0, 1)

plot( tmp.x, tmp.y)

# draw a diagonal line across the plot area
tmp1 <- cnvrt.coords( c(0,1), c(0,1), input='plt' )
lines(tmp1$usr, col='blue')

# draw a diagonal line accross figure region
tmp2 <- cnvrt.coords( c(0,1), c(1,0), input='fig')
lines(tmp2$usr, col='red')

# save coordinate of point 1 and y value near top of plot for future plots
tmp.point1 <- cnvrt.coords(tmp.x[1], tmp.y[1])
tmp.range1 <- cnvrt.coords(NA, 0.98, input='plt')

# make a second plot and draw a line linking point 1 in each plot
plot(tmp.y, tmp.z)

tmp.point2 <- cnvrt.coords( tmp.point1$dev, input='dev' )
arrows( tmp.y[1], tmp.z[1], tmp.point2$usr$x, tmp.point2$usr$y,
 col='green')

# draw another plot and add rectangle showing same range in 2 plots

plot(tmp.x, tmp.z)
tmp.range2 <- cnvrt.coords(NA, 0.02, input='plt')
tmp.range3 <- cnvrt.coords(NA, tmp.range1$dev$y, input='dev')
rect( 9, tmp.range2$usr$y, 11, tmp.range3$usr$y, border='yellow')

# put a label just to the right of the plot and
#  near the top of the figure region.
text( cnvrt.coords(1.05, NA, input='plt')$usr$x,
 cnvrt.coords(NA, 0.75, input='fig')$usr$y,
 "Label", adj=0)

par(mfrow=c(1,1))

## create a subplot within another plot (see also subplot)

plot(1:10, 1:10)

tmp <- cnvrt.coords( c( 1, 4, 6, 9), c(6, 9, 1, 4) )
```

```
par(plt = c(tmp$dev$x[1:2], tmp$dev$y[1:2]), new=TRUE)
hist(rnorm(100))

par(fig = c(tmp$dev$x[3:4], tmp$dev$y[3:4]), new=TRUE)
hist(rnorm(100))

par(old.par)
```

---

colorFacet *Miscellaneous ggplot2 and grid Helper Functions*

Description

These functions are used on ggplot2 objects or as layers when building a ggplot2 object, and to facilitate use of gridExtra. colorFacet colors the thin rectangles used to separate panels created by facet_grid (and probably by facet_wrap). A better approach may be found at https://stackoverflow.com/questions/28652284/. arrGrob is a front-end to gridExtra::arrangeGrob that allows for proper printing. See https://stackoverflow.com/questions/29062766/store-output-from-gridextr The arrGrob print method calls grid::grid.draw.

Usage

```
colorFacet(g, col = adjustcolor("blue", alpha.f = 0.3))

arrGrob(...)

## S3 method for class 'arrGrob'
print(x, ...)
```

Arguments

g	a ggplot2 object that used faceting
col	color for facet separator rectanges
...	passed to arrangeGrob
x	an object created by arrGrob

Author(s)

Sandy Muspratt

Examples

```
## Not run:
require(ggplot2)
s <- summaryP(age + sex ~ region + treatment)
colorFacet(ggplot(s))   # prints directly
# arrGrob is called by rms::ggplot.Predict and others
```

```
## End(Not run)
```

`combine.levels` *combine.levels*

Description

Combine Infrequent Levels of a Categorical Variable

Usage

```
combine.levels(
  x,
  minlev = 0.05,
  m,
  ord = is.ordered(x),
  plevels = FALSE,
  sep = ","
)
```

Arguments

`x`	a factor, ‘ordered‘ factor, or numeric or character variable that will be turned into a ‘factor‘
`minlev`	the minimum proportion of observations in a cell before that cell is combined with one or more cells. If more than one cell has fewer than minlev*n observations, all such cells are combined into a new cell labeled ‘"OTHER"‘. Otherwise, the lowest frequency cell is combined with the next lowest frequency cell, and the level name is the combination of the two old level levels. When ‘ord=TRUE‘ combinations happen only for consecutive levels.
`m`	alternative to ‘minlev‘, is the minimum number of observations in a cell before it will be combined with others
`ord`	set to ‘TRUE‘ to treat ‘x‘ as if it were an ordered factor, which allows only consecutive levels to be combined
`plevels`	by default ‘combine.levels‘ pools low-frequency levels into a category named ‘OTHER‘ when ‘x‘ is not ordered and ‘ord=FALSE‘. To instead name this category the concatenation of all the pooled level names, separated by a comma, set ‘plevels=TRUE‘.
`sep`	the separator for concatenating levels when ‘plevels=TRUE‘

Details

After turning ‘x‘ into a ‘factor‘ if it is not one already, combines levels of ‘x‘ whose frequency falls below a specified relative frequency ‘minlev‘ or absolute count ‘m‘. When ‘x‘ is not treated as ordered, all of the small frequency levels are combined into ‘"OTHER"‘, unless ‘plevels=TRUE‘. When ‘ord=TRUE‘ or ‘x‘ is an ordered factor, only consecutive levels are combined. New levels are constructed by concatenating the levels with ‘sep‘ as a separator. This is useful when comparing ordinal regression with polytomous (multinomial) regression and there are too many categories for polytomous regression. ‘combine.levels‘ is also useful when assumptions of ordinal models are being checked empirically by computing exceedance probabilities for various cutoffs of the dependent variable.

Value

a factor variable, or if ‘ord=TRUE‘ an ordered factor variable

Author(s)

Frank Harrell

Examples

```
x <- c(rep('A', 1), rep('B', 3), rep('C', 4), rep('D',1), rep('E',1))
combine.levels(x, m=3)
combine.levels(x, m=3, plevels=TRUE)
combine.levels(x, ord=TRUE, m=3)
x <- c(rep('A', 1), rep('B', 3), rep('C', 4), rep('D',1), rep('E',1),
       rep('F',1))
combine.levels(x, ord=TRUE, m=3)
```

---

combplotp *Combination Plot*

Description

Generates a plotly attribute plot given a series of possibly overlapping binary variables

Usage

```
combplotp(
  formula,
  data = NULL,
  subset,
  na.action = na.retain,
  vnames = c("labels", "names"),
  includenone = FALSE,
  showno = FALSE,
  maxcomb = NULL,
  minfreq = NULL,
```

```
  N = NULL,
  pos = function(x) 1 * (tolower(x) %in% c("true", "yes", "y", "positive", "+",
    "present", "1")),
  obsname = "subjects",
  ptsize = 35,
  width = NULL,
  height = NULL,
  ...
)
```

Arguments

formula	a formula containing all the variables to be cross-tabulated, on the formula's right hand side. There is no left hand side variable. If formula is omitted, then all variables from data are analyzed.
data	input data frame. If none is specified the data are assumed to come from the parent frame.
subset	an optional subsetting expression applied to data
na.action	see lm etc.
vnames	set to "names" to use variable names to label axes instead of variable labels. When using the default labels, any variable not having a label will have its name used instead.
includenone	set to TRUE to include the combination where all conditions are absent
showno	set to TRUE to show a light dot for conditions that are not part of the currently tabulated combination
maxcomb	maximum number of combinations to display
minfreq	if specified, any combination having a frequency less than this will be omitted from the display
N	set to an integer to override the global denominator, instead of using the number of rows in the data
pos	a function of vector returning a logical vector with TRUE values indicating positive
obsname	character string noun describing observations, default is "subjects"
ptsize	point size, defaults to 35
width	width of plotly plot
height	height of plotly plot
...	optional arguments to pass to table

Details

Similar to the UpSetR package, draws a special dot chart sometimes called an attribute plot that depicts all possible combination of the binary variables. By default a positive value, indicating that a certain condition pertains for a subject, is any of logical TRUE, numeric 1, "yes", "y", "positive", "+" or "present" value, and all others are considered negative. The user can override this determination by specifying her own pos function. Case is ignored in the variable values.

The plot uses solid dots arranged in a vertical line to indicate which combination of conditions is being considered. Frequencies of all possible combinations are shown above the dot chart. Marginal frequencies of positive values for the input variables are shown to the left of the dot chart. More information for all three of these component symbols is provided in hover text.

Variables are sorted in descending order of marginal frqeuencies and likewise for combinations of variables.

Value

`plotly` object

Author(s)

Frank Harrell

Examples

```
if (requireNamespace("plotly")) {
  g <- function() sample(0:1, n, prob=c(1 - p, p), replace=TRUE)
  set.seed(2); n <- 100; p <- 0.5
  x1 <- g(); label(x1) <- 'A long label for x1 that describes it'
  x2 <- g()
  x3 <- g(); label(x3) <- 'This is<br>a label for x3'
  x4 <- g()
  combplotp(~ x1 + x2 + x3 + x4, showno=TRUE, includenone=TRUE)

  n <- 1500; p <- 0.05
  pain       <- g()
  anxiety    <- g()
  depression <- g()
  soreness   <- g()
  numbness   <- g()
  tiredness  <- g()
  sleepiness <- g()
  combplotp(~ pain + anxiety + depression + soreness + numbness +
            tiredness + sleepiness, showno=TRUE)
}
```

`completer` *completer*

Description

Create imputed dataset(s) using `transcan` and `aregImpute` objects

Usage

```
completer(a, nimpute, oneimpute = FALSE, mydata)
```

Arguments

a	An object of class transcan or aregImpute
nimpute	A numeric vector between 1 and a$n.impute. For transcan object, this is set to 1. For aregImpute object, returns a list of nimpute datasets when oneimpute is set to FALSE (default).
oneimpute	A logical vector. When set to TRUE, returns a single completed dataset for the imputation number specified by nimpute
mydata	A data frame in which its missing values will be imputed.

Details

Similar in function to mice::complete, this function uses transcan and aregImpute objects to impute missing data and returns the completed dataset(s) as a dataframe or a list. It assumes that transcan is used for single regression imputation.

Value

A single or a list of completed dataset(s).

Author(s)

Yong-Hao Pua, Singapore General Hospital

Examples

```
## Not run:
mtcars$hp[1:5]    <- NA
mtcars$wt[1:10]   <- NA
myrform <- ~ wt + hp + I(carb)
mytranscan  <- transcan( myrform,  data = mtcars, imputed = TRUE,
  pl = FALSE, pr = FALSE, trantab = TRUE, long = TRUE)
myareg      <- aregImpute(myrform, data = mtcars, x=TRUE, n.impute = 5)
completer(mytranscan)                    # single completed dataset
completer(myareg, 3, oneimpute = TRUE)
# single completed dataset based on the `n.impute`th set of multiple imputation
completer(myareg, 3)
# list of completed datasets based on first `nimpute` sets of multiple imputation
completer(myareg)
# list of completed datasets based on all available sets of multiple imputation
# To get a stacked data frame of all completed datasets use
# do.call(rbind, completer(myareg, data=mydata))
# or use rbindlist in data.table

## End(Not run)
```

consolidate *Element Merging*

Description

Merges an object by the names of its elements. Inserting elements in `value` into `x` that do not exists in `x` and replacing elements in `x` that exists in `value` with `value` elements if `protect` is false.

Usage

```
consolidate(x, value, protect, ...)
## Default S3 method:
consolidate(x, value, protect=FALSE, ...)

consolidate(x, protect, ...) <- value
```

Arguments

`x`	named list or vector
`value`	named list or vector
`protect`	logical; should elements in `x` be kept instead of elements in `value`?
`...`	currently does nothing; included if ever want to make generic.

Author(s)

Charles Dupont

See Also

`names`

Examples

```
x <- 1:5
names(x) <- LETTERS[x]

y <- 6:10
names(y) <- LETTERS[y-2]

x                  # c(A=1,B=2,C=3,D=4,E=5)
y                  # c(D=6,E=7,F=8,G=9,H=10)

consolidate(x, y)      # c(A=1,B=2,C=3,D=6,E=7,F=8,G=9,H=10)
consolidate(x, y, protect=TRUE)      # c(A=1,B=2,C=3,D=4,E=5,F=8,G=9,H=10)
```

contents *Metadata for a Data Frame*

Description

contents is a generic method for which contents.data.frame is currently the only method. contents.data.frame creates an object containing the following attributes of the variables from a data frame: names, labels (if any), units (if any), number of factor levels (if any), factor levels, class, storage mode, and number of NAs. print.contents.data.frame will print the results, with options for sorting the variables. html.contents.data.frame creates HTML code for displaying the results. This code has hyperlinks so that if the user clicks on the number of levels the browser jumps to the correct part of a table of factor levels for all the factor variables. If long labels are present ("longlabel" attributes on variables), these are printed at the bottom and the html method links to them through the regular labels. Variables having the same levels in the same order have the levels factored out for brevity.

contents.list prints a directory of datasets when sasxport.get imported more than one SAS dataset.

If options(prType='html') is in effect, calling print on an object that is the contents of a data frame will result in rendering the HTML version. If run from the console a browser window will open.

Usage

```
contents(object, ...)
## S3 method for class 'data.frame'
contents(object, sortlevels=FALSE, id=NULL,
  range=NULL, values=NULL, ...)
## S3 method for class 'contents.data.frame'
print(x,
    sort=c('none','names','labels','NAs'), prlevels=TRUE, maxlevels=Inf,
    number=FALSE, ...)
## S3 method for class 'contents.data.frame'
html(object,
           sort=c('none','names','labels','NAs'), prlevels=TRUE, maxlevels=Inf,
           levelType=c('list','table'),
           number=FALSE, nshow=TRUE, ...)
## S3 method for class 'list'
contents(object, dslabels, ...)
## S3 method for class 'contents.list'
print(x,
    sort=c('none','names','labels','NAs','vars'), ...)
```

Arguments

object	a data frame. For html is an object created by contents. For contents.list is a list of data frames.

sortlevels	set to TRUE to sort levels of all factor variables into alphabetic order. This is especially useful when two variables use the same levels but in different orders. They will still be recognized by the html method as having identical levels if sorted.
id	an optional subject ID variable name that if present in object will cause the number of unique IDs to be printed in the contents header
range	an optional variable name that if present in object will cause its range to be printed in the contents header
values	an optional variable name that if present in object will cause its unique values to be printed in the contents header
x	an object created by contents
sort	Default is to print the variables in their original order in the data frame. Specify one of "names", "labels", or "NAs" to sort the variables by, respectively, alphabetically by names, alphabetically by labels, or by increaseing order of number of missing values. For contents.list, sort may also be the value "vars" to cause sorting by the number of variables in the dataset.
prlevels	set to FALSE to not print all levels of factor variables
maxlevels	maximum number of levels to print for a factor variable
number	set to TRUE to have the print and latex methods number the variables by their order in the data frame
nshow	set to FALSE to suppress outputting number of observations and number of NAs; useful when these counts would unblind information to blinded reviewers
levelType	By default, bullet lists of category levels are constructed in html. Set levelType='table' to put levels in html table format.
...	arguments passed from html to format.df, unused otherwise
dslabels	named vector of SAS dataset labels, created for example by sasdsLabels

Value

an object of class "contents.data.frame" or "contents.list". For the html method is an html character vector object.

Author(s)

Frank Harrell
Vanderbilt University
<fh@fharrell.com>

See Also

describe, html, upData, extractlabs, hlab

Examples

```
set.seed(1)
dfr <- data.frame(x=rnorm(400),y=sample(c('male','female'),400,TRUE),
                  stringsAsFactors=TRUE)
contents(dfr)
dfr <- upData(dfr, labels=c(x='Label for x', y='Label for y'))
attr(dfr$x, 'longlabel') <-
 'A very long label for x that can continue onto multiple long lines of text'

k <- contents(dfr)
print(k, sort='names', prlevels=FALSE)
## Not run:
html(k)
html(contents(dfr))           # same result
latex(k$contents)             # latex.default just the main information

## End(Not run)
```

---

cpower *Power of Cox/log-rank Two-Sample Test*

Description

Assumes exponential distributions for both treatment groups. Uses the George-Desu method along with formulas of Schoenfeld that allow estimation of the expected number of events in the two groups. To allow for drop-ins (noncompliance to control therapy, crossover to intervention) and noncompliance of the intervention, the method of Lachin and Foulkes is used.

Usage

```
cpower(tref, n, mc, r, accrual, tmin, noncomp.c=0, noncomp.i=0,
       alpha=0.05, nc, ni, pr=TRUE)
```

Arguments

tref	time at which mortalities estimated
n	total sample size (both groups combined). If allocation is unequal so that there are not n/2 observations in each group, you may specify the sample sizes in nc and ni.
mc	tref-year mortality, control
r	% reduction in mc by intervention
accrual	duration of accrual period
tmin	minimum follow-up time
noncomp.c	% non-compliant in control group (drop-ins)
noncomp.i	% non-compliant in intervention group (non-adherers)

alpha	type I error probability. A 2-tailed test is assumed.
nc	number of subjects in control group
ni	number of subjects in intervention group. nc and ni are specified exclusive of n.
pr	set to FALSE to suppress printing of details

Details

For handling noncompliance, uses a modification of formula (5.4) of Lachin and Foulkes. Their method is based on a test for the difference in two hazard rates, whereas cpower is based on testing the difference in two log hazards. It is assumed here that the same correction factor can be approximately applied to the log hazard ratio as Lachin and Foulkes applied to the hazard difference.

Note that Schoenfeld approximates the variance of the log hazard ratio by 4/m, where m is the total number of events, whereas the George-Desu method uses the slightly better 1/m1 + 1/m2. Power from this function will thus differ slightly from that obtained with the SAS samsizc program.

Value

power

Side Effects

prints

Author(s)

Frank Harrell
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Vanderbilt University
<fh@fharrell.com>

References

Peterson B, George SL: Controlled Clinical Trials 14:511–522; 1993.

Lachin JM, Foulkes MA: Biometrics 42:507–519; 1986.

Schoenfeld D: Biometrics 39:499–503; 1983.

See Also

spower, ciapower, bpower

Examples

```
#In this example, 4 plots are drawn on one page, one plot for each
#combination of noncompliance percentage.  Within a plot, the
#5-year mortality % in the control group is on the x-axis, and
#separate curves are drawn for several % reductions in mortality
#with the intervention.  The accrual period is 1.5y, with all
#patients followed at least 5y and some 6.5y.
```

```
par(mfrow=c(2,2),oma=c(3,0,3,0))


morts <- seq(10,25,length=50)
red <- c(10,15,20,25)


for(noncomp in c(0,10,15,-1)) {
  if(noncomp>=0) nc.i <- nc.c <- noncomp else {nc.i <- 25; nc.c <- 15}
  z <- paste("Drop-in ",nc.c,"%, Non-adherence ",nc.i,"%",sep="")
  plot(0,0,xlim=range(morts),ylim=c(0,1),
           xlab="5-year Mortality in Control Patients (%)",
           ylab="Power",type="n")
  title(z)
  cat(z,"\n")
  lty <- 0
  for(r in red) {
        lty <- lty+1
        power <- morts
        i <- 0
        for(m in morts) {
          i <- i+1
          power[i] <- cpower(5, 14000, m/100, r, 1.5, 5, nc.c, nc.i, pr=FALSE)
        }
        lines(morts, power, lty=lty)
  }
  if(noncomp==0)legend(18,.55,rev(paste(red,"% reduction",sep="")),
           lty=4:1,bty="n")
}
mtitle("Power vs Non-Adherence for Main Comparison",
           ll="alpha=.05, 2-tailed, Total N=14000",cex.l=.8)
#
# Point sample size requirement vs. mortality reduction
# Root finder (uniroot()) assumes needed sample size is between
# 1000 and 40000
#
nc.i <- 25; nc.c <- 15; mort <- .18
red <- seq(10,25,by=.25)
samsiz <- red


i <- 0
for(r in red) {
  i <- i+1
  samsiz[i] <- uniroot(function(x) cpower(5, x, mort, r, 1.5, 5,
                                          nc.c, nc.i, pr=FALSE) - .8,
                       c(1000,40000))$root
}


samsiz <- samsiz/1000
```

```
par(mfrow=c(1,1))
plot(red, samsiz, xlab='% Reduction in 5-Year Mortality',
  ylab='Total Sample Size (Thousands)', type='n')
lines(red, samsiz, lwd=2)
title('Sample Size for Power=0.80\nDrop-in 15%, Non-adherence 25%')
title(sub='alpha=0.05, 2-tailed', adj=0)
```

Cs *Character strings from unquoted names*

Description

Cs makes a vector of character strings from a list of valid R names. .q is similar but also makes uses of names of arguments.

Usage

```
Cs(...)
.q(...)
```

Arguments

...	any number of names separated by commas. For .q any names of arguments will be used.

Value

character string vector. For .q there will be a names attribute to the vector if any names appeared in ....

See Also

sys.frame, deparse

Examples

```
Cs(a,cat,dog)
# subset.data.frame <- dataframe[,Cs(age,sex,race,bloodpressure,height)]
.q(a, b, c, 'this and that')
.q(dog=a, giraffe=b, cat=c)
```

csv.get *Read Comma-Separated Text Data Files*

Description

Read comma-separated text data files, allowing optional translation to lower case for variable names after making them valid S names. There is a facility for reading long variable labels as one of the rows. If labels are not specified and a final variable name is not the same as that in the header, the original variable name is saved as a variable label. Uses `read.csv` if the `data.table` package is not in effect, otherwise calls `fread`.

Usage

```
csv.get(file, lowernames=FALSE, datevars=NULL, datetimevars=NULL,
        dateformat='%F',
        fixdates=c('none','year'), comment.char="", autodate=TRUE,
        allow=NULL, charfactor=FALSE,
        sep=',', skip=0, vnames=NULL, labels=NULL, text=NULL, ...)
```

Arguments

`file`	the file name for import.
`lowernames`	set this to `TRUE` to change variable names to lower case.
`datevars`	character vector of names (after `lowernames` is applied) of variables to consider as a factor or character vector containing dates in a format matching `dateformat`. The default is `"%F"` which uses the yyyy-mm-dd format.
`datetimevars`	character vector of names (after `lowernames` is applied) of variables to consider to be date-time variables, with date formats as described under `datevars` followed by a space followed by time in hh:mm:ss format. `chron` is used to store such variables. If all times in the variable are 00:00:00 the variable will be converted to an ordinary date variable.
`dateformat`	for `cleanup.import` is the input format (see `strptime`)
`fixdates`	for any of the variables listed in `datevars` that have a `dateformat` that `cleanup.import` understands, specifying `fixdates` allows corrections of certain formatting inconsistencies before the fields are attempted to be converted to dates (the default is to assume that the `dateformat` is followed for all observation for `datevars`). Currently `fixdates='year'` is implemented, which will cause 2-digit or 4-digit years to be shifted to the alternate number of digits when `dateform` is the default `"%F"` or is `"%y-%m-%d"`, `"%m/%d/%y"`, or `"%m/%d/%Y"`. Two-digits years are padded with `20` on the left. Set `dateformat` to the desired format, not the exceptional format.
`comment.char`	a character vector of length one containing a single character or an empty string. Use `""` to turn off the interpretation of comments altogether.
`autodate`	Set to true to allow function to guess at which variables are dates

allow	a vector of characters allowed by R that should not be converted to periods in variable names. By default, underscores in variable names are converted to periods as with R before version 1.9.
charfactor	set to TRUE to change character variables to factors if they have fewer than n/2 unique values. Blanks and null strings are converted to NAs.
sep	field separator, defaults to comma
skip	number of records to skip before data start. Required if vnames or labels is given.
vnames	number of row containing variable names, default is one
labels	number of row containing variable labels, default is no labels
text	a character string containing the .csv file to use instead of file=. Passed to read.csv as the text= argument.
...	arguments to pass to read.csv other than skip and sep.

Details

csv.get reads comma-separated text data files, allowing optional translation to lower case for variable names after making them valid S names. Original possibly non-legal names are taken to be variable labels if labels is not specified. Character or factor variables containing dates can be converted to date variables. cleanup.import is invoked to finish the job.

Value

a new data frame.

Author(s)

Frank Harrell, Vanderbilt University

See Also

sas.get, data.frame, cleanup.import, read.csv, strptime, POSIXct, Date, fread

Examples

```
## Not run:
dat <- csv.get('myfile.csv')

# Read a csv file with junk in the first row, variable names in the
# second, long variable labels in the third, and junk in the 4th row
dat <- csv.get('myfile.csv', vnames=2, labels=3, skip=4)

## End(Not run)
```

curveRep *Representative Curves*

Description

curveRep finds representative curves from a relatively large collection of curves. The curves usually represent time-response profiles as in serial (longitudinal or repeated) data with possibly unequal time points and greatly varying sample sizes per subject. After excluding records containing missing x or y, records are first stratified into kn groups having similar sample sizes per curve (subject). Within these strata, curves are next stratified according to the distribution of x points per curve (typically measurement times per subject). The clara clustering/partitioning function is used to do this, clustering on one, two, or three x characteristics depending on the minimum sample size in the current interval of sample size. If the interval has a minimum number of unique values of one, clustering is done on the single x values. If the minimum number of unique x values is two, clustering is done to create groups that are similar on both min(x) and max(x). For groups containing no fewer than three unique x values, clustering is done on the trio of values min(x), max(x), and the longest gap between any successive x. Then within sample size and x distribution strata, clustering of time-response profiles is based on p values of y all evaluated at the same p equally-spaced x's within the stratum. An option allows per-curve data to be smoothed with lowess before proceeding. Outer x values are taken as extremes of x across all curves within the stratum. Linear interpolation within curves is used to estimate y at the grid of x's. For curves within the stratum that do not extend to the most extreme x values in that stratum, extrapolation uses flat lines from the observed extremes in the curve unless extrap=TRUE. The p y values are clustered using clara.

print and plot methods show results. By specifying an auxiliary idcol variable to plot, other variables such as treatment may be depicted to allow the analyst to determine for example whether subjects on different treatments are assigned to different time-response profiles. To write the frequencies of a variable such as treatment in the upper left corner of each panel (instead of the grand total number of clusters in that panel), specify freq.

curveSmooth takes a set of curves and smooths them using lowess. If the number of unique x points in a curve is less than p, the smooth is evaluated at the unique x values. Otherwise it is evaluated at an equally spaced set of x points over the observed range. If fewer than 3 unique x values are in a curve, those points are used and smoothing is not done.

Usage

```
curveRep(x, y, id, kn = 5, kxdist = 5, k = 5, p = 5,
         force1 = TRUE, metric = c("euclidean", "manhattan"),
         smooth=FALSE, extrap=FALSE, pr=FALSE)

## S3 method for class 'curveRep'
print(x, ...)

## S3 method for class 'curveRep'
plot(x, which=1:length(res),
                        method=c('all','lattice','data'),
```

```
                          m=NULL, probs=c(.5, .25, .75), nx=NULL, fill=TRUE,
                          idcol=NULL, freq=NULL, plotfreq=FALSE,
                          xlim=range(x), ylim=range(y),
                          xlab='x', ylab='y', colorfreq=FALSE, ...)
curveSmooth(x, y, id, p=NULL, pr=TRUE)
```

Arguments

x	a numeric vector, typically measurement times. For `plot.curveRep` is an object created by `curveRep`.
y	a numeric vector of response values
id	a vector of curve (subject) identifiers, the same length as `x` and `y`
kn	number of curve sample size groups to construct. `curveRep` tries to divide the data into equal numbers of curves across sample size intervals.
kxdist	maximum number of x-distribution clusters to derive using `clara`
k	maximum number of x-y profile clusters to derive using `clara`
p	number of `x` points at which to interpolate `y` for profile clustering. For `curveSmooth` is the number of equally spaced points at which to evaluate the lowess smooth, and if `p` is omitted the smooth is evaluated at the original `x` values (which will allow `curveRep` to still know the `x` distribution
force1	By default if any curves have only one point, all curves consisting of one point will be placed in a separate stratum. To prevent this separation, set `force1 = FALSE`.
metric	see `clara`
smooth	By default, linear interpolation is used on raw data to obtain `y` values to cluster to determine x-y profiles. Specify `smooth = TRUE` to replace observed points with `lowess` before computing `y` points on the grid. Also, when `smooth` is used, it may be desirable to use `extrap=TRUE`.
extrap	set to `TRUE` to use linear extrapolation to evaluate `y` points for x-y clustering. Not recommended unless smoothing has been or is being done.
pr	set to `TRUE` to print progress notes
which	an integer vector specifying which sample size intervals to plot. Must be specified if `method='lattice'` and must be a single number in that case.
method	The default makes individual plots of possibly all x-distribution by sample size by cluster combinations. Fewer may be plotted by specifying `which`. Specify `method='lattice'` to show a lattice `xyplot` of a single sample size interval, with x distributions going across and clusters going down. To not plot but instead return a data frame for a single sample size interval, specify `method='data'`
m	the number of curves in a cluster to randomly sample if there are more than `m` in a cluster. Default is to draw all curves in a cluster. For `method = "lattice"` you can specify `m = "quantiles"` to use the `xYplot` function to show quantiles of `y` as a function of `x`, with the quantiles specified by the `probs` argument. This cannot be used to draw a group containing `n = 1`.

nx	applies if m = "quantiles". See xYplot.
probs	3-vector of probabilities with the central quantile first. Default uses quartiles.
fill	for method = "all", by default if a sample size x-distribution stratum did not have enough curves to stratify into k x-y profiles, empty graphs are drawn so that a matrix of graphs will have the next row starting with a different sample size range or x-distribution. See the example below.
idcol	a named vector to be used as a table lookup for color assignments (does not apply when m = "quantile"). The names of this vector are curve ids and the values are color names or numbers.
freq	a named vector to be used as a table lookup for a grouping variable such as treatment. The names are curve ids and values are any values useful for grouping in a frequency tabulation.
plotfreq	set to TRUE to plot the frequencies from the freq variable as horizontal bars instead of printing them. Applies only to method = "lattice". By default the largest bar is 0.1 times the length of a panel's x-axis. Specify plotfreq = 0.5 for example to make the longest bar half this long.
colorfreq	set to TRUE to color the frequencies printed by plotfreq using the colors provided by idcol.
xlim, ylim, xlab, ylab	plotting parameters. Default ranges are the ranges in the entire set of raw data given to curveRep.
...	arguments passed to other functions.

Details

In the graph titles for the default graphic output, n refers to the minimum sample size, x refers to the sequential x-distribution cluster, and c refers to the sequential x-y profile cluster. Graphs from method = "lattice" are produced by xyplot and in the panel titles distribution refers to the x-distribution stratum and cluster refers to the x-y profile cluster.

Value

a list of class "curveRep" with the following elements

res	a hierarchical list first split by sample size intervals, then by x distribution clusters, then containing a vector of cluster numbers with id values as a names attribute
ns	a table of frequencies of sample sizes per curve after removing NAs
nomit	total number of records excluded due to NAs
missfreq	a table of frequencies of number of NAs excluded per curve
ncuts	cut points for sample size intervals
kn	number of sample size intervals
kxdist	number of clusters on x distribution
k	number of clusters of curves within sample size and distribution groups
p	number of points at which to evaluate each curve for clustering

x

y

id input data after removing NAs

curveSmooth returns a list with elements x,y,id.

Note

The references describe other methods for deriving representative curves, but those methods were not used here. The last reference which used a cluster analysis on principal components motivated curveRep however. The kml package does k-means clustering of longitudinal data with imputation.

Author(s)

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References

Segal M. (1994): Representative curves for longitudinal data via regression trees. J Comp Graph Stat 3:214-233.

Jones MC, Rice JA (1992): Displaying the important features of large collections of similar curves. Am Statistician 46:140-145.

Zheng X, Simpson JA, et al (2005): Data from a study of effectiveness suggested potential prognostic factors related to the patterns of shoulder pain. J Clin Epi 58:823-830.

See Also

clara,dataRep

Examples

```
## Not run:
# Simulate 200 curves with per-curve sample sizes ranging from 1 to 10
# Make curves with odd-numbered IDs have an x-distribution that is random
# uniform [0,1] and those with even-numbered IDs have an x-dist. that is
# half as wide but still centered at 0.5.  Shift y values higher with
# increasing IDs
set.seed(1)
N <- 200
nc <- sample(1:10, N, TRUE)
id <- rep(1:N, nc)
x <- y <- id
for(i in 1:N) {
  x[id==i] <- if(i %% 2) runif(nc[i]) else runif(nc[i], c(.25, .75))
  y[id==i] <- i + 10*(x[id==i] - .5) + runif(nc[i], -10, 10)
}
```

```
w <- curveRep(x, y, id, kxdist=2, p=10)
w
par(ask=TRUE, mfrow=c(4,5))
plot(w)                # show everything, profiles going across
par(mfrow=c(2,5))
plot(w,1)              # show n=1 results
# Use a color assignment table, assigning low curves to green and
# high to red.  Unique curve (subject) IDs are the names of the vector.
cols <- c(rep('green', N/2), rep('red', N/2))
names(cols) <- as.character(1:N)
plot(w, 3, idcol=cols)
par(ask=FALSE, mfrow=c(1,1))

plot(w, 1, 'lattice')  # show n=1 results
plot(w, 3, 'lattice')  # show n=4-5 results
plot(w, 3, 'lattice', idcol=cols)  # same but different color mapping
plot(w, 3, 'lattice', m=1)  # show a single "representative" curve
# Show median, 10th, and 90th percentiles of supposedly representative curves
plot(w, 3, 'lattice', m='quantiles', probs=c(.5,.1,.9))
# Same plot but with much less grouping of x variable
plot(w, 3, 'lattice', m='quantiles', probs=c(.5,.1,.9), nx=2)

# Use ggplot2 for one sample size interval
z <- plot(w, 2, 'data')
require(ggplot2)
ggplot(z, aes(x, y, color=curve)) + geom_line() +
       facet_grid(distribution ~ cluster) +
       theme(legend.position='none') +
       labs(caption=z$ninterval[1])


# Smooth data before profiling.  This allows later plotting to plot
# smoothed representative curves rather than raw curves (which
# specifying smooth=TRUE to curveRep would do, if curveSmooth was not used)
d <- curveSmooth(x, y, id)
w <- with(d, curveRep(x, y, id))

# Example to show that curveRep can cluster profiles correctly when
# there is no noise.  In the data there are four profiles - flat, flat
# at a higher mean y, linearly increasing then flat, and flat at the
# first height except for a sharp triangular peak

set.seed(1)
x <- 0:100
m <- length(x)
profile <- matrix(NA, nrow=m, ncol=4)
profile[,1] <- rep(0, m)
profile[,2] <- rep(3, m)
profile[,3] <- c(0:3, rep(3, m-4))
profile[,4] <- c(0,1,3,1,rep(0,m-4))
col <- c('black','blue','green','red')
matplot(x, profile, type='l', col=col)
xeval <- seq(0, 100, length.out=5)
```

```
s <- x
matplot(x[s], profile[s,], type='l', col=col)

id <- rep(1:100, each=m)
X <- Y <- id
cols <- character(100)
names(cols) <- as.character(1:100)
for(i in 1:100) {
  s <- id==i
  X[s] <- x
  j <- sample(1:4,1)
  Y[s] <- profile[,j]
  cols[i] <- col[j]
}
table(cols)
yl <- c(-1,4)
w <- curveRep(X, Y, id, kn=1, kxdist=1, k=4)
plot(w, 1, 'lattice', idcol=cols, ylim=yl)
# Found 4 clusters but two have same profile
w <- curveRep(X, Y, id, kn=1, kxdist=1, k=3)
plot(w, 1, 'lattice', idcol=cols, freq=cols, plotfreq=TRUE, ylim=yl)
# Incorrectly combined black and red because default value p=5 did
# not result in different profiles at x=xeval
w <- curveRep(X, Y, id, kn=1, kxdist=1, k=4, p=40)
plot(w, 1, 'lattice', idcol=cols, ylim=yl)
# Found correct clusters because evaluated curves at 40 equally
# spaced points and could find the sharp triangular peak in profile 4

## End(Not run)
```

---

cut2 *Cut a Numeric Variable into Intervals*

Description

cut2 is a function like cut but left endpoints are inclusive and labels are of the form [lower, upper), except that last interval is [lower,upper]. If cuts are given, will by default make sure that cuts include entire range of x. Also, if cuts are not given, will cut x into quantile groups (g given) or groups with a given minimum number of observations (m). Whereas cut creates a category object, cut2 creates a factor object. m is not guaranteed but is a target.

cutGn guarantees that the grouped variable will have a minimum of m observations in any group. This is done by an exhaustive algorithm that runs fast due to being coded in Fortran.

Usage

```
cut2(x, cuts, m=150, g, levels.mean=FALSE, digits, minmax=TRUE,
oneval=TRUE, onlycuts=FALSE, formatfun=format, ...)

cutGn(x, m, what=c('mean', 'factor', 'summary', 'cuts', 'function'), rcode=FALSE)
```

Arguments

x	numeric vector to classify into intervals
cuts	cut points
m	desired minimum number of observations in a group. The algorithm does not guarantee that all groups will have at least m observations.
g	number of quantile groups
levels.mean	set to TRUE to make the new categorical vector have levels attribute that is the group means of x instead of interval endpoint labels
digits	number of significant digits to use in constructing levels. Default is 3 (5 if levels.mean=TRUE)
minmax	if cuts is specified but min(x)<min(cuts) or max(x)>max(cuts), augments cuts to include min and max x
oneval	if an interval contains only one unique value, the interval will be labeled with the formatted version of that value instead of the interval endpoints, unless oneval=FALSE
onlycuts	set to TRUE to only return the vector of computed cuts. This consists of the interior values plus outer ranges.
formatfun	formatting function, supports formula notation (if rlang is installed)
...	additional arguments passed to formatfun
what	specifies the kind of vector values to return from cutGn, the default being like 'levels.mean' of cut2. Specify 'summary' to return a numeric 3-column matrix that summarizes the intervals satisfying the m requirement. Use what='cuts' to only return the vector of computed cutpoints. To create a function that will recode the variable in play using the same intervals as computed by cutGn, specify what='function'. This function will have a what argument to allow the user to decide later whether to recode into interval means or into a factor variable.
rcode	set to TRUE to run the cutgn algorithm in R. This is useful for speed comparisons with the default compiled code.

Value

a factor variable with levels of the form [a,b) or formatted means (character strings) unless onlycuts is TRUE in which case a numeric vector is returned

See Also

cut, quantile, combine.levels

Examples

```
set.seed(1)
x <- runif(1000, 0, 100)
z <- cut2(x, c(10,20,30))
table(z)
table(cut2(x, g=10))      # quantile groups
```

```
table(cut2(x, m=50))      # group x into intevals with at least 50 obs.

table(cutGn(x, m=50, what='factor'))
f <- cutGn(x, m=50, what='function')
f
f(c(-1, 2, 10), what='mean')
f(c(-1, 2, 10), what='factor')
## Not run:
  x <- round(runif(200000), 3)
  system.time(a <- cutGn(x, m=20))              # 0.02s
  system.time(b <- cutGn(x, m=20, rcode=TRUE))  # 1.51s
  identical(a, b)

## End(Not run)
```

`data.frame.create.modify.check`

Tips for Creating, Modifying, and Checking Data Frames

Description

This help file contains a template for importing data to create an R data frame, correcting some problems resulting from the import and making the data frame be stored more efficiently, modifying the data frame (including better annotating it and changing the names of some of its variables), and checking and inspecting the data frame for reasonableness of the values of its variables and to describe patterns of missing data. Various built-in functions and functions in the Hmisc library are used. At the end some methods for creating data frames "from scratch" within R are presented.

The examples below attempt to clarify the separation of operations that are done on a data frame as a whole, operations that are done on a small subset of its variables without attaching the whole data frame, and operations that are done on many variables after attaching the data frame in search position one. It also tries to clarify that for analyzing several separate variables using R commands that do not support a `data` argument, it is helpful to attach the data frame in a search position later than position one.

It is often useful to create, modify, and process datasets in the following order.

1. Import external data into a data frame (if the raw data do not contain column names, provide these during the import if possible)
2. Make global changes to a data frame (e.g., changing variable names)
3. Change attributes or values of variables within a data frame
4. Do analyses involving the whole data frame (without attaching it)
   (Data frame still in .Data)
5. Do analyses of individual variables (after attaching the data frame in search position two or later)

Details

The examples below use the FEV dataset from *Rosner 1995*. Almost any dataset would do. The jcetable data are taken from *Galobardes, etal.*

Presently, giving a variable the "units" attribute (using the **Hmisc** units function) only benefits the **Hmisc** describe function and the **rms** library's version of the link[rms]{Surv} function. Variables labels defined with the Hmisc label function are used by describe, summary.formula, and many of the plotting functions in **Hmisc** and **rms**.

References

Alzola CF, Harrell FE (2006): *An Introduction to S and the Hmisc and Design Libraries.* Chapters 3 and 4, https://hbiostat.org/R/doc/sintro.pdf.

Galobardes, et al. (1998), *J Clin Epi* 51:875-881.

Rosner B (1995): *Fundamentals of Biostatistics, 4th Edition.* New York: Duxbury Press.

See Also

scan, read.table, cleanup.import, sas.get, data.frame, attach, detach, describe, datadensity, plot.data.frame, hist.data.frame, naclus, factor, label, units, names, expand.grid, summary.formula, summary.data.frame, casefold, edit, page, plot.data.frame, Cs, combine.levels,upData

Examples

```
## Not run:
# First, we do steps that create or manipulate the data
# frame in its entirety.  For S-Plus, these are done with
# .Data in search position one (the default at the
# start of the session).
#
# ------------------------------------------------------------------------
# Step 1: Create initial draft of data frame
#
# We usually begin by importing a dataset from
# # another application.  ASCII files may be imported
# using the scan and read.table functions.  SAS
# datasets may be imported using the Hmisc sas.get
# function (which will carry more attributes from
# SAS than using File \dots  Import) from the GUI
# menus.  But for most applications (especially
# Excel), File \dots Import will suffice.  If using
# the GUI, it is often best to provide variable
# names during the import process, using the Options
# tab, rather than renaming all fields later Of
# course, if the data to be imported already have
# field names (e.g., in Excel), let S use those
# automatically.  If using S-Plus, you can use a
# command to execute File \dots  Import, e.g.:


import.data(FileName = "/windows/temp/fev.asc",
```

```
             FileType = "ASCII", DataFrame = "FEV")


# Here we name the new data frame FEV rather than
# fev, because we wanted to distinguish a variable
# in the data frame named fev from the data frame
# name.  For S-Plus the command will look
# instead like the following:


FEV <- importData("/tmp/fev.asc")




# ---------------------------------------------------------------------
# Step 2: Clean up data frame / make it be more
# efficiently stored
#
# Unless using sas.get to import your dataset
# (sas.get already stores data efficiently), it is
# usually a good idea to run the data frame through
# the Hmisc cleanup.import function to change
# numeric variables that are always whole numbers to
# be stored as integers, the remaining numerics to
# single precision, strange values from Excel to
# NAs, and character variables that always contain
# legal numeric values to numeric variables.
# cleanup.import typically halves the size of the
# data frame.  If you do not specify any parameters
# to cleanup.import, the function assumes that no
# numeric variable needs more than 7 significant
# digits of precision, so all non-integer-valued
# variables will be converted to single precision.


FEV <- cleanup.import(FEV)




# ---------------------------------------------------------------------
# Step 3: Make global changes to the data frame
#
# A data frame has attributes that are "external" to
# its variables.  There are the vector of its
# variable names ("names" attribute), the
# observation identifiers ("row.names"), and the
# "class" (whose value is "data.frame").  The
# "names" attribute is the one most commonly in need
# of modification.  If we had wanted to change all
# the variable names to lower case, we could have
# specified lowernames=TRUE to the cleanup.import
```

```
# invocation above, or type


names(FEV) <- casefold(names(FEV))


# The upData function can also be used to change
# variable names in two ways (see below).
# To change names in a non-systematic way we use
# other options.  Under Windows/NT the most
# straigtforward approach is to change the names
# interactively.  Click on the data frame in the
# left panel of the Object Browser, then in the
# right pane click twice (slowly) on a variable.
# Use the left arrow and other keys to edit the
# name.  Click outside that name field to commit the
# change.  You can also rename columns while in a
# Data Sheet.  To instead use programming commands
# to change names, use something like:


names(FEV)[6] <- 'smoke'   # assumes you know the positions!
names(FEV)[names(FEV)=='smoking'] <- 'smoke'
names(FEV) <- edit(names(FEV))


# The last example is useful if you are changing
# many names.  But none of the interactive
# approaches such as edit() are handy if you will be
# re-importing the dataset after it is updated in
# its original application.  This problem can be
# addressed by saving the new names in a permanent
# vector in .Data:


new.names <- names(FEV)


# Then if the data are re-imported, you can type


names(FEV) <- new.names


# to rename the variables.




# ---------------------------------------------------------------------
# Step 4: Delete unneeded variables
#
# To delete some of the variables, you can
```

```
# right-click on variable names in the Object
# Browser's right pane, then select Delete.  You can
# also set variables to have NULL values, which
# causes the system to delete them.  We don't need
# to delete any variables from FEV but suppose we
# did need to delete some from mydframe.


mydframe$x1 <- NULL
mydframe$x2 <- NULL
mydframe[c('age','sex')] <- NULL   # delete 2 variables
mydframe[Cs(age,sex)]    <- NULL   # same thing


# The last example uses the Hmisc short-cut quoting
# function Cs.  See also the drop parameter to upData.




# ----------------------------------------------------------------------
# Step 5: Make changes to individual variables
#         within the data frame
#
# After importing data, the resulting variables are
# seldom self - documenting, so we commonly need to
# change or enhance attributes of individual
# variables within the data frame.
#
# If you are only changing a few variables, it is
# efficient to change them directly without
# attaching the entire data frame.


FEV$sex   <- factor(FEV$sex,   0:1, c('female','male'))
FEV$smoke <- factor(FEV$smoke, 0:1,
                    c('non-current smoker','current smoker'))
units(FEV$age)    <- 'years'
units(FEV$fev)    <- 'L'
label(FEV$fev)    <- 'Forced Expiratory Volume'
units(FEV$height) <- 'inches'


# When changing more than one or two variables it is
# more convenient change the data frame using the
# Hmisc upData function.


FEV2 <- upData(FEV,
  rename=c(smoking='smoke'),
  # omit if renamed above
  drop=c('var1','var2'),
  levels=list(sex  =list(female=0,male=1),
```

```
              smoke=list('non-current smoker'=0,
                         'current smoker'=1)),
  units=list(age='years', fev='L', height='inches'),
  labels=list(fev='Forced Expiratory Volume'))


# An alternative to levels=list(\dots) is for example
# upData(FEV, sex=factor(sex,0:1,c('female','male'))).
#
# Note that we saved the changed data frame into a
# new data frame FEV2.  If we were confident of the
# correctness of our changes we could have stored
# the new data frame on top of the old one, under
# the original name FEV.


# ------------------------------------------------------------------------
# Step 6:  Check the data frame
#
# The Hmisc describe function is perhaps the first
# function that should be used on the new data
# frame.  It provides documentation of all the
# variables and the frequency tabulation, counts of
# NAs,  and 5 largest and smallest values are
# helpful in detecting data errors.  Typing
# describe(FEV) will write the results to the
# current output window.  To put the results in a
# new window that can persist, even upon exiting
# S, we use the page function.  The describe
# output can be minimized to an icon but kept ready
# for guiding later steps of the analysis.


page(describe(FEV2), multi=TRUE)
# multi=TRUE allows that window to persist while
# control is returned to other windows


# The new data frame is OK.  Store it on top of the
# old FEV and then use the graphical user interface
# to delete FEV2 (click on it and hit the Delete
# key) or type rm(FEV2) after the next statement.


FEV <- FEV2


# Next, we can use a variety of other functions to
# check and describe all of the variables.  As we
# are analyzing all or almost all of the variables,
# this is best done without attaching the data
# frame.  Note that plot.data.frame plots inverted
# CDFs for continuous variables and dot plots
```

```
# showing frequency distributions of categorical
# ones.


summary(FEV)
# basic summary function (summary.data.frame)


plot(FEV)               # plot.data.frame
datadensity(FEV)
# rug plots and freq. bar charts for all var.


hist.data.frame(FEV)
# for variables having > 2 values


by(FEV, FEV$smoke, summary)
# use basic summary function with stratification




# ------------------------------------------------------------------------
# Step 7:  Do detailed analyses involving individual
#          variables
#
# Analyses based on the formula language can use
# data= so attaching the data frame may not be
# required.  This saves memory.  Here we use the
# Hmisc summary.formula function to compute 5
# statistics on height, stratified separately by age
# quartile and by sex.


options(width=80)
summary(height ~ age + sex, data=FEV,
        fun=function(y)c(smean.sd(y),
                         smedian.hilow(y,conf.int=.5)))
# This computes mean height, S.D., median, outer quartiles


fit <- lm(height ~ age*sex, data=FEV)
summary(fit)


# For this analysis we could also have attached the
# data frame in search position 2.  For other
# analyses, it is mandatory to attach the data frame
# unless FEV$ prefixes each variable name.
# Important: DO NOT USE attach(FEV, 1) or
# attach(FEV, pos=1, \dots) if you are only analyzing
# and not changing the variables, unless you really
```

```
# need to avoid conflicts with variables in search
# position 1 that have the same names as the
# variables in FEV.  Attaching into search position
# 1 will cause S-Plus to be more of a memory hog.


attach(FEV)
# Use e.g. attach(FEV[,Cs(age,sex)]) if you only
# want to analyze a small subset of the variables
# Use e.g. attach(FEV[FEV$sex=='male',]) to
# analyze a subset of the observations


summary(height ~ age + sex,
        fun=function(y)c(smean.sd(y),
          smedian.hilow(y,conf.int=.5)))
fit <- lm(height ~ age*sex)


# Run generic summary function on height and fev,
# stratified by sex
by(data.frame(height,fev), sex, summary)


# Cross-classify into 4 sex x smoke groups
by(FEV, list(sex,smoke), summary)


# Plot 5 quantiles
s <- summary(fev ~ age + sex + height,
              fun=function(y)quantile(y,c(.1,.25,.5,.75,.9)))


plot(s, which=1:5, pch=c(1,2,15,2,1), #pch=c('=','[','o',']','='),
     main='A Discovery', xlab='FEV')


# Use the nonparametric bootstrap to compute a
# 0.95 confidence interval for the population mean fev
smean.cl.boot(fev)    # in Hmisc


# Use the Statistics \dots Compare Samples \dots One Sample
# keys to get a normal-theory-based C.I.  Then do it
# more manually.  The following method assumes that
# there are no NAs in fev


sd <- sqrt(var(fev))
xbar <- mean(fev)
xbar
sd
n <- length(fev)
```

```
qt(.975,n-1)
# prints 0.975 critical value of t dist. with n-1 d.f.


xbar + c(-1,1)*sd/sqrt(n)*qt(.975,n-1)
# prints confidence limits


# Fit a linear model
# fit <- lm(fev ~ other variables \dots)


detach()


# The last command is only needed if you want to
# start operating on another data frame and you want
# to get FEV out of the way.




# ---------------------------------------------------------------------
# Creating data frames from scratch
#
# Data frames can be created from within S.  To
# create a small data frame containing ordinary
# data, you can use something like


dframe <- data.frame(age=c(10,20,30),
                     sex=c('male','female','male'),
                     stringsAsFactors=TRUE)


# You can also create a data frame using the Data
# Sheet.  Create an empty data frame with the
# correct variable names and types, then edit in the
# data.


dd <- data.frame(age=numeric(0),sex=character(0),
                 stringsAsFactors=TRUE)


# The sex variable will be stored as a factor, and
# levels will be automatically added to it as you
# define new values for sex in the Data Sheet's sex
# column.
#
# When the data frame you need to create is defined
# by systematically varying variables (e.g., all
# possible combinations of values of each variable),
```

```
# the expand.grid function is useful for quickly
# creating the data.  Then you can add
# non-systematically-varying variables to the object
# created by expand.grid, using programming
# statements or editing the Data Sheet.  This
# process is useful for creating a data frame
# representing all the values in a printed table.
# In what follows we create a data frame
# representing the combinations of values from an 8
# x 2 x 2 x 2 (event x method x sex x what) table,
# and add a non-systematic variable percent to the
# data.


jcetable <- expand.grid(
 event=c('Wheezing at any time',
         'Wheezing and breathless',
         'Wheezing without a cold',
         'Waking with tightness in the chest',
         'Waking with shortness of breath',
         'Waking with an attack of cough',
         'Attack of asthma',
         'Use of medication'),
 method=c('Mail','Telephone'),
 sex=c('Male','Female'),
 what=c('Sensitivity','Specificity'))


jcetable$percent <-
c(756,618,706,422,356,578,289,333,
  576,421,789,273,273,212,212,212,
  613,763,713,403,377,541,290,226,
  613,684,632,290,387,613,258,129,
  656,597,438,780,732,679,938,919,
  714,600,494,877,850,703,963,987,
  755,420,480,794,779,647,956,941,
  766,423,500,833,833,604,955,986) / 10


# In jcetable, event varies most rapidly, then
# method, then sex, and what.

## End(Not run)
```

---

dataRep *Representativeness of Observations in a Data Set*

Description

These functions are intended to be used to describe how well a given set of new observations (e.g., new subjects) were represented in a dataset used to develop a predictive model. The dataRep

function forms a data frame that contains all the unique combinations of variable values that existed in a given set of variable values. Cross–classifications of values are created using exact values of variables, so for continuous numeric variables it is often necessary to round them to the nearest v and to possibly curtail the values to some lower and upper limit before rounding. Here v denotes a numeric constant specifying the matching tolerance that will be used. dataRep also stores marginal distribution summaries for all the variables. For numeric variables, all 101 percentiles are stored, and for all variables, the frequency distributions are also stored (frequencies are computed after any rounding and curtailment of numeric variables). For the purposes of rounding and curtailing, the roundN function is provided. A print method will summarize the calculations made by dataRep, and if long=TRUE all unique combinations of values and their frequencies in the original dataset are printed.

The predict method for dataRep takes a new data frame having variables named the same as the original ones (but whose factor levels are not necessarily in the same order) and examines the collapsed cross-classifications created by dataRep to find how many observations were similar to each of the new observations after any rounding or curtailment of limits is done. predict also does some calculations to describe how the variable values of the new observations "stack up" against the marginal distributions of the original data. For categorical variables, the percent of observations having a given variable with the value of the new observation (after rounding for variables that were through roundN in the formula given to dataRep) is computed. For numeric variables, the percentile of the original distribution in which the current value falls will be computed. For this purpose, the data are not rounded because the 101 original percentiles were retained; linear interpolation is used to estimate percentiles for values between two tabulated percentiles. The lowest marginal frequency of matching values across all variables is also computed. For example, if an age, sex combination matches 10 subjects in the original dataset but the age value matches 100 ages (after rounding) and the sex value matches the sex code of 300 observations, the lowest marginal frequency is 100, which is a "best case" upper limit for multivariable matching. I.e., matching on all variables has to result on a lower frequency than this amount. A print method for the output of predict.dataRep prints all calculations done by predict by default. Calculations can be selectively suppressed.

Usage

```
dataRep(formula, data, subset, na.action)

roundN(x, tol=1, clip=NULL)

## S3 method for class 'dataRep'
print(x, long=FALSE, ...)

## S3 method for class 'dataRep'
predict(object, newdata, ...)

## S3 method for class 'predict.dataRep'
print(x, prdata=TRUE, prpct=TRUE, ...)
```

Arguments

formula	a formula with no left-hand-side. Continuous numeric variables in need of rounding should appear in the formula as e.g. roundN(x,5) to have a tolerance

	of e.g. +/- 2.5 in matching. Factor or character variables as well as numeric ones not passed through `roundN` are matched on exactly.
`x`	a numeric vector or an object created by `dataRep`
`object`	the object created by `dataRep` or `predict.dataRep`
`data, subset, na.action`	standard modeling arguments. Default `na.action` is `na.delete`, i.e., observations in the original dataset having any variables missing are deleted up front.
`tol`	rounding constant (tolerance is actually `tol/2` as values are rounded to the nearest `tol`)
`clip`	a 2-vector specifying a lower and upper limit to curtail values of `x` before rounding
`long`	set to `TRUE` to see all unique combinations and frequency count
`newdata`	a data frame containing all the variables given to `dataRep` but not necessarily in the same order or having factor levels in the same order
`prdata`	set to `FALSE` to suppress printing `newdata` and the count of matching observations (plus the worst-case marginal frequency).
`prpct`	set to `FALSE` to not print percentiles and percents
`...`	unused

Value

`dataRep` returns a list of class `"dataRep"` containing the collapsed data frame and frequency counts along with marginal distribution information. `predict` returns an object of class `"predict.dataRep"` containing information determined by matching observations in `newdata` with the original (collapsed) data.

Side Effects

`print.dataRep` prints.

Author(s)

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See Also

`round`, `table`

Examples

```
set.seed(13)
num.symptoms <- sample(1:4, 1000,TRUE)
sex <- factor(sample(c('female','male'), 1000,TRUE))
x    <- runif(1000)
```

```
x[1] <- NA
table(num.symptoms, sex, .25*round(x/.25))


d <- dataRep(~ num.symptoms + sex + roundN(x,.25))
print(d, long=TRUE)


predict(d, data.frame(num.symptoms=1:3, sex=c('male','male','female'),
                      x=c(.03,.5,1.5)))
```

---

deff *Design Effect and Intra-cluster Correlation*

Description

Computes the Kish design effect and corresponding intra-cluster correlation for a single cluster-sampled variable

Usage

```
deff(y, cluster)
```

Arguments

y	variable to analyze
cluster	a variable whose unique values indicate cluster membership. Any type of variable is allowed.

Value

a vector with named elements n (total number of non-missing observations), clusters (number of clusters after deleting missing data), rho(intra-cluster correlation), and deff (design effect).

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See Also

bootcov, robcov

Examples

```
set.seed(1)
blood.pressure <- rnorm(1000, 120, 15)
clinic <- sample(letters, 1000, replace=TRUE)
deff(blood.pressure, clinic)
```

`describe` *Concise Statistical Description of a Vector, Matrix, Data Frame, or Formula*

Description

`describe` is a generic method that invokes `describe.data.frame`, `describe.matrix`, `describe.vector`, or `describe.formula`. `describe.vector` is the basic function for handling a single variable. This function determines whether the variable is character, factor, category, binary, discrete numeric, and continuous numeric, and prints a concise statistical summary according to each. A numeric variable is deemed discrete if it has <= 10 distinct values. In this case, quantiles are not printed. A frequency table is printed for any non-binary variable if it has no more than 20 distinct values. For any variable for which the frequency table is not printed, the 5 lowest and highest values are printed. This behavior can be overriden for long character variables with many levels using the `listunique` parameter, to get a complete tabulation.

`describe` is especially useful for describing data frames created by `*.get`, as labels, formats, value labels, and (in the case of `sas.get`) frequencies of special missing values are printed.

For a binary variable, the sum (number of 1's) and mean (proportion of 1's) are printed. If the first argument is a formula, a model frame is created and passed to describe.data.frame. If a variable is of class `"impute"`, a count of the number of imputed values is printed. If a date variable has an attribute `partial.date` (this is set up by `sas.get`), counts of how many partial dates are actually present (missing month, missing day, missing both) are also presented. If a variable was created by the special-purpose function `substi` (which substitutes values of a second variable if the first variable is NA), the frequency table of substitutions is also printed.

For numeric variables, `describe` adds an item called `Info` which is a relative information measure using the relative efficiency of a proportional odds/Wilcoxon test on the variable relative to the same test on a variable that has no ties. `Info` is related to how continuous the variable is, and ties are less harmful the more untied values there are. The formula for `Info` is one minus the sum of the cubes of relative frequencies of values divided by one minus the square of the reciprocal of the sample size. The lowest information comes from a variable having only one distinct value following by a highly skewed binary variable. `Info` is reported to two decimal places.

A latex method exists for converting the `describe` object to a LaTeX file, and Typst is also supported, triggered by `options(prType='typst')`. For numeric variables having more than 20 distinct values, `describe` saves in its returned object the frequencies of 100 evenly spaced bins running from minimum observed value to the maximum. When there are less than or equal to 20 distinct values, the original values are maintained. `latex`, `html`, and `typst` insert a spike histogram displaying these frequency counts in the tabular material using the LaTeX picture environment. For example output see https://hbiostat.org/doc/rms/book/chapter7edition1.pdf. Note that the latex method assumes you have the following styles installed in your latex installation: setspace and relsize.

The html method mimics the LaTeX output. This is useful in the context of Quarto/Rmarkdown html and html notebook output. If options(prType='html') is in effect, calling print on an object that is the result of running describe on a data frame will result in rendering the HTML version. If run from the console a browser window will open. When which is specified to print, whether or not prType='html' is in effect, a gt package html table will be produced containing only the types of variables requested. When which='both' a list with element names Continuous and Categorical is produced, making it convenient for the user to print as desired, or to pass the list directed to the qreport maketabs function when using Quarto.

The plot method is for describe objects run on data frames. It produces spike histograms for a graphic of continuous variables and a dot chart for categorical variables, showing category proportions. The graphic format is ggplot2 if the user has not set options(grType='plotly') or has set the grType option to something other than 'plotly'. Otherwise plotly graphics that are interactive are produced, and these can be placed into an Rmarkdown html notebook. The user must install the plotly package for this to work. When the use hovers the mouse over a bin for a raw data value, the actual value will pop-up (formatted using digits). When the user hovers over the minimum data value, most of the information calculated by describe will pop up. For each variable, the number of missing values is used to assign the color to the histogram or dot chart, and a legend is drawn. Color is not used if there are no missing values in any variable. For categorical variables, hovering over the leftmost point for a variable displays details, and for all points proportions, numerators, and denominators are displayed in the popup. If both continuous and categorical variables are present and which='both' is specified, the plot method returns an unclassed list containing two objects, named 'Categorical' and 'Continuous', in that order.

Sample weights may be specified to any of the functions, resulting in weighted means, quantiles, and frequency tables.

Note: As discussed in Cox and Longton (2008), Stata Technical Bulletin 8(4) pp. 557, the term "unique" has been replaced with "distinct" in the output (but not in parameter names).

When weights are not used, the pseudomedian and Gini's mean difference are computed for numeric variables. The pseudomedian is labeled pMedian and is the median of all possible pairwise averages. It is a robust and efficient measure of location that equals the mean and median for symmetric distributions. It is also called the Hodges-Lehmann one-sample estimator. Gini's mean difference is a robust measure of dispersion that is the mean absolute difference between any pairs of observations. In simple output Gini's difference is labeled Gmd.

formatdescribeSingle is a service function for latex, html, and print methods for single variables that is not intended to be called by the user.

Usage

```
## S3 method for class 'vector'
describe(x, descript, exclude.missing=TRUE, digits=4,
         listunique=0, listnchar=12,
         weights=NULL, normwt=FALSE, minlength=NULL, shortmChoice=TRUE,
         rmhtml=FALSE, trans=NULL, lumptails=0.01, ...)
## S3 method for class 'matrix'
describe(x, descript, exclude.missing=TRUE, digits=4, ...)
## S3 method for class 'data.frame'
describe(x, descript, exclude.missing=TRUE,
    digits=4, trans=NULL, ...)
```

```
## S3 method for class 'formula'
describe(x, descript, data, subset, na.action,
    digits=4, weights, ...)
## S3 method for class 'describe'
print(x, which = c('both', 'categorical', 'continuous'), ...)
## S3 method for class 'describe'
latex(object, title=NULL,
    file=paste('describe',first.word(expr=attr(object,'descript')),'tex',sep='.'),
      append=FALSE, size='small', tabular=TRUE, greek=TRUE,
      spacing=0.7, lspace=c(0,0), ...)
## S3 method for class 'describe.single'
latex(object, title=NULL, vname,
      file, append=FALSE, size='small', tabular=TRUE, greek=TRUE,
      lspace=c(0,0), ...)
## S3 method for class 'describe'
html(object, size=85, tabular=TRUE,
      greek=TRUE, scroll=FALSE, rows=25, cols=100, ...)
## S3 method for class 'describe.single'
html(object, size=85,
      tabular=TRUE, greek=TRUE, ...)
formatdescribeSingle(x, condense=c('extremes', 'frequencies', 'both', 'none'),
           lang=c('plain', 'latex', 'html', 'typst'), verb=0, lspace=c(0, 0),
           size=85, ...)
## S3 method for class 'describe'
plot(x, which=c('both', 'continuous', 'categorical'),
                          what=NULL,
                          sort=c('ascending', 'descending', 'none'),
                          n.unique=10, digits=5, bvspace=2, ...)
```

Arguments

x	a data frame, matrix, vector, or formula. For a data frame, the `describe.data.frame` function is automatically invoked. For a matrix, `describe.matrix` is called. For a formula, describe.data.frame(model.frame(x)) is invoked. The formula may or may not have a response variable. For `print`, `latex`, `html`, or `formatdescribeSingle`, `x` is an object created by `describe`.
descript	optional title to print for x. The default is the name of the argument or the "label" attributes of individual variables. When the first argument is a formula, `descript` defaults to a character representation of the formula.
exclude.missing	set toTRUE to print the names of variables that contain only missing values. This list appears at the bottom of the printout, and no space is taken up for such variables in the main listing.
digits	number of significant digits to print. For `plot.describe` is the number of significant digits to put in hover text for `plotly` when showing raw variable values.
listunique	For a character variable that is not an `mChoice` variable, that has its longest string length greater than `listnchar`, and that has no more than `listunique` distinct values, all values are listed in alphabetic order. Any value having more than

	one occurrence has the frequency of occurrence included. Specify `listunique` equal to some value at least as large as the number of observations to ensure that all character variables will have all their values listed. For purposes of tabulating character strings, multiple white spaces of any kind are translated to a single space, leading and trailing white space are ignored, and case is ignored.
`listnchar`	see `listunique`
`weights`	a numeric vector of frequencies or sample weights. Each observation will be treated as if it were sampled `weights` times.
`minlength`	value passed to summary.mChoice
`shortmChoice`	set to `FALSE` to have summary of `mChoice` variables use actual levels everywhere, instead of abbreviating to integers and printing of all original labels at the top
`rmhtml`	set to `TRUE` to strip html from variable labels
`trans`	for `describe.vector` is a list specifying how to transform `x` for constructing the frequency distribution used in spike histograms. The first element of the list is a character string describing the transformation, the second is the transformation function, and the third argument is the inverse of this function that is used in labeling points on the original scale, e.g. `trans=list('log', log, exp)`. For `describe.data.frame` `trans` is a list of such lists, with the name of each list being name of the variable to which the transformation applies. See https://hbiostat.org/rmsc/impred.html#data for an example.
`lumptails`	specifies the quantile to use (its complement is also used) for grouping observations in the tails so that outliers have less chance of distorting the variable's range for sparkline spike histograms. The default is 0.01, i.e., observations below the 0.01 quantile are grouped together in the leftmost bin, and observations above the 0.99 quantile are grouped to form the last bin.
`normwt`	The default, `normwt=FALSE` results in the use of `weights` as weights in computing various statistics. In this case the sample size is assumed to be equal to the sum of `weights`. Specify `normwt=TRUE` to divide `weights` by a constant so that `weights` sum to the number of observations (length of vectors specified to `describe`). In this case the number of observations is taken to be the actual number of records given to `describe`.
`object`	a result of `describe`
`title`	unused
`data`	a data frame, data table, or list
`subset`	a subsetting expression
`na.action`	These are used if a formula is specified. `na.action` defaults to `na.retain` which does not delete any `NA`s from the data frame. Use `na.action=na.omit` or `na.delete` to drop any observation with any `NA` before processing.
`...`	arguments passed to `describe.default` which are passed to calls to `format` for numeric variables. For example if using R `POSIXct` or `Date` date/time formats, specifying `describe(d,format='%d%b%y')` will print date/time variables as `"01Jan2000"`. This is useful for omitting the time component. See the help file for `format.POSIXct` or `format.Date` for more information. For `plot` methods, ...is ignored. For `html` and `latex` methods, ...is used to pass optional

	arguments to formatdescribeSingle, especially the condense argument. For the print method when which= is given, possible arguments to use for tabulating continuous variable output are sparkwidth (the width of the spike histogram sparkline in pixels, defaulting to 200), qcondense (set to FALSE to devote separate columns to all quantiles), extremes (set to TRUE to print the 5 lowest and highest values in the table of continuous variables). For categorical variable output, the argument freq can be used to specify how frequency tables are rendered: 'chart' (the default; an interactive sparkline frequency bar chart) or freq='table' for small tables. sort is another argument passed to html_describe_cat. For sparkline frequency charts the default is to sort non-numeric categories in descending order of frequency. Set code=FALSE to use the original data order. The w argument also applies to categorical variable output.
file	name of output file (should have a suffix of .tex). Default name is formed from the first word of the descript element of the describe object, prefixed by "describe". Set file="" to send LaTeX code to standard output instead of a file.
append	set to TRUE to have latex append text to an existing file named file
size	LaTeX text size ("small", the default, or "normalsize", "tiny", "scriptsize", etc.) for the describe output in LaTeX. For html is the percent of the prevailing font size to use for the output.
tabular	set to FALSE to use verbatim rather than tabular (or html table) environment for the summary statistics output. By default, tabular is used if the output is not too wide.
greek	By default, the latex and html methods will change names of greek letters that appear in variable labels to appropriate LaTeX symbols in math mode, or html symbols, unless greek=FALSE.
spacing	By default, the latex method for describe run on a matrix or data frame uses the setspace LaTeX package with a line spacing of 0.7 so as to no waste space. Specify spacing=0 to suppress the use of the setspace's spacing environment, or specify another positive value to use this environment with a different spacing.
lspace	extra vertical scape, in character size units (i.e., "ex" as appended to the space). When using certain font sizes, there is too much space left around LaTeX verbatim environments. This two-vector specifies space to remove (i.e., the values are negated in forming the vspace command) before (first element) and after (second element of lspace) verbatims
scroll	set to TRUE to create an html scrollable box for the html output
rows, cols	the number of rows or columns to allocate for the scrollable box
vname	unused argument in latex.describe.single
which	specifies whether to plot numeric continuous or binary/categorical variables, or both. When "both" a list with two elements is created. Each element is a ggplot2 or plotly object. If there are no variables of a given type, a single ggplot2 or plotly object is returned, ready to print. For print.describe may be "categorical" or "continuous", causing a gt table to be created with the categorical or continuous variable describe results.
what	character or numeric vector specifying which variables to plot; default is to plot all

sort	specifies how and whether variables are sorted in order of the proportion of positives when which="categorical". Specify sort="none" to leave variables in the order they appear in the original data.
n.unique	the minimum number of distinct values a numeric variable must have before plot.describe uses it in a continuous variable plot
bvspace	the between-variable spacing for categorical variables. Defaults to 2, meaning twice the amount of vertical space as what is used for between-category spacing within a variable
condense	specifies whether to condense the output with regard to the 5 lowest and highest values ("extremes") and the frequency table
lang	specifies the markup language
verb	set to 1 if a verbatim environment is already in effect for LaTeX

Details

Infinite values and NaNs are treated and counted the same as NAs.

If options(na.detail.response=TRUE) has been set and na.action is "na.delete" or "na.keep", summary statistics on the response variable are printed separately for missing and non-missing values of each predictor. The default summary function returns the number of non-missing response values and the mean of the last column of the response values, with a names attribute of c("N","Mean"). When the response is a Surv object and the mean is used, this will result in the crude proportion of events being used to summarize the response. The actual summary function can be designated through options(na.fun.response = "function name").

If you are modifying LaTex parskip or certain other parameters, you may need to shrink the area around tabular and verbatim environments produced by latex.describe. You can do this using for example \usepackage{etoolbox}\makeatletter\preto{\@verbatim}{\topsep=-1.4pt \partopsep=0pt}\preto{
\parsep=0pt}\makeatother in the LaTeX preamble.

Multiple choice (mChoice) variables' describe output renders well in html but not when included in a Quarto document.

Value

a list containing elements descript, counts, values. The list is of class describe. If the input object was a matrix or a data frame, the list is a list of lists, one list for each variable analyzed. latex returns a standard latex object. For numeric variables having at least 20 distinct values, an additional component intervalFreq. This component is a list with two elements, range (containing two values) and count, a vector of 100 integer frequency counts. print with which= returns a 'gt' table object. The user can modify the table by piping formatting changes, column removals, and other operations, before final rendering.

Author(s)

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See Also

spikecomp, sas.get, quantile, GiniMd, pMedian, table, summary, model.frame.default, naprint, lapply, tapply, Surv, na.delete, na.keep, na.detail.response, latex

Examples

```
set.seed(1)
describe(runif(200),dig=2)    #single variable, continuous
                              #get quantiles .05,.10,\dots

dfr <- data.frame(x=rnorm(400),y=sample(c('male','female'),400,TRUE))
describe(dfr)

## Not run:
options(grType='plotly')
d <- describe(mydata)
p <- plot(d)   # create plots for both types of variables
p[[1]]; p[[2]] # or p$Categorical; p$Continuous
plotly::subplot(p[[1]], p[[2]], nrows=2)  # plot both in one
plot(d, which='categorical')    # categorical ones

d <- sas.get(".","mydata",special.miss=TRUE,recode=TRUE)
describe(d)      #describe entire data frame
attach(d, 1)
describe(relig)  #Has special missing values .D .F .M .R .T
                 #attr(relig,"label") is "Religious preference"

#relig : Religious preference  Format:relig
#    n missing  D  F M R T distinct
# 4038     263 45 33 7 2 1        8
#
#0:none (251, 6%), 1:Jewish (372, 9%), 2:Catholic (1230, 30%)
#3:Jehovah's Witnes (25, 1%), 4:Christ Scientist (7, 0%)
#5:Seventh Day Adv (17, 0%), 6:Protestant (2025, 50%), 7:other (111, 3%)


# Method for describing part of a data frame:
 describe(death.time ~ age*sex + rcs(blood.pressure))
 describe(~ age+sex)
 describe(~ age+sex, weights=freqs)  # weighted analysis

 fit <- lrm(y ~ age*sex + log(height))
 describe(formula(fit))
 describe(y ~ age*sex, na.action=na.delete)
# report on number deleted for each variable
 options(na.detail.response=TRUE)
# keep missings separately for each x, report on dist of y by x=NA
 describe(y ~ age*sex)
 options(na.fun.response="quantile")
 describe(y ~ age*sex)   # same but use quantiles of y by x=NA

 d <- describe(my.data.frame)
```

```
 d$age                  # print description for just age
 d[c('age','sex')]      # print description for two variables
 d[sort(names(d))]      # print in alphabetic order by var. names
 d2 <- d[20:30]         # keep variables 20-30
 page(d2)               # pop-up window for these variables

# Test date/time formats and suppression of times when they don't vary
 library(chron)
 d <- data.frame(a=chron((1:20)+.1),
                 b=chron((1:20)+(1:20)/100),
                 d=ISOdatetime(year=rep(2003,20),month=rep(4,20),day=1:20,
                               hour=rep(11,20),min=rep(17,20),sec=rep(11,20)),
                 f=ISOdatetime(year=rep(2003,20),month=rep(4,20),day=1:20,
                               hour=1:20,min=1:20,sec=1:20),
                 g=ISOdate(year=2001:2020,month=rep(3,20),day=1:20))
 describe(d)

# Make a function to run describe, latex.describe, and use the kdvi
# previewer in Linux to view the result and easily make a pdf file

 ldesc <- function(data) {
  options(xdvicmd='kdvi')
  d <- describe(data, desc=deparse(substitute(data)))
  dvi(latex(d, file='/tmp/z.tex'), nomargins=FALSE, width=8.5, height=11)
 }

 ldesc(d)

## End(Not run)
```

---

discrete *Discrete Vector tools*

Description

discrete creates a discrete vector which is distinct from a continuous vector, or a factor/ordered vector. The other function are tools for manipulating descrete vectors.

Usage

```
as.discrete(x, ...)
## Default S3 method:
as.discrete(x, ...)
discrete(x, levels = sort(unique.default(x), na.last = TRUE), exclude = NA)
## S3 replacement method for class 'discrete'
x[...] <- value
## S3 method for class 'discrete'
x[..., drop = FALSE]
## S3 method for class 'discrete'
```

```
x[[i]]
is.discrete(x)
## S3 replacement method for class 'discrete'
is.na(x) <- value
## S3 replacement method for class 'discrete'
length(x) <- value
```

Arguments

x	a vector
drop	Should unused levels be dropped.
exclude	logical: should NA be excluded.
i	indexing vector
levels	charater: list of individual level values
value	index of elements to set to NA
...	arguments to be passed to other functions

Details

as.discrete converts a vector into a discrete vector.

discrete creates a discrete vector from provided values.

is.discrete tests to see if the vector is a discrete vector.

Value

as.discrete, discrete returns a vector of discrete type.

is.discrete returan logical TRUE if the vector is of class discrete other wise it returns FALSE.

Author(s)

Charles Dupont

See Also

[[, [, factor

Examples

```
a <- discrete(1:25)
a

is.discrete(a)

b <- as.discrete(2:4)
b
```

dotchart2 *Enhanced Dot Chart*

Description

dotchart2 is an enhanced version of the dotchart function with several new options.

Usage

```
dotchart2(data, labels, groups=NULL, gdata=NA, horizontal=TRUE, pch=16,
          xlab='', ylab='', xlim=NULL, auxdata, auxgdata=NULL, auxtitle,
          lty=1, lines=TRUE, dotsize = .8,
          cex = par("cex"), cex.labels = cex,
          cex.group.labels = cex.labels*1.25, sort.=TRUE,
       add=FALSE, dotfont=par('font'), groupfont=2,
       reset.par=add, xaxis=TRUE, width.factor=1.1,
          lcolor='gray', leavepar=FALSE,
          axisat=NULL, axislabels=NULL, ...)
```

Arguments

data	a numeric vector whose values are shown on the x-axis
labels	a vector of labels for each point, corresponding to x. If omitted, names(data) are used, and if there are no names, integers prefixed by "#" are used.
groups	an optional categorical variable indicating how data values are grouped
gdata	data values for groups, typically summaries such as group medians
horizontal	set to FALSE to make the chart vertical instead of the default
pch	default character number or value for plotting dots in dot charts. The default is 16.
xlab	x-axis title
ylab	y-axis title
xlim	x-axis limits. Applies only to horizontal=TRUE.
auxdata	a vector of auxiliary data given to dotchart2, of the same length as the first (data) argument. If present, this vector of values will be printed outside the right margin of the dot chart. Usually auxdata represents cell sizes.
auxgdata	similar to auxdata but corresponding to the gdata argument. These usually represent overall sample sizes for each group of lines.
auxtitle	if auxdata is given, auxtitle specifies a column heading for the extra printed data in the chart, e.g., "N"
lty	line type for horizontal lines. Default is 1 for R, 2 for S-Plus
lines	set to FALSE to suppress drawing of reference lines
dotsize	cex value for drawing dots. Default is 0.8. Note that the original dotchart function used a default of 1.2.

cex	see par
cex.labels	cex parameter that applies only to the line labels for the dot chart cex parameter for major grouping labels for dotchart2. Defaults to cex.
cex.group.labels	value of cex corresponding to gdata
sort.	set to FALSE to keep dotchart2 from sorting the input data, i.e., it will assume that the data are already properly arranged. This is especially useful when you are using gdata and groups and you want to control the order that groups appear on the chart (from top to bottom).
add	set to TRUE to add to an existing plot
dotfont	font number of plotting dots. Default is one. Use -1 to use "outline" fonts. For example, pch=183, dotfont=-1 plots an open circle for UNIX on postscript. pch=1 makes an open octagon under Windows.
groupfont	font number to use in drawing group labels for dotchart2. Default is 2 for boldface.
reset.par	set to FALSE to cause dotchart2 to not reset the par parameters when finished. This is useful when add=TRUE is about to be used in another call. The default is to reset the par parameters if add=TRUE and not if add=FALSE, i.e., the program assumes that only one set of points will be added to an existing set. If you fail to use reset.par=TRUE for the first of a series of plots, the next call to plot with add=TRUE will result in distorted x-axis scaling.
xaxis	set to FALSE to suppress drawing x-axis
width.factor	When the calculated left margin turns out to be faulty, specify a factor by which to multiple the left margin as width.factor to get the appropriate space for labels on horizonal charts.
lcolor	color for horizontal reference lines. Default is "gray" for R, par("col") for S-Plus.
leavepar	set to TRUE to leave par() unchanged. This assumes the user has allocated sufficient left and right margins for a horizontal dot chart.
axisat	a vector of tick mark locations to pass to axis. Useful if transforming the data axis
axislabels	a vector of strings specifying axis tick mark labels. Useful if transforming the data axis
...	arguments passed to plot.default

Side Effects

dotchart will leave par altered if reset.par=FALSE.

Author(s)

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See Also

dotchart

Examples

```
set.seed(135)
maj <- factor(c(rep('North',13),rep('South',13)))
g <- paste('Category',rep(letters[1:13],2))
n <- sample(1:15000, 26, replace=TRUE)
y1 <- runif(26)
y2 <- pmax(0, y1 - runif(26, 0, .1))
dotchart2(y1, g, groups=maj, auxdata=n, auxtitle='n', xlab='Y')
dotchart2(y2, g, groups=maj, pch=17, add=TRUE)
## Compare with dotchart function (no superpositioning or auxdata allowed):
## dotchart(y1, g, groups=maj, xlab='Y')

## To plot using a transformed scale add for example
## axisat=sqrt(pretty(y)), axislabels=pretty(y)
```

---

dotchart3 *Enhanced Version of dotchart Function*

Description

These are adaptations of the R dotchart function that sorts categories top to bottom, adds auxdata and auxtitle arguments to put extra information in the right margin, and for dotchart3 adds arguments cex.labels, cex.group.labels, and groupfont. By default, group headings are in a larger, bold font. dotchart3 also cuts a bit of white space from the top and bottom of the chart. The most significant change, however, is in how x is interpreted. Columns of x no longer provide an alternate way to define groups. Instead, they define superpositioned values. This is useful for showing three quartiles, for example. Going along with this change, for dotchart3 pch can now be a vector specifying symbols to use going across columns of x. x was changed in this way because to put multiple points on a line (e.g., quartiles) and keeping track of par() parameters when dotchart2 was called with add=TRUE was cumbersome. dotchart3 changes the margins to account for horizontal labels.

dotchartp is a version of dotchart3 for making the chart with the plotly package.

summaryD creates aggregate data using summarize and calls dotchart3 with suitable arguments to summarize data by major and minor categories. If options(grType='plotly') is in effect and the plotly package is installed, summaryD uses dotchartp instead of dotchart3.

summaryDp is a streamlined summaryD-like function that uses the dotchartpl function to render a plotly graphic. It is used to compute summary statistics stratified separately by a series of variables.

Usage

```
dotchart3(x, labels = NULL, groups = NULL, gdata = NULL,
          cex = par("cex"), pch = 21, gpch = pch, bg = par("bg"),
          color = par("fg"), gcolor = par("fg"), lcolor = "gray",
          xlim = range(c(x, gdata), na.rm=TRUE), main = NULL, xlab = NULL,
          ylab = NULL, auxdata = NULL, auxtitle = NULL, auxgdata=NULL,
          axisat=NULL, axislabels=NULL,
          cex.labels = cex, cex.group.labels = cex.labels * 1.25,
          cex.auxdata=cex, groupfont = 2,
          auxwhere=NULL, height=NULL, width=NULL, ...)

dotchartp(x, labels = NULL, groups = NULL, gdata = NULL,
            xlim = range(c(x, gdata), na.rm=TRUE), main=NULL,
            xlab = NULL, ylab = '', auxdata=NULL, auxtitle=NULL,
            auxgdata=NULL, auxwhere=c('right', 'hover'),
            symbol='circle', col=colorspace::rainbow_hcl,
            legendgroup=NULL,
            axisat=NULL, axislabels=NULL, sort=TRUE, digits=4, dec=NULL,
            height=NULL, width=700, layoutattr=FALSE, showlegend=TRUE, ...)

summaryD(formula, data=NULL, fun=mean, funm=fun,
         groupsummary=TRUE, auxvar=NULL, auxtitle='',
         auxwhere=c('hover', 'right'),
         vals=length(auxvar) > 0, fmtvals=format,
         symbol=if(use.plotly) 'circle' else 21,
         col=if(use.plotly) colorspace::rainbow_hcl else 1:10,
         legendgroup=NULL,
         cex.auxdata=.7, xlab=v[1], ylab=NULL,
         gridevery=NULL, gridcol=gray(.95), sort=TRUE, ...)

summaryDp(formula,
          fun=function(x) c(Mean=mean(x, na.rm=TRUE),
                            N=sum(! is.na(x))),
          overall=TRUE, xlim=NULL, xlab=NULL,
          data=NULL, subset=NULL, na.action=na.retain,
          ncharsmax=c(50, 30),
          digits=4, ...)
```

Arguments

x	a numeric vector or matrix
labels	labels for categories corresponding to rows of x. If not specified these are taken from row names of x.
groups, gdata, cex, pch, gpch, bg, color, gcolor, lcolor, xlim, main, xlab, ylab	see dotchart
auxdata	a vector of information to be put in the right margin, in the same order as x. May be numeric, character, or a vector of expressions containing plotmath markup.

For dotchartp, auxdata may be a matrix to go along with the numeric x-axis variable, to result in point-specific hover text.

auxtitle — a column heading for auxdata

auxgdata — similar to auxdata but corresponding to the gdata argument. These usually represent overall sample sizes for each group of lines.

axisat — a vector of tick mark locations to pass to axis. Useful if transforming the data axis

axislabels — a vector of strings specifying axis tick mark labels. Useful if transforming the data axis

digits — number of significant digits for formatting numeric data in hover text for dotchartp and summaryDp

dec — for dotchartp only, overrides digits to specify the argument to round() for rounding values for hover labels

cex.labels — cex for labels

cex.group.labels — cex for group labels

cex.auxdata — cex for auxdata

groupfont — font number for group headings

auxwhere — for summaryD and dotchartp specifies whether auxdata and auxgdata are to be placed on the far right of the chart, or should appear as pop-up tooltips when hovering the mouse over the ordinary x data points on the chart. Ignored for dotchart3.

... — other arguments passed to some of the graphics functions, or to dotchart3 or dotchartp from summaryD. The auxwhere='hover' option is a useful argument to pass from summaryD to dotchartp. Also used to pass other arguments to dotchartpl from summaryDp.

layoutattr — set to TRUE to put plotly::layout information in a list as an attribute layout of the returned plotly object instead of running the plotly object through the layout function. This is useful if running dotchartp multiple times to later put together using plotly::subplot and only then running the result through plotly::layout.

showlegend — set to FALSE to suppress the plotly legend with dotchartp

formula — a formula with one variable on the left hand side (the variable to compute summary statistics on), and one or two variables on the right hand side. If there are two variables, the first is taken as the major grouping variable. If the left hand side variable is a matrix it has to be a legal R variable name, not an expression, and fun needs to be able to process a matrix. For summaryDp there may be more than two right-hand-side variables.

data — a data frame or list used to find the variables in formula. If omitted, the parent environment is used.

fun — a summarization function creating a single number from a vector. Default is the mean. For summaryDp, fun produces a named vector of summary statistics, with the default computing the Mean and N (number of non-missing values).

funm	applies if there are two right hand variables and groupsummary=TRUE and the marginal summaries over just the first x variable need to be computed differently than the summaries that are cross-classified by both variables. funm defaults to fun and should have the same structure as fun.
groupsummary	By default, when there are two right-hand variables, summarize(..., fun) is called a second time without the use of the second variable, to obtain marginal summaries for the major grouping variable and display the results as a dot (and optionally in the right margin). Set groupsummary=FALSE to suppress this information.
auxvar	when fun returns more than one statistic and the user names the elements in the returned vector, you can specify auxvar as a single character string naming one of them. This will cause the named element to be written in the right margin, and that element to be deleted when plotting the statistics.
vals	set to TRUE to show data values (dot locations) in the right margin. Defaults to TRUE if auxvar is specified.
fmtvals	an optional function to format values before putting them in the right margin. Default is the format function.
symbol	a scalar or vector of pch values for ordinary graphics or a character vector or scalar of plotly symbols. These correspond to columns of x or elements produced by fun.
col	a function or vector of colors to assign to multiple points plotted in one line. If a function it will be evaluated with an argument equal to the number of groups/columns.
legendgroup	see plotly documentation; corresponds to column names/fun output for plotly graphs only
gridevery	specify a positive number to draw very faint vertical grid lines every gridevery x-axis units; for non-plotly charts
gridcol	color for grid lines; default is very faint gray scale
sort	specify sort=FALSE to plot data in the original order, from top to bottom on the dot chart. For dotchartp, set sort to 'descending' to sort in descending order of the first column of x, or 'ascending' to do the reverse. These do not make sense if groups is present.
height, width	height and width in pixels for dotchartp if not using plotly defaults. Ignored for dotchart3. If set to "auto" the height is computed using Hmisc::plotlyHeightDotchart.
overall	set to FALSE to suppress plotting of unstratified estimates
subset	an observation subsetting expression
na.action	an NA action function
ncharsmax	a 2-vector specifying the number of characters after which an html new line character should be placed, respectively for the x-axis label and the stratification variable levels

Value

the function returns invisibly

Author(s)

Frank Harrell

See Also

dotchart,dotchart2,summarize, rlegend

Examples

```
set.seed(135)
maj <- factor(c(rep('North',13),rep('South',13)))
g <- paste('Category',rep(letters[1:13],2))
n <- sample(1:15000, 26, replace=TRUE)
y1 <- runif(26)
y2 <- pmax(0, y1 - runif(26, 0, .1))
dotchart3(cbind(y1,y2), g, groups=maj, auxdata=n, auxtitle='n',
          xlab='Y', pch=c(1,17))
## Compare with dotchart function (no superpositioning or auxdata allowed):
## dotchart(y1, g, groups=maj, xlab='Y')

## Not run:
dotchartp(cbind(y1, y2), g, groups=maj, auxdata=n, auxtitle='n',
          xlab='Y', gdata=cbind(c(0,.1), c(.23,.44)), auxgdata=c(-1,-2),
          symbol=c('circle', 'line-ns-open'))

summaryDp(sbp ~ region + sex + race + cut2(age, g=5), data=mydata)

## End(Not run)

## Put options(grType='plotly') to have the following use dotchartp
## (rlegend will not apply)
## Add argument auxwhere='hover' to summaryD or dotchartp to put
## aux info in hover text instead of right margin
summaryD(y1 ~ maj + g, xlab='Mean')
summaryD(y1 ~ maj + g, groupsummary=FALSE)
summaryD(y1 ~ g, fmtvals=function(x) sprintf('%4.2f', x))
Y <- cbind(y1, y2)   # summaryD cannot handle cbind(...) ~ ...
summaryD(Y  ~ maj + g, fun=function(y) y[1,], symbol=c(1,17))
rlegend(.1, 26, c('y1','y2'), pch=c(1,17))

summaryD(y1 ~ maj, fun=function(y) c(Mean=mean(y), n=length(y)),
         auxvar='n', auxtitle='N')
```

---

dotchartpl *Enhanced Version of dotchart Function for plotly*

Description

This function produces a plotly interactive graphic and accepts a different format of data input than the other dotchart functions. It was written to handle a hierarchical data structure including strata that further subdivide the main classes. Strata, indicated by the mult variable, are shown on the same horizontal line, and if the variable big is FALSE will appear slightly below the main line, using smaller symbols, and having some transparency. This is intended to handle output such as that from the summaryP function when there is a superpositioning variable group and a stratification variable mult, especially when the data have been run through the addMarginal function to create mult categories labelled "All" for which the user will specify big=TRUE to indicate non-stratified estimates (stratified only on group) to emphasize.

When viewing graphics that used mult and big, the user can click on the legends for the small points for groups to vanish the finely stratified estimates.

When group is used by mult and big are not, and when the group variable has exactly two distinct values, you can specify refgroup to get the difference between two proportions in addition to the individual proportions. The individual proportions are plotted, but confidence intervals for the difference are shown in hover text and half-width confidence intervals for the difference, centered at the midpoint of the proportions, are shown. These have the property of intersecting the two proportions if and only if there is no significant difference at the 1 - conf.int level.

Specify fun=exp and ifun=log if estimates and confidence limits are on the log scale. Make sure that zeros were prevented in the original calculations. For exponential hazard rates this can be accomplished by replacing event counts of 0 with 0.5.

Usage

```
dotchartpl(x, major=NULL, minor=NULL, group=NULL, mult=NULL,
           big=NULL, htext=NULL, num=NULL, denom=NULL,
           numlabel='', denomlabel='',
           fun=function(x) x, ifun=function(x) x, op='-',
           lower=NULL, upper=NULL,
           refgroup=NULL, sortdiff=TRUE, conf.int=0.95,
           minkeep=NULL, xlim=NULL, xlab='Proportion',
           tracename=NULL, limitstracename='Limits',
           nonbigtracename='Stratified Estimates',
           dec=3, width=800, height=NULL,
           col=colorspace::rainbow_hcl)
```

Arguments

x	a numeric vector used for values on the x-axis
major	major vertical category, e.g., variable labels
minor	minor vertical category, e.g. category levels within variables
group	superpositioning variable such as treatment
mult	strata names for further subdivisions without groups
big	omit if all levels of mult are equally important or if mult is omitted. Otherwise denotes major (larger points, right on horizontal lines) vs. minor (smaller, transparent points slightly below the line).

htext	additional hover text per point
num	if x represents proportions, optionally specifies numerators to be used in fractions added to hover text. When num is given, x is automatically added to hover text, rounded to 3 digits after the decimal point.
denom	like num but for denominators
numlabel	character string to put to the right of the numerator in hover text
denomlabel	character string to put to the right of the denominator in hover text
fun	a transformation to make when printing estimates. For example, one may specify fun=exp to anti-log estimates and confidence limites that were computed on a log basis
ifun	inverse transformation of fun
op	set to for example '/' when fun=exp and effects are computed as ratios instead of differences. This is used in hover text.
lower	lower limits for optional error bars
upper	upper limits for optional error bars
refgroup	if group is specified and there are exactly two groups, specify the character string for the reference group in computing difference in proportions. For example if refgroup='A' and the group levels are 'A','B', you will get B - A.
sortdiff	minor categories are sorted by descending values of the difference in proportions when refgroup is used, unless you specify sortdiff=FALSE
conf.int	confidence level for computing confidence intervals for the difference in two proportions. Specify conf.int=FALSE to suppress confidence intervals.
minkeep	if refgroup and minkeep are both given, observations that are at or above minkeep for at least one of the groups are retained. The defaults to to keep all observations.
xlim	x-axis limits
xlab	x-axis label
tracename	plotly trace name if group is not used
limitstracename	plotly trace name for lower and upper if group is not used
nonbigtracename	plotly trace name used for non-big elements, which usually represent stratified versions of the "big" observations
col	a function or vector of colors to assign to group. If a function it will be evaluated with an argument equal to the number of distinct groups.
dec	number of places to the right of the decimal place for formatting numeric quantities in hover text
width	width of plot in pixels
height	height of plot in pixels; computed from number of strata by default

Value

a `plotly` object. An attribute `levelsRemoved` is added if `minkeep` is used and any categories were omitted from the plot as a result. This is a character vector with categories removed. If `major` is present, the strings are of the form `major:minor`

Author(s)

Frank Harrell

See Also

dotchartp

Examples

```
## Not run:
set.seed(1)
d <- expand.grid(major=c('Alabama', 'Alaska', 'Arkansas'),
                 minor=c('East', 'West'),
                 group=c('Female', 'Male'),
                 city=0:2)
n <- nrow(d)
d$num   <- round(100*runif(n))
d$denom <- d$num + round(100*runif(n))
d$x     <- d$num / d$denom
d$lower <- d$x - runif(n)
d$upper <- d$x + runif(n)

with(d,
 dotchartpl(x, major, minor, group, city, lower=lower, upper=upper,
            big=city==0, num=num, denom=denom, xlab='x'))

# Show half-width confidence intervals for Female - Male differences
# after subsetting the data to have only one record per
# state/region/group
d <- subset(d, city == 0)
with(d,
 dotchartpl(x, major, minor, group, num=num, denom=denom,
            lower=lower, upper=upper, refgroup='Male')
)

n <- 500
set.seed(1)
d <- data.frame(
  race         = sample(c('Asian', 'Black/AA', 'White'), n, TRUE),
  sex          = sample(c('Female', 'Male'), n, TRUE),
  treat        = sample(c('A', 'B'), n, TRUE),
  smoking      = sample(c('Smoker', 'Non-smoker'), n, TRUE),
  hypertension = sample(c('Hypertensive', 'Non-Hypertensive'), n, TRUE),
  region       = sample(c('North America','Europe','South America',
                          'Europe', 'Asia', 'Central America'), n, TRUE))
```

```
d <- upData(d, labels=c(race='Race', sex='Sex'))

dm <- addMarginal(d, region)
s <- summaryP(race + sex + smoking + hypertension ~
                region + treat,  data=dm)

s$region <- ifelse(s$region == 'All', 'All Regions', as.character(s$region))

with(s,
 dotchartpl(freq / denom, major=var, minor=val, group=treat, mult=region,
            big=region == 'All Regions', num=freq, denom=denom)
)

s2 <- s[- attr(s, 'rows.to.exclude1'), ]
with(s2,
     dotchartpl(freq / denom, major=var, minor=val, group=treat, mult=region,
                big=region == 'All Regions', num=freq, denom=denom)
)
# Note these plots can be created by plot.summaryP when options(grType='plotly')

# Plot hazard rates and ratios with confidence limits, on log scale
d <- data.frame(tx=c('a', 'a', 'b', 'b'),
                event=c('MI', 'stroke', 'MI', 'stroke'),
                count=c(10, 5, 5, 2),
                exposure=c(1000, 1000, 900, 900))
# There were no zero event counts in this dataset.  In general we
# want to handle that, hence the 0.5 below
d <- upData(d, hazard = pmax(0.5, count) / exposure,
               selog  = sqrt(1. / pmax(0.5, count)),
               lower  = log(hazard) - 1.96 * selog,
               upper  = log(hazard) + 1.96 * selog)
with(d,
     dotchartpl(log(hazard), minor=event, group=tx, num=count, denom=exposure,
                lower=lower, upper=upper,
                fun=exp, ifun=log, op='/',
                numlabel='events', denomlabel='years',
                refgroup='a', xlab='Events Per Person-Year')
)

## End(Not run)
```

---

dualSD *Dual Standard Deviations*

Description

Computes one standard deviation for the lower half of the distribution of a numeric vector and another SD for the upper half. By default the center of the distribution for purposes of splitting into "halves" is the mean. The user may override this with `center`. When splitting into halves, observations equal to the `center` value are included in both subsets.

Usage

```
dualSD(x, na.rm = FALSE, nmin = 10, center = xbar)
```

Arguments

x	a numeric vector
na.rm	set to TRUE to find any NA values and remove them before computing SDs.
nmin	the minimum number of non-NA obesrvations that must be present for two SDs to be computed. If the mumber of non-missing values falls below nmin, the regular SD is duplicated in the result.
center	center point for making the two subsets. The sample mean is used to compute the two SDs no matter what is specified for center.

Details

The purpose of dual SDs is to describe variability for asymmetric distributions. Symmetric distributions are also handled, though slightly less efficiently than a single SD does.

Value

a 2-vector of SDs with names bottom and top

Author(s)

Frank Harrell

See Also

pMedian()

Examples

```
set.seed(1)
x <- rnorm(20000)
sd(x)
dualSD(x)
y <- exp(x)
s1 <- sd(y)
s2 <- dualSD(y)
s1
s2
quantile(y, c(0.025, 0.975))
mean(y) + 1.96 * c(-1, 1) * s1
mean(y) + 1.96 * c(- s2['bottom'], s2['top'])
c(mean=mean(y), pseudomedian=pMedian(y), median=median(y))
```

ebpcomp *ebpcomp*

Description

Computation of Coordinates of Extended Box Plots Elements

Usage

```
ebpcomp(x, qref = c(0.5, 0.25, 0.75), probs = c(0.05, 0.125, 0.25, 0.375))
```

Arguments

x	a numeric variable
qref	quantiles for major corners
probs	quantiles for minor corners

Details

For an extended box plots computes all the elements needed for plotting it. This is typically used when adding to a ggplot2 plot.

Value

list with elements segments, lines, points, points2

Author(s)

Frank Harrell

Examples

```
ebpcomp(1:1000)
```

Ecdf *Empirical Cumulative Distribution Plot*

Description

Computes coordinates of cumulative distribution function of x, and by defaults plots it as a step function. A grouping variable may be specified so that stratified estimates are computed and (by default) plotted. If there is more than one group, the `labcurve` function is used (by default) to label the multiple step functions or to draw a legend defining line types, colors, or symbols by linking them with group labels. A `weights` vector may be specified to get weighted estimates. Specify `normwt` to make `weights` sum to the length of `x` (after removing NAs). Other wise the total sample size is taken to be the sum of the weights.

`Ecdf` is actually a method, and `Ecdf.default` is what's called for a vector argument. `Ecdf.data.frame` is called when the first argument is a data frame. This function can automatically set up a matrix of ECDFs and wait for a mouse click if the matrix requires more than one page. Categorical variables, character variables, and variables having fewer than a set number of unique values are ignored. If `par(mfrow=..)` is not set up before `Ecdf.data.frame` is called, the function will try to figure the best layout depending on the number of variables in the data frame. Upon return the original `mfrow` is left intact.

When the first argument to `Ecdf` is a formula, a Trellis/Lattice function `Ecdf.formula` is called. This allows for multi-panel conditioning, superposition using a `groups` variable, and other Trellis features, along with the ability to easily plot transformed ECDFs using the `fun` argument. For example, if `fun=qnorm`, the inverse normal transformation will be used for the y-axis. If the transformed curves are linear this indicates normality. Like the `xYplot` function, `Ecdf` will create a function `Key` if the `groups` variable is used. This function can be invoked by the user to define the keys for the groups.

Usage

```
Ecdf(x, ...)

## Default S3 method:
Ecdf(x, what=c('F','1-F','f','1-f'),
     weights=rep(1, length(x)), normwt=FALSE,
     xlab, ylab, q, pl=TRUE, add=FALSE, lty=1,
     col=1, group=rep(1,length(x)), label.curves=TRUE, xlim,
     subtitles=TRUE, datadensity=c('none','rug','hist','density'),
     side=1,
     frac=switch(datadensity,none=NA,rug=.03,hist=.1,density=.1),
     dens.opts=NULL, lwd=1, log='', ...)


## S3 method for class 'data.frame'
Ecdf(x, group=rep(1,nrows),
     weights=rep(1, nrows), normwt=FALSE,
     label.curves=TRUE, n.unique=10, na.big=FALSE, subtitles=TRUE,
     vnames=c('labels','names'),...)

## S3 method for class 'formula'
Ecdf(x, data=sys.frame(sys.parent()), groups=NULL,
     prepanel=prepanel.Ecdf, panel=panel.Ecdf, ..., xlab,
     ylab, fun=function(x)x, what=c('F','1-F','f','1-f'), subset=TRUE)
```

Arguments

x	a numeric vector, data frame, or Trellis/Lattice formula
what	The default is "F" which results in plotting the fraction of values <= x. Set to "1-F" to plot the fraction > x or "f" to plot the cumulative frequency of values <= x. Use "1-f" to plot the cumulative frequency of values >= x.
weights	numeric vector of weights. Omit or specify a zero-length vector or NULL to get unweighted estimates.
normwt	see above
xlab	x-axis label. Default is label(x) or name of calling argument. For Ecdf.formula, xlab defaults to the label attribute of the x-axis variable.
ylab	y-axis label. Default is "Proportion <= x", "Proportion > x", or "Frequency <= x" depending on value of what.
q	a vector for quantiles for which to draw reference lines on the plot. Default is not to draw any.
pl	set to F to omit the plot, to just return estimates
add	set to TRUE to add the cdf to an existing plot. Does not apply if using lattice graphics (i.e., if a formula is given as the first argument).
lty	integer line type for plot. If group is specified, this can be a vector.
lwd	line width for plot. Can be a vector corresponding to groups.
log	see plot. Set log='x' to use log scale for x-axis.
col	color for step function. Can be a vector.
group	a numeric, character, or factor categorical variable used for stratifying estimates. If group is present, as many ECDFs are drawn as there are non–missing group levels.
label.curves	applies if more than one group exists. Default is TRUE to use labcurve to label curves where they are farthest apart. Set label.curves to a list to specify options to labcurve, e.g., label.curves=list(method="arrow", cex=.8). These option names may be abbreviated in the usual way arguments are abbreviated. Use for example label.curves=list(keys=1:5) to draw symbols periodically (as in pch=1:5 - see points) on the curves and automatically position a legend in the most empty part of the plot. Set label.curves=FALSE to suppress drawing curve labels. The col, lty, and type parameters are automatically passed to labcurve, although you can override them here. You can set label.curves=list(keys="lines") to have different line types defined in an automatically positioned key.
xlim	x-axis limits. Default is entire range of x.
subtitles	set to FALSE to suppress putting a subtitle at the bottom left of each plot. The subtitle indicates the numbers of non-missing and missing observations, which are labeled n, m.
datadensity	If datadensity is not "none", either scat1d or histSpike is called to add a rug plot (datadensity="rug"), spike histogram (datadensity="hist"), or smooth density estimate ("density") to the bottom or top of the ECDF.

side	If datadensity is not "none", the default is to place the additional information on top of the x-axis (side=1). Use side=3 to place at the top of the graph.
frac	passed to histSpike
dens.opts	a list of optional arguments for histSpike
...	other parameters passed to plot if add=F. For data frames, other parameters to pass to Ecdf.default. For Ecdf.formula, if groups is not used, you can also add data density information to each panel's ECDF by specifying the datadensity and optional frac, side, dens.opts arguments.
n.unique	minimum number of unique values before an ECDF is drawn for a variable in a data frame. Default is 10.
na.big	set to TRUE to draw the number of NAs in larger letters in the middle of the plot for Ecdf.data.frame
vnames	By default, variable labels are used to label x-axes. Set vnames="names" to instead use variable names.
method	method for computing the empirical cumulative distribution. See wtd.Ecdf. The default is to use the standard "i/n" method as is used by the non-Trellis versions of Ecdf.
fun	a function to transform the cumulative proportions, for the Trellis-type usage of Ecdf
data, groups, subset, prepanel, panel	the usual Trellis/Lattice parameters, with groups causing Ecdf.formula to overlay multiple ECDFs on one panel.

Value

for Ecdf.default an invisible list with elements x and y giving the coordinates of the cdf. If there is more than one group, a list of such lists is returned. An attribute, N, is in the returned object. It contains the elements n and m, the number of non-missing and missing observations, respectively.

Side Effects

plots

Author(s)

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See Also

wtd.Ecdf, label, table, cumsum, labcurve, xYplot, histSpike

Examples

```
set.seed(1)
ch <- rnorm(1000, 200, 40)
Ecdf(ch, xlab="Serum Cholesterol")
scat1d(ch)                       # add rug plot
histSpike(ch, add=TRUE, frac=.15)   # add spike histogram
# Better: add a data density display automatically:
Ecdf(ch, datadensity='density')


label(ch) <- "Serum Cholesterol"
Ecdf(ch)
other.ch <- rnorm(500, 220, 20)
Ecdf(other.ch,add=TRUE,lty=2)


sex <- factor(sample(c('female','male'), 1000, TRUE))
Ecdf(ch, q=c(.25,.5,.75))  # show quartiles
Ecdf(ch, group=sex,
     label.curves=list(method='arrow'))


# Example showing how to draw multiple ECDFs from paired data
pre.test <- rnorm(100,50,10)
post.test <- rnorm(100,55,10)
x <- c(pre.test, post.test)
g <- c(rep('Pre',length(pre.test)),rep('Post',length(post.test)))
Ecdf(x, group=g, xlab='Test Results', label.curves=list(keys=1:2))
# keys=1:2 causes symbols to be drawn periodically on top of curves


# Draw a matrix of ECDFs for a data frame
m <- data.frame(pre.test, post.test,
                sex=sample(c('male','female'),100,TRUE))
Ecdf(m, group=m$sex, datadensity='rug')


freqs <- sample(1:10, 1000, TRUE)
Ecdf(ch, weights=freqs)  # weighted estimates


# Trellis/Lattice examples:


region <- factor(sample(c('Europe','USA','Australia'),100,TRUE))
year <- factor(sample(2001:2002,1000,TRUE))
Ecdf(~ch | region*year, groups=sex)
Key()           # draw a key for sex at the default location
# Key(locator(1)) # user-specified positioning of key
age <- rnorm(1000, 50, 10)
Ecdf(~ch | lattice::equal.count(age), groups=sex)  # use overlapping shingles
Ecdf(~ch | sex, datadensity='hist', side=3)  # add spike histogram at top
```

ecdfSteps *ecdfSteps*

Description

Compute Coordinates of an Empirical Distribution Function

Usage

```
ecdfSteps(x, extend)
```

Arguments

x	numeric vector, possibly with NAs that are ignored
extend	a 2-vector do extend the range of x (low, high). Set extend=FALSE to not extend x, or leave it missing to extend it 1/20th of the observed range on other side.

Details

For a numeric vector uses the R built-in ecdf function to compute coordinates of the ECDF, with extension slightly below and above the range of x by default. This is useful for ggplot2 where the ECDF may need to be transformed. The returned object is suitable for creating stratified statistics using data.table and other methods.

Value

a list with components x and y

Author(s)

Frank Harrell

See Also

stats::ecdf()

Examples

```
ecdfSteps(0:10)
## Not run:
# Use data.table for obtaining ECDFs by country and region
w <- d[, ecdfSteps(z, extend=c(1,11)), by=.(country, region)]  # d is a DT
# Use ggplot2 to make one graph with multiple regions' ECDFs
# and use faceting for countries
ggplot(w, aes(x, y, color=region)) + geom_step() +
       facet_wrap(~ country)

## End(Not run)
```

equalBins *Multicolumn Formating*

Description

Expands the width either supercolumns or the subcolumns so that the the sum of the supercolumn widths is the same as the sum of the subcolumn widths.

Usage

```
equalBins(widths, subwidths)
```

Arguments

widths	widths of the supercolumns.
subwidths	list of widths of the subcolumns for each supercolumn.

Details

This determins the correct subwidths of each of various columns in a table for printing. The correct width of the multicolumns is deterimed by summing the widths of it subcolumns.

Value

widths of the the columns for a table.

Author(s)

Charles Dupont

See Also

nchar, stringDims

Examples

```
mcols <- c("Group 1", "Group 2")
mwidth <- nchar(mcols, type="width")
spancols <- c(3,3)
ccols <- c("a", "deer", "ad", "cat", "help", "bob")
cwidth <- nchar(ccols, type="width")

subwidths <- partition.vector(cwidth, spancols)

equalBins(mwidth, subwidths)
```

errbar *Plot Error Bars*

Description

Add vertical error bars to an existing plot or makes a new plot with error bars.

Usage

```
errbar(x, y, yplus, yminus, cap=0.015, main = NULL,
       sub=NULL, xlab=as.character(substitute(x)),
       ylab=if(is.factor(x) || is.character(x)) ""
           else as.character(substitute(y)),
       add=FALSE, lty=1, type='p', ylim=NULL,
       lwd=1, pch=16, errbar.col, Type=rep(1, length(y)),
       ...)
```

Arguments

x	vector of numeric x-axis values (for vertical error bars) or a factor or character variable (for horizontal error bars, x representing the group labels)
y	vector of y-axis values.
yplus	vector of y-axis values: the tops of the error bars.
yminus	vector of y-axis values: the bottoms of the error bars.
cap	the width of the little lines at the tops and bottoms of the error bars in units of the width of the plot. Defaults to 0.015.
main	a main title for the plot, passed to plot, see also title.
sub	a sub title for the plot, passed to plot
xlab	optional x-axis labels if add=FALSE.
ylab	optional y-axis labels if add=FALSE. Defaults to blank for horizontal charts.
add	set to TRUE to add bars to an existing plot (available only for vertical error bars)
lty	type of line for error bars
type	type of point. Use type="b" to connect dots.
ylim	y-axis limits. Default is to use range of y, yminus, and yplus. For horizonal charts, ylim is really the x-axis range, excluding differences.
lwd	line width for line segments (not main line)
pch	character to use as the point.
errbar.col	color to use for drawing error bars.
Type	used for horizontal bars only. Is an integer vector with values 1 if corresponding values represent simple estimates, 2 if they represent differences.
...	other parameters passed to all graphics functions.

Details

errbar adds vertical error bars to an existing plot or makes a new plot with error bars. It can also make a horizontal error bar plot that shows error bars for group differences as well as bars for groups. For the latter type of plot, the lower x-axis scale corresponds to group estimates and the upper scale corresponds to differences. The spacings of the two scales are identical but the scale for differences has its origin shifted so that zero may be included. If at least one of the confidence intervals includes zero, a vertical dotted reference line at zero is drawn.

Author(s)

Charles Geyer, University of Chicago. Modified by Frank Harrell, Vanderbilt University, to handle missing data, to add the parameters add and lty, and to implement horizontal charts with differences.

Examples

```
set.seed(1)
x <- 1:10
y <- x + rnorm(10)
delta <- runif(10)
errbar( x, y, y + delta, y - delta )


# Show bootstrap nonparametric CLs for 3 group means and for
# pairwise differences on same graph
group <- sample(c('a','b','d'), 200, TRUE)
y     <- runif(200) + .25*(group=='b') + .5*(group=='d')
cla <- smean.cl.boot(y[group=='a'],B=100,reps=TRUE)  # usually B=1000
a   <- attr(cla,'reps')
clb <- smean.cl.boot(y[group=='b'],B=100,reps=TRUE)
b   <- attr(clb,'reps')
cld <- smean.cl.boot(y[group=='d'],B=100,reps=TRUE)
d   <- attr(cld,'reps')
a.b <- quantile(a-b,c(.025,.975))
a.d <- quantile(a-d,c(.025,.975))
b.d <- quantile(b-d,c(.025,.975))
errbar(c('a','b','d','a - b','a - d','b - d'),
       c(cla[1],clb[1],cld[1],cla[1]-clb[1],cla[1]-cld[1],clb[1]-cld[1]),
       c(cla[3],clb[3],cld[3],a.b[2],a.d[2],b.d[2]),
       c(cla[2],clb[2],cld[2],a.b[1],a.d[1],b.d[1]),
       Type=c(1,1,1,2,2,2), xlab='', ylab='')
```

---

escapeRegex *Escapes any characters that would have special meaning in a regular expression.*

Description

Escapes any characters that would have special meaning in a regular expression.

Usage

```
escapeRegex(string)
escapeBS(string)
```

Arguments

string	string being operated on.

Details

escapeRegex will escape any characters that would have special meaning in a requlars expression. For any string grep(regexpEscape(string), string) will always be true.

escapeBS will escape any backslash '\' in a string.

Value

The value of the string with any characters that would have special meaning in a requlars expression escaped.

Author(s)

Charles Dupont
Department of Biostatistics
Vanderbilt University

See Also

grep

Examples

```
string <- "this\\(system) {is} [full]."
escapeRegex(string)

escapeBS(string)
```

---

estSeqMarkovOrd *estSeqMarkovOrd*

Description

Simulate Comparisons For Use in Sequential Markov Longitudinal Clinical Trial Simulations

Usage

```
estSeqMarkovOrd(
  y,
  times,
  initial,
  absorb = NULL,
  intercepts,
  parameter,
  looks,
  g,
  formula,
  ppo = NULL,
  yprevfactor = TRUE,
  groupContrast = NULL,
  cscov = FALSE,
  timecriterion = NULL,
  coxzph = FALSE,
  sstat = NULL,
  rdsample = NULL,
  maxest = NULL,
  maxvest = NULL,
  nsim = 1,
  progress = FALSE,
  pfile = ""
)
```

Arguments

y	vector of possible y values in order (numeric, character, factor)
times	vector of measurement times
initial	a vector of probabilities summing to 1.0 that specifies the frequency distribution of initial values to be sampled from. The vector must have names that correspond to values of y representing non-absorbing states.
absorb	vector of absorbing states, a subset of y. The default is no absorbing states. Observations are truncated when an absorbing state is simulated. May be numeric, character, or factor.
intercepts	vector of intercepts in the proportional odds model. There must be one fewer of these than the length of y.
parameter	vector of true parameter (effects; group differences) values. These are group 2:1 log odds ratios in the transition model, conditioning on the previous y.
looks	integer vector of ID numbers at which maximum likelihood estimates and their estimated variances are computed. For a single look specify a scalar value for loops equal to the number of subjects in the sample.
g	a user-specified function of three or more arguments which in order are yprev - the value of y at the previous time, the current time t, the gap between the

previous time and the current time, an optional (usually named) covariate vector X, and optional arguments such as a regression coefficient value to simulate from. The function needs to allow yprev to be a vector and yprev must not include any absorbing states. The g function returns the linear predictor for the proportional odds model aside from intercepts. The returned value must be a matrix with row names taken from yprev. If the model is a proportional odds model, the returned value must be one column. If it is a partial proportional odds model, the value must have one column for each distinct value of the response variable Y after the first one, with the levels of Y used as optional column names. So columns correspond to intercepts. The different columns are used for y-specific contributions to the linear predictor (aside from intercepts) for a partial or constrained partial proportional odds model. Parameters for partial proportional odds effects may be included in the ... arguments.

formula — a formula object given to the lrm() function using variables with these name: y, time, yprev, and group (factor variable having values '1' and '2'). The yprev variable is converted to a factor before fitting the model unless yprevfactor=FALSE.

ppo — a formula specifying the part of formula for which proportional odds is not to be assumed, i.e., that specifies a partial proportional odds model. Specifying ppo triggers the use of VGAM::vglm() instead of rms::lrm and will make the simulations run slower.

yprevfactor — see formula

groupContrast — omit this argument if group has only one regression coefficient in formula. Otherwise if ppo is omitted, provide groupContrast as a list of two lists that are passed to rms::contrast.rms() to compute the contrast of interest and its standard error. The first list corresponds to group 1, the second to group 2, to get a 2:1 contrast. If ppo is given and the group effect is not just a simple regression coefficient, specify as groupContrast a function of a vglm fit that computes the contrast of interest and its standard error and returns a list with elements named Contrast and SE. For the latter type you can optionally have formal arguments n1, n2, and parameter that are passed to groupContrast to compute the standard error of the group contrast, where n1 and n2 respectively are the sample sizes for the two groups and parameter is the true group effect parameter value.

cscov — applies if ppo is not used. Set to TRUE to use the cluster sandwich covariance estimator of the variance of the group comparison.

timecriterion — a function of a time-ordered vector of simulated ordinal responses y that returns a vector FALSE or TRUE values denoting whether the current y level met the condition of interest. For example estSeqMarkovOrd will compute the first time at which y >= 5 if you specify timecriterion=function(y) y >= 5. This function is only called at the last data look for each simulated study. To have more control, instead of timecriterion returning a logical vector have it return a numeric 2-vector containing, in order, the event/censoring time and the 1/0 event/censoring indicator.

coxzph — set to TRUE if timecriterion is specified and you want to compute a statistic for testing proportional hazards at the last look of each simulated data

sstat	set to a function of the time vector and the corresponding vector of ordinal responses for a single group if you want to compute a Wilcoxon test on a derived quantity such as the number of days in a given state.
rdsample	an optional function to do response-dependent sampling. It is a function of these arguments, which are vectors that stop at any absorbing state: times (ascending measurement times for one subject), y (vector of ordinal outcomes at these times for one subject. The function returns NULL if no observations are to be dropped, returns the vector of new times to sample.
maxest	maximum acceptable absolute value of the contrast estimate, ignored if NULL. Any values exceeding maxest will result in the estimate being set to NA.
maxvest	like maxest but for the estimated variance of the contrast estimate
nsim	number of simulations (default is 1)
progress	set to TRUE to send current iteration number to pfile every 10 iterations. Each iteration will really involve multiple simulations, if parameter has length greater than 1.
pfile	file to which to write progress information. Defaults to '' which is the console. Ignored if progress=FALSE.

Details

Simulates sequential clinical trials of longitudinal ordinal outcomes using a first-order Markov model. Looks are done sequentially after subject ID numbers given in the vector looks with the earliest possible look being after subject 2. At each look, a subject's repeated records are either all used or all ignored depending on the sequent ID number. For each true effect parameter value, simulation, and at each look, runs a function to compute the estimate of the parameter of interest along with its variance. For each simulation, data are first simulated for the last look, and these data are sequentially revealed for earlier looks. The user provides a function g that has extra arguments specifying the true effect of parameter the treatment group expecting treatments to be coded 1 and 2. parameter is usually on the scale of a regression coefficient, e.g., a log odds ratio. Fitting is done using the rms::lrm() function, unless non-proportional odds is allowed in which case VGAM::vglm() is used. If timecriterion is specified, the function also, for the last data look only, computes the first time at which the criterion is satisfied for the subject or use the event time and event/censoring indicator computed by timecriterion. The Cox/logrank chi-square statistic for comparing groups on the derived time variable is saved. If coxzph=TRUE, the survival package correlation coefficient rho from the scaled partial residuals is also saved so that the user can later determine to what extent the Markov model resulted in the proportional hazards assumption being violated when analyzing on the time scale. vglm is accelerated by saving the first successful fit for the largest sample size and using its coefficients as starting value for further vglm fits for any sample size for the same setting of parameter.

Value

a data frame with number of rows equal to the product of nsim, the length of looks, and the length of parameter, with variables sim, parameter, look, est (log odds ratio for group), and vest (the variance of the latter). If timecriterion is specified the data frame also contains loghr (Cox log hazard ratio for group), lrchisq (chi-square from Cox test for group), and if coxph=TRUE, phchisq, the chi-square for testing proportional hazards. The attribute etimefreq is also present

if timecriterion is present, and it probvides the frequency distribution of derived event times by group and censoring/event indicator. If sstat is given, the attribute sstat is also present, and it contains an array with dimensions corresponding to simulations, parameter values within simulations, id, and a two-column subarray with columns group and y, the latter being the summary measure computed by the sstat function. The returned data frame also has attribute lrmcoef which are the last-look logistic regression coefficient estimates over the nsim simulations and the parameter settings, and an attribute failures which is a data frame containing the variables reason and frequency cataloging the reasons for unsuccessful model fits.

Author(s)

Frank Harrell

See Also

gbayesSeqSim(), simMarkovOrd(), https://hbiostat.org/R/Hmisc/markov/

---

estSeqSim *estSeqSim*

Description

Simulate Comparisons For Use in Sequential Clinical Trial Simulations

Usage

```
estSeqSim(parameter, looks, gendat, fitter, nsim = 1, progress = FALSE)
```

Arguments

parameter	vector of true parameter (effects; group differences) values
looks	integer vector of observation numbers at which posterior probabilities are computed
gendat	a function of three arguments: true parameter value (scalar), sample size for first group, sample size for second group
fitter	a function of two arguments: 0/1 group indicator vector and the dependent variable vector
nsim	number of simulations (default is 1)
progress	set to TRUE to send current iteration number to the console

Details

Simulates sequential clinical trials. Looks are done sequentially at observation numbers given in the vector `looks` with the earliest possible look being at observation 2. For each true effect parameter value, simulation, and at each look, runs a function to compute the estimate of the parameter of interest along with its variance. For each simulation, data are first simulated for the last look, and these data are sequentially revealed for earlier looks. The user provides a function `gendat` that given a true effect of `parameter` and the two sample sizes (for treatment groups 1 and 2) returns a list with vectors `y1` and `y2` containing simulated data. The user also provides a function `fitter` with arguments `x` (group indicator 0/1) and `y` (response variable) that returns a 2-vector containing the effect estimate and its variance. `parameter` is usually on the scale of a regression coefficient, e.g., a log odds ratio.

Value

a data frame with number of rows equal to the product of `nsim`, the length of `looks`, and the length of `parameter`.

Author(s)

Frank Harrell

See Also

`gbayesSeqSim()`, `simMarkovOrd()`, `estSeqMarkovOrd()`

Examples

```
if (requireNamespace("rms", quietly = TRUE)) {
  # Run 50 simulations, 5 looks, 2 true parameter values
  # Total simulation time: 2s
  lfit <- function(x, y) {
  f <- rms::lrm.fit(x, y)
    k <- length(coef(f))
    c(coef(f)[k], vcov(f)[k, k])
  }
  gdat <- function(beta, n1, n2) {
    # Cell probabilities for a 7-category ordinal outcome for the control group
    p <- c(2, 1, 2, 7, 8, 38, 42) / 100

    # Compute cell probabilities for the treated group
    p2 <- pomodm(p=p, odds.ratio=exp(beta))
    y1 <- sample(1 : 7, n1, p,  replace=TRUE)
    y2 <- sample(1 : 7, n2, p2, replace=TRUE)
    list(y1=y1, y2=y2)
  }

  set.seed(1)
  est <- estSeqSim(c(0, log(0.7)), looks=c(50, 75, 95, 100, 200),
                   gendat=gdat,
                   fitter=lfit, nsim=50)
  head(est)
```

```
}
```

`event.chart` *Flexible Event Chart for Time-to-Event Data*

Description

Creates an event chart on the current graphics device. Also, allows user to plot legend on plot area or on separate page. Contains features useful for plotting data with time-to-event outcomes Which arise in a variety of studies including randomized clinical trials and non-randomized cohort studies. This function can use as input a matrix or a data frame, although greater utility and ease of use will be seen with a data frame.

Usage

```
event.chart(data, subset.r = 1:dim(data)[1], subset.c = 1:dim(data)[2],

            sort.by = NA, sort.ascending = TRUE,
            sort.na.last = TRUE, sort.after.subset = TRUE,
            y.var = NA, y.var.type = "n",
            y.jitter = FALSE, y.jitter.factor = 1,
            y.renum = FALSE, NA.rm = FALSE, x.reference = NA,
            now = max(data[, subset.c], na.rm = TRUE),
            now.line = FALSE, now.line.lty = 2,
            now.line.lwd = 1, now.line.col = 1, pty = "m",
            date.orig = c(1, 1, 1960), titl = "Event Chart",

            y.idlabels = NA, y.axis = "auto",
            y.axis.custom.at = NA, y.axis.custom.labels = NA,
            y.julian = FALSE, y.lim.extend = c(0, 0),
            y.lab = ifelse(is.na(y.idlabels), "", as.character(y.idlabels)),

            x.axis.all = TRUE, x.axis = "auto",
            x.axis.custom.at = NA, x.axis.custom.labels = NA,
            x.julian = FALSE, x.lim.extend = c(0, 0), x.scale = 1,
            x.lab = ifelse(x.julian, "Follow-up Time", "Study Date"),

            line.by = NA, line.lty = 1, line.lwd = 1, line.col = 1,
            line.add = NA, line.add.lty = NA,
            line.add.lwd = NA, line.add.col = NA,
            point.pch = 1:length(subset.c),
            point.cex = rep(0.6, length(subset.c)),
            point.col = rep(1, length(subset.c)),

            point.cex.mult = 1., point.cex.mult.var = NA,
            extra.points.no.mult = rep(NA, length(subset.c)),
```

```
  legend.plot = FALSE, legend.location = "o", legend.titl = titl,
  legend.titl.cex = 3, legend.titl.line = 1,
  legend.point.at = list(x = c(5, 95), y = c(95, 30)),
  legend.point.pch = point.pch,
 legend.point.text = ifelse(rep(is.data.frame(data), length(subset.c)),
                            names(data[, subset.c]),
                            subset.c),
  legend.cex = 2.5, legend.bty = "n",
  legend.line.at = list(x = c(5, 95), y = c(20, 5)),
  legend.line.text = names(table(as.character(data[, line.by]),
                                 exclude = c("", "NA"))),
  legend.line.lwd = line.lwd, legend.loc.num = 1,

  ...)
```

Arguments

data	a matrix or data frame with rows corresponding to subjects and columns corresponding to variables. Note that for a data frame or matrix containing multiple time-to-event data (e.g., time to recurrence, time to death, and time to last follow-up), one column is required for each specific event.
subset.r	subset of rows of original matrix or data frame to place in event chart. Logical arguments may be used here (e.g., `treatment.arm == 'a'`, if the data frame, data, has been attached to the search directory; otherwise, `data$treatment.arm == "a"`).
subset.c	subset of columns of original matrix or data frame to place in event chart; if working with a data frame, a vector of data frame variable names may be used for subsetting purposes (e.g., `c('randdate', 'event1')`.
sort.by	column(s) or data frame variable name(s) with which to sort the chart's output. The default is NA, thereby resulting in a chart sorted by original row number.
sort.ascending	logical flag (which takes effect only if the argument sort.by is utilized). If TRUE (default), sorting is done in ascending order; if FALSE, descending order.
sort.na.last	logical flag (which takes effect only if the argument sort.by is utilized). If TRUE (default), NA values are considered as last values in ordering.
sort.after.subset	logical flag (which takes effect only if the argument sort.by is utilized). If FALSE, sorting data (via sort.by specified variables or columns) will be performed prior to row subsetting (via subset.r); if TRUE (default), row subsetting of original data will be done before sorting.
y.var	variable name or column number of original matrix or data frame with which to scale y-axis. Default is NA, which will result in equally spaced lines on y-axis (based on original data or sorted data if requested by sort.by). Otherwise, location of lines on y-axis will be dictated by specified variable or column. Examples of specified variables may be date of an event or a physiological covariate. Any observation which has a missing value for the y.var variable will not appear on the graph.

y.var.type — type of variable specified in y.var (which will only take effect if argument y.var is utilized). If "d", specifed variable is a date (either numeric julian date or an S-Plus dates object); if "n", specifed variable is numeric (e.g., systolic blood pressure level) although not a julian date.

y.jitter — logical flag (which takes effect only if the argument y.var is utilized). Due to potential ties in y.var variable, y.jitter (when TRUE) will jitter the data to allow discrimination between observations at the possible cost of producing slightly inaccurate dates or covariate values; if FALSE (the default), no jittering will be performed. The y.jitter algorithm assumes a uniform distribution of observations across the range of y.var. The algorithm is as follows:

```
size.jitter <- ( diff(range(y.var)) / (2 * (length(y.var) - 1)) ) * y.jitter.factor
```

The default of y.jitter.factor is 1. The entire product is then used as an argument into runif: y.var <- y.var + runif(length(y.var), -size.jitter, size.jitter)

y.jitter.factor — an argument used with the y.jitter function to scale the range of added noise. Default is 1.

y.renum — logical flag. If TRUE, subset observations are listed on y-axis from 1 to length(subset.r); if FALSE (default), subset observations are listed on y-axis in original form. As an example, if subset.r = 301:340 and y.renum ==TRUE, y-axis will be shown as 1 through 40. However, if y.renum ==FALSE, y-axis will be shown as 301 through 340. The above examples assume the following argument, NA.rm, is set to FALSE.

NA.rm — logical flag. If TRUE, subset observations which have NA for each variable specified in subset.c will not have an entry on the y-axis. Also, if the following argument, x.reference, is specified, observations with missing x.reference values will also not have an entry on the y-axis. If FALSE (default), user can identify those observations which do have NA for every variable specified in subset.c (or, if x.reference is specified, also those observations which are missing only the x.reference value); this can easily be done by examining the resulting y-axis and recognizing the observations without any plotting symbols.

x.reference — column of original matrix or data frame with which to reference the x-axis. That is, if specified, all columns specified in subset.c will be substracted by x.reference. An example may be to see the timing of events before and after treatment or to see time-to-event after entry into study. The event times will be aligned using the x.reference argument as the reference point.

now — the "now" date which will be used for top of y-axis when creating the Goldman eventchart (see reference below). Default is max(data[, subset.c], na.rm =TRUE).

now.line — logical flag. A feature utilized by the Goldman Eventchart. When x.reference is specified as the start of follow-up and y.var = x.reference, then the Goldman chart can be created. This argument, if TRUE, will cause the plot region to be square, and will draw a line with a slope of -1 from the top of the y-axis to the right end of the x-axis. Essentially, it denotes end of current follow-up period for looking at the time-to-event data. Default is FALSE.

now.line.lty — line type of now.line.

now.line.lwd — line width of now.line.

now.line.col — color of now.line.

pty — graph option, pty='m' is the default; use pty='s' for the square looking Goldman's event chart.

date.orig — date of origin to consider if dates are in julian, SAS , or S-Plus dates object format; default is January 1, 1960 (which is the default origin used by both S-Plus and SAS). Utilized when either y.julian = FALSE or x.julian = FALSE.

titl — title for event chart. Default is 'Event Chart'.

y.idlabels — column or data frame variable name used for y-axis labels. For example, if c('pt.no') is specified, patient ID (stored in pt.no) will be seen on y-axis labels instead of sequence specified by subset.r. This argument takes precedence over both y.axis = 'auto' and y.axis = 'custom' (see below). NOTE: Program will issue warning if this argument is specified and if is.na(y.var) == FALSE; y.idlabels will not be used in this situation. Also, attempting to plot too many patients on a single event chart will cause undesirable plotting of y.idlabels.

y.axis — character string specifying whether program will control labelling of y-axis (with argument "auto"), or if user will control labelling (with argument "custom"). If "custom" is chosen, user must specify location and text of labels using y.axis.custom.at and y.axis.custom.labels arguments, respectively, listed below. This argument will not be utilized if y.idlabels is specified.

y.axis.custom.at — user-specified vector of y-axis label locations. Must be used when y.axis = "custom"; will not be used otherwise.

y.axis.custom.labels — user-specified vector of y-axis labels. Must be used when y.axis = "custom"; will not be used otherwise.

y.julian — logical flag (which will only be considered if y.axis == "auto" and (!is.na(y.var) & y.var.type== "d"). If FALSE (default), will convert julian numeric dates or S-Plus dates objects into "mm/dd/yy" format for the y-axis labels. If TRUE, dates will be printed in julian (numeric) format.

y.lim.extend — two-dimensional vector representing the number of units that the user wants to increase ylim on bottom and top of y-axis, respectively. Default c(0,0). This argument will not take effect if the Goldman chart is utilized.

y.lab — single label to be used for entire y-axis. Default will be the variable name or column number of y.idlabels (if non-missing) and blank otherwise.

x.axis.all — logical flag. If TRUE (default), lower and upper limits of x-axis will be based on all observations (rows) in matrix or data frame. If FALSE, lower and upper limits will be based only on those observations specified by subset.r (either before or after sorting depending on specification of sort.by and value of sort.after.subset).

x.axis — character string specifying whether program will control labelling of x-axis (with argument "auto"), or if user will control labelling (with argument "custom"). If "custom" is chosen, user must specify location and text of labels using x.axis.custom.at and x.axis.custom.labels arguments, respectively, listed below.

x.axis.custom.at
: user-specified vector of x-axis label locations. Must be used when x.axis == "custom"; will not be used otherwise.

x.axis.custom.labels
: user-specified vector of x-axis labels. Must be used when x.axis == "custom"; will not be used otherwise.

x.julian
: logical flag (which will only be considered if x.axis == "auto"). If FALSE (default), will convert julian dates or S-plus dates objects into "mm/dd/yy" format for the x-axis labels. If TRUE, dates will be printed in julian (numeric) format. NOTE: This argument should remain TRUE if x.reference is specified.

x.lim.extend
: two-dimensional vector representing the number of time units (usually in days) that the user wants to increase xlim on left-hand side and right-hand side of x-axis, respectively. Default is c(0,0). This argument will not take effect if the Goldman chart is utilized.

x.scale
: a factor whose reciprocal is multiplied to original units of the x-axis. For example, if the original data frame is in units of days, x.scale = 365 will result in units of years (notwithstanding leap years). Default is 1.

x.lab
: single label to be used for entire x-axis. Default will be "On Study Date" if x.julian = FALSE and "Time on Study" if x.julian = TRUE.

line.by
: column or data frame variable name for plotting unique lines by unique values of vector (e.g., specify c('arm') to plot unique lines by treatment arm). Can take at most one column or variable name. Default is NA which produces identical lines for each patient.

line.lty
: vector of line types corresponding to ascending order of line.by values. If line.by is specified, the vector should be the length of the number of unique values of line.by. If line.by is NA, only line.lty[1] will be used. The default is 1.

line.lwd
: vector of line widths corresponding to ascending order of line.by values. If line.by is specified, the vector should be the length of the number of unique values of line.by. If line.by is NA, only line.lwd[1] will be used. The default is 1.

line.col
: vector of line colors corresponding to ascending order of line.by values. If line.by is specified, the vector should be the length of the number of unique values of line.by. If line.by is NA, only line.col[1] will be used. The default is 1.

line.add
: a 2xk matrix with k=number of pairs of additional line segments to add. For example, if it is of interest to draw additional line segments connecting events one and two, two and three, and four and five, (possibly with different colors), an appropriate line.add argument would be matrix(c('first.event','second.event','second.event' 'fourth.event','fifth.event'), 2, 3). One line segment would be drawn between first.event and second.event, a second line segment would be drawn between second.event and third.event, and a third line segment would be drawn between fourth.event and fifth.event. Different line types, widths and colors can be specified (in arguments listed just below).

  The convention use of subset.c and line.add must match (i.e., column name must be used for both or column number must be used for both).

If line.add != NA, length of line.add.lty, line.add.lwd, and line.add.col must be the same as number of pairs of additional line segments to add.
NOTE: The drawing of the original default line may be suppressed (with line.col = 0), and line.add can be used to do all the line plotting for the event chart.

line.add.lty — a kx1 vector corresponding to the columns of line.add; specifies the line types for the k line segments.

line.add.lwd — a kx1 vector corresponding to the columns of line.add; specifies the line widths for the k line segments.

line.add.col — a kx1 vector corresponding to the columns of line.add; specifies the line colors for the k line segments.

point.pch — vector of pch values for points representing each event. If similar events are listed in multiple columns (e.g., regular visits or a recurrent event), repeated pch values may be listed in the vector (e.g., c(2,4,rep(183,3))). If length(point.pch) < length(subset.c), point.pch will be repeated until lengths are equal; a warning message will verify this condition.

point.cex — vector of size of points representing each event. If length(point.cex) < length(subset.c), point.cex will be repeated until lengths are equal; a warning message will verify this condition.

point.col — vector of colors of points representing each event. If length(point.col) < length(subset.c), point.col will be repeated until lengths are equal; a warning message will verify this condition.

point.cex.mult — a single number (may be non-integer), which is the base multiplier for the value of the cex of the plotted points, when interest lies in a variable size allowed for certain points, as a function of the quantity of the variable(s) in the dataset specified in the point.cex.mult.var argument; multiplied by original point.cex value and then the value of interest (for an individual) from the point.cex.mult.var argument; used only when non-NA arguments are provided to point.cex.mult.var; default is 1. .

point.cex.mult.var — vector of variables to be used in determining what point.cex.mult is multiplied by for determining size of plotted points from (possibly a subset of) subset.c variables, when interest lies in a variable size allowed for certain points, as a function of the level of some variable(s) in the dataset; default is NA.

extra.points.no.mult — vector of variables in the dataset to ignore for purposes of using point.cex.mult; for example, for some variables there may be interest in allowing a variable size allowed for the plotting of the points, whereas other variables (e.g., dropout time), there may be no interest in such manipulation; the vector should be the same size as the number of variables specified in subset.c, with NA entries where variable point size is of interest and the variable name (or location in subset.c) specified when the variable point size is not of interest; in this latter case, the associated argument in point.cex is instead used as the point cex; used only when non-NA arguments are provided to point.cex.mult.var; default is NA

legend.plot — logical flag; if TRUE, a legend will be plotted. Location of legend will be based on specification of legend.location along with values of other arguments listed below. Default is FALSE (i.e., no legend plotting).

legend.location
: will be used only if legend.plot = TRUE. If "o" (default), a one-page legend will precede the output of the chart. The user will need to hit enter in order for the event chart to be displayed. This feature is possible due to the dev.ask option. If "i", an internal legend will be placed in the plot region based on legend.point.at. If "l", a legend will be placed in the plot region using the locator option. Legend will map points to events (via column names, by default) and, if line.by is specified, lines to groups (based on levels of line.by).

legend.titl
: title for the legend; default is title to be used for main plot. Only used when legend.location = "o".

legend.titl.cex
: size of text for legend title. Only used when legend.location = "o".

legend.titl.line
: line location of legend title dictated by mtext function with outer = FALSE option; default is 1.0. Only used when legend.location = "o".

legend.point.at
: location of upper left and lower right corners of legend area to be utilized for describing events via points and text.

legend.point.pch
: vector of pch values for points representing each event in the legend. Default is point.pch.

legend.point.text
: text to be used for describing events; the default is setup for a data frame, as it will print the names of the columns specified by subset.c.

legend.cex
: size of text for points and event descriptions. Default is 2.5 which is setup for legend.location = "o". A much smaller cex is recommended (possibly 0.75) for use with legend.location = "i" or legend.location = "l".

legend.bty
: option to put a box around the legend(s); default is to have no box (legend.bty = "n"). Option legend.bty = "o" will produce a legend box.

legend.line.at
: if line.by was specified (with legend.location = "o" or legend.location = "i"), this argument will dictate the location of the upper left and lower right corners of legend area to be utilized for describing the different line.by values (e.g., treatment.arm). The default is setup for legend.location = "o".

legend.line.text
: text to be used for describing line.by values; the default are the names of the unique non-missing line.by values as produced from the table function.

legend.line.lwd
: vector of line widths corresponding to line.by values.

legend.loc.num
: number used for locator argument when legend.locator = "l". If 1 (default), user is to locate only the top left corner of the legend box. If 2, user is to locate both the top left corner and the lower right corner. This will be done twice when line.by is specified (once for points and once for lines).

...
: additional par arguments for use in main plot.

Details

if you want to put, say, two eventcharts side-by-side, in a plot region, you should not set up `par(mfrow=c(1,2))` before running the first plot. Instead, you should add the argument `mfg=c(1,1,1,2)` to the first plot call followed by the argument `mfg=c(1,2,1,2)` to the second plot call.

if dates in original data frame are in a specialized form (eg., mm/dd/yy) of mode CHARACTER, the user must convert those columns to become class dates or julian numeric mode (see `Date` for more information). For example, in a data frame called `testdata`, with specialized dates in columns 4 thru 10, the following code could be used: `as.numeric(dates(testdata[,4:10]))`. This will convert the columns to numeric julian dates based on the function's default origin of January 1, 1960. If original dates are in class dates or julian form, no extra work is necessary.

In the survival analysis, the data typically come in two columns: one column containing survival time and the other containing censoring indicator or event code. The `event.convert` function converts this type of data into multiple columns of event times, one column of each event type, suitable for the `event.chart` function.

Side Effects

an event chart is created on the current graphics device. If legend.plot =TRUE and legend.location = 'o', a one-page legend will precede the event chart. Please note that par parameters on completion of function will be reset to par parameters existing prior to start of function.

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References

Lee J.J., Hess, K.R., Dubin, J.A. (2000). Extensions and applications of event charts. *The American Statistician,* **54:1**, 63–70.

Dubin, J.A., Lee, J.J., Hess, K.R. (1997). The Utility of Event Charts. *Proceedings of the Biometrics Section, American* Statistical Association.

Dubin, J.A., Muller H-G, Wang J-L (2001). Event history graphs for censored survival data. *Statistics in Medicine,* **20:** 2951–2964.

Goldman, A.I. (1992). EVENTCHARTS: Visualizing Survival and Other Timed-Events Data. *The American Statistician,* **46:1**, 13–18.

See Also

event.history, Date

Examples

```
# The sample data set is an augmented CDC AIDS dataset (ASCII)
# which is used in the examples in the help file.  This dataset is
# described in Kalbfleisch and Lawless (JASA, 1989).
# Here, we have included only children 4 years old and younger.
# We have also added a new field, dethdate, which
# represents a fictitious death date for each patient.  There was
# no recording of death date on the original dataset.  In addition, we have
# added a fictitious viral load reading (copies/ml) for each patient at time of AIDS diagnosis,
# noting viral load was also not part of the original dataset.
#
# All dates are julian with julian=0 being
# January 1, 1960, and julian=14000 being 14000 days beyond
# January 1, 1960 (i.e., May 1, 1998).


cdcaids <- data.frame(
age=c(4,2,1,1,2,2,2,4,2,1,1,3,2,1,3,2,1,2,4,2,2,1,4,2,4,1,4,2,1,1,3,3,1,3),
infedate=c(
7274,7727,7949,8037,7765,8096,8186,7520,8522,8609,8524,8213,8455,8739,
8034,8646,8886,8549,8068,8682,8612,9007,8461,8888,8096,9192,9107,9001,
9344,9155,8800,8519,9282,8673),
diagdate=c(
8100,8158,8251,8343,8463,8489,8554,8644,8713,8733,8854,8855,8863,8983,
9035,9037,9132,9164,9186,9221,9224,9252,9274,9404,9405,9433,9434,9470,
9470,9472,9489,9500,9585,9649),
diffdate=c(
826,431,302,306,698,393,368,1124,191,124,330,642,408,244,1001,391,246,
615,1118,539,612,245,813,516,1309,241,327,469,126,317,689,981,303,976),
dethdate=c(
8434,8304,NA,8414,8715,NA,8667,9142,8731,8750,8963,9120,9005,9028,9445,
9180,9189,9406,9711,9453,9465,9289,9640,9608,10010,9488,9523,9633,9667,
9547,9755,NA,9686,10084),
censdate=c(
NA,NA,8321,NA,NA,8519,NA,NA,NA,NA,NA,NA,NA,NA,NA,NA,NA,NA,NA,NA,NA,NA,NA,
NA,NA,NA,NA,NA,NA,NA,NA,10095,NA,NA),
viralload=c(
13000,36000,70000,90000,21000,110000,75000,12000,125000,110000,13000,39000,79000,135000,14000,
42000,123000,20000,12000,18000,16000,140000,16000,58000,11000,120000,85000,31000,24000,115000,
17000,13100,72000,13500)
)

cdcaids <- upData(cdcaids,
 labels=c(age     ='Age, y', infedate='Date of blood transfusion',
          diagdate='Date of AIDS diagnosis',
          diffdate='Incubation period (days from HIV to AIDS)',
          dethdate='Fictitious date of death',
          censdate='Fictitious censoring date',
```

```
   viralload='Fictitious viral load'))


# Note that the style options listed with these
# examples are best suited for output to a postscript file (i.e., using
# the postscript function with horizontal=TRUE) as opposed to a graphical
# window (e.g., motif).


# To produce simple calendar event chart (with internal legend):
# postscript('example1.ps', horizontal=TRUE)
 event.chart(cdcaids,
  subset.c=c('infedate','diagdate','dethdate','censdate'),
  x.lab = 'observation dates',
  y.lab='patients (sorted by AIDS diagnosis date)',
  titl='AIDS data calendar event chart 1',
  point.pch=c(1,2,15,0), point.cex=c(1,1,0.8,0.8),
  legend.plot=TRUE, legend.location='i', legend.cex=1.0,
  legend.point.text=c('transfusion','AIDS diagnosis','death','censored'),
  legend.point.at = list(c(7210, 8100), c(35, 27)), legend.bty='o')


# To produce simple interval event chart (with internal legend):
# postscript('example2.ps', horizontal=TRUE)
 event.chart(cdcaids,
  subset.c=c('infedate','diagdate','dethdate','censdate'),
  x.lab = 'time since transfusion (in days)',
  y.lab='patients (sorted by AIDS diagnosis date)',
  titl='AIDS data interval event chart 1',
  point.pch=c(1,2,15,0), point.cex=c(1,1,0.8,0.8),
  legend.plot=TRUE, legend.location='i', legend.cex=1.0,
  legend.point.text=c('transfusion','AIDS diagnosis','death','censored'),
  x.reference='infedate', x.julian=TRUE,
  legend.bty='o', legend.point.at = list(c(1400, 1950), c(7, -1)))


# To produce simple interval event chart (with internal legend),
# but now with flexible diagdate symbol size based on viral load variable:
# postscript('example2a.ps', horizontal=TRUE)
 event.chart(cdcaids,
  subset.c=c('infedate','diagdate','dethdate','censdate'),
  x.lab = 'time since transfusion (in days)',
  y.lab='patients (sorted by AIDS diagnosis date)',
  titl='AIDS data interval event chart 1a, with viral load at diagdate represented',
  point.pch=c(1,2,15,0), point.cex=c(1,1,0.8,0.8),
 point.cex.mult = 0.00002, point.cex.mult.var = 'viralload', extra.points.no.mult = c(1,NA,1,1),
  legend.plot=TRUE, legend.location='i', legend.cex=1.0,
  legend.point.text=c('transfusion','AIDS diagnosis','death','censored'),
  x.reference='infedate', x.julian=TRUE,
  legend.bty='o', legend.point.at = list(c(1400, 1950), c(7, -1)))


# To produce more complicated interval chart which is
```

```
# referenced by infection date, and sorted by age and incubation period:
# postscript('example3.ps', horizontal=TRUE)
 event.chart(cdcaids,
  subset.c=c('infedate','diagdate','dethdate','censdate'),
  x.lab = 'time since diagnosis of AIDS (in days)',
  y.lab='patients (sorted by age and incubation length)',
  titl='AIDS data interval event chart 2 (sorted by age, incubation)',
  point.pch=c(1,2,15,0), point.cex=c(1,1,0.8,0.8),
  legend.plot=TRUE, legend.location='i',legend.cex=1.0,
  legend.point.text=c('transfusion','AIDS diagnosis','death','censored'),
  x.reference='diagdate', x.julian=TRUE, sort.by=c('age','diffdate'),
  line.by='age', line.lty=c(1,3,2,4), line.lwd=rep(1,4), line.col=rep(1,4),
  legend.bty='o', legend.point.at = list(c(-1350, -800), c(7, -1)),
  legend.line.at = list(c(-1350, -800), c(16, 8)),
  legend.line.text=c('age = 1', '       = 2', '       = 3', '       = 4'))


# To produce the Goldman chart:
# postscript('example4.ps', horizontal=TRUE)
 event.chart(cdcaids,
  subset.c=c('infedate','diagdate','dethdate','censdate'),
  x.lab = 'time since transfusion (in days)', y.lab='dates of observation',
  titl='AIDS data Goldman event chart 1',
  y.var = c('infedate'), y.var.type='d', now.line=TRUE, y.jitter=FALSE,
  point.pch=c(1,2,15,0), point.cex=c(1,1,0.8,0.8), mgp = c(3.1,1.6,0),
  legend.plot=TRUE, legend.location='i',legend.cex=1.0,
  legend.point.text=c('transfusion','AIDS diagnosis','death','censored'),
  x.reference='infedate', x.julian=TRUE,
  legend.bty='o', legend.point.at = list(c(1500, 2800), c(9300, 10000)))


# To convert coded time-to-event data, then, draw an event chart:
surv.time <- c(5,6,3,1,2)
cens.ind   <- c(1,0,1,1,0)
surv.data  <- cbind(surv.time,cens.ind)
event.data <- event.convert(surv.data)
event.chart(cbind(rep(0,5),event.data),x.julian=TRUE,x.reference=1)
```

`event.convert` *Event Conversion for Time-to-Event Data*

Description

Convert a two-column data matrix with event time and event code into multiple column event time with one event in each column

Usage

```
event.convert(data2, event.time = 1, event.code = 2)
```

Arguments

data2	a matrix or dataframe with at least 2 columns; by default, the first column contains the event time and the second column contains the k event codes (e.g. 1=dead, 0=censord)
event.time	the column number in data contains the event time
event.code	the column number in data contains the event code

Details

In the survival analysis, the data typically come in two columns: one column containing survival time and the other containing censoring indicator or event code. The event.convert function converts this type of data into multiple columns of event times, one column of each event type, suitable for the event.chart function.

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See Also

event.history, Date, event.chart

Examples

```
# To convert coded time-to-event data, then, draw an event chart:
surv.time <- c(5,6,3,1,2)
cens.ind   <- c(1,0,1,1,0)
surv.data  <- cbind(surv.time,cens.ind)
event.data <- event.convert(surv.data)
event.chart(cbind(rep(0,5),event.data),x.julian=TRUE,x.reference=1)
```

---

event.history *Produces event.history graph for survival data*

Description

Produces an event history graph for right-censored survival data, including time-dependent covariate status, as described in Dubin, Muller, and Wang (2001). Effectively, a Kaplan-Meier curve is produced with supplementary information regarding individual survival information, censoring information, and status over time of an individual time-dependent covariate or time-dependent covariate function for both uncensored and censored individuals.

Usage

```
event.history(data, survtime.col, surv.col,
              surv.ind = c(1, 0), subset.rows = NULL,
              covtime.cols = NULL, cov.cols = NULL,
              num.colors = 1, cut.cov = NULL, colors = 1,
              cens.density = 10, mult.end.cens = 1.05,
              cens.mark.right =FALSE, cens.mark = "-",
              cens.mark.ahead = 0.5, cens.mark.cutoff = -1e-08,
              cens.mark.cex = 1,
              x.lab = "time under observation",
              y.lab = "estimated survival probability",
              title = "event history graph", ...)
```

Arguments

`data`	A matrix or data frame with rows corresponding to units (often individuals) and columns corresponding to survival time, event/censoring indicator. Also, multiple columns may be devoted to time-dependent covariate level and time change.
`survtime.col`	Column (in data) representing minimum of time-to-event or right-censoring time for individual.
`surv.col`	Column (in data) representing event indicator for an individual. Though, traditionally, such an indicator will be 1 for an event and 0 for a censored observation, this indicator can be represented by any two numbers, made explicit by the surv.ind argument.
`surv.ind`	Two-element vector representing, respectively, the number for an event, as listed in `surv.col`, followed by the number for a censored observation. Default is traditional survival data represention, i.e., `c(1,0)`.
`subset.rows`	Subset of rows of original matrix or data frame (data) to place in event history graph. Logical arguments may be used here (e.g., `treatment.arm == "a"`, if the data frame, data, has been attached to the search directory;
`covtime.cols`	Column(s) (in data) representing the time when change of time-dependent covariate (or time-dependent covariate function) occurs. There should be a unique non-`NA` entry in the column for each such change (along with corresponding `cov.cols` column entry representing the value of the covariate or function at that change time). Default is `NULL`, meaning no time-dependent covariate information will be presented in the graph.
`cov.cols`	Column(s) (in data) representing the level of the time-dependent covariate (or time-dependent covariate function). There should be a unique non-`NA` column

entry representing each change in the level (along with a corresponding cov-time.cols column entry representing the time of the change). Default is NULL, meaning no time-dependent covariate information will be presented in the graph.

num.colors — Colors are utilized for the time-dependent covariate level for an individual. This argument provides the number of unique covariate levels which will be displayed by mapping the number of colors (via num.colors) to the number of desired covariate levels. This will divide the covariate span into roughly equally-sized intervals, via the S-Plus cut function. Default is one color, meaning no time-dependent information will be presented in the graph. Note that this argument will be ignored/superceded if a non-NULL argument is provided for the cut.cov parameter.

cut.cov — This argument allows the user to explicitly state how to define the intervals for the time-dependent covariate, such that different colors will be allocated to the user-defined covariate levels. For example, for plotting five colors, six ordered points within the span of the data's covariate levels should be provided. Default is NULL, meaning that the num.colors argument value will dictate the number of breakpoints, with the covariate span defined into roughly equally-sized intervals via the S-Plus cut function. However, if is.null(cut.cov) == FALSE, then this argument supercedes any entry for the num.colors argument.

colors — This is a vector argument defining the actual colors used for the time-dependent covariate levels in the plot, with the index of this vector corresponding to the ordered levels of the covariate. The number of colors (i.e., the length of the colors vector) should correspond to the value provided to the num.colors argument or the number of ordered points - 1 as defined in the cut.cov argument (with cut.cov superceding num.colors if is.null(cut.cov) == FALSE). The function, as currently written, allows for as much as twenty distinct colors. This argument effectively feeds into the col argument for the S-Plus polygon function. Default is colors = 1. See the col argument for the both the S-Plus par function and polygon function for more information.

cens.density — This will provide the shading density at the end of the individual bars for those who are censored. For more information on shading density, see the density argument in the S-Plus polygon function. Default is cens.density=10.

mult.end.cens — This is a multiplier that extends the length of the longest surviving individual bar (or bars, if a tie exists) if right-censored, presuming that no event times eventually follow this final censored time. Default extends the length 5 percent beyond the length of the observed right-censored survival time.

cens.mark.right — A logical argument that states whether an explicit mark should be placed to the right of the individual right-censored survival bars. This argument is most useful for large sample sizes, where it may be hard to detect the special shading via cens.density, particularly for the short-term survivors.

cens.mark — Character argument which describes the censored mark that should be used if cens.mark.right = TRUE. Default is "-".

cens.mark.ahead — A numeric argument, which specifies the absolute distance to be placed between the individual right-censored survival bars and the mark as defined in the above

cens.mark argument. Default is 0.5 (that is, a half of day, if survival time is measured in days), but may very well need adjusting depending on the maximum survival time observed in the dataset.

`cens.mark.cutoff`
: A negative number very close to 0 (by default `cens.mark.cutoff = -1e-8`) to ensure that the censoring marks get plotted correctly. See `event.history` code in order to see its usage. This argument typically will not need adjustment.

`cens.mark.cex`
: Numeric argument defining the size of the mark defined in the `cens.mark` argument above. See more information by viewing the `cex` argument for the S-Plus `par` function. Default is `cens.mark.cex = 1.0`.

`x.lab`
: Single label to be used for entire x-axis. Default is `"time under observation"`.

`y.lab`
: Single label to be used for entire y-axis. Default is `"estimated survival probability"`.

`title`
: Title for the event history graph. Default is `"event history graph"`.

`...`
: This allows arguments to the plot function call within the `event.history` function. So, for example, the axes representations can be manipulated with appropriate arguments, or particular areas of the `event.history` graph can be "zoomed". See the details section for more comments about zooming.

Details

In order to focus on a particular area of the event history graph, zooming can be performed. This is best done by specifying appropriate `xlim` and `ylim` arguments at the end of the `event.history` function call, taking advantage of the `...` argument link to the plot function. An example of zooming can be seen in Plate 4 of the paper referenced below.

Please read the reference below to understand how the individual covariate and survival information is provided in the plot, how ties are handled, how right-censoring is handled, etc.

WARNING

This function has been tested thoroughly, but only within a restricted version and environment, i.e., only within S-Plus 2000, Version 3, and within S-Plus 6.0, version 2, both on a Windows 2000 machine. Hence, we cannot currently vouch for the function's effectiveness in other versions of S-Plus (e.g., S-Plus 3.4) nor in other operating environments (e.g., Windows 95, Linux or Unix). The function has also been verified to work on R under Linux.

Note

The authors have found better control of the use of color by producing the graphs via the postscript plotting device in S-Plus. In fact, the provided examples utilize the postscript function. However, your past experiences may be different, and you may prefer to control color directly (to the graphsheet in Windows environment, for example). The event.history function will work with either approach.

Author(s)

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References

Dubin, J.A., Muller, H.-G., and Wang, J.-L. (2001). Event history graphs for censored survival data. *Statistics in Medicine*, **20**, 2951-2964.

See Also

plot,polygon, event.chart, par

Examples

```
# Code to produce event history graphs for SIM paper
#
# before generating plots, some pre-processing needs to be performed,
#  in order to get dataset in proper form for event.history function;
#  need to create one line per subject and sort by time under observation,
#  with those experiencing event coming before those tied with censoring time;
require('survival')
data(heart)

# creation of event.history version of heart dataset (call heart.one):

heart.one <- matrix(nrow=length(unique(heart$id)), ncol=8)
for(i in 1:length(unique(heart$id)))
 {
  if(length(heart$id[heart$id==i]) == 1)
   heart.one[i,] <- as.numeric(unlist(heart[heart$id==i, ]))
  else if(length(heart$id[heart$id==i]) == 2)
   heart.one[i,] <- as.numeric(unlist(heart[heart$id==i,][2,]))
 }

heart.one[,3][heart.one[,3] == 0] <- 2  ## converting censored events to 2, from 0
if(is.factor(heart$transplant))
 heart.one[,7] <- heart.one[,7] - 1
 ## getting back to correct transplantation coding
heart.one <- as.data.frame(heart.one[order(unlist(heart.one[,2]), unlist(heart.one[,3])),])
names(heart.one) <- names(heart)
# back to usual censoring indicator:
heart.one[,3][heart.one[,3] == 2] <- 0
# note: transplant says 0 (for no transplants) or 1 (for one transplant)
#        and event = 1 is death, while event = 0 is censored

# plot single Kaplan-Meier curve from heart data, first creating survival object
heart.surv <- survfit(Surv(stop, event) ~ 1, data=heart.one, conf.int = FALSE)

# figure 3: traditional Kaplan-Meier curve
# postscript('ehgfig3.ps', horiz=TRUE)
# omi <- par(omi=c(0,1.25,0.5,1.25))
 plot(heart.surv, ylab='estimated survival probability',
      xlab='observation time (in days)')
 title('Figure 3: Kaplan-Meier curve for Stanford data', cex=0.8)
# dev.off()
```

```
## now, draw event history graph for Stanford heart data; use as Figure 4

# postscript('ehgfig4.ps', horiz=TRUE, colors = seq(0, 1, len=20))
# par(omi=c(0,1.25,0.5,1.25))
 event.history(heart.one,
  survtime.col=heart.one[,2], surv.col=heart.one[,3],
  covtime.cols = cbind(rep(0, dim(heart.one)[1]), heart.one[,1]),
  cov.cols = cbind(rep(0, dim(heart.one)[1]), heart.one[,7]),
  num.colors=2, colors=c(6,10),
  x.lab = 'time under observation (in days)',
  title='Figure 4: Event history graph for\nStanford data',
  cens.mark.right =TRUE, cens.mark = '-',
  cens.mark.ahead = 30.0, cens.mark.cex = 0.85)
# dev.off()



# now, draw age-stratified event history graph for Stanford heart data;
#  use as Figure 5

# two plots, stratified by age status
# postscript('c:\temp\ehgfig5.ps', horiz=TRUE, colors = seq(0, 1, len=20))
# par(omi=c(0,1.25,0.5,1.25))
 par(mfrow=c(1,2))

 event.history(data=heart.one, subset.rows = (heart.one[,4] < 0),
  survtime.col=heart.one[,2], surv.col=heart.one[,3],
  covtime.cols = cbind(rep(0, dim(heart.one)[1]), heart.one[,1]),
  cov.cols = cbind(rep(0, dim(heart.one)[1]), heart.one[,7]),
  num.colors=2, colors=c(6,10),
  x.lab = 'time under observation\n(in days)',
  title = 'Figure 5a:\nStanford data\n(age < 48)',
  cens.mark.right =TRUE, cens.mark = '-',
  cens.mark.ahead = 40.0, cens.mark.cex = 0.85,
  xlim=c(0,1900))

 event.history(data=heart.one, subset.rows = (heart.one[,4] >= 0),
  survtime.col=heart.one[,2], surv.col=heart.one[,3],
  covtime.cols = cbind(rep(0, dim(heart.one)[1]), heart.one[,1]),
  cov.cols = cbind(rep(0, dim(heart.one)[1]), heart.one[,7]),
  num.colors=2, colors=c(6,10),
  x.lab = 'time under observation\n(in days)',
  title = 'Figure 5b:\nStanford data\n(age >= 48)',
  cens.mark.right =TRUE, cens.mark = '-',
  cens.mark.ahead = 40.0, cens.mark.cex = 0.85,
  xlim=c(0,1900))
# dev.off()
# par(omi=omi)

# we will not show liver cirrhosis data manipulation, as it was
#  a bit detailed; however, here is the
#  event.history code to produce Figure 7 / Plate 1
```

```
# Figure 7 / Plate 1 : prothrombin ehg with color
## Not run:
second.arg <- 1    ### second.arg is for shading
third.arg <- c(rep(1,18),0,1)  ### third.arg is for intensity

# postscript('c:\temp\ehgfig7.ps', horiz=TRUE,
# colors = cbind(seq(0, 1, len = 20), second.arg, third.arg))
# par(omi=c(0,1.25,0.5,1.25), col=19)
 event.history(cirrhos2.eh, subset.rows = NULL,
               survtime.col=cirrhos2.eh$time, surv.col=cirrhos2.eh$event,
  covtime.cols = as.matrix(cirrhos2.eh[, ((2:18)*2)]),
  cov.cols = as.matrix(cirrhos2.eh[, ((2:18)*2) + 1]),
  cut.cov =  as.numeric(quantile(as.matrix(cirrhos2.eh[, ((2:18)*2) + 1]),
    c(0,.2,.4,.6,.8,1), na.rm=TRUE) + c(-1,0,0,0,0,1)),
   colors=c(20,4,8,11,14),
  x.lab = 'time under observation (in days)',
  title='Figure 7: Event history graph for liver cirrhosis data (color)',
  cens.mark.right =TRUE, cens.mark = '-',
  cens.mark.ahead = 100.0, cens.mark.cex = 0.85)
# dev.off()

## End(Not run)
```

`extractlabs` *extractlabs*

Description

Extract Labels and Units From Multiple Datasets

Usage

```
extractlabs(..., print = TRUE)
```

Arguments

`...`	one ore more data frames or data tables
`print`	set to `FALSE` to not print details about variables with conflicting attributes

Details

For one or more data frames/tables extracts all labels and units and comb ines them over dataset, dropping any variables not having either labels or units defined. The resulting data table is returned and is used by the `hlab` function if the user stores the result in an objectnamed `LabelsUnits`. The result is `NULL` if no variable in any dataset has a non-blank `label` or `units`. Variables found in more than one dataset with duplicate `label` and `units` are consolidated. A warning message is issued when duplicate variables have conflicting labels or units, and by default, details are printed. No attempt is made to resolve these conflicts.

Value

a data table

Author(s)

Frank Harrell

See Also

label(), contents(), units(), hlab()

Examples

```
d <- data.frame(x=1:10, y=(1:10)/10)
d <- upData(d, labels=c(x='X', y='Y'), units=c(x='mmHg'), print=FALSE)
d2 <- d
units(d2$x) <- 'cm'
LabelsUnits <- extractlabs(d, d2)
LabelsUnits
```

Fdebug *Debug Printing Function Generator*

Description

Takes the name of a system options(opt=) and checks to see if option opt is set to TRUE, taking its default value to be FALSE. If TRUE, a function is created that calls prn() to print an object with the object's name in the description along with the option name and the name of the function within which the generated function was called, if any. If option opt is not set, a dummy function is generated instead. If options(debug_file=) is set when the generated function is called, prn() output will be appended to that file name instead of the console. At any time, set options(debug_file='') to resume printing to the console.

Usage

```
Fdebug(opt)
```

Arguments

opt	character string containing an option name

Value

a function

Author(s)

Fran Harrell

Examples

```
dfun <- Fdebug('my_option_name')   # my_option_name not currently set
dfun
dfun(sqrt(2))
options(my_option_name=TRUE)
dfun <- Fdebug('my_option_name')
dfun
dfun(sqrt(2))
# options(debug_file='/tmp/z') to append output to /tmp/z
options(my_option_name=NULL)
```

`fImport` *fImport*

Description

General File Import Using `rio`

Usage

```
fImport(
  file,
  format,
  lowernames = c("not mixed", "no", "yes"),
  und. = FALSE,
  ...
)
```

Arguments

`file`	name of file to import, or full URL. `rio` determines the file type from the file suffix unless you override this with `format`
`format`	format of file to import, usually not needed. See `rio::import()` for details
`lowernames`	defaults to changing variable names to all lower case unless the name as mixed upper and lower case, which results in keeping the original characters in the name. Set `lowernames='no'` to leave variable names as they were created in the original file export, or set `lowernames='yes'` to set all names to lower case whether they have mixed case or not. For all options, a check is made to see if the name conversions would result in any duplicate names. If so, the original names are retained and a warning message issued.
`und.`	set to `TRUE` to change all underscores in names to periods
`...`	more arguments to pass to `rio::import()`

Details

This is a front-end for the rio package's import function. fImport includes options for setting variable names to lower case and to change underscores in names to periods. Variables on the imported data frame that have labels are converted to Hmisc package labelled class so that subsetting the data frame will preserve the labels.

Value

a data frame created by rio, unless a rio option is given to use another format

Author(s)

Frank Harrell

See Also

upData, especially the moveUnits option

Examples

```
## Not run:
# Get a Stata dataset
d <- fImport('http://www.principlesofeconometrics.com/stata/alcohol.dta')
contents(d)

## End(Not run)
```

---

find.matches *Find Close Matches*

Description

Compares each row in x against all the rows in y, finding rows in y with all columns within a tolerance of the values a given row of x. The default tolerance tol is zero, i.e., an exact match is required on all columns. For qualifying matches, a distance measure is computed. This is the sum of squares of differences between x and y after scaling the columns. The default scaling values are tol, and for columns with tol=1 the scale values are set to 1.0 (since they are ignored anyway). Matches (up to maxmatch of them) are stored and listed in order of increasing distance.

The summary method prints a frequency distribution of the number of matches per observation in x, the median of the minimum distances for all matches per x, as a function of the number of matches, and the frequency of selection of duplicate observations as those having the smallest distance. The print method prints the entire matches and distance components of the result from find.matches.

matchCases finds all controls that match cases on a single variable x within a tolerance of tol. This is intended for prospective cohort studies that use matching for confounder adjustment (even though regression models usually work better).

Usage

```
find.matches(x, y, tol=rep(0, ncol(y)), scale=tol, maxmatch=10)
## S3 method for class 'find.matches'
summary(object, ...)
## S3 method for class 'find.matches'
print(x, digits, ...)

matchCases(xcase,    ycase,    idcase=names(ycase),
           xcontrol, ycontrol, idcontrol=names(ycontrol),
           tol=NULL,
           maxobs=max(length(ycase),length(ycontrol))*10,
           maxmatch=20, which=c('closest','random'))
```

Arguments

x	a numeric matrix or the result of find.matches
y	a numeric matrix with same number of columns as x
xcase	numeric vector to match on for cases
xcontrol	numeric vector to match on for controls, not necessarily the same length as xcase
ycase	a vector or matrix
ycontrol	ycase and ycontrol are vectors or matrices, not necessarily having the same number of rows, specifying a variable to carry along from cases and matching controls. If you instead want to carry along rows from a data frame, let ycase and ycontrol be non-overlapping integer subscripts of the donor data frame.
tol	a vector of tolerances with number of elements the same as the number of columns of y, for find.matches. For matchCases is a scalar tolerance.
scale	a vector of scaling constants with number of elements the same as the number of columns of y.
maxmatch	maximum number of matches to allow. For matchCases, maximum number of controls to match with a case (default is 20). If more than maxmatch matching controls are available, a random sample without replacement of maxmatch controls is used (if which="random").
object	an object created by find.matches
digits	number of digits to use in printing distances
idcase	vector the same length as xcase
idcontrol	idcase and idcontrol are vectors the same length as xcase and xcontrol respectively, specifying the id of cases and controls. Defaults are integers specifying original element positions within each of cases and controls.
maxobs	maximum number of cases and all matching controls combined (maximum dimension of data frame resulting from matchControls). Default is ten times the maximum of the number of cases and number of controls. maxobs is used to allocate space for the resulting data frame.

which	set to "closest" (the default) to match cases with up to maxmatch controls that most closely match on x. Set which="random" to use randomly chosen controls. In either case, only those controls within tol on x are allowed to be used.
...	unused

Value

find.matches returns a list of class find.matches with elements matches and distance. Both elements are matrices with the number of rows equal to the number of rows in x, and with k columns, where k is the maximum number of matches (<= maxmatch) that occurred. The elements of matches are row identifiers of y that match, with zeros if fewer than maxmatch matches are found (blanks if y had row names). matchCases returns a data frame with variables idcase (id of case currently being matched), type (factor variable with levels "case" and "control"), id (id of case if case row, or id of matching case), and y.

Author(s)

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References

Ming K, Rosenbaum PR (2001): A note on optimal matching with variable controls using the assignment algorithm. J Comp Graph Stat 10:455–463.

Cepeda MS, Boston R, Farrar JT, Strom BL (2003): Optimal matching with a variable number of controls vs. a fixed number of controls for a cohort study: trade-offs. J Clin Epidemiology 56:230-237. Note: These papers were not used for the functions here but probably should have been.

See Also

scale, apply

Examples

```
y <- rbind(c(.1, .2),c(.11, .22), c(.3, .4), c(.31, .41), c(.32, 5))
x <- rbind(c(.09,.21), c(.29,.39))
y
x
w <- find.matches(x, y, maxmatch=5, tol=c(.05,.05))


set.seed(111)       # so can replicate results
x <- matrix(runif(500), ncol=2)
y <- matrix(runif(2000), ncol=2)
w <- find.matches(x, y, maxmatch=5, tol=c(.02,.03))
w$matches[1:5,]
w$distance[1:5,]
# Find first x with 3 or more y-matches
```

```
num.match <- apply(w$matches, 1, function(x)sum(x > 0))
j <- ((1:length(num.match))[num.match > 2])[1]
x[j,]
y[w$matches[j,],]


summary(w)


# For many applications would do something like this:
# attach(df1)
# x <- cbind(age, sex) # Just do as.matrix(df1) if df1 has no factor objects
# attach(df2)
# y <- cbind(age, sex)
# mat <- find.matches(x, y, tol=c(5,0)) # exact match on sex, 5y on age


# Demonstrate matchCases
xcase     <- c(1,3,5,12)
xcontrol  <- 1:6
idcase    <- c('A','B','C','D')
idcontrol <- c('a','b','c','d','e','f')
ycase     <- c(11,33,55,122)
ycontrol  <- c(11,22,33,44,55,66)
matchCases(xcase, ycase, idcase,
           xcontrol, ycontrol, idcontrol, tol=1)


# If y is a binary response variable, the following code
# will produce a Mantel-Haenszel summary odds ratio that
# utilizes the matching.
# Standard variance formula will not work here because
# a control will match more than one case
# WARNING: The M-H procedure exemplified here is suspect
# because of the small strata and widely varying number
# of controls per case.


x    <- c(1, 2, 3, 3, 3, 6, 7, 12,  1, 1:7)
y    <- c(0, 0, 0, 1, 0, 1, 1,  1,  1, 0, 0, 0, 0, 1, 1, 1)
case <- c(rep(TRUE, 8), rep(FALSE, 8))
id   <- 1:length(x)


m <- matchCases(x[case],  y[case],  id[case],
                x[!case], y[!case], id[!case], tol=1)
iscase <- m$type=='case'
# Note: the first tapply on insures that event indicators are
# sorted by case id.  The second actually does something.
event.case    <- tapply(m$y[iscase],  m$idcase[iscase],  sum)
event.control <- tapply(m$y[!iscase], m$idcase[!iscase], sum)
n.control     <- tapply(!iscase,      m$idcase,          sum)
n             <- tapply(m$y,          m$idcase,          length)
```

```
or <- sum(event.case * (n.control - event.control) / n) /
      sum(event.control * (1 - event.case) / n)
or


# Bootstrap this estimator by sampling with replacement from
# subjects.  Assumes id is unique when combine cases+controls
# (id was constructed this way above).  The following algorithms
# puts all sampled controls back with the cases to whom they were
# originally matched.


ids <- unique(m$id)
idgroups <- split(1:nrow(m), m$id)
B   <- 50   # in practice use many more
ors <- numeric(B)
# Function to order w by ids, leaving unassigned elements zero
align <- function(ids, w) {
  z <- structure(rep(0, length(ids)), names=ids)
  z[names(w)] <- w
  z
}
for(i in 1:B) {
  j <- sample(ids, replace=TRUE)
  obs <- unlist(idgroups[j])
  u <- m[obs,]
  iscase <- u$type=='case'
  n.case <- align(ids, tapply(u$type, u$idcase,
                              function(v)sum(v=='case')))
  n.control <- align(ids, tapply(u$type, u$idcase,
                                 function(v)sum(v=='control')))
  event.case <- align(ids, tapply(u$y[iscase],  u$idcase[iscase],  sum))
  event.control <- align(ids, tapply(u$y[!iscase], u$idcase[!iscase], sum))
  n <- n.case + n.control
  # Remove sets having 0 cases or 0 controls in resample
  s             <- n.case > 0 & n.control > 0
  denom <- sum(event.control[s] * (n.case[s] - event.case[s]) / n[s])
  or <- if(denom==0) NA else
   sum(event.case[s] * (n.control[s] - event.control[s]) / n[s]) / denom
  ors[i] <- or
}
describe(ors)
```

`first.word` *First Word in a String or Expression*

Description

`first.word` finds the first word in an expression. A word is defined by unlisting the elements of the expression found by the S parser and then accepting any elements whose first character is either a

letter or period. The principal intended use is for the automatic generation of temporary file names where it is important to exclude special characters from the file name. For Microsoft Windows, periods in names are deleted and only up to the first 8 characters of the word is returned.

Usage

```
first.word(x, i=1, expr=substitute(x))
```

Arguments

x	any scalar character string
i	word number, default value = 1. Used when the second or ith word is wanted. Currently only the i=1 case is implemented.
expr	any S object of mode expression.

Value

a character string

Author(s)

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Examples

```
first.word(expr=expression(y ~ x + log(w)))
```

---

format.df *Format a Data Frame or Matrix for LaTeX or HTML*

Description

format.df does appropriate rounding and decimal alignment, and outputs a character matrix containing the formatted data. If x is a data.frame, then do each component separately. If x is a matrix, but not a data.frame, make it a data.frame with individual components for the columns. If a component x$x is a matrix, then do all columns the same.

Usage

```
format.df(x, digits, dec=NULL, rdec=NULL, cdec=NULL,
          numeric.dollar=!dcolumn, na.blank=FALSE, na.dot=FALSE,
          blank.dot=FALSE, col.just=NULL, cdot=FALSE,
          dcolumn=FALSE, matrix.sep=' ', scientific=c(-4,4),
          math.row.names=FALSE, already.math.row.names=FALSE,
          math.col.names=FALSE, already.math.col.names=FALSE,
          double.slash=FALSE, format.Date="%m/%d/%Y",
          format.POSIXt="%m/%d/%Y %H:%M:%OS", ...)
```

Arguments

x	a matrix (usually numeric) or data frame
digits	causes all values in the table to be formatted to digits significant digits. dec is usually preferred.
dec	If dec is a scalar, all elements of the matrix will be rounded to dec decimal places to the right of the decimal. dec can also be a matrix whose elements correspond to x, for customized rounding of each element. A matrix dec must have number of columns equal to number of columns of input x. A scalar dec is expanded to a vector cdec with number of items equal to number of columns of input x.
rdec	a vector specifying the number of decimal places to the right for each row (cdec is more commonly used than rdec) A vector rdec must have number of items equal to number of rows of input x. rdec is expanded to matrix dec.
cdec	a vector specifying the number of decimal places for each column. The vector must have number of items equal to number of columns or components of input x.
cdot	Set to TRUE to use centered dots rather than ordinary periods in numbers. The output uses a syntax appropriate for latex.
na.blank	Set to TRUE to use blanks rather than NA for missing values. This usually looks better in latex.
dcolumn	Set to TRUE to use David Carlisle's dcolumn style for decimal alignment in latex. Default is FALSE. You will probably want to use dcolumn if you use rdec, as a column may then contain varying number of places to the right of the decimal. dcolumn can line up all such numbers on the decimal point, with integer values right justified at the decimal point location of numbers that actually contain decimal places. When you use dcolumn = TRUE, numeric.dollar is set by default to FALSE. When you use dcolumn = TRUE, the object attribute "style" set to 'dcolumn' as the latex usepackage must reference [dcolumn]. The three files 'dcolumn.sty', 'newarray.sty', and 'array.sty' will need to be in a directory in your TEXINPUTS path. When you use dcolumn=TRUE, numeric.dollar should be set to FALSE.
numeric.dollar	logical, default !dcolumn. Set to TRUE to place dollar signs around numeric values when dcolumn = FALSE. This assures that latex will use minus signs rather than hyphens to indicate negative numbers. Set to FALSE when dcolumn = TRUE, as dcolumn.sty automatically uses minus signs.

math.row.names	logical, set true to place dollar signs around the row names.
already.math.row.names	set to TRUE to prevent any math mode changes to row names
math.col.names	logical, set true to place dollar signs around the column names.
already.math.col.names	set to TRUE to prevent any math mode changes to column names
na.dot	Set to TRUE to use periods rather than NA for missing numeric values. This works with the SAS convention that periods indicate missing values.
blank.dot	Set to TRUE to use periods rather than blanks for missing character values. This works with the SAS convention that periods indicate missing values.
col.just	Input vector col.just must have number of columns equal to number of columns of the output matrix. When NULL, the default, the col.just attribute of the result is set to 'l' for character columns and to 'r' for numeric columns. The user can override the default by an argument vector whose length is equal to the number of columns of the result matrix. When format.df is called by latex.default, the col.just is used as the cols argument to the tabular environment and the letters 'l', 'r', and 'c' are valid values. When format.df is called by SAS, the col.just is used to determine whether a '\$' is needed on the 'input' line of the 'sysin' file, and the letters 'l' and 'r' are valid values. You can pass specifications other than l,r,c in col.just, e.g., "p{3in}" to get paragraph-formatted columns from latex().
matrix.sep	When x is a data frame containing a matrix, so that new column names are constructed from the name of the matrix object and the names of the individual columns of the matrix, matrix.sep specifies the character to use to separate object names from individual column names.
scientific	specifies ranges of exponents (or a logical vector) specifying values not to convert to scientific notation. See format.default for details.
double.slash	should escaping backslashes be themselves escaped.
format.Date	String used to format objects of the Date class.
format.POSIXt	String used to format objects of the POSIXt class.
...	other arguments are accepted and passed to format.default. For latexVerbatim these arguments are passed to the print function.

Value

a character matrix with character images of properly rounded x. Matrix components of input x are now just sets of columns of character matrix. Object attribute"col.just" repeats the value of the argument col.just when provided, otherwise, it includes the recommended justification for columns of output. See the discussion of the argument col.just. The default justification is 'l' for characters and factors, 'r' for numeric. When dcolumn==TRUE, numerics will have '.' as the justification character.

Author(s)

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See Also

latex

Examples

```
## Not run:
x <- data.frame(a=1:2, b=3:4)
x$m <- 10000*matrix(5:8,nrow=2)
names(x)
dim(x)
x
format.df(x, big.mark=",")
dim(format.df(x))

## End(Not run)
```

---

format.pval *Format P Values*

Description

format.pval is intended for formatting p-values.

Usage

```
format.pval(x, pv=x, digits = max(1, .Options$digits - 2),
            eps = .Machine$double.eps, na.form = "NA", ...)
```

Arguments

pv	a numeric vector.
x	argument for method compliance.
digits	how many significant digits are to be used.
eps	a numerical tolerance: see Details.
na.form	character representation of NAs.
...	arguments passed to format in the format.pval function body.

Details

format.pval is mainly an auxiliary function for print.summary.lm etc., and does separate formatting for fixed, floating point and very small values; those less than eps are formatted as "'< [eps]"' (where "'[eps]"' stands for format(eps, digits)).

Value

A character vector.

Note

This is the base format.pval function with the ablitiy to pass the nsmall argument to format

Examples

```
format.pval(c(runif(5), pi^-100, NA))
format.pval(c(0.1, 0.0001, 1e-27))
format.pval(c(0.1, 1e-27), nsmall=3)
```

---

gbayes *Gaussian Bayesian Posterior and Predictive Distributions*

Description

gbayes derives the (Gaussian) posterior and optionally the predictive distribution when both the prior and the likelihood are Gaussian, and when the statistic of interest comes from a 2-sample problem. This function is especially useful in obtaining the expected power of a statistical test, averaging over the distribution of the population effect parameter (e.g., log hazard ratio) that is obtained using pilot data. gbayes is also useful for summarizing studies for which the statistic of interest is approximately Gaussian with known variance. An example is given for comparing two proportions using the angular transformation, for which the variance is independent of unknown parameters except for very extreme probabilities. A plot method is also given. This plots the prior, posterior, and predictive distributions on a single graph using a nice default for the x-axis limits and using the labcurve function for automatic labeling of the curves.

gbayes2 uses the method of Spiegelhalter and Freedman (1986) to compute the probability of correctly concluding that a new treatment is superior to a control. By this we mean that a 1-alpha normal theory-based confidence interval for the new minus old treatment effect lies wholly to the right of delta.w, where delta.w is the minimally worthwhile treatment effect (which can be zero to be consistent with ordinary null hypothesis testing, a method not always making sense). This kind of power function is averaged over a prior distribution for the unknown treatment effect. This procedure is applicable to the situation where a prior distribution is not to be used in constructing the test statistic or confidence interval, but is only used for specifying the distribution of delta, the parameter of interest.

Even though gbayes2 assumes that the test statistic has a normal distribution with known variance (which is strongly a function of the sample size in the two treatment groups), the prior distribution function can be completely general. Instead of using a step-function for the prior distribution as

Spiegelhalter and Freedman used in their appendix, gbayes2 uses the built-in integrate function for numerical integration. gbayes2 also allows the variance of the test statistic to be general as long as it is evaluated by the user. The conditional power given the parameter of interest delta is 1 - pnorm((delta.w - delta)/sd + z), where z is the normal critical value corresponding to 1 - alpha/2.

gbayesMixPredNoData derives the predictive distribution of a statistic that is Gaussian given delta when no data have yet been observed and when the prior is a mixture of two Gaussians.

gbayesMixPost derives the posterior density, cdf, or posterior mean of delta given the statistic x, when the prior for delta is a mixture of two Gaussians and when x is Gaussian given delta.

gbayesMixPowerNP computes the power for a test for delta > delta.w for the case where (1) a Gaussian prior or mixture of two Gaussian priors is used as the prior distribution, (2) this prior is used in forming the statistical test or credible interval, (3) no prior is used for the distribution of delta for computing power but instead a fixed single delta is given (as in traditional frequentist hypothesis tests), and (4) the test statistic has a Gaussian likelihood with known variance (and mean equal to the specified delta). gbayesMixPowerNP is handy where you want to use an earlier study in testing for treatment effects in a new study, but you want to mix with this prior a non-informative prior. The mixing probability mix can be thought of as the "applicability" of the previous study. As with gbayes2, power here means the probability that the new study will yield a left credible interval that is to the right of delta.w. gbayes1PowerNP is a special case of gbayesMixPowerNP when the prior is a single Gaussian.

Usage

```
gbayes(mean.prior, var.prior, m1, m2, stat, var.stat,
       n1, n2, cut.prior, cut.prob.prior=0.025)

## S3 method for class 'gbayes'
plot(x, xlim, ylim, name.stat='z', ...)

gbayes2(sd, prior, delta.w=0, alpha=0.05, upper=Inf, prior.aux)

gbayesMixPredNoData(mix=NA, d0=NA, v0=NA, d1=NA, v1=NA,
                    what=c('density','cdf'))

gbayesMixPost(x=NA, v=NA, mix=1, d0=NA, v0=NA, d1=NA, v1=NA,
              what=c('density','cdf','postmean'))

gbayesMixPowerNP(pcdf, delta, v, delta.w=0, mix, interval,
                 nsim=0, alpha=0.05)

gbayes1PowerNP(d0, v0, delta, v, delta.w=0, alpha=0.05)
```

Arguments

mean.prior	mean of the prior distribution
cut.prior, cut.prob.prior, var.prior	variance of the prior. Use a large number such as 10000 to effectively use a flat (noninformative) prior. Sometimes it is useful to compute the variance so that

	the prior probability that stat is greater than some impressive value u is only alpha. The correct var.prior to use is then ((u-mean.prior)/qnorm(1-alpha))^2. You can specify cut.prior=u and cut.prob.prior=alpha (whose default is 0.025) in place of var.prior to have gbayes compute the prior variance in this manner.
m1	sample size in group 1
m2	sample size in group 2
stat	statistic comparing groups 1 and 2, e.g., log hazard ratio, difference in means, difference in angular transformations of proportions
var.stat	variance of stat, assumed to be known. var.stat should either be a constant (allowed if n1 is not specified), or a function of two arguments which specify the sample sizes in groups 1 and 2. Calculations will be approximate when the variance is estimated from the data.
x	an object returned by gbayes or the value of the statistic which is an estimator of delta, the parameter of interest
sd	the standard deviation of the treatment effect
prior	a function of possibly a vector of unknown treatment effects, returning the prior density at those values
pcdf	a function computing the posterior CDF of the treatment effect delta, such as a function created by gbayesMixPost with what="cdf".
delta	a true unknown single treatment effect to detect
v	the variance of the statistic x, e.g., s^2 * (1/n1 + 1/n2). Neither x nor v need to be defined to gbayesMixPost, as they can be defined at run time to the function created by gbayesMixPost.
n1	number of future observations in group 1, for obtaining a predictive distribution
n2	number of future observations in group 2
xlim	vector of 2 x-axis limits. Default is the mean of the posterior plus or minus 6 standard deviations of the posterior.
ylim	vector of 2 y-axis limits. Default is the range over combined prior and posterior densities.
name.stat	label for x-axis. Default is "z".
...	optional arguments passed to labcurve from plot.gbayes
delta.w	the minimum worthwhile treatment difference to detech. The default is zero for a plain uninteristing null hypothesis.
alpha	type I error, or more accurately one minus the confidence level for a two-sided confidence limit for the treatment effect
upper	upper limit of integration over the prior distribution multiplied by the normal likelihood for the treatment effect statistic. Default is infinity.
prior.aux	argument to pass to prior from integrate through gbayes2. Inside of power the argument must be named prior.aux if it exists. You can pass multiple parameters by passing prior.aux as a list and pulling off elements of the list inside prior. This setup was used because of difficulties in passing ... arguments through integrate for some situations.

mix	mixing probability or weight for the Gaussian prior having mean d0 and variance v0. mix must be between 0 and 1, inclusive.
d0	mean of the first Gaussian distribution (only Gaussian for gbayes1PowerNP and is a required argument)
v0	variance of the first Gaussian (only Gaussian for gbayes1PowerNP and is a required argument)
d1	mean of the second Gaussian (if mix < 1)
v1	variance of the second Gaussian (if mix < 1). Any of these last 5 arguments can be omitted to gbayesMixPredNoData as they can be provided at run time to the function created by gbayesMixPredNoData.
what	specifies whether the predictive density or the CDF is to be computed. Default is "density".
interval	a 2-vector containing the lower and upper limit for possible values of the test statistic x that would result in a left credible interval exceeding delta.w with probability 1-alpha/2
nsim	defaults to zero, causing gbayesMixPowerNP to solve numerically for the critical value of x, then to compute the power accordingly. Specify a nonzero number such as 20000 for nsim to instead have the function estimate power by simulation. In this case 0.95 confidence limits on the estimated power are also computed. This approach is sometimes necessary if uniroot can't solve the equation for the critical value.

Value

gbayes returns a list of class "gbayes" containing the following names elements: mean.prior,var.prior,mean.post, var.post, and if n1 is specified, mean.pred and var.pred. Note that mean.pred is identical to mean.post. gbayes2 returns a single number which is the probability of correctly rejecting the null hypothesis in favor of the new treatment. gbayesMixPredNoData returns a function that can be used to evaluate the predictive density or cumulative distribution. gbayesMixPost returns a function that can be used to evaluate the posterior density or cdf. gbayesMixPowerNP returns a vector containing two values if nsim = 0. The first value is the critical value for the test statistic that will make the left credible interval > delta.w, and the second value is the power. If nsim > 0, it returns the power estimate and confidence limits for it if nsim > 0. The examples show how to use these functions.

Author(s)

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References

Spiegelhalter DJ, Freedman LS, Parmar MKB (1994): Bayesian approaches to randomized trials. JRSS A 157:357–416. Results for gbayes are derived from Equations 1, 2, 3, and 6.

Spiegelhalter DJ, Freedman LS (1986): A predictive approach to selecting the size of a clinical trial, based on subjective clinical opinion. Stat in Med 5:1–13.

Joseph, Lawrence and Belisle, Patrick (1997): Bayesian sample size determination for normal means and differences between normal means. The Statistician 46:209–226.

Grouin, JM, Coste M, Bunouf P, Lecoutre B (2007): Bayesian sample size determination in non-sequential clinical trials: Statistical aspects and some regulatory considerations. Stat in Med 26:4914–4924.

See Also

gbayesSeqSim

Examples

```
# Compare 2 proportions using the var stabilizing transformation
# arcsin(sqrt((x+3/8)/(n+3/4))) (Anscombe), which has variance
# 1/[4(n+.5)]


m1 <- 100;     m2 <- 150
deaths1 <- 10; deaths2 <- 30


f <- function(events,n) asin(sqrt((events+3/8)/(n+3/4)))
stat <- f(deaths1,m1) - f(deaths2,m2)
var.stat <- function(m1, m2) 1/4/(m1+.5) + 1/4/(m2+.5)
cat("Test statistic:",format(stat),"  s.d.:",
    format(sqrt(var.stat(m1,m2))), "\n")
#Use unbiased prior with variance 1000 (almost flat)
b <- gbayes(0, 1000, m1, m2, stat, var.stat, 2*m1, 2*m2)
print(b)
plot(b)
#To get posterior Prob[parameter > w] use
# 1-pnorm(w, b$mean.post, sqrt(b$var.post))


#If g(effect, n1, n2) is the power function to
#detect an effect of 'effect' with samples size for groups 1 and 2
#of n1,n2, estimate the expected power by getting 1000 random
#draws from the posterior distribution, computing power for
#each value of the population effect, and averaging the 1000 powers
#This code assumes that g will accept vector-valued 'effect'
#For the 2-sample proportion problem just addressed, 'effect'
#could be taken approximately as the change in the arcsin of
#the square root of the probability of the event


g <- function(effect, n1, n2, alpha=.05) {
  sd <- sqrt(var.stat(n1,n2))
  z <- qnorm(1 - alpha/2)
  effect <- abs(effect)
  1 - pnorm(z - effect/sd) + pnorm(-z - effect/sd)
}
```

```
effects <- rnorm(1000, b$mean.post, sqrt(b$var.post))
powers <- g(effects, 500, 500)
hist(powers, nclass=35, xlab='Power')
describe(powers)



# gbayes2 examples
# First consider a study with a binary response where the
# sample size is n1=500 in the new treatment arm and n2=300
# in the control arm.  The parameter of interest is the
# treated:control log odds ratio, which has variance
# 1/[n1 p1 (1-p1)] + 1/[n2 p2 (1-p2)].  This is not
# really constant so we average the variance over plausible
# values of the probabilities of response p1 and p2.  We
# think that these are between .4 and .6 and we take a
# further short cut


v <- function(n1, n2, p1, p2) 1/(n1*p1*(1-p1)) + 1/(n2*p2*(1-p2))
n1 <- 500; n2 <- 300
ps <- seq(.4, .6, length=100)
vguess <- quantile(v(n1, n2, ps, ps), .75)
vguess
#        75%
# 0.02183459


# The minimally interesting treatment effect is an odds ratio
# of 1.1.  The prior distribution on the log odds ratio is
# a 50:50 mixture of a vague Gaussian (mean 0, sd 100) and
# an informative prior from a previous study (mean 1, sd 1)


prior <- function(delta)
  0.5*dnorm(delta, 0, 100)+0.5*dnorm(delta, 1, 1)
deltas <- seq(-5, 5, length=150)
plot(deltas, prior(deltas), type='l')


# Now compute the power, averaged over this prior
gbayes2(sqrt(vguess), prior, log(1.1))
# [1] 0.6133338


# See how much power is lost by ignoring the previous
# study completely


gbayes2(sqrt(vguess), function(delta)dnorm(delta, 0, 100), log(1.1))
# [1] 0.4984588
```

```
# What happens to the power if we really don't believe the treatment
# is very effective?  Let's use a prior distribution for the log
# odds ratio that is uniform between log(1.2) and log(1.3).
# Also check the power against a true null hypothesis


prior2 <- function(delta) dunif(delta, log(1.2), log(1.3))
gbayes2(sqrt(vguess), prior2, log(1.1))
# [1] 0.1385113


gbayes2(sqrt(vguess), prior2, 0)
# [1] 0.3264065


# Compare this with the power of a two-sample binomial test to
# detect an odds ratio of 1.25
bpower(.5, odds.ratio=1.25, n1=500, n2=300)
#     Power
# 0.3307486


# For the original prior, consider a new study with equal
# sample sizes n in the two arms.  Solve for n to get a
# power of 0.9.  For the variance of the log odds ratio
# assume a common p in the center of a range of suspected
# probabilities of response, 0.3.  For this example we
# use a zero null value and the uniform prior above


v   <- function(n) 2/(n*.3*.7)
pow <- function(n) gbayes2(sqrt(v(n)), prior2)
uniroot(function(n) pow(n)-0.9, c(50,10000))$root
# [1] 2119.675
# Check this value
pow(2119.675)
# [1] 0.9


# Get the posterior density when there is a mixture of two priors,
# with mixing probability 0.5.  The first prior is almost
# non-informative (normal with mean 0 and variance 10000) and the
# second has mean 2 and variance 0.3.  The test statistic has a value
# of 3 with variance 0.4.
f <- gbayesMixPost(3, 4, mix=0.5, d0=0, v0=10000, d1=2, v1=0.3)


args(f)


# Plot this density
```

```
delta <- seq(-2, 6, length=150)
plot(delta, f(delta), type='l')


# Add to the plot the posterior density that used only
# the almost non-informative prior
lines(delta, f(delta, mix=1), lty=2)


# The same but for an observed statistic of zero
lines(delta, f(delta, mix=1, x=0), lty=3)


# Derive the CDF instead of the density
g <- gbayesMixPost(3, 4, mix=0.5, d0=0, v0=10000, d1=2, v1=0.3,
                   what='cdf')
# Had mix=0 or 1, gbayes1PowerNP could have been used instead
# of gbayesMixPowerNP below


# Compute the power to detect an effect of delta=1 if the variance
# of the test statistic is 0.2
gbayesMixPowerNP(g, 1, 0.2, interval=c(-10,12))


# Do the same thing by simulation
gbayesMixPowerNP(g, 1, 0.2, interval=c(-10,12), nsim=20000)


# Compute by what factor the sample size needs to be larger
# (the variance needs to be smaller) so that the power is 0.9
ratios <- seq(1, 4, length=50)
pow <- single(50)
for(i in 1:50)
  pow[i] <- gbayesMixPowerNP(g, 1, 0.2/ratios[i], interval=c(-10,12))[2]


# Solve for ratio using reverse linear interpolation
approx(pow, ratios, xout=0.9)$y


# Check this by computing power
gbayesMixPowerNP(g, 1, 0.2/2.1, interval=c(-10,12))
# So the study will have to be 2.1 times as large as earlier thought
```

---

gbayesSeqSim *gbayesSeqSim*

Description

Simulate Bayesian Sequential Treatment Comparisons Using a Gaussian Model

Usage

```
gbayesSeqSim(est, asserts)
```

Arguments

est	data frame created by estSeqSim()
asserts	list of lists. The first element of each list is the user-specified name for each assertion/prior combination, e.g., "efficacy". The other elements are, in order, a character string equal to "<", ">", or "in", a parameter value cutoff (for "<" and ">") or a 2-vector specifying an interval for "in", and either a prior distribution mean and standard deviation named mu and sigma respectively, or a parameter value ("cutprior") and tail area "tailprob". If the latter is used, mu is assumed to be zero and sigma is solved for such that P(parameter > 'cutprior') = P(parameter < - 'cutprior') = tailprob.

Details

Simulate a sequential trial under a Gaussian model for parameter estimates, and Gaussian priors using simulated estimates and variances returned by estSeqSim. For each row of the data frame est and for each prior/assertion combination, computes the posterior probability of the assertion.

Value

a data frame with number of rows equal to that of est with a number of new columns equal to the number of assertions added. The new columns are named p1, p2, p3, ... (posterior probabilities), mean1, mean2, ... (posterior means), and sd1, sd2, ... (posterior standard deviations). The returned data frame also has an attribute asserts added which is the original asserts augmented with any derived mu and sigma and converted to a data frame, and another attribute alabels which is a named vector used to map p1, p2, ... to the user-provided labels in asserts.

Author(s)

Frank Harrell

See Also

gbayes(), estSeqSim(), simMarkovOrd(), estSeqMarkovOrd()

Examples

```
## Not run:
# Simulate Bayesian operating characteristics for an unadjusted
# proportional odds comparison (Wilcoxon test)
# For 100 simulations, 5 looks, 2 true parameter values, and
# 2 assertion/prior combinations, compute the posterior probability
# Use a low-level logistic regression call to speed up simuluations
# Use data.table to compute various summary measures
# Total simulation time: 2s
lfit <- function(x, y) {
f <- rms::lrm.fit(x, y)
```

```
  k <- length(coef(f))
  c(coef(f)[k], vcov(f)[k, k])
}
gdat <- function(beta, n1, n2) {
  # Cell probabilities for a 7-category ordinal outcome for the control group
  p <- c(2, 1, 2, 7, 8, 38, 42) / 100

  # Compute cell probabilities for the treated group
  p2 <- pomodm(p=p, odds.ratio=exp(beta))
  y1 <- sample(1 : 7, n1, p,  replace=TRUE)
  y2 <- sample(1 : 7, n2, p2, replace=TRUE)
  list(y1=y1, y2=y2)
}

# Assertion 1: log(OR) < 0 under prior with prior mean 0.1 and sigma 1 on log OR scale
# Assertion 2: OR between 0.9 and 1/0.9 with prior mean 0 and sigma computed so that
# P(OR > 2) = 0.05
asserts <- list(list('Efficacy', '<', 0, mu=0.1, sigma=1),
                list('Similarity', 'in', log(c(0.9, 1/0.9)),
                     cutprior=log(2), tailprob=0.05))

set.seed(1)
est <- estSeqSim(c(0, log(0.7)), looks=c(50, 75, 95, 100, 200),
                   gendat=gdat,
                   fitter=lfit, nsim=100)
z <- gbayesSeqSim(est, asserts)
head(z)
attr(z, 'asserts')

# Compute the proportion of simulations that hit targets (different target posterior
# probabilities for efficacy vs. similarity)

# For the efficacy assessment compute the first look at which the target
# was hit (set to infinity if never hit)
require(data.table)
z <- data.table(z)
u <- z[, .(first=min(p1 > 0.95)), by=.(parameter, sim)]
# Compute the proportion of simulations that ever hit the target and
# that hit it by the 100th subject
u[, .(ever=mean(first < Inf)),  by=.(parameter)]
u[, .(by75=mean(first <= 100)), by=.(parameter)]

## End(Not run)
```

`geom_stepconfint` *Step function confidence intervals for ggplot2*

Description

Produces a step function confidence interval for survival curves. This function is taken from the `utile.visuals` package by Eric Finnesgard. That package is not used because of its strong depen-

dencies.

Usage

```
geom_stepconfint(
  mapping = NULL,
  data = NULL,
  stat = "identity",
  position = "identity",
  na.rm = FALSE,
  ...
)
```

Arguments

mapping	Aesthetic mappings with aes() function. Like geom_ribbon(), you must provide columns for x, ymin (lower limit), ymax (upper limit).
data	The data to be displayed in this layer. Can inherit from ggplot parent.
stat	The statistical transformation to use on the data for this layer, as a string. Defaults to 'identity'.
position	Position adjustment, either as a string, or the result of a call to a position adjustment function.
na.rm	If FALSE, the default, missing values are removed with a warning. If TRUE, missing values are silently removed.
...	Optional. Any other ggplot geom_ribbon() arguments.

Note

Originally adapted from the survminer package <https://github.com/kassambara/survminer>.

Author(s)

Eric Finnesgard

Examples

```
require(survival)
require(ggplot2)

f <- survfit(Surv(time, status) ~ trt, data = diabetic)
d <- with(f, data.frame(time, surv, lower, upper, trt=rep(names(f$strata), f$strata)))
ggplot(d, aes(x = time, y=surv)) +
  geom_step(aes(color = trt)) +
  geom_stepconfint(aes(ymin = lower, ymax = upper, fill = trt), alpha = 0.3) +
  coord_cartesian(c(0, 50)) +
  scale_x_continuous(expand = c(0.02,0)) +
  labs(x = 'Time', y = 'Freedom From Event') +
  scale_color_manual(
    values = c('#d83641', '#1A45A7'),
```

```
name = 'Treatment',
labels = c('None', 'Laser'),
aesthetics = c('colour', 'fill'))
```

`getabd` *getabd*

Description

Data from The Analysis of Biological Data by Shitlock and Schluter

Usage

```
getabd(name = "", lowernames = FALSE, allow = "_")
```

Arguments

`name`	name of dataset to fetch. Omit to get a data table listing all available datasets.
`lowernames`	set to `TRUE` to change variable names to lower case
`allow`	set to `NULL` to convert underscores in variable names to periods

Details

Fetches csv files for exercises in the book

Value

data frame with attributes `label` and `url`

Author(s)

Frank Harrell

`getHdata` *Download and Install Datasets for* **Hmisc**, **rms**, *and Statistical Modeling*

Description

This function downloads and makes ready to use datasets from the main web site for the **Hmisc** and **rms** libraries. For R, the datasets were stored in compressed `save` format and `getHdata` makes them available by running `load` after download. For S-Plus, the datasets were stored in `data.dump` format and are made available by running `data.restore` after import. The dataset is run through the `cleanup.import` function. Calling `getHdata` with no `file` argument provides a character vector of names of available datasets that are currently on the web site. For R, R's default browser can optionally be launched to view `html` files that were already prepared using the **Hmisc** command `html(contents())` or to view '`.txt`' or '`.html`' data description files when available.

If `options(localHfiles=TRUE)` the scripts are read from local directory `~/web/data/repo` instead of from the web server.

Usage

```
getHdata(file, what = c("data", "contents", "description", "all"),
         where="https://hbiostat.org/data/repo")
```

Arguments

`file`	an unquoted name of a dataset on the web site, e.g. '`prostate`'. Omit `file` to obtain a list of available datasets.
`what`	specify `what="contents"` to browse the contents (metadata) for the dataset rather than fetching the data themselves. Specify `what="description"` to browse a data description file if available. Specify `what="all"` to retrieve the data and see the metadata and description.
`where`	URL containing the data and metadata files

Value

`getHdata()` without a `file` argument returns a character vector of dataset base names. When a dataset is downloaded, the data frame is placed in search position one and is not returned as value of `getHdata`.

Author(s)

Frank Harrell

See Also

`download.file`, `cleanup.import`, `data.restore`, `load`

Examples

```
## Not run:
getHdata()          # download list of available datasets
getHdata(prostate)  # downloads, load( ) or data.restore( )
                    # runs cleanup.import for S-Plus 6
getHdata(valung, "contents")   # open browser (options(browser="whatever"))
                    # after downloading valung.html
```

```
                    # (result of html(contents()))
getHdata(support, "all")  # download and open one browser window
datadensity(support)
attach(support)     # make individual variables available
getHdata(plasma,  "all")  # download and open two browser windows
                          # (description file is available for plasma)

## End(Not run)
```

---

getRs *Interact with github rscripts Project*

Description

The github rscripts project at https://github.com/harrelfe/rscripts contains R scripts that are primarily analysis templates for teaching with RStudio. This function allows the user to print an organized list of available scripts, to download a script and `source()` it into the current session (the default), to download a script and load it into an RStudio script editor window, to list scripts whose major category contains a given string (ignoring case), or to list all major and minor categories. If `options(localHfiles=TRUE)` the scripts are read from local directory `~/R/rscripts` instead of from github.

Usage

```
getRs(file=NULL, guser='harrelfe', grepo='rscripts', gdir='raw/master',
      dir=NULL, browse=c('local', 'browser'), cats=FALSE,
      put=c('source', 'rstudio'))
```

Arguments

`file`	a character string containing a script file name. Omit `file` to obtain a list of available scripts with major and minor categories.
`guser`	GitHub user name, default is `'harrelfe'`
`grepo`	Github repository name, default is `'rscripts'`
`gdir`	Github directory under which to find retrievable files
`dir`	directory under `grepo` in which to find files
`browse`	When showing the rscripts contents directory, the default is to list in tabular form in the console. Specify `browse='browser'` to open the online contents in a web browser.
`cats`	Leave at the default (`FALSE`) to list whole contents or download a script. Specify `cats=TRUE` to list major and minor categories available. Specify a character string to list all scripts whose major category contains the string (ignoring case).
`put`	Leave at the default (`'source'`) to `source()` the file. This is useful when the file just defines a function you want to use in the session. Use load `put='rstudio'` to load the file into the RStudio script editor window using the `rstudioapi navigateToFile` function. If RStudio is not running, `file.edit()` is used instead.

Value

a data frame or list, depending on arguments

Author(s)

Frank Harrell and Cole Beck

See Also

download.file

Examples

```
## Not run:
getRs()             # list available scripts
scripts <- getRs()  # likewise, but store in an object that can easily
                    # be viewed on demand in RStudio
getRs('introda.r')  # download introda.r and put in script editor
getRs(cats=TRUE)    # list available major and minor categories
categories <- getRs(cats=TRUE)
# likewise but store results in a list for later viewing
getRs(cats='reg')   # list all scripts in a major category containing 'reg'
getRs('importREDCap.r')   # source() to define a function
# source() a new version of the Hmisc package's cut2 function:
getRs('cut2.s', grepo='Hmisc', dir='R')

## End(Not run)
```

---

getZip *Open a Zip File From a URL*

Description

Allows downloading and reading of a zip file containing one file

Usage

```
getZip(url, password=NULL)
```

Arguments

url	either a path to a local file or a valid URL.
password	required to decode password-protected zip files

Details

Allows downloading and reading of zip file containing one file. The file may be password protected. If a password is needed then one will be requested unless given.

Note: to make password-protected zip file z.zip, do zip -e z myfile

Value

Returns a file O/I pipe.

Author(s)

Frank E. Harrell

See Also

pipe

Examples

```
## Not run:
read.csv(getZip('http://test.com/z.zip'))

## End(Not run)
```

---

ggfreqScatter *Frequency Scatterplot*

Description

Uses ggplot2 to plot a scatterplot or dot-like chart for the case where there is a very large number of overlapping values. This works for continuous and categorical x and y. For continuous variables it serves the same purpose as hexagonal binning. Counts for overlapping points are grouped into quantile groups and level of transparency and rainbow colors are used to provide count information.

Instead, you can specify stick=TRUE not use color but to encode cell frequencies with the height of a black line y-centered at the middle of the bins. Relative frequencies are not transformed, and the maximum cell frequency is shown in a caption. Every point with at least a frequency of one is depicted with a full-height light gray vertical line, scaled to the above overall maximum frequency. In this way to relative frequency is to proportion of these light gray lines that are black, and one can see points whose frequencies are too low to see the black lines.

The result can also be passed to ggplotly. Actual cell frequencies are added to the hover text in that case using the label ggplot2 aesthetic.

Usage

```
ggfreqScatter(x, y, by=NULL, bins=50, g=10, cuts=NULL,
              xtrans = function(x) x,
              ytrans = function(y) y,
              xbreaks = pretty(x, 10),
              ybreaks = pretty(y, 10),
              xminor  = NULL, yminor = NULL,
              xlab = as.character(substitute(x)),
              ylab = as.character(substitute(y)),
              fcolors = viridisLite::viridis(10), nsize=FALSE,
              stick=FALSE, html=FALSE, prfreq=FALSE, ...)
```

Arguments

x	x-variable
y	y-variable
by	an optional vector used to make separate plots for each distinct value using facet_wrap()
bins	for continuous x or y is the number of bins to create by rounding. Ignored for categorical variables. If a 2-vector, the first element corresponds to x and the second to y.
g	number of quantile groups to make for frequency counts. Use g=0 to use frequencies continuously for color coding. This is recommended only when using plotly.
cuts	instead of using g, specify cuts to provide the vector of cuts for categorizing frequencies for assignment to colors
xtrans, ytrans	functions specifying transformations to be made before binning and plotting
xbreaks, ybreaks	vectors of values to label on axis, on original scale
xminor, yminor	values at which to put minor tick marks, on original scale
xlab, ylab	axis labels. If not specified and variable has a label, thatu label will be used.
fcolors	colors argument to pass to scale_color_gradientn to color code frequencies. Use fcolors=gray.colors(10, 0.75, 0) to show gray scale, for example. Another good choice is fcolors=hcl.colors(10, 'Blue-Red').
nsize	set to TRUE to not vary color or transparency but instead to size the symbols in relation to the number of points. Best with both x and y are discrete. ggplot2 size is taken as the fourth root of the frequency. If there are 15 or unique frequencies all the unique frequencies are used, otherwise g quantile groups of frequencies are used.
stick	set to TRUE to not use colors but instead use varying-height black vertical lines to depict cell frequencies.
html	set to TRUE to use html in axis labels instead of plotmath
prfreq	set to TRUE to print the frequency distributions of the binned coordinate frequencies
...	arguments to pass to geom_point such as shape and size

Value

a ggplot object

Author(s)

Frank Harrell

See Also

cut2

Examples

```
require(ggplot2)
set.seed(1)
x <- rnorm(1000)
y <- rnorm(1000)
count <- sample(1:100, 1000, TRUE)
x <- rep(x, count)
y <- rep(y, count)
# color=alpha=NULL below makes loess smooth over all points
g <- ggfreqScatter(x, y) +   # might add g=0 if using plotly
      geom_smooth(aes(color=NULL, alpha=NULL), se=FALSE) +
      ggtitle("Using Deciles of Frequency Counts, 2500 Bins")
g
# plotly::ggplotly(g, tooltip='label')  # use plotly, hover text = freq. only
# Plotly makes it somewhat interactive, with hover text tooltips

# Instead use varying-height sticks to depict frequencies
ggfreqScatter(x, y, stick=TRUE) +
 labs(subtitle='Relative height of black lines to gray lines
is proportional to cell frequency.
Note that points with even tiny frequency are visable
(gray line with no visible black line).')


# Try with x categorical
x1 <- sample(c('cat', 'dog', 'giraffe'), length(x), TRUE)
ggfreqScatter(x1, y)

# Try with y categorical
y1 <- sample(LETTERS[1:10], length(x), TRUE)
ggfreqScatter(x, y1)

# Both categorical, larger point symbols, box instead of circle
ggfreqScatter(x1, y1, shape=15, size=7)
# Vary box size instead
ggfreqScatter(x1, y1, nsize=TRUE, shape=15)
```

---

ggplotlyr *ggplotlyr*

Description

Render `plotly` Graphic from a `ggplot2` Object

Usage

```
ggplotlyr(ggobject, tooltip = "label", remove = "txt: ", ...)
```

Arguments

ggobject	an object produced by ggplot
tooltip	attribute specified to ggplot to hold hover text
remove	extraneous text to remove from hover text. Default is set to assume tooltip='label' and assumed the user specified aes(..., label=txt). If you instead specified aes(..., label=myvar) use remove='myvar: '.
...	other arguments passed to ggplotly

Details

Uses plotly::ggplotly() to render a plotly graphic with a specified tooltip attribute, removing extraneous text that ggplotly puts in hover text when tooltip='label'

Value

a plotly object

Author(s)

Frank Harrell

GiniMd *Gini's Mean Difference*

Description

GiniMD computes Gini's mean difference on a numeric vector. This index is defined as the mean absolute difference between any two distinct elements of a vector. For a Bernoulli (binary) variable with proportion of ones equal to p and sample size n, Gini's mean difference is $2\frac{n}{n-1}p(1-p)$. For a trinomial variable (e.g., predicted values for a 3-level categorical predictor using two dummy variables) having (predicted) values A, B, C with corresponding proportions a, b, c, Gini's mean difference is $2\frac{n}{n-1}[ab|A-B| + ac|A-C| + bc|B-C|]$

Usage

```
GiniMd(x, na.rm=FALSE)
```

Arguments

x	a numeric vector (for GiniMd)
na.rm	set to TRUE if you suspect there may be NAs in x; these will then be removed. Otherwise an error will result.

Value

a scalar numeric

Author(s)

Frank Harrell
Department of Biostatistics
Vanderbilt University
<fh@fharrell.com>

References

David HA (1968): Gini's mean difference rediscovered. Biometrika 55:573–575.

Examples

```
set.seed(1)
x <- rnorm(40)
# Test GiniMd against a brute-force solution
gmd <- function(x) {
  n <- length(x)
  sum(outer(x, x, function(a, b) abs(a - b))) / n / (n - 1)
  }
GiniMd(x)
gmd(x)

z <- c(rep(0,17), rep(1,6))
n <- length(z)
GiniMd(z)
2*mean(z)*(1-mean(z))*n/(n-1)

a <- 12; b <- 13; c <- 7; n <- a + b + c
A <- -.123; B <- -.707; C <- 0.523
xx <- c(rep(A, a), rep(B, b), rep(C, c))
GiniMd(xx)
2*(a*b*abs(A-B) + a*c*abs(A-C) + b*c*abs(B-C))/n/(n-1)
```

---

hashCheck *hashCheck*

Description

Check for Changes in List of Objects

Usage

```
hashCheck(..., file, .print. = TRUE, .names. = NULL)
```

Arguments

...	a list of objects including data frames, vectors, functions, and all other types of R objects that represent dependencies of a certain calculation
file	name of file in which results are stored
.print.	set to FALSE to suppress printing information messages about what has changed
.names.	vector of names of original arguments if not calling hashCheck directly

Details

Given an RDS file name and a list of objects, does the following:

- makes a vector of hashes, one for each object. Function objects are run through deparse so that the environment of the function will not be considered.
- see if the file exists; if not, return a list with result=NULL, hash = new vector of hashes, changed='All'
- if the file exists, read the file and its hash attribute as prevhash
- if prevhash is not identical to hash: if .print.=TRUE (default), print to console a summary of what's changed return a list with result=NULL, hash = new hash vector, changed
- if prevhash = hash, return a list with result=file object, hash=new hash, changed="

Set options(debughash=TRUE) to trace results in /tmp/debughash.txt

Value

a list with elements result (the computations), hash (the new hash), and changed which details what changed to make computations need to be run

Author(s)

Frank Harrell

---

hdquantile *Harrell-Davis Distribution-Free Quantile Estimator*

Description

Computes the Harrell-Davis (1982) quantile estimator and jacknife standard errors of quantiles. The quantile estimator is a weighted linear combination or order statistics in which the order statistics used in traditional nonparametric quantile estimators are given the greatest weight. In small samples the H-D estimator is more efficient than traditional ones, and the two methods are asymptotically equivalent. The H-D estimator is the limit of a bootstrap average as the number of bootstrap resamples becomes infinitely large.

Usage

```
hdquantile(x, probs = seq(0, 1, 0.25),
           se = FALSE, na.rm = FALSE, names = TRUE, weights=FALSE)
```

Arguments

x	a numeric vector
probs	vector of quantiles to compute
se	set to TRUE to also compute standard errors
na.rm	set to TRUE to remove NAs from x before computing quantiles
names	set to FALSE to prevent names attributions from being added to quantiles and standard errors
weights	set to TRUE to return a "weights" attribution with the matrix of weights used in the H-D estimator corresponding to order statistics, with columns corresponding to quantiles.

Details

A Fortran routine is used to compute the jackknife leave-out-one quantile estimates. Standard errors are not computed for quantiles 0 or 1 (NAs are returned).

Value

A vector of quantiles. If se=TRUE this vector will have an attribute se added to it, containing the standard errors. If weights=TRUE, also has a "weights" attribute which is a matrix.

Author(s)

Frank Harrell

References

Harrell FE, Davis CE (1982): A new distribution-free quantile estimator. Biometrika 69:635-640.

Hutson AD, Ernst MD (2000): The exact bootstrap mean and variance of an L-estimator. J Roy Statist Soc B 62:89-94.

See Also

quantile

Examples

```
set.seed(1)
x <- runif(100)
hdquantile(x, (1:3)/4, se=TRUE)

## Not run:
# Compare jackknife standard errors with those from the bootstrap
library(boot)
boot(x, function(x,i) hdquantile(x[i], probs=(1:3)/4), R=400)

## End(Not run)
```

hidingTOC *Moving and Hiding Table of Contents*

Description

Moving and hiding table of contents for Rmd HTML documents

Usage

```
hidingTOC(
  buttonLabel = "Contents",
  levels = 3,
  tocSide = c("right", "left"),
  buttonSide = c("right", "left"),
  posCollapse = c("margin", "top", "bottom"),
  hidden = FALSE
)
```

Arguments

buttonLabel	the text on the button that hides and unhides the table of contents. Defaults to Contents.
levels	the max depth of the table of contents that it is desired to have control over the display of. (defaults to 3)
tocSide	which side of the page should the table of contents be placed on. Can be either 'right' or 'left'. Defaults to 'right'
buttonSide	which side of the page should the button that hides the TOC be placed on. Can be either 'right' or 'left'. Defaults to 'right'
posCollapse	if 'margin' then display the depth select buttons vertically along the side of the page choosen by buttonSide. If 'top' then display the depth select buttons horizontally under the button that hides the TOC. Defaults to 'margin'. 'bottom' is currently unimplemented.
hidden	Logical should the table of contents be hidden at page load Defaults to FALSE

Details

hidingTOC creates a table of contents in a Rmd document that can be hidden at the press of a button. It also generate buttons that allow the hiding or unhiding of the diffrent level depths of the table of contents.

Value

a HTML formated text string to be inserted into an markdown document

Author(s)

Thomas Dupont

Examples

```
## Not run:
hidingTOC()

## End(Not run)
```

`hist.data.frame` *Histograms for Variables in a Data Frame*

Description

This functions tries to compute the maximum number of histograms that will fit on one page, then it draws a matrix of histograms. If there are more qualifying variables than will fit on a page, the function waits for a mouse click before drawing the next page.

Usage

```
## S3 method for class 'data.frame'
hist(x, n.unique = 3, nclass = "compute",
                na.big = FALSE, rugs = FALSE, freq=TRUE, mtitl = FALSE, ...)
```

Arguments

`x`	a data frame
`n.unique`	minimum number of unique values a variable must have before a histogram is drawn
`nclass`	number of bins. Default is max(2,trunc(min(n/10,25*log(n,10))/2)), where n is the number of non-missing values for a variable.
`na.big`	set to `TRUE` to draw the number of missing values on the top of the histogram in addition to in a subtitle. In the subtitle, n is the number of non-missing values and m is the number of missing values
`rugs`	set to `TRUE` to add rug plots at the top of each histogram
`freq`	see `hist`. Default is to show frequencies.
`mtitl`	set to a character string to set aside extra outside top margin and to use the string for an overall title
`...`	arguments passed to `scat1d`

Value

the number of pages drawn

Author(s)

Frank E Harrell Jr

See Also

hist, scat1d

Examples

```
d <- data.frame(a=runif(200), b=rnorm(200),
                w=factor(sample(c('green','red','blue'), 200, TRUE)))
hist.data.frame(d)   # in R, just say hist(d)
```

---

histbackback *Back to Back Histograms*

Description

Takes two vectors or a list with x and y components, and produces back to back histograms of the two datasets.

Usage

```
histbackback(x, y, brks=NULL, xlab=NULL, axes=TRUE, probability=FALSE,
             xlim=NULL, ylab='', ...)
```

Arguments

x, y	either two vectors or a list given as x with two components. If the components have names, they will be used to label the axis (modification FEH).
brks	vector of the desired breakpoints for the histograms.
xlab	a vector of two character strings naming the two datasets.
axes	logical flag stating whether or not to label the axes.
probability	logical flag: if TRUE, then the x-axis corresponds to the units for a density. If FALSE, then the units are counts.
xlim	x-axis limits. First value must be negative, as the left histogram is placed at negative x-values. Second value must be positive, for the right histogram. To make the limits symmetric, use e.g. ylim=c(-20,20).
ylab	label for y-axis. Default is no label.
...	additional graphics parameters may be given.

Value

a list is returned invisibly with the following components:

left	the counts for the dataset plotted on the left.
right	the counts for the dataset plotted on the right.
breaks	the breakpoints used.

Side Effects

a plot is produced on the current graphics device.

Author(s)

Pat Burns
Salomon Smith Barney
London
<pburns@dorado.sbi.com>

See Also

hist, histogram

Examples

```
options(digits=3)
set.seed(1)
histbackback(rnorm(20), rnorm(30))


fool <- list(x=rnorm(40), y=rnorm(40))
histbackback(fool)
age <- rnorm(1000,50,10)
sex <- sample(c('female','male'),1000,TRUE)
histbackback(split(age, sex))
agef <- age[sex=='female']; agem <- age[sex=='male']
histbackback(list(Female=agef,Male=agem), probability=TRUE, xlim=c(-.06,.06))
```

---

histboxp *Use plotly to Draw Stratified Spike Histogram and Box Plot Statistics*

Description

Uses `plotly` to draw horizontal spike histograms stratified by `group`, plus the mean (solid dot) and vertical bars for these quantiles: 0.05 (red, short), 0.25 (blue, medium), 0.50 (black, long), 0.75 (blue, medium), and 0.95 (red, short). The robust dispersion measure Gini's mean difference and the SD may optionally be added. These are shown as horizontal lines starting at the minimum value of `x` having a length equal to the mean difference or SD. Even when Gini's and SD are computed, they are not drawn unless the user clicks on their legend entry.

Spike histograms have the advantage of effectively showing the raw data for both small and huge datasets, and unlike box plots allow multi-modality to be easily seen.

`histboxpM` plots multiple histograms stacked vertically, for variables in a data frame having a common `group` variable (if any) and combined using `plotly::subplot`.

`dhistboxp` is like `histboxp` but no `plotly` graphics are actually drawn. Instead, a data frame suitable for use with `plotlyM` is returned. For `dhistboxp` an additional level of stratification `strata` is implemented. `group` causes a different result here to produce back-to-back histograms (in the case of two groups) for each level of `strata`.

Usage

```
histboxp(p = plotly::plot_ly(height=height), x, group = NULL,
         xlab=NULL, gmd=TRUE, sd=FALSE, bins = 100, wmax=190, mult=7,
         connect=TRUE, showlegend=TRUE)

dhistboxp(x, group = NULL, strata=NULL, xlab=NULL,
          gmd=FALSE, sd=FALSE, bins = 100, nmin=5, ff1=1, ff2=1)

histboxpM(p=plotly::plot_ly(height=height, width=width), x, group=NULL,
          gmd=TRUE, sd=FALSE, width=NULL, nrows=NULL, ncols=NULL, ...)
```

Arguments

p	plotly graphics object if already begun
x	a numeric vector, or for histboxpM a numeric vector or a data frame of numeric vectors, hopefully with label and units attributes
group	a discrete grouping variable. If omitted, defaults to a vector of ones
strata	a discrete numeric stratification variable. Values are also used to space out different spike histograms. Defaults to a vector of ones.
xlab	x-axis label, defaults to labelled version include units of measurement if any
gmd	set to FALSE to not compute Gini's mean difference
sd	set to TRUE to compute the SD
width	width in pixels
nrows	number of rows for layout of multiple plots
ncols	number of columns for layout of multiple plots. At most one of nrows,ncols should be specified.
bins	number of equal-width bins to use for spike histogram. If the number of distinct values of x is less than bins, the actual values of x are used.
nmin	minimum number of non-missing observations for a group-stratum combination before the spike histogram and quantiles are drawn
ff1, ff2	fudge factors for position and bar length for spike histograms
wmax, mult	tweaks for margin to allocate
connect	set to FALSE to suppress lines connecting quantiles
showlegend	used if producing multiple plots to be combined with subplot; set to FALSE for all but one plot
...	other arguments for histboxpM that are passed to histboxp

Value

a plotly object. For dhistboxp a data frame as expected by plotlyM

Author(s)

Frank Harrell

See Also

histSpike, plot.describe, scat1d

Examples

```
## Not run:
dist <- c(rep(1, 500), rep(2, 250), rep(3, 600))
Distribution <- factor(dist, 1 : 3, c('Unimodal', 'Bimodal', 'Trimodal'))
x <- c(rnorm(500, 6, 1),
       rnorm(200, 3, .7), rnorm(50, 7, .4),
       rnorm(200, 2, .7), rnorm(300, 5.5, .4), rnorm(100, 8, .4))
histboxp(x=x, group=Distribution, sd=TRUE)
X <- data.frame(x, x2=runif(length(x)))
histboxpM(x=X, group=Distribution, ncols=2)  # separate plots

## End(Not run)
```

---

hlab *hlab*

Description

Easy Extraction of Labels/Units Expressions for Plotting

Usage

```
hlab(x, name = NULL, html = FALSE, plotmath = TRUE)
```

Arguments

x	a single variable name, unquoted
name	a single character string providing an alternate way to name x that is useful when hlab is called from another function such as hlabs
html	set to TRUE to return HTML strings instead of plotmath expressions
plotmath	set to FALSE to use plain text instead of plotmath

Details

Given a single unquoted variable, first looks to see if a non-NULL LabelsUnits object exists (produced by extractlabs()). When LabelsUnits does not exist or is NULL, looks up the attributes in the current dataset, which defaults to d or may be specified by options(current_ds='name of the data frame/table'). Finally the existence of a variable of the given name in the global environment is checked. When a variable is not found in any of these three sources or has a blank label and units, an expression() with the variable name alone is returned. If html=TRUE, HTML strings are constructed instead, suitable for plotly graphics.

The result is useful for xlab and ylab in base plotting functions or in ggplot2, along with being useful for labs in ggplot2. See example.

Value

an expression created by `labelPlotmath` with `plotmath=TRUE`

Author(s)

Frank Harrell

See Also

`label()`, `units()`, `contents()`, `hlabs()`, `extractlabs()`, plotmath

Examples

```
d <- data.frame(x=1:10, y=(1:10)/10)
d <- upData(d, labels=c(x='X', y='Y'), units=c(x='mmHg'), print=FALSE)
hlab(x)
hlab(x, html=TRUE)
hlab(z)
require(ggplot2)
ggplot(d, aes(x, y)) + geom_point() + labs(x=hlab(x), y=hlab(y))
# Can use xlab(hlab(x)) + ylab(hlab(y)) also
# Store names, labels, units for all variables in d in object
LabelsUnits <- extractlabs(d)
# Remove d; labels/units still found
rm(d)
hlab(x)
# Remove LabelsUnits and use a current dataset named
# d2 instead of the default d
rm(LabelsUnits)
options(current_ds='d2')
```

`hlabs` *hlabs*

Description

Front-end to ggplot2 labs Function

Usage

```
hlabs(x, y, html = FALSE)
```

Arguments

`x`	a single variable name, unquoted
`y`	a single variable name, unquoted
`html`	set to `TRUE` to render in html (for `plotly`), otherwise the result is `plotmath` expressions

Details

Runs x, y, or both through hlab() and passes the constructed labels to the ggplot2::labs function to specify x- and y-axis labels specially formatted for units of measurement

Value

result of ggplot2::labs()

Author(s)

Frank Harrell

Examples

```
# Name the current dataset d, or specify a name with
# options(curr_ds='...') or run `extractlabs`, then
# ggplot(d, aes(x,y)) + geom_point() + hlabs(x,y)
# to specify only the x-axis label use hlabs(x), or to
# specify only the y-axis label use hlabs(y=...)
```

HmiscOverview *Overview of Hmisc Library*

Description

The Hmisc library contains many functions useful for data analysis, high-level graphics, utility operations, functions for computing sample size and power, translating SAS datasets into R, imputing missing values, advanced table making, variable clustering, character string manipulation, conversion of R objects to LaTeX code, recoding variables, and bootstrap repeated measures analysis. Most of these functions were written by F Harrell, but a few were collected from statlib and from s-news; other authors are indicated below. This collection of functions includes all of Harrell's submissions to statlib other than the functions in the **rms** and display libraries. A few of the functions do not have "Help" documentation.

To make **Hmisc** load silently, issue `options(Hverbose=FALSE)` before `library(Hmisc)`.

Functions

Function Name	Purpose
abs.error.pred	Computes various indexes of predictive accuracy based on absolute errors, for linear models
addMarginal	Add marginal observations over selected variables
all.is.numeric	Check if character strings are legal numerics
approxExtrap	Linear extrapolation
aregImpute	Multiple imputation based on additive regression, bootstrapping, and predictive mean matching
areg.boot	Nonparametrically estimate transformations for both

	sides of a multiple additive regression, and bootstrap these estimates and R^2
ballocation	Optimum sample allocations in 2-sample proportion test
binconf	Exact confidence limits for a proportion and more accurate (narrower!) score stat.-based Wilson interval (Rollin Brant, mod. FEH)
bootkm	Bootstrap Kaplan-Meier survival or quantile estimates
bpower	Approximate power of 2-sided test for 2 proportions Includes bpower.sim for exact power by simulation
bpplot	Box-Percentile plot (Jeffrey Banfield, <umsfjban@bill.oscs.montana.edu>)
bpplotM	Chart extended box plots for multiple variables
bsamsize	Sample size requirements for test of 2 proportions
bystats	Statistics on a single variable by levels of >=1 factors
bystats2	2-way statistics
character.table	Shows numeric equivalents of all latin characters Useful for putting many special chars. in graph titles (Pierre Joyet, <pierre.joyet@bluewin.ch>)
ciapower	Power of Cox interaction test
cleanup.import	More compactly store variables in a data frame, and clean up problem data when e.g. Excel spreadsheet had a non-numeric value in a numeric column
combine.levels	Combine infrequent levels of a categorical variable
confbar	Draws confidence bars on an existing plot using multiple confidence levels distinguished using color or gray scale
contents	Print the contents (variables, labels, etc.) of a data frame
cpower	Power of Cox 2-sample test allowing for noncompliance
Cs	Vector of character strings from list of unquoted names
csv.get	Enhanced importing of comma separated files labels
cut2	Like cut with better endpoint label construction and allows construction of quantile groups or groups with given n
datadensity	Snapshot graph of distributions of all variables in a data frame. For continuous variables uses scat1d.
dataRep	Quantify representation of new observations in a database
ddmmmyy	SAS "date7" output format for a chron object
deff	Kish design effect and intra-cluster correlation
describe	Function to describe different classes of objects. Invoke by saying describe(object). It calls one of the following:
describe.data.frame	Describe all variables in a data frame (generalization of SAS UNIVARIATE)
describe.default	Describe a variable (generalization of SAS UNIVARIATE)
dotplot3	A more flexible version of dotplot
Dotplot	Enhancement of Trellis dotplot allowing for matrix x-var., auto generation of Key function, superposition
drawPlot	Simple mouse-driven drawing program, including a function for fitting Bezier curves
Ecdf	Empirical cumulative distribution function plot

errbar	Plot with error bars (Charles Geyer, U. Chi., mod FEH)
event.chart	Plot general event charts (Jack Lee, <jjlee@mdanderson.org>, Ken Hess, Joel Dubin; Am Statistician 54:63-70,2000)
event.history	Event history chart with time-dependent cov. status (Joel Dubin, <jdubin@uwaterloo.ca>)
find.matches	Find matches (with tolerances) between columns of 2 matrices
first.word	Find the first word in an R expression (R Heiberger)
fit.mult.impute	Fit most regression models over multiple transcan imputations, compute imputation-adjusted variances and avg. betas
format.df	Format a matrix or data frame with much user control (R Heiberger and FE Harrell)
ftupwr	Power of 2-sample binomial test using Fleiss, Tytun, Ury
ftuss	Sample size for 2-sample binomial test using " " " " (Both by Dan Heitjan, <dheitjan@biostats.hmc.psu.edu>)
gbayes	Bayesian posterior and predictive distributions when both the prior and the likelihood are Gaussian
getHdata	Fetch and list datasets on our web site
hdquantile	Harrell-Davis nonparametric quantile estimator with s.e.
histbackback	Back-to-back histograms (Pat Burns, Salomon Smith Barney, London, <pburns@dorado.sbi.com>)
hist.data.frame	Matrix of histograms for all numeric vars. in data frame Use hist.data.frame(data.frame.name)
histSpike	Add high-resolution spike histograms or density estimates to an existing plot
hoeffd	Hoeffding's D test (omnibus test of independence of X and Y)
impute	Impute missing data (generic method)
interaction	More flexible version of builtin function
is.present	Tests for non-blank character values or non-NA numeric values
james.stein	James-Stein shrinkage estimates of cell means from raw data
labcurve	Optimally label a set of curves that have been drawn on an existing plot, on the basis of gaps between curves. Also position legends automatically at emptiest rectangle.
label	Set or fetch a label for an R-object
Lag	Lag a vector, padding on the left with NA or "
latex	Convert an R object to LaTeX (R Heiberger & FE Harrell)
list.tree	Pretty-print the structure of any data object (Alan Zaslavsky, <zaslavsk@hcp.med.harvard.edu>)
Load	Enhancement of load
mask	8-bit logical representation of a short integer value (Rick Becker)
matchCases	Match each case on one continuous variable
matxv	Fast matrix * vector, handling intercept(s) and NAs
mgp.axis	Version of axis() that uses appropriate mgp from mgp.axis.labels and gets around bug in axis(2, ...) that causes it to assume las=1
mgp.axis.labels	Used by survplot and plot in **rms** library (and other functions in the future) so that different spacing between tick marks and axis tick mark labels may be

	specified for x- and y-axes. Use mgp.axis.labels('default') to set defaults. Users can set values manually using mgp.axis.labels(x,y) where x and y are 2nd value of par('mgp') to use. Use mgp.axis.labels(type=w) to retrieve values, where w='x', 'y', 'x and y', 'xy', to get 3 mgp values (first 3 types) or 2 mgp.axis.labels.
minor.tick	Add minor tick marks to an existing plot
mtitle	Add outer titles and subtitles to a multiple plot layout
multLines	Draw multiple vertical lines at each x in a line plot
%nin%	Opposite of %in%
nobsY	Compute no. non-NA observations for left hand formula side
nomiss	Return a matrix after excluding any row with an NA
panel.bpplot	Panel function for trellis bwplot - box-percentile plots
panel.plsmo	Panel function for trellis xyplot - uses plsmo
pBlock	Block variables for certain lattice charts
pc1	Compute first prin. component and get coefficients on original scale of variables
plotCorrPrecision	Plot precision of estimate of correlation coefficient
plsmo	Plot smoothed x vs. y with labeling and exclusion of NAs Also allows a grouping variable and plots unsmoothed data
popower	Power and sample size calculations for ordinal responses (two treatments, proportional odds model)
prn	prn(expression) does print(expression) but titles the output with 'expression'. Do prn(expression,txt) to add a heading ('txt') before the 'expression' title
pstamp	Stamp a plot with date in lower right corner (pstamp()) Add ,pwd=T and/or ,time=T to add current directory name or time Put additional text for label as first argument, e.g. pstamp('Figure 1') will draw 'Figure 1 date'
putKey	Different way to use key()
putKeyEmpty	Put key at most empty part of existing plot
rcorr	Pearson or Spearman correlation matrix with pairwise deletion of missing data
rcorr.cens	Somers' Dxy rank correlation with censored data
rcorrp.cens	Assess difference in concordance for paired predictors
rcspline.eval	Evaluate restricted cubic spline design matrix
rcspline.plot	Plot spline fit with nonparametric smooth and grouped estimates
rcspline.restate	Restate restricted cubic spline in unrestricted form, and create TeX expression to print the fitted function
reShape	Reshape a matrix into 3 vectors, reshape serial data
rm.boot	Bootstrap spline fit to repeated measurements model, with simultaneous confidence region - least squares using spline function in time
rMultinom	Generate multinomial random variables with varying prob.
samplesize.bin	Sample size for 2-sample binomial problem

	(Rick Chappell, <chappell@stat.wisc.edu>)
sas.get	Convert SAS dataset to S data frame
sasxport.get	Enhanced importing of SAS transport dataset in R
Save	Enhancement of save
scat1d	Add 1-dimensional scatterplot to an axis of an existing plot (like bar-codes, FEH/Martin Maechler, <maechler@stat.math.ethz.ch>/Jens Oehlschlaegel-Akiyoshi, <oehl@psyres-stuttgart.de>)
score.binary	Construct a score from a series of binary variables or expressions
sedit	A set of character handling functions written entirely in R. sedit() does much of what the UNIX sed program does. Other functions included are substring.location, substring<-, replace.string.wild, and functions to check if a string is numeric or contains only the digits 0-9
setTrellis	Set Trellis graphics to use blank conditioning panel strips, line thickness 1 for dot plot reference lines: setTrellis(); 3 optional arguments
show.col	Show colors corresponding to col=0,1,...,99
show.pch	Show all plotting characters specified by pch=. Just type show.pch() to draw the table on the current device.
showPsfrag	Use LaTeX to compile, and dvips and ghostview to display a postscript graphic containing psfrag strings
solvet	Version of solve with argument tol passed to qr
somers2	Somers' rank correlation and c-index for binary y
spearman	Spearman rank correlation coefficient spearman(x,y)
spearman.test	Spearman 1 d.f. and 2 d.f. rank correlation test
spearman2	Spearman multiple d.f. ρ^2, adjusted ρ^2, Wilcoxon-Kruskal-Wallis test, for multiple predictors
spower	Simulate power of 2-sample test for survival under complex conditions Also contains the Gompertz2,Weibull2,Lognorm2 functions.
spss.get	Enhanced importing of SPSS files using read.spss function
src	src(name) = source("name.s") with memory
store	store an object permanently (easy interface to assign function)
strmatch	Shortest unique identifier match (Terry Therneau, <therneau@mayo.edu>)
subset	More easily subset a data frame
substi	Substitute one var for another when observations NA
summarize	Generate a data frame containing stratified summary statistics. Useful for passing to trellis.
summary.formula	General table making and plotting functions for summarizing data
summaryD	Summarizing using user-provided formula and dotchart3
summaryM	Replacement for summary.formula(..., method='reverse')
summaryP	Multi-panel dot chart for summarizing proportions

summaryS	Summarize multiple response variables for multi-panel dot chart or scatterplot
summaryRc	Summary for continuous variables using lowess
symbol.freq	X-Y Frequency plot with circles' area prop. to frequency
sys	Execute unix() or dos() depending on what's running
tabulr	Front-end to tabular function in the tables package
tex	Enclose a string with the correct syntax for using with the LaTeX psfrag package, for postscript graphics
transace	ace() packaged for easily automatically transforming all variables in a matrix
transcan	automatic transformation and imputation of NAs for a series of predictor variables
trap.rule	Area under curve defined by arbitrary x and y vectors, using trapezoidal rule
trellis.strip.blank	To make the strip titles in trellis more visible, you can make the backgrounds blank by saying trellis.strip.blank(). Use before opening the graphics device.
t.test.cluster	2-sample t-test for cluster-randomized observations
uncbind	Form individual variables from a matrix
upData	Update a data frame (change names, labels, remove vars, etc.)
units	Set or fetch "units" attribute - units of measurement for var.
varclus	Graph hierarchical clustering of variables using squared Pearson or Spearman correlations or Hoeffding D as similarities Also includes the naclus function for examining similarities in patterns of missing values across variables.
wtd.mean	
wtd.var	
wtd.quantile	
wtd.Ecdf	
wtd.table	
wtd.rank	
wtd.loess.noiter	
num.denom.setup	Set of function for obtaining weighted estimates
xy.group	Compute mean x vs. function of y by groups of x
xYplot	Like trellis xyplot but supports error bars and multiple response variables that are connected as separate lines
ynbind	Combine a series of yes/no true/false present/absent variables into a matrix
zoom	Zoom in on any graphical display (Bill Dunlap, <bill@statsci.com>)

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If this software is used is work presented for publication, kindly reference it using for example:
Harrell FE (2014): Hmisc: A package of miscellaneous R functions. Programs available from https://hbiostat.org/R/Hmisc/.
Be sure to reference R itself and other libraries used.

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References

See Alzola CF, Harrell FE (2004): An Introduction to S and the Hmisc and Design Libraries at https://hbiostat.org/R/doc/sintro.pdf for extensive documentation and examples for the Hmisc package.

`hoeffd` *Matrix of Hoeffding's D Statistics*

Description

Computes a matrix of Hoeffding's (1948) `D` statistics for all possible pairs of columns of a matrix. `D` is a measure of the distance between `F(x,y)` and `G(x)H(y)`, where `F(x,y)` is the joint CDF of `X` and `Y`, and `G` and `H` are marginal CDFs. Missing values are deleted in pairs rather than deleting all rows of `x` having any missing variables. The `D` statistic is robust against a wide variety of alternatives to independence, such as non-monotonic relationships. The larger the value of `D`, the more dependent are `X` and `Y` (for many types of dependencies). `D` used here is 30 times Hoeffding's original `D`, and ranges from -0.5 to 1.0 if there are no ties in the data. `print.hoeffd` prints the information derived by `hoeffd`. The higher the value of `D`, the more dependent are `x` and `y`. `hoeffd` also computes the mean and maximum absolute values of the difference between the joint empirical CDF and the product of the marginal empirical CDFs.

Usage

```
hoeffd(x, y)
## S3 method for class 'hoeffd'
print(x, ...)
```

Arguments

x	a numeric matrix with at least 5 rows and at least 2 columns (if y is absent), or an object created by hoeffd
y	a numeric vector or matrix which will be concatenated to x
...	ignored

Details

Uses midranks in case of ties, as described by Hollander and Wolfe. P-values are approximated by linear interpolation on the table in Hollander and Wolfe, which uses the asymptotically equivalent Blum-Kiefer-Rosenblatt statistic. For P<.0001 or >0.5, P values are computed using a well-fitting linear regression function in log P vs. the test statistic. Ranks (but not bivariate ranks) are computed using efficient algorithms (see reference 3).

Value

a list with elements D, the matrix of D statistics, n the matrix of number of observations used in analyzing each pair of variables, and P, the asymptotic P-values. Pairs with fewer than 5 non-missing values have the D statistic set to NA. The diagonals of n are the number of non-NAs for the single variable corresponding to that row and column.

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References

Hoeffding W. (1948): A non-parametric test of independence. Ann Math Stat 19:546–57.

Hollander M. and Wolfe D.A. (1973). Nonparametric Statistical Methods, pp. 228–235, 423. New York: Wiley.

Press WH, Flannery BP, Teukolsky SA, Vetterling, WT (1988): Numerical Recipes in C. Cambridge: Cambridge University Press.

See Also

rcorr, varclus

Examples

```
x <- c(-2, -1, 0, 1, 2)
y <- c(4,   1, 0, 1, 4)
z <- c(1,   2, 3, 4, NA)
q <- c(1,   2, 3, 4, 5)
hoeffd(cbind(x,y,z,q))


# Hoeffding's test can detect even one-to-many dependency
set.seed(1)
x <- seq(-10,10,length=200)
y <- x*sign(runif(200,-1,1))
plot(x,y)
hoeffd(x,y)
```

`html` *Convert an S object to HTML*

Description

`html` is a generic function, for which only two methods are currently implemented, `html.latex` and a rudimentary `html.data.frame`. The former uses the `HeVeA` LaTeX to HTML translator by Maranget to create an HTML file from a LaTeX file like the one produced by `latex`. `html.default` just runs `html.data.frame`. `htmlVerbatim` prints all of its arguments to the console in an html verbatim environment, using a specified percent of the prevailing character size. This is useful for R Markdown with `knitr`.

Most of the html-producing functions in the Hmisc and rms packages return a character vector passed through `htmltools::HTML` so that `kintr` will correctly format the result without the need for the user putting `results='asis'` in the chunk header.

Usage

```
html(object, ...)
## S3 method for class 'latex'
html(object, file, where=c('cwd', 'tmp'),
  method=c('hevea', 'htlatex'),
  rmarkdown=FALSE, cleanup=TRUE, ...)
## S3 method for class 'data.frame'
html(object,
  file=paste(first.word(deparse(substitute(object))),'html',sep='.'), header,
     caption=NULL, rownames=FALSE, align='r', align.header='c',
     bold.header=TRUE, col.header='Black',
     border=2, width=NULL, size=100, translate=FALSE,
     append=FALSE, link=NULL, linkCol=1,
     linkType=c('href','name'), disableq=FALSE, ...)
## Default S3 method:
html(object,
```

```
     file=paste(first.word(deparse(substitute(object))),'html',sep='.'),
     append=FALSE, link=NULL, linkCol=1, linkType=c('href','name'), ...)
htmlVerbatim(..., size=75, width=85, scroll=FALSE, rows=10, cols=100,
             propts=NULL, omit1b=FALSE)
```

Arguments

object	a data frame or an object created by latex. For the generic html is any object for which an html method exists.
file	name of the file to create. The default file name is object.html where object is the first word in the name of the argument for object. For html.latex specify file='' or file=character(0) to print html code to the console, as when using knitr. For the data.frame method, file may be set to FALSE which causes a character vector enclosed in htmltools::HTML to be returned instead of writing to the console.
where	for html. Default is to put output files in current working directory. Specify where='tmp' to put in a system temporary directory area.
method	default is to use system command hevea to convert from LaTeX to html. Specifymethod='htlatex' to use system command htlatex, assuming the system package TeX4ht is installed.
rmarkdown	set to TRUE if using RMarkdown (usually under knitr and RStudio). This causes html to be packaged for RMarkdown and output to go into the console stream. file is ignored when rmarkdown=TRUE.
cleanup	if using method='htlatex' set to FALSE if where='cwd' to prevent deletion of auxiliary files created by htlatex that are not needed when using the final html document (only the .css file is needed in addition to .html). If using method='hevea', cleanup=TRUE causes deletion of the generated .haux file.
header	vector of column names. Defaults to names in object. Set to NULL to suppress column names.
caption	a character string to be used as a caption before the table
rownames	set to FALSE to ignore row names even if they are present
align	alignment for table columns (all are assumed to have the same if is a scalar). Specify "c", "r", "l" for center, right, or left alignment.
align.header	same coding as for align but pertains to header
bold.header	set to FALSE to not bold face column headers
col.header	color for column headers
border	set to 0 to not include table cell borders, 1 to include only outer borders, or 2 (the default) to put borders around cells too
translate	set to TRUE to run header and table cell text through the htmlTranslate function
width	optional table width for html.data.frame. For full page width use width="100%", for use in options() for printing objects.
size	a number between 0 and 100 representing the percent of the prevailing character size to be used by htmlVerbatim and the data frame method.
append	set to TRUE to append to an existing file

link	character vector specifying hyperlink names to attach to selected elements of the matrix or data frame. No hyperlinks are used if link is omitted or for elements of link that are "". To allow multiple links per link, link may also be a character matrix shaped as object in which case linkCol is ignored.
linkCol	column number of object to which hyperlinks are attached. Defaults to first column.
linkType	defaults to "href"
disableq	set to TRUE to add code to the html table tag that makes Quarto not use its usual table style
...	ignored except for htmlVerbatim - is a list of objects to print()
scroll	set to TRUE to put the html in a scrollable textarea
rows, cols	the number of rows and columns to devote to the visable part of the scrollable box
propts	options, besides quote=FALSE to pass to the print method, for htmlVerbatim
omit1b	for htmlVerbatim if TRUE causes an initial and a final line of output that is all blank to be deleted

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References

Maranget, Luc. HeVeA: a LaTeX to HTML translater. URL: http://para.inria.fr/~maranget/hevea/

See Also

latex

Examples

```
## Not run:
x <- matrix(1:6, nrow=2, dimnames=list(c('a','b'),c('c','d','e')))
w <- latex(x)
h <- html(w) # run HeVeA to convert .tex to .html
h <- html(x) # convert x directly to html
w <- html(x, link=c('','B'))   # hyperlink first row first col to B

# Assuming system package tex4ht is installed, easily convert advanced
# LaTeX tables to html
getHdata(pbc)
s <- summaryM(bili + albumin + stage + protime + sex + age + spiders ~ drug,
              data=pbc, test=TRUE)
w <- latex(s, npct='slash', file='s.tex')
z <- html(w)
```

```
browseURL(z$file)

d <- describe(pbc)
w <- latex(d, file='d.tex')
z <- html(w)
browseURL(z$file)

## End(Not run)
```

---

htmltabv *htmltabc*

Description

Simple HTML Table of Verbatim Output

Usage

```
htmltabv(..., cols = 2, propts = list(quote = FALSE))
```

Arguments

...	objects to print(). The arguments must be named with the labels you want to print before the verbatim print().
cols	number of columns in the html table
propts	an option list of arguments to pass to the print() methods; default is to not quote character strings

Details

Uses capture.output to capture as character strings the results of running print() on each element of .... If an element of ... has length of 1 and is a blank string, nothing is printed for that cell other than its name (not in verbatim).

Value

character string of html

Author(s)

Frank Harrell

impute *Generic Functions and Methods for Imputation*

Description

These functions do simple and transcan imputation and print, summarize, and subscript variables that have NAs filled-in with imputed values. The simple imputation method involves filling in NAs with constants, with a specified single-valued function of the non-NAs, or from a sample (with replacement) from the non-NA values (this is useful in multiple imputation). More complex imputations can be done with the transcan function, which also works with the generic methods shown here, i.e., impute can take a transcan object and use the imputed values created by transcan (with imputed=TRUE) to fill-in NAs. The print method places * after variable values that were imputed. The summary method summarizes all imputed values and then uses the next summary method available for the variable. The subscript method preserves attributes of the variable and subsets the list of imputed values corresponding with how the variable was subsetted. The is.imputed function is for checking if observations are imputed.

Usage

```
impute(x, ...)

## Default S3 method:
impute(x, fun=median, ...)

## S3 method for class 'impute'
print(x, ...)

## S3 method for class 'impute'
summary(object, ...)

is.imputed(x)
```

Arguments

x	a vector or an object created by transcan, or a vector needing basic unconditional imputation. If there are no NAs and x is a vector, it is returned unchanged.
fun	the name of a function to use in computing the (single) imputed value from the non-NAs. The default is median. If instead of specifying a function as fun, a single value or vector (numeric, or character if object is a factor) is specified, those values are used for insertion. fun can also be the character string "random" to draw random values for imputation, with the random values not forced to be the same if there are multiple NAs. For a vector of constants, the vector must be of length one (indicating the same value replaces all NAs) or must be as long as the number of NAs, in which case the values correspond to consecutive NAs to replace. For a factor object, constants for imputation may include character values not in the current levels of object. In that case new levels are added. If

	object is of class "factor", fun is ignored and the most frequent category is used for imputation.
object	an object of class "impute"
...	ignored

Value

a vector with class "impute" placed in front of existing classes. For is.imputed, a vector of logical values is returned (all TRUE if object is not of class impute).

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See Also

transcan, impute.transcan, describe, na.include, sample

Examples

```
age <- c(1,2,NA,4)
age.i <- impute(age)
# Could have used impute(age,2.5), impute(age,mean), impute(age,"random")
age.i
summary(age.i)
is.imputed(age.i)
```

---

intMarkovOrd *intMarkovOrd*

Description

Compute Parameters for Proportional Odds Markov Model

Usage

```
intMarkovOrd(
  y,
  times,
  initial,
  absorb = NULL,
  intercepts,
  extra = NULL,
  g,
  target,
```

```
  t,
  ftarget = NULL,
  onlycrit = FALSE,
  constraints = NULL,
  printsop = FALSE,
  ...
)
```

Arguments

y	vector of possible y values in order (numeric, character, factor)
times	vector of measurement times
initial	initial value of y (baseline state; numeric, character, or factor matching y). If length 1 this value is used for all subjects, otherwise it is a vector of length n.
absorb	vector of absorbing states, a subset of y (numeric, character, or factor matching y). The default is no absorbing states. Observations are truncated when an absorbing state is simulated.
intercepts	vector of initial guesses for the intercepts
extra	an optional vector of intial guesses for other parameters passed to g such as regression coefficients for previous states and for general time trends. Name the elements of extra for more informative output.
g	a user-specified function of three or more arguments which in order are yprev - the value of y at the previous time, the current time t, the gap between the previous time and the current time, an optional (usually named) covariate vector X, and optional arguments such as a regression coefficient value to simulate from. The function needs to allow yprev to be a vector and yprev must not include any absorbing states. The g function returns the linear predictor for the proportional odds model aside from intercepts. The returned value must be a matrix with row names taken from yprev. If the model is a proportional odds model, the returned value must be one column. If it is a partial proportional odds model, the value must have one column for each distinct value of the response variable Y after the first one, with the levels of Y used as optional column names. So columns correspond to intercepts. The different columns are used for y-specific contributions to the linear predictor (aside from intercepts) for a partial or constrained partial proportional odds model. Parameters for partial proportional odds effects may be included in the ... arguments.
target	vector of target state occupancy probabilities at time t. If extra is specified, target must be a matrix where row names are character versions of t and columns represent occupancy probabilities corresponding to values of y at the time given in the row.
t	target times. Can have more than one element only if extra is given.
ftarget	an optional function defining constraints that relate to transition probabilities. The function returns a penalty which is a sum of absolute differences in probabilities from target probabilities over possibly multiple targets. The ftarget function must have two arguments: intercepts and extra.
onlycrit	set to TRUE to only return the achieved objective criterion and not print anything

constraints	a function of two arguments: the vector of current intercept values and the vector of extra parameters, returning TRUE if that vector meets the constrains and FALSE otherwise
printsop	set to TRUE to print solved-for state occupancy probabilities for groups 1 and 2 and log odds ratios corresponding to them
...	optional arguments to pass to stats::nlm(). If this is specified, the arguments that intMarkovOrd normally sends to nlm are not used.

Details

Given a vector intercepts of initial guesses at the intercepts in a Markov proportional odds model, and a vector extra if there are other parameters, solves for the intercepts and extra vectors that yields a set of occupancy probabilities at time t that equal, as closely as possible, a vector of target values.

Value

list containing two vectors named intercepts and extra unless oncrit=TRUE in which case the best achieved sum of absolute errors is returned

Author(s)

Frank Harrell

See Also

https://hbiostat.org/R/Hmisc/markov/

---

knitrSet *knitr Setup and plotly Service Function*

Description

'knitrSet' sets up knitr to use better default parameters for base graphics, better code formatting, and to allow several arguments to be passed from code chunk headers, such as 'bty', 'mfrow', 'ps', 'bot' (extra bottom margin for base graphics), 'top' (extra top margin), 'left' (extra left margin), 'rt' (extra right margin), 'lwd', 'mgp', 'las', 'tcl', 'axes', 'xpd', 'h' (usually 'fig.height' in knitr), 'w' (usually 'fig.width' in knitr), 'wo' ('out.width' in knitr), 'ho' ('out.height' in knitr), 'cap' (character string containing figure caption), 'scap' (character string containing short figure caption for the table of figures).

Usage

```
knitrSet(
  basename = NULL,
  w = if (!bd) 4,
  h = if (!bd) 3,
  wo = NULL,
  ho = NULL,
  fig.path = if (length(basename)) basename else "",
  fig.align = if (!bd) "center",
  fig.show = "hold",
  fig.pos = if (lang == "latex") "htbp",
  fig.lp = if (!bd) paste("fig", basename, sep = ":"),
 dev = switch(lang, latex = "pdf", markdown = "png", blogdown = NULL, quarto = NULL,
    typst = "pdf"),
  tidy = FALSE,
  error = FALSE,
  messages = c("messages.txt", "console"),
  width = 61,
  decinline = 5,
  size = NULL,
  cache = FALSE,
  echo = TRUE,
  results = "markup",
  capfile = NULL,
  lang = c("latex", "markdown", "blogdown", "quarto", "typst")
)
```

Arguments

basename	base name to be added in front of graphics file names. ‘basename‘ is followed by a minus sign.
w, h	default figure width and height in inches
wo, ho	default figure rendering width and height, in integer pixels or percent as a character string, e.g. ‘’40%’‘
fig.path	path for figures. To put figures in a subdirectory specify e.g. ‘fig.path='folder/'‘. Ignored for ‘blogdown‘ and ‘quarto‘.
fig.align, fig.show, fig.lp, tidy, cache, echo, results, error, size	see the ‘knitr‘ documentation
fig.pos	LaTeX float placement specification such as ‘’htbp’‘. Only meaningful, and only defaulted, when ‘lang='latex’‘; left unset for every other ‘lang‘ value including ‘’typst’‘, none of which use LaTeX-style float placement letters. (Previously this also defaulted to ‘’htbp’‘ under ‘lang='markdown’‘, where the value was inert; that default has been narrowed to ‘lang=='latex’‘ only.)
dev	graphics device, with default figured from ‘lang‘. Defaults to ‘’pdf’‘ for both ‘latex‘ and the new ‘typst‘ value (Typst's ‘image()‘ function natively embeds PDF figures as vector graphics, so the same ‘.pdf‘ figure files already produced

for the LaTeX build can be reused as-is for ‘typst‘), ‘’png’‘ for ‘markdown‘, and the ‘knitr‘/rmarkdown default (‘NULL‘) for ‘blogdown‘ and ‘quarto‘. If the final Typst build must conform to an archival PDF standard such as PDF/A, embedded PDF images are not supported by Typst and ‘dev‘ should be overridden to ‘’svg’‘ (ideally produced via the ‘svglite‘ package rather than base R’s ‘svg()‘ device) instead.

`messages` By default warning and other messages such as those from loading packages are sent to file ‘’messages.txt’‘ in the current working directory. You can specify ‘messages=’console’‘ to send them directly to the console.

`width` text output width for R code and output

`decinline` number of digits to the right of the decimal point to round numeric values appearing inside ‘Sexpr‘/inline R expressions

`capfile` the name of a file in the current working directory that is used to accumulate chunk labels, figure cross-reference tags, and figure short captions (long captions if no short caption is defined) for the purpose of inserting a table of figures in a report (e.g. via ‘markupSpecs$markdown$tof()‘, or an analogous Typst-side builder for ‘lang=’typst’‘). The file is appended to, which is useful if ‘cache=TRUE‘ is used since this will keep some chunks from running. If not ‘cache‘ing, the user should initialize the file to empty at the top of the script.

`lang` Default is ‘’latex’‘ to use LaTeX. Set to ‘’markdown’‘ when using R Markdown, ‘’blogdown’‘, ‘’quarto’‘, or the new ‘’typst’‘ value to target a direct ‘knitr‘ -> Typst -> PDF pipeline (requires a ‘knitr‘ build providing ‘render_typst()‘; see Details). For ‘’blogdown’‘ and ‘’quarto’‘, ‘par‘ and ‘knitr‘ graphics-related hooks are not called, as this would prevent writing graphics files to the correct directory for the blog system. ‘’typst’‘, like ‘’latex’‘, is treated as a paginated, print-oriented target, so those hooks *are* called for ‘’typst’‘.

Details

As of this version, ‘knitrSet‘ also supports ‘lang=’typst’‘, targeting a direct ‘knitr‘ -> Typst -> PDF pipeline made possible by ‘knitr‘’s preliminary native Typst support (files with extension ‘.Rtyp‘; see ‘knitr::render_typst()‘ and ‘knitr::pat_typst()‘). Because that support is still preliminary in ‘knitr‘, ‘knitrSet‘ checks for the presence of ‘knitr::render_typst‘ before calling it and issues a ‘warning‘ (rather than an error) if it is not yet available in the installed version of ‘knitr‘, so that scripts written against a ‘knitr‘ development build degrade gracefully rather than failing outright on a release build. ‘lang=’typst’‘ is treated as a paginated, print-oriented target (like ‘’latex’‘), so, unlike ‘’blogdown’‘ and ‘’quarto’‘, the ‘par‘ and ‘knitr‘ graphics-related hooks documented below **are** run for it.

The ‘capfile‘ argument facilitates auto-generating a table of figures for certain non-LaTeX report themes (R Markdown/blogdown/quarto/typst). This is done by the addition of a hook function that appends data to the ‘capfile‘ file each time a chunk runs that has a long or short caption in the chunk header. For ‘lang=’quarto’‘ and ‘lang=’typst’‘ the recorded cross-reference tag uses native ‘@label‘-style reference syntax understood by those two systems; for ‘lang=’latex’‘ and ‘lang=’markdown’‘ (assumed to be processed by ‘bookdown‘) a ‘\@ref(...)‘ tag is recorded instead.

Value

‘knitrSet‘ is called for its side effect of setting ‘knitr‘ options and hooks; it returns ‘NULL‘ invisibly.

Author(s)

Frank Harrell

See Also

[knitr::knit()]

Examples

```
## Not run:
# Typical call, LaTeX target (without # comment symbols):
# <<echo=FALSE>>=
# require(Hmisc)
# knitrSet()
# @

knitrSet()    # use all defaults and don't use a graphics file prefix
knitrSet('modeling')   # use modeling- prefix for a major section or chapter
knitrSet(cache=TRUE, echo=FALSE)  # global default to cache and not print code
knitrSet(w=5, h=3.75)   # override default figure width, height

# Typical call, Typst target, in a .Rtyp file:
# ```{r setup, include=FALSE}
# require(Hmisc)
# knitrSet(lang='typst')
# ```

## End(Not run)
```

---

labcurve *Label Curves, Make Keys, and Interactively Draw Points and Curves*

Description

`labcurve` optionally draws a set of curves then labels the curves. A variety of methods for drawing labels are implemented, ranging from positioning using the mouse to automatic labeling to automatic placement of key symbols with manual placement of key legends to automatic placement of legends. For automatic positioning of labels or keys, a curve is labeled at a point that is maximally separated from all of the other curves. Gaps occurring when curves do not start or end at the same x-coordinates are given preference for positioning labels. If labels are offset from the curves (the default behaviour), if the closest curve to curve i is above curve i, curve i is labeled below its line. If the closest curve is below curve i, curve i is labeled above its line. These directions are reversed if the resulting labels would appear outside the plot region.

Both ordinary lines and step functions are handled, and there is an option to draw the labels at the same angle as the curve within a local window.

Unless the mouse is used to position labels or plotting symbols are placed along the curves to distinguish them, curves are examined at 100 (by default) equally spaced points over the range of

x-coordinates in the current plot area. Linear interpolation is used to get y-coordinates to line up (step function or constant interpolation is used for step functions). There is an option to instead examine all curves at the set of unique x-coordinates found by unioning the x-coordinates of all the curves. This option is especially useful when plotting step functions. By setting `adj="auto"` you can have `labcurve` try to optimally left- or right-justify labels depending on the slope of the curves at the points at which labels would be centered (plus a vertical offset). This is especially useful when labels must be placed on steep curve sections.

You can use the `on top` method to write (short) curve names directly on the curves (centered on the y-coordinate). This is especially useful when there are many curves whose full labels would run into each other. You can plot letters or numbers on the curves, for example (using the `keys` option), and have `labcurve` use the `key` function to provide long labels for these short ones (see the end of the example). There is another option for connecting labels to curves using arrows. When `keys` is a vector of integers, it is taken to represent plotting symbols (`pchs`), and these symbols are plotted at equally-spaced x-coordinates on each curve (by default, using 5 points per curve). The points are offset in the x-direction between curves so as to minimize the chance of collisions.

To add a legend defining line types, colors, or line widths with no symbols, specify `keys="lines"`, e.g., `labcurve(curves,keys="lines", lty=1:2)`.

`putKey` provides a different way to use `key()` by allowing the user to specify vectors for labels, line types, plotting characters, etc. Elements that do not apply (e.g., `pch` for lines (`type="l"`)) may be `NA`. When a series of points is represented by both a symbol and a line, the corresponding elements of both `pch` and `lty`, `col.`, or `lwd` will be non-missing.

`putKeyEmpty`, given vectors of all the x-y coordinates that have been plotted, uses `largest.empty` to find the largest empty rectangle large enough to hold the key, and draws the key using `putKey`.

`drawPlot` is a simple mouse-driven function for drawing series of lines, step functions, polynomials, Bezier curves, and points, and automatically labeling the point groups using `labcurve` or `putKeyEmpty`. When `drawPlot` is invoked it creates temporary functions `Points`, `Curve`, and `Abline`. The user calls these functions inside the call to `drawPlot` to define groups of points in the order they are defined with the mouse. `Abline` is used to call `abline` and not actually great a group of points. For some curve types, the curve generated to represent the corresponding series of points is drawn after all points are entered for that series, and this curve may be different than the simple curve obtained by connecting points at the mouse clicks. For example, to draw a general smooth Bezier curve the user need only click on a few points, and she must overshoot the final curve coordinates to define the curve. The originally entered points are not erased once the curve is drawn. The same goes for step functions and polynomials. If you `plot()` the object returned by `drawPlot`, however, only final curves will be shown. The last examples show how to use `drawPlot`.

The `largest.empty` function finds the largest rectangle that is large enough to hold a rectangle of a given height and width, such that the rectangle does not contain any of a given set of points. This is used by `labcurve` and `putKeyEmpty` to position keys at the most empty part of an existing plot. The default method was created by Hans Borchers.

Usage

```
labcurve(curves, labels=names(curves),
         method=NULL, keys=NULL, keyloc=c("auto","none"),
         type="l", step.type=c("left", "right"),
         xmethod=if(any(type=="s")) "unique" else "grid",
         offset=NULL, xlim=NULL,
```

```
          tilt=FALSE, window=NULL, npts=100, cex=NULL,
          adj="auto", angle.adj.auto=30,
          lty=pr$lty, lwd=pr$lwd, col.=pr$col, transparent=TRUE,
          arrow.factor=1, point.inc=NULL, opts=NULL, key.opts=NULL,
          empty.method=c('area','maxdim'), numbins=25,
          pl=!missing(add), add=FALSE,
          ylim=NULL, xlab="", ylab="",
          whichLabel=1:length(curves),
          grid=FALSE, xrestrict=NULL, ...)

putKey(z, labels, type, pch, lty, lwd,
       cex=par('cex'), col=rep(par('col'),nc),
       transparent=TRUE, plot=TRUE, key.opts=NULL, grid=FALSE)

putKeyEmpty(x, y, labels, type=NULL,
            pch=NULL, lty=NULL, lwd=NULL,
            cex=par('cex'), col=rep(par('col'),nc),
            transparent=TRUE, plot=TRUE, key.opts=NULL,
            empty.method=c('area','maxdim'),
            numbins=25,
            xlim=pr$usr[1:2], ylim=pr$usr[3:4], grid=FALSE)

drawPlot(..., xlim=c(0,1), ylim=c(0,1), xlab='', ylab='',
         ticks=c('none','x','y','xy'),
         key=FALSE, opts=NULL)

# Points(label=' ', type=c('p','r'),
#        n, pch=pch.to.use[1], cex=par('cex'), col=par('col'),
#        rug = c('none','x','y','xy'), ymean)

# Curve(label=' ',
#       type=c('bezier','polygon','linear','pol','loess','step','gauss'),
#       n=NULL, lty=1, lwd=par('lwd'), col=par('col'), degree=2,
#      evaluation=100, ask=FALSE)

# Abline(\dots)

## S3 method for class 'drawPlot'
plot(x, xlab, ylab, ticks,
     key=x$key, keyloc=x$keyloc, ...)

largest.empty(x, y, width=0, height=0,
              numbins=25, method=c('exhaustive','rexhaustive','area','maxdim'),
              xlim=pr$usr[1:2], ylim=pr$usr[3:4],
              pl=FALSE, grid=FALSE)
```

Arguments

curves	a list of lists, each of which have at least two components: a vector of x values and a vector of corresponding y values. curves is mandatory except when method="mouse" or "locator", in which case labels is mandatory. Each list in curves may optionally have any of the parameters type, lty, lwd, or col for that curve, as defined below (see one of the last examples).
z	a two-element list specifying the coordinate of the center of the key, e.g. locator(1) to use the mouse for positioning
labels	For labcurve, a vector of character strings used to label curves (which may contain newline characters to stack labels vertically). The default labels are taken from the names of the curves list. Setting labels=FALSE will suppress drawing any labels (for labcurve only). For putKey and putKeyEmpty is a vector of character strings specifying group labels
x	see below
y	for putKeyEmpty and largest.empty, x and y are same-length vectors specifying points that have been plotted. x can also be an object created by drawPlot.
...	For drawPlot is a series of invocations of Points and Curve (see example). Any number of point groups can be defined in this way. For Abline these may be any arguments to abline. For labcurve, other parameters to pass to text.
width	see below
height	for largest.empty, specifies the minimum allowable width in x units and the minimum allowable height in y units
method	"offset" (the default) offsets labels at largest gaps between curves, and draws labels beside curves. "on top" draws labels on top of the curves (especially good when using keys). "arrow" draws arrows connecting labels to the curves. "mouse" or "locator" positions labels according to mouse clicks. If keys is specified and is an integer vector or is "lines", method defaults to "on top". If keys is character, method defaults to "offset". Set method="none" to suppress all curve labeling and key drawing, which is useful when pl=TRUE and you only need labcurve to draw the curves and the rest of the basic graph. For largest.empty specifies the method a rectangle that does not collide with any of the (x, y) points. The default method, 'exhaustive', uses a Fortran translation of an R function and algorithm developed by Hans Borchers. The same result, more slowly, may be obtained by using pure R code by specifying method='rexhaustive'. The original algorithms using binning (and the only methods supported for S-Plus) are still available. For all methods, screening of candidate rectangles having at least a given width in x-units of width or having at least a given height in y-units of height is possible. Use method="area" to use the binning method to find the rectangle having the largest area, or method="maxdim" to use the binning method to return with last rectangle searched that had both the largest width and largest height over all previous rectangles.
keys	This causes keys (symbols or short text) to be drawn on or beside curves, and if keyloc is not equal to "none", a legend to be automatically drawn. The legend links keys with full curve labels and optionally with colors and line types. Set

keys to a vector of character strings, or a vector of integers specifying plotting character (pch values - see points). For the latter case, the default behavior is to plot the symbols periodically, at equally spaced x-coordinates.

keyloc When keys is specified, keyloc specifies how the legend is to be positioned for drawing using the key function in trellis. The default is "auto", for which the largest.empty function to used to find the most empty part of the plot. If no empty rectangle large enough to hold the key is found, no key will be drawn. Specify keyloc="none" to suppress drawing a legend, or set keyloc to a 2-element list containing the x and y coordinates for the center of the legend. For example, use keyloc=locator(1) to click the mouse at the center. keyloc specifies the coordinates of the center of the key to be drawn with plot.drawPlot when key=TRUE.

type for labcurve, a scalar or vector of character strings specifying the method that the points in the curves were connected. "l" means ordinary connections between points and "s" means step functions. For putKey and putKeyEmpty is a vector of plotting types, "l" for regular line, "p" for point, "b" for both point and line, and "n" for none. For Points is either "p" (the default) for regular points, or "r" for rugplot (one-dimensional scatter diagram to be drawn using the scat1d function). For Curve, type is "bezier" (the default) for drawing a smooth Bezier curves (which can represent a non-1-to-1 function such as a circle), "polygon" for orginary line segments, "linear" for a straight line defined by two endpoints, "pol" for a degree-degree polynomial to be fitted to the mouse-clicked points, "step" for a left-step-function, "gauss" to plot a Gaussian density fitted to 3 clicked points, "loess" to use the lowess function to smooth the clicked points, or a function to draw a user-specified function, evaluated at evaluation points spanning the whole x-axis. For the density the user must click in the left tail, at the highest value (at the mean), and in the right tail, with the two tail values being approximately equidistant from the mean. The density is scaled to fit in the highest value regardless of its area.

step.type type of step functions used (default is "left")

xmethod method for generating the unique set of x-coordinates to examine (see above). Default is "grid" for type="l" or "unique" for type="s".

offset distance in y-units between the center of the label and the line being labeled. Default is 0.75 times the height of an "m" that would be drawn in a label. For R grid/lattice you must specify offset using the grid unit function, e.g., offset=unit(2,"native") or offset=unit(.25,"cm") ("native" means data units)

xlim limits for searching for label positions, and is also used to set up plots when pl=TRUE and add=FALSE. Default is total x-axis range for current plot (par("usr")[1:2]). For largest.empty, xlim limits the search for largest rectanges, but it has the same default as above. For pl=TRUE,add=FALSE you may want to extend xlim somewhat to allow large keys to fit, when using keyloc="auto". For drawPlot default is c(0,1). When using largest.empty with ggplot2, xlim and ylim are mandatory.

tilt set to TRUE to tilt labels to follow the curves, for method="offset" when keys is not given.

window	width of a window, in x-units, to use in determining the local slope for tilting labels. Default is 0.5 times number of characters in the label times the x-width of an "m" in the current character size and font.
npts	number of points to use if xmethod="grid"
cex	character size to pass to text and key. Default is current par("cex"). For putKey, putKeyEmpty, and Points is the size of the plotting symbol.
adj	Default is "auto" which has labcurve figure justification automatically when method="offset". This will cause centering to be used when the local angle of the curve is less than angle.adj.auto in absolute value, left justification if the angle is larger and either the label is under a curve of positive slope or over a curve of negative slope, and right justification otherwise. For step functions, left justification is used when the label is above the curve and right justifcation otherwise. Set adj=.5 to center labels at computed coordinates. Set to 0 for left-justification, 1 for right. Set adj to a vector to vary adjustments over the curves.
angle.adj.auto	see adj. Does not apply to step functions.
lty	vector of line types which were used to draw the curves. This is only used when keys are drawn. If all of the line types, line widths, and line colors are the same, lines are not drawn in the key.
lwd	vector of line widths which were used to draw the curves. This is only used when keys are drawn. See lty also.
col.	vector of integer color numbers
col	vector of integer color numbers for use in curve labels, symbols, lines, and legends. Default is par("col") for all curves. See lty also.
transparent	Default is TRUE to make key draw transparent legends, i.e., to suppress drawing a solid rectangle background for the legend. Set to FALSE otherwise.
arrow.factor	factor by which to multiply default arrow lengths
point.inc	When keys is a vector of integers, point.inc specifies the x-increment between the point symbols that are overlaid periodically on the curves. By default, point.inc is equal to the range for the x-axis divided by 5.
opts	an optional list which can be used to specify any of the options to labcurve, with the usual element name abbreviations allowed. This is useful when labcurve is being called from another function. Example: opts=list(method="arrow", cex=.8, np=200). For drawPlot a list of labcurve options to pass as labcurve(..., opts=).
key.opts	a list of extra arguments you wish to pass to key(), e.g., key.opts=list(background=1, between=3). The argument names must be spelled out in full.
empty.method	see below
numbins	These two arguments are passed to the largest.empty function's method and numbins arguments (see below). For largest.empty specifies the number of bins in which to discretize both the x and y directions for searching for rectangles. Default is 25.

pl	set to TRUE (or specify add) to cause the curves in curves to be drawn, under the control of type,lty,lwd,col parameters defined either in the curves lists or in the separate arguments given to labcurve or through opts. For largest.empty, set pl=TRUE to show the rectangle the function found by drawing it with a solid color. May not be used under ggplot2.
add	By default, when curves are actually drawn by labcurve a new plot is started. To add to an existing plot, set add=TRUE.
ylim	When a plot has already been started, ylim defaults to par("usr")[3:4]. When pl=TRUE, ylim and xlim are determined from the ranges of the data. Specify ylim yourself to take control of the plot construction. In some cases it is advisable to make ylim larger than usual to allow for automatically-positioned keys. For largest.empty, ylim specifies the limits on the y-axis to limit the search for rectangle. Here ylim defaults to the same as above, i.e., the range of the y-axis of an open plot from par. For drawPlot the default is c(0,1).
xlab	see below
ylab	x-axis and y-axis labels when pl=TRUE and add=FALSE or for drawPlot. Defaults to "" unless the first curve has names for its first two elements, in which case the names of these elements are taken as xlab and ylab.
whichLabel	integer vector corresponding to curves specifying which curves are to be labelled or have a legend
grid	set to TRUE if the R grid package was used to draw the current plot. This prevents labcurve from using par("usr") etc. If using R grid you can pass coordinates and lengths having arbitrary units, as documented in the unit function. This is especially useful for offset.
xrestrict	When having labcurve label curves where they are most separated, you can restrict the search for this separation point to a range of the x-axis, specified as a 2-vector xrestrict. This is useful when one part of the curve is very steep. Even though steep regions may have maximum separation, the labels will collide when curves are steep.
pch	vector of plotting characters for putKey and putKeyEmpty. Can be any value including NA when only a line is used to indentify the group. Is a single plotting character for Points, with the default being the next unused value from among 1, 2, 3, 4, 16, 17, 5, 6, 15, 18, 19.
plot	set to FALSE to keep putKey or putKeyEmpty from actually drawing the key. Instead, the size of the key will be return by putKey, or the coordinates of the key by putKeyEmpty.
ticks	tells drawPlot which axes to draw tick marks and tick labels. Default is "none".
key	for drawPlot and plot.drawPlot. Default is FALSE so that labcurve is used to label points or curves. Set to TRUE to use putKeyEmpty.

Details

The internal functions Points, Curve, Abline have unique arguments as follows.

label: for Points and Curve is a single character string to label that group of points

n: number of points to accept from the mouse. Default is to input points until a right mouse click.

rug: for Points. Default is "none" to not show the marginal x or y distributions as rug plots, for the points entered. Other possibilities are used to execute scat1d to show the marginal distribution of x, y, or both as rug plots.

ymean: for Points, subtracts a constant from each y-coordinate entered to make the overall mean ymean

degree: degree of polynomial to fit to points by Curve

evaluation: number of points at which to evaluate Bezier curves, polynomials, and other functions in Curve

ask: set ask=TRUE to give the user the opportunity to try again at specifying points for Bezier curves, step functions, and polynomials

The labcurve function used some code from the function plot.multicurve written by Rod Tjoelker of The Boeing Company (<tjoelker@espresso.rt.cs.boeing.com>).

If there is only one curve, a label is placed at the middle x-value, and no fancy features such as angle or positive/negative offsets are used.

key is called once (with the argument plot=FALSE) to find the key dimensions. Then an empty rectangle with at least these dimensions is searched for using largest.empty. Then key is called again to draw the key there, using the argument corner=c(.5,.5) so that the center of the rectangle can be specified to key.

If you want to plot the data, an easier way to use labcurve is through xYplot as shown in some of its examples.

Value

labcurve returns an invisible list with components x, y, offset, adj, cex, col, and if tilt=TRUE, angle. offset is the amount to add to y to draw a label. offset is negative if the label is drawn below the line. adj is a vector containing the values 0, .5, 1.

largest.empty returns a list with elements x and y specifying the coordinates of the center of the rectangle which was found, and element rect containing the 4 x and y coordinates of the corners of the found empty rectangle. The area of the rectangle is also returned.

Author(s)

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See Also

approx, text, legend, scat1d, xYplot, abline

Examples

```
n <- 2:8
m <-  length(n)
type <- c('l','l','l','l','s','l','l')
```

```
# s=step function l=ordinary line (polygon)
curves <- vector('list', m)


plot(0,1,xlim=c(0,1),ylim=c(-2.5,4),type='n')


set.seed(39)


for(i in 1:m) {
  x <- sort(runif(n[i]))
  y <- rnorm(n[i])
  lines(x, y, lty=i, type=type[i], col=i)
  curves[[i]] <- list(x=x,y=y)
}


labels <- paste('Label for',letters[1:m])
labcurve(curves, labels, tilt=TRUE, type=type, col=1:m)


# Put only single letters on curves at points of
# maximum space, and use key() to define the letters,
# with automatic positioning of the key in the most empty
# part of the plot
# Have labcurve do the plotting, leaving extra space for key


names(curves) <- labels
labcurve(curves, keys=letters[1:m], type=type, col=1:m,
         pl=TRUE, ylim=c(-2.5,4))


# Put plotting symbols at equally-spaced points,
# with a key for the symbols, ignoring line types


labcurve(curves, keys=1:m, lty=1, type=type, col=1:m,
         pl=TRUE, ylim=c(-2.5,4))




# Plot and label two curves, with line parameters specified with data
set.seed(191)
ages.f <- sort(rnorm(50,20,7))
ages.m <- sort(rnorm(40,19,7))
height.f <- pmin(ages.f,21)*.2+60
height.m <- pmin(ages.m,21)*.16+63


labcurve(list(Female=list(ages.f,height.f,col=2),
```

```
              Male  =list(ages.m,height.m,col=3,lty='dashed')),
         xlab='Age', ylab='Height', pl=TRUE)
# add ,keys=c('f','m') to label curves with single letters
# For S-Plus use lty=2


# Plot power for testing two proportions vs. n for various odds ratios,
# using 0.1 as the probability of the event in the control group.
# A separate curve is plotted for each odds ratio, and the curves are
# labeled at points of maximum separation


n  <- seq(10, 1000, by=10)
OR <- seq(.2,.9,by=.1)
pow <- lapply(OR, function(or,n)list(x=n,y=bpower(p1=.1,odds.ratio=or,n=n)),
              n=n)
names(pow) <- format(OR)
labcurve(pow, pl=TRUE, xlab='n', ylab='Power')


# Plot some random data and find the largest empty rectangle
# that is at least .1 wide and .1 tall


x <- runif(50)
y <- runif(50)
plot(x, y)
z <- largest.empty(x, y, .1, .1)
z
points(z,pch=3)  # mark center of rectangle, or
polygon(z$rect, col='blue')  # to draw the rectangle, or
#key(z$x, z$y, \dots stuff for legend)




# Use the mouse to draw a series of points using one symbol, and
# two smooth curves or straight lines (if two points are clicked),
# none of these being labeled


# d <- drawPlot(Points(), Curve(), Curve())
# plot(d)


## Not run:
# Use the mouse to draw a Gaussian density, two series of points
# using 2 symbols, one Bezier curve, a step function, and raw data
# along the x-axis as a 1-d scatter plot (rug plot).  Draw a key.
# The density function is fit to 3 mouse clicks
# Abline draws a dotted horizontal reference line
d <- drawPlot(Curve('Normal',type='gauss'),
              Points('female'), Points('male'),
```

```
              Curve('smooth',ask=TRUE,lty=2), Curve('step',type='s',lty=3),
              Points(type='r'), Abline(h=.5, lty=2),
              xlab='X', ylab='y', xlim=c(0,100), key=TRUE)
plot(d, ylab='Y')
plot(d, key=FALSE)  # label groups using labcurve

## End(Not run)
```

`label` *Label Attribute of an Object*

Description

`label(x)` retrieves the `label` attribute of `x`. `label(x) <- "a label"` stores the label attribute, and also puts the class `labelled` as the first class of `x` (for S-Plus this class is not used and methods for handling this class are not defined so the `"label"` and `"units"` attributes are lost upon subsetting). The reason for having this class is so that the subscripting method for `labelled`, `[.labelled`, can preserve the `label` attribute in S. Also, the `print` method for `labelled` objects prefaces the print with the object's `label` (and `units` if there). If the variable is also given a `"units"` attribute using the `units` function, subsetting the variable (using `[.labelled`) will also retain the `"units"` attribute.

`label` can optionally append a `"units"` attribute to the string, and it can optionally return a string or expression (for R's `plotmath` facility) suitable for plotting. `labelPlotmath` is a function that also has this function, when the input arguments are the `'label'` and `'units'` rather than a vector having those attributes. When `plotmath` mode is used to construct labels, the `'label'` or `'units'` may contain math expressions but they are typed verbatim if they contain percent signs, blanks, or underscores. `labelPlotmath` can optionally create the expression as a character string, which is useful in building `ggplot` commands.

For `Surv` objects, `label` first looks to see if there is an overall `"label"` attribute for the object, then it looks for saved attributes that `Surv` put in the `"inputAttributes"` object, looking first at the `event` variable, then `time2`, and finally `time`. You can restrict the looking by specifying `type`.

`labelLatex` constructs suitable LaTeX labels a variable or from the `label` and `units` arguments, optionally right-justifying `units` if `hfill=TRUE`. This is useful when making tables when the variable in question is not a column heading. If `x` is specified, `label` and `units` values are extracted from its attributes instead of from the other arguments.

`Label` (actually `Label.data.frame`) is a function which generates S source code that makes the labels in all the variables in a data frame easy to edit.

`llist` is like `list` except that it preserves the names or labels of the component variables in the variables `label` attribute. This can be useful when looping over variables or using `sapply` or `lapply`. By using `llist` instead of `list` one can annotate the output with the current variable's name or label. `llist` also defines a `names` attribute for the list and pulls the `names` from the arguments' expressions for non-named arguments.

`prList` prints a list with element names (without the dollar sign as in default list printing) and if an element of the list is an unclassed list with a name, all of those elements are printed, with titles of the form "primary list name : inner list name". This is especially useful for Rmarkdown html notebooks

when a user-written function creates multiple html and graphical outputs to all be printed in a code chunk. Optionally the names can be printed after the object, and the `htmlfig` option provides more capabilities when making html reports. `prList` does not work for regular html documents.

`putHfig` is similar to `prList` but for a single graphical object that is rendered with a `print` method, making it easy to specify long captions, and short captions for the table of contents in HTML documents. Table of contents entries are generated with the short caption, which is taken as the long caption if there is none. One can optionally not make a table of contents entry. If argument `table=TRUE` table captions will be produced instead. Using `expcoll`, `markupSpecs` `html` function `expcoll` will be used to make tables expand upon clicking an arrow rather than always appear.

`putHcap` is like `putHfig` except that it assumes that users render the graphics or table outside of the `putHcap` call. This allows things to work in ordinary html documents. `putHcap` does not handle collapsed text.

`plotmathTranslate` is a simple function that translates certain character strings to character strings that can be used as part of R `plotmath` expressions. If the input string has a space or percent inside, the string is surrounded by a call to `plotmath`'s `paste` function.

`as.data.frame.labelled` is a utility function that is called by `[.data.frame`. It is just a copy of `as.data.frame.vector`. `data.frame.labelled` is another utility function, that adds a class `"labelled"` to every variable in a data frame that has a `"label"` attribute but not a `"labelled"` class.

`relevel.labelled` is a method for preserving `labels` with the `relevel` function.

`reLabelled` is used to add a `'labelled'` class back to variables in data frame that have a 'label' attribute but no 'labelled' class. Useful for changing `cleanup.import()`'d S-Plus data frames back to general form for R and old versions of S-Plus.

Usage

```
label(x, default=NULL, ...)

## Default S3 method:
label(x, default=NULL, units=plot, plot=FALSE,
      grid=FALSE, html=FALSE, ...)

## S3 method for class 'Surv'
label(x, default=NULL, units=plot, plot=FALSE,
      grid=FALSE, html=FALSE, type=c('any', 'time', 'event'), ...)

## S3 method for class 'data.frame'
label(x, default=NULL, self=FALSE, ...)

label(x, ...) <- value

## Default S3 replacement method:
label(x, ...) <- value

## S3 replacement method for class 'data.frame'
label(x, self=TRUE, ...) <- value
```

```
labelPlotmath(label, units=NULL, plotmath=TRUE, html=FALSE, grid=FALSE,
              chexpr=FALSE)

labelLatex(x=NULL, label='', units='', size='smaller[2]',
           hfill=FALSE, bold=FALSE, default='', double=FALSE)

## S3 method for class 'labelled'
print(x, ...)   ## or x - calls print.labelled

Label(object, ...)

## S3 method for class 'data.frame'
Label(object, file='', append=FALSE, ...)

llist(..., labels=TRUE)

prList(x, lcap=NULL, htmlfig=0, after=FALSE)

putHfig(x, ..., scap=NULL, extra=NULL, subsub=TRUE, hr=TRUE,
        table=FALSE, file='', append=FALSE, expcoll=NULL)

putHcap(..., scap=NULL, extra=NULL, subsub=TRUE, hr=TRUE,
        table=FALSE, file='', append=FALSE)

plotmathTranslate(x)

data.frame.labelled(object)

## S3 method for class 'labelled'
relevel(x, ...)

reLabelled(object)

combineLabels(...)
```

Arguments

x	any object (for plotmathTranslate is a character string). For relevel is a factor variable. For prList is a named list. For putHfig is a graphical object for which a print method will render the graphic (e.g., a ggplot2 or plotly object).
self	lgoical, where to interact with the object or its components
units	set to TRUE to append the 'units' attribute (if present) to the returned label. The 'units' are surrounded by brackets. For labelPlotmath and labelLatex is a character string containing the units of measurement. When plot is TRUE, units defaults to TRUE.
plot	set to TRUE to return a label suitable for R's plotmath facility (returns an expression instead of a character string) if R is in effect. If units is also TRUE, and if

	both 'label' and 'units' attributes are present, the 'units' will appear after the label but in smaller type and will not be surrounded by brackets.
default	if x does not have a 'label' attribute and default (a character string) is specified, the label will be taken as default. For labelLatex the default is the name of the first argument if it is a variable and not a label.
grid	Currently R's lattice and grid functions do not support plotmath expressions for xlab and ylab arguments. When using lattice functions in R, set the argument grid to TRUE so that labelPlotmath can return an ordinary character string instead of an expression.
html	set to TRUE to use HTML formatting instead of plotmath expressions for constructing labels with units
type	for Surv objects specifies the type of element for which to restrict the search for a label
label	a character string containing a variable's label
plotmath	set to TRUE to have labelMathplot return an expression for plotting using R's plotmath facility. If R is not in effect, an ordinary character string is returned.
chexpr	set to TRUE to have labelPlotmath return a character string of the form "expression(...)"
size	LaTeX size for units. Default is two sizes smaller than label, which assumes that the LaTeX relsize package is in use.
hfill	set to TRUE to right-justify units in the field. This is useful when multiple labels are being put into rows in a LaTeX tabular environment, and will cause a problem if the label is used in an environment where hfill is not appropriate.
bold	set to TRUE to have labelLatex put the label in bold face.
double	set to TRUE to represent backslash in LaTeX as four backslashes in place of two. This is needed if, for example, you need to convert the result using as.formula
value	the label of the object, or "".
object	a data frame
...	a list of variables or expressions to be formed into a list. Ignored for print.labelled. For relevel is the level (a single character string) to become the new reference (first) category. For putHfig and putHcap represents one or more character strings that are pasted together, separated by a blank.
file	the name of a file to which to write S source code. Default is "", meaning standard output. For putHcap, set file to FALSE to return a character vector instead of writing to file.
append	set to TRUE to append code generated by Label to file file. Also used for putHfig, putHcap.
labels	set to FALSE to make llist ignore the variables' label attribute and use the variables' names.
lcap	an optional vector of character strings corresponding to elements in x for prList. These contain long captions that do not appear in the table of contents but which are printed right after the short caption in the body, in the same font.
htmlfig	for prList set to 1 to use HTML markup by running the object names through markupSpecs$html$cap for figure captions. Set htmlfig=2 to also preface the figure caption with "### " so that it will appear in the table of contents.

after	set to TRUE to have prList put names after the printed object instead of before
scap	a character string specifying the short (or possibly only) caption.
extra	an optional vector of character strings. When present the long caption will be put in the first column of an HTML table and the elements of extra in subsequent columns. This allows extra information to appear in the long caption in a way that is right-justified to the right of the flowing caption text.
subsub	set to FALSE to suppress "### " from being placed in front of the short caption. Set it to different character string to use that instead. Set it to "" to ignore short captions entirely. For example to use second-level headings for the table of contents specify subsub="## ".
hr	applies if a caption is present. Specify FALSE to not put a horizontal line before the caption and figure.
table	set to TRUE to produce table captions instead of figure captions
expcoll	character string to be visible, with a clickable arrow following to allow initial hiding of a table and its captions. Cannot be used with table=FALSE.

Value

label returns the label attribute of x, if any; otherwise, "". label is used most often for the individual variables in data frames. The function sas.get copies labels over from SAS if they exist.

See Also

sas.get, describe, extractlabs, hlab

Examples

```
age <- c(21,65,43)
y   <- 1:3
label(age) <- "Age in Years"
plot(age, y, xlab=label(age))

data <- data.frame(age=age, y=y)
label(data)

label(data, self=TRUE) <- "A data frame"
label(data, self=TRUE)

x1 <- 1:10
x2 <- 10:1
label(x2) <- 'Label for x2'
units(x2) <- 'mmHg'
x2
x2[1:5]
dframe <- data.frame(x1, x2)
Label(dframe)

labelLatex(x2, hfill=TRUE, bold=TRUE)
```

```
labelLatex(label='Velocity', units='m/s')

##In these examples of llist, note that labels are printed after
##variable names, because of print.labelled
a <- 1:3
b <- 4:6
label(b) <- 'B Label'
llist(a,b)
llist(a,b,d=0)
llist(a,b,0)


w <- llist(a, b>5, d=101:103)
sapply(w, function(x){
  hist(as.numeric(x), xlab=label(x))
  # locator(1)   ## wait for mouse click
})

# Or: for(u in w) {hist(u); title(label(u))}
```

Lag *Lag a Numeric, Character, or Factor Vector*

Description

Shifts a vector `shift` elements later. Character or factor variables are padded with `""`, numerics with `NA`. The shift may be negative.

Usage

```
Lag(x, shift = 1)
```

Arguments

`x`	a vector
`shift`	integer specifying the number of observations to be shifted to the right. Negative values imply shifts to the left.

Details

A.ttributes of the original object are carried along to the new lagged one.

Value

a vector like `x`

Author(s)

Frank Harrell

See Also

lag

Examples

```
Lag(1:5,2)
Lag(letters[1:4],2)
Lag(factor(letters[1:4]),-2)
# Find which observations are the first for a given subject
id <- c('a','a','b','b','b','c')
id != Lag(id)
!duplicated(id)
```

---

latestFile *latestFile*

Description

Find File With Latest Modification Time

Usage

```
latestFile(pattern, path = ".", verbose = TRUE)
```

Arguments

pattern	a regular expression; see base::list.files()
path	full path, defaulting to current working directory
verbose	set to FALSE to not report on total number of matching files

Details

Subject to matching on pattern finds the last modified file, and if verbose is TRUE reports on how many total files matched pattern.

Value

the name of the last modified file

Author(s)

Frank Harrell

See Also

base::list.files()

latex *Convert an S object to LaTeX, and Related Utilities*

Description

latex converts its argument to a '.tex' file appropriate for inclusion in a LaTeX2e document. latex is a generic function that calls one of latex.default, latex.function, latex.list.

latex.default does appropriate rounding and decimal alignment and produces a file containing a LaTeX tabular environment to print the matrix or data.frame x as a table.

latex.function prepares an S function for printing by issuing sed commands that are similar to those in the S.to.latex procedure in the s.to.latex package (Chambers and Hastie, 1993). latex.function can also produce verbatim output or output that works with the Sweavel LaTeX style.

latex.list calls latex recursively for each element in the argument.

latexTranslate translates particular items in character strings to LaTeX format, e.g., makes 'a^2 = a\$^2\$' for superscript within variable labels. LaTeX names of greek letters (e.g., "alpha") will have backslashes added if greek==TRUE. Math mode is inserted as needed. latexTranslate assumes that input text always has matches, e.g. [) [] (] (), and that surrounding by '\$\$' is OK.

htmlTranslate is similar to latexTranslate but for html translation. It doesn't need math mode and assumes dollar signs are just that.

latexSN converts a vector floating point numbers to character strings using LaTeX exponents. Dollar signs to enter math mode are not added. Similarly, htmlSN converts to scientific notation in html.

latexVerbatim on an object executes the object's print method, capturing the output for a file inside a LaTeX verbatim environment.

dvi uses the system latex command to compile LaTeX code produced by latex, including any needed styles. dvi will put a '\documentclass{report}' and '\end{document}' wrapper around a file produced by latex. By default, the 'geometry' LaTeX package is used to omit all margins and to set the paper size to a default of 5.5in wide by 7in tall. The result of dvi is a .dvi file. To both format and screen display a non-default size, use for example print(dvi(latex(x), width=3, height=4),width=3,height=4). Note that you can use something like 'xdvi -geometry 460x650 -margins 2.25in file' without changing LaTeX defaults to emulate this.

dvips will use the system dvips command to print the .dvi file to the default system printer, or create a postscript file if file is specified.

dvigv uses the system dvips command to convert the input object to a .dvi file, and uses the system dvips command to convert it to postscript. Then the postscript file is displayed using Ghostview (assumed to be the system command gv).

There are show methods for displaying typeset LaTeX on the screen using the system xdvi command. If you show a LaTeX file created by latex without running it through dvi using show.dvi(object), the show method will run it through dvi automatically. These show methods are not S Version 4 methods so you have to use full names such as show.dvi and show.latex. Use the print methods for more automatic display of typesetting, e.g. typing latex(x) will invoke xdvi to view the typeset document.

Usage

```
latex(object, ...)

## Default S3 method:
latex(object,
    title=first.word(deparse(substitute(object))),
    file=paste(title, ".tex", sep=""),
    append=FALSE, label=title,
    rowlabel=title, rowlabel.just="l",
    cgroup=NULL, n.cgroup=NULL,
    rgroup=NULL, n.rgroup=NULL,
    cgroupTexCmd="bfseries",
    rgroupTexCmd="bfseries",
    rownamesTexCmd=NULL,
    colnamesTexCmd=NULL,
    cellTexCmds=NULL,
    rowname, cgroup.just=rep("c",length(n.cgroup)),
    colheads=NULL,
    extracolheads=NULL, extracolsize='scriptsize',
    dcolumn=FALSE, numeric.dollar=!dcolumn, cdot=FALSE,
    longtable=FALSE, draft.longtable=TRUE, ctable=FALSE, booktabs=FALSE,
    table.env=TRUE, here=FALSE, lines.page=40,
    caption=NULL, caption.lot=NULL, caption.loc=c('top','bottom'),
    star=FALSE,
    double.slash=FALSE,
    vbar=FALSE, collabel.just=rep("c",nc), na.blank=TRUE,
    insert.bottom=NULL, insert.bottom.width=NULL,
    insert.top=NULL,
    first.hline.double=!(booktabs | ctable),
    where='!tbp', size=NULL,
    center=c('center','centering','centerline','none'),
    landscape=FALSE,
    multicol=TRUE,
    math.row.names=FALSE, already.math.row.names=FALSE,
    math.col.names=FALSE, already.math.col.names=FALSE,
    hyperref=NULL, continued='continued',
    ...) # x is a matrix or data.frame

## S3 method for class 'function'
latex(
 object,
 title=first.word(deparse(substitute(object))),
 file=paste(title, ".tex", sep=""),
 append=FALSE,
 assignment=TRUE,  type=c('example','verbatim','Sinput'),
    width.cutoff=70, size='', ...)

## S3 method for class 'list'
```

```
latex(
           object,
           title=first.word(deparse(substitute(object))),
           file=paste(title, ".tex", sep=""),
           append=FALSE,
           label,
           caption,
           caption.lot,
           caption.loc=c('top','bottom'),
           ...)

## S3 method for class 'latex'
print(x, ...)

latexTranslate(object, inn=NULL, out=NULL, pb=FALSE, greek=FALSE, na='',
               ...)

htmlTranslate(object, inn=NULL, out=NULL, greek=FALSE, na='',
              code=htmlSpecialType(), ...)

latexSN(x)

htmlSN(x, pretty=TRUE, ...)

latexVerbatim(x, title=first.word(deparse(substitute(x))),
    file=paste(title, ".tex", sep=""),
    append=FALSE, size=NULL, hspace=NULL,
    width=.Options$width, length=.Options$length, ...)

dvi(object, ...)
## S3 method for class 'latex'
dvi(object, prlog=FALSE, nomargins=TRUE, width=5.5, height=7, ...)
## S3 method for class 'dvi'
print(x, ...)
dvips(object, ...)
## S3 method for class 'latex'
dvips(object, ...)
## S3 method for class 'dvi'
dvips(object, file, ...)
## S3 method for class 'latex'
show(object)  # or show.dvi(object) or just object
dvigv(object, ...)
## S3 method for class 'latex'
dvigv(object, ...)       # or gvdvi(dvi(object))
## S3 method for class 'dvi'
dvigv(object, ...)
```

Arguments

object	For latex, any S object. For dvi or dvigv, an object created by latex. For latexTranslate is a vector of character strings to translate. Any NAs are set to blank strings before conversion.
x	any object to be printed verbatim for latexVerbatim. For latexSN or htmlSN, x is a numeric vector.
title	name of file to create without the '.tex' extension. If this option is not set, value/string of x (see above) is printed in the top left corner of the table. Set title='' to suppress this output.
file	name of the file to create. The default file name is 'x.tex' where x is the first word in the name of the argument for x. Set file="" to have the generated LaTeX code just printed to standard output. This is especially useful when running under Sweave in R using its 'results=tex' tag, to save having to manage many small external files. When file="", latex keeps track of LaTeX styles that are called for by creating or modifying an object latexStyles (in .GlobalTemp in R or in frame 0 in S-Plus). latexStyles is a vector containing the base names of all the unique LaTeX styles called for so far in the current session. See the end of the examples section for a way to use this object to good effect. For dvips, file is the name of an output postscript file.
append	defaults to FALSE. Set to TRUE to append output to an existing file.
label	a text string representing a symbolic label for the table for referencing in the LaTeX '\label' and '\ref' commands. label is only used if caption is given.
rowlabel	If x has row dimnames, rowlabel is a character string containing the column heading for the row dimnames. The default is the name of the argument for x.
rowlabel.just	If x has row dimnames, specifies the justification for printing them. Possible values are "l", "r", "c". The heading (rowlabel) itself is left justified if rowlabel.just="l", otherwise it is centered.
cgroup	a vector of character strings defining major column headings. The default is to have none.
n.cgroup	a vector containing the number of columns for which each element in cgroup is a heading. For example, specify cgroup=c("Major 1","Major 2"), n.cgroup=c(3,3) if "Major 1" is to span columns 1-3 and "Major 2" is to span columns 4-6. rowlabel does not count in the column numbers. You can omit n.cgroup if all groups have the same number of columns.
rgroup	a vector of character strings containing headings for row groups. n.rgroup must be present when rgroup is given. The first n.rgroup[1] rows are sectioned off and rgroup[1] is used as a bold heading for them. The usual row dimnames (which must be present if rgroup is) are indented. The next n.rgroup[2] rows are treated likewise, etc.
n.rgroup	integer vector giving the number of rows in each grouping. If rgroup is not specified, n.rgroup is just used to divide off blocks of rows by horizontal lines. If rgroup is given but n.rgroup is omitted, n.rgroup will default so that each row group contains the same number of rows.

cgroupTexCmd A character string specifying a LaTeX command to be used to format column group labels. The default, "bfseries", sets the current font to 'bold'. It is possible to supply a vector of strings so that each column group label is formatted differently. Please note that the first item of the vector is used to format the title (even if a title is not used). Currently the user needs to handle these issue. Multiple effects can be achieved by creating custom LaTeX commands; for example, "\providecommand{\redscshape}{\color{red}\scshape}" creates a LaTeX command called '\redscshape' that formats the text in red small-caps.

rgroupTexCmd A character string specifying a LaTeX command to be used to format row group labels. The default, "bfseries", sets the current font to 'bold'. A vector of strings can be supplied to format each row group label differently. Normal recycling applies if the vector is shorter than n.rgroups. See also cgroupTexCmd above regarding multiple effects.

rownamesTexCmd A character string specifying a LaTeX command to be used to format rownames. The default, NULL, applies no command. A vector of different commands can also be supplied. See also cgroupTexCmd above regarding multiple effects.

colnamesTexCmd A character string specifying a LaTeX command to be used to format column labels. The default, NULL, applies no command. It is possible to supply a vector of strings to format each column label differently. If column groups are not used, the first item in the vector will be used to format the title. Please note that if column groups are used the first item of cgroupTexCmd and not colnamesTexCmd is used to format the title. The user needs to allow for these issues when supplying a vector of commands. See also cgroupTexCmd above regarding multiple effects.

cellTexCmds A matrix of character strings which are LaTeX commands to be used to format each element, or cell, of the object. The matrix must have the same NROW() and NCOL() as the object. The default, NULL, applies no formats. Empty strings also apply no formats, and one way to start might be to create a matrix of empty strings with matrix(rep("", NROW(x) * NCOL(x)), nrow=NROW(x)) and then selectively change appropriate elements of the matrix. Note that you might need to set numeric.dollar=FALSE (to disable math mode) for some effects to work. See also cgroupTexCmd above regarding multiple effects.

na.blank Set to TRUE to use blanks rather than NA for missing values. This usually looks better in latex.

insert.bottom an optional character string to typeset at the bottom of the table. For "ctable" style tables, this is placed in an unmarked footnote.

insert.bottom.width
character string; a tex width controlling the width of the insert.bottom text. Currently only does something with using longtable=TRUE.

insert.top a character string to insert as a heading right before beginning tabular environment. Useful for multiple sub-tables.

first.hline.double
set to FALSE to use single horizontal rules for styles other than "bookmark" or "ctable"

rowname rownames for tabular environment. Default is rownames of matrix or data.frame. Specify rowname=NULL to suppress the use of row names.

cgroup.just	justification for labels for column groups. Defaults to "c".
colheads	a character vector of column headings if you don't want to use dimnames(object)[[2]]. Specify colheads=FALSE to suppress column headings.
extracolheads	an optional vector of extra column headings that will appear under the main headings (e.g., sample sizes). This character vector does not need to include an empty space for any rowname in effect, as this will be added automatically. You can also form subheadings by splitting character strings defining the column headings using the usual backslash n newline character.
extracolsize	size for extracolheads or for any second lines in column names; default is "scriptsize"
dcolumn	see format.df
numeric.dollar	logical, default !dcolumn. Set to TRUE to place dollar signs around numeric values when dcolumn=FALSE. This assures that latex will use minus signs rather than hyphens to indicate negative numbers. Set to FALSE when dcolumn=TRUE, as dcolumn.sty automatically uses minus signs.
math.row.names	logical, set true to place dollar signs around the row names.
already.math.row.names	set to TRUE to prevent any math mode changes to row names
math.col.names	logical, set true to place dollar signs around the column names.
already.math.col.names	set to TRUE to prevent any math mode changes to column names
hyperref	if table.env=TRUE is a character string used to generate a LaTeX hyperref enclosure
continued	a character string used to indicate pages after the first when making a long table
cdot	see format.df
longtable	Set to TRUE to use David Carlisle's LaTeX longtable style, allowing long tables to be split over multiple pages with headers repeated on each page. The "style" element is set to "longtable". The latex '\usepackage' must reference '[longtable]'. The file 'longtable.sty' will need to be in a directory in your TEXINPUTS path.
draft.longtable	I forgot what this does.
ctable	set to TRUE to use Wybo Dekker's 'ctable' style from CTAN. Even though for historical reasons it is not the default, it is generally the preferred method. Thicker but not doubled '\hline's are used to start a table when ctable is in effect.
booktabs	set booktabs=TRUE to use the 'booktabs' style of horizontal rules for better tables. In this case, double '\hline's are not used to start a table.
table.env	Set table.env=FALSE to suppress enclosing the table in a LaTeX 'table' environment. table.env only applies when longtable=FALSE. You may not specify a caption if table.env=FALSE.
here	Set to TRUE if you are using table.env=TRUE with longtable=FALSE and you have installed David Carlisle's 'here.sty' LaTeX style. This will cause the LaTeX 'table' environment to be set up with option 'H' to guarantee that the table

will appear exactly where you think it will in the text. The "style" element is set to "here". The latex '\usepackage' must reference '[here]'. The file 'here.sty' will need to be in a directory in your TEXINPUTS path. 'here' is largely obsolete with LaTeX2e.

lines.page — Applies if longtable=TRUE. No more than lines.page lines in the body of a table will be placed on a single page. Page breaks will only occur at rgroup boundaries.

caption — a text string to use as a caption to print at the top of the first page of the table. Default is no caption.

caption.lot — a text string representing a short caption to be used in the "List of Tables". By default, LaTeX will use caption. If you get inexplicable 'latex' errors, you may need to supply caption.lot to make the errors go away.

caption.loc — set to "bottom" to position a caption below the table instead of the default of "top".

star — apply the star option for ctables to allow a table to spread over two columns when in twocolumn mode.

double.slash — set to TRUE to output '"\"' as '"\\"' in LaTeX commands. Useful when you are reading the output file back into an S vector for later output.

vbar — logical. When vbar==TRUE, columns in the tabular environment are separated with vertical bar characters. When vbar==FALSE, columns are separated with white space. The default, vbar==FALSE, produces tables consistent with the style sheet for the Journal of the American Statistical Association.

collabel.just — justification for column labels.

assignment — logical. When TRUE, the default, the name of the function and the assignment arrow are printed to the file.

where — specifies placement of floats if a table environment is used. Default is "!tbp". To allow tables to appear in the middle of a page of text you might specify where="!htbp" to latex.default.

size — size of table text if a size change is needed (default is no change). For example you might specify size="small" to use LaTeX font size "small". For latex.function is a character string that will be appended to "Sinput" such as "small".

center — default is "center" to enclose the table in a 'center' environment. Use center="centering" or "centerline" to instead use LaTeX 'centering' or centerline directives, or center="none" to use no centering. centerline can be useful when objects besides a tabular are enclosed in a single table environment. This option was implemented by Markus Jï¿½ntti <markus.jantti@iki.fi> of Abo Akademi University.

landscape — set to TRUE to enclose the table in a 'landscape' environment. When ctable is TRUE, will use the rotate argument to ctable.

type — The default uses the S alltt environment for latex.function, Set type="verbatim" to instead use the LaTeX 'verbatim' environment. Use type="Sinput" if using Sweave, especially if you have customized the Sinput environment, for example using the Sweavel style which uses the listings LaTeX package.

width.cutoff	width of function text output in columns; see deparse
...	other arguments are accepted and ignored except that latex passes arguments to format.df (e.g., col.just and other formatting options like dec, rdec, and cdec). For latexVerbatim these arguments are passed to the print function. Ignored for latexTranslate and htmlTranslate. For htmlSN, these arguments are passed to prettyNum or format.
inn, out	specify additional input and translated strings over the usual defaults
pb	If pb=TRUE, latexTranslate also translates '[()]' to math mode using '\left, \right'.
greek	set to TRUE to have latexTranslate put names for greek letters in math mode and add backslashes. For htmlTranslate, translates greek letters to corresponding html characters, ignoring "modes".
na	single character string to translate NA values to for latexTranslate and htmlTranslate
code	set to 'unicode' to use HTML unicode characters or '&' to use the ampersand pound number format
pretty	set to FALSE to have htmlSN use format instead of prettyNum
hspace	horizontal space, e.g., extra left margin for verbatim text. Default is none. Use e.g. hspace="10ex" to add 10 extra spaces to the left of the text.
length	for S-Plus only; is the length of the output page for printing and capturing verbatim text
width, height	are the options( ) to have in effect only for when print is executed. Defaults are current options. For dvi these specify the paper width and height in inches if nomargins=TRUE, with defaults of 5.5 and 7, respectively.
prlog	set to TRUE to have dvi print, to the S-Plus session, the LaTeX .log file.
multicol	set to FALSE to not use '\multicolumn' in header of table
nomargins	set to FALSE to use default LaTeX margins when making the .dvi file

Details

latex.default optionally outputs a LaTeX comment containing the calling statement. To output this comment, run options(omitlatexcom=FALSE) before running. The default behavior or suppressing the comment is helpful when running RMarkdown to produce pdf output using LaTeX, as this uses pandoc which is fooled into try to escape the percent comment symbol.

If running under Windows and using MikTeX, latex and yap must be in your system path, and yap is used to browse '.dvi' files created by latex. You should install the 'geometry.sty' and 'ctable.sty' styles in MikTeX to make optimum use of latex().

On Mac OS X, you may have to append the '/usr/texbin' directory to the system path. Thanks to Kevin Thorpe (<kevin.thorpe@utoronto.ca>) one way to set up Mac OS X is to install 'X11' and 'X11SDK' if not already installed, start 'X11' within the R GUI, and issue the command Sys.setenv(PATH=paste(Sys.getenv("PATH"),"/usr/texbin",sep=":")). To avoid any complications of using 'X11' under MacOS, users can install the 'TeXShop' package, which will associate '.dvi' files with a viewer that displays a 'pdf' version of the file after a hidden conversion from 'dvi' to 'pdf'.

System options can be used to specify external commands to be used. Defaults are given by `options(xdvicmd='xdvi')` or `options(xdvicmd='yap')`, `options(dvipscmd='dvips')`, `options(latexcmd='latex')` For MacOS specify `options(xdvicmd='MacdviX')` or if TeXShop is installed, `options(xdvicmd='open')`.

To use 'pdflatex' rather than 'latex', set `options(latexcmd='pdflatex')`, `options(dviExtension='pdf')`, and set `options('xdvicmd')` to your chosen PDF previewer.

If running S-Plus and your directory for temporary files is not '/tmp' (Unix/Linux) or '\windows\temp' (Windows), add your own `tempdir` function such as `tempdir <- function() "/yourmaindirectory/yoursubdirectory"`

To prevent the latex file from being displayed store the result of `latex` in an object, e.g. `w <- latex(object, file='foo.tex')`.

Value

`latex` and `dvi` return a list of class `latex` or `dvi` containing character string elements `file` and `style`. `file` contains the name of the generated file, and `style` is a vector (possibly empty) of styles to be included using the LaTeX2e '\usepackage' command.

`latexTranslate` returns a vector of character strings

Side Effects

creates various system files and runs various Linux/UNIX system commands which are assumed to be in the system path.

Author(s)

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See Also

`html`, `format.df`, `texi2dvi`

Examples

```
x <- matrix(1:6, nrow=2, dimnames=list(c('a','b'),c('c','d','this that')))
## Not run:
latex(x)   # creates x.tex in working directory
# The result of the above command is an object of class "latex"
# which here is automatically printed by the latex print method.
```

```
# The latex print method prepends and appends latex headers and
# calls the latex program in the PATH.  If the latex program is
# not in the PATH, you will get error messages from the operating
# system.

w <- latex(x, file='/tmp/my.tex')
# Does not call the latex program as the print method was not invoked
print.default(w)
# Shows the contents of the w variable without attempting to latex it.

d <- dvi(w)  # compile LaTeX document, make .dvi
             # latex assumed to be in path
d            # or show(d) : run xdvi (assumed in path) to display
w            # or show(w) : run dvi then xdvi
dvips(d)     # run dvips to print document
dvips(w)     # run dvi then dvips
library(tools)
texi2dvi('/tmp/my.tex')   # compile and produce pdf file in working dir.

## End(Not run)
latex(x, file="")   # just write out LaTeX code to screen

## Not run:
# Use paragraph formatting to wrap text to 3 in. wide in a column
d <- data.frame(x=1:2,
                y=c(paste("a",
                    paste(rep("very",30),collapse=" "),"long string"),
                "a short string"))
latex(d, file="", col.just=c("l", "p{3in}"), table.env=FALSE)

## End(Not run)

## Not run:
# After running latex( ) multiple times with different special styles in
# effect, make a file that will call for the needed LaTeX packages when
# latex is run (especially when using Sweave with R)
if(exists(latexStyles))
  cat(paste('\usepackage{',latexStyles,'}',sep=''),
      file='stylesused.tex', sep='\n')
# Then in the latex job have something like:
# \documentclass{article}
# \input{stylesused}
# \begin{document}
# ...

## End(Not run)
```

`latexCheckOptions` *Check whether the options for latex functions have been specified.*

Description

Check whether the options for latex functions have been specified. If any of `options()[c("latexcmd","dviExtension","xdvicmd")]` are `NULL`, an error message is displayed.

Usage

```
latexCheckOptions(...)
```

Arguments

...	Any arguments are ignored.

Value

If any `NULL` options are detected, the invisible text of the error message. If all three options have non-`NULL` values, NULL.

Author(s)

Richard M. Heiberger <rmh@temple.edu>

See Also

`latex`

---

latexDotchart *Enhanced Dot Chart for LaTeX Picture Environment with epic*

Description

`latexDotchart` is a translation of the `dotchart3` function for producing a vector of character strings containing LaTeX picture environment markup that mimics `dotchart3` output. The LaTeX `epic` and `color` packages are required. The `add` and `horizontal=FALSE` options are not available for `latexDotchart`, however.

Usage

```
latexDotchart(data, labels, groups=NULL, gdata=NA,
  xlab='', auxdata, auxgdata=NULL, auxtitle,
  w=4, h=4, margin,
  lines=TRUE, dotsize = .075, size='small', size.labels='small',
  size.group.labels='normalsize', ttlabels=FALSE, sort.=TRUE,
  xaxis=TRUE, lcolor='gray', ...)
```

Arguments

data	a numeric vector whose values are shown on the x-axis
labels	a vector of labels for each point, corresponding to x. If omitted, names(data) are used, and if there are no names, integers prefixed by "#" are used.
groups	an optional categorical variable indicating how data values are grouped
gdata	data values for groups, typically summaries such as group medians
xlab	x-axis title
auxdata	a vector of auxiliary data, of the same length as the first (data) argument. If present, this vector of values will be printed outside the right margin of the dot chart. Usually auxdata represents cell sizes.
auxgdata	similar to auxdata but corresponding to the gdata argument. These usually represent overall sample sizes for each group of lines.
auxtitle	if auxdata is given, auxtitle specifies a column heading for the extra printed data in the chart, e.g., "N"
w	width of picture in inches
h	height of picture in inches
margin	a 4-vector representing, in inches, the margin to the left of the x-axis, below the y-axis, to the right of the x-axis, and above the y-axis. By default these are computed making educated cases about how to accommodate auxdata etc.
lines	set to FALSE to suppress drawing of reference lines
dotsize	diameter of filled circles, in inches, for drawing dots
size	size of text in picture. This and the next two arguments are LaTeX font commands without the opening backslash, e.g., 'normalsize', 'small', 'large', smaller[2].
size.labels	size of labels
size.group.labels	size of labels corresponding to groups
ttlabels	set to TRUE to use typewriter monospaced font for labels
sort.	set to FALSE to keep latexDotchart from sorting the input data, i.e., it will assume that the data are already properly arranged. This is especially useful when you are using gdata and groups and you want to control the order that groups appear on the chart (from top to bottom).
xaxis	set to FALSE to suppress drawing x-axis
lcolor	color for horizontal reference lines. Default is "gray"
...	ignored

Author(s)

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See Also

dotchart3

Examples

```
## Not run:
z <- latexDotchart(c(.1,.2), c('a','bbAAb'), xlab='This Label',
                   auxdata=c(.1,.2), auxtitle='Zcriteria')
f <- '/tmp/t.tex'
cat('\documentclass{article}\n\usepackage{epic,color}\n\begin{document}\n', file=f)
cat(z, sep='\n', file=f, append=TRUE)
cat('\end{document}\n', file=f, append=TRUE)

set.seed(135)
maj <- factor(c(rep('North',13),rep('South',13)))
g <- paste('Category',rep(letters[1:13],2))
n <- sample(1:15000, 26, replace=TRUE)
y1 <- runif(26)
y2 <- pmax(0, y1 - runif(26, 0, .1))
z <- latexDotchart(y1, g, groups=maj, auxdata=n, auxtitle='n', xlab='Y',
                   size.group.labels='large', ttlabels=TRUE)
f <- '/tmp/t2.tex'
cat('\documentclass{article}\n\usepackage{epic,color}\n\begin{document}\n\framebox{', file=f)
cat(z, sep='\n', file=f, append=TRUE)
cat('}\end{document}\n', file=f, append=TRUE)

## End(Not run)
```

---

latexTabular *Convert a Data Frame or Matrix to a LaTeX Tabular*

Description

latexTabular creates a character vector representing a matrix or data frame in a simple 'tabular' environment.

Usage

```
latexTabular(x, headings=colnames(x),
             align =paste(rep('c',ncol(x)),collapse=''),
             halign=paste(rep('c',ncol(x)),collapse=''),
             helvetica=TRUE, translate=TRUE, hline=0, center=FALSE, ...)
```

Arguments

x	a matrix or data frame, or a vector that is automatically converted to a matrix
headings	a vector of character strings specifying column headings for 'latexTabular', defaulting to x's colnames. To make multi-line headers use the newline character inside elements of headings.

align	a character strings specifying column alignments for 'latexTabular', defaulting to paste(rep('c',ncol(x)),collapse='') to center. You may specify align='c|c' and other LaTeX tabular formatting.
halign	a character strings specifying alignment for column headings, defaulting to centered.
helvetica	set to FALSE to use default LaTeX font in 'latexTabular' instead of helvetica.
translate	set to FALSE if column headings and table entries are already in LaTeX format, otherwise latexTabular will run them through latexTranslate
hline	set to 1 to put hline after heading, 2 to also put hlines before and after heading and at table end
center	set to TRUE to enclose the tabular in a LaTeX center environment
...	if present, x is run through format.df with those extra arguments

Value

a character string containing LaTeX markup

Author(s)

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<fh@fharrell.com>

See Also

latex.default, format.df

Examples

```
x <- matrix(1:6, nrow=2, dimnames=list(c('a','b'),c('c','d','this that')))
latexTabular(x)   # a character string with LaTeX markup
```

---

latexTherm *Create LaTeX Thermometers and Colored Needles*

Description

latexTherm creates a LaTeX picture environment for drawing a series of thermometers whose heights depict the values of a variable y assumed to be scaled from 0 to 1. This is useful for showing fractions of sample analyzed in any table or plot, intended for a legend. For example, four thermometers might be used to depict the fraction of enrolled patients included in the current analysis, the fraction randomized, the fraction of patients randomized to treatment A being analyzed, and the fraction randomized to B being analyzed. The picture is placed inside a LaTeX macro definition for macro variable named name, to be invoked by the user later in the LaTeX file using name preceeded by a backslash.

If y has an attribute "table", it is assumed to contain a character string with LaTeX code. This code is used as a tooltip popup for PDF using the LaTeX ocgtools package or using style tooltips. Typically the code will contain a tabular environment. The user must define a LaTeX macro tooltipn that takes two arguments (original object and pop-up object) that does the pop-up.

latexNeedle is similar to latexTherm except that vertical needles are produced and each may have its own color. A grayscale box is placed around the needles and provides the 0-1 y-axis reference. Horizontal grayscale grid lines may be drawn.

pngNeedle is similar to latexNeedle but is for generating small png graphics. The full graphics file name is returned invisibly.

Usage

```
latexTherm(y, name, w = 0.075, h = 0.15, spacefactor = 1/2, extra = 0.07,
           file = "", append = TRUE)

latexNeedle(y, x=NULL, col='black', href=0.5, name, w=.05, h=.15,
            extra=0, file = "", append=TRUE)

pngNeedle(y, x=NULL, col='black', href=0.5, lwd=3.5, w=6, h=18,
          file=tempfile(fileext='.png'))
```

Arguments

y	a vector of 0-1 scaled values. Boxes and their frames are omitted for NA elements
x	a vector corresponding to y giving x-coordinates. Scaled accordingly, or defaults to equally-spaced values.
name	name of LaTeX macro variable to be defined
w	width of a single box (thermometer) in inches. For latexNeedle and pngNeedle is the spacing between needles, the latter being in pixels.
h	height of a single box in inches. For latexNeedle and pngNeedle is the height of the frame, the latter in pixels.
spacefactor	fraction of w added for extra space between boxes for latexTherm
extra	extra space in inches to set aside to the right of and above the series of boxes or frame
file	name of file to which to write LaTeX code. Default is the console. Also used as base file name for png graphic. Default for that is from tempfile.
append	set to FALSE to write over file
col	a vector of colors corresponding to positions in y. col is repeated if too short.
href	values of y (0-1) for which horizontal grayscale reference lines are drawn for latexNeedle and pngNeedle. Set to NULL to not draw any reference lines
lwd	line width of needles for pngNeedle

Author(s)

Frank Harrell

Examples

```
## Not run:
# The following is in the Hmisc tests directory
# For a knitr example see latexTherm.Rnw in that directory
ct <- function(...) cat(..., sep='')
ct('\documentclass{report}\begin{document}\n')
latexTherm(c(1, 1, 1, 1), name='lta')
latexTherm(c(.5, .7, .4, .2), name='ltb')
latexTherm(c(.5, NA, .75, 0), w=.3, h=1, name='ltc', extra=0)
latexTherm(c(.5, NA, .75, 0), w=.3, h=1, name='ltcc')
latexTherm(c(0, 0, 0, 0), name='ltd')
ct('This is a the first:\lta and the second:\ltb\\ and the third
without extra:\ltc END\\\nThird with extra:\ltcc END\\
\vspace{2in}\\
All data = zero, frame only:\ltd\\
\end{document}\n')
w <- pngNeedle(c(.2, .5, .7))
cat(tobase64image(w))  # can insert this directly into an html file

## End(Not run)
```

---

legendfunctions *Legend Creation Functions*

Description

Wrapers to plot defined legend ploting functions

Usage

```
Key(...)
Key2(...)
sKey(...)
```

Arguments

...	arguments to pass to wrapped functions

---

list.tree *Pretty-print the Structure of a Data Object*

Description

This is a function to pretty-print the structure of any data object (usually a list). It is similar to the R function `str`.

Usage

```
list.tree(struct, depth=-1, numbers=FALSE, maxlen=22, maxcomp=12,
          attr.print=TRUE, front="", fill=". ", name.of, size=TRUE)
```

Arguments

struct	The object to be displayed
depth	Maximum depth of recursion (of lists within lists ...) to be printed; negative value means no limit on depth.
numbers	If TRUE, use numbers in leader instead of dots to represent position in structure.
maxlen	Approximate maximum length (in characters) allowed on each line to give the first few values of a vector. maxlen=0 suppresses printing any values.
maxcomp	Maximum number of components of any list that will be described.
attr.print	Logical flag, determining whether a description of attributes will be printed.
front	Front material of a line, for internal use.
fill	Fill character used for each level of indentation.
name.of	Name of object, for internal use (deparsed version of struct by default).
size	Logical flag, should the size of the object in bytes be printed?
	A description of the structure of struct will be printed in outline form, with indentation for each level of recursion, showing the internal storage mode, length, class(es) if any, attributes, and first few elements of each data vector. By default each level of list recursion is indicated by a "." and attributes by "A".

Author(s)

Alan Zaslavsky, <zaslavsk@hcp.med.harvard.edu>

See Also

str

Examples

```
X <- list(a=ordered(c(1:30,30:1)),b=c("Rick","John","Allan"),
          c=diag(300),e=cbind(p=1008:1019,q=4))
list.tree(X)
# In R you can say str(X)
```

makeNstr *creates a string that is a repeat of a substring*

Description

Takes a character and creates a string that is the character repeated `len` times.

Usage

```
makeNstr(char, len)
```

Arguments

`char`	character to be repeated
`len`	number of times to repeat `char`.

Value

A string that is `char` repeated `len` times.

Author(s)

Charles Dupont

See Also

`paste`, `rep`

Examples

```
makeNstr(" ", 5)
```

mApply *Apply a Function to Rows of a Matrix or Vector*

Description

`mApply` is like `tapply` except that the first argument can be a matrix or a vector, and the output is cleaned up if `simplify=TRUE`. It uses code adapted from Tony Plate (`<tplate@blackmesacapital.com>`) to operate on grouped submatrices.

As `mApply` can be much faster than using by, it is often worth the trouble of converting a data frame to a numeric matrix for processing by `mApply`. `asNumericMatrix` will do this, and `matrix2dataFrame` will convert a numeric matrix back into a data frame.

Usage

```
mApply(X, INDEX, FUN, ..., simplify=TRUE, keepmatrix=FALSE)
```

Arguments

X	a vector or matrix capable of being operated on by the function specified as the FUN argument
INDEX	list of factors, each of same number of rows as 'X' has.
FUN	the function to be applied. In the case of functions like '+', '
...	optional arguments to 'FUN'.
simplify	set to 'FALSE' to suppress simplification of the result in to an array, matrix, etc.
keepmatrix	set to TRUE to keep result as a matrix even if simplify is TRUE, in the case of only one stratum

Value

For mApply, the returned value is a vector, matrix, or list. If FUN returns more than one number, the result is an array if simplify=TRUE and is a list otherwise. If a matrix is returned, its rows correspond to unique combinations of INDEX. If INDEX is a list with more than one vector, FUN returns more than one number, and simplify=FALSE, the returned value is a list that is an array with the first dimension corresponding to the last vector in INDEX, the second dimension corresponding to the next to last vector in INDEX, etc., and the elements of the list-array correspond to the values computed by FUN. In this situation the returned value is a regular array if simplify=TRUE. The order of dimensions is as previously but the additional (last) dimension corresponds to values computed by FUN.

Author(s)

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See Also

asNumericMatrix, matrix2dataFrame, tapply, sapply, lapply, mapply, by.

Examples

```
require(datasets, TRUE)
a <- mApply(iris[,-5], iris$Species, mean)
```

mChoice *Methods for Storing and Analyzing Multiple Choice Variables*

Description

mChoice is a function that is useful for grouping variables that represent individual choices on a multiple choice question. These choices are typically factor or character values but may be of any type. Levels of component factor variables need not be the same; all unique levels (or unique character values) are collected over all of the multiple variables. Then a new character vector is formed with integer choice numbers separated by semicolons. Optimally, a database system would have exported the semicolon-separated character strings with a levels attribute containing strings defining value labels corresponding to the integer choice numbers. mChoice is a function for creating a multiple-choice variable after the fact. mChoice variables are explicitly handed by the describe and summary.formula functions. NAs or blanks in input variables are ignored.

format.mChoice will convert the multiple choice representation to text form by substituting levels for integer codes. as.double.mChoice converts the mChoice object to a binary numeric matrix, one column per used level (or all levels of drop=FALSE. This is called by the user by invoking as.numeric. There is a print method and a summary method, and a print method for the summary.mChoice object. The summary method computes frequencies of all two-way choice combinations, the frequencies of the top 5 combinations, information about which other choices are present when each given choice is present, and the frequency distribution of the number of choices per observation. This summary output is used in the describe function. The print method returns an html character string if options(prType='html') is in effect if render=FALSE or renders the html otherwise. This is used by print.describe and is most effective when short=TRUE is specified to summary.

in.mChoice creates a logical vector the same length as x whose elements are TRUE when the observation in x contains at least one of the codes or value labels in the second argument.

match.mChoice creates an integer vector of the indexes of all elements in table which contain any of the speicified levels

nmChoice returns an integer vector of the number of choices that were made

is.mChoice returns TRUE is the argument is a multiple choice variable.

Usage

```
mChoice(..., label='',
        sort.levels=c('original','alphabetic'),
        add.none=FALSE, drop=TRUE, ignoreNA=TRUE)

## S3 method for class 'mChoice'
format(x, minlength=NULL, sep=";", ...)

## S3 method for class 'mChoice'
as.double(x, drop=FALSE, ...)

## S3 method for class 'mChoice'
```

```
print(x, quote=FALSE, max.levels=NULL,
       width=getOption("width"), ...)

## S3 method for class 'mChoice'
as.character(x, ...)

## S3 method for class 'mChoice'
summary(object, ncombos=5, minlength=NULL,
  drop=TRUE, short=FALSE, ...)

## S3 method for class 'summary.mChoice'
print(x, prlabel=TRUE, render=TRUE, ...)

## S3 method for class 'mChoice'
x[..., drop=FALSE]

match.mChoice(x, table, nomatch=NA, incomparables=FALSE)

inmChoice(x, values, condition=c('any', 'all'))

inmChoicelike(x, values, condition=c('any', 'all'),
              ignore.case=FALSE, fixed=FALSE)

nmChoice(object)

is.mChoice(x)

## S3 method for class 'mChoice'
Summary(..., na.rm)
```

Arguments

na.rm	Logical: remove NA's from data
table	a vector (mChoice) of values to be matched against.
nomatch	value to return if a value for x does not exist in table.
incomparables	logical whether incomparable values should be compaired.
...	a series of vectors
label	a character string label attribute to attach to the matrix created by mChoice
sort.levels	set sort.levels="alphabetic" to sort the columns of the matrix created by mChoice alphabetically by category rather than by the original order of levels in component factor variables (if there were any input variables that were factors)
add.none	Set add.none to TRUE to make a new category 'none' if it doesn't already exist and if there is an observations with no choices selected.
drop	set drop=FALSE to keep unused factor levels as columns of the matrix produced by mChoice
ignoreNA	set to FALSE to keep any NAs present in data as a real level. Prior to Hmisc 4.7-2 FALSE was the default.

x	an object of class "mchoice" such as that created by mChoice. For is.mChoice is any object.
object	an object of class "mchoice" such as that created by mChoice
ncombos	maximum number of combos.
width	With of a line of text to be formated
quote	quote the output
max.levels	max levels to be displayed
minlength	By default no abbreviation of levels is done in format and summary. Specify a positive integer to use abbreviation in those functions. See abbreviate.
short	set to TRUE to have summary.mChoice use integer choice numbers in its tables, and to print the choice level definitions at the top
sep	character to use to separate levels when formatting
prlabel	set to FALSE to keep print.summary.mChoice from printing the variable label and number of unique values. Ignore for html output.
render	applies of options(prType='html') is in effect. Set to FALSE to return the html text instead of rendering the html.
values	a scalar or vector. If values is integer, it is the choice codes, and if it is a character vector, it is assumed to be value labels. For inmChoicelike values must be character strings which are pieces of choice labels.
condition	set to 'all' for inmChoice to require that all choices in values be present instead of the default of any of them present.
ignore.case	set to TRUE to have inmChoicelike ignore case in the data when matching on values
fixed	see grep

Value

mChoice returns a character vector of class "mChoice" plus attributes "levels" and "label". summary.mChoice returns an object of class "summary.mChoice". inmChoice and inmChoicelike return a logical vector. format.mChoice returns a character vector, and as.double.mChoice returns a binary numeric matrix. nmChoice returns an integer vector. print.summary.mChoice returns an html character string if options(prType='html') is in effect.

Author(s)

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See Also

label, combplotp

Examples

```
options(digits=3)
set.seed(3)
n <- 20
sex <- factor(sample(c("m","f"), n, rep=TRUE))
age <- rnorm(n, 50, 5)
treatment <- factor(sample(c("Drug","Placebo"), n, rep=TRUE))


# Generate a 3-choice variable; each of 3 variables has 5 possible levels
symp <- c('Headache','Stomach Ache','Hangnail',
          'Muscle Ache','Depressed')
symptom1 <- sample(symp, n, TRUE)
symptom2 <- sample(symp, n, TRUE)
symptom3 <- sample(symp, n, TRUE)
cbind(symptom1, symptom2, symptom3)[1:5,]
Symptoms <- mChoice(symptom1, symptom2, symptom3, label='Primary Symptoms')
Symptoms
print(Symptoms, long=TRUE)
format(Symptoms[1:5])
inmChoice(Symptoms,'Headache')
inmChoicelike(Symptoms, 'head', ignore.case=TRUE)
levels(Symptoms)
inmChoice(Symptoms, 3)
# Find all subjects with either of two symptoms
inmChoice(Symptoms, c('Headache','Hangnail'))
# Note: In this example, some subjects have the same symptom checked
# multiple times; in practice these redundant selections would be NAs
# mChoice will ignore these redundant selections
# Find all subjects with both symptoms
inmChoice(Symptoms, c('Headache', 'Hangnail'), condition='all')

meanage <- N <- numeric(5)
for(j in 1:5) {
 meanage[j] <- mean(age[inmChoice(Symptoms,j)])
 N[j] <- sum(inmChoice(Symptoms,j))
}
names(meanage) <- names(N) <- levels(Symptoms)
meanage
N

# Manually compute mean age for 2 symptoms
mean(age[symptom1=='Headache' | symptom2=='Headache' | symptom3=='Headache'])
mean(age[symptom1=='Hangnail' | symptom2=='Hangnail' | symptom3=='Hangnail'])

summary(Symptoms)

#Frequency table sex*treatment, sex*Symptoms
summary(sex ~ treatment + Symptoms, fun=table)
# Check:
ma <- inmChoice(Symptoms, 'Muscle Ache')
table(sex[ma])
```

```
# could also do:
# summary(sex ~ treatment + mChoice(symptom1,symptom2,symptom3), fun=table)

#Compute mean age, separately by 3 variables
summary(age ~ sex + treatment + Symptoms)


summary(age ~ sex + treatment + Symptoms, method="cross")

f <- summary(treatment ~ age + sex + Symptoms, method="reverse", test=TRUE)
f
# trio of numbers represent 25th, 50th, 75th percentile
print(f, long=TRUE)
```

---

mdb.get *Read Tables in a Microsoft Access Database*

Description

Assuming the mdbtools package has been installed on your system and is in the system path, mdb.get imports one or more tables in a Microsoft Access database. Date-time variables are converted to dates or chron package date-time variables. The csv.get function is used to import automatically exported csv files. If tables is unspecified all tables in the database are retrieved. If more than one table is imported, the result is a list of data frames.

Usage

```
mdb.get(file, tables=NULL, lowernames=FALSE, allow=NULL,
        dateformat='%m/%d/%y', mdbexportArgs='-b strip', ...)
```

Arguments

file	the file name containing the Access database
tables	character vector specifying the names of tables to import. Default is to import all tables. Specify tables=TRUE to return the list of available tables.
lowernames	set this to TRUE to change variable names to lower case
allow	a vector of characters allowed by R that should not be converted to periods in variable names. By default, underscores in variable names are converted to periods as with R before version 1.9.
dateformat	see cleanup.import. Default is the usual Access format used in the U.S.
mdbexportArgs	command line arguments to issue to mdb-export. Set to '' to omit '-b strip'.
...	arguments to pass to csv.get

Details

Uses the mdbtools package executables mdb-tables, mdb-schema, and mdb-export (with by default option -b strip to drop any binary output). In Debian/Ubuntu Linux run apt get install mdbtools. cleanup.import is invoked by csv.get to transform variables and store them as efficiently as possible.

Value

a new data frame or a list of data frames

Author(s)

Frank Harrell, Vanderbilt University

See Also

data.frame, cleanup.import, csv.get, Date, chron

Examples

```
## Not run:
# Read all tables in the Microsoft Access database Nwind.mdb
d <- mdb.get('Nwind.mdb')
contents(d)
for(z in d) print(contents(z))
# Just print the names of tables in the database
mdb.get('Nwind.mdb', tables=TRUE)
# Import one table
Orders <- mdb.get('Nwind.mdb', tables='Orders')

## End(Not run)
```

---

meltData *meltData*

Description

Melt a Dataset To Examine All Xs vs Y

Usage

```
meltData(
  formula,
  data,
  tall = c("right", "left"),
  vnames = c("labels", "names"),
  sepunits = FALSE,
  ...
)
```

Arguments

formula	a formula
data	data frame or table
tall	see above
vnames	set to names to always use variable names instead of labels for X
sepunits	set to TRUE to create a separate variable Units to hold units of measurement. The variable is not created if no original variables have a non-blank units attribute.
...	passed to label()

Details

Uses a formula with one or more left hand side variables (Y) and one or more right hand side variables (X). Uses data.table::melt() to melt data so that each X is played against the same Y if tall='right' (the default) or each Y is played against the same X combination if tall='left'. The resulting data table has variables Y with their original names (if tall='right') or variables X with their original names (if tall='left'), variable, and value. By default variable is taken as label()s of the tall variables.

Value

data table

Author(s)

Frank Harrell

See Also

label()

Examples

```
d <- data.frame(y1=(1:10)/10, y2=(1:10)/100, x1=1:10, x2=101:110)
label(d$x1) <- 'X1'
units(d$x1) <- 'mmHg'
m=meltData(y1 + y2 ~ x1 + x2, data=d, units=TRUE) # consider also html=TRUE
print(m)
m=meltData(y1 + y2 ~ x1 + x2, data=d, tall='left')
print(m)
```

Merge *Merge Multiple Data Frames or Data Tables*

Description

Merges an arbitrarily large series of data frames or data tables containing common `id` variables. Information about number of observations and number of unique `id`s in individual and final merged datasets is printed. The first data frame/table has special meaning in that all of its observations are kept whether they match `id`s in other data frames or not. For all other data frames, by default non-matching observations are dropped. The first data frame is also the one against which counts of unique `id`s are compared. Sometimes `merge` drops variable attributes such as `labels` and `units`. These are restored by `Merge`.

Usage

```
Merge(..., id = NULL, all = TRUE, verbose = TRUE)
```

Arguments

`...`	two or more dataframes or data tables
`id`	a formula containing all the identification variables such that the combination of these variables uniquely identifies subjects or records of interest. May be omitted for data tables; in that case the `key` function retrieves the id variables.
`all`	set to `FALSE` to drop observations not found in second and later data frames (only applies if not using `data.table`)
`verbose`	set to `FALSE` to not print information about observations

Examples

```
## Not run:
a <- data.frame(sid=1:3, age=c(20,30,40))
b <- data.frame(sid=c(1,2,2), bp=c(120,130,140))
d <- data.frame(sid=c(1,3,4), wt=c(170,180,190))
all <- Merge(a, b, d, id = ~ sid)
# First file should be the master file and must
# contain all ids that ever occur.  ids not in the master will
# not be merged from other datasets.
a <- data.table(a); setkey(a, sid)
# data.table also does not allow duplicates without allow.cartesian=TRUE
b <- data.table(sid=1:2, bp=c(120,130)); setkey(b, sid)
d <- data.table(d); setkey(d, sid)
all <- Merge(a, b, d)

## End(Not run)
```

mgp.axis *Draw Axes With Side-Specific mgp Parameters*

Description

mgp.axis is a version of axis that uses the appropriate side-specific mgp parameter (see par) to account for different space requirements for axis labels vertical vs. horizontal tick marks. mgp.axis also fixes a bug in axis(2,...) that causes it to assume las=1.

mgp.axis.labels is used so that different spacing between tick marks and axis tick mark labels may be specified for x- and y-axes. Use mgp.axis.labels('default') to set defaults. Users can set values manually using mgp.axis.labels(x,y) where x and y are 2nd value of par('mgp') to use. Use mgp.axis.labels(type=w) to retrieve values, where w='x', 'y', 'x and y', 'xy', to get 3 mgp values (first 3 types) or 2 mgp.axis.labels.

Usage

```
mgp.axis(side, at = NULL, ...,
         mgp = mgp.axis.labels(type = if (side == 1 | side == 3) "x"
                               else "y"),
         axistitle = NULL, cex.axis=par('cex.axis'), cex.lab=par('cex.lab'))

mgp.axis.labels(value,type=c('xy','x','y','x and y'))
```

Arguments

side, at	see par
...	arguments passed through to axis
mgp, cex.axis, cex.lab	see par
axistitle	if specified will cause axistitle to be drawn on the appropriate axis as a title
value	vector of values to which to set system option mgp.axis.labels
type	see above

Value

mgp.axis.labels returns the value of mgp (only the second element of mgp if type="xy" or a list with elements x and y if type="x or y", each list element being a 3-vector) for the appropriate axis if value is not specified, otherwise it returns nothing but the system option mgp.axis.labels is set.

mgp.axis returns nothing.

Side Effects

mgp.axis.labels stores the value in the system option mgp.axis.labels

Author(s)

Frank Harrell

See Also

par

Examples

```
## Not run:
mgp.axis.labels(type='x')  # get default value for x-axis
mgp.axis.labels(type='y')  # get value for y-axis
mgp.axis.labels(type='xy') # get 2nd element of both mgps
mgp.axis.labels(type='x and y')  # get a list with 2 elements
mgp.axis.labels(c(3,.5,0), type='x')  # set
options('mgp.axis.labels')            # retrieve

plot(..., axes=FALSE)
mgp.axis(1, "X Label")
mgp.axis(2, "Y Label")


## End(Not run)
```

---

mhgr *Miscellaneous Functions for Epidemiology*

Description

The mhgr function computes the Cochran-Mantel-Haenszel stratified risk ratio and its confidence limits using the Greenland-Robins variance estimator.

The lrcum function takes the results of a series of 2x2 tables representing the relationship between test positivity and diagnosis and computes positive and negative likelihood ratios (with all their deficiencies) and the variance of their logarithms. Cumulative likelihood ratios and their confidence intervals (assuming independence of tests) are computed, assuming a string of all positive tests or a string of all negative tests. The method of Simel et al as described in Altman et al is used.

Usage

```
mhgr(y, group, strata, conf.int = 0.95)
## S3 method for class 'mhgr'
print(x, ...)

lrcum(a, b, c, d, conf.int = 0.95)
## S3 method for class 'lrcum'
print(x, dec=3, ...)
```

Arguments

y	a binary response variable
group	a variable with two unique values specifying comparison groups
strata	the stratification variable
conf.int	confidence level
x	an object created by mhgr or lrcum
a	frequency of true positive tests
b	frequency of false positive tests
c	frequency of false negative tests
d	frequency of true negative tests
dec	number of places to the right of the decimal to print for lrcum
...	addtitional arguments to be passed to other print functions

Details

Uses equations 4 and 13 from Greenland and Robins.

Value

a list of class "mhgr" or of class "lrcum".

Author(s)

Frank E Harrell Jr <fh@fharrell.com>

References

Greenland S, Robins JM (1985): Estimation of a common effect parameter from sparse follow-up data. Biometrics 41:55-68.

Altman DG, Machin D, Bryant TN, Gardner MJ, Eds. (2000): Statistics with Confidence, 2nd Ed. Bristol: BMJ Books, 105-110.

Simel DL, Samsa GP, Matchar DB (1991): Likelihood ratios with confidence: sample size estimation for diagnostic test studies. J Clin Epi 44:763-770.

See Also

logrank

Examples

```
# Greate Migraine dataset used in Example 28.6 in the SAS PROC FREQ guide
d <- expand.grid(response=c('Better','Same'),
                 treatment=c('Active','Placebo'),
                 sex=c('female','male'))
d$count <- c(16, 11, 5, 20, 12, 16, 7, 19)
d
```

```
# Expand data frame to represent raw data
r <- rep(1:8, d$count)
d <- d[r,]
with(d, mhgr(response=='Better', treatment, sex))

# Discrete survival time example, to get Cox-Mantel relative risk and CL
# From Stokes ME, Davis CS, Koch GG, Categorical Data Analysis Using the
# SAS System, 2nd Edition, Sectino 17.3, p. 596-599
#
# Input data in Table 17.5
d <- expand.grid(treatment=c('A','P'), center=1:3)
d$healed2w    <- c(15,15,17,12, 7, 3)
d$healed4w    <- c(17,17,17,13,17,17)
d$notHealed4w <- c( 2, 7,10,15,16,18)
d
# Reformat to the way most people would collect raw data
d1 <- d[rep(1:6, d$healed2w),]
d1$time <- '2'
d1$y <- 1
d2 <- d[rep(1:6, d$healed4w),]
d2$time <- '4'
d2$y <- 1
d3 <- d[rep(1:6, d$notHealed4w),]
d3$time <- '4'
d3$y <- 0
d <- rbind(d1, d2, d3)
d$healed2w <- d$healed4w <- d$notHealed4w <- NULL
d
# Finally, duplicate appropriate observations to create 2 and 4-week
# risk sets.  Healed and not healed at 4w need to be in the 2-week
# risk set as not healed
d2w      <- subset(d, time=='4')
d2w$time <- '2'
d2w$y    <- 0
d24      <- rbind(d, d2w)
with(d24, table(y, treatment, time, center))
# Matches Table 17.6

with(d24, mhgr(y, treatment, interaction(center, time, sep=';')))

# Get cumulative likelihood ratios and their 0.95 confidence intervals
# based on the following two tables
#
#          Disease       Disease
#          +     -       +     -
# Test +   39    3       20    5
# Test -   21   17       22   15

lrcum(c(39,20), c(3,5), c(21,22), c(17,15))
```

---

minor.tick *Minor Tick Marks*

Description

Adds minor tick marks to an existing plot. All minor tick marks that will fit on the axes will be drawn.

Usage

```
minor.tick(nx=2, ny=2, tick.ratio=0.5, x.args = list(), y.args = list())
```

Arguments

nx	number of intervals in which to divide the area between major tick marks on the X-axis. Set to 1 to suppress minor tick marks.
ny	same as nx but for the Y-axis.
tick.ratio	ratio of lengths of minor tick marks to major tick marks. The length of major tick marks is retrieved from par("tck").
x.args	additionl arguments (e.g. post, lwd) used by axis() function when rendering the X-axis.
y.args	same as x.args but for Y-axis.

Side Effects

plots

Author(s)

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See Also

axis

Examples

```
# Plot with default settings
plot(runif(20), runif(20))
minor.tick()

# Plot with arguments passed to axis()
plot(c(0,1), c(0,1), type = 'n', axes = FALSE, ann = FALSE)
# setting up a plot without axes and annotation
```

```
points(runif(20), runif(20))                    # plotting data
axis(1, pos = 0.5, lwd = 2)                   # showing X-axis at Y = 0.5 with formatting
axis(2, col = 2)                                # formatted Y-axis
minor.tick( nx = 4, ny = 4, tick.ratio = 0.3,
            x.args = list(pos = 0.5, lwd = 2),     # X-minor tick format argumnets
            y.args = list(col = 2))                # Y-minor tick format arguments
```

Misc *Miscellaneous Functions*

Description

This documents miscellaneous small functions in Hmisc that may be of interest to users.

`clowess` runs `lowess` but if the `iter` argument exceeds zero, sometimes wild values can result, in which case `lowess` is re-run with `iter=0`.

`confbar` draws multi-level confidence bars using small rectangles that may be of different colors.

`getLatestSource` fetches and `source`s the most recent source code for functions in GitHub.

`grType` retrieves the system option `grType`, which is forced to be `"base"` if the `plotly` package is not installed.

`prType` retrieves the system option `prType`, which is set to `"plain"` if the option is not set. `print` methods that allow for markdown/html/latex can be automatically invoked by setting `options(prType="html")` or `options(prType='latex')`.

`htmlSpecialType` retrieves the system option `htmlSpecialType`, which is set to `"unicode"` if the option is not set. `htmlSpecialType='unicode'` cause html-generating functions in `Hmisc` and `rms` to use unicode for special characters, and `htmlSpecialType='&'` uses the older ampersand 3-digit format.

`inverseFunction` generates a function to find all inverses of a monotonic or nonmonotonic function that is tabulated at vectors (x,y), typically 1000 points. If the original function is monotonic, simple linear interpolation is used and the result is a vector, otherwise linear interpolation is used within each interval in which the function is monotonic and the result is a matrix with number of columns equal to the number of monotonic intervals. If a requested y is not within any interval, the extreme x that pertains to the nearest extreme y is returned. Specifying what='sample' to the returned function will cause a vector to be returned instead of a matrix, with elements taken as a random choice of the possible inverses.

`james.stein` computes James-Stein shrunken estimates of cell means given a response variable (which may be binary) and a grouping indicator.

`keepHattrib` for an input variable or a data frame, creates a list object saving special Hmisc attributes such as `label` and `units` that might be lost during certain operations such as running `data.table`. `restoreHattrib` restores these attributes.

`km.quick` provides a fast way to invoke `survfitKM` in the `survival` package to efficiently get Kaplan-Meier or Fleming-Harrington estimates for a single stratum for a vector of time points (if `times` is given) or to get a vector of survival time quantiles (if `q` is given). If neither is given, the whole curve is returned in a list with objects `time` and `surv`, and there is an option to consider an

interval as pertaining to greater than or equal to a specific time instead of the traditional greater than. If the censoring is not right censoring, the more general `survfit` is called by `km.quick`.

`latexBuild` takes pairs of character strings and produces a single character string containing concatenation of all of them, plus an attribute `"close"` which is a character string containing the LaTeX closure that will balance LaTeX code with respect to parentheses, braces, brackets, or `begin` vs. `end`. When an even-numbered element of the vector is not a left parenthesis, brace, or bracket, the element is taken as a word that was surrounded by `begin` and braces, for which the corresponding `end` is constructed in the returned attribute.

`lm.fit.qr.bare` is a fast stripped-down function for computing regression coefficients, residuals, R^2, and fitted values. It uses `lm.fit`.

`matxv` multiplies a matrix by a vector, handling automatic addition of intercepts if the matrix does not have a column of ones. If the first argument is not a matrix, it will be converted to one. An optional argument allows the second argument to be treated as a matrix, useful when its rows represent bootstrap reps of coefficients. Then ab' is computed. `matxv` respects the `"intercepts"` attribute if it is stored on `b` by the `rms` package. This is used by `orm` fits that are bootstrap-repeated by `bootcov` where only the intercept corresponding to the median is retained. If `kint` has nonzero length, it is checked for consistency with the attribute.

`makeSteps` is a copy of the dostep function inside the `survival` package's `plot.survfit` function. It expands a series of points to include all the segments needed to plot step functions. This is useful for drawing polygons to shade confidence bands for step functions.

`nomiss` returns a data frame (if its argument is one) with rows corresponding to `NA`s removed, or it returns a matrix with rows with any element missing removed.

`outerText` uses `axis()` to put right-justified text strings in the right margin. Placement depends on `par('mar')[4]`

`rendHTML` renders HTML in a character vector, first converting to one character string with newline delimeters. If `knitr` is currently running, runs this string through `knitr::asis_output` so that the user need not include `results='asis'` in the chunk header for R Markdown or Quarto. If `knitr` is not running, uses `htmltools::browsable` and `htmltools::HTML` and prints the result so that an RStudio viewer (if running inside RStudio) or separate browser window displays the rendered HTML. The HTML code is surrounded by yaml markup to make Pandoc not fiddle with the HTML. Set the argument `html=FALSE` to not add this, in case you are really rendering markdown. `html=FALSE` also invokes `rmarkdown::render` to convert the character vector to HTML before using `htmltools` to view, assuming the characters represent RMarkdown/Quarto text other than the YAML header. If `options(rawmarkup=TRUE)` is in effect, `rendHTML` will just `cat()` its first argument. This is useful when rendering is happening inside a Quarto margin, for example.

`sepUnitsTrans` converts character vectors containing values such as `c("3 days","3day","4month","2 years","2weeks","7")` to numeric vectors (here `c(3,3,122,730,14,7)`) in a flexible fashion. The user can specify a vector of units of measurements and conversion factors. The units with a conversion factor of `1` are taken as the target units, and if those units are present in the character strings they are ignored. The target units are added to the resulting vector as the `"units"` attribute.

`strgraphwrap` is like `strwrap` but is for the current graphics environment.

`tobase64image` is a function written by Dirk Eddelbuettel that uses the `base64enc` package to convert a png graphic file to base64 encoding to include as an inline image in an html file.

`trap.rule` computes the area under a curve using the trapezoidal rule, assuming `x` is sorted.

`trellis.strip.blank` sets up Trellis or Lattice graphs to have a clear background on the strips for panel labels.

`unPaste` provides a version of the S-Plus `unpaste` that works for R and S-Plus.

`whichClosePW` is a very fast function using weighted multinomial sampling to determine which element of a vector is "closest" to each element of another vector. `whichClosest` quickly finds the closest element without any randomness.

`whichClosek` is a slow function that finds, after jittering the lookup table, the `k` closest matchest to each element of the other vector, and chooses from among these one at random.

`xless` is a function for Linux/Unix users to invoke the system `xless` command to pop up a window to display the result of `print`ing an object. For MacOS `xless` uses the system `open` command to pop up a `TextEdit` window.

Usage

```
confbar(at, est, se, width, q = c(0.7, 0.8, 0.9, 0.95, 0.99),
        col = gray(c(0, 0.25, 0.5, 0.75, 1)),
        type = c("v", "h"), labels = TRUE, ticks = FALSE,
        cex = 0.5, side = "l", lwd = 5, clip = c(-1e+30, 1e+30),
        fun = function(x) x,
        qfun = function(x) ifelse(x == 0.5, qnorm(x),
                           ifelse(x < 0.5, qnorm(x/2),
                           qnorm((1 +  x)/2))))
getLatestSource(x=NULL, package='Hmisc', recent=NULL, avail=FALSE)
grType()
prType()
htmlSpecialType()
inverseFunction(x, y)
james.stein(y, group)
keepHattrib(obj)
km.quick(S, times, q,
        type = c("kaplan-meier", "fleming-harrington", "fh2"),
     interval = c(">", ">="), method=c('constant', 'linear'), fapprox=0, n.risk=FALSE)
latexBuild(..., insert, sep='')
lm.fit.qr.bare(x, y, tolerance, intercept=TRUE, xpxi=FALSE, singzero=FALSE)
matxv(a, b, kint=1, bmat=FALSE)
nomiss(x)
outerText(string, y, cex=par('cex'), ...)
rendHTML(x, html=TRUE)
restoreHattrib(obj, attribs)
sepUnitsTrans(x, conversion=c(day=1, month=365.25/12, year=365.25, week=7),
              round=FALSE, digits=0)
strgraphwrap(x, width = 0.9 * getOption("width"),
             indent = 0, exdent = 0,
             prefix = "", simplify = TRUE, units='user', cex=NULL)
tobase64image(file, Rd = FALSE, alt = "image")
trap.rule(x, y)
trellis.strip.blank()
```

```
unPaste(str, sep="/")
whichClosest(x, w)
whichClosePW(x, w, f=0.2)
whichClosek(x, w, k)
xless(x, ..., title)
```

Arguments

a	a numeric matrix or vector
alt, Rd	see base64::img
at	x-coordinate for vertical confidence intervals, y-coordinate for horizontal
attribs	an object returned by keepHattrib
avail	set to TRUE to have getLatestSource return a data frame of available files and latest versions instead of fetching any
b	a numeric vector
cex	character expansion factor
clip	interval to truncate limits
col	vector of colors
conversion	a named numeric vector
digits	number of digits used for round
est	vector of point estimates for confidence limits
f	a scaling constant
file	a file name
fun	function to transform scale
group	a categorical grouping variable
html	set to FALSE to tell rendHTML to not surround HTML code with yaml
insert	a list of 3-element lists for latexBuild. The first of each 3-element list is a character string with an environment name. The second specifies the order: "before" or "after", the former indicating that when the environment is found, the third element of the list is inserted before or after it, according to the second element.
intercept	set to FALSE to not automatically add a column of ones to the x matrix
k	get the k closest matches
kint	which element of b to add to the result if a does not contain a column for intercepts
bmat	set to TRUE to consider b a matrix of repeated coefficients, usually resampled estimates with rows corresponding to resamples
labels	set to FALSE to omit drawing confidence coefficients
lwd	line widths
package	name of package for getLatestSource, default is 'Hmisc'
obj	a variable, data frame, or data table

q	vector of confidence coefficients or quantiles
qfun	quantiles on transformed scale
recent	an integer telling getLatestSource to get the recent most recently modified files from the package
round	set to TRUE to round converted values
S	a Surv object
se	vector of standard errors
sep	a single character string specifying the delimiter. For latexBuild the default is "".
side	for confbar is "b","l","t","r" for bottom, left, top, right.
str	a character string vector
string	a character string vector
ticks	set to TRUE to draw lines between rectangles
times	a numeric vector of times
title	a character string to title a window or plot. Ignored for xless under MacOs.
tolerance	tolerance for judging singularity in matrix
type	"v" for vertical, "h" for horizontal. For km.quick specifies the type of survival estimator.
w	a numeric vector
width	width of confidence rectanges in user units, or see strwrap
x	a numeric vector (matrix for lm.fit.qr.bare) or data frame. For xless may be any object that is sensible to print. For sepUnitsTrans is a character or factor variable. For getLatestSource is a character string or vector of character strings containing base file names to retrieve from CVS. Set x='all' to retrieve all source files. For clowess, x may also be a list with x and y components. For inverseFunction, x and y contain evaluations of the function whose inverse is needed. x is typically an equally-spaced grid of 1000 points. For strgraphwrap is a character vector. For rendHTML x is a character vector.
xpxi	set to TRUE to add an element to the result containing the inverse of $X'X$
singzero	set to TRUE to set coefficients corresponding to singular variables to zero instead of NA.
y	a numeric vector. For inverseFunction y is the evaluated function values at x.
indent, exdent, prefix	see strwrap
simplify	see sapply
units	see par
interval	specifies whether to deal with probabilities of exceeding a value (the default) or of exceeding or equalling the value
method, fapprox	see approx
n.risk	set to TRUE to include the number at risk in the result
...	arguments passed through to another function. For latexBuild represents pairs, with odd numbered elements being character strings containing LaTeX code or a zero-length object to ignore, and even-numbered elements representing LaTeX left parenthesis, left brace, or left bracket, or environment name.

Author(s)

Frank Harrell and Charles Dupont

Examples

```
trap.rule(1:100,1:100)

unPaste(c('a;b or c','ab;d','qr;s'), ';')

sepUnitsTrans(c('3 days','4 months','2 years','7'))

set.seed(1)
whichClosest(1:100, 3:5)
whichClosest(1:100, rep(3,20))

whichClosePW(1:100, rep(3,20))
whichClosePW(1:100, rep(3,20), f=.05)
whichClosePW(1:100, rep(3,20), f=1e-10)

x <- seq(-1, 1, by=.01)
y <- x^2
h <- inverseFunction(x,y)
formals(h)$turns   # vertex
a <- seq(0, 1, by=.01)
plot(0, 0, type='n', xlim=c(-.5,1.5))
lines(a, h(a)[,1])            ## first inverse
lines(a, h(a)[,2], col='red') ## second inverse
a <- c(-.1, 1.01, 1.1, 1.2)
points(a, h(a)[,1])

d <- data.frame(x=1:2, y=3:4, z=5:6)
d <- upData(d, labels=c(x='X', z='Z lab'), units=c(z='mm'))
a <- keepHattrib(d)

d <- data.frame(x=1:2, y=3:4, z=5:6)
d2 <- restoreHattrib(d, a)
sapply(d2, attributes)

## Not run:
getLatestSource(recent=5)  # source() most recent 5 revised files in Hmisc
getLatestSource('cut2')    # fetch and source latest cut2.s
getLatestSource('all')     # get everything
getLatestSource(avail=TRUE) # list available files and latest versions

## End(Not run)
```

---

movStats *movStats*

Description

Moving Estimates Using Overlapping Windows

Usage

```
movStats(
  formula,
  stat = NULL,
  discrete = FALSE,
  space = c("n", "x"),
  eps = if (space == "n") 15,
  varyeps = FALSE,
  nignore = 10,
  xinc = NULL,
  xlim = NULL,
  times = NULL,
  tunits = "year",
  msmooth = c("smoothed", "raw", "both"),
  tsmooth = c("supsmu", "lowess"),
  bass = 8,
  span = 1/4,
  maxdim = 6,
  penalty = NULL,
  trans = function(x) x,
  itrans = function(x) x,
  loess = FALSE,
  ols = FALSE,
  qreg = FALSE,
  lrm = FALSE,
  orm = FALSE,
  hare = FALSE,
  ordsurv = FALSE,
  lrm_args = NULL,
  family = "logistic",
  k = 5,
  tau = (1:3)/4,
  melt = FALSE,
  data = environment(formula),
  pr = c("none", "kable", "plain", "margin")
)
```

Arguments

formula	a formula with the analysis variable on the left and the x-variable on the right, following by optional stratification variables
stat	function of one argument that returns a named list of computed values. Defaults to computing mean and quartiles + N except when y is binary in which case it

	computes moving proportions. If y has two columns the default statistics are Kaplan-Meier estimates of cumulative incidence at a vector of `times`.
`discrete`	set to `TRUE` if x-axis variable is discrete and no intervals should be created for windows
`space`	defines whether intervals used fixed width or fixed sample size
`eps`	tolerance for window (half width of window). For `space='x'` is in data units, otherwise is the sample size for half the window, not counting the middle target point.
`varyeps`	applies to `space='n'` and causes a smaller `eps` to be used in strata with fewer than " observations so as to arrive at three x points
`nignore`	see description, default is to exclude `nignore=10` points on the left and right tails from estimation and plotting
`xinc`	increment in x to evaluate stats, default is xlim range/100 for `space='x'`. For `space='n'` `xinc` defaults to m observations, where m = max(n/200, 1).
`xlim`	2-vector of limits to evaluate if `space='x'` (default is `nignore` smallest to `nignore` largest)
`times`	vector of times for evaluating one minus Kaplan-Meier estimates
`tunits`	time units when `times` is given
`msmooth`	set to `'smoothed'` or `'both'` to compute `lowess`-smooth moving estimates. `msmooth='both'` will display both. `'raw'` will display only the moving statistics. `msmooth='smoothed'` (the default) will display only he smoothed moving estimates.
`tsmooth`	defaults to the super-smoother `'supsmu'` for after-moving smoothing. Use `tsmooth='lowess'` to instead use `lowess`.
`bass`	the `supsmu` `bass` parameter used to smooth the moving statistics if `tsmooth='supsmu'`. The default of 8 represents quite heavy smoothing.
`span`	the `lowess` `span` used to smooth the moving statistics
`maxdim`	passed to `hare`, default is 6
`penalty`	passed to `hare`, default is to use BIC. Specify 2 to use AIC.
`trans`	transformation to apply to x
`itrans`	inverse transformation
`loess`	set to TRUE to also compute loess estimates
`ols`	set to TRUE to include rcspline estimate of mean using ols
`qreg`	set to TRUE to include quantile regression estimates w rcspline
`lrm`	set to TRUE to include logistic regression estimates w rcspline
`orm`	set to TRUE to include ordinal logistic regression estimates w rcspline (mean + quantiles in `tau`)
`hare`	set to TRUE to include hazard regression estimtes of incidence at `times`, using the `polspline` package
`ordsurv`	set to TRUE to include ordinal regression estimates of incidence at `times`, using the `rms` package `adapt_orm` and `survest.orm` functions

lrm_args	a list of optional arguments to pass to lrm when lrm=TRUE, e.g., list(maxit=20)
family	link function for ordinal regression (see rms::orm)
k	number of knots to use for ols, lrm, qreg restricted cubic splines. Linearity is forced for binary y when the minimum of the number of events and number of non-events is below 10 for a by-group. For ordsurv=TRUE is the maximum number of knots tried and is passed as argument maxk to the rms adapt_orm function.
tau	quantile numbers to estimate with quantile regression
melt	set to TRUE to melt data table and derive Type and Statistic
data	data.table or data.frame, default is calling frame
pr	defaults to no printing of window information. Use pr='plain' to print in the ordinary way, pr='kable to convert the object to knitr::kable and print, or pr='margin' to convert to kable and place in the Quarto right margin. For the latter two results='asis' must be in the chunk header.

Details

Function to compute moving averages and other statistics as a function of a continuous variable, possibly stratified by other variables. Estimates are made by creating overlapping moving windows and computing the statistics defined in the stat function for each window. The default method, space='n' creates varying-width intervals each having a sample size of 2*eps +1, and the smooth estimates are made every xinc observations. Outer intervals are not symmetric in sample size (but the mean x in those intervals will reflect that) unless eps=nignore, as outer intervals are centered at observations nignore and n - nignore + 1 where the default for nignore is 10. The mean x-variable within each windows is taken to represent that window. If trans and itrans are given, x means are computed on the trans(x) scale and then itrans'd. For space='x', by default estimates are made on to the nignore smallest to the nignore largest observed values of the x variable to avoid extrapolation and to help getting the moving statistics off on an adequate start for the left tail. Also by default the moving estimates are smoothed using supsmu. When melt=TRUE you can feed the result into ggplot like this: ggplot(w, aes(x=age, y=crea, col=Type)) + geom_line() + facet_wrap(~ Statistic)

See here for several examples.

Value

a data table, with attribute infon which is a data frame with rows corresponding to strata and columns N, Wmean, Wmin, Wmax if stat computed N. These summarize the number of observations used in the windows. If varyeps=TRUE there is an additional column eps with the computed per-stratum eps. When space='n' and xinc is not given, the computed xinc also appears as a column. An additional attribute info is a kable object ready for printing to describe the window characteristics.

Author(s)

Frank Harrell

`mtitle` *Margin Titles*

Description

Writes overall titles and subtitles after a multiple image plot is drawn. If `par()$oma==c(0,0,0,0)`, `title` is used instead of `mtext`, to draw titles or subtitles that are inside the plotting region for a single plot.

Usage

```
mtitle(main, ll, lc,
       lr=format(Sys.time(),'%d%b%y'),
       cex.m=1.75, cex.l=.5, ...)
```

Arguments

`main`	main title to be centered over entire figure, default is none
`ll`	subtitle for lower left of figure, default is none
`lc`	subtitle for lower center of figure, default is none
`lr`	subtitle for lower right of figure, default is today's date in format 23Jan91 for UNIX or R (Thu May 30 09:08:13 1996 format for Windows). Set to `""` to suppress lower right title.
`cex.m`	character size for main, default is 1.75
`cex.l`	character size for subtitles
`...`	other arguments passed to `mtext`

Value

nothing

Side Effects

plots

Author(s)

Frank Harrell
Department of Biostatistics, Vanderbilt University
<fh@fharrell.com>

See Also

`par`, `mtext`, `title`, `unix`, `pstamp`

Examples

```
#Set up for 1 plot on figure, give a main title,
#use date for lr
plot(runif(20),runif(20))
mtitle("Main Title")


#Set up for 2 x 2 matrix of plots with a lower left subtitle and overall title
par(mfrow=c(2,2), oma=c(3,0,3,0))
plot(runif(20),runif(20))
plot(rnorm(20),rnorm(20))
plot(exp(rnorm(20)),exp(rnorm(20)))
mtitle("Main Title",ll="n=20")
```

`multLines` *Plot Multiple Lines*

Description

Plots multiple lines based on a vector `x` and a matrix `y`, draws thin vertical lines connecting limits represented by columns of `y` beyond the first. It is assumed that either (1) the second and third columns of `y` represent lower and upper confidence limits, or that (2) there is an even number of columns beyond the first and these represent ascending quantiles that are symmetrically arranged around 0.5. If `options(grType='plotly')` is in effect, uses `plotly` graphics instead of `grid` or base graphics. For `plotly` you may want to set the list of possible colors, etc. using `pobj=plot_ly(colors=...)`. `lwd,lty,lwd.vert` are ignored under `plotly`.

Usage

```
multLines(x, y, pos = c('left', 'right'), col='gray',
          lwd=1, lty=1, lwd.vert = .85, lty.vert = 1,
          alpha = 0.4, grid = FALSE,
          pobj=plotly::plot_ly(), xlim, name=colnames(y)[1], legendgroup=name,
          showlegend=TRUE, ...)
```

Arguments

`x`	a numeric vector
`y`	a numeric matrix with number of rows equal to the number of `x` elements
`pos`	when `pos='left'` the vertical lines are drawn, right to left, to the left of the point `(x, y[,1)`. Otherwise lines are drawn left to right to the right of the point.
`col`	a color used to connect `(x, y[,1])` pairs. The same color but with transparency given by the `alpha` argument is used to draw the vertical lines
`lwd`	line width for main lines
`lty`	line types for main lines
`lwd.vert`	line width for vertical lines

lty.vert	line type for vertical lines
alpha	transparency
grid	set to TRUE when using grid/lattice
pobj	an already started plotly object to add to
xlim	global x-axis limits (required if using plotly)
name	trace name if using plotly
legendgroup	legend group name if using plotly
showlegend	whether or not to show traces in legend, if using plotly
...	passed to add_lines or add_segments if using plotly

Author(s)

Frank Harrell

Examples

```
if (requireNamespace("plotly")) {
  x <- 1:4
  y <- cbind(x, x-3, x-2, x-1, x+1, x+2, x+3)
  plot(NA, NA, xlim=c(1,4), ylim=c(-2, 7))
  multLines(x, y, col='blue')
  multLines(x, y, col='red', pos='right')
}
```

---

na.delete *Row-wise Deletion na.action*

Description

Does row-wise deletion as na.omit, but adds frequency of missing values for each predictor to the "na.action" attribute of the returned model frame. Optionally stores further details if options(na.detail.response=TRUE

Usage

```
na.delete(frame)
```

Arguments

frame	a model frame

Value

a model frame with rows deleted and the "na.action" attribute added.

Author(s)

Frank Harrell
Department of Biostatistics
Vanderbilt University
<fh@fharrell.com>

See Also

na.omit, na.keep, na.detail.response, model.frame.default, naresid, naprint

Examples

```
# options(na.action="na.delete")
# ols(y ~ x)
```

---

na.detail.response *Detailed Response Variable Information*

Description

This function is called by certain na.action functions if options(na.detail.response=TRUE) is set. By default, this function returns a matrix of counts of non-NAs and the mean of the response variable computed separately by whether or not each predictor is NA. The default action uses the last column of a Surv object, in effect computing the proportion of events. Other summary functions may be specified by using options(na.fun.response="name of function").

Usage

```
na.detail.response(mf)
```

Arguments

mf	a model frame

Value

a matrix, with rows representing the different statistics that are computed for the response, and columns representing the different subsets for each predictor (NA and non-NA value subsets).

Author(s)

Frank Harrell
Department of Biostatistics
Vanderbilt University
<fh@fharrell.com>

See Also

na.omit, na.delete, model.frame.default, naresid, naprint, describe

Examples

```
# sex
# [1] m f f m f f m m m m m m m f f f m f m
# age
# [1] NA 41 23 30 44 22 NA 32 37 34 38 36 36 50 40 43 34 22 42 30
# y
# [1] 0 1 0 0 1 0 1 0 0 1 1 1 0 0 1 1 0 1 0 0
# options(na.detail.response=TRUE, na.action="na.delete", digits=3)
# lrm(y ~ age*sex)
#
# Logistic Regression Model
#
# lrm(formula = y ~ age * sex)
#
#
# Frequencies of Responses
#   0 1
#  10 8
#
# Frequencies of Missing Values Due to Each Variable
#  y age sex
#  0   2   0
#
#
# Statistics on Response by Missing/Non-Missing Status of Predictors
#
#     age=NA age!=NA sex!=NA Any NA  No NA
#   N    2.0  18.000   20.00    2.0 18.000
# Mean    0.5   0.444    0.45    0.5  0.444
#
# \dots\dots
# options(na.action="na.keep")
# describe(y ~ age*sex)
# Statistics on Response by Missing/Non-Missing Status of Predictors
#
#      age=NA age!=NA sex!=NA Any NA  No NA
#    N    2.0  18.000   20.00    2.0 18.000
# Mean    0.5   0.444    0.45    0.5  0.444
#
# \dots
# options(na.fun.response="table")  #built-in function table()
# describe(y ~ age*sex)
#
# Statistics on Response by Missing/Non-Missing Status of Predictors
#
#   age=NA age!=NA sex!=NA Any NA No NA
# 0      1      10      11      1    10
# 1      1       8       9      1     8
```

```
#
# \dots
```

`na.keep` *Do-nothing na.action*

Description

Does not delete rows containing NAs, but does add details concerning the distribution of the response variable if `options(na.detail.response=TRUE)`. This `na.action` is primarily for use with `describe.formula`.

Usage

```
na.keep(mf)
```

Arguments

`mf`	a model frame

Value

the same model frame with the `"na.action"` attribute

Author(s)

Frank Harrell
Department of Biostatistics
Vanderbilt University
<fh@fharrell.com>

See Also

`na.omit`, `na.delete`, `model.frame.default`, `na.detail.response`, `naresid`, `naprint`, `describe`

Examples

```
options(na.action="na.keep", na.detail.response=TRUE)
x1 <- runif(20)
x2 <- runif(20)
x2[1:4] <- NA
y <- rnorm(20)
describe(y ~ x1*x2)
```

nCoincident *nCoincident*

Description

Number of Coincident Points

Usage

```
nCoincident(x, y, bins = 400)
```

Arguments

x	numeric vector
y	numeric vector
bins	number of bins in both directions

Details

Computes the number of x,y pairs that are likely to be obscured in a regular scatterplot, in the sense of overlapping pairs after binning into bins x bins squares where bins defaults to 400. NAs are removed first.

Value

integer count

Author(s)

Frank Harrell

Examples

```
nCoincident(c(1:5, 4:5), c(1:5, 4:5)/10)
```

---

nobsY *Compute Number of Observations for Left Hand Side of Formula*

Description

After removing any artificial observations added by addMarginal, computes the number of non-missing observations for all left-hand-side variables in formula. If formula contains a term id(variable) variable is assumed to be a subject ID variable, and only unique subject IDs are counted. If group is given and its value is the name of a variable in the right-hand-side of the model, an additional object nobsg is returned that is a matrix with as many columns as there are left-hand variables, and as many rows as there are levels to the group variable. This matrix has the further breakdown of unique non-missing observations by group. The concatenation of all ID variables, is returned in a list element id.

Usage

```
nobsY(formula, group=NULL, data = NULL, subset = NULL,
      na.action = na.retain, matrixna=c('all', 'any'))
```

Arguments

formula	a formula object
group	character string containing optional name of a stratification variable for computing sample sizes
data	a data frame
subset	an optional subsetting criterion
na.action	an optional NA-handling function
matrixna	set to "all" if an observation is to be considered NA if all the columns of the variable are NA, otherwise use matrixna="any" to consider the row missing if any of the columns are missing

Value

an integer, with an attribute "formula" containing the original formula but with an id variable (if present) removed

Examples

```
d <- expand.grid(sex=c('female', 'male', NA),
                 country=c('US', 'Romania'),
                 reps=1:2)
d$subject.id <- c(0, 0, 3:12)
dm <- addMarginal(d, sex, country)
dim(dm)
nobsY(sex + country ~ 1, data=d)
nobsY(sex + country ~ id(subject.id), data=d)
nobsY(sex + country ~ id(subject.id) + reps, group='reps', data=d)
nobsY(sex ~ 1, data=d)
nobsY(sex ~ 1, data=dm)
nobsY(sex ~ id(subject.id), data=dm)
```

---

nstr *Creates a string of arbitry length*

Description

Creates a vector of strings which consists of the string segment given in each element of the string vector repeated times.

Usage

```
nstr(string, times)
```

Arguments

`string`	character: vector of string segments to be repeated. Will be recycled if argument `times` is longer.
`times`	integer: vector of number of times to repeat the corisponding segment. Will be recycled if argument `string` is longer.

Value

returns a character vector the same length as the longest of the two arguments.

Note

Will throw a warning if the length of the longer argment is not a even multiple of the shorter argument.

Author(s)

Charles Dupont

See Also

`paste`, `rep`

Examples

```
nstr(c("a"), c(0,3,4))

nstr(c("a", "b", "c"), c(1,2,3))

nstr(c("a", "b", "c"), 4)
```

`num.intercepts` *Extract number of intercepts*

Description

Extract the number of intercepts from a model

Usage

```
num.intercepts(fit, type=c('fit', 'var', 'coef'))
```

Arguments

fit	a model fit object
type	the default is to return the formal number of intercepts used when fitting the model. Set type='var' to return the actual number of intercepts stored in the var object, or type='coef' to return the actual number in the fitted coefficients. The former will be less than the number fitted for orm fits, and the latter for orm fits passed through fit.mult.impute. If the var object is not present, the number of intercepts is determined from the ab element of the info.matrix object if it is present.

Value

num.intercepts returns an integer with the number of intercepts in the model.

See Also

orm, fit.mult.impute

---

ordGroupBoot *Minimally Group an Ordinal Variable So Bootstrap Samples Will Contain All Distinct Values*

Description

When bootstrapping models for ordinal Y when Y is fairly continuous, it is frequently the case that one or more bootstrap samples will not include one or more of the distinct original Y values. When fitting an ordinal model (including a Cox PH model), this means that an intercept cannot be estimated, and the parameter vectors will not align over bootstrap samples. To prevent this from happening, some grouping of Y may be necessary. The ordGroupBoot function uses cutGn() to group Y so that the minimum number in any group is guaranteed to not exceed a certain integer m. ordGroupBoot tries a range of m and stops at the lowest m such that either all B tested bootstrap samples contain all the original distinct values of Y (if B>0), or that the probability that a given sample of size n with replacement will contain all the distinct original values exceeds aprob (B=0). This probability is computed approximately using an approximation to the probability of complete sample coverage from the *coupon collector's problem* and is quite accurate for our purposes.

Usage

```
ordGroupBoot(
  y,
  B = 0,
  m = 7:min(15, floor(n/3)),
  what = c("mean", "factor", "m"),
  aprob = 0.9999,
  pr = TRUE
)
```

Arguments

y	a numeric vector
B	number of bootstrap samples to test, or zero to use a coverage probability approximation
m	range of minimum group sizes to test; the default range is usually adequate
what	specifies that either the mean y in each group should be returned, a factor version of this with interval endpoints in the levels, or the computed value of m should be returned
aprob	minimum coverage probability sought
pr	set to FALSE to not print the computed value of the minimum m satisfying the needed condition

Value

a numeric vector corresponding to y but grouped, containing eithr the mean of y in each group or a factor variable representing grouped y, either with the minimum m that satisfied the required sample covrage

Author(s)

Frank Harrell

See Also

cutGn()

Examples

```
set.seed(1)
x <- c(1:6, NA, 7:22)
ordGroupBoot(x, m=5:10)
ordGroupBoot(x, m=5:10, B=5000, what='factor')
```

---

pairUpDiff *pairUpDiff*

Description

Pair-up and Compute Differences

Usage

```
pairUpDiff(
  x,
  major = NULL,
  minor = NULL,
  group,
  refgroup,
  lower = NULL,
  upper = NULL,
  minkeep = NULL,
  sortdiff = TRUE,
  conf.int = 0.95
)
```

Arguments

x	a numeric vector
major	an optional factor or character vector
minor	an optional factor or character vector
group	a required factor or character vector with two levels
refgroup	a character string specifying which level of group is to be subtracted
lower	an optional numeric vector giving the lower conf.int confidence limit for x
upper	similar to lower but for the upper limit
minkeep	the minimum value of x required to keep the observation. An observation is kept if either group has x exceeding or equalling minkeep. Default is to keep all observations.
sortdiff	set to FALSE to avoid sorting observations by descending between-group differences
conf.int	confidence level; must have been the value used to compute lower and upper if they are provided

Details

This function sets up for plotting half-width confidence intervals for differences, sorting by descending order of differences within major categories, especially for dot charts as produced by dotchartpl(). Given a numeric vector x and a grouping (superpositioning) vector group with exactly two levels, computes differences in possibly transformed x between levels of group for the two observations that are equal on major and minor. If lower and upper are specified, using conf.int and approximate normality on the transformed scale to backsolve for the standard errors of estimates, and uses approximate normality to get confidence intervals on differences by taking the square root of the sum of squares of the two standard errors. Coordinates for plotting half-width confidence intervals are also computed. These intervals may be plotted on the same scale as x, having the property that they overlap the two x values if and only if there is no "significant" difference at the conf.int level.

Value

a list of two objects both sorted by descending values of differences in `x`. The `X` object is a data frame that contains the original variables sorted by descending differences across `group` and in addition a variable `subscripts` denoting the subscripts of original observations with possible re-sorting and dropping depending on `sortdiff` and `minkeep`. The `D` data frame contains sorted differences (`diff`), `major`, `minor`, `sd` of difference, `lower` and `upper` confidence limits for the difference, `mid`, the midpoint of the two `x` values involved in the difference, `lowermid`, the midpoint minus 1/2 the width of the confidence interval, and `uppermid`, the midpoint plus 1/2 the width of the confidence interval. Another element returned is `dropped` which is a vector of `major` / `minor` combinations dropped due to `minkeep`.

Author(s)

Frank Harrell

Examples

```
x <- c(1, 4, 7, 2, 5, 3, 6)
pairUpDiff(x, c(rep('A', 4), rep('B', 3)),
  c('u','u','v','v','z','z','q'),
  c('a','b','a','b','a','b','a'), 'a', x-.1, x+.1)
```

`panel.bpplot` *Box-Percentile Panel Function for Trellis*

Description

For all their good points, box plots have a high ink/information ratio in that they mainly display 3 quartiles. Many practitioners have found that the "outer values" are difficult to explain to non-statisticians and many feel that the notion of "outliers" is too dependent on (false) expectations that data distributions should be Gaussian.

`panel.bpplot` is a `panel` function for use with `trellis`, especially for `bwplot`. It draws box plots (without the whiskers) with any number of user-specified "corners" (corresponding to different quantiles), but it also draws box-percentile plots similar to those drawn by Jeffrey Banfield's (<umsfjban@bill.oscs.montana.edu>) `bpplot` function. To quote from Banfield, "box-percentile plots supply more information about the univariate distributions. At any height the width of the irregular 'box' is proportional to the percentile of that height, up to the 50th percentile, and above the 50th percentile the width is proportional to 100 minus the percentile. Thus, the width at any given height is proportional to the percent of observations that are more extreme in that direction. As in boxplots, the median, 25th and 75th percentiles are marked with line segments across the box."

`panel.bpplot` can also be used with base graphics to add extended box plots to an existing plot, by specifying `nogrid=TRUE, height=...`.

`panel.bpplot` is a generalization of `bpplot` and `panel.bwplot` in that it works with `trellis` (making the plots horizontal so that category labels are more visable), it allows the user to specify

the quantiles to connect and those for which to draw reference lines, and it displays means (by default using dots).

bpplt draws horizontal box-percentile plot much like those drawn by panel.bpplot but taking as the starting point a matrix containing quantiles summarizing the data. bpplt is primarily intended to be used internally by plot.summary.formula.reverse or plot.summaryM but when used with no arguments has a general purpose: to draw an annotated example box-percentile plot with the default quantiles used and with the mean drawn with a solid dot. This schematic plot is rendered nicely in postscript with an image height of 3.5 inches.

bppltp is like bpplt but for plotly graphics, and it does not draw an annotated extended box plot example.

bpplotM uses the lattice bwplot function to depict multiple numeric continuous variables with varying scales in a single lattice graph, after reshaping the dataset into a tall and thin format.

Usage

```
panel.bpplot(x, y, box.ratio=1, means=TRUE, qref=c(.5,.25,.75),
             probs=c(.05,.125,.25,.375), nout=0,
             nloc=c('right lower', 'right', 'left', 'none'), cex.n=.7,
             datadensity=FALSE, scat1d.opts=NULL,
             violin=FALSE, violin.opts=NULL,
             font=box.dot$font, pch=box.dot$pch,
             cex.means =box.dot$cex,  col=box.dot$col,
             nogrid=NULL, height=NULL, ...)

# E.g. bwplot(formula, panel=panel.bpplot, panel.bpplot.parameters)

bpplt(stats, xlim, xlab='', box.ratio = 1, means=TRUE,
      qref=c(.5,.25,.75), qomit=c(.025,.975),
      pch=16, cex.labels=par('cex'), cex.points=if(prototype)1 else 0.5,
      grid=FALSE)

bppltp(p=plotly::plot_ly(),
       stats, xlim, xlab='', box.ratio = 1, means=TRUE,
       qref=c(.5,.25,.75), qomit=c(.025,.975),
       teststat=NULL, showlegend=TRUE)

bpplotM(formula=NULL, groups=NULL, data=NULL, subset=NULL, na.action=NULL,
        qlim=0.01, xlim=NULL,
        nloc=c('right lower','right','left','none'),
        vnames=c('labels', 'names'), cex.n=.7, cex.strip=1,
        outerlabels=TRUE, ...)
```

Arguments

x	continuous variable whose distribution is to be examined
y	grouping variable
box.ratio	see panel.bwplot

means	set to FALSE to suppress drawing a character at the mean value
qref	vector of quantiles for which to draw reference lines. These do not need to be included in probs.
probs	vector of quantiles to display in the box plot. These should all be less than 0.5; the mirror-image quantiles are added automatically. By default, probs is set to c(.05,.125,.25,.375) so that intervals contain 0.9, 0.75, 0.5, and 0.25 of the data. To draw all 99 percentiles, i.e., to draw a box-percentile plot, set probs=seq(.01,.49,by=.01). To make a more traditional box plot, use probs=.25.
nout	tells the function to use scat1d to draw tick marks showing the nout smallest and nout largest values if nout >= 1, or to show all values less than the nout quantile or greater than the 1-nout quantile if 0 < nout <= 0.5. If nout is a whole number, only the first n/2 observations are shown on either side of the median, where n is the total number of observations.
nloc	location to plot number of non-NA observations next to each box. Specify nloc='none' to suppress. For panel.bpplot, the default nloc is 'none' if nogrid=TRUE.
cex.n	character size for nloc
datadensity	set to TRUE to invoke scat1d to draw a data density (one-dimensional scatter diagram or rug plot) inside each box plot.
scat1d.opts	a list containing named arguments (without abbreviations) to pass to scat1d when datadensity=TRUE or nout > 0
violin	set to TRUE to invoke panel.violin in addition to drawing box-percentile plots
violin.opts	a list of options to pass to panel.violin
cex.means	character size for dots representing means
font, pch, col	see panel.bwplot
nogrid	set to TRUE to use in base graphics
height	if nogrid=TRUE, specifies the height of the box in user y units
...	arguments passed to points or panel.bpplot or bwplot
stats, xlim, xlab, qomit, cex.labels, cex.points, grid	undocumented arguments to bpplt. For bpplotM, xlim is a list with elements named as the x-axis variables, to override the qlim calculations with user-specified x-axis limits for selected variables. Example: xlim=list(age=c(20,60)).
p	an already-started plotly object
teststat	an html expression containing a test statistic
showlegend	set to TRUE to have plotly include a legend. Not recommended when plotting more than one variable.
formula	a formula with continuous numeric analysis variables on the left hand side and stratification variables on the right. The first variable on the right is the one that will vary the fastest, forming the y-axis. formula may be omitted, in which case all numeric variables with more than 5 unique values in data will be analyzed. Or formula may be a vector of variable names in data to analyze. In the latter two cases (and only those cases), groups must be given, representing a character vector with names of stratification variables.

groups	see above
data	an optional data frame
subset	an optional subsetting expression or logical vector
na.action	specifies a function to possibly subset the data according to NAs (default is no such subsetting).
qlim	the outer quantiles to use for scaling each panel in bpplotM
vnames	default is to use variable label attributes when they exist, or use variable names otherwise. Specify vnames='names' to always use variable names for panel labels in bpplotM
cex.strip	character size for panel strip labels
outerlabels	if TRUE, pass the lattice graphics through the latticeExtra package's useOuterStrips function if there are two conditioning (paneling) variables, to put panel labels in outer margins.

Author(s)

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References

Esty WW, Banfield J: The box-percentile plot. J Statistical Software 8 No. 17, 2003.

See Also

bpplot, panel.bwplot, scat1d, quantile, Ecdf, summaryP, useOuterStrips

Examples

```
set.seed(13)
x <- rnorm(1000)
g <- sample(1:6, 1000, replace=TRUE)
x[g==1][1:20] <- rnorm(20)+3   # contaminate 20 x's for group 1


# default trellis box plot
require(lattice)
bwplot(g ~ x)


# box-percentile plot with data density (rug plot)
bwplot(g ~ x, panel=panel.bpplot, probs=seq(.01,.49,by=.01), datadensity=TRUE)
# add ,scat1d.opts=list(tfrac=1) to make all tick marks the same size
# when a group has > 125 observations


# small dot for means, show only .05,.125,.25,.375,.625,.75,.875,.95 quantiles
```

```
bwplot(g ~ x, panel=panel.bpplot, cex.means=.3)


# suppress means and reference lines for lower and upper quartiles
bwplot(g ~ x, panel=panel.bpplot, probs=c(.025,.1,.25), means=FALSE, qref=FALSE)


# continuous plot up until quartiles ("Tootsie Roll plot")
bwplot(g ~ x, panel=panel.bpplot, probs=seq(.01,.25,by=.01))


# start at quartiles then make it continuous ("coffin plot")
bwplot(g ~ x, panel=panel.bpplot, probs=seq(.25,.49,by=.01))


# same as previous but add a spike to give 0.95 interval
bwplot(g ~ x, panel=panel.bpplot, probs=c(.025,seq(.25,.49,by=.01)))


# decile plot with reference lines at outer quintiles and median
bwplot(g ~ x, panel=panel.bpplot, probs=c(.1,.2,.3,.4), qref=c(.5,.2,.8))


# default plot with tick marks showing all observations outside the outer
# box (.05 and .95 quantiles), with very small ticks
bwplot(g ~ x, panel=panel.bpplot, nout=.05, scat1d.opts=list(frac=.01))


# show 5 smallest and 5 largest observations
bwplot(g ~ x, panel=panel.bpplot, nout=5)


# Use a scat1d option (preserve=TRUE) to ensure that the right peak extends
# to the same position as the extreme scat1d
bwplot(~x , panel=panel.bpplot, probs=seq(.00,.5,by=.001),
       datadensity=TRUE, scat1d.opt=list(preserve=TRUE))

# Add an extended box plot to an existing base graphics plot
plot(x, 1:length(x))
panel.bpplot(x, 1070, nogrid=TRUE, pch=19, height=15, cex.means=.5)

# Draw a prototype showing how to interpret the plots
bpplt()

# Example for bpplotM
set.seed(1)
n <- 800
d <- data.frame(treatment=sample(c('a','b'), n, TRUE),
                sex=sample(c('female','male'), n, TRUE),
                age=rnorm(n, 40, 10),
                bp =rnorm(n, 120, 12),
                wt =rnorm(n, 190, 30))
label(d$bp) <- 'Systolic Blood Pressure'
```

```
units(d$bp) <- 'mmHg'
bpplotM(age + bp + wt ~ treatment, data=d)
bpplotM(age + bp + wt ~ treatment * sex, data=d, cex.strip=.8)
bpplotM(age + bp + wt ~ treatment*sex, data=d,
        violin=TRUE,
        violin.opts=list(col=adjustcolor('blue', alpha.f=.15),
                         border=FALSE))


bpplotM(c('age', 'bp', 'wt'), groups='treatment', data=d)
# Can use Hmisc Cs function, e.g. Cs(age, bp, wt)
bpplotM(age + bp + wt ~ treatment, data=d, nloc='left')

# Without treatment: bpplotM(age + bp + wt ~ 1, data=d)

## Not run:
# Automatically find all variables that appear to be continuous
getHdata(support)
bpplotM(data=support, group='dzgroup',
        cex.strip=.4, cex.means=.3, cex.n=.45)

# Separate displays for categorical vs. continuous baseline variables
getHdata(pbc)
pbc <- upData(pbc, moveUnits=TRUE)

s <- summaryM(stage + sex + spiders ~ drug, data=pbc)
plot(s)
Key(0, .5)
s <- summaryP(stage + sex + spiders ~ drug, data=pbc)
plot(s, val ~ freq | var, groups='drug', pch=1:3, col=1:3,
     key=list(x=.6, y=.8))

bpplotM(bili + albumin + protime + age ~ drug, data=pbc)

## End(Not run)
```

`partition` *Patitions an object into different sets*

Description

Partitions an object into subsets of length defined in the `sep` argument.

Usage

```
partition.vector(x, sep, ...)
partition.matrix(x, rowsep, colsep, ...)
```

Arguments

x	object to be partitioned.
sep	determines how many elements should go into each set. The sum of sep should be equal to the length of x.
rowsep	determins how many rows should go into each set. The sum of rowsep must equal the number of rows in x.
colsep	determins how many columns should go into each set. The sum of colsep must equal the number of columns in x.
...	arguments used in other methods of partition.

Value

A list of equal length as sep containing the partitioned objects.

Author(s)

Charles Dupont

See Also

split

Examples

```
a <- 1:7
partition.vector(a, sep=c(1,3,2,1))
```

---

pc1 *First Principal Component*

Description

Given a numeric matrix which may or may not contain NAs, pc1 standardizes the columns to have mean 0 and variance 1 and computes the first principal component using prcomp. The proportion of variance explained by this component is printed, and so are the coefficients of the original (not scaled) variables. These coefficients may be applied to the raw data to obtain the first PC.

Usage

```
pc1(x, hi)
```

Arguments

x	numeric matrix
hi	if specified, the first PC is scaled so that its maximum value is hi and its minimum value is zero

Value

The vector of observations with the first PC. An attribute `"coef"` is attached to this vector. `"coef"` contains the raw-variable coefficients.

Author(s)

Frank Harrell

See Also

`prcomp`

Examples

```
set.seed(1)
x1 <- rnorm(100)
x2 <- x1 + rnorm(100)
w <- pc1(cbind(x1,x2))
attr(w,'coef')
```

`plot.princmp` *plot.princmp*

Description

Plot Method for princmp

Usage

```
## S3 method for class 'princmp'
plot(
  x,
  which = c("scree", "loadings"),
  k = x$k,
  offset = 0.8,
  col = 1,
  adj = 0,
  ylim = NULL,
  add = FALSE,
  abbrev = 25,
  nrow = NULL,
  ...
)
```

Arguments

x	results of ‘princmp‘
which	’‘scree‘’ or ’‘loadings’‘
k	number of components to show, default is ‘k‘ specified to ‘princmp‘
offset	controls positioning of text labels for cumulative fraction of variance explained
col	color of plotted text in scree plot
adj	angle for plotting text in scree plot
ylim	y-axis scree plotting limits, a 2-vector
add	set to ‘TRUE‘ to add a line to an existing scree plot without drawing axes
abbrev	an integer specifying the variable name length above which names are passed through [abbreviate(..., minlength=abbrev)]
nrow	number of rows to use in plotting loadings. Defaults to the ‘ggplot2‘ ‘facet_wrap‘ default.
...	unused

Details

Uses base graphics to by default plot the scree plot from a [princmp()] result, showing cumultive proportion of variance explained. Alternatively the standardized PC loadings are shown in a ‘ggplot2‘ bar chart.

Value

‘ggplot2‘ object if ‘which=’loadings’‘

Author(s)

Frank Harrell

---

plotCorrM *plotCorrM*

Description

Plot Correlation Matrix and Correlation vs. Time Gap

Usage

```
plotCorrM(
  r,
  what = c("plots", "data"),
  type = c("rectangle", "circle"),
  xlab = "",
  ylab = "",
  maxsize = 12,
  xangle = 0
)
```

Arguments

r	correlation matrix
what	specifies whether to return plots or the data frame used in making the plots
type	specifies whether to use bottom-aligned rectangles (the default) or centered circles
xlab	x-axis label for correlation matrix
ylab	y-axis label for correlation matrix
maxsize	maximum circle size if type='circle'
xangle	angle for placing x-axis labels, defaulting to 0. Consider using xangle=45 when labels are long.

Details

Constructs two ggplot2 graphics. The first is a half matrix of rectangles where the height of the rectangle is proportional to the absolute value of the correlation coefficient, with positive and negative coefficients shown in different colors. The second graphic is a variogram-like graph of correlation coefficients on the y-axis and absolute time gap on the x-axis, with a loess smoother added. The times are obtained from the correlation matrix's row and column names if these are numeric. If any names are not numeric, the times are taken as the integers 1, 2, 3, ... The two graphics are ggplotly-ready if you use plotly::ggplotly(..., tooltip='label').

Value

a list containing two ggplot2 objects if what='plots', or a data frame if what='data'

Author(s)

Frank Harrell

Examples

```
set.seed(1)
r <- cor(matrix(rnorm(100), ncol=10))
g <- plotCorrM(r)
g[[1]]  # plot matrix
g[[2]]  # plot correlation vs gap time
# ggplotlyr(g[[2]])
# ggplotlyr uses ggplotly with tooltip='label' then removes
# txt: from hover text
```

plotCorrPrecision *Plot Precision of Estimate of Pearson Correlation Coefficient*

Description

This function plots the precision (margin of error) of the product-moment linear correlation coefficient r vs. sample size, for a given vector of correlation coefficients rho. Precision is defined as the larger of the upper confidence limit minus rho and rho minus the lower confidence limit. labcurve is used to automatically label the curves.

Usage

```
plotCorrPrecision(rho = c(0, 0.5), n = seq(10, 400, length.out = 100),
                  conf.int = 0.95, offset=0.025, ...)
```

Arguments

rho	single or vector of true correlations. A worst-case precision graph results from rho=0
n	vector of sample sizes to use on the x-axis
conf.int	confidence coefficient; default uses 0.95 confidence limits
offset	see labcurve
...	other arguments to labcurve

Author(s)

Xing Wang and Frank Harrell

See Also

rcorr,cor,cor.test

Examples

```
plotCorrPrecision()
plotCorrPrecision(rho=0)
```

plotlyM *plotly Multiple*

Description

Generates multiple plotly graphics, driven by specs in a data frame

Usage

```
plotlyM(
  data,
  x = ~x,
  y = ~y,
  xhi = ~xhi,
  yhi = ~yhi,
  htext = NULL,
  multplot = NULL,
  strata = NULL,
  fitter = NULL,
  color = NULL,
  size = NULL,
  showpts = !length(fitter),
  rotate = FALSE,
  xlab = NULL,
  ylab = NULL,
  ylabpos = c("top", "y"),
  xlim = NULL,
  ylim = NULL,
  shareX = TRUE,
  shareY = FALSE,
  height = NULL,
  width = NULL,
  nrows = NULL,
  ncols = NULL,
  colors = NULL,
  alphaSegments = 1,
  alphaCline = 0.3,
  digits = 4,
  zeroline = TRUE
)
```

Arguments

data	input data frame
x	formula specifying the x-axis variable
y	formula for y-axis variable

xhi	formula for upper x variable limits (x taken to be lower value)
yhi	formula for upper y variable limit (y taken to be lower value)
htext	formula for hovertext variable
multplot	formula specifying a variable in data that when stratified on produces a separate plot
strata	formula specifying an optional stratification variable
fitter	a fitting such as loess that comes with a predict method. Alternatively specify fitter='ecdf' to use an internal function for computing and displaying ECDFs, which moves the analysis variable from the y-axis to the x-axis
color	plotly formula specifying a color variable or e.g. ~I('black'). To keep colors constant over multiple plots you will need to specify an AsIs color when you don't have a variable representing color groups.
size	plotly formula specifying a symbol size variable or AsIs
showpts	if fitter is given, set to TRUE to show raw data points in addition to smooth fits
rotate	set to TRUE to reverse the roles of x and y, for example to get horizontal dot charts with error bars
xlab	x-axis label. May contain html.
ylab	a named vector of y-axis labels, possibly containing html (see example below). The names of the vector must correspond to levels of the multplot variable. ylab can be unnamed if multplot is not used.
ylabpos	position of y-axis labels. Default is on top left of plot. Specify ylabpos='y' for usual y-axis placement.
xlim	2-vector of x-axis limits, optional
ylim	2-vector of y-axis limits, optional
shareX	specifies whether x-axes should be shared when they align vertically over multiple plots
shareY	specifies whether y-axes should be shared when they align horizontally over multiple plots
height	height of the combined image in pixels
width	width of the combined image in pixels
nrows	the number of rows to produce using subplot
ncols	the number of columns to produce using subplot (specify at most one of nrows,ncols)
colors	the color palette. Leave unspecified to use the default plotly palette
alphaSegments	alpha transparency for line segments (when xhi or yhi is not NA)
alphaCline	alpha transparency for lines used to connect points
digits	number of significant digits to use in constructing hovertext
zeroline	set to FALSE to suppress vertical line at x=0

Details

Generates multiple plotly traces and combines them with plotly::subplot. The traces are controlled by specifications in data frame data plus various arguments. data must contain these variables: x, y, and tracename (if color is not an "AsIs" color such as ~ I('black')), and can contain these optional variables: xhi, yhi (rows containing NA for both xhi and yhi represent points, and those with non-NA xhi or yhi represent segments, connect (set to TRUE for rows for points, to connect the symbols), legendgroup (see plotly documentation), and htext (hovertext). If the color argument is given and it is not an "AsIs" color, the variable named in the color formula must also be in data. Likewise for size. If the multplot is given, the variable given in the formula must be in data. If strata is present, another level of separate plots is generated by levels of strata, within levels of multplot.

If fitter is specified, x,y coordinates for an individual plot are run through fitter, and a line plot is made instead of showing data points. Alternatively you can specify fitter='ecdf' to compute and plot emirical cumulative distribution functions.

Value

plotly object produced by subplot

Author(s)

Frank Harrell

Examples

```
## Not run:
set.seed(1)
pts     <- expand.grid(v=c('y1', 'y2', 'y3'), x=1:4, g=c('a', 'b'), yhi=NA,
                       tracename='mean', legendgroup='mean',
                       connect=TRUE, size=4)

pts$y   <- round(runif(nrow(pts)), 2)

segs     <- expand.grid(v=c('y1', 'y2', 'y3'), x=1:4, g=c('a', 'b'),
                        tracename='limits', legendgroup='limits',
                        connect=NA, size=6)
segs$y   <- runif(nrow(pts))
segs$yhi <- segs$y + runif(nrow(pts), .05, .15)

z <- rbind(pts, segs)

xlab <- labelPlotmath('X<sub>12</sub>', 'm/sec<sup>2</sup>', html=TRUE)
ylab <- c(y1=labelPlotmath('Y1', 'cm', html=TRUE),
          y2='Y2',
          y3=labelPlotmath('Y3', 'mm', html=TRUE))

W=plotlyM(z, multplot=~v, color=~g, xlab=xlab, ylab=ylab, ncols=2,
          colors=c('black', 'blue'))

W2=plotlyM(z, multplot=~v, color=~I('black'), xlab=xlab, ylab=ylab,
```

```
            colors=c('black', 'blue'))

## End(Not run)
```

`plotlyParm` *Parameters for Plotly Graphics*

Description

`plotlyParm` is a list of functions useful for specifying parameters to `plotly` graphics, such as chart heights, colors, and margins.

Usage

```
plotlyParm
```

Format

A list of functions:

- `heightDotchart(rows, per=25, low=200, high=800)`: computes the needed height in pixels for a plotly dot chart given the number of rows in the chart.
- `heightDotchartb(x, per=40, low, high=1700)`: given a vector of row labels that appear to the left on a dot chart, computes the needed chart height, taking label line breaks into account. Since `plotly` devotes the same vertical space to each category, this only needs to find the maximum number of breaks present.
- `colUnorder(n=5, col=colorspace::rainbow_hcl)`: colors for unordered categories.
- `colOrdered(n=5, col=viridisLite::viridis)`: colors for ordered levels.
- `lrmargin(x, wmax=190, mult=7)`: margin to leave enough room for long labels on the left or right, as in dot charts.

`plotlySave` *Save a Plotly Graphic to PNG*

Description

`plotlySave` saves a plotly graphic with name `foo.png` where `foo` is the name of the current chunk. You must have a free `plotly` account from `plot.ly` to use this function, and you must have run `Sys.setenv(plotly_username="your_plotly_username")` and `Sys.setenv(plotly_api_key="your_api_key")`. The API key can be found in one's profile settings. See http://stackoverflow.com/questions/33959635/exporting-png-files-from-plotly-in-r.

Usage

```
plotlySave(x, ...)
```

Arguments

x	a plotly graphics object or a named list of such objects. The resulting png file will go in the file path given by the knitr fig.path value, and have a base name equal to the current knitr chunk name. If x is a list, a minus sign followed by the chunk name are inserted before .png.
...	additional arguments passed to plotly::plotly_IMAGE

Value

called for its side effect of writing one or more PNG files; returns invisible(NULL)

Examples

```
# ```{r chunkname}
# p <- plotly::plot_ly(...)
# plotlySave(p)   # creates fig.path/chunkname.png
# ```
```

---

plotp *Generic Method for Making Plotly Graphics*

Description

plotp is a generic function that dispatches to plotp methods to make plotly graphics.

Usage

```
plotp(data, ...)
```

Arguments

data	an object having a plotp method
...	additional arguments passed to the specific plotp method

Value

typically a plotly object, as produced by the dispatched method

plsmo *Plot smoothed estimates*

Description

Plot smoothed estimates of x vs. y, handling missing data for lowess or supsmu, and adding axis labels. Optionally suppresses plotting extrapolated estimates. An optional group variable can be specified to compute and plot the smooth curves by levels of group. When group is present, the datadensity option will draw tick marks showing the location of the raw x-values, separately for each curve. plsmo has an option to plot connected points for raw data, with no smoothing. The non-panel version of plsmo allows y to be a matrix, for which smoothing is done separately over its columns. If both group and multi-column y are used, the number of curves plotted is the product of the number of groups and the number of y columns.

method='intervals' is often used when y is binary, as it may be tricky to specify a reasonable smoothing parameter to lowess or supsmu in this case. The 'intervals' method uses the cutGn function to form intervals of x containing a minimum of mobs observations. For each interval the ifun function summarizes y, with the default being the mean (proportions for binary y). The results are plotted as step functions, with vertical discontinuities drawn with a saturation of 0.15 of the original color. A plus sign is drawn at the mean x within each interval. For this approach, the default x-range is the entire raw data range, and trim and evaluate are ignored. For panel.plsmo it is best to specify type='l' when using 'intervals'.

panel.plsmo is a panel function for trellis for the xyplot function that uses plsmo and its options to draw one or more nonparametric function estimates on each panel. This has advantages over using xyplot with panel.xyplot and panel.loess: (1) by default it will invoke labcurve to label the curves where they are most separated, (2) the datadensity option will put rug plots on each curve (instead of a single rug plot at the bottom of the graph), and (3) when panel.plsmo invokes plsmo it can use the "super smoother" (supsmu function) instead of lowess, or pass method='intervals'. panel.plsmo senses when a group variable is specified to xyplot so that it can invoke panel.superpose instead of panel.xyplot. Using panel.plsmo through trellis has some advantages over calling plsmo directly in that conditioning variables are allowed and trellis uses nicer fonts etc.

When a group variable was used, panel.plsmo creates a function Key in the session frame that the user can invoke to draw a key for individual data point symbols used for the groups. By default, the key is positioned at the upper right corner of the graph. If Key(locator(1)) is specified, the key will appear so that its upper left corner is at the coordinates of the mouse click.

For ggplot2 graphics the counterparts are stat_plsmo and histSpikeg.

Usage

```
plsmo(x, y, method=c("lowess","supsmu","raw","intervals"), xlab, ylab,
      add=FALSE, lty=1 : lc, col=par("col"), lwd=par("lwd"),
      iter=if(length(unique(y))>2) 3 else 0, bass=0, f=2/3, mobs=30, trim,
      fun, ifun=mean, group, prefix, xlim, ylim,
      label.curves=TRUE, datadensity=FALSE, scat1d.opts=NULL,
      lines.=TRUE, subset=TRUE,
```

```
      grid=FALSE, evaluate=NULL, ...)


#To use panel function:
#xyplot(formula=y ~ x | conditioningvars, groups,
#       panel=panel.plsmo, type='b',
#       label.curves=TRUE,
#       lwd = superpose.line$lwd,
#       lty = superpose.line$lty,
#       pch = superpose.symbol$pch,
#       cex = superpose.symbol$cex,
#       font = superpose.symbol$font,
#       col = NULL, scat1d.opts=NULL, \dots)
```

Arguments

x	vector of x-values, NAs allowed
y	vector or matrix of y-values, NAs allowed
method	"lowess" (the default), "supsmu", "raw" to not smooth at all, or "intervals" to use intervals (see above)
xlab	x-axis label iff add=F. Defaults of label(x) or argument name.
ylab	y-axis label, like xlab.
add	Set to T to call lines instead of plot. Assumes axes already labeled.
lty	line type, default=1,2,3,..., corresponding to columns of y and group combinations
col	color for each curve, corresponding to group. Default is current par("col").
lwd	vector of line widths for the curves, corresponding to group. Default is current par("lwd"). lwd can also be specified as an element of label.curves if label.curves is a list.
iter	iter parameter if method="lowess", default=0 if y is binary, and 3 otherwise.
bass	bass parameter if method="supsmu", default=0.
f	passed to the lowess function, for method="lowess"
mobs	for method='intervals', the minimum number of observations per interval
trim	only plots smoothed estimates between trim and 1-trim quantiles of x. Default is to use 10th smallest to 10th largest x in the group if the number of observations in the group exceeds 200 (0 otherwise). Specify trim=0 to plot over entire range.
fun	after computing the smoothed estimates, if fun is given the y-values are transformed by fun()
ifun	a summary statistic function to apply to the y-variable for method='intervals'. Default is mean.
group	a variable, either a factor vector or one that will be converted to factor by plsmo, that is used to stratify the data so that separate smooths may be computed
prefix	a character string to appear in group of group labels. The presence of prefix ensures that labcurve will be called even when add=TRUE.

xlim	a vector of 2 x-axis limits. Default is observed range.
ylim	a vector of 2 y-axis limits. Default is observed range.
label.curves	set to FALSE to prevent labcurve from being called to label multiple curves corresponding to groups. Set to a list to pass options to labcurve. lty and col are passed to labcurve automatically.
datadensity	set to TRUE to draw tick marks on each curve, using x-coordinates of the raw data x values. This is done using scat1d.
scat1d.opts	a list of options to hand to scat1d
lines.	set to FALSE to suppress smoothed curves from being drawn. This can make sense if datadensity=TRUE.
subset	a logical or integer vector specifying a subset to use for processing, with respect too all variables being analyzed
grid	set to TRUE if the R grid package drew the current plot
evaluate	number of points to keep from smoother. If specified, an equally-spaced grid of evaluate x values will be obtained from the smoother using linear interpolation. This will keep from plotting an enormous number of points if the dataset contains a very large number of unique x values.
...	optional arguments that are passed to scat1d, or optional parameters to pass to plsmo from panel.plsmo. See optional arguments for plsmo above.
type	set to p to have panel.plsmo plot points (and not call plsmo), l to call plsmo and not plot points, or use the default b to plot both.
pch, cex, font	vectors of graphical parameters corresponding to the groups (scalars if group is absent). By default, the parameters set up by trellis will be used.

Value

plsmo returns a list of curves (x and y coordinates) that was passed to labcurve

Side Effects

plots, and panel.plsmo creates the Key function in the session frame.

See Also

lowess, supsmu, label, quantile, labcurve, scat1d, xyplot, panel.superpose, panel.xyplot, stat_plsmo, histSpikeg, cutGn

Examples

```
set.seed(1)
x <- 1:100
y <- x + runif(100, -10, 10)
plsmo(x, y, "supsmu", xlab="Time of Entry")
#Use label(y) or "y" for ylab


plsmo(x, y, add=TRUE, lty=2)
```

```
#Add lowess smooth to existing plot, with different line type


age <- rnorm(500, 50, 15)
survival.time <- rexp(500)
sex <- sample(c('female','male'), 500, TRUE)
race <- sample(c('black','non-black'), 500, TRUE)
plsmo(age, survival.time < 1, fun=qlogis, group=sex) # plot logit by sex

#Bivariate Y
sbp <- 120 + (age - 50)/10 + rnorm(500, 0, 8) + 5 * (sex == 'male')
dbp <-  80 + (age - 50)/10 + rnorm(500, 0, 8) - 5 * (sex == 'male')
Y <- cbind(sbp, dbp)
plsmo(age, Y)
plsmo(age, Y, group=sex)


#Plot points and smooth trend line using trellis
# (add type='l' to suppress points or type='p' to suppress trend lines)
require(lattice)
xyplot(survival.time ~ age, panel=panel.plsmo)


#Do this for multiple panels
xyplot(survival.time ~ age | sex, panel=panel.plsmo)

#Repeat this using equal sample size intervals (n=25 each) summarized by
#the median, then a proportion (mean of binary y)
xyplot(survival.time ~ age | sex, panel=panel.plsmo, type='l',
       method='intervals', mobs=25, ifun=median)
ybinary <- ifelse(runif(length(sex)) < 0.5, 1, 0)
xyplot(ybinary ~ age, groups=sex, panel=panel.plsmo, type='l',
       method='intervals', mobs=75, ifun=mean, xlim=c(0, 120))


#Do this for subgroups of points on each panel, show the data
#density on each curve, and draw a key at the default location
xyplot(survival.time ~ age | sex, groups=race, panel=panel.plsmo,
       datadensity=TRUE)
Key()


#Use wloess.noiter to do a fast weighted smooth
plot(x, y)
lines(wtd.loess.noiter(x, y))
lines(wtd.loess.noiter(x, y, weights=c(rep(1,50), 100, rep(1,49))), col=2)
points(51, y[51], pch=18)   # show overly weighted point
#Try to duplicate this smooth by replicating 51st observation 100 times
lines(wtd.loess.noiter(c(x,rep(x[51],99)),c(y,rep(y[51],99)),
      type='ordered all'), col=3)
#Note: These two don't agree exactly
```

pMedian *pMedian*

Description

Pseudomedian

Usage

```
pMedian(
  x,
  na.rm = FALSE,
  conf.int = 0,
  B = 1000,
  type = c("percentile", "bca")
)
```

Arguments

x	a numeric vector
na.rm	set to TRUE to exclude NAs and other non-numbers before computing the pseudomedian
conf.int	confidence level, defaulting to 0 so that no confidence limits are computed. Set to a number between 0 and 1 to compute bootstrap confidence limits
B	number of bootstrap samples if conf.int > 0
type	type of bootstrap interval, defaulting to 'percentile' for n >= 150 or 'bca' for n < 150

Details

Uses fast Fortran code to compute the pseudomedian of a numeric vector. The pseudomedian is the median of all possible midpoints of two observations. The pseudomedian is also called the Hodges-Lehmann one-sample estimator. The Fortran code is was originally from JF Monahan, and was converted to C++ in the DescTools package. It has been converted to Fortran 2018 here. Bootstrap confidence intervals are optionally computed.

If n > 250,000 a random sample of 250,000 values of x is used to limit execution time. For n > 1,000 only the percentile bootstrap confidence interval is computed.

Bootstrapping uses the Fortran subroutine directly, for efficiency.

Value

a scalar numeric value if conf.int = 0, or a 3-vector otherwise, with named elements estimate, lower, upper and attribute type. If the number of non-missing values is less than 5, NA is returned for both lower and upper limits.

See Also

https://dl.acm.org/toc/toms/1984/10/3/, https://www4.stat.ncsu.edu/~monahan/jul10/, https://www.fharrell.com/post/aci/

Examples

```
x <- c(1:4, 10000)
pMedian(x)
pMedian(x, conf.int=0.95)
# Compare with brute force calculation and with wilcox.test
w <- outer(x, x, '+')
median(w[lower.tri(w, diag=TRUE)]) / 2
wilcox.test(x, conf.int=TRUE)
```

---

popower *Power and Sample Size for Ordinal Response*

Description

popower computes the power for a two-tailed two sample comparison of ordinal outcomes under the proportional odds ordinal logistic model. The power is the same as that of the Wilcoxon test but with ties handled properly. posamsize computes the total sample size needed to achieve a given power. Both functions compute the efficiency of the design compared with a design in which the response variable is continuous. print methods exist for both functions. Any of the input arguments may be vectors, in which case a vector of powers or sample sizes is returned. These functions use the methods of Whitehead (1993).

pomodm is a function that assists in translating odds ratios to differences in mean or median on the original scale.

simPOcuts simulates simple unadjusted two-group comparisons under a PO model to demonstrate the natural sampling variability that causes estimated odds ratios to vary over cutoffs of Y.

propsPO uses ggplot2 to plot a stacked bar chart of proportions stratified by a grouping variable (and optionally a stratification variable), with an optional additional graph showing what the proportions would be had proportional odds held and an odds ratio was applied to the proportions in a reference group. If the result is passed to ggplotly, customized tooltip hover text will appear.

propsTrans uses ggplot2 to plot all successive transition proportions. formula has the state variable on the left hand side, the first right-hand variable is time, and the second right-hand variable is a subject ID variable.\

multEventChart uses ggplot2 to plot event charts showing state transitions, account for absorbing states/events. It is based on code written by Lucy D'Agostino McGowan posted at https://livefreeordichotomize.com/posts/2020-05-21-survival-model-detective-1/.

Usage

```
popower(p, odds.ratio, n, n1, n2, alpha=0.05)
## S3 method for class 'popower'
print(x, ...)
posamsize(p, odds.ratio, fraction=.5, alpha=0.05, power=0.8)
## S3 method for class 'posamsize'
print(x, ...)
pomodm(x=NULL, p, odds.ratio=1)
simPOcuts(n, nsim=10, odds.ratio=1, p)
propsPO(formula, odds.ratio=NULL, ref=NULL, data=NULL, ncol=NULL, nrow=NULL )
propsTrans(formula, data=NULL, labels=NULL, arrow='\u2794',
           maxsize=12, ncol=NULL, nrow=NULL)
multEventChart(formula, data=NULL, absorb=NULL, sortbylast=FALSE,
   colorTitle=label(y), eventTitle='Event',
   palette='OrRd',
   eventSymbols=c(15, 5, 1:4, 6:10),
   timeInc=min(diff(unique(x))/2))
```

Arguments

p	a vector of marginal cell probabilities which must add up to one. For popower and posamsize, The ith element specifies the probability that a patient will be in response level i, averaged over the two treatment groups. For pomodm and simPOcuts, p is the vector of cell probabilities to be translated under a given odds ratio. For simPOcuts, if p has names, those names are taken as the ordered distinct Y-values. Otherwise Y-values are taken as the integers 1, 2, ... up to the length of p.
odds.ratio	the odds ratio to be able to detect. It doesn't matter which group is in the numerator. For propsPO, odds.ratio is a function of the grouping (right hand side) variable value. The value of the function specifies the odds ratio to apply to the refernce group to get all other group's expected proportions were proportional odds to hold against the first group. Normally the function should return 1.0 when its x argument corresponds to the ref group. For pomodm and simPOcuts is the odds ratio to apply to convert the given cell probabilities.
n	total sample size for popower. You must specify either n or n1 and n2. If you specify n, n1 and n2 are set to n/2. For simPOcuts is a single number equal to the combined sample sizes of two groups.
n1	for popower, the number of subjects in treatment group 1
n2	for popower, the number of subjects in group 2
nsim	number of simulated studies to create by simPOcuts
alpha	type I error
x	an object created by popower or posamsize, or a vector of data values given to pomodm that corresponds to the vector p of probabilities. If x is omitted for pomodm, the odds.ratio will be applied and the new vector of individual probabilities will be returned. Otherwise if x is given to pomodm, a 2-vector with the mean and median x after applying the odds ratio is returned.

fraction	for posamsize, the fraction of subjects that will be allocated to group 1
power	for posamsize, the desired power (default is 0.8)
formula	an R formula expressure for proposPO where the outcome categorical variable is on the left hand side and the grouping variable is on the right. It is assumed that the left hand variable is either already a factor or will have its levels in the right order for an ordinal model when it is converted to factor. For multEventChart the left hand variable is a categorial status variable, the first right hand side variable represents time, and the second right side variable is a unique subject ID. One line is produced per subject.
ref	for propsPO specifies the reference group (value of the right hand side formula variable) to use in computing proportions on which too translate proportions in other groups, under the proportional odds assumption.
data	a data frame or data.table
labels	for propsTrans is an optional character vector corresponding to y=1,2,3,... that is used to construct plotly hovertext as a label attribute in the ggplot2 aesthetic. Used with y is integer on axes but you want long labels in hovertext.
arrow	character to use as the arrow symbol for transitions in propsTrans. The default is the dingbats heavy wide-headed rightwards arror.
nrow, ncol	see facet_wrap
maxsize	maximum symbol size
...	unused
absorb	character vector specifying the subset of levels of the left hand side variable that are absorbing states such as death or hospital discharge
sortbylast	set to TRUE to sort the subjects by the severity of the status at the last time point
colorTitle	label for legend for status
eventTitle	label for legend for absorb
palette	a single character string specifying the scale_fill_brewer color palette
eventSymbols	vector of symbol codes. Default for first two symbols is a solid square and an open diamond.
timeInc	time increment for the x-axis. Default is 1/2 the shortest gap between any two distincttimes in the data.

Value

a list containing power, eff (relative efficiency), and approx.se (approximate standard error of log odds ratio) for popower, or containing n and eff for posamsize.

Author(s)

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References

Whitehead J (1993): Sample size calculations for ordered categorical data. Stat in Med 12:2257–2271.

Julious SA, Campbell MJ (1996): Letter to the Editor. Stat in Med 15: 1065–1066. Shows accuracy of formula for binary response case.

See Also

simRegOrd, bpower, cpower, impactPO

Examples

```
# For a study of back pain (none, mild, moderate, severe) here are the
# expected proportions (averaged over 2 treatments) that will be in
# each of the 4 categories:


p <- c(.1,.2,.4,.3)
popower(p, 1.2, 1000)   # OR=1.2, total n=1000
posamsize(p, 1.2)
popower(p, 1.2, 3148)
# If p was the vector of probabilities for group 1, here's how to
# compute the average over the two groups:
# p2   <- pomodm(p=p, odds.ratio=1.2)
# pavg <- (p + p2) / 2

# Compare power to test for proportions for binary case,
# proportion of events in control group of 0.1
p <- 0.1; or <- 0.85; n <- 4000
popower(c(1 - p, p), or, n)    # 0.338
bpower(p, odds.ratio=or, n=n)  # 0.320
# Add more categories, starting with 0.1 in middle
p <- c(.8, .1, .1)
popower(p, or, n)   # 0.543
p <- c(.7, .1, .1, .1)
popower(p, or, n)   # 0.67
# Continuous scale with final level have prob. 0.1
p <- c(rep(1 / n, 0.9 * n), 0.1)
popower(p, or, n)   # 0.843

# Compute the mean and median x after shifting the probability
# distribution by an odds ratio under the proportional odds model
x <- 1 : 5
p <- c(.05, .2, .2, .3, .25)
# For comparison make up a sample that looks like this
X <- rep(1 : 5, 20 * p)
c(mean=mean(X), median=median(X))
pomodm(x, p, odds.ratio=1)  # still have to figure out the right median
pomodm(x, p, odds.ratio=0.5)

# Show variation of odds ratios over possible cutoffs of Y even when PO
```

```
# truly holds.  Run 5 simulations for a total sample size of 300.
# The two groups have 150 subjects each.
s <- simPOcuts(300, nsim=5, odds.ratio=2, p=p)
round(s, 2)

# An ordinal outcome with levels a, b, c, d, e is measured at 3 times
# Show the proportion of values in each outcome category stratified by
# time.  Then compute what the proportions would be had the proportions
# at times 2 and 3 been the proportions at time 1 modified by two odds ratios

set.seed(1)
d   <- expand.grid(time=1:3, reps=1:30)
d$y <- sample(letters[1:5], nrow(d), replace=TRUE)
propsPO(y ~ time, data=d, odds.ratio=function(time) c(1, 2, 4)[time])
# To show with plotly, save previous result as object p and then:
# plotly::ggplotly(p, tooltip='label')

# Add a stratification variable and don't consider an odds ratio
d   <- expand.grid(time=1:5, sex=c('female', 'male'), reps=1:30)
d$y <- sample(letters[1:5], nrow(d), replace=TRUE)
propsPO(y ~ time + sex, data=d)  # may add nrow= or ncol=

# Show all successive transition proportion matrices
d   <- expand.grid(id=1:30, time=1:10)
d$state <- sample(LETTERS[1:4], nrow(d), replace=TRUE)
propsTrans(state ~ time + id, data=d)

pt1 <- data.frame(pt=1, day=0:3,
   status=c('well', 'well', 'sick', 'very sick'))
pt2 <- data.frame(pt=2, day=c(1,2,4,6),
   status=c('sick', 'very sick', 'coma', 'death'))
pt3 <- data.frame(pt=3, day=1:5,
   status=c('sick', 'very sick', 'sick', 'very sick', 'discharged'))
pt4 <- data.frame(pt=4, day=c(1:4, 10),
   status=c('well', 'sick', 'very sick', 'well', 'discharged'))
d <- rbind(pt1, pt2, pt3, pt4)
d$status <- factor(d$status, c('discharged', 'well', 'sick',
                               'very sick', 'coma', 'death'))
label(d$day) <- 'Day'
require(ggplot2)
multEventChart(status ~ day + pt, data=d,
               absorb=c('death', 'discharged'),
               colorTitle='Status', sortbylast=TRUE) +
               theme_classic() +
               theme(legend.position='bottom')
```

---

princmp *princmp*

Description

Enhanced Output for Principal and Sparse Principal Components

Usage

```
princmp(
  formula,
  data = environment(formula),
  method = c("regular", "sparse"),
  k = min(5, p - 1),
  kapprox = min(5, k),
  cor = TRUE,
  sw = FALSE,
  nvmax = 5
)
```

Arguments

formula	a formula with no left hand side, or a numeric matrix
data	a data frame or table. By default variables come from the calling environment.
method	specifies whether to use regular or sparse principal components are computed
k	the number of components to plot, display, and return
kapprox	the number of components to approximate with stepwise regression when sw=TRUE
cor	set to FALSE to compute PCs on the original data scale, which is useful if all variables have the same units of measurement
sw	set to TRUE to run stepwise regression PC prediction/approximation
nvmax	maximum number of predictors to allow in stepwise regression PC approximations

Details

Expands any categorical predictors into indicator variables, and calls princomp (if method='regular' (the default)) or sPCAgrid in the pcaPP package (method='sparse') to compute lasso-penalized sparse principal components. By default all variables are first scaled by their standard deviation after observations with any NAs on any variables in formula are removed. Loadings of standardized variables, and if orig=TRUE loadings on the original data scale are printed. If pl=TRUE a scree plot is drawn with text added to indicate cumulative proportions of variance explained. If sw=TRUE, the leaps package regsubsets function is used to approximate the PCs using forward stepwise regression with the original variables as individual predictors.

A print method prints the results and a plot method plots the scree plot of variance explained.

Value

a list of class princmp with elements scores, a k-column matrix with principal component scores, with NAs when the input data had an NA, and other components useful for printing and plotting. If k=1 scores is a vector. Other components include vars (vector of variances explained), method, k.

Author(s)

Frank Harrell

print.char.list *prints a list of lists in a visually readable format.*

Description

Takes a list that is composed of other lists and matrixes and prints it in a visually readable format.

Usage

```
## S3 method for class 'char.list'
print(x, ..., hsep = c("|"), vsep = c("-"), csep = c("+"), print.it = TRUE,
                rowname.halign = c("left", "centre", "right"),
                rowname.valign = c("top", "centre", "bottom"),
                colname.halign = c("centre", "left", "right"),
                colname.valign = c("centre", "top", "bottom"),
                text.halign = c("right", "centre", "left"),
                text.valign = c("top", "centre", "bottom"),
                rowname.width, rowname.height,
                min.colwidth = .Options$digits, max.rowheight = NULL,
                abbreviate.dimnames = TRUE, page.width = .Options$width,
                colname.width, colname.height, prefix.width,
                superprefix.width = prefix.width)
```

Arguments

x	list object to be printed
...	place for extra arguments to reside.
hsep	character used to separate horizontal fields
vsep	character used to separate veritcal feilds
csep	character used where horizontal and veritcal separators meet.
print.it	should the value be printed to the console or returned as a string.
rowname.halign	horizontal justification of row names.
rowname.valign	verical justification of row names.
colname.halign	horizontal justification of column names.
colname.valign	verical justification of column names.
text.halign	horizontal justification of cell text.
text.valign	vertical justification of cell text.
rowname.width	minimum width of row name strings.
rowname.height	minimum height of row name strings.
min.colwidth	minimum column width.
max.rowheight	maximum row height.

abbreviate.dimnames	should the row and column names be abbreviated.
page.width	width of the page being printed on.
colname.width	minimum width of the column names.
colname.height	minimum height of the column names
prefix.width	maximum width of the rowname columns
superprefix.width	maximum width of the super rowname columns

Value

String that formated table of the list object.

Author(s)

Charles Dupont

---

print.char.matrix *Function to print a matrix with stacked cells*

Description

Prints a dataframe or matrix in stacked cells. Line break charcters in a matrix element will result in a line break in that cell, but tab characters are not supported.

Usage

```
## S3 method for class 'char.matrix'
print(x, file = "", col.name.align = "cen", col.txt.align = "right",
    cell.align = "cen", hsep = "|", vsep = "-", csep = "+", row.names = TRUE,
    col.names = FALSE, append = FALSE,
    top.border = TRUE, left.border = TRUE, ...)
```

Arguments

x	a matrix or dataframe
file	name of file if file output is desired. If left empty, output will be to the screen
col.name.align	if column names are used, they can be aligned right, left or centre. Default "cen" results in names centred between the sides of the columns they name. If the width of the text in the columns is less than the width of the name, col.name.align will have no effect. Other options are "right" and "left".
col.txt.align	how character columns are aligned. Options are the same as for col.name.align with no effect when the width of the column is greater than its name.
cell.align	how numbers are displayed in columns
hsep	character string to use as horizontal separator, i.e. what separates columns

vsep	character string to use as vertical separator, i.e. what separates rows. Length cannot be more than one.
csep	character string to use where vertical and horizontal separators cross. If hsep is more than one character, csep will need to be the same length. There is no provision for multiple vertical separators
row.names	logical: are we printing the names of the rows?
col.names	logical: are we printing the names of the columns?
append	logical: if file is not "", are we appending to the file or overwriting?
top.border	logical: do we want a border along the top above the columns?
left.border	logical: do we want a border along the left of the first column?
...	unused

Details

If any column of x is a mixture of character and numeric, the distinction between character and numeric columns will be lost. This is especially so if the matrix is of a form where you would not want to print the column names, the column information being in the rows at the beginning of the matrix.

Row names, if not specified in the making of the matrix will simply be numbers. To prevent printing them, set row.names = FALSE.

Value

No value is returned. The matrix or dataframe will be printed to file or to the screen.

Author(s)

Patrick Connolly <p.connolly@hortresearch.co.nz>

See Also

write, write.table

Examples

```
data(HairEyeColor)
print.char.matrix(HairEyeColor[ , , "Male"], col.names = TRUE)
print.char.matrix(HairEyeColor[ , , "Female"], col.txt.align = "left", col.names = TRUE)


z <- rbind(c("", "N", "y"),
           c("[ 1.34,40.3)\n[40.30,48.5)\n[48.49,58.4)\n[58.44,87.8]",
             " 50\n 50\n 50\n 50",
             "0.530\n0.489\n0.514\n0.507"),
           c("female\nmale", " 94\n106", "0.552\n0.473"  ),
           c("", "200", "0.510"))
dimnames(z) <- list(c("", "age", "sex", "Overall"),NULL)

print.char.matrix(z)
```

print.princmp *print.princmp*

Description

Print Results of princmp

Usage

```
## S3 method for class 'princmp'
print(x, which = c("none", "standardized", "original", "both"), k = x$k, ...)
```

Arguments

x	results of princmp
which	specifies which loadings to print, the default being 'none' and other values being 'standardized', 'original', or 'both'
k	number of components to show, defaults to k specified to princmp
...	unused

Details

Simple print method for princmp()

Value

nothing

Author(s)

Frank Harrell

printL *printL*

Description

Print an object or a named list of objects. When multiple objects are given, their names are printed before their contents. When an object is a vector that is not longer than maxoneline and its elements are not named, all the elements will be printed on one line separated by commas. When dec is given, numeric vectors or numeric columns of data frames or data tables are rounded to the nearest dec before printing. This function is especially helpful when printing objects in a Quarto or RMarkdown document and the code is not currently being shown to place the output in context.

Usage

```
printL(..., dec = NULL, maxoneline = 5)
```

Arguments

...	any number of objects to print()
dec	optional decimal places to the right of the decimal point for rounding
maxoneline	controls how many elements may be printed on a single line for vector objects

Value

nothing

Author(s)

Frank Harrell

See Also

prn()

Examples

```
w <- pi + 1 : 2
printL(w=w)
printL(w, dec=3)
printL('this is it'=c(pi, pi, 1, 2),
       yyy=pi,
       z=data.frame(x=pi+1:2, y=3:4, z=c('a', 'b')),
       qq=1:10,
       dec=4)
```

---

prnz *Print and Object with its Name*

Description

Prints an object with its name and with an optional descriptive text string. This is useful for annotating analysis output files and for debugging.

Usage

```
prn(x, txt, file, head=deparse(substitute(x), width.cutoff=500)[1])
```

Arguments

x	any object
txt	optional text string
file	optional file name. By default, writes to console. append=TRUE is assumed.
head	optional heading. Default is derived from the user's expression for x

Side Effects

prints

See Also

print, cat, printL

Examples

```
x <- 1:5
prn(x)
# prn(fit, 'Full Model Fit')
```

---

prselect *Selectively Print Lines of a Text Vector*

Description

Given one or two regular expressions or exact text matches, removes elements of the input vector that match these specifications. Omitted lines are replaced by .... This is useful for selectively suppressing some of the printed output of R functions such as regression fitting functions, especially in the context of making statistical reports using Sweave or Odfweave.

Usage

```
prselect(x, start = NULL, stop = NULL, i = 0, j = 0, pr = TRUE)
```

Arguments

x	input character vector
start	text or regular expression to look for starting line to omit. If omitted, deletions start at the first line.
stop	text or regular expression to look for ending line to omit. If omitted, deletions proceed until the last line.
i	increment in number of first line to delete after match is found
j	increment in number of last line to delete after match is found
pr	set to FALSE to suppress printing

Value

an invisible vector of retained lines of text

Author(s)

Frank Harrell

See Also

Sweave

Examples

```
x <- c('the','cat','ran','past','the','dog')
prselect(x, 'big','bad')     # omit nothing- no match
prselect(x, 'the','past')    # omit first 4 lines
prselect(x,'the','junk')     # omit nothing- no match for stop
prselect(x,'ran','dog')      # omit last 4 lines
prselect(x,'cat')            # omit lines 2-
prselect(x,'cat',i=1)        # omit lines 3-
prselect(x,'cat','past')     # omit lines 2-4
prselect(x,'cat','past',j=1) # omit lines 2-5
prselect(x,'cat','past',j=-1)# omit lines 2-3
prselect(x,'t$','dog')       # omit lines 2-6; t must be at end

# Example for Sweave: run a regression analysis with the rms package
# then selectively output only a portion of what print.ols prints.
# (Thanks to \email{romain.francois@dbmail.com})
# <<z,eval=FALSE,echo=T>>=
# library(rms)
# y <- rnorm(20); x1 <- rnorm(20); x2 <- rnorm(20)
# ols(y ~ x1 + x2)
# <<echo=F>>=
# z <- capture.output( {
# <<z>>
#    } )
# prselect(z, 'Residuals:') # keep only summary stats; or:
# prselect(z, stop='Coefficients', j=-1)  # keep coefficients, rmse, R^2; or:
# prselect(z, 'Coefficients', 'Residual standard error', j=-1) # omit coef
# @
```

---

pstamp *Date/Time/Directory Stamp the Current Plot*

Description

Date-time stamp the current plot in the extreme lower right corner. Optionally add the current working directory and arbitrary other text to the stamp.

Usage

```
pstamp(txt, pwd = FALSE, time. = TRUE)
```

Arguments

txt	an optional single text string
pwd	set to TRUE to add the current working directory name to the stamp
time.	set to FALSE to use the date without the time

Details

Certain functions are not supported for S-Plus under Windows. For R, results may not be satisfactory if par(mfrow=) is in effect.

Author(s)

Frank Harrell

Examples

```
plot(1:20)
pstamp(pwd=TRUE, time=FALSE)
```

---

qcrypt *qcrypt*

Description

Store and Encrypt R Objects or Files or Read and Decrypt Them

Usage

```
qcrypt(obj, base, service = "R-keyring-service", file, pw)
```

Arguments

obj	an R object to write to disk and encrypt (if base is specified) or the base file name to read and uncrypted (if base is not specified). Not used when file is given.
base	base file name when creating a file. Not used when file is given.
service	a fairly arbitrary keyring service name. The default is almost always OK unless you need to use different passwords for different files. service is ignored if pw is specified as an argument.
file	full name of file to encrypt or decrypt
pw	a single character string containing an actual password

Details

qcrypt is used to protect sensitive information on a user's computer or when transmitting a copy of the file to another R user. Unencrypted information only exists for a moment, and the encryption password does not appear in the user's script but instead is managed by the keyring package to remember the password across R sessions, and the getPass package, which pops up a password entry window and does not allow the password to be visible. The password is requested only once, except perhaps when the user logs out of their operating system session or reboots.

The keyring can be bypassed and the password entered in a popup window by specifying service=NA. This is the preferred approach when sending an encrypted file to a user on a different computer.

qcrypt writes R objects to disk in a temporary file using the qs2 package qs_save function. The file is quickly encrypted using the safer package, and the temporary unencrypted qs2 file is deleted. When reading an encrypted file the process is reversed and uses qs2::qs_read.

To save an object in an encrypted file, specify the object as the first argument obj and specify a base file name as a character string in the second argument base. The full qs2 file name will be of the form base.qs2.encrypted in the user's current working directory. To unencrypt the file into a short-lived temporary file and use qs2::qs_read to read it, specify the base file name as a character string with the first argument, and do not specify the base argument.

Alternatively, qcrypt can be used to encrypt or decrypt existing files of any type using the same password and keyring mechanism. The former is done by specifying file that does not end in '.encrypted' and the latter is done by ending file with '.encrypted'. When file does not contain a path it is assumed to be in the current working directory. When a file is encrypted the original file is removed. Files are decrypted into a temporary directory created by tempdir(), with the name of the file being the value of file with '.encrypted' removed.

Interactive password provision works when running R, Rscript, RStudio, or Quarto but does not work when running R CMD BATCH. getPass fails under RStudio on Macs.

It is also possible to pass the password as the pw argument. This is only safe if running interactively and the password is defined by typing e.g. pw <- 'whateverpassword' in the console, then running the script interactively with pw=pw added to the qcrypt call.

See R Workflow for more information.

Value

(invisibly) the full encrypted file name if writing the file, or the restored R object if reading the file. When decrypting a general file with file=, the returned value is the full path to a temporary file containing the decrypted data.

Author(s)

Frank Harrell

Examples

```
## Not run:
# Suppose x is a data.table or data.frame
# The first time qcrypt is run with a service a password will
# be requested.  It will be remembered across sessions thanks to
# the keyring package
```

```
qcrypt(x, 'x')   # creates x.qs2.encrypted in current working directory
x <- qcrypt('x') # unencrypts x.qs2.encrypted into a temporary
                 # directory, uses qs2::qs_read to read it, and
                 # stores the result in x
# Encrypt a general file using a different password
qcrypt(file='report.pdf', service='pdfkey')
# Decrypt that file
fi <- qcrypt(file='report.pdf.encrypted', service='pdfkey')
fi contains the full unencrypted file name which is in a temporary directory
# Encrypt without using a keyring
qcrypt(x, 'x', service=NA)
x <- qcrypt('x', service=NA)

pw <- 'somepassword'     # run this in the console
x <- qcrypt('x', pw=pw)  # interactively run this in a script

## End(Not run)
```

`qrxcenter` *qrxcenter*

Description

Mean-center a data matrix and QR transform it

Usage

```
qrxcenter(x, ...)
```

Arguments

`x`	a numeric matrix or vector with at least 2 rows
`...`	passed to `base::qr()`

Details

For a numeric matrix `x` (or a numeric vector that is automatically changed to a one-column matrix), computes column means and subtracts them from `x` columns, and passes this matrix to `base::qr()` to orthogonalize columns. Columns of the transformed `x` are negated as needed so that original directions are preserved (which are arbitrary with QR decomposition). Instead of the default `qr` operation for which sums of squares of column values are 1.0, `qrxcenter` makes all the transformed columns have standard deviation of 1.0.

Value

a list with components `x` (transformed data matrix), `R` (the matrix that can be used to transform raw `x` and to transform regression coefficients computed on transformed `x` back to the original space), `Ri` (transforms transformed `x` back to original scale except for `xbar`), and `xbar` (vector of means of original `x` columns‘)

Examples

```
set.seed(1)
age <- 1:10
country <- sample(c('Slovenia', 'Italy', 'France'), 10, TRUE)
x <- model.matrix(~ age + country)[, -1]
x
w <- qrxcenter(x)
w
# Reproduce w$x
sweep(x, 2, w$xbar) %*% w$R
# Reproduce x from w$x
sweep(w$x %*% w$Ri, 2, w$xbar, FUN='+')
# See also https://hbiostat.org/r/examples/gtrans/gtrans#sec-splinebasis
```

`r2describe` *r2describe*

Description

Summarize Strength of Relationships Using R-Squared From Linear Regression

Usage

```
r2describe(x, nvmax = 10)
```

Arguments

`x`	numeric matrix with 2 or more columns
`nvmax`	maxmum number of columns of x to use in predicting a given column

Details

Function to use `leaps::regsubsets()` to briefly describe which variables more strongly predict another variable. Variables are in a numeric matrix and are assumed to be transformed so that relationships are linear (e.g., using `redun()` or `transcan()`.)

Value

nothing

Author(s)

Frank Harrell

Examples

```
## Not run:
r <- redun(...)
r2describe(r$scores)

## End(Not run)
```

R2Measures *R2Measures*

Description

Generalized R^2 Measures

Usage

```
R2Measures(lr, p, n, ess = NULL, padj = 1)
```

Arguments

lr	likelihoood ratio chi-square statistic
p	number of non-intercepts in the model that achieved lr
n	raw number of observations
ess	if a single number, is the effective sample size. If a vector of numbers is assumed to be the frequency tabulation of all distinct values of the outcome variable, from which the effective sample size is computed.
padj	set to 2 to use the classical adjusted R^2 penalty, 1 (the default) to subtract p from lr

Details

Computes various generalized R^2 measures related to the Maddala-Cox-Snell (MCS) R^2 for regression models fitted with maximum likelihood. The original MCS R^2 is labeled R2 in the result. This measure uses the raw sample size n and does not penalize for the number of free parameters, so it can be rewarded for overfitting. A measure adjusted for the number of fitted regression coefficients p uses the analogy to R^2 in linear models by computing 1 - exp(- lr / n) * (n-1)/(n-p-1) if padj=2, which is approximately 1 - exp(- (lr - p) / n), the version used if padj=1 (the default). The latter measure is appealing because the expected value of the likelihood ratio chi-square statistic lr is p under the global null hypothesis of no predictors being associated with the response variable. See https://hbiostat.org/bib/r2.html for more details.

It is well known that in logistic regression the MCS R^2 cannot achieve a value of 1.0 even with a perfect model, which prompted Nagelkerke to divide the R^2 measure by its maximum attainable value. This is not necessarily the best recalibration of R^2 throughout its range. An alternative is to use the formulas above but to replace the raw sample size n with the effective sample size, which for data with many ties can be significantly lower than the number of observations. As used in the popower() and describe() functions, in the context of a Wilcoxon test or the proportional

odds model, the effective sample size is `n * (1 - f)` where `f` is the sums of cubes of the proportion of observations at each distict value of the response variable. Whitehead derived this from an approximation to the variance of a log odds ratio in a proportional odds model. To obtain R^2 measures using the effective sample size, either provide `ess` as a single number specifying the effective sample size, or specify a vector of frequencies of distinct Y values from which the effective sample size will be computed. In the context of survival analysis, the single number effective sample size you may wish to specify is the number of uncensored observations. This is exactly correct when estimating the hazard rate from a simple exponential distribution or when using the Cox PH/log-rank test. For failure time distributions with a very high early hazard, censored observations contain enough information that the effective sample size is greater than the number of events. See Benedetti et al, 1982.

If the effective sample size equals the raw sample size, measures involving the effective sample size are set to `NA`.

Value

named vector of R2 measures. The notation for results is `R^2(p, n)` where the `p` component is empty for unadjusted estimates and `n` is the sample size used (actual sample size for first measures, effective sample size for remaining ones). For indexes that are not adjusted, only `n` appears.

Author(s)

Frank Harrell

References

Smith TJ and McKenna CM (2013): A comparison of logistic regression pseudo R^2 indices. Multiple Linear Regression Viewpoints 39:17-26. https://www.glmj.org/archives/articles/Smith_v39n2.pdf

Benedetti JK, et al (1982): Effective sample size for tests of censored survival data. Biometrika 69:343–349.

Mittlbock M, Schemper M (1996): Explained variation for logistic regression. Stat in Med 15:1987-1997.

Date, S: R-squared, adjusted R-squared and pseudo R-squared. https://timeseriesreasoning.com/contents/r-squared-adjusted-r-squared-pseudo-r-squared/

UCLA: What are pseudo R-squareds? https://stats.oarc.ucla.edu/other/mult-pkg/faq/general/faq-what-are-pseudo-r-squareds/

Allison P (2013): What's the beset R-squared for logistic regression? https://statisticalhorizons.com/r2logistic/

Menard S (2000): Coefficients of determination for multiple logistic regression analysis. The Am Statistician 54:17-24.

Whitehead J (1993): Sample size calculations for ordered categorical data. Stat in Med 12:2257-2271. See errata (1994) 13:871 and letter to the editor by Julious SA, Campbell MJ (1996) 15:1065-1066 showing that for 2-category Y the Whitehead sample size formula agrees closely with the usual formula for comparing two proportions.

Examples

```
x <- c(rep(0, 50), rep(1, 50))
y <- x
# f <- lrm(y ~ x)
# f   # Nagelkerke R^2=1.0
# lr <- f$stats['Model L.R.']
# 1 - exp(- lr / 100)  # Maddala-Cox-Snell (MCS) 0.75
lr <- 138.6267  # manually so don't need rms package

R2Measures(lr, 1, 100, c(50, 50))  # 0.84 Effective n=75
R2Measures(lr, 1, 100, 50)         # 0.94
# MCS requires unreasonable effective sample size = minimum outcome
# frequency to get close to the 1.0 that Nagelkerke R^2 achieves
```

---

rcorr *Matrix of Correlations and P-values*

Description

rcorr Computes a matrix of Pearson's r or Spearman's rho rank correlation coefficients for all possible pairs of columns of a matrix. Missing values are deleted in pairs rather than deleting all rows of x having any missing variables. Ranks are computed using efficient algorithms (see reference 2), using midranks for ties.

Usage

```
rcorr(x, y, type=c("pearson","spearman"))

## S3 method for class 'rcorr'
print(x, ...)
```

Arguments

x	a numeric matrix with at least 5 rows and at least 2 columns (if y is absent). For print, x is an object produced by rcorr.
y	a numeric vector or matrix which will be concatenated to x. If y is omitted for rcorr, x must be a matrix.
type	specifies the type of correlations to compute. Spearman correlations are the Pearson linear correlations computed on the ranks of non-missing elements, using midranks for ties.
...	argument for method compatiblity.

Details

Uses midranks in case of ties, as described by Hollander and Wolfe. P-values are approximated by using the t or F distributions.

Value

rcorr returns a list with elements r, the matrix of correlations, n the matrix of number of observations used in analyzing each pair of variables, P, the asymptotic P-values, and type. Pairs with fewer than 2 non-missing values have the r values set to NA. The diagonals of n are the number of non-NAs for the single variable corresponding to that row and column.

Author(s)

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References

Hollander M. and Wolfe D.A. (1973). Nonparametric Statistical Methods. New York: Wiley.

Press WH, Flannery BP, Teukolsky SA, Vetterling, WT (1988): Numerical Recipes in C. Cambridge: Cambridge University Press.

See Also

hoeffd, cor, combine.levels, varclus, dotchart3, impute, chisq.test, cut2.

Examples

```
x <- c(-2, -1, 0, 1, 2)
y <- c(4,   1, 0, 1, 4)
z <- c(1,   2, 3, 4, NA)
v <- c(1,   2, 3, 4, 5)
rcorr(cbind(x,y,z,v))
```

---

rcorr.cens *Rank Correlation for Censored Data*

Description

Computes the c index and the corresponding generalization of Somers' Dxy rank correlation for a censored response variable. Also works for uncensored and binary responses, although its use of all possible pairings makes it slow for this purpose. Dxy and c are related by $Dxy = 2(c - 0.5)$.

rcorr.cens handles one predictor variable. rcorrcens computes rank correlation measures separately by a series of predictors. In addition, rcorrcens has a rough way of handling categorical predictors. If a categorical (factor) predictor has two levels, it is coverted to a numeric having values 1 and 2. If it has more than 2 levels, an indicator variable is formed for the most frequently level vs. all others, and another indicator for the second most frequent level and all others. The correlation is taken as the maximum of the two (in absolute value).

Usage

```
rcorr.cens(x, S, outx=FALSE)

## S3 method for class 'formula'
rcorrcens(formula, data=NULL, subset=NULL,
          na.action=na.retain, exclude.imputed=TRUE, outx=FALSE,
          ...)
```

Arguments

x	a numeric predictor variable
S	an Surv object or a vector. If a vector, assumes that every observation is uncensored.
outx	set to TRUE to not count pairs of observations tied on x as a relevant pair. This results in a Goodman–Kruskal gamma type rank correlation.
formula	a formula with a Surv object or a numeric vector on the left-hand side
data, subset, na.action	the usual options for models. Default for na.action is to retain all values, NA or not, so that NAs can be deleted in only a pairwise fashion.
exclude.imputed	set to FALSE to include imputed values (created by impute) in the calculations.
...	extra arguments passed to biVar.

Value

rcorr.cens returns a vector with the following named elements: C Index, Dxy, S.D., n, missing, uncensored, Relevant Pairs, Concordant, and Uncertain

n	number of observations not missing on any input variables
missing	number of observations missing on x or S
relevant	number of pairs of non-missing observations for which S could be ordered
concordant	number of relevant pairs for which x and S are concordant.
uncertain	number of pairs of non-missing observations for which censoring prevents classification of concordance of x and S.

rcorrcens.formula returns an object of class biVar which is documented with the biVar function.

Author(s)

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References

Newson R: Confidence intervals for rank statistics: Somers' D and extensions. Stata Journal 6:309-334; 2006.

See Also

concordance, somers2, biVar, rcorrp.cens

Examples

```
set.seed(1)
x <- round(rnorm(200))
y <- rnorm(200)
rcorr.cens(x, y, outx=TRUE)   # can correlate non-censored variables
library(survival)
age <- rnorm(400, 50, 10)
bp  <- rnorm(400,120, 15)
bp[1]  <- NA
d.time <- rexp(400)
cens   <- runif(400,.5,2)
death  <- d.time <= cens
d.time <- pmin(d.time, cens)
rcorr.cens(age, Surv(d.time, death))
r <- rcorrcens(Surv(d.time, death) ~ age + bp)
r
plot(r)

# Show typical 0.95 confidence limits for ROC areas for a sample size
# with 24 events and 62 non-events, for varying population ROC areas
# Repeat for 138 events and 102 non-events
set.seed(8)
par(mfrow=c(2,1))
for(i in 1:2) {
 n1 <- c(24,138)[i]
 n0 <- c(62,102)[i]
 y <- c(rep(0,n0), rep(1,n1))
 deltas <- seq(-3, 3, by=.25)
 C <- se <- deltas
 j <- 0
 for(d in deltas) {
  j <- j + 1
  x <- c(rnorm(n0, 0), rnorm(n1, d))
  w <- rcorr.cens(x, y)
  C[j]  <- w['C Index']
  se[j] <- w['S.D.']/2
 }
 low <- C-1.96*se; hi <- C+1.96*se
 print(cbind(C, low, hi))
 errbar(deltas, C, C+1.96*se, C-1.96*se,
        xlab='True Difference in Mean X',
        ylab='ROC Area and Approx. 0.95 CI')
 title(paste('n1=',n1,'  n0=',n0,sep=''))
 abline(h=.5, v=0, col='gray')
 true <- 1 - pnorm(0, deltas, sqrt(2))
 lines(deltas, true, col='blue')
}
par(mfrow=c(1,1))
```

rcorrp.cens *Rank Correlation for Paired Predictors with a Possibly Censored Response, and Integrated Discrimination Index*

Description

Computes U-statistics to test for whether predictor X1 is more concordant than predictor X2, extending `rcorr.cens`. For `method=1`, estimates the fraction of pairs for which the `x1` difference is more impressive than the `x2` difference. For `method=2`, estimates the fraction of pairs for which `x1` is concordant with `S` but `x2` is not.

For binary responses the function `improveProb` provides several assessments of whether one set of predicted probabilities is better than another, using the methods describe in *Pencina et al (2007)*. This involves NRI and IDI to test for whether predictions from model `x1` are significantly different from those obtained from predictions from model `x2`. This is a distinct improvement over comparing ROC areas, sensitivity, or specificity.

Usage

```
rcorrp.cens(x1, x2, S, outx=FALSE, method=1)

improveProb(x1, x2, y)

## S3 method for class 'improveProb'
print(x, digits=3, conf.int=.95, ...)
```

Arguments

`x1`	first predictor (a probability, for `improveProb`)
`x2`	second predictor (a probability, for `improveProb`)
`S`	a possibly right-censored `Surv` object. If `S` is a vector instead, it is converted to a `Surv` object and it is assumed that no observations are censored.
`outx`	set to `TRUE` to exclude pairs tied on `x1` or `x2` from consideration
`method`	see above
`y`	a binary 0/1 outcome variable
`x`	the result from `improveProb`
`digits`	number of significant digits for use in printing the result of `improveProb`
`conf.int`	level for confidence limits
`...`	unused

Details

If x1,x2 represent predictions from models, these functions assume either that you are using a separate sample from the one used to build the model, or that the amount of overfitting in x1 equals the amount of overfitting in x2. An example of the latter is giving both models equal opportunity to be complex so that both models have the same number of effective degrees of freedom, whether a predictor was included in the model or was screened out by a variable selection scheme.

Note that in the first part of their paper, *Pencina et al.* presented measures that required binning the predicted probabilities. Those measures were then replaced with better continuous measures that are implementedhere.

Value

a vector of statistics for `rcorrp.cens`, or a list with class `improveProb` of statistics for `improveProb`:

n	number of cases
na	number of events
nb	number of non-events
pup.ev	mean of pairwise differences in probabilities for those with events and a pairwise difference of probabilities > 0
pup.ne	mean of pairwise differences in probabilities for those without events and a pairwise difference of probabilities > 0
pdown.ev	mean of pairwise differences in probabilities for those with events and a pairwise difference of probabilities > 0
pdown.ne	mean of pairwise differences in probabilities for those without events and a pairwise difference of probabilities > 0
nri	Net Reclassification Index = $(pup.ev - pdown.ev) - (pup.ne - pdown.ne)$
se.nri	standard error of NRI
z.nri	Z score for NRI
nri.ev	Net Reclassification Index = $pup.ev - pdown.ev$
se.nri.ev	SE of NRI of events
z.nri.ev	Z score for NRI of events
nri.ne	Net Reclassification Index = $pup.ne - pdown.ne$
se.nri.ne	SE of NRI of non-events
z.nri.ne	Z score for NRI of non-events
improveSens	improvement in sensitivity
improveSpec	improvement in specificity
idi	Integrated Discrimination Index
se.idi	SE of IDI
z.idi	Z score of IDI

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References

Pencina MJ, D'Agostino Sr RB, D'Agostino Jr RB, Vasan RS (2008): Evaluating the added predictive ability of a new marker: From area under the ROC curve to reclassification and beyond. Stat in Med 27:157-172. DOI: 10.1002/sim.2929

Pencina MJ, D'Agostino Sr RB, D'Agostino Jr RB, Vasan RS: Rejoinder: Comments on Integrated discrimination and net reclassification improvements-Practical advice. Stat in Med 2007; DOI: 10.1002/sim.3106

Pencina MJ, D'Agostino RB, Steyerberg EW (2011): Extensions of net reclassification improvement calculations to measure usefulness of new biomarkers. Stat in Med 30:11-21; DOI: 10.1002/sim.4085

See Also

rcorr.cens, somers2, Surv, val.prob, concordance

Examples

```
set.seed(1)
library(survival)

x1 <- rnorm(400)
x2 <- x1 + rnorm(400)
d.time <- rexp(400) + (x1 - min(x1))
cens   <- runif(400,.5,2)
death  <- d.time <= cens
d.time <- pmin(d.time, cens)
rcorrp.cens(x1, x2, Surv(d.time, death))
#rcorrp.cens(x1, x2, y) ## no censoring

set.seed(1)
x1 <- runif(1000)
x2 <- runif(1000)
y  <- sample(0:1, 1000, TRUE)
rcorrp.cens(x1, x2, y)
improveProb(x1, x2, y)
```

rcspline.eval *Restricted Cubic Spline Design Matrix*

Description

Computes matrix that expands a single variable into the terms needed to fit a restricted cubic spline (natural spline) function using the truncated power basis. Two normalization options are given for somewhat reducing problems of ill-conditioning. The antiderivative function can be optionally created. If knot locations are not given, they will be estimated from the marginal distribution of x.

Usage

```
rcspline.eval(x, knots, nk=5, inclx=FALSE, knots.only=FALSE,
              type="ordinary", norm=2, rpm=NULL, pc=FALSE,
              fractied=0.05)
```

Arguments

x	a vector representing a predictor variable
knots	knot locations. If not given, knots will be estimated using default quantiles of x. For 3 knots, the outer quantiles used are 0.10 and 0.90. For 4-6 knots, the outer quantiles used are 0.05 and 0.95. For nk $>$ 6, the outer quantiles are 0.025 and 0.975. The knots are equally spaced between these on the quantile scale. For fewer than 100 non-missing values of x, the outer knots are the 5th smallest and largest x.
nk	number of knots. Default is 5. The minimum value is 3.
inclx	set to TRUE to add x as the first column of the returned matrix
knots.only	return the estimated knot locations but not the expanded matrix
type	'"ordinary"' to fit the function, '"integral"' to fit its anti-derivative.
norm	'0' to use the terms as originally given by *Devlin and Weeks (1986)*, '1' to normalize non-linear terms by the cube of the spacing between the last two knots, '2' to normalize by the square of the spacing between the first and last knots (the default). norm=2 has the advantage of making all nonlinear terms beon the x-scale.
rpm	If given, any NAs in x will be replaced with the value rpm after estimating any knot locations.
pc	Set to TRUE to replace the design matrix with orthogonal (uncorrelated) principal components computed on the scaled, centered design matrix
fractied	If the fraction of observations tied at the lowest and/or highest values of x is greater than or equal to fractied, the algorithm attempts to use a different algorithm for knot finding based on quantiles of x after excluding the one or two values with excessive ties. And if the number of unique x values excluding these values is small, the unique values will be used as the knots. If the number of knots to use other than these exterior values is only one, that knot will be at the median of the non-extreme x. This algorithm is not used if any interior values of x also have a proportion of ties equal to or exceeding fractied.

Value

If knots.only=TRUE, returns a vector of knot locations. Otherwise returns a matrix with x (if inclx=TRUE) followed by nk − 2 nonlinear terms. The matrix has an attribute knots which is the vector of knots used. When pc is TRUE, an additional attribute is stored: pcparms, which contains the center and scale vectors and the rotation matrix.

References

Devlin TF and Weeks BJ (1986): Spline functions for logistic regression modeling. Proc 11th Annual SAS Users Group Intnl Conf, p. 646–651. Cary NC: SAS Institute, Inc.

See Also

ns, rcspline.restate, rcs

Examples

```
x <- 1:100
rcspline.eval(x, nk=4, inclx=TRUE)
#lrm.fit(rcspline.eval(age,nk=4,inclx=TRUE), death)
x <- 1:1000
attributes(rcspline.eval(x))
x <- c(rep(0, 744),rep(1,6), rep(2,4), rep(3,10),rep(4,2),rep(6,6),
  rep(7,3),rep(8,2),rep(9,4),rep(10,2),rep(11,9),rep(12,10),rep(13,13),
  rep(14,5),rep(15,5),rep(16,10),rep(17,6),rep(18,3),rep(19,11),rep(20,16),
  rep(21,6),rep(22,16),rep(23,17), 24, rep(25,8), rep(26,6),rep(27,3),
  rep(28,7),rep(29,9),rep(30,10),rep(31,4),rep(32,4),rep(33,6),rep(34,6),
  rep(35,4), rep(36,5), rep(38,6), 39, 39, 40, 40, 40, 41, 43, 44, 45)
attributes(rcspline.eval(x, nk=3))
attributes(rcspline.eval(x, nk=5))
u <- c(rep(0,30), 1:4, rep(5,30))
attributes(rcspline.eval(u))
```

---

rcspline.plot *Plot Restricted Cubic Spline Function*

Description

Provides plots of the estimated restricted cubic spline function relating a single predictor to the response for a logistic or Cox model. The rcspline.plot function does not allow for interactions as do lrm and cph, but it can provide detailed output for checking spline fits. This function uses the rcspline.eval, lrm.fit, and Therneau's coxph.fit functions and plots the estimated spline regression and confidence limits, placing summary statistics on the graph. If there are no adjustment variables, rcspline.plot can also plot two alternative estimates of the regression function when model="logistic": proportions or logit proportions on grouped data, and a nonparametric estimate. The nonparametric regression estimate is based on smoothing the binary responses and taking the logit transformation of the smoothed estimates, if desired. The smoothing uses supsmu.

Usage

```
rcspline.plot(x,y,model=c("logistic", "cox", "ols"), xrange, event, nk=5,
              knots=NULL, show=c("xbeta","prob"), adj=NULL, xlab, ylab,
              ylim, plim=c(0,1), plotcl=TRUE, showknots=TRUE, add=FALSE,
              subset, lty=1, noprint=FALSE, m, smooth=FALSE, bass=1,
              main="auto", statloc)
```

Arguments

x	a numeric predictor
y	a numeric response. For binary logistic regression, y should be either 0 or 1.
model	"logistic" or "cox". For "cox", uses the coxph.fit function with method="efron" arguement set.
xrange	range for evaluating x, default is f and $1-f$ quantiles of x, where $f = \frac{10}{\max(n,200)}$
event	event/censoring indicator if model="cox". If event is present, model is assumed to be "cox"
nk	number of knots
knots	knot locations, default based on quantiles of x (by rcspline.eval)
show	"xbeta" or "prob" - what is plotted on y-axis
adj	optional matrix of adjustment variables
xlab	x-axis label, default is the "label" attribute of x
ylab	y-axis label, default is the "label" attribute of y
ylim	y-axis limits for logit or log hazard
plim	y-axis limits for probability scale
plotcl	plot confidence limits
showknots	show knot locations with arrows
add	add this plot to an already existing plot
subset	subset of observations to process, e.g. sex == "male"
lty	line type for plotting estimated spline function
noprint	suppress printing regression coefficients and standard errors
m	for model="logistic", plot grouped estimates with triangles. Each group contains m ordered observations on x.
smooth	plot nonparametric estimate if model="logistic" and adj is not specified
bass	smoothing parameter (see supsmu)
main	main title, default is "Estimated Spline Transformation"
statloc	location of summary statistics. Default positioning by clicking left mouse button where upper left corner of statistics should appear. Alternative is "ll" to place below the graph on the lower left, or the actual x and y coordinates. Use "none" to suppress statistics.

Value

list with components ('knots', 'x', 'xbeta', 'lower', 'upper') which are respectively the knot locations, design matrix, linear predictor, and lower and upper confidence limits

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See Also

lrm, cph, rcspline.eval, plot, supsmu, coxph.fit, lrm.fit

Examples

```
#rcspline.plot(cad.dur, tvdlm, m=150)
#rcspline.plot(log10(cad.dur+1), tvdlm, m=150)
```

---

rcspline.restate *Re-state Restricted Cubic Spline Function*

Description

This function re-states a restricted cubic spline function in the un-linearly-restricted form. Coefficients for that form are returned, along with an R functional representation of this function and a LaTeX character representation of the function. rcsplineFunction is a fast function that creates a function to compute a restricted cubic spline function with given coefficients and knots, without reformatting the function to be pretty (i.e., into unrestricted form).

Usage

```
rcspline.restate(knots, coef,
                 type=c("ordinary","integral"),
                 x="X", lx=nchar(x),
                 norm=2, columns=65, before="& &", after="\\\\",
                 begin="", nbegin=0, digits=max(8, .Options$digits))

rcsplineFunction(knots, coef, norm=2, type=c('ordinary', 'integral'))
```

Arguments

knots	vector of knots used in the regression fit
coef	vector of coefficients from the fit. If the length of coef is $k-1$, where k is equal to the length(knots), the first coefficient must be for the linear term and remaining $k-2$ coefficients must be for the constructed terms (e.g., from rcspline.eval). If the length of coef is k, an intercept is assumed to be in the first element (or a zero is prepended to coef for rcsplineFunction).

type	The default is to represent the cubic spline function corresponding to the coefficients and knots. Set type = "integral" to instead represent its anti-derivative.
x	a character string to use as the variable name in the LaTeX expression for the formula.
lx	length of x to count with respect to columns. Default is length of character string contained by x. You may want to set lx smaller than this if it includes non-printable LaTeX commands.
norm	normalization that was used in deriving the original nonlinear terms used in the fit. See rcspline.eval for definitions.
columns	maximum number of symbols in the LaTeX expression to allow before inserting a newline ('\\') command. Set to a very large number to keep text all on one line.
before	text to place before each line of LaTeX output. Use '"& &"' for an equation array environment in LaTeX where you want to have a left-hand prefix e.g. '"f(X) & = &"' or using '"\lefteqn"'.
after	text to place at the end of each line of output.
begin	text with which to start the first line of output. Useful when adding LaTeX output to part of an existing formula
nbegin	number of columns of printable text in begin
digits	number of significant digits to write for coefficients and knots

Value

rcspline.restate returns a vector of coefficients. The coefficients are un-normalized and two coefficients are added that are linearly dependent on the other coefficients and knots. The vector of coefficients has four attributes. knots is a vector of knots, latex is a vector of text strings with the LaTeX representation of the formula. columns.used is the number of columns used in the output string since the last newline command. function is an R function, which is also return in character string format as the text attribute. rcsplineFunction returns an R function with arguments x (a user-supplied numeric vector at which to evaluate the function), and some automatically-supplied other arguments.

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See Also

rcspline.eval, ns, rcs, latex, Function.transcan

Examples

```
set.seed(1)
x <- 1:100
y <- (x - 50)^2 + rnorm(100, 0, 50)
```

```
plot(x, y)
xx <- rcspline.eval(x, inclx=TRUE, nk=4)
knots <- attr(xx, "knots")
coef <- lsfit(xx, y)$coef
options(digits=4)
# rcspline.restate must ignore intercept
w <- rcspline.restate(knots, coef[-1], x="{\\rm BP}")
# could also have used coef instead of coef[-1], to include intercept
cat(attr(w,"latex"), sep="\n")


xtrans <- eval(attr(w, "function"))
# This is an S function of a single argument
lines(x, coef[1] + xtrans(x), type="l")
# Plots fitted transformation

xtrans <- rcsplineFunction(knots, coef)
xtrans
lines(x, xtrans(x), col='blue')


#x <- blood.pressure
xx.simple <- cbind(x, pmax(x-knots[1],0)^3, pmax(x-knots[2],0)^3,
                      pmax(x-knots[3],0)^3, pmax(x-knots[4],0)^3)
pred.value <- coef[1] + xx.simple %*% w
plot(x, pred.value, type='l')   # same as above
```

---

redun *Redundancy Analysis*

Description

Uses flexible parametric additive models (see areg and its use of regression splines), or alternatively to run a regular regression after replacing continuous variables with ranks, to determine how well each variable can be predicted from the remaining variables. Variables are dropped in a stepwise fashion, removing the most predictable variable at each step. The remaining variables are used to predict. The process continues until no variable still in the list of predictors can be predicted with an R^2 or adjusted R^2 of at least r2 or until dropping the variable with the highest R^2 (adjusted or ordinary) would cause a variable that was dropped earlier to no longer be predicted at least at the r2 level from the now smaller list of predictors.

There is also an option qrank to expand each variable into two columns containing the rank and square of the rank. Whenever ranks are used, they are computed as fractional ranks for numerical reasons.

Usage

```
redun(formula, data=NULL, subset=NULL, r2 = 0.9,
      type = c("ordinary", "adjusted"), nk = 3, tlinear = TRUE,
      rank=qrank, qrank=FALSE,
```

```
      allcat=FALSE, minfreq=0, iterms=FALSE, pc=FALSE, pr = FALSE, ...)
## S3 method for class 'redun'
print(x, digits=3, long=TRUE, ...)
```

Arguments

formula	a formula. Enclose a variable in `I()` to force linearity. Alternately, can be a numeric matrix, in which case the data are not run through `dataframeReduce`. This is useful when running the data through `transcan` first for nonlinearly transforming the data.
data	a data frame, which must be omitted if `formula` is a matrix
subset	usual subsetting expression
r2	ordinary or adjusted R^2 cutoff for redundancy
type	specify `"adjusted"` to use adjusted R^2
nk	number of knots to use for continuous variables. Use `nk=0` to force linearity for all variables.
tlinear	set to `FALSE` to allow a variable to be automatically nonlinearly transformed (see `areg`) while being predicted. By default, only continuous variables on the right hand side (i.e., while they are being predictors) are automatically transformed, using regression splines. Estimating transformations for target (dependent) variables causes more overfitting than doing so for predictors.
rank	set to `TRUE` to replace non-categorical varibles with ranks before running the analysis. This causes `nk` to be set to zero.
qrank	set to `TRUE` to also include squares of ranks to allow for non-monotonic transformations
allcat	set to `TRUE` to ensure that all categories of categorical variables having more than two categories are redundant (see details below)
minfreq	For a binary or categorical variable, there must be at least two categories with at least `minfreq` observations or the variable will be dropped and not checked for redundancy against other variables. `minfreq` also specifies the minimum frequency of a category or its complement before that category is considered when `allcat=TRUE`.
iterms	set to `TRUE` to consider derived terms (dummy variables and nonlinear spline components) as separate variables. This will perform a redundancy analysis on pieces of the variables.
pc	if `iterms=TRUE` you can set `pc` to `TRUE` to replace the submatrix of terms corresponding to each variable with the orthogonal principal components before doing the redundancy analysis. The components are based on the correlation matrix.
pr	set to `TRUE` to monitor progress of the stepwise algorithm
...	arguments to pass to `dataframeReduce` to remove "difficult" variables from `data` if `formula` is `~.` to use all variables in `data` (`data` must be specified when these arguments are used). Ignored for `print`.
x	an object created by `redun`

digits	number of digits to which to round R^2 values when printing
long	set to FALSE to prevent the print method from printing the R^2 history and the original R^2 with which each variable can be predicted from ALL other variables.

Details

A categorical variable is deemed redundant if a linear combination of dummy variables representing it can be predicted from a linear combination of other variables. For example, if there were 4 cities in the data and each city's rainfall was also present as a variable, with virtually the same rainfall reported for all observations for a city, city would be redundant given rainfall (or vice-versa; the one declared redundant would be the first one in the formula). If two cities had the same rainfall, city might be declared redundant even though tied cities might be deemed non-redundant in another setting. To ensure that all categories may be predicted well from other variables, use the allcat option. To ignore categories that are too infrequent or too frequent, set minfreq to a nonzero integer. When the number of observations in the category is below this number or the number of observations not in the category is below this number, no attempt is made to predict observations being in that category individually for the purpose of redundancy detection.

Value

an object of class "redun" including an element "scores", a numeric matrix with all transformed values when each variable was the dependent variable and the first canonical variate was computed

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See Also

areg, dataframeReduce, transcan, varclus, r2describe, subselect::genetic

Examples

```
set.seed(1)
n <- 100
x1 <- runif(n)
x2 <- runif(n)
x3 <- x1 + x2 + runif(n)/10
x4 <- x1 + x2 + x3 + runif(n)/10
x5 <- factor(sample(c('a','b','c'),n,replace=TRUE))
x6 <- 1*(x5=='a' | x5=='c')
redun(~x1+x2+x3+x4+x5+x6, r2=.8)
redun(~x1+x2+x3+x4+x5+x6, r2=.8, minfreq=40)
redun(~x1+x2+x3+x4+x5+x6, r2=.8, allcat=TRUE)
# x5 is no longer redundant but x6 is
redun(~x1+x2+x3+x4+x5+x6, r2=.8, rank=TRUE)
redun(~x1+x2+x3+x4+x5+x6, r2=.8, qrank=TRUE)
```

```
# To help decode which variables made a particular variable redundant:
# r <- redun(...)
# r2describe(r$scores)
```

---

reShape *Reshape Matrices and Serial Data*

Description

If the first argument is a matrix, reShape strings out its values and creates row and column vectors specifying the row and column each element came from. This is useful for sending matrices to Trellis functions, for analyzing or plotting results of table or crosstabs, or for reformatting serial data stored in a matrix (with rows representing multiple time points) into vectors. The number of observations in the new variables will be the product of the number of rows and number of columns in the input matrix. If the first argument is a vector, the id and colvar variables are used to restructure it into a matrix, with NAs for elements that corresponded to combinations of id and colvar values that did not exist in the data. When more than one vector is given, multiple matrices are created. This is useful for restructuring irregular serial data into regular matrices. It is also useful for converting data produced by expand.grid into a matrix (see the last example). The number of rows of the new matrices equals the number of unique values of id, and the number of columns equals the number of unique values of colvar.

When the first argument is a vector and the id is a data frame (even with only one variable), reShape will produce a data frame, and the unique groups are identified by combinations of the values of all variables in id. If a data frame constant is specified, the variables in this data frame are assumed to be constant within combinations of id variables (if not, an arbitrary observation in constant will be selected for each group). A row of constant corresponding to the target id combination is then carried along when creating the data frame result.

A different behavior of reShape is achieved when base and reps are specified. In that case x must be a list or data frame, and those data are assumed to contain one or more non-repeating measurements (e.g., baseline measurements) and one or more repeated measurements represented by variables named by pasting together the character strings in the vector base with the integers 1, 2, ..., reps. The input data are rearranged by repeating each value of the baseline variables reps times and by transposing each observation's values of one of the set of repeated measurements as reps observations under the variable whose name does not have an integer pasted to the end. if x has a row.names attribute, those observation identifiers are each repeated reps times in the output object. See the last example.

Usage

```
reShape(x, ..., id, colvar, base, reps, times=1:reps,
        timevar='seqno', constant=NULL)
```

Arguments

x	a matrix or vector, or, when base is specified, a list or data frame
...	other optional vectors, if x is a vector

id	A numeric, character, category, or factor variable containing subject identifiers, or a data frame of such variables that in combination form groups of interest. Required if x is a vector, ignored otherwise.
colvar	A numeric, character, category, or factor variable containing column identifiers. colvar is using a "time of data collection" variable. Required if x is a vector, ignored otherwise.
base	vector of character strings containing base names of repeated measurements
reps	number of times variables named in base are repeated. This must be a constant.
times	when base is given, times is the vector of times to create if you do not want to use consecutive integers beginning with 1.
timevar	specifies the name of the time variable to create if times is given, if you do not want to use seqno
constant	a data frame with the same number of rows in id and x, containing auxiliary information to be merged into the resulting data frame. Logically, the rows of constant within each group should have the same value of all of its variables.

Details

In converting dimnames to vectors, the resulting variables are numeric if all elements of the matrix dimnames can be converted to numeric, otherwise the corresponding row or column variable remains character. When the dimnames if x have a names attribute, those two names become the new variable names. If x is a vector and another vector is also given (in ...), the matrices in the resulting list are named the same as the input vector calling arguments. You can specify customized names for these on-the-fly by using e.g. reShape(X=x, Y=y, id= , colvar=). The new names will then be X and Y instead of x and y. A new variable named seqnno is also added to the resulting object. seqno indicates the sequential repeated measurement number. When base and times are specified, this new variable is named the character value of timevar and the values are given by a table lookup into the vector times.

Value

If x is a matrix, returns a list containing the row variable, the column variable, and the as.vector(x) vector, named the same as the calling argument was called for x. If x is a vector and no other vectors were specified as ..., the result is a matrix. If at least one vector was given to ..., the result is a list containing k matrices, where k one plus the number of vectors in .... If x is a list or data frame, the same type of object is returned. If x is a vector and id is a data frame, a data frame will be the result.

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See Also

reshape, as.vector, matrix, dimnames, outer, table

Examples

```
set.seed(1)
Solder  <- factor(sample(c('Thin','Thick'),200,TRUE),c('Thin','Thick'))
Opening <- factor(sample(c('S','M','L'),  200,TRUE),c('S','M','L'))

tab <- table(Opening, Solder)
tab
reShape(tab)
# attach(tab)  # do further processing

# An example where a matrix is created from irregular vectors
follow <- data.frame(id=c('a','a','b','b','b','d'),
                     month=c(1, 2,  1,  2,  3,  2),
                     cholesterol=c(225,226, 320,319,318, 270))
follow
attach(follow)
reShape(cholesterol, id=id, colvar=month)
detach('follow')
# Could have done :
# reShape(cholesterol, triglyceride=trig, id=id, colvar=month)

# Create a data frame, reshaping a long dataset in which groups are
# formed not just by subject id but by combinations of subject id and
# visit number.  Also carry forward a variable that is supposed to be
# constant within subject-visit number combinations.  In this example,
# it is not constant, so an arbitrary visit number will be selected.
w <- data.frame(id=c('a','a','a','a','b','b','b','d','d','d'),
             visit=c(  1,  1,  2,  2,  1,  1,  2,  2,  2,  2),
                 k=c('A','A','B','B','C','C','D','E','F','G'),
               var=c('x','y','x','y','x','y','y','x','y','z'),
               val=1:10)
with(w,
     reShape(val, id=data.frame(id,visit),
             constant=data.frame(k), colvar=var))

# Get predictions from a regression model for 2 systematically
# varying predictors.  Convert the predictions into a matrix, with
# rows corresponding to the predictor having the most values, and
# columns corresponding to the other predictor
# d <- expand.grid(x2=0:1, x1=1:100)
# pred <- predict(fit, d)
# reShape(pred, id=d$x1, colvar=d$x2)  # makes 100 x 2 matrix


# Reshape a wide data frame containing multiple variables representing
# repeated measurements (3 repeats on 2 variables; 4 subjects)
set.seed(33)
n <- 4
w <- data.frame(age=rnorm(n, 40, 10),
                sex=sample(c('female','male'), n,TRUE),
                sbp1=rnorm(n, 120, 15),
                sbp2=rnorm(n, 120, 15),
```

```
                sbp3=rnorm(n, 120, 15),
                dbp1=rnorm(n,  80, 15),
                dbp2=rnorm(n,  80, 15),
                dbp3=rnorm(n,  80, 15), row.names=letters[1:n])
options(digits=3)
w


u <- reShape(w, base=c('sbp','dbp'), reps=3)
u
reShape(w, base=c('sbp','dbp'), reps=3, timevar='week', times=c(0,3,12))
```

---

rlegend *Special Version of legend for R*

Description

rlegend is a version of legend for R that implements plot=FALSE, adds grid=TRUE, and defaults lty, lwd, pch to NULL and checks for length>0 rather than missing(), so it's easier to deal with non-applicable parameters. But when **grid** is in effect, the preferred function to use is rlegendg, which calls the **lattice** draw.key function.

Usage

```
rlegend(x, y, legend, fill, col = "black", lty = NULL, lwd = NULL,
        pch = NULL, angle = NULL, density = NULL, bty = "o",
        bg = par("bg"), pt.bg = NA, cex = 1, xjust = 0, yjust = 1,
        x.intersp = 1, y.intersp = 1, adj = 0, text.width = NULL,
        merge = do.lines && has.pch, trace = FALSE, ncol = 1,
        horiz = FALSE, plot = TRUE, grid = FALSE, ...)

rlegendg(x, y, legend, col=pr$col[1], lty=NULL,
         lwd=NULL, pch=NULL, cex=pr$cex[1], other=NULL)
```

Arguments

x, y, legend, fill, col, lty, lwd, pch, angle, density, bty, bg, pt.bg, cex, xjust, yjust, x.intersp, y.intersp, adj, text.width, merge, trace, ncol, horiz	see legend
plot	set to FALSE to suppress drawing the legend. This is used the compute the size needed for when the legend is drawn with a later call to rlegend.
grid	set to TRUE if the **grid** package is in effect
...	see legend
other	a list containing other arguments to pass to draw.key. See the help file for xyplot.

Value

a list with elements `rect` and `text`. `rect` has elements `w, h, left, top` with size/position information.

Author(s)

Frank Harrell and R-Core

See Also

`legend`, `draw.key`, `xyplot`

`rm.boot` *Bootstrap Repeated Measurements Model*

Description

For a dataset containing a time variable, a scalar response variable, and an optional subject identification variable, obtains least squares estimates of the coefficients of a restricted cubic spline function or a linear regression in time after adjusting for subject effects through the use of subject dummy variables. Then the fit is bootstrapped `B` times, either by treating time and subject ID as fixed (i.e., conditioning the analysis on them) or as random variables. For the former, the residuals from the original model fit are used as the basis of the bootstrap distribution. For the latter, samples are taken jointly from the time, subject ID, and response vectors to obtain unconditional distributions.

If a subject `id` variable is given, the bootstrap sampling will be based on samples with replacement from subjects rather than from individual data points. In other words, either none or all of a given subject's data will appear in a bootstrap sample. This cluster sampling takes into account any correlation structure that might exist within subjects, so that confidence limits are corrected for within-subject correlation. Assuming that ordinary least squares estimates, which ignore the correlation structure, are consistent (which is almost always true) and efficient (which would not be true for certain correlation structures or for datasets in which the number of observation times vary greatly from subject to subject), the resulting analysis will be a robust, efficient repeated measures analysis for the one-sample problem.

Predicted values of the fitted models are evaluated by default at a grid of 100 equally spaced time points ranging from the minimum to maximum observed time points. Predictions are for the average subject effect. Pointwise confidence intervals are optionally computed separately for each of the points on the time grid. However, simultaneous confidence regions that control the level of confidence for the entire regression curve lying within a band are often more appropriate, as they allow the analyst to draw conclusions about nuances in the mean time response profile that were not stated apriori. The method of *Tibshirani (1997)* is used to easily obtain simultaneous confidence sets for the set of coefficients of the spline or linear regression function as well as the average intercept parameter (over subjects). Here one computes the objective criterion (here both the -2 log likelihood evaluated at the bootstrap estimate of beta but with respect to the original design matrix and response vector, and the sum of squared errors in predicting the original response vector) for the original fit as well as for all of the bootstrap fits. The confidence set of the regression coefficients is the set of all coefficients that are associated with objective function values that are less than or

equal to say the 0.95 quantile of the vector of B + 1 objective function values. For the coefficients satisfying this condition, predicted curves are computed at the time grid, and minima and maxima of these curves are computed separately at each time point toderive the final simultaneous confidence band.

By default, the log likelihoods that are computed for obtaining the simultaneous confidence band assume independence within subject. This will cause problems unless such log likelihoods have very high rank correlation with the log likelihood allowing for dependence. To allow for correlation or to estimate the correlation function, see the cor.pattern argument below.

Usage

```
rm.boot(time, y, id=seq(along=time), subset,
        plot.individual=FALSE,
        bootstrap.type=c('x fixed','x random'),
        nk=6, knots, B=500, smoother=supsmu,
        xlab, xlim, ylim=range(y),
        times=seq(min(time), max(time), length.out=100),
        absorb.subject.effects=FALSE,
        rho=0, cor.pattern=c('independent','estimate'), ncor=10000,
        ...)


## S3 method for class 'rm.boot'
plot(x, obj2, conf.int=.95,
     xlab=x$xlab, ylab=x$ylab,
     xlim, ylim=x$ylim,
     individual.boot=FALSE,
     pointwise.band=FALSE,
     curves.in.simultaneous.band=FALSE,
     col.pointwise.band=2,
     objective=c('-2 log L','sse','dep -2 log L'), add=FALSE, ncurves,
     multi=FALSE, multi.method=c('color','density'),
     multi.conf   =c(.05,.1,.2,.3,.4,.5,.6,.7,.8,.9,.95,.99),
     multi.density=c( -1,90,80,70,60,50,40,30,20,10,  7,  4),
     multi.col    =c(  1, 8,20, 5, 2, 7,15,13,10,11,  9, 14),
     subtitles=TRUE, ...)
```

Arguments

time	numeric time vector
y	continuous numeric response vector of length the same as time. Subjects having multiple measurements have the measurements strung out.
x	an object returned from rm.boot
id	subject ID variable. If omitted, it is assumed that each time-response pair is measured on a different subject.
subset	subset of observations to process if not all the data

plot.individual
: set to TRUE to plot nonparametrically smoothed time-response curves for each subject

bootstrap.type
: specifies whether to treat the time and subject ID variables as fixed or random

nk
: number of knots in the restricted cubic spline function fit. The number of knots may be 0 (denoting linear regression) or an integer greater than 2 in which k knots results in $k-1$ regression coefficients excluding the intercept. The default is 6 knots.

knots
: vector of knot locations. May be specified if nk is omitted.

B
: number of bootstrap repetitions. Default is 500.

smoother
: a smoothing function that is used if plot.individual=TRUE. Default is supsmu.

xlab
: label for x-axis. Default is "units" attribute of the original time variable, or "Time" if no such attribute was defined using the units function.

xlim
: specifies x-axis plotting limits. Default is to use range of times specified to rm.boot.

ylim
: for rm.boot this is a vector of y-axis limits used if plot.individual=TRUE. It is also passed along for later use by plot.rm.boot. For plot.rm.boot, ylim can be specified, to override the value stored in the object stored by rm.boot. The default is the actual range of y in the input data.

times
: a sequence of times at which to evaluated fitted values and confidence limits. Default is 100 equally spaced points in the observed range of time.

absorb.subject.effects
: If TRUE, adjusts the response vector y before re-sampling so that the subject-specific effects in the initial model fit are all zero. Then in re-sampling, subject effects are not used in the models. This will downplay one of the sources of variation. This option is used mainly for checking for consistency of results, as the re-sampling analyses are simpler when absort.subject.effects=TRUE.

rho
: The log-likelihood function that is used as the basis of simultaneous confidence bands assumes normality with independence within subject. To check the robustness of this assumption, if rho is not zero, the log-likelihood under multivariate normality within subject, with constant correlation rho between any two time points, is also computed. If the two log-likelihoods have the same ranks across re-samples, alllowing the correlation structure does not matter. The agreement in ranks is quantified using the Spearman rank correlation coefficient. The plot method allows the non-zero intra-subject correlation log-likelihood to be used in deriving the simultaneous confidence band. Note that this approach does assume homoscedasticity.

cor.pattern
: More generally than using an equal-correlation structure, you can specify a function of two time vectors that generates as many correlations as the length of these vectors. For example, cor.pattern=function(time1,time2) 0.2^(abs(time1-time2)/10) would specify a dampening serial correlation pattern. cor.pattern can also be a list containing vectors x (a vector of absolute time differences) and y (a corresponding vector of correlations). To estimate the correlation function as a function of absolute time differences within subjects, specify cor.pattern="estimate". The products of all possible pairs of residuals (or at least up to ncor of them)

within subjects will be related to the absolute time difference. The correlation function is estimated by computing the sample mean of the products of standardized residuals, stratified by absolute time difference. The correlation for a zero time difference is set to 1 regardless of the lowess estimate. NOTE: This approach fails in the presence of large subject effects; correcting for such effects removes too much of the correlation structure in the residuals.

ncor — the maximum number of pairs of time values used in estimating the correlation function if cor.pattern="estimate"

... — other arguments to pass to smoother if plot.individual=TRUE

obj2 — a second object created by rm.boot that can also be passed to plot.rm.boot. This is used for two-sample problems for which the time profiles are allowed to differ between the two groups. The bootstrapped predicted y values for the second fit are subtracted from the fitted values for the first fit so that the predicted mean response for group 1 minus the predicted mean response for group 2 is what is plotted. The confidence bands that are plotted are also for this difference. For the simultaneous confidence band, the objective criterion is taken to be the sum of the objective criteria (-2 log L or sum of squared errors) for the separate fits for the two groups. The times vectors must have been identical for both calls to rm.boot, although NAs can be inserted by the user of one or both of the time vectors in the rm.boot objects so as to suppress certain sections of the difference curve from being plotted.

conf.int — the confidence level to use in constructing simultaneous, and optionally pointwise, bands. Default is 0.95.

ylab — label for y-axis. Default is the "label" attribute of the original y variable, or "y" if no label was assigned to y (using the label function, for example).

individual.boot — set to TRUE to plot the first 100 bootstrap regression fits

pointwise.band — set to TRUE to draw a pointwise confidence band in addition to the simultaneous band

curves.in.simultaneous.band — set to TRUE to draw all bootstrap regression fits that had a sum of squared errors (obtained by predicting the original y vector from the original time vector and id vector) that was less that or equal to the conf.int quantile of all bootstrapped models (plus the original model). This will show how the point by point max and min were computed to form the simultaneous confidence band.

col.pointwise.band — color for the pointwise confidence band. Default is '2', which defaults to red for default Windows S-PLUS setups.

objective — the default is to use the -2 times log of the Gaussian likelihood for computing the simultaneous confidence region. If neither cor.pattern nor rho was specified to rm.boot, the independent homoscedastic Gaussian likelihood is used. Otherwise the dependent homoscedastic likelihood is used according to the specified or estimated correlation pattern. Specify objective="sse" to instead use the sum of squared errors.

add — set to TRUE to add curves to an existing plot. If you do this, titles and subtitles are omitted.

ncurves	when using individual.boot=TRUE or curves.in.simultaneous.band=TRUE, you can plot a random sample of ncurves of the fitted curves instead of plotting up to B of them.
multi	set to TRUE to draw multiple simultaneous confidence bands shaded with different colors. Confidence levels vary over the values in the multi.conf vector.
multi.method	specifies the method of shading when multi=TRUE. Default is to use colors, with the default colors chosen so that when the graph is printed under S-Plus for Windows 4.0 to an HP LaserJet printer, the confidence regions are naturally ordered by darkness of gray-scale. Regions closer to the point estimates (i.e., the center) are darker. Specify multi.method="density" to instead use densities of lines drawn per inch in the confidence regions, with all regions drawn with the default color. The polygon function is used to shade the regions.
multi.conf	vector of confidence levels, in ascending order. Default is to use 12 confidence levels ranging from 0.05 to 0.99.
multi.density	vector of densities in lines per inch corresponding to multi.conf. As is the convention in the polygon function, a density of -1 indicates a solid region.
multi.col	vector of colors corresponding to multi.conf. See multi.method for rationale.
subtitles	set to FALSE to suppress drawing subtitles for the plot

Details

Observations having missing time or y are excluded from the analysis.

As most repeated measurement studies consider the times as design points, the fixed covariable case is the default. Bootstrapping the residuals from the initial fit assumes that the model is correctly specified. Even if the covariables are fixed, doing an unconditional bootstrap is still appropriate, and for large sample sizes unconditional confidence intervals are only slightly wider than conditional ones. For moderate to small sample sizes, the bootstrap.type="x random" method can be fairly conservative.

If not all subjects have the same number of observations (after deleting observations containing missing values) and if bootstrap.type="x fixed", bootstrapped residual vectors may have a length m that is different from the number of original observations n. If $m > n$ for a bootstrap repetition, the first n elements of the randomly drawn residuals are used. If $m < n$, the residual vector is appended with a random sample with replacement of length $n - m$ from itself. A warning message is issued if this happens. If the number of time points per subject varies, the bootstrap results for bootstrap.type="x fixed" can still be invalid, as this method assumes that a vector (over subjects) of all residuals can be added to the original yhats, and varying number of points will cause mis-alignment.

For bootstrap.type="x random" in the presence of significant subject effects, the analysis is approximate as the subjects used in any one bootstrap fit will not be the entire list of subjects. The average (over subjects used in the bootstrap sample) intercept is used from that bootstrap sample as a predictor of average subject effects in the overall sample.

Once the bootstrap coefficient matrix is stored by rm.boot, plot.rm.boot can be run multiple times with different options (e.g, different confidence levels).

See bootcov in the **rms** library for a general approach to handling repeated measurement data for ordinary linear models, binary and ordinal models, and survival models, using the unconditional bootstrap. bootcov does not handle bootstrapping residuals.

Value

an object of class `rm.boot` is returned by `rm.boot`. The principal object stored in the returned object is a matrix of regression coefficients for the original fit and all of the bootstrap repetitions (object `Coef`), along with vectors of the corresponding -2 log likelihoods are sums of squared errors. The original fit object from `lm.fit.qr` is stored in `fit`. For this fit, a cell means model is used for the `id` effects.

`plot.rm.boot` returns a list containing the vector of times used for plotting along with the overall fitted values, lower and upper simultaneous confidence limits, and optionally the pointwise confidence limits.

Author(s)

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References

Feng Z, McLerran D, Grizzle J (1996): A comparison of statistical methods for clustered data analysis with Gaussian error. Stat in Med 15:1793–1806.

Tibshirani R, Knight K (1997):Model search and inference by bootstrap "bumping". Technical Report, Department of Statistics, University of Toronto.
https://www.jstor.org/stable/1390820. Presented at the Joint Statistical Meetings, Chicago, August 1996.

Efron B, Tibshirani R (1993): An Introduction to the Bootstrap. New York: Chapman and Hall.

Diggle PJ, Verbyla AP (1998): Nonparametric estimation of covariance structure in logitudinal data. Biometrics 54:401–415.

Chapman IM, Hartman ML, et al (1997): Effect of aging on the sensitivity of growth hormone secretion to insulin-like growth factor-I negative feedback. J Clin Endocrinol Metab 82:2996–3004.

Li Y, Wang YG (2008): Smooth bootstrap methods for analysis of longitudinal data. Stat in Med 27:937-953. (potential improvements to cluster bootstrap; not implemented here)

See Also

`rcspline.eval`, `lm`, `lowess`, `supsmu`, `bootcov`, `units`, `label`, `polygon`, `reShape`

Examples

```
# Generate multivariate normal responses with equal correlations (.7)
# within subjects and no correlation between subjects
# Simulate realizations from a piecewise linear population time-response
# profile with large subject effects, and fit using a 6-knot spline
# Estimate the correlation structure from the residuals, as a function
# of the absolute time difference


# Function to generate n p-variate normal variates with mean vector u and
```

```
# covariance matrix S
# Slight modification of function written by Bill Venables
# See also the built-in function rmvnorm
mvrnorm <- function(n, p = 1, u = rep(0, p), S = diag(p)) {
  Z <- matrix(rnorm(n * p), p, n)
  t(u + t(chol(S)) %*% Z)
}


n     <- 20         # Number of subjects
sub   <- .5*(1:n)   # Subject effects


# Specify functional form for time trend and compute non-stochastic component
times <- seq(0, 1, by=.1)
g     <- function(times) 5*pmax(abs(times-.5),.3)
ey    <- g(times)


# Generate multivariate normal errors for 20 subjects at 11 times
# Assume equal correlations of rho=.7, independent subjects


nt    <- length(times)
rho   <- .7



set.seed(19)
errors <- mvrnorm(n, p=nt, S=diag(rep(1-rho,nt))+rho)
# Note:  first random number seed used gave rise to mean(errors)=0.24!


# Add E[Y], error components, and subject effects
y      <- matrix(rep(ey,n), ncol=nt, byrow=TRUE) + errors +
          matrix(rep(sub,nt), ncol=nt)


# String out data into long vectors for times, responses, and subject ID
y      <- as.vector(t(y))
times  <- rep(times, n)
id     <- sort(rep(1:n, nt))


# Show lowess estimates of time profiles for individual subjects
f <- rm.boot(times, y, id, plot.individual=TRUE, B=25, cor.pattern='estimate',
             smoother=lowess, bootstrap.type='x fixed', nk=6)
# In practice use B=400 or 500
# This will compute a dependent-structure log-likelihood in addition
# to one assuming independence.  By default, the dep. structure
# objective will be used by the plot method  (could have specified rho=.7)
# NOTE: Estimating the correlation pattern from the residual does not
# work in cases such as this one where there are large subject effects
```

```
# Plot fits for a random sample of 10 of the 25 bootstrap fits
plot(f, individual.boot=TRUE, ncurves=10, ylim=c(6,8.5))


# Plot pointwise and simultaneous confidence regions
plot(f, pointwise.band=TRUE, col.pointwise=1, ylim=c(6,8.5))


# Plot population response curve at average subject effect
ts <- seq(0, 1, length=100)
lines(ts, g(ts)+mean(sub), lwd=3)


## Not run:
#
# Handle a 2-sample problem in which curves are fitted
# separately for males and females and we wish to estimate the
# difference in the time-response curves for the two sexes.
# The objective criterion will be taken by plot.rm.boot as the
# total of the two sums of squared errors for the two models
#
knots <- rcspline.eval(c(time.f,time.m), nk=6, knots.only=TRUE)
# Use same knots for both sexes, and use a times vector that
# uses a range of times that is included in the measurement
# times for both sexes
#
tm <- seq(max(min(time.f),min(time.m)),
          min(max(time.f),max(time.m)),length=100)


f.female <- rm.boot(time.f, bp.f, id.f, knots=knots, times=tm)
f.male   <- rm.boot(time.m, bp.m, id.m, knots=knots, times=tm)
plot(f.female)
plot(f.male)
# The following plots female minus male response, with
# a sequence of shaded confidence band for the difference
plot(f.female,f.male,multi=TRUE)


# Do 1000 simulated analyses to check simultaneous coverage
# probability.  Use a null regression model with Gaussian errors


n.per.pt <- 30
n.pt     <- 10


null.in.region <- 0


for(i in 1:1000) {
```

```
  y    <- rnorm(n.pt*n.per.pt)
  time <- rep(1:n.per.pt, n.pt)
#  Add the following line and add ,id=id to rm.boot to use clustering
#  id   <- sort(rep(1:n.pt, n.per.pt))
#  Because we are ignoring patient id, this simulation is effectively
#  using 1 point from each of 300 patients, with times 1,2,3,,,30


  f <- rm.boot(time, y, B=500, nk=5, bootstrap.type='x fixed')
  g <- plot(f, ylim=c(-1,1), pointwise=FALSE)
  null.in.region <- null.in.region + all(g$lower<=0 & g$upper>=0)
  prn(c(i=i,null.in.region=null.in.region))
}


# Simulation Results: 905/1000 simultaneous confidence bands
# fully contained the horizontal line at zero

## End(Not run)
```

`rmClose` *rmClose*

Description

Remove close values from a numeric vector that are not at the outer limtis. This is useful for removing axis breaks that overlap when plotting.

Usage

```
rmClose(x, minfrac = 0.05)
```

Arguments

`x`	a numeric vector with no `NA`s
`minfrac`	minimum allowed spacing between consecutive ordered `x`, as a fraction of the range of `x`

Value

a sorted numeric vector of non-close values of `x`

Author(s)

Frank Harrell

Examples

```
rmClose(c(1, 2, 4, 47, 48, 49, 50), minfrac=0.07)
```

rMultinom *Generate Multinomial Random Variables with Varying Probabilities*

Description

Given a matrix of multinomial probabilities where rows correspond to observations and columns to categories (and each row sums to 1), generates a matrix with the same number of rows as has `probs` and with `m` columns. The columns represent multinomial cell numbers, and within a row the columns are all samples from the same multinomial distribution. The code is a modification of that in the `impute.polyreg` function in the `MICE` package.

Usage

```
rMultinom(probs, m)
```

Arguments

`probs`	matrix of probabilities
`m`	number of samples for each row of `probs`

Value

an integer matrix having `m` columns

See Also

`rbinom`

Examples

```
set.seed(1)
w <- rMultinom(rbind(c(.1,.2,.3,.4),c(.4,.3,.2,.1)),200)
t(apply(w, 1, table)/200)
```

runifChanged *runifChanged*

Description

Re-run Code if an Input Changed

Usage

```
runifChanged(fun, ..., file = NULL, .print. = TRUE, .inclfun. = TRUE)
```

Arguments

fun	the (usually slow) function to run
...	input objects the result of running the function is dependent on
file	file in which to store the result of fun augmented by attributes containing hash digests
.print.	set to TRUE to list which objects changed that neessitated re-running f
.inclfun.	set to FALSE to not include fun in the hash digest, i.e., to not require re-running fun if only fun itself has changed

Details

Uses hashCheck to run a function and save the results if specified inputs have changed, otherwise to retrieve results from a file. This makes it easy to see if any objects changed that require re-running a long simulation, and reports on any changes. The file name is taken as the chunk name appended with .rds unless it is given as file=. fun has no arguments. Set .inclfun.=FALSE to not include fun in the hash check (for legacy uses). The typical workflow is as follows.

```
f <- function(       ) {
# . . . do the real work with multiple function calls ...
}
seed <- 3
set.seed(seed)
w <- runifChanged(f, seed, obj1, obj2, ....)
```

seed, obj1, obj2, ... are all the objects that f() uses that if changed would give a different result of f(). This can include functions such as those in a package, and f will be re-run if any of the function's code changes. f is also re-run if the code inside f changes. The result of f is stored with saveRDS by default in file named xxx.rds where xxx is the label for the current chunk. To control this use instead file=xxx.rds add the file argument to runifChanged(...). If nothing has changed and the file already exists, the file is read to create the result object (e.g., w above). If f() needs to be run, the hashed input objects are stored as attributes for the result then the enhanced result is written to the file.

See here for examples.

Value

the result of running fun

Author(s)

Frank Harrell

runParallel *runParallel*

Description

parallel Package Easy Front-End

Usage

```
runParallel(
  onecore,
  reps,
  seed = round(runif(1, 0, 10000)),
  cores = max(1, parallel::detectCores() - 1),
  simplify = TRUE,
  along
)
```

Arguments

onecore	function to run the analysis on one core
reps	total number of repetitions
seed	species the base random number seed. The seed used for core i will be seed + i.
cores	number of cores to use, defaulting to one less than the number available
simplify	set to FALSE to not create an outer list if a onecore result has only one element
along	see Details

Details

Given a function onecore that runs the needed set of simulations on one CPU core, and given a total number of repetitions reps, determines the number of available cores and by default uses one less than that. By default the number of cores is one less than the number available on your machine. reps is divided as evenly as possible over these cores, and batches are run on the cores using the parallel package mclapply function. The current per-core repetition number is continually updated in your system's temporary directory (/tmp for Linux and Mac, TEMP for Windows) in a file name progressX.log where X is the core number. The random number seed is set for each core and is equal to the scalar seed - core number + 1. The default seed is a random number between 0 and 10000 but it's best if the user provides the seed so the simulation is reproducible. The total run time is computed and printed onefile must create a named list of all the results created during that one simulation batch. Elements of this list must be data frames, vectors, matrices, or arrays. Upon completion of all batches, all the results are rbind'd and saved in a single list.

onecore must have an argument reps that will tell the function how many simulations to run for one batch, another argument showprogress which is a function to be called inside onecore to write to the progress file for the current core and repetition, and an argument core which informs onecore

which sequential core number (batch number) it is processing. When calling `showprogress` inside `onecore`, the arguments, in order, must be the integer value of the repetition to be noted, the number of reps, `core`, an optional 4th argument `other` that can contain a single character string to add to the output, and an optional 5th argument `pr`. You can set `pr=FALSE` to suppress printing and have `showprogress` return the file name for holding progress information if you want to customize printing.

If any of the objects appearing as list elements produced by onecore are multi-dimensional arrays, you must specify an integer value for `along`. This specifies to the `abind` package `abind` function the dimension along which to bind the arrays. For example, if the first dimension of the array corresponding to repetitions, you would specify along=1. All arrays present must use the same `along` unless `along` is a named vector and the names match elements of the simulation result object. Set `simplify=FALSE` if you don't want the result simplified if onecore produces only one list element. The default returns the first (and only) list element rather than the list if there is only one element.

When `onecore` returns a `data.table`, `runParallel` simplifies all this and merely rbinds all the per-core data tables into one large data table. In that case when you have `onecore` include a column containing a simulation number, it is wise to prepend that number with the core number so that you will have unique simulation IDs when all the cores' results are combined.

See here for examples.

Value

result from combining all the parallel runs, formatting as similar to the result produced from one run as possible

Author(s)

Frank Harrell

`samplesize.bin` *Sample Size for 2-sample Binomial*

Description

Computes sample size(s) for 2-sample binomial problem given vector or scalar probabilities in the two groups.

Usage

```
samplesize.bin(alpha, beta, pit, pic, rho=0.5)
```

Arguments

`alpha`	scalar ONE-SIDED test size, or two-sided size/2
`beta`	scalar or vector of powers
`pit`	hypothesized treatment probability of success
`pic`	hypothesized control probability of success
`rho`	proportion of the sample devoted to treated group ($0 <$ `rho` < 1)

Value

TOTAL sample size(s)

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Examples

```
alpha <- .05
beta <- c(.70,.80,.90,.95)


# N1 is a matrix of total sample sizes whose
# rows vary by hypothesized treatment success probability and
# columns vary by power
# See Meinert's book for formulae.


N1 <- samplesize.bin(alpha, beta, pit=.55, pic=.5)
N1 <- rbind(N1, samplesize.bin(alpha, beta, pit=.60, pic=.5))
N1 <- rbind(N1, samplesize.bin(alpha, beta, pit=.65, pic=.5))
N1 <- rbind(N1, samplesize.bin(alpha, beta, pit=.70, pic=.5))
attr(N1,"dimnames") <- NULL


#Accounting for 5% noncompliance in the treated group
inflation <- (1/.95)**2
print(round(N1*inflation+.5,0))
```

---

sas.get *Convert a SAS Dataset to an S Data Frame*

Description

Converts a SAS dataset into an S data frame. You may choose to extract only a subset of variables or a subset of observations in the SAS dataset. You may have the function automatically convert

```
PROC FORMAT
```

-coded variables to factor objects. The original SAS codes are stored in an attribute called `sas.codes` and these may be added back to the `levels` of a `factor` variable using the `code.levels` function. Information about special missing values may be captured in an attribute of each variable having special missing values. This attribute is called `special.miss`, and such variables are given class `special.miss`. There are `print`, `[]`, `format`, and `is.special.miss` methods for such variables.

The chron function is used to set up date, time, and date-time variables. If using S-Plus 5 or 6 or later, the timeDate function is used instead. Under R, Dates is used for dates and chron for date-times. For times without dates, these still need to be stored in date-time format in POSIX. Such SAS time variables are given a major class of POSIXt and a format.POSIXt function so that the date portion (which will always be 1/1/1970) will not print by default. If a date variable represents a partial date (0.5 added if month missing, 0.25 added if day missing, 0.75 if both), an attribute partial.date is added to the variable, and the variable also becomes a class imputed variable. The describe function uses information about partial dates and special missing values. There is an option to automatically uncompress (or gunzip) compressed SAS datasets.

Usage

```
sas.get(libraryName, member, variables=character(0), ifs=character(0),
     format.library=libraryName, id,
     dates.=c("sas","yymmdd","yearfrac","yearfrac2"),
     keep.log=TRUE, log.file="_temp_.log", macro=sas.get.macro,
     data.frame.out=existsFunction("data.frame"), clean.up=FALSE, quiet=FALSE,
     temp=tempfile("SaS"), formats=TRUE, recode=formats,
     special.miss=FALSE, sasprog="sas",
     as.is=.5, check.unique.id=TRUE, force.single=FALSE,
     pos, uncompress=FALSE, defaultencoding="latin1", var.case="lower")

is.special.miss(x, code)

## S3 method for class 'special.miss'
x[..., drop=FALSE]

## S3 method for class 'special.miss'
print(x, ...)

## S3 method for class 'special.miss'
format(x, ...)

sas.codes(object)

code.levels(object)
```

Arguments

libraryName	character string naming the directory in which the dataset is kept.
drop	logical. If TRUE the result is coerced to the lowest possible dimension.
member	character string giving the second part of the two part SAS dataset name. (The first part is irrelevant here - it is mapped to the UNIX directory name.)
x	a variable that may have been created by sas.get with special.miss=T or with recode in effect.
variables	vector of character strings naming the variables in the SAS dataset. The S dataset will contain only those variables from the SAS dataset. To get all of the variables (the default), an empty string may be given. It is a fatal error if any one of

the variables is not in the SAS dataset. You can use sas.contents to get the variables in the SAS dataset. If you have retrieved a subset of the variables in the SAS dataset and which to retrieve the same list of variables from another dataset, you can program the value of variables - see one of the last examples.

ifs — a vector of character strings, each containing one SAS "subsetting if" statement. These will be used to extract a subset of the observations in the SAS dataset.

format.library — The UNIX directory containing the file 'formats.sct', which contains the definitions of the user defined formats used in this dataset. By default, we look for the formats in the same directory as the data. The user defined formats must be available (so SAS can read the data).

formats — Set formats to FALSE to keep sas.get from telling the SAS macro to retrieve value label formats from format.library. When you do not specify formats or recode, sas.get will set format to TRUE if a SAS format catalog ('.sct' or '.sc2') file exists in format.library. Value label formats if present are stored as the formats attribute of the returned object (see below). A format is used if it is referred to by one or more variables in the dataset, if it contains no ranges of values (i.e., it identifies value labels for single values), and if it is a character format or a numeric format that is not used just to label missing values. If you set recode to TRUE, 1, or 2, formats defaults to TRUE. To fetch the values and labels for variable x in the dataset d you could type:

```
f <- attr(d\$x, "format")
formats <- attr(d, "formats")
formats\$f\$values; formats\$f\$labels
```

recode — This parameter defaults to TRUE if formats is TRUE. If it is TRUE, variables that have an appropriate format (see above) are recoded as factor objects, which map the values to the value labels for the format. Alternatively, set recode to 1 to use labels of the form value:label, e.g. 1:good 2:better 3:best. Set recode to 2 to use labels such as good(1) better(2) best(3). Since sas.codes and code.levels add flexibility, the usual choice for recode is TRUE.

special.miss — For numeric variables, any missing values are stored as NA in S. You can recover special missing values by setting special.miss to TRUE. This will cause the special.miss attribute and the special.miss class to be added to each variable that has at least one special missing value. Suppose that variable y was .E in observation 3 and .G in observation 544. The special.miss attribute for y then has the value

```
list(codes=c("E","G"),obs=c(3,544))
```

To fetch this information for variable y you would say for example

```
s <- attr(y, "special.miss")
s\$codes; s\$obs
```

or use is.special.miss(x) or the print.special.miss method, which will replace NA values for the variable with 'E' or 'G' if they correspond to special missing values. The describe function uses this information in printing a data summary.

id — The name of the variable to be used as the row names of the S dataset. The id variable becomes the row.names attribute of a data frame, but the id variable is still retained as a variable in the data frame. (if data.frame.out is FALSE, this will be the attribute 'id' of the R dataset.) You can also specify a vector of

variable names as the id parameter. After fetching the data from SAS, all these variables will be converted to character format and concatenated (with a space as a separator) to form a (hopefully) unique identification variable.

dates. specifies the format for storing SAS dates in the resulting data frame

as.is IF data.frame.out = TRUE, SAS character variables are converted to S factor objects if as.is = FALSE or if as.is is a number between 0 and 1 inclusive and the number of unique values of the variable is less than the number of observations (n) times as.is. The default if as.is is 0.5, so character variables are converted to factors only if they have fewer than n/2 unique values. The primary purpose of this is to keep unique identification variables as character values in the data frame instead of using more space to store both the integer factor codes and the factor labels.

check.unique.id

If id is specified, the row names are checked for uniqueness if check.unique.id = TRUE. If any are duplicated, a warning is printed. Note that if a data frame is being created with duplicate row names, statements such as my.data.frame["B23",] will retrieve only the first row with a row name of

B23

.

force.single By default, SAS numeric variables having $LENGTH > 4$ are stored as S double precision numerics, which allow for the same precision as a SAS

LENGTH

8 variable. Set force.single = TRUE to store every numeric variable in single precision (7 digits of precision). This option is useful when the creator of the SAS dataset has failed to use a

LENGTH

statement. R does not have single precision, so no attempt is made to convert to single if running R.

dates One of the character strings "sas", "yearfrac", "yearfrac2", "yymmdd". If a SAS variable has a date format (one of "DATE", "MMDDYY", "YYMMDD", "DDMMYY", "YYQ", "MONYY", "JULIAN"), it will be converted to the format specified by dates before being given to S. "sas" gives days from 1/1/1960 (from 1/1/1970 if using chron), "yearfrac" gives days from 1/1/1900 divided by 365.25, "yearfrac2" gives year plus fraction of current year, and "yymmdd" gives a 6 digit number

YYMMDD

(year%%100, month, day). Note that R will store these as numbers, not as character strings. If dates="sas" and a variable has one of the SAS date formats listed above, the variable will be given a class of 'date' to work with Terry Therneau's implementation of the 'date' class in S. If the chron package or timeDate function is available, these are used instead.

keep.log logical flag: if FALSE, delete the SAS log file upon completion.

log.file the name of the SAS log file.

macro	the name of an S object in the current search path that contains the text of the SAS macro called by R. The R object is a character vector that can be edited using for example `sas.get.macro <- editor(sas.get.macro)`.
data.frame.out	logical flag: if TRUE, the return value will be an S data frame, otherwise it will be a list.
clean.up	logical flag: if TRUE, remove all temporary files when finished. You may want to keep these while debugging the SAS macro. Not needed for R.
quiet	logical flag: if FALSE, print the contents of the SAS log file if there has been an error.
temp	the prefix to use for the temporary files. Two characters will be added to this, the resulting name must fit on your file system.
sasprog	the name of the system command to invoke SAS
uncompress	set to TRUE to automatically invoke the UNIX gunzip command (if '*member*.ssd01.gz' exists) or the uncompress command (if '*member*.ssd01.Z' exists) to uncompress the SAS dataset before proceeding. This assumes you have the file permissions to allow uncompressing in place. If the file is already uncompressed, this option is ignored.
pos	by default, a list or data frame which contains all the variables is returned. If you specify pos, each individual variable is placed into a separate object (whose name is the name of the variable) using the assign function with the pos argument. For example, you can put each variable in its own file in a directory, which in some cases may save memory over attaching a data frame.
code	a special missing value code ('A' through 'Z' or '_') to check against. If code is omitted, is.special.miss will return a TRUE for each observation that has any special missing value.
defaultencoding	encoding to assume if the SAS dataset does not specify one. Defaults to "latin1".
var.case	default is to change case of SAS variable names to lower case. Specify alternatively "upper" or "preserve".
object	a variable in a data frame created by sas.get
...	ignored

Details

If you specify special.miss = TRUE and there are no special missing values in the data SAS dataset, the SAS step will bomb.

For variables having a

```
PROC FORMAT VALUE
```

format with some of the levels undefined, sas.get will interpret those values as NA if you are using recode.

The SAS macro 'sas_get' uses record lengths of up to 4096 in two places. If you are exporting records that are very long (because of a large number of variables and/or long character variables), you may want to edit these

LRECL

s to quadruple them, for example.

Value

if data.frame.out is TRUE, the output will be a data frame resembling the SAS dataset. If id was specified, that column of the data frame will be used as the row names of the data frame. Each variable in the data frame or vector in the list will have the attributes label and format containing SAS labels and formats. Underscores in formats are converted to periods. Formats for character variables have \$ placed in front of their names. If formats is TRUE and there are any appropriate format definitions in format.library, the returned object will have attribute formats containing lists named the same as the format names (with periods substituted for underscores and character formats prefixed by \$). Each of these lists has a vector called values and one called labels with the

PROC FORMAT; VALUE ...

definitions.

If data.frame.out is FALSE, the output will be a list of vectors, each containing a variable from the SAS dataset. If id was specified, that element of the list will be used as the id attribute of the entire list.

Side Effects

if a SAS error occurs and quiet is FALSE, then the SAS log file will be printed under the control of the less pager.

BACKGROUND

The references cited below explain the structure of SAS datasets and how they are stored under UNIX. See SAS *Language* for a discussion of the "subsetting if" statement.

Note

You must be able to run SAS (by typing sas) on your system. If the S command !sas does not start SAS, then this function cannot work.

If you are reading time or date-time variables, you will need to execute the command library(chron) to print those variables or the data frame if the timeDate function is not available.

Author(s)

Terry Therneau, Mayo Clinic
Frank Harrell, Vanderbilt University
Bill Dunlap, University of Washington and Insightful Corporation
Michael W. Kattan, Cleveland Clinic Foundation
Reinhold Koch (encoding)

References

SAS Institute Inc. (1990). SAS *Language: Reference, Version 6.* First Edition. SAS Institute Inc., Cary, North Carolina.

SAS Institute Inc. (1988). SAS Technical Report P-176, *Using the* SAS *System, Release 6.03, under UNIX Operating Systems and Derivatives.* SAS Institute Inc., Cary, North Carolina.

SAS Institute Inc. (1985). SAS *Introductory Guide.* Third Edition. SAS Institute Inc., Cary, North Carolina.

See Also

data.frame, describe, label, upData, cleanup.import

Examples

```
## Not run:
sas.contents("saslib", "mice")
# [1] "dose"  "ld50"  "strain"  "lab_no"
attr(, "n"):
# [1] 117
mice <- sas.get("saslib", mem="mice", var=c("dose", "strain", "ld50"))
plot(mice$dose, mice$ld50)


nude.mice <- sas.get(lib=unix("echo $HOME/saslib"), mem="mice",
 ifs="if strain='nude'")


nude.mice.dl <- sas.get(lib=unix("echo $HOME/saslib"), mem="mice",
 var=c("dose", "ld50"), ifs="if strain='nude'")


# Get a dataset from current directory, recode PROC FORMAT; VALUE \dots
# variables into factors with labels of the form "good(1)" "better(2)",
# get special missing values, recode missing codes .D and .R into new
# factor levels "Don't know" and "Refused to answer" for variable q1
d <- sas.get(".", "mydata", recode=2, special.miss=TRUE)
attach(d)
nl <- length(levels(q1))
lev <- c(levels(q1), "Don't know", "Refused")
q1.new <- as.integer(q1)
q1.new[is.special.miss(q1,"D")] <- nl+1
q1.new[is.special.miss(q1,"R")] <- nl+2
q1.new <- factor(q1.new, 1:(nl+2), lev)
# Note: would like to use factor() in place of as.integer \dots but
# factor in this case adds "NA" as a category level


d <- sas.get(".", "mydata")
sas.codes(d$x)    # for PROC FORMATted variables returns original data codes
d$x <- code.levels(d$x)   # or attach(d); x <- code.levels(x)
# This makes levels such as "good" "better" "best" into e.g.
```

```
# "1:good" "2:better" "3:best", if the original SAS values were 1,2,3


# Retrieve the same variables from another dataset (or an update of
# the original dataset)
mydata2 <- sas.get('mydata2', var=names(d))
# This only works if none of the original SAS variable names contained _
mydata2 <- cleanup.import(mydata2) # will make true integer variables

# Code from Don MacQueen to generate SAS dataset to test import of
# date, time, date-time variables
# data ssd.test;
#     d1='3mar2002'd ;
#     dt1='3mar2002 9:31:02'dt;
#     t1='11:13:45't;
#     output;
#
#     d1='3jun2002'd ;
#     dt1='3jun2002 9:42:07'dt;
#     t1='11:14:13't;
#     output;
#     format d1 mmddyy10. dt1 datetime. t1 time.;
# run;

## End(Not run)
```

---

sasxport.get *Enhanced Importing of SAS Transport Files using read.xport*

Description

Uses the `read.xport` and `lookup.xport` functions in the `foreign` library to import SAS datasets. SAS date, time, and date/time variables are converted respectively to `Date`, POSIX, or `POSIXct` objects in R, variable names are converted to lower case, SAS labels are associated with variables, and (by default) integer-valued variables are converted from storage mode `double` to `integer`. If the user ran `PROC FORMAT CNTLOUT=` in SAS and included the resulting dataset in the SAS version 5 transport file, variables having customized formats that do not include any ranges (i.e., variables having standard `PROC FORMAT; VALUE` label formats) will have their format labels looked up, and these variables are converted to S `factors`.

For those users having access to SAS, `method='csv'` is preferred when importing several SAS datasets. Run SAS macro `exportlib.sas` available from https://github.com/harrelfe/Hmisc/blob/master/src/sas/exportlib.sas to convert all SAS datasets in a SAS data library (from any engine supported by your system) into `CSV` files. If any customized formats are used, it is assumed that the `PROC FORMAT CNTLOUT=` dataset is in the data library as a regular SAS dataset, as above.

`SASdsLabels` reads a file containing `PROC CONTENTS` printed output to parse dataset labels, assuming that `PROC CONTENTS` was run on an entire library.

Usage

```
sasxport.get(file, lowernames=TRUE, force.single = TRUE,
             method=c('read.xport','dataload','csv'), formats=NULL, allow=NULL,
             out=NULL, keep=NULL, drop=NULL, as.is=0.5, FUN=NULL)
sasdsLabels(file)
```

Arguments

file	name of a file containing the SAS transport file. file may be a URL beginning with https://. For sasdsLabels, file is the name of a file containing a PROC CONTENTS output listing. For method='csv', file is the name of the directory containing all the CSV files created by running the exportlib SAS macro.
lowernames	set to FALSE to keep from converting SAS variable names to lower case
force.single	set to FALSE to keep integer-valued variables not exceeding $2^31 - 1$ in value from being converted to integer storage mode
method	set to "dataload" if you have the dataload executable installed and want to use it instead of read.xport. This seems to correct some errors in which rarely some factor variables are always missing when read by read.xport when in fact they have some non-missing values.
formats	a data frame or list (like that created by read.xport) containing PROC FORMAT output, if such output is not stored in the main transport file.
allow	a vector of characters allowed by R that should not be converted to periods in variable names. By default, underscores in variable names are converted to periods as with R before version 1.9.
out	a character string specifying a directory in which to write separate R save files (.rda files) for each regular dataset. Each file and the data frame inside it is named with the SAS dataset name translated to lower case and with underscores changed to periods. The default NULL value of out results in a data frame or a list of data frames being returned. When out is given, sasxport.get returns only metadata (see below), invisibly. out only works with methods='csv'. out should not have a trailing slash.
keep	a vector of names of SAS datasets to process (original SAS upper case names). Must include PROC FORMAT dataset if it exists, and if the kept datasets use any of its value label formats.
drop	a vector of names of SAS datasets to ignore (original SAS upper case names)
as.is	SAS character variables are converted to S factor objects if as.is=FALSE or if as.is is a number between 0 and 1 inclusive and the number of unique values of the variable is less than the number of observations (n) times as.is. The default if as.is is .5, so character variables are converted to factors only if they have fewer than n/2 unique values. The primary purpose of this is to keep unique identification variables as character values in the data frame instead of using more space to store both the integer factor codes and the factor labels.
FUN	an optional function that will be run on each data frame created, when method='csv' and out are specified. The result of all the FUN calls is made into a list corresponding to the SAS datasets that are read. This list is the FUN attribute of the result returned by sasxport.get.

Details

See contents.list for a way to print the directory of SAS datasets when more than one was imported.

Value

If there is more than one dataset in the transport file other than the PROC FORMAT file, the result is a list of data frames containing all the non-PROC FORMAT datasets. Otherwise the result is the single data frame. There is an exception if out is specified; that causes separate R save files to be written and the returned value to be a list corresponding to the SAS datasets, with key PROC CONTENTS information in a data frame making up each part of the list. sasdsLabels returns a named vector of dataset labels, with names equal to the dataset names.

Author(s)

Frank E Harrell Jr

See Also

read.xport,label,sas.get, Dates,DateTimeClasses, lookup.xport,contents,describe

Examples

```
## Not run:
# SAS code to generate test dataset:
# libname y SASV5XPT "test2.xpt";
#
# PROC FORMAT; VALUE race 1=green 2=blue 3=purple; RUN;
# PROC FORMAT CNTLOUT=format;RUN;  * Name, e.g. 'format', unimportant;
# data test;
# LENGTH race 3 age 4;
# age=30; label age="Age at Beginning of Study";
# race=2;
# d1='3mar2002'd ;
# dt1='3mar2002 9:31:02'dt;
# t1='11:13:45't;
# output;
#
# age=31;
# race=4;
# d1='3jun2002'd ;
# dt1='3jun2002 9:42:07'dt;
# t1='11:14:13't;
# output;
# format d1 mmddyy10. dt1 datetime. t1 time. race race.;
# run;
# data z; LENGTH x3 3 x4 4 x5 5 x6 6 x7 7 x8 8;
#    DO i=1 TO 100;
#        x3=ranuni(3);
#        x4=ranuni(5);
#        x5=ranuni(7);
```

```
#        x6=ranuni(9);
#        x7=ranuni(11);
#        x8=ranuni(13);
#        output;
#        END;
#    DROP i;
#    RUN;
# PROC MEANS; RUN;
# PROC COPY IN=work OUT=y;SELECT test format z;RUN; *Creates test2.xpt;
w <- sasxport.get('test2.xpt')
# To use an existing copy of test2.xpt available on the web:
w <- sasxport.get('https://github.com/harrelfe/Hmisc/raw/master/inst/tests/test2.xpt')

describe(w$test)   # see labels, format names for dataset test
# Note: if only one dataset (other than format) had been exported,
# just do describe(w) as sasxport.get would not create a list for that
lapply(w, describe)# see descriptive stats for both datasets
contents(w$test)   # another way to see variable attributes
lapply(w, contents)# show contents of both datasets
options(digits=7)  # compare the following matrix with PROC MEANS output
t(sapply(w$z, function(x)
 c(Mean=mean(x),SD=sqrt(var(x)),Min=min(x),Max=max(x))))

## End(Not run)
```

Save *Faciliate Use of save and load to Remote Directories*

Description

These functions are slightly enhanced versions of `save` and `load` that allow a target directory to be specified using `options(LoadPath="pathname")`. If the `LoadPath` option is not set, the current working directory is used.

Usage

```
# options(LoadPath='mypath')
Save(object, name=deparse(substitute(object)), compress=TRUE)
Load(object)
```

Arguments

`object`	the name of an object, usually a data frame. It must not be quoted.
`name`	an optional name to assign to the object and file name prefix, if the argument name is not used
`compress`	see `save`. Default is `TRUE` which corresponds to `gzip`.

Details

Save creates a temporary version of the object under the name given by the user, so that save will internalize this name. Then subsequent Load or load will cause an object of the original name to be created in the global environment. The name of the R data file is assumed to be the name of the object (or the value of name) appended with ".rda".

Author(s)

Frank Harrell

See Also

save, load

Examples

```
## Not run:
d <- data.frame(x=1:3, y=11:13)
options(LoadPath='../data/rda')
Save(d)   # creates ../data/rda/d.rda
Load(d)   # reads   ../data/rda/d.rda
Save(d, 'D')   # creates object D and saves it in .../D.rda

## End(Not run)
```

---

scat1d *One-Dimensional Scatter Diagram, Spike Histogram, or Density*

Description

scat1d adds tick marks (bar codes. rug plot) on any of the four sides of an existing plot, corresponding with non-missing values of a vector x. This is used to show the data density. Can also place the tick marks along a curve by specifying y-coordinates to go along with the x values.

If any two values of x are within eps $*$ w of each other, where eps defaults to .001 and w is the span of the intended axis, values of x are jittered by adding a value uniformly distributed in $[-\texttt{jitfrac} * w, \texttt{jitfrac} * w]$, where jitfrac defaults to .008. Specifying preserve=TRUE invokes jitter2 with a different logic of jittering. Allows plotting random sub-segments to handle very large x vectors (seetfrac).

jitter2 is a generic method for jittering, which does not add random noise. It retains unique values and ranks, and randomly spreads duplicate values at equidistant positions within limits of enclosing values. jitter2 is especially useful for numeric variables with discrete values, like rating scales. Missing values are allowed and are returned. Currently implemented methods are jitter2.default for vectors and jitter2.data.frame which returns a data.frame with each numeric column jittered.

datadensity is a generic method used to show data densities in more complex situations. Here, another datadensity method is defined for data frames. Depending on the which argument, some

or all of the variables in a data frame will be displayed, with scat1d used to display continuous variables and, by default, bars used to display frequencies of categorical, character, or discrete numeric variables. For such variables, when the total length of value labels exceeds 200, only the first few characters from each level are used. By default, datadensity.data.frame will construct one axis (i.e., one strip) per variable in the data frame. Variable names appear to the left of the axes, and the number of missing values (if greater than zero) appear to the right of the axes. An optional group variable can be used for stratification, where the different strata are depicted using different colors. If the q vector is specified, the desired quantiles (over all groups) are displayed with solid triangles below each axis.

When the sample size exceeds 2000 (this value may be modified using the nhistSpike argument, datadensity calls histSpike instead of scat1d to show the data density for numeric variables. This results in a histogram-like display that makes the resulting graphics file much smaller. In this case, datadensity uses the minf argument (see below) so that very infrequent data values will not be lost on the variable's axis, although this will slightly distortthe histogram.

histSpike is another method for showing a high-resolution data distribution that is particularly good for very large datasets (say n > 1000). By default, histSpike bins the continuous x variable into 100 equal-width bins and then computes the frequency counts within bins (if n does not exceed 10, no binning is done). If add=FALSE (the default), the function displays either proportions or frequencies as in a vertical histogram. Instead of bars, spikes are used to depict the frequencies. If add=FALSE, the function assumes you are adding small density displays that are intended to take up a small amount of space in the margins of the overall plot. The frac argument is used as with scat1d to determine the relative length of the whole plot that is used to represent the maximum frequency. No jittering is done by histSpike.

histSpike can also graph a kernel density estimate for x, or add a small density curve to any of 4 sides of an existing plot. When y or curve is specified, the density or spikes are drawn with respect to the curve rather than the x-axis.

histSpikeg is similar to histSpike but is for adding layers to a ggplot2 graphics object or traces to a plotly object. histSpikeg can also add lowess curves to the plot.

ecdfpM makes a plotly graph or series of graphs showing possibly superposed empirical cumulative distribution functions.

Usage

```
scat1d(x, side=3, frac=0.02, jitfrac=0.008, tfrac,
       eps=ifelse(preserve,0,.001),
       lwd=0.1, col=par("col"),
       y=NULL, curve=NULL,
       bottom.align=FALSE,
       preserve=FALSE, fill=1/3, limit=TRUE, nhistSpike=2000, nint=100,
       type=c('proportion','count','density'), grid=FALSE, ...)

jitter2(x, ...)

## Default S3 method:
jitter2(x, fill=1/3, limit=TRUE, eps=0,
        presorted=FALSE, ...)
```

```
## S3 method for class 'data.frame'
jitter2(x, ...)

datadensity(object, ...)

## S3 method for class 'data.frame'
datadensity(object, group,
            which=c("all","continuous","categorical"),
            method.cat=c("bar","freq"),
            col.group=1:10,
            n.unique=10, show.na=TRUE, nint=1, naxes,
            q, bottom.align=nint>1,
            cex.axis=sc(.5,.3), cex.var=sc(.8,.3),
            lmgp=NULL, tck=sc(-.009,-.002),
            ranges=NULL, labels=NULL, ...)
# sc(a,b) means default to a if number of axes <= 3, b if >=50, use
# linear interpolation within 3-50

histSpike(x, side=1, nint=100, bins=NULL, frac=.05, minf=NULL, mult.width=1,
          type=c('proportion','count','density'),
          xlim=range(x), ylim=c(0,max(f)), xlab=deparse(substitute(x)),
          ylab=switch(type,proportion='Proportion',
                           count     ='Frequency',
                           density   ='Density'),
          y=NULL, curve=NULL, add=FALSE, minimal=FALSE,
          bottom.align=type=='density', col=par('col'), lwd=par('lwd'),
          grid=FALSE, ...)

histSpikeg(formula=NULL, predictions=NULL, data, plotly=NULL,
           lowess=FALSE, xlim=NULL, ylim=NULL,
           side=1, nint=100,
           frac=function(f) 0.01 + 0.02*sqrt(f-1)/sqrt(max(f,2)-1),
           span=3/4, histcol='black', showlegend=TRUE)

ecdfpM(x, group=NULL, what=c('F','1-F','f','1-f'), q=NULL,
       extra=c(0.025, 0.025), xlab=NULL, ylab=NULL, height=NULL, width=NULL,
       colors=NULL, nrows=NULL, ncols=NULL, ...)
```

Arguments

x	a vector of numeric data, or a data frame (for jitter2 or ecdfpM)
object	a data frame or list (even with unequal number of observations per variable, as long as group is notspecified)
side	axis side to use (1=bottom (default for histSpike), 2=left, 3=top (default for scat1d), 4=right)
frac	fraction of smaller of vertical and horizontal axes for tick mark lengths. Can be negative to move tick marks outside of plot. For histSpike, this is the relative y-direction length to be used for the largest frequency. When scat1d calls

histSpike, it multiplies its frac argument by 2.5. For histSpikeg, frac is a function of f, the vector of all frequencies. The default function scales tick marks so that they are between 0.01 and 0.03 of the y range, linearly scaled in the square root of the frequency less one.

jitfrac — fraction of axis for jittering. If jitfrac ≤ 0, no jittering is done. If preserve=TRUE, the amount of jittering is independent of jitfrac.

tfrac — Fraction of tick mark to actually draw. If tfrac < 1, will draw a random fraction tfrac of the line segment at each point. This is useful for very large samples or ones with some very dense points. The default value is 1 if the number of non-missing observations n is less than 125, and $\max(.1, 125/n)$ otherwise.

eps — fraction of axis for determining overlapping points in x. For preserve=TRUE the default is 0 and original unique values are retained, bigger values of eps tends to bias observations from dense to sparse regions, but ranks are still preserved.

lwd — line width for tick marks, passed to segments

col — color for tick marks, passed to segments

y — specify a vector the same length as x to draw tick marks along a curve instead of by one of the axes. The y values are often predicted values from a model. The side argument is ignored when y is given. If the curve is already represented as a table look-up, you may specify it using the curve argument instead. y may be a scalar to use a constant verticalplacement.

curve — a list containing elements x and y for which linear interpolation is used to derive y values corresponding to values of x. This results in tick marks being drawn along the curve. For histSpike, interpolated y values are derived for binmidpoints.

minimal — for histSpike set minimal=TRUE to draw a minimalist spike histogram with no y-axis. This works best when produce graphics images that are short, e.g., have a height of two inches. add is forced to be FALSE in this case so that a standalone graph is produced. Only base graphics are used.

bottom.align — set to TRUE to have the bottoms of tick marks (for side=1 or side=3) aligned at the y-coordinate. The default behavior is to center the tick marks. For datadensity.data.frame, bottom.align defaults to TRUE if nint>1. In other words, if you are only labeling the first and last axis tick mark, the scat1d tick marks are centered on the variable's axis.

preserve — set to TRUE to invoke jitter2

fill — maximum fraction of the axis filled by jittered values. If d are duplicated values between a lower value l and upper value u, then d will be spread within $\pm$fill $*$ $\min(u-d, d-l)/2$.

limit — specifies a limit for maximum shift in jittered values. Duplicate values will be spread within $\pm$fill $*\min(u-d, d-l)/2$. The default TRUE restricts jittering to the smallest $\min(u-d, d-l)/2$ observed and results in equal amount of jittering for all d. Setting to FALSE allows for locally different amount of jittering, using maximum space available.

nhistSpike — If the number of observations exceeds or equals nhistSpike, scat1d will automatically call histSpike to draw the data density, to prevent the graphics file from being too large.

type	used by or passed to histSpike. Set to "count" to display frequency counts rather than relative frequencies, or "density" to display a kernel density estimate computed using the density function.
grid	set to TRUE if the R grid package is in effect for the current plot
nint	number of intervals to divide each continuous variable's axis for datadensity. For histSpike, is the number of equal-width intervals for which to bin x, and if instead nint is a character string (e.g.,nint="all"), the frequency tabulation is done with no binning. In other words, frequencies for all unique values of x are derived and plotted. For histSpikeg, if x has no more than nint unique values, all observed values are used, otherwise the data are rounded before tabulation so that there are no more than nint intervals. For histSpike, nint is ignored if bins is given.
bins	for histSpike specifies the actual cutpoints to use for binning x. The default is to use nint in conjunction with xlim.
...	optional arguments passed to scat1d from datadensity or to histSpike from scat1d. For histSpikep are passed to the lines list to add_trace. For ecdfpM these arguments are passed to add_lines.
presorted	set to TRUE to prevent from sorting for determining the order $l < d < u$. This is usefull if an existing meaningfull local order would be destroyed by sorting, as in $\sin(\pi * \texttt{sort}(\texttt{round}(\texttt{runif}(1000, 0, 10), 1)))$.
group	an optional stratification variable, which is converted to a factor vector if it is not one already
which	set which="continuous" to only plot continuous variables, or which="categorical" to only plot categorical, character, or discrete numeric ones. By default, all types of variables are depicted.
method.cat	set method.cat="freq" to depict frequencies of categorical variables with digits representing the cell frequencies, with size proportional to the square root of the frequency. By default, vertical bars are used.
col.group	colors representing the group strata. The vector of colors is recycled to be the same length as the levels of group.
n.unique	number of unique values a numeric variable must have before it is considered to be a continuous variable
show.na	set to FALSE to suppress drawing the number of NAs to the right of each axis
naxes	number of axes to draw on each page before starting a new plot. You can set naxes larger than the number of variables in the data frame if you want to compress the plot vertically.
q	a vector of quantiles to display. By default, quantiles are not shown.
extra	a two-vector specifying the fraction of the x range to add on the left and the fraction to add on the right
cex.axis	character size for draw labels for axis tick marks
cex.var	character size for variable names and frequence of NAs
lmgp	spacing between numeric axis labels and axis (see par for mgp)
tck	see tck under par

ranges	a list containing ranges for some or all of the numeric variables. If ranges is not given or if a certain variable is not found in the list, the empirical range, modified by pretty, is used. Example: ranges=list(age=c(10,100), pressure=c(50,150)).
labels	a vector of labels to use in labeling the axes for datadensity.data.frame. Default is to use the names of the variable in the input data frame. Note: margin widths computed for setting aside names of variables use the names, and not these labels.
minf	For histSpike, if minf is specified low bin frequencies are set to a minimum value of minf times the maximum bin frequency, so that rare data points will remain visible. A good choice of minf is 0.075. datadensity.data.frame passes minf=0.075 to scat1d to pass to histSpike. Note that specifying minf will cause the shape of the histogram to be distorted somewhat.
mult.width	multiplier for the smoothing window width computed by histSpike when type="density"
xlim	a 2-vector specifying the outer limits of x for binning (and plotting, if add=FALSE and nint is a number). For histSpikeg, observations outside the xlim range are ignored.
ylim	y-axis range for plotting (if add=FALSE). Often needed for histSpikeg to help scale the tick mark line segments.
xlab	x-axis label (add=FALSE or for ecdfpM); default is name of input argument, or for ecdfpM comes from label and units attributes of the analysis variable. For ecdfpM xlab may be a vector if there is more than one analysis variable.
ylab	y-axis label (add=FALSE or for ecdfpM)
add	set to TRUE to add the spike-histogram to an existing plot, to show marginal data densities
formula	a formula of the form y ~ x1 or y ~ x1 + ... where y is the name of the y-axis variable being plotted with ggplot, x1 is the name of the x-axis variable, and optional ... are variables used by ggplot to produce multiple curves on a panel and/or facets.
predictions	the data frame being plotted by ggplot, containing x and y coordinates of curves. If omitted, spike histograms are drawn at the bottom (default) or top of the plot according to side.
data	for histSpikeg is a mandatory data frame containing raw data whose frequency distribution is to be summarized, using variables in formula.
plotly	an existing plotly object. If not NULL, histSpikeg uses plotly instead of ggplot.
lowess	set to TRUE to have histSpikeg add a geom_line layer to the ggplot2 graphic, containing lowess() nonparametric smoothers. This causes the returned value of histSpikeg to be a list with two components: "hist" and "lowess" each containing a layer. Fortunately, ggplot2 plots both layers automatically. If the dependent variable is binary, iter=0 is passed to lowess so that outlier detection is turned off; otherwise iter=3 is passed.
span	passed to lowess as the f argument
histcol	color of line segments (tick marks) for histSpikeg. Default is black. Set to any color or to "default" to use the prevailing colors for the graphic.

showlegend	set to FALSE too have the added plotly traces not have entries in the plot legend
what	set to "1-F" to plot 1 minus the ECDF instead of the ECDF, "f" to plot cumulative frequency, or "1-f" to plot the inverse cumulative frequency
height, width	passed to plot_ly
colors	a vector of colors to pas to add_lines
nrows, ncols	passed to plotly::subplot

Details

For scat1d the length of line segments used is frac*min(par()$pin)/par()$uin[opp] data units, where opp is the index of the opposite axis and frac defaults to .02. Assumes that plot has already been called. Current par("usr") is used to determine the range of data for the axis of the current plot. This range is used in jittering and in constructing line segments.

Value

histSpike returns the actual range of x used in its binning. histSpikeg returns a list of ggplot2 layers that ggplot2 will easily add with +.

Side Effects

scat1d adds line segments to plot. datadensity.data.frame draws a complete plot. histSpike draws a complete plot or adds to an existing plot.

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See Also

segments, jitter, rug, plsmo, lowess, stripplot, hist.data.frame,Ecdf, hist, histogram, table, density, stat_plsmo, histboxp

Examples

```
plot(x <- rnorm(50), y <- 3*x + rnorm(50)/2 )
scat1d(x)                 # density bars on top of graph
scat1d(y, 4)              # density bars at right
histSpike(x, add=TRUE)       # histogram instead, 100 bins
histSpike(y, 4, add=TRUE)
histSpike(x, type='density', add=TRUE)  # smooth density at bottom
histSpike(y, 4, type='density', add=TRUE)


smooth <- lowess(x, y)    # add nonparametric regression curve
lines(smooth)             # Note: plsmo() does this
scat1d(x, y=approx(smooth, xout=x)$y) # data density on curve
scat1d(x, curve=smooth)   # same effect as previous command
histSpike(x, curve=smooth, add=TRUE) # same as previous but with histogram
histSpike(x, curve=smooth, type='density', add=TRUE)
# same but smooth density over curve


plot(x <- rnorm(250), y <- 3*x + rnorm(250)/2)
scat1d(x, tfrac=0)        # dots randomly spaced from axis
scat1d(y, 4, frac=-.03)   # bars outside axis
scat1d(y, 2, tfrac=.2)    # same bars with smaller random fraction


x <- c(0:3,rep(4,3),5,rep(7,10),9)
plot(x, jitter2(x))       # original versus jittered values
abline(0,1)               # unique values unjittered on abline
points(x+0.1, jitter2(x, limit=FALSE), col=2)
                          # allow locally maximum jittering
points(x+0.2, jitter2(x, fill=1), col=3); abline(h=seq(0.5,9,1), lty=2)
                          # fill 3/3 instead of 1/3
x <- rnorm(200,0,2)+1; y <- x^2
x2 <- round((x+rnorm(200))/2)*2
x3 <- round((x+rnorm(200))/4)*4
dfram <- data.frame(y,x,x2,x3)
plot(dfram$x2, dfram$y)   # jitter2 via scat1d
scat1d(dfram$x2, y=dfram$y, preserve=TRUE, col=2)
scat1d(dfram$x2, preserve=TRUE, frac=-0.02, col=2)
scat1d(dfram$y, 4, preserve=TRUE, frac=-0.02, col=2)


pairs(jitter2(dfram))     # pairs for jittered data.frame
# This gets reasonable pairwise scatter plots for all combinations of
# variables where
#
# - continuous variables (with unique values) are not jittered at all, thus
#   all relations between continuous variables are shown as they are,
#   extreme values have exact positions.
#
# - discrete variables get a reasonable amount of jittering, whether they
#   have 2, 3, 5, 10, 20 \dots levels
```

```
#
# - different from adding noise, jitter2() will use the available space
#   optimally and no value will randomly mask another
#
# If you want a scatterplot with lowess smooths on the *exact* values and
# the point clouds shown jittered, you just need
#
pairs( dfram ,panel=function(x,y) { points(jitter2(x),jitter2(y))
                                    lines(lowess(x,y)) } )



datadensity(dfram)     # graphical snapshot of entire data frame
datadensity(dfram, group=cut2(dfram$x2,g=3))
                          # stratify points and frequencies by
                          # x2 tertiles and use 3 colors


# datadensity.data.frame(split(x, grouping.variable))
# need to explicitly invoke datadensity.data.frame when the
# first argument is a list

## Not run:
require(rms)
require(ggplot2)
f <- lrm(y ~ blood.pressure + sex * (age + rcs(cholesterol,4)),
         data=d)
p <- Predict(f, cholesterol, sex)
g <- ggplot(p, aes(x=cholesterol, y=yhat, color=sex)) + geom_line() +
  xlab(xl2) + ylim(-1, 1)
g <- g + geom_ribbon(data=p, aes(ymin=lower, ymax=upper), alpha=0.2,
                linetype=0, show_guide=FALSE)
g + histSpikeg(yhat ~ cholesterol + sex, p, d)

# colors <- c('red', 'blue')
# p <- plot_ly(x=x, y=y, color=g, colors=colors, mode='markers')
# histSpikep(p, x, y, z, color=g, colors=colors)

w <- data.frame(x1=rnorm(100), x2=exp(rnorm(100)))
g <- c(rep('a', 50), rep('b', 50))
ecdfpM(w, group=g, ncols=2)

## End(Not run)
```

---

score.binary *Score a Series of Binary Variables*

Description

Creates a new variable from a series of logical conditions. The new variable can be a hierarchical category or score derived from considering the rightmost TRUE value among the input variables, an additive point score, a union, or any of several others by specifying a function using the fun argument.

Usage

```
score.binary(..., fun=max, points=1:p,
             na.rm=funtext == "max", retfactor=TRUE)
```

Arguments

...	a list of variables or expressions which are considered to be binary or logical
fun	a function to compute on each row of the matrix represented by a specific observation of all the variables in ...
points	points to assign to successive elements of ... . The default is 1, 2, ..., p, where p is the number of elements. If you specify one number for points, that number will be duplicated (i.e., equal weights are assumed).
na.rm	set to TRUE to remove NAs from consideration when processing each row of the matrix of variables in ... . For fun=max, na.rm=TRUE is the default since score.binary assumes that a hierarchical scale is based on available information. Otherwise, na.rm=FALSE is assumed. For fun=mean you may want to specify na.rm=TRUE.
retfactor	applies if fun=max, in which case retfactor=TRUE makes score.binary return a factor object since a hierarchical scale implies a unique choice.

Value

a factor object if retfactor=TRUE and fun=max or a numeric vector otherwise. Will not contain NAs if na.rm=TRUE unless every variable in a row is NA. If a factor object is returned, it has levels "none" followed by character string versions of the arguments given in ... .

See Also

any, sum, max, factor

Examples

```
set.seed(1)
age <- rnorm(25, 70, 15)
previous.disease <- sample(0:1, 25, TRUE)
#Hierarchical scale, highest of 1:age>70  2:previous.disease
score.binary(age>70, previous.disease, retfactor=FALSE)
#Same as above but return factor variable with levels "none" "age>70"
# "previous.disease"
score.binary(age>70, previous.disease)
```

```
#Additive scale with weights 1:age>70  2:previous.disease
score.binary(age>70, previous.disease, fun=sum)
#Additive scale, equal weights
score.binary(age>70, previous.disease, fun=sum, points=c(1,1))
#Same as saying points=1


#Union of variables, to create a new binary variable
score.binary(age>70, previous.disease, fun=any)
```

---

sedit *Character String Editing and Miscellaneous Character Handling Functions*

Description

This suite of functions was written to implement many of the features of the UNIX sed program entirely within S (function sedit). The substring.location function returns the first and last position numbers that a sub-string occupies in a larger string. The substring2<- function does the opposite of the builtin function substring. It is named substring2 because for S-Plus there is a built-in function substring, but it does not handle multiple replacements in a single string. replace.substring.wild edits character strings in the fashion of "change xxxxANYTHINGyyyy to aaaaANYTHINGbbbb", if the "ANYTHING" passes an optional user-specified test function. Here, the "yyyy" string is searched for from right to left to handle balancing parentheses, etc. numeric.string and all.digits are two examples of test functions, to check, respectively if each of a vector of strings is a legal numeric or if it contains only the digits 0-9. For the case where old="*$" or "^*", or for replace.substring.wild with the same values of old or with front=TRUE or back=TRUE, sedit (if wild.literal=FALSE) and replace.substring.wild will edit the largest substring satisfying test.

substring2 is just a copy of substring so that substring2<- will work.

Usage

```
sedit(text, from, to, test, wild.literal=FALSE)
substring.location(text, string, restrict)
# substring(text, first, last) <- setto   # S-Plus only
replace.substring.wild(text, old, new, test, front=FALSE, back=FALSE)
numeric.string(string)
all.digits(string)
substring2(text, first, last)
substring2(text, first, last) <- value
```

Arguments

text	a vector of character strings for sedit, substring2, substring2<- or a single character string for substring.location, replace.substring.wild.

from	a vector of character strings to translate from, for sedit. A single asterisk wild card, meaning allow any sequence of characters (subject to the test function, if any) in place of the "*". An element of from may begin with "^" to force the match to begin at the beginning of text, and an element of from can end with "$" to force the match to end at the end of text.
to	a vector of character strings to translate to, for sedit. If a corresponding element in from had an "*", the element in to may also have an "*". Only single asterisks are allowed. If to is not the same length as from, the rep function is used to make it the same length.
string	a single character string, for substring.location, numeric.string, all.digits
first	a vector of integers specifying the first position to replace for substring2<-. first may also be a vector of character strings that are passed to sedit to use as patterns for replacing substrings with setto. See one of the last examples below.
last	a vector of integers specifying the ending positions of the character substrings to be replaced. The default is to go to the end of the string. When first is character, last must be omitted.
setto	a character string or vector of character strings used as replacements, in substring2<-
old	a character string to translate from for replace.substring.wild. May be "*$" or "^*" or any string containing a single "*" but not beginning with "^" or ending with "$".
new	a character string to translate to for replace.substring.wild
test	a function of a vector of character strings returning a logical vector whose elements are TRUE or FALSE according to whether that string element qualifies as the wild card string for sedit, replace.substring.wild
wild.literal	set to TRUE to not treat asterisks as wild cards and to not look for "^" or "$" in old
restrict	a vector of two integers for substring.location which specifies a range to which the search for matches should be restricted
front	specifying front = TRUE and old = "*" is the same as specifying old = "^*"
back	specifying back = TRUE and old = "*" is the same as specifying old = "*$"
value	a character vector

Value

sedit returns a vector of character strings the same length as text. substring.location returns a list with components named first and last, each specifying a vector of character positions corresponding to matches. replace.substring.wild returns a single character string. numeric.string and all.digits return a single logical value.

Side Effects

substring2<- modifies its first argument

Author(s)

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See Also

grep, substring

Examples

```
x <- 'this string'
substring2(x, 3, 4) <- 'IS'
x
substring2(x, 7) <- ''
x


substring.location('abcdefgabc', 'ab')
substring.location('abcdefgabc', 'ab', restrict=c(3,999))


replace.substring.wild('this is a cat','this*cat','that*dog')
replace.substring.wild('there is a cat','is a*', 'is not a*')
replace.substring.wild('this is a cat','is a*', 'Z')


qualify <- function(x) x==' 1.5 ' | x==' 2.5 '
replace.substring.wild('He won 1.5 million $','won*million',
                       'lost*million', test=qualify)
replace.substring.wild('He won 1 million $','won*million',
                       'lost*million', test=qualify)
replace.substring.wild('He won 1.2 million $','won*million',
                       'lost*million', test=numeric.string)


x <- c('a = b','c < d','hello')
sedit(x, c('=','he*o'),c('==','he*'))


sedit('x23', '*$', '[*]', test=numeric.string)
sedit('23xx', '^*', 'Y_{*} ', test=all.digits)


replace.substring.wild("abcdefabcdef", "d*f", "xy")


x <- "abcd"
substring2(x, "bc") <- "BCX"
x
substring2(x, "B*d") <- "B*D"
```

x

---

seqFreq *seqFreq*

Description

Find Sequential Exclusions Due to NAs

Usage

```
seqFreq(..., labels = NULL, noneNA = FALSE)
```

Arguments

...	any number of variables
labels	if specified variable labels will be used in place of variable names
noneNA	set to TRUE to not include 'none' as a level in the result

Details

Finds the variable with the highest number of NAs. From the non-NAs on that variable find the next variable from those remaining with the highest number of NAs. Proceed in like fashion. The resulting variable summarizes sequential exclusions in a hierarchical fashion. See this for more information.

Value

factor variable with obs.per.numcond attribute

Author(s)

Frank Harrell

---

show.pch *Display Colors, Plotting Symbols, and Symbol Numeric Equivalents*

Description

show.pch plots the definitions of the pch parameters. show.col plots definitions of integer-valued colors. character.table draws numeric equivalents of all latin characters; the character on line xy and column z of the table has numeric code "xyz", which you would surround in quotes and preceed by a backslash.

Usage

```
show.pch(object = par("font"))
show.col(object=NULL)
character.table(font=1)
```

Arguments

object	font for show.pch, ignored for show.col.
font	font

Author(s)

Pierre Joyet <pierre.joyet@bluewin.ch>, Frank Harrell

See Also

points, text

Examples

```
## Not run:
show.pch()
show.col()
character.table()

## End(Not run)
```

---

showPsfrag *Display image from psfrag LaTeX strings*

Description

showPsfrag is used to display (using ghostview) a postscript image that contained psfrag LaTeX strings, by building a small LaTeX script and running latex and dvips.

Usage

```
showPsfrag(filename)
```

Arguments

filename	name or character string or character vector specifying file prefix.

Author(s)

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References

Grant MC, Carlisle (1998): The PSfrag System, Version 3. Full documentation is obtained by searching www.ctan.org for 'pfgguide.ps'.

See Also

postscript, par, ps.options, mgp.axis.labels, pdf, trellis.device, setTrellis

---

simMarkovOrd *simMarkovOrd*

Description

Simulate Ordinal Markov Process

Usage

```
simMarkovOrd(
  n = 1,
  y,
  times,
  initial,
  X = NULL,
  absorb = NULL,
  intercepts,
  g,
  carry = FALSE,
  rdsample = NULL,
  ...
)
```

Arguments

n	number of subjects to simulate
y	vector of possible y values in order (numeric, character, factor)
times	vector of measurement times
initial	initial value of y (baseline state; numeric, character, or factor matching y). If length 1 this value is used for all subjects, otherwise it is a vector of length n.
X	an optional vector of matrix of baseline covariate values passed to g. If a vector, X represents a set of single values for all the covariates and those values are used for every subject. Otherwise X is a matrix with rows corresponding to subjects and columns corresponding to covariates which g must know how to handle. g only sees one row of X at a time.
absorb	vector of absorbing states, a subset of y (numeric, character, or factor matching y). The default is no absorbing states. Observations are truncated when an absorbing state is simulated.

intercepts	vector of intercepts in the proportional odds model. There must be one fewer of these than the length of y.
g	a user-specified function of three or more arguments which in order are yprev - the value of y at the previous time, the current time t, the gap between the previous time and the current time, an optional (usually named) covariate vector X, and optional arguments such as a regression coefficient value to simulate from. The function needs to allow yprev to be a vector and yprev must not include any absorbing states. The g function returns the linear predictor for the proportional odds model aside from intercepts. The returned value must be a matrix with row names taken from yprev. If the model is a proportional odds model, the returned value must be one column. If it is a partial proportional odds model, the value must have one column for each distinct value of the response variable Y after the first one, with the levels of Y used as optional column names. So columns correspond to intercepts. The different columns are used for y-specific contributions to the linear predictor (aside from intercepts) for a partial or constrained partial proportional odds model. Parameters for partial proportional odds effects may be included in the ... arguments.
carry	set to TRUE to carry absorbing state forward after it is first hit; the default is to end records for the subject once the absorbing state is hit
rdsample	an optional function to do response-dependent sampling. It is a function of these arguments, which are vectors that stop at any absorbing state: times (ascending measurement times for one subject), y (vector of ordinal outcomes at these times for one subject. The function returns NULL if no observations are to be dropped, returns the vector of new times to sample.
...	additional arguments to pass to g such as a regresson coefficient

Details

Simulates longitudinal data for subjects following a first-order Markov process under a proportional odds model. Optionally, response-dependent sampling can be done, e.g., if a subject hits a specified state at time t, measurements are removed for times t+1, t+3, t+5, ... This is applicable when for example a study of hospitalized patients samples every day, Y=1 denotes patient discharge to home, and sampling is less frequent outside the hospital. This example assumes that arriving home is not an absorbing state, i.e., a patient could return to the hospital.

Value

data frame with one row per subject per time, and columns id, time, gap, yprev, y

Author(s)

Frank Harrell

See Also

https://hbiostat.org/R/Hmisc/markov/

`simplifyDims` *List Simplification*

Description

Takes a list where each element is a group of rows that have been spanned by a multirow row and combines it into one large matrix.

Usage

```
simplifyDims(x)
```

Arguments

`x`	list of spanned rows

Details

All rows must have the same number of columns. This is used to format the list for printing.

Value

a matrix that contains all of the spanned rows.

Author(s)

Charles Dupont

See Also

`rbind`

Examples

```
a <- list(a = matrix(1:25, ncol=5), b = matrix(1:10, ncol=5), c = 1:5)

simplifyDims(a)
```

simRegOrd *Simulate Power for Adjusted Ordinal Regression Two-Sample Test*

Description

This function simulates the power of a two-sample test from a proportional odds ordinal logistic model for a continuous response variable- a generalization of the Wilcoxon test. The continuous data model is normal with equal variance. Nonlinear covariate adjustment is allowed, and the user can optionally specify discrete ordinal level overrides to the continuous response. For example, if the main response is systolic blood pressure, one can add two ordinal categories higher than the highest observed blood pressure to capture heart attack or death.

Usage

```
simRegOrd(n, nsim=1000, delta=0, odds.ratio=1, sigma,
          p=NULL, x=NULL, X=x, Eyx, alpha=0.05, pr=FALSE)
```

Arguments

n	combined sample size (both groups combined)
nsim	number of simulations to run
delta	difference in means to detect, for continuous portion of response variable
odds.ratio	odds ratio to detect for ordinal overrides of continuous portion
sigma	standard deviation for continuous portion of response
p	a vector of marginal cell probabilities which must add up to one. The ith element specifies the probability that a patient will be in response level i for the control arm for the discrete ordinal overrides.
x	optional covariate to adjust for - a vector of length n
X	a design matrix for the adjustment covariate x if present. This could represent for example x and x^2 or cubic spline components.
Eyx	a function of x that provides the mean response for the control arm treatment
alpha	type I error
pr	set to TRUE to see iteration progress

Value

a list containing n, delta, sigma, power, betas, se, pvals where power is the estimated power (scalar), and betas, se,pvals are nsim-vectors containing, respectively, the ordinal model treatment effect estimate, standard errors, and 2-tailed p-values. When a model fit failed, the corresponding entries in betas, se, pvals are NA and power is the proportion of non-failed iterations for which the treatment p-value is significant at the alpha level.

Author(s)

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See Also

popower

Examples

```
## Not run:
## First use no ordinal high-end category overrides, and compare power
## to t-test when there is no covariate

n <- 100
delta <- .5
sd <- 1
require(pwr)
power.t.test(n = n / 2, delta=delta, sd=sd, type='two.sample')  # 0.70
set.seed(1)
w <- simRegOrd(n, delta=delta, sigma=sd, pr=TRUE)     # 0.686

## Now do ANCOVA with a quadratic effect of a covariate
n <- 100
x <- rnorm(n)
w <- simRegOrd(n, nsim=400, delta=delta, sigma=sd, x=x,
               X=cbind(x, x^2),
               Eyx=function(x) x + x^2, pr=TRUE)
w$power  # 0.68

## Fit a cubic spline to some simulated pilot data and use the fitted
## function as the true equation in the power simulation
require(rms)
N <- 1000
set.seed(2)
x <- rnorm(N)
y <- x + x^2 + rnorm(N, 0, sd=sd)
f <- ols(y ~ rcs(x, 4), x=TRUE)

n <- 100
j <- sample(1 : N, n, replace=n > N)
x <-   x[j]
X <- f$x[j,]
w <- simRegOrd(n, nsim=400, delta=delta, sigma=sd, x=x,
               X=X,
               Eyx=Function(f), pr=TRUE)
w$power  ## 0.70

## Finally, add discrete ordinal category overrides and high end of y
## Start with no effect of treatment on these ordinal event levels (OR=1.0)
```

```
w <- simRegOrd(n, nsim=400, delta=delta, odds.ratio=1, sigma=sd,
               x=x, X=X, Eyx=Function(f),
               p=c(.98, .01, .01),
               pr=TRUE)
w$power  ## 0.61   (0.3 if p=.8 .1 .1, 0.37 for .9 .05 .05, 0.50 for .95 .025 .025)

## Now assume that odds ratio for treatment is 2.5
## First compute power for clinical endpoint portion of Y alone
or <- 2.5
p <- c(.9, .05, .05)
popower(p, odds.ratio=or, n=100)   # 0.275
## Compute power of t-test on continuous part of Y alone
power.t.test(n = 100 / 2, delta=delta, sd=sd, type='two.sample')  # 0.70
## Note this is the same as the p.o. model power from simulation above
## Solve for OR that gives the same power estimate from popower
popower(rep(.01, 100), odds.ratio=2.4, n=100)   # 0.706
## Compute power for continuous Y with ordinal override
w <- simRegOrd(n, nsim=400, delta=delta, odds.ratio=or, sigma=sd,
               x=x, X=X, Eyx=Function(f),
               p=c(.9, .05, .05),
               pr=TRUE)
w$power  ## 0.72

## End(Not run)
```

---

smean.sd *Compute Summary Statistics on a Vector*

Description

A number of statistical summary functions is provided for use with `summary.formula` and `summarize` (as well as `tapply` and by themselves). `smean.cl.normal` computes 3 summary variables: the sample mean and lower and upper Gaussian confidence limits based on the t-distribution. `smean.sd` computes the mean and standard deviation. `smean.sdl` computes the mean plus or minus a constant times the standard deviation. `smean.cl.boot` is a very fast implementation of the basic nonparametric bootstrap for obtaining confidence limits for the population mean without assuming normality. These functions all delete NAs automatically. `smedian.hilow` computes the sample median and a selected pair of outer quantiles having equal tail areas.

Usage

```
smean.cl.normal(x, mult=qt((1+conf.int)/2,n-1), conf.int=.95, na.rm=TRUE)

smean.sd(x, na.rm=TRUE)

smean.sdl(x, mult=2, na.rm=TRUE)

smean.cl.boot(x, conf.int=.95, B=1000, na.rm=TRUE, reps=FALSE)
```

```
smedian.hilow(x, conf.int=.95, na.rm=TRUE)
```

Arguments

x	for summary functions smean.*, smedian.hilow, a numeric vector from which NAs will be removed automatically
na.rm	defaults to TRUE unlike built-in functions, so that by default NAs are automatically removed
mult	for smean.cl.normal is the multiplier of the standard error of the mean to use in obtaining confidence limits of the population mean (default is appropriate quantile of the t distribution). For smean.sdl, mult is the multiplier of the standard deviation used in obtaining a coverage interval about the sample mean. The default is mult=2 to use plus or minus 2 standard deviations.
conf.int	for smean.cl.normal and smean.cl.boot specifies the confidence level (0-1) for interval estimation of the population mean. For smedian.hilow, conf.int is the coverage probability the outer quantiles should target. When the default, 0.95, is used, the lower and upper quantiles computed are 0.025 and 0.975.
B	number of bootstrap resamples for smean.cl.boot
reps	set to TRUE to have smean.cl.boot return the vector of bootstrapped means as the reps attribute of the returned object

Value

a vector of summary statistics

Author(s)

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See Also

summarize, summary.formula

Examples

```
set.seed(1)
x <- rnorm(100)
smean.sd(x)
smean.sdl(x)
smean.cl.normal(x)
smean.cl.boot(x)
smedian.hilow(x, conf.int=.5)  # 25th and 75th percentiles

# Function to compute 0.95 confidence interval for the difference in two means
# g is grouping variable
```

```
bootdif <- function(y, g) {
 g <- as.factor(g)
 a <- attr(smean.cl.boot(y[g==levels(g)[1]], B=2000, reps=TRUE),'reps')
 b <- attr(smean.cl.boot(y[g==levels(g)[2]], B=2000, reps=TRUE),'reps')
 meandif <- diff(tapply(y, g, mean, na.rm=TRUE))
 a.b <- quantile(b-a, c(.025,.975))
 res <- c(meandif, a.b)
 names(res) <- c('Mean Difference','.025','.975')
 res
}
```

---

solvet *solve Function with tol argument*

Description

A slightly modified version of `solve` that allows a tolerance argument for singularity (`tol`) which is passed to `qr`.

Usage

```
solvet(a, b, tol=1e-09)
```

Arguments

`a`	a square numeric matrix
`b`	a numeric vector or matrix
`tol`	tolerance for detecting linear dependencies in columns of `a`

See Also

`solve`

---

somers2 *Somers' Dxy Rank Correlation*

Description

Computes Somers' Dxy rank correlation between a variable `x` and a binary (0-1) variable `y`, and the corresponding receiver operating characteristic curve area `c`. Note that `Dxy = 2(c-0.5)`. `somers` allows for a `weights` variable, which specifies frequencies to associate with each observation.

Usage

```
somers2(x, y, weights=NULL, normwt=FALSE, na.rm=TRUE)
```

Arguments

x	typically a predictor variable. NAs are allowed.
y	a numeric outcome variable coded 0-1. NAs are allowed.
weights	a numeric vector of observation weights (usually frequencies). Omit or specify a zero-length vector to do an unweighted analysis.
normwt	set to TRUE to make weights sum to the actual number of non-missing observations.
na.rm	set to FALSE to suppress checking for NAs.

Details

The rcorr.cens function, which although slower than somers2 for large sample sizes, can also be used to obtain Dxy for non-censored binary y, and it has the advantage of computing the standard deviation of the correlation index.

Value

a vector with the named elements C, Dxy, n (number of non-missing pairs), and Missing. Uses the formula C = (mean(rank(x)[y == 1]) - (n1 + 1)/2)/(n - n1), where n1 is the frequency of y=1.

Author(s)

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See Also

concordance, rcorr.cens, rank, wtd.rank,

Examples

```
set.seed(1)
predicted <- runif(200)
dead      <- sample(0:1, 200, TRUE)
roc.area <- somers2(predicted, dead)["C"]

# Check weights
x <- 1:6
y <- c(0,0,1,0,1,1)
f <- c(3,2,2,3,2,1)
somers2(x, y)
somers2(rep(x, f), rep(y, f))
somers2(x, y, f)
```

soprobMarkovOrd *soprobMarkovOrd*

Description

State Occupancy Probabilities for First-Order Markov Ordinal Model

Usage

```
soprobMarkovOrd(y, times, initial, absorb = NULL, intercepts, g, ...)
```

Arguments

y	a vector of possible y values in order (numeric, character, factor)
times	vector of measurement times
initial	initial value of y (baseline state; numeric, character, factr)
absorb	vector of absorbing states, a subset of y. The default is no absorbing states. (numeric, character, factor)
intercepts	vector of intercepts in the proportional odds model, with length one less than the length of y
g	a user-specified function of three or more arguments which in order are yprev - the value of y at the previous time, the current time t, the gap between the previous time and the current time, an optional (usually named) covariate vector X, and optional arguments such as a regression coefficient value to simulate from. The function needs to allow yprev to be a vector and yprev must not include any absorbing states. The g function returns the linear predictor for the proportional odds model aside from intercepts. The returned value must be a matrix with row names taken from yprev. If the model is a proportional odds model, the returned value must be one column. If it is a partial proportional odds model, the value must have one column for each distinct value of the response variable Y after the first one, with the levels of Y used as optional column names. So columns correspond to intercepts. The different columns are used for y-specific contributions to the linear predictor (aside from intercepts) for a partial or constrained partial proportional odds model. Parameters for partial proportional odds effects may be included in the ... arguments.
...	additional arguments to pass to g such as covariate settings

Value

matrix with rows corresponding to times and columns corresponding to states, with values equal to exact state occupancy probabilities

Author(s)

Frank Harrell

See Also

https://hbiostat.org/R/Hmisc/markov/

---

soprobMarkovOrdm *soprobMarkovOrdm*

Description

State Occupancy Probabilities for First-Order Markov Ordinal Model from a Model Fit

Usage

```
soprobMarkovOrdm(
  object,
  data,
  times,
  ylevels,
  absorb = NULL,
  tvarname = "time",
  pvarname = "yprev",
  gap = NULL
)
```

Arguments

object	a fit object created by blrm, lrm, orm, VGAM::vglm(), or VGAM::vgam()
data	a single observation list or data frame with covariate settings, including the initial state for Y
times	vector of measurement times
ylevels	a vector of ordered levels of the outcome variable (numeric or character)
absorb	vector of absorbing states, a subset of ylevels. The default is no absorbing states. (numeric, character, factor)
tvarname	name of time variable, defaulting to time
pvarname	name of previous state variable, defaulting to yprev
gap	name of time gap variable, defaults assuming that gap time is not in the model

Details

Computes state occupancy probabilities for a single setting of baseline covariates. If the model fit was from rms::blrm(), these probabilities are from all the posterior draws of the basic model parameters. Otherwise they are maximum likelihood point estimates.

Value

if `object` was not a Bayesian model, a matrix with rows corresponding to times and columns corresponding to states, with values equal to exact state occupancy probabilities. If `object` was created by `blrm`, the result is a 3-dimensional array with the posterior draws as the first dimension.

Author(s)

Frank Harrell

See Also

https://hbiostat.org/R/Hmisc/markov/

---

spikecomp *spikecomp*

Description

Compute Elements of a Spike Histogram

Usage

```
spikecomp(
  x,
  method = c("tryactual", "simple", "grid"),
  lumptails = 0.01,
  normalize = TRUE,
  y,
  trans = NULL,
  tresult = c("list", "segments", "roundeddata")
)
```

Arguments

`x`	a numeric variable
`method`	specifies the binning and output method. The default is `'tryactual'` and is intended to be used for spike histograms plotted in a way that allows for random x-coordinates and data gaps. No binning is done if there are less than 100 distinct values and the closest distinct `x` values are distinguishable (not with 1/500th of the data range of each other). Binning uses `pretty`. When `trans` is specified to transform `x` to reduce long tails due to outliers, `pretty` rounding is not done, and `lumptails` is ignored. `method='grid'` is intended for sparkline spike histograms drawn with bar charts, where plotting is done in a way that x-coordinates must be equally spaced. For this method, extensive binning information is returned. For either `'tryactual'` or `'grid'`, the default if `trans` is omitted is to put all values beyond the 0.01 or 0.99 quantiles into a single bin so that outliers will not create long nearly empty tails. When `y` is specified, `method` is ignored.

lumptails	the quantile to use for lumping values into a single left and a single right bin for two of the methods. When outer quantiles using lumptails equal outer quantiles using 2*lumptails, lumptails is ignored as this indicates a large number of ties in the tails of the distribution.
normalize	set to FALSE to not divide frequencies by maximum frequency
y	a vector of frequencies corresponding to x if you want the (x, y) pairs to be taken as a possibly irregular-spaced frequency tabulation for which you want to convert to a regularly-spaced tabulation like count='tabulate' produces. If there is a constant gap between x values, the original pairs are return, with possible removal of NAs.
trans	a list with three elements: the name of a transformation to make on x, the transformation function, and the inverse transformation function. The latter is used for method='grid'. When trans is given lumptails is ignored. trans applies only to method='tryactual'.
tresult	applies only to method='tryactual'. The default 'list' returns a list with elements x, y, and roundedTo. method='segments' returns a list suitable for drawing line segments, with elements x, y1, y2. method='roundeddata' returns a list with elements x (non-tabulated rounded data vector after excluding NAs) and vector roundedTo.

Details

Derives the line segment coordinates need to draw a spike histogram. This is useful for adding elements to ggplot2 plots and for the describe function to construct spike histograms. Date/time variables are handled by doing calculations on the underlying numeric scale then converting back to the original class. For them the left endpoint of the first bin is taken as the minimal data value instead of rounded using pretty().

Value

when y is specified, a list with elements x and y. When method='tryactual' the returned value depends on tresult. For method='grid', a list with elements x and y and scalar element roundedTo containing the typical bin width. Here x is a character string.

Author(s)

Frank Harrell

Examples

```
spikecomp(1:1000)
spikecomp(1:1000, method='grid')
## Not run:
On a data.table d use ggplot2 to make spike histograms by country and sex groups
s <- d[, spikecomp(x, tresult='segments'), by=.(country, sex)]
ggplot(s) + geom_segment(aes(x=x, y=y1, xend=x, yend=y2, alpha=I(0.3))) +
   scale_y_continuous(breaks=NULL, labels=NULL) + ylab('') +
   facet_grid(country ~ sex)
```

```
## End(Not run)
```

---

spower *Simulate Power of 2-Sample Test for Survival under Complex Conditions*

Description

Given functions to generate random variables for survival times and censoring times, spower simulates the power of a user-given 2-sample test for censored data. By default, the logrank (Cox 2-sample) test is used, and a logrank function for comparing 2 groups is provided. Optionally a Cox model is fitted for each each simulated dataset and the log hazard ratios are saved (this requires the survival package). A print method prints various measures from these. For composing R functions to generate random survival times under complex conditions, the Quantile2 function allows the user to specify the intervention:control hazard ratio as a function of time, the probability of a control subject actually receiving the intervention (dropin) as a function of time, and the probability that an intervention subject receives only the control agent as a function of time (non-compliance, dropout). Quantile2 returns a function that generates either control or intervention uncensored survival times subject to non-constant treatment effect, dropin, and dropout. There is a plot method for plotting the results of Quantile2, which will aid in understanding the effects of the two types of non-compliance and non-constant treatment effects. Quantile2 assumes that the hazard function for either treatment group is a mixture of the control and intervention hazard functions, with mixing proportions defined by the dropin and dropout probabilities. It computes hazards and survival distributions by numerical differentiation and integration using a grid of (by default) 7500 equally-spaced time points.

The logrank function is intended to be used with spower but it can be used by itself. It returns the 1 degree of freedom chi-square statistic, with the associated Pike hazard ratio estimate as an attribute.

The Weibull2 function accepts as input two vectors, one containing two times and one containing two survival probabilities, and it solves for the scale and shape parameters of the Weibull distribution ($S(t) = e^{-\alpha t^{\gamma}}$) which will yield those estimates. It creates an R function to evaluate survival probabilities from this Weibull distribution. Weibull2 is useful in creating functions to pass as the first argument to Quantile2.

The Lognorm2 and Gompertz2 functions are similar to Weibull2 except that they produce survival functions for the log-normal and Gompertz distributions.

When cox=TRUE is specified to spower, the analyst may wish to extract the two margins of error by using the print method for spower objects (see example below) and take the maximum of the two.

Usage

```
spower(rcontrol, rinterv, rcens, nc, ni,
       test=logrank, cox=FALSE, nsim=500, alpha=0.05, pr=TRUE)

## S3 method for class 'spower'
print(x, conf.int=.95, ...)

Quantile2(scontrol, hratio,
```

```
          dropin=function(times)0, dropout=function(times)0,
          m=7500, tmax, qtmax=.001, mplot=200, pr=TRUE, ...)

## S3 method for class 'Quantile2'
print(x, ...)

## S3 method for class 'Quantile2'
plot(x,
     what=c("survival", "hazard", "both", "drop", "hratio", "all"),
     dropsep=FALSE, lty=1:4, col=1, xlim, ylim=NULL,
     label.curves=NULL, ...)

logrank(S, group)

Gompertz2(times, surv)
Lognorm2(times, surv)
Weibull2(times, surv)
```

Arguments

rcontrol	a function of n which returns n random uncensored failure times for the control group. spower assumes that non-compliance (dropin) has been taken into account by this function.
rinterv	similar to rcontrol but for the intervention group
rcens	a function of n which returns n random censoring times. It is assumed that both treatment groups have the same censoring distribution.
nc	number of subjects in the control group
ni	number in the intervention group
scontrol	a function of a time vector which returns the survival probabilities for the control group at those times assuming that all patients are compliant.
hratio	a function of time which specifies the intervention:control hazard ratio (treatment effect)
x	an object of class "Quantile2" created by Quantile2, or of class "spower" created by spower
conf.int	confidence level for determining fold-change margins of error in estimating the hazard ratio
S	a Surv object or other two-column matrix for right-censored survival times
group	group indicators have length equal to the number of rows in S argument.
times	a vector of two times
surv	a vector of two survival probabilities
test	any function of a Surv object and a grouping variable which computes a chi-square for a two-sample censored data test. The default is logrank.
cox	If true TRUE the two margins of error are available by using the print method for spower objects (see example below) and taking the maximum of the two.

nsim	number of simulations to perform (default=500)
alpha	type I error (default=.05)
pr	If FALSE prevents spower from printing progress notes for simulations. If FALSE prevents Quantile2 from printing tmax when it calculates tmax.
dropin	a function of time specifying the probability that a control subject actually is treated with the new intervention at the corresponding time
dropout	a function of time specifying the probability of an intervention subject dropping out to control conditions. As a function of time, dropout specifies the probability that a patient is treated with the control therapy at time t. dropin and dropout form mixing proportions for control and intervention hazard functions.
m	number of time points used for approximating functions (default is 7500)
tmax	maximum time point to use in the grid of m times. Default is the time such that scontrol(time) is qtmax.
qtmax	survival probability corresponding to the last time point used for approximating survival and hazard functions. Default is 0.001. For qtmax of the time for which a simulated time is needed which corresponds to a survival probability of less than qtmax, the simulated value will be tmax.
mplot	number of points used for approximating functions for use in plotting (default is 200 equally spaced points)
...	optional arguments passed to the scontrol function when it's evaluated by Quantile2. Unused for print.spower.
what	a single character constant (may be abbreviated) specifying which functions to plot. The default is '"both"' meaning both survival and hazard functions. Specify what="drop" to just plot the dropin and dropout functions, what="hratio" to plot the hazard ratio functions, or '"all"' to make 4 separate plots showing all functions (6 plots if dropsep=TRUE).
dropsep	If TRUE makes plot.Quantile2 separate pure and contaminated functions onto separate plots
lty	vector of line types
col	vector of colors
xlim	optional x-axis limits
ylim	optional y-axis limits
label.curves	optional list which is passed as the opts argument to labcurve.

Value

spower returns the power estimate (fraction of simulated chi-squares greater than the alpha-critical value). If cox=TRUE, spower returns an object of class "spower" containing the power and various other quantities.

Quantile2 returns an R function of class "Quantile2" with attributes that drive the plot method. The major attribute is a list containing several lists. Each of these sub-lists contains a Time vector along with one of the following: survival probabilities for either treatment group and with or without contamination caused by non-compliance, hazard rates in a similar way, intervention:control hazard ratio function with and without contamination, and dropin and dropout functions.

`logrank` returns a single chi-square statistic and an attribute `hr` which is the Pike hazard ratio estimate.

`Weibull2`, `Lognorm2` and `Gompertz2` return an R function with three arguments, only the first of which (the vector of `times`) is intended to be specified by the user.

Side Effects

`spower` prints the interation number every 10 iterations if `pr=TRUE`.

Author(s)

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References

Lakatos E (1988): Sample sizes based on the log-rank statistic in complex clinical trials. Biometrics 44:229–241 (Correction 44:923).

Cuzick J, Edwards R, Segnan N (1997): Adjusting for non-compliance and contamination in randomized clinical trials. Stat in Med 16:1017–1029.

Cook, T (2003): Methods for mid-course corrections in clinical trials with survival outcomes. Stat in Med 22:3431–3447.

Barthel FMS, Babiker A et al (2006): Evaluation of sample size and power for multi-arm survival trials allowing for non-uniform accrual, non-proportional hazards, loss to follow-up and cross-over. Stat in Med 25:2521–2542.

See Also

`cpower`, `ciapower`, `bpower`, `cph`, `coxph`, `labcurve`

Examples

```
# Simulate a simple 2-arm clinical trial with exponential survival so
# we can compare power simulations of logrank-Cox test with cpower()
# Hazard ratio is constant and patients enter the study uniformly
# with follow-up ranging from 1 to 3 years
# Drop-in probability is constant at .1 and drop-out probability is
# constant at .175.  Two-year survival of control patients in absence
# of drop-in is .8 (mortality=.2).  Note that hazard rate is -log(.8)/2
# Total sample size (both groups combined) is 1000
# % mortality reduction by intervention (if no dropin or dropout) is 25
# This corresponds to a hazard ratio of 0.7283 (computed by cpower)


cpower(2, 1000, .2, 25, accrual=2, tmin=1,
       noncomp.c=10, noncomp.i=17.5)
```

```
ranfun <- Quantile2(function(x)exp(log(.8)/2*x),
                    hratio=function(x)0.7283156,
                    dropin=function(x).1,
                    dropout=function(x).175)


rcontrol <- function(n) ranfun(n, what='control')
rinterv  <- function(n) ranfun(n, what='int')
rcens    <- function(n) runif(n, 1, 3)


set.seed(11)   # So can reproduce results
spower(rcontrol, rinterv, rcens, nc=500, ni=500,
       test=logrank, nsim=50)  # normally use nsim=500 or 1000

## Not run:
# Run the same simulation but fit the Cox model for each one to
# get log hazard ratios for the purpose of assessing the tightness
# confidence intervals that are likely to result

set.seed(11)
u <- spower(rcontrol, rinterv, rcens, nc=500, ni=500,
       test=logrank, nsim=50, cox=TRUE)
u
v <- print(u)
v[c('MOElower','MOEupper','SE')]

## End(Not run)

# Simulate a 2-arm 5-year follow-up study for which the control group's
# survival distribution is Weibull with 1-year survival of .95 and
# 3-year survival of .7.  All subjects are followed at least one year,
# and patients enter the study with linearly increasing probability  after that
# Assume there is no chance of dropin for the first 6 months, then the
# probability increases linearly up to .15 at 5 years
# Assume there is a linearly increasing chance of dropout up to .3 at 5 years
# Assume that the treatment has no effect for the first 9 months, then
# it has a constant effect (hazard ratio of .75)


# First find the right Weibull distribution for compliant control patients
sc <- Weibull2(c(1,3), c(.95,.7))
sc


# Inverse cumulative distribution for case where all subjects are followed
# at least a years and then between a and b years the density rises
# as (time - a) ^ d is a + (b-a) * u ^ (1/(d+1))


rcens <- function(n) 1 + (5-1) * (runif(n) ^ .5)
# To check this, type hist(rcens(10000), nclass=50)
```

```
# Put it all together


f <- Quantile2(sc,
      hratio=function(x)ifelse(x<=.75, 1, .75),
      dropin=function(x)ifelse(x<=.5, 0, .15*(x-.5)/(5-.5)),
      dropout=function(x).3*x/5)


par(mfrow=c(2,2))
# par(mfrow=c(1,1)) to make legends fit
plot(f, 'all', label.curves=list(keys='lines'))


rcontrol <- function(n) f(n, 'control')
rinterv  <- function(n) f(n, 'intervention')


set.seed(211)
spower(rcontrol, rinterv, rcens, nc=350, ni=350,
       test=logrank, nsim=50)  # normally nsim=500 or more
par(mfrow=c(1,1))

# Compose a censoring time generator function such that at 1 year
# 5% of subjects are accrued, at 3 years 70% are accured, and at 10
# years 100% are accrued.  The trial proceeds two years past the last
# accrual for a total of 12 years of follow-up for the first subject.
# Use linear interporation between these 3 points

rcens <- function(n)
{
  times <- c(0,1,3,10)
  accrued <- c(0,.05,.7,1)
  # Compute inverse of accrued function at U(0,1) random variables
  accrual.times <- approx(accrued, times, xout=runif(n))$y
  censor.times <- 12 - accrual.times
  censor.times
}

censor.times <- rcens(500)
# hist(censor.times, nclass=20)
accrual.times <- 12 - censor.times
# Ecdf(accrual.times)
# lines(c(0,1,3,10), c(0,.05,.7,1), col='red')
# spower(..., rcens=rcens, ...)

## Not run:
# To define a control survival curve from a fitted survival curve
# with coordinates (tt, surv) with tt[1]=0, surv[1]=1:

Scontrol <- function(times, tt, surv) approx(tt, surv, xout=times)$y
tt <- 0:6
```

```
surv <- c(1, .9, .8, .75, .7, .65, .64)
formals(Scontrol) <- list(times=NULL, tt=tt, surv=surv)

# To use a mixture of two survival curves, with e.g. mixing proportions
# of .2 and .8, use the following as a guide:
#
# Scontrol <- function(times, t1, s1, t2, s2)
#  .2*approx(t1, s1, xout=times)$y + .8*approx(t2, s2, xout=times)$y
# t1 <- ...; s1 <- ...; t2 <- ...; s2 <- ...;
# formals(Scontrol) <- list(times=NULL, t1=t1, s1=s1, t2=t2, s2=s2)

# Check that spower can detect a situation where generated censoring times
# are later than all failure times

rcens <- function(n) runif(n, 0, 7)
f <- Quantile2(scontrol=Scontrol, hratio=function(x).8, tmax=6)
cont <- function(n) f(n, what='control')
int  <- function(n) f(n, what='intervention')
spower(rcontrol=cont, rinterv=int, rcens=rcens, nc=300, ni=300, nsim=20)

# Do an unstratified logrank test
library(survival)
# From SAS/STAT PROC LIFETEST manual, p. 1801
days <- c(179,256,262,256,255,224,225,287,319,264,237,156,270,257,242,
          157,249,180,226,268,378,355,319,256,171,325,325,217,255,256,
          291,323,253,206,206,237,211,229,234,209)
status <- c(1,1,1,1,1,0,1,1,1,1,0,1,1,1,1,1,1,1,1,0,
            0,rep(1,19))
treatment <- c(rep(1,10), rep(2,10), rep(1,10), rep(2,10))
sex <- Cs(F,F,M,F,M,F,F,M,M,M,F,F,M,M,M,F,M,F,F,M,
          M,M,M,M,F,M,M,F,F,F,M,M,M,F,F,M,F,F,F,F)
data.frame(days, status, treatment, sex)
table(treatment, status)
logrank(Surv(days, status), treatment)  # agrees with p. 1807
# For stratified tests the picture is puzzling.
# survdiff(Surv(days,status) ~ treatment + strata(sex))$chisq
# is 7.246562, which does not agree with SAS (7.1609)
# But summary(coxph(Surv(days,status) ~ treatment + strata(sex)))
# yields 7.16 whereas summary(coxph(Surv(days,status) ~ treatment))
# yields 5.21 as the score test, not agreeing with SAS or logrank() (5.6485)

## End(Not run)
```

`spss.get` *Enhanced Importing of SPSS Files*

Description

`spss.get` invokes the `read.spss` function in the **foreign** package to read an SPSS file, with a default output format of `"data.frame"`. The `label` function is used to attach labels to individual

variables instead of to the data frame as done by `read.spss`. By default, integer-valued variables are converted to a storage mode of integer unless `force.single=FALSE`. Date variables are converted to R `Date` variables. By default, underscores in names are converted to periods.

Usage

```
spss.get(file, lowernames=FALSE, datevars = NULL,
         use.value.labels = TRUE, to.data.frame = TRUE,
         max.value.labels = Inf, force.single=TRUE,
         allow=NULL, charfactor=FALSE, reencode = NA)
```

Arguments

`file`	input SPSS save file. May be a file on the WWW, indicated by `file` starting with `'http://'` or `'https://'`.
`lowernames`	set to `TRUE` to convert variable names to lower case
`datevars`	vector of variable names containing dates to be converted to R internal format
`use.value.labels`	see `read.spss`
`to.data.frame`	see `read.spss`; default is `TRUE` for `spss.get`
`max.value.labels`	see `read.spss`
`force.single`	set to `FALSE` to prevent integer-valued variables from being converted from storage mode `double` to `integer`
`allow`	a vector of characters allowed by R that should not be converted to periods in variable names. By default, underscores in variable names are converted to periods as with R before version 1.9.
`charfactor`	set to `TRUE` to change character variables to factors if they have fewer than n/2 unique values. Blanks and null strings are converted to `NA`s.
`reencode`	see `read.spss`

Value

a data frame or list

Author(s)

Frank Harrell

See Also

`read.spss`,`cleanup.import`,`sas.get`

Examples

```
## Not run:
w <- spss.get('/tmp/my.sav', datevars=c('birthdate','deathdate'))

## End(Not run)
```

`src` *Source a File from the Current Working Directory*

Description

`src` concatenates `".s"` to its argument, quotes the result, and `sources` in the file. It sets `options(last.source)` to this file name so that `src()` can be issued to re-`source` the file when it is edited.

Usage

```
src(x)
```

Arguments

`x`	an unquoted file name aside from `".s"`. This base file name must be a legal S name.

Side Effects

Sets system option `last.source`

Author(s)

Frank Harrell

See Also

`source`

Examples

```
## Not run:
src(myfile)   # source("myfile.s")
src()         # re-source myfile.s

## End(Not run)
```

stat_plsmo *Add a lowess smoother without counfidence bands.*

Description

Automatically selects `iter=0` for `lowess` if `y` is binary, otherwise uses `iter=3`.

Usage

```
stat_plsmo(
  mapping = NULL,
  data = NULL,
  geom = "smooth",
  position = "identity",
  n = 80,
  fullrange = FALSE,
  span = 2/3,
  fun = function(x) x,
  na.rm = FALSE,
  show.legend = NA,
  inherit.aes = TRUE,
  ...
)
```

Arguments

`mapping`, `data`, `geom`, `position`, `show.legend`, `inherit.aes`	see ggplot2 documentation
`n`	number of points to evaluate smoother at
`fullrange`	should the fit span the full range of the plot, or just the data
`span`	see `f` argument to `lowess`
`fun`	a function to transform smoothed `y`
`na.rm`	If `FALSE` (the default), removes missing values with a warning. If `TRUE` silently removes missing values.
`...`	other arguments are passed to smoothing function

Value

a data.frame with additional columns

`y`	predicted value

See Also

`lowess` for `loess` smoother.

Examples

```
require(ggplot2)
c <- ggplot(mtcars, aes(qsec, wt))
c + stat_plsmo()
c + stat_plsmo() + geom_point()

c + stat_plsmo(span = 0.1) + geom_point()

# Smoothers for subsets
c <- ggplot(mtcars, aes(y=wt, x=mpg)) + facet_grid(. ~ cyl)
c + stat_plsmo() + geom_point()
c + stat_plsmo(fullrange = TRUE) + geom_point()

# Geoms and stats are automatically split by aesthetics that are factors
c <- ggplot(mtcars, aes(y=wt, x=mpg, colour=factor(cyl)))
c + stat_plsmo() + geom_point()
c + stat_plsmo(aes(fill = factor(cyl))) + geom_point()
c + stat_plsmo(fullrange=TRUE) + geom_point()

# Example with logistic regression
data("kyphosis", package="rpart")
qplot(Age, as.numeric(Kyphosis) - 1, data = kyphosis) + stat_plsmo()
```

---

stata.get *Enhanced Importing of STATA Files*

Description

Reads a file in Stata version 5-11 binary format format into a data frame.

Usage

```
stata.get(file, lowernames = FALSE, convert.dates = TRUE,
          convert.factors = TRUE, missing.type = FALSE,
          convert.underscore = TRUE, warn.missing.labels = TRUE,
          force.single = TRUE, allow=NULL, charfactor=FALSE, ...)
```

Arguments

file	input SPSS save file. May be a file on the WWW, indicated by file starting with ''https://''.
lowernames	set to TRUE to convert variable names to lower case
convert.dates	see read.dta
convert.factors	see read.dta
missing.type	see read.dta

convert.underscore
: see read.dta

warn.missing.labels
: see read.dta

force.single
: set to FALSE to prevent integer-valued variables from being converted from storage mode double to integer

allow
: a vector of characters allowed by R that should not be converted to periods in variable names. By default, underscores in variable names are converted to periods as with R before version 1.9.

charfactor
: set to TRUE to change character variables to factors if they have fewer than n/2 unique values. Blanks and null strings are converted to NAs.

...
: arguments passed to read.dta.

Details

stata.get invokes the read.dta function in the **foreign** package to read an STATA file, with a default output format of data.frame. The label function is used to attach labels to individual variables instead of to the data frame as done by read.dta. By default, integer-valued variables are converted to a storage mode of integer unless force.single=FALSE. Date variables are converted to R Date variables. By default, underscores in names are converted to periods.

Value

A data frame

Author(s)

Charles Dupont

See Also

read.dta,cleanup.import,label,data.frame,Date

Examples

```
## Not run:
w <- stata.get('/tmp/my.dta')

## End(Not run)
```

string.bounding.box *Determine Dimensions of Strings*

Description

This determines the number of rows and maximum number of columns of each string in a vector.

Usage

```
string.bounding.box(string, type = c("chars", "width"))
```

Arguments

string	vector of strings
type	character: whether to count characters or screen columns

Value

rows	vector containing the number of character rows in each string
columns	vector containing the maximum number of character columns in each string

Author(s)

Charles Dupont

See Also

nchar, stringDims

Examples

```
a <- c("this is a single line string", "This is a\nmulti-line string")
stringDims(a)
```

string.break.line *Break a String into Many Lines at Newlines*

Description

Takes a string and breaks it into seperate substrings where there are newline characters.

Usage

```
string.break.line(string)
```

Arguments

string	character vector to be separated into many lines.

Value

Returns a list that is the same length of as the string argument.

Each list element is a character vector.

Each character vectors elements are the split lines of the corresponding element in the string argument vector.

Author(s)

Charles Dupont

See Also

strsplit

Examples

```
a <- c('', 'this is a single line string',
       'This is a\nmulti-line string.')

b <- string.break.line(a)
```

---

stringDims *String Dimentions*

Description

Finds the height and width of all the string in a character vector.

Usage

```
stringDims(string)
```

Arguments

string	vector of strings

Details

stringDims finds the number of characters in width and number of lines in height for each string in the string argument.

Value

height	a vector of the number of lines in each string.
width	a vector with the number of character columns in the longest line.

Author(s)

Charles Dupont

See Also

string.bounding.box, nchar

Examples

```
a <- c("this is a single line string", "This is a\nmulty line string")
stringDims(a)
```

---

subplot *Embed a new plot within an existing plot*

Description

Subplot will embed a new plot within an existing plot at the coordinates specified (in user units of the existing plot).

Usage

```
subplot(fun, x, y, size=c(1,1), vadj=0.5, hadj=0.5, pars=NULL)
```

Arguments

fun	an expression or function defining the new plot to be embedded.
x	x-coordinate(s) of the new plot (in user coordinates of the existing plot).
y	y-coordinate(s) of the new plot, x and y can be specified in any of the ways understood by xy.coords.
size	The size of the embedded plot in inches if x and y have length 1.
vadj	vertical adjustment of the plot when y is a scalar, the default is to center vertically, 0 means place the bottom of the plot at y, 1 places the top of the plot at y.
hadj	horizontal adjustment of the plot when x is a scalar, the default is to center horizontally, 0 means place the left edge of the plot at x, and 1 means place the right edge of the plot at x.
pars	a list of parameters to be passed to par before running fun.

Details

The coordinates x and y can be scalars or vectors of length 2. If vectors of length 2 then they determine the opposite corners of the rectangle for the embedded plot (and the parameters size, vadj, and hadj are all ignored.

If x and y are given as scalars then the plot position relative to the point and the size of the plot will be determined by the arguments size, vadj, and hadj. The default is to center a 1 inch by 1 inch plot at x,y. Setting vadj and hadj to (0,0) will position the lower left corner of the plot at (x,y).

The rectangle defined by x, y, size, vadj, and hadj will be used as the plotting area of the new plot. Any tick marks, axis labels, main and sub titles will be outside of this rectangle.

Any graphical parameter settings that you would like to be in place before fun is evaluated can be specified in the pars argument (warning: specifying layout parameters here (plt, mfrow, etc.) may cause unexpected results).

After the function completes the graphical parameters will have been reset to what they were before calling the function (so you can continue to augment the original plot).

Value

An invisible list with the graphical parameters that were in effect when the subplot was created. Passing this list to par will enable you to augment the embedded plot.

Author(s)

Greg Snow <greg.snow@imail.org>

See Also

cnvrt.coords, par, symbols

Examples

```
# make an original plot
plot( 11:20, sample(51:60) )

# add some histograms

subplot( hist(rnorm(100)), 15, 55)
subplot( hist(runif(100),main='',xlab='',ylab=''), 11, 51, hadj=0, vadj=0)
subplot( hist(rexp(100, 1/3)), 20, 60, hadj=1, vadj=1, size=c(0.5,2) )
subplot( hist(rt(100,3)), c(12,16), c(57,59), pars=list(lwd=3,ask=FALSE) )

tmp <- rnorm(25)
qqnorm(tmp)
qqline(tmp)
tmp2 <- subplot( hist(tmp,xlab='',ylab='',main=''),
  cnvrt.coords(0.1,0.9,'plt')$usr, vadj=1, hadj=0 )
abline(v=0, col='red') # wrong way to add a reference line to histogram

# right way to add a reference line to histogram
op <- par(no.readonly=TRUE)
```

```
par(tmp2)
abline(v=0, col='green')
par(op)
```

---

summarize *Summarize Scalars or Matrices by Cross-Classification*

Description

summarize is a fast version of summary.formula(formula,method="cross",overall=FALSE) for producing stratified summary statistics and storing them in a data frame for plotting (especially with trellis xyplot and dotplot and Hmisc xYplot). Unlike aggregate, summarize accepts a matrix as its first argument and a multi-valued FUN argument and summarize also labels the variables in the new data frame using their original names. Unlike methods based on tapply, summarize stores the values of the stratification variables using their original types, e.g., a numeric by variable will remain a numeric variable in the collapsed data frame. summarize also retains "label" attributes for variables. summarize works especially well with the Hmisc xYplot function for displaying multiple summaries of a single variable on each panel, such as means and upper and lower confidence limits.

asNumericMatrix converts a data frame into a numeric matrix, saving attributes to reverse the process by matrix2dataframe. It saves attributes that are commonly preserved across row subsetting (i.e., it does not save dim, dimnames, or names attributes).

matrix2dataFrame converts a numeric matrix back into a data frame if it was created by asNumericMatrix.

Usage

```
summarize(X, by, FUN, ...,
          stat.name=deparse(substitute(X)),
          type=c('variables','matrix'), subset=TRUE,
          keepcolnames=FALSE)

asNumericMatrix(x)

matrix2dataFrame(x, at=attr(x, 'origAttributes'), restoreAll=TRUE)
```

Arguments

X	a vector or matrix capable of being operated on by the function specified as the FUN argument
by	one or more stratification variables. If a single variable, by may be a vector, otherwise it should be a list. Using the Hmisc llist function instead of list will result in individual variable names being accessible to summarize. For example, you can specify llist(age.group,sex) or llist(Age=age.group,sex). The latter gives age.group a new temporary name, Age.

FUN	a function of a single vector argument, used to create the statistical summaries for summarize. FUN may compute any number of statistics.
...	extra arguments are passed to FUN
stat.name	the name to use when creating the main summary variable. By default, the name of the X argument is used. Set stat.name to NULL to suppress this name replacement.
type	Specify type="matrix" to store the summary variables (if there are more than one) in a matrix.
subset	a logical vector or integer vector of subscripts used to specify the subset of data to use in the analysis. The default is to use all observations in the data frame.
keepcolnames	by default when type="matrix", the first column of the computed matrix is the name of the first argument to summarize. Set keepcolnames=TRUE to retain the name of the first column created by FUN
x	a data frame (for asNumericMatrix) or a numeric matrix (for matrix2dataFrame).
at	List containing attributes of original data frame that survive subsetting. Defaults to attribute "origAttributes" of the object x, created by the call to asNumericMatrix
restoreAll	set to FALSE to only restore attributes label, units, and levels instead of all attributes

Value

For summarize, a data frame containing the by variables and the statistical summaries (the first of which is named the same as the X variable unless stat.name is given). If type="matrix", the summaries are stored in a single variable in the data frame, and this variable is a matrix.

asNumericMatrix returns a numeric matrix and stores an object origAttributes as an attribute of the returned object, with original attributes of component variables, the storage.mode.

matrix2dataFrame returns a data frame.

Author(s)

Frank Harrell
Department of Biostatistics
Vanderbilt University
<fh@fharrell.com>

See Also

label, cut2, llist, by

Examples

```
## Not run:
s <- summarize(ap>1, llist(size=cut2(sz, g=4), bone), mean,
               stat.name='Proportion')
dotplot(Proportion ~ size | bone, data=s7)
```

```
## End(Not run)

set.seed(1)
temperature <- rnorm(300, 70, 10)
month <- sample(1:12, 300, TRUE)
year  <- sample(2000:2001, 300, TRUE)
g <- function(x)c(Mean=mean(x,na.rm=TRUE),Median=median(x,na.rm=TRUE))
summarize(temperature, month, g)
mApply(temperature, month, g)

mApply(temperature, month, mean, na.rm=TRUE)
w <- summarize(temperature, month, mean, na.rm=TRUE)
library(lattice)
xyplot(temperature ~ month, data=w) # plot mean temperature by month

w <- summarize(temperature, llist(year,month),
               quantile, probs=c(.5,.25,.75), na.rm=TRUE, type='matrix')
xYplot(Cbind(temperature[,1],temperature[,-1]) ~ month | year, data=w)
mApply(temperature, llist(year,month),
       quantile, probs=c(.5,.25,.75), na.rm=TRUE)

# Compute the median and outer quartiles.  The outer quartiles are
# displayed using "error bars"
set.seed(111)
dfr <- expand.grid(month=1:12, year=c(1997,1998), reps=1:100)
attach(dfr)
y <- abs(month-6.5) + 2*runif(length(month)) + year-1997
s <- summarize(y, llist(month,year), smedian.hilow, conf.int=.5)
s
mApply(y, llist(month,year), smedian.hilow, conf.int=.5)

xYplot(Cbind(y,Lower,Upper) ~ month, groups=year, data=s,
       keys='lines', method='alt')
# Can also do:
s <- summarize(y, llist(month,year), quantile, probs=c(.5,.25,.75),
               stat.name=c('y','Q1','Q3'))
xYplot(Cbind(y, Q1, Q3) ~ month, groups=year, data=s, keys='lines')
# To display means and bootstrapped nonparametric confidence intervals
# use for example:
s <- summarize(y, llist(month,year), smean.cl.boot)
xYplot(Cbind(y, Lower, Upper) ~ month | year, data=s)

# For each subject use the trapezoidal rule to compute the area under
# the (time,response) curve using the Hmisc trap.rule function
x <- cbind(time=c(1,2,4,7, 1,3,5,10),response=c(1,3,2,4, 1,3,2,4))
subject <- c(rep(1,4),rep(2,4))
trap.rule(x[1:4,1],x[1:4,2])
summarize(x, subject, function(y) trap.rule(y[,1],y[,2]))

## Not run:
# Another approach would be to properly re-shape the mm array below
# This assumes no missing cells.  There are many other approaches.
# mApply will do this well while allowing for missing cells.
```

```
m <- tapply(y, list(year,month), quantile, probs=c(.25,.5,.75))
mm <- array(unlist(m), dim=c(3,2,12),
            dimnames=list(c('lower','median','upper'),c('1997','1998'),
                          as.character(1:12)))
# aggregate will help but it only allows you to compute one quantile
# at a time; see also the Hmisc mApply function
dframe <- aggregate(y, list(Year=year,Month=month), quantile, probs=.5)

# Compute expected life length by race assuming an exponential
# distribution - can also use summarize
g <- function(y) { # computations for one race group
  futime <- y[,1]; event <- y[,2]
  sum(futime)/sum(event)  # assume event=1 for death, 0=alive
}
mApply(cbind(followup.time, death), race, g)

# To run mApply on a data frame:
xn <- asNumericMatrix(x)
m <- mApply(xn, race, h)
# Here assume h is a function that returns a matrix similar to x
matrix2dataFrame(m)


# Get stratified weighted means
g <- function(y) wtd.mean(y[,1],y[,2])
summarize(cbind(y, wts), llist(sex,race), g, stat.name='y')
mApply(cbind(y,wts), llist(sex,race), g)

# Compare speed of mApply vs. by for computing
d <- data.frame(sex=sample(c('female','male'),100000,TRUE),
                country=sample(letters,100000,TRUE),
                y1=runif(100000), y2=runif(100000))
g <- function(x) {
  y <- c(median(x[,'y1']-x[,'y2']),
         med.sum =median(x[,'y1']+x[,'y2']))
  names(y) <- c('med.diff','med.sum')
  y
}

system.time(by(d, llist(sex=d$sex,country=d$country), g))
system.time({
             x <- asNumericMatrix(d)
             a <- subsAttr(d)
             m <- mApply(x, llist(sex=d$sex,country=d$country), g)
            })
system.time({
             x <- asNumericMatrix(d)
             summarize(x, llist(sex=d$sex, country=d$country), g)
            })

# An example where each subject has one record per diagnosis but sex of
# subject is duplicated for all the rows a subject has.  Get the cross-
# classified frequencies of diagnosis (dx) by sex and plot the results
```

```
# with a dot plot

count <- rep(1,length(dx))
d <- summarize(count, llist(dx,sex), sum)
Dotplot(dx ~ count | sex, data=d)

## End(Not run)
d <- list(x=1:10, a=factor(rep(c('a','b'), 5)),
          b=structure(letters[1:10], label='label for b'),
          d=c(rep(TRUE,9), FALSE), f=pi*(1 : 10))
x <- asNumericMatrix(d)
attr(x, 'origAttributes')
matrix2dataFrame(x)

detach('dfr')

# Run summarize on a matrix to get column means
x <- c(1:19,NA)
y <- 101:120
z <- cbind(x, y)
g <- c(rep(1, 10), rep(2, 10))
summarize(z, g, colMeans, na.rm=TRUE, stat.name='x')
# Also works on an all numeric data frame
summarize(as.data.frame(z), g, colMeans, na.rm=TRUE, stat.name='x')
```

`summary.formula` *Summarize Data for Making Tables and Plots*

Description

`summary.formula` summarizes the variables listed in an S formula, computing descriptive statistics (including ones in a user-specified function). The summary statistics may be passed to `print` methods, `plot` methods for making annotated dot charts, and `latex` methods for typesetting tables using LaTeX. `summary.formula` has three methods for computing descriptive statistics on univariate or multivariate responses, subsetted by categories of other variables. The method of summarization is specified in the parameter `method` (see details below). For the `response` and `cross` methods, the statistics used to summarize the data may be specified in a very flexible way (e.g., the geometric mean, 33rd percentile, Kaplan-Meier 2-year survival estimate, mixtures of several statistics). The default summary statistic for these methods is the mean (the proportion of positive responses for a binary response variable). The `cross` method is useful for creating data frames which contain summary statistics that are passed to `trellis` as raw data (to make multi-panel dot charts, for example). The `print` methods use the `print.char.matrix` function to print boxed tables.

The right hand side of `formula` may contain `mChoice` ("multiple choice") variables. When `test=TRUE` each choice is tested separately as a binary categorical response.

The `plot` method for `method="reverse"` creates a temporary function `Key` in frame 0 as is done by the `xYplot` and `Ecdf.formula` functions. After `plot` runs, you can type `Key()` to put a legend in a default location, or e.g. `Key(locator(1))` to draw a legend where you click the left mouse button. This key is for categorical variables, so to have the opportunity to put the key on the graph

you will probably want to use the command `plot(object, which="categorical")`. A second function `Key2` is created if continuous variables are being plotted. It is used the same as `Key`. If the `which` argument is not specified to `plot`, two pages of plots will be produced. If you don't define `par(mfrow=)` yourself, `plot.summary.formula.reverse` will try to lay out a multi-panel graph to best fit all the individual dot charts for continuous variables.

There is a subscripting method for objects created with `method="response"`. This can be used to print or plot selected variables or summary statistics where there would otherwise be too many on one page.

`cumcategory` is a utility function useful when summarizing an ordinal response variable. It converts such a variable having `k` levels to a matrix with `k-1` columns, where column `i` is a vector of zeros and ones indicating that the categorical response is in level `i+1` or greater. When the left hand side of `formula` is `cumcategory(y)`, the default `fun` will summarize it by computing all of the relevant cumulative proportions.

Functions `conTestkw`, `catTestchisq`, `ordTestpo` are the default statistical test functions for `summary.formula`. These defaults are: Wilcoxon-Kruskal-Wallis test for continuous variables, Pearson chi-square test for categorical variables, and the likelihood ratio chi-square test from the proportional odds model for ordinal variables. These three functions serve also as templates for the user to create her own testing functions that are self-defining in terms of how the results are printed or rendered in LaTeX, or plotted.

Usage

```
## S3 method for class 'formula'
summary(formula, data=NULL, subset=NULL,
        na.action=NULL, fun = NULL,
        method = c("response", "reverse", "cross"),
        overall = method == "response" | method == "cross",
        continuous = 10, na.rm = TRUE, na.include = method != "reverse",
        g = 4, quant = c(0.025, 0.05, 0.125, 0.25, 0.375, 0.5, 0.625,
                         0.75, 0.875, 0.95, 0.975),
        nmin = if (method == "reverse") 100
               else 0,
        test = FALSE, conTest = conTestkw, catTest = catTestchisq,
        ordTest = ordTestpo, ...)

## S3 method for class 'summary.formula.response'
x[i, j, drop=FALSE]

## S3 method for class 'summary.formula.response'
print(x, vnames=c('labels','names'), prUnits=TRUE,
      abbreviate.dimnames=FALSE,
      prefix.width, min.colwidth, formatArgs=NULL, markdown=FALSE, ...)

## S3 method for class 'summary.formula.response'
plot(x, which = 1, vnames = c('labels','names'), xlim, xlab,
     pch = c(16, 1, 2, 17, 15, 3, 4, 5, 0), superposeStrata = TRUE,
     dotfont = 1, add = FALSE, reset.par = TRUE, main, subtitles = TRUE,
     ...)
```

```
## S3 method for class 'summary.formula.response'
latex(object, title = first.word(deparse(substitute(object))), caption,
      trios, vnames = c('labels', 'names'), prn = TRUE, prUnits = TRUE,
      rowlabel = '', cdec = 2, ncaption = TRUE, ...)

## S3 method for class 'summary.formula.reverse'
print(x, digits, prn = any(n != N), pctdig = 0,
      what=c('%', 'proportion'),
      npct = c('numerator', 'both', 'denominator', 'none'),
      exclude1 = TRUE, vnames = c('labels', 'names'), prUnits = TRUE,
      sep = '/', abbreviate.dimnames = FALSE,
     prefix.width = max(nchar(lab)), min.colwidth, formatArgs=NULL, round=NULL,
      prtest = c('P','stat','df','name'), prmsd = FALSE, long = FALSE,
      pdig = 3, eps = 0.001, ...)

## S3 method for class 'summary.formula.reverse'
plot(x, vnames = c('labels', 'names'), what = c('proportion', '%'),
     which = c('both', 'categorical', 'continuous'),
     xlim = if(what == 'proportion') c(0,1)
            else c(0,100),
     xlab = if(what=='proportion') 'Proportion'
            else 'Percentage',
     pch = c(16, 1, 2, 17, 15, 3, 4, 5, 0), exclude1 = TRUE,
     dotfont = 1, main,
     prtest = c('P', 'stat', 'df', 'name'), pdig = 3, eps = 0.001,
     conType = c('dot', 'bp', 'raw'), cex.means = 0.5, ...)

## S3 method for class 'summary.formula.reverse'
latex(object, title = first.word(deparse(substitute(object))), digits,
      prn = any(n != N), pctdig = 0, what=c('%', 'proportion'),
      npct = c("numerator", "both", "denominator", "slash", "none"),
      npct.size = 'scriptsize', Nsize = "scriptsize", exclude1 = TRUE,
      vnames=c("labels", "names"), prUnits = TRUE, middle.bold = FALSE,
      outer.size = "scriptsize", caption, rowlabel = "",
      insert.bottom = TRUE, dcolumn = FALSE, formatArgs=NULL, round = NULL,
      prtest = c('P', 'stat', 'df', 'name'), prmsd = FALSE,
      msdsize = NULL, long = dotchart, pdig = 3, eps = 0.001,
      auxCol = NULL, dotchart=FALSE, ...)

## S3 method for class 'summary.formula.cross'
print(x, twoway = nvar == 2, prnmiss = any(stats$Missing > 0), prn = TRUE,
      abbreviate.dimnames = FALSE, prefix.width = max(nchar(v)),
      min.colwidth, formatArgs = NULL, ...)

## S3 method for class 'summary.formula.cross'
latex(object, title = first.word(deparse(substitute(object))),
      twoway = nvar == 2, prnmiss = TRUE, prn = TRUE,
```

```
      caption=attr(object, "heading"), vnames=c("labels", "names"),
      rowlabel="", ...)

stratify(..., na.group = FALSE, shortlabel = TRUE)

## S3 method for class 'summary.formula.cross'
formula(x, ...)

cumcategory(y)

conTestkw(group, x)
catTestchisq(tab)
ordTestpo(group, x)
```

Arguments

formula	An R formula with additive effects. For method="response" or "cross", the dependent variable has the usual connotation. For method="reverse", the dependent variable is what is usually thought of as an independent variable, and it is one that is used to stratify all of the right hand side variables. For method="response" (only), the formula may contain one or more invocations of the stratify function whose arguments are defined below. This causes the entire analysis to be stratified by cross-classifications of the combined list of stratification factors. This stratification will be reflected as major column groupings in the resulting table, or as more response columns for plotting. If formula has no dependent variable method="reverse" is the only legal value and so method defaults to "reverse" in this case.
x	an object created by summary.formula. For conTestkw a numeric vector, and for ordTestpo, a numeric or factor variable that can be considered ordered
y	a numeric, character, category, or factor vector for cumcategory. Is converted to a categorical variable is needed.
drop	logical. If TRUE the result is coerced to the lowest possible dimension.
data	name or number of a data frame. Default is the current frame.
subset	a logical vector or integer vector of subscripts used to specify the subset of data to use in the analysis. The default is to use all observations in the data frame.
na.action	function for handling missing data in the input data. The default is a function defined here called na.retain, which keeps all observations for processing, with missing variables or not.
fun	function for summarizing data in each cell. Default is to take the mean of each column of the possibly multivariate response variable. You can specify fun="%" to compute percentages (100 times the mean of a series of logical or binary variables). User–specified functions can also return a matrix. For example, you might compute quartiles on a bivariate response. Does not apply to method="reverse".
method	The default is "response", in which case the response variable may be multivariate and any number of statistics may be used to summarize them. Here

the responses are summarized separately for each of any number of independent variables. Continuous independent variables (see the continuous parameter below) are automatically stratified into g (see below) quantile groups (if you want to control the discretization for selected variables, use the cut2 function on them). Otherwise, the data are subsetted by all levels of discrete right hand side variables. For multivariate responses, subjects are considered to be missing if any of the columns is missing.

The method="reverse" option is typically used to make baseline characteristic tables, for example. The single left hand side variable must be categorical (e.g., treatment), and the right hand side variables are broken down one at a time by the "dependent" variable. Continuous variables are described by three quantiles (quartiles by default) along with outer quantiles (used only for scaling x-axes when plotting quartiles; all are used when plotting box-percentile plots), and categorical ones are described by counts and percentages. If there is no left hand side variable, summary assumes that there is only one group in the data, so that only one column of summaries will appear. If there is no dependent variable in formula, method defaults to "reverse" automatically.

The method="cross" option allows for a multivariate dependent variable and for up to three independents. Continuous independent variables (those with at least continuous unique values) are automatically divided into g quantile groups. The independents are cross-classified, and marginal statistics may optionally be computed. The output of summary.formula in this case is a data frame containing the independent variable combinations (with levels of "All" corresponding to marginals) and the corresponding summary statistics in the matrix S. The output data frame is suitable for direct use in trellis. The print and latex typesetting methods for this method allows for a special two-way format if there are two right hand variables.

overall — For method="reverse", setting overall=TRUE makes a new column with overall statistics for the whole sample. For method="cross", overall=TRUE (the default) results in all marginal statistics being computed. For trellis displays (usually multi-panel dot plots), these marginals just form other categories. For "response", the default is overall=TRUE, causing a final row of global summary statistics to appear in tables and dot charts. If test=TRUE these marginal statistics are ignored in doing statistical tests.

continuous — specifies the threshold for when a variable is considered to be continuous (when there are at least continuous unique values). factor variables are always considered to be categorical no matter how many levels they have.

na.rm — TRUE (the default) to exclude NAs before passing data to fun to compute statistics, FALSE otherwise. na.rm=FALSE is useful if the response variable is a matrix and you do not wish to exclude a row of the matrix if any of the columns in that row are NA. na.rm also applies to summary statistic functions such as smean.cl.normal. For these na.rm defaults to TRUE unlike built-in functions.

na.include — for method="response", set na.include=FALSE to exclude missing values from being counted as their own category when subsetting the response(s) by levels of a categorical variable. For method="reverse" set na.include=TRUE to keep missing values of categorical variables from being excluded from the table.

g — number of quantile groups to use when variables are automatically categorized with method="response" or "cross" using cut2

nmin — if fewer than nmin observations exist in a category for "response" (over all strata combined), that category will be ignored. For "reverse", for categories of the response variable in which there are less than or equal to nmin non-missing observations, the raw data are retained for later plotting in place of box plots.

test — applies if method="reverse". Set to TRUE to compute test statistics using tests specified in conTest and catTest.

conTest — a function of two arguments (grouping variable and a continuous variable) that returns a list with components P (the computed P-value), stat (the test statistic, either chi-square or F), df (degrees of freedom), testname (test name), statname (statistic name), namefun ("chisq", "fstat"), an optional component latexstat (LaTeX representation of statname), an optional component plotmathstat (for R - the plotmath representation of statname, as a character string), and an optional component note that contains a character string note about the test (e.g., "test not done because n < 5"). conTest is applied to continuous variables on the right-hand-side of the formula when method="reverse". The default uses the spearman2 function to run the Wilcoxon or Kruskal-Wallis test using the F distribution.

catTest — a function of a frequency table (an integer matrix) that returns a list with the same components as created by conTest. By default, the Pearson chi-square test is done, without continuity correction (the continuity correction would make the test conservative like the Fisher exact test).

ordTest — a function of a frequency table (an integer matrix) that returns a list with the same components as created by conTest. By default, the Proportional odds likelihood ratio test is done.

... — for summary.formula these are optional arguments for cut2 when variables are automatically categorized. For plot methods these arguments are passed to dotchart2. For Key and Key2 these arguments are passed to key, text, or mtitle. For print methods these are optional arguments to print.char.matrix. For latex methods these are passed to latex.default. One of the most important of these is file. Specifying file="" will cause LaTeX code to just be printed to standard output rather than be stored in a permanent file.

object — an object created by summary.formula

quant — vector of quantiles to use for summarizing data with method="reverse". This must be numbers between 0 and 1 inclusive and must include the numbers 0.5, 0.25, and 0.75 which are used for printing and for plotting quantile intervals. The outer quantiles are used for scaling the x-axes for such plots. Specify outer quantiles as 0 and 1 to scale the x-axes using the whole observed data ranges instead of the default (a 0.95 quantile interval). Box-percentile plots are drawn using all but the outer quantiles.

vnames — By default, tables and plots are usually labeled with variable labels (see the label and sas.get functions). To use the shorter variable names, specify vnames="name".

pch — vector of plotting characters to represent different groups, in order of group levels. For method="response" the characters correspond to levels of the stratify variable if superposeStrata=TRUE, and if no strata are used or if superposeStrata=FALSE, the pch vector corresponds to the which argument for method="response".

superposeStrata — If stratify was used, set superposeStrata=FALSE to make separate dot charts for each level of the stratification variable, for method='response'. The default is to superposition all strata on one dot chart.

dotfont — font for plotting points

reset.par — set to FALSE to suppress the restoring of the old par values in plot.summary.formula.response

abbreviate.dimnames — see print.char.matrix

prefix.width — see print.char.matrix

min.colwidth — minimum column width to use for boxes printed with print.char.matrix. The default is the maximum of the minimum column label length and the minimum length of entries in the data cells.

formatArgs — a list containing other arguments to pass to format.default such as scientific, e.g., formatArgs=list(scientific=c(-5,5)). For print.summary.formula.reverse and format.summary.formula.reverse, formatArgs applies only to statistics computed on continuous variables, not to percents, numerators, and denominators. The round argument may be preferred.

markdown — for print.summary.formula.response set to TRUE to use knitr::kable to produce the table in markdown format rather than using raw text output created by print.char.matrix

digits — number of significant digits to print. Default is to use the current value of the digits system option.

prn — set to TRUE to print the number of non-missing observations on the current (row) variable. The default is to print these only if any of the counts of non-missing values differs from the total number of non-missing values of the left-hand-side variable. For method="cross" the default is to always print N.

prnmiss — set to FALSE to suppress printing counts of missing values for "cross"

what — for method="reverse" specifies whether proportions or percentages are to be plotted

pctdig — number of digits to the right of the decimal place for printing percentages. The default is zero, so percents will be rounded to the nearest percent.

npct — specifies which counts are to be printed to the right of percentages. The default is to print the frequency (numerator of the percent) in parentheses. You can specify "both" to print both numerator and denominator, "denominator", "slash" to typeset horizontally using a forward slash, or "none".

npct.size — the size for typesetting npct information which appears after percents. The default is "scriptsize".

Nsize — When a second row of column headings is added showing sample sizes, Nsize specifies the LaTeX size for these subheadings. Default is "scriptsize".

exclude1 — by default, method="reverse" objects will be printed, plotted, or typeset by removing redundant entries from percentage tables for categorical variables. For example, if you print the percent of females, you don't need to print the percent of males. To override this, set exclude1=FALSE.

prUnits — set to FALSE to suppress printing or latexing units attributes of variables, when method='reverse' or 'response'

sep — character to use to separate quantiles when printing method="reverse" tables

prtest — a vector of test statistic components to print if test=TRUE was in effect when summary.formula was called. Defaults to printing all components. Specify prtest=FALSE or prtest="none" to not print any tests. This applies to print, latex, and plot methods for method='reverse'.

round — for print.summary.formula.reverse and latex.summary.formula.reverse specify round to round the quantiles and optional mean and standard deviation to round digits after the decimal point

prmsd — set to TRUE to print mean and SD after the three quantiles, for continuous variables with method="reverse"

msdsize — defaults to NULL to use the current font size for the mean and standard deviation if prmsd is TRUE. Set to a character string to specify an alternate LaTeX font size.

long — set to TRUE to print the results for the first category on its own line, not on the same line with the variable label (for method="reverse" with print and latex methods)

pdig — number of digits to the right of the decimal place for printing P-values. Default is 3. This is passed to format.pval.

eps — P-values less than eps will be printed as < eps. See format.pval.

auxCol — an optional auxiliary column of information, right justified, to add in front of statistics typeset by latex.summary.formula.reverse. This argument is a list with a single element that has a name specifying the column heading. If this name includes a newline character, the portions of the string before and after the newline form respectively the main heading and the subheading (typically set in smaller font), respectively. See the extracolheads argument to latex.default. auxCol is filled with blanks when a variable being summarized takes up more than one row in the output. This happens with categorical variables.

twoway — for method="cross" with two right hand side variables, twoway controls whether the resulting table will be printed in enumeration format or as a two-way table (the default)

which — For method="response" specifies the sequential number or a vector of subscripts of statistics to plot. If you had any stratify variables, these are counted as if more statistics were computed. For method="reverse" specifies whether to plot results for categorical variables, continuous variables, or both (the default).

conType — For plotting method="reverse" plots for continuous variables, dot plots showing quartiles are drawn by default. Specify conType='bp' to draw box-percentile plots using all the quantiles in quant except the outermost ones. Means are

	drawn with a solid dot and vertical reference lines are placed at the three quartiles. Specify conType='raw' to make a strip chart showing the raw data. This can only be used if the sample size for each left-hand-side group is less than or equal to nmin.
cex.means	character size for means in box-percentile plots; default is .5
xlim	vector of length two specifying x-axis limits. For method="reverse", this is only used for plotting categorical variables. Limits for continuous variables are determined by the outer quantiles specified in quant.
xlab	x-axis label
add	set to TRUE to add to an existing plot
main	a main title. For method="reverse" this applies only to the plot for categorical variables.
subtitles	set to FALSE to suppress automatic subtitles
caption	character string containing LaTeX table captions.
title	name of resulting LaTeX file omitting the .tex suffix. Default is the name of the summary object. If caption is specied, title is also used for the table's symbolic reference label.
trios	If for method="response" you summarized the response(s) by using three quantiles, specify trios=TRUE or trios=v to group each set of three statistics into one column for latex output, using the format a B c, where the outer quantiles are in smaller font (scriptsize). For trios=TRUE, the overall column names are taken from the column names of the original data matrix. To give new column names, specify trios=v, where v is a vector of column names, of length m/3, where m is the original number of columns of summary statistics.
rowlabel	see latex.default (under the help file latex)
cdec	number of decimal places to the right of the decimal point for latex. This value should be a scalar (which will be properly replicated), or a vector with length equal to the number of columns in the table. For "response" tables, this length does not count the column for N.
ncaption	set to FALSE to not have latex.summary.formula.response put sample sizes in captions
i	a vector of integers, or character strings containing variable names to subset on. Note that each row subsetted on in an summary.formula.reverse object subsets on all the levels that make up the corresponding variable (automatically).
j	a vector of integers representing column numbers
middle.bold	set to TRUE to have LaTeX use bold face for the middle quantile for method="reverse"
outer.size	the font size for outer quantiles for "reverse" tables
insert.bottom	set to FALSE to suppress inclusion of definitions placed at the bottom of LaTeX tables for method="reverse"
dcolumn	see latex
na.group	set to TRUE to have missing stratification variables given their own category (NA)
shortlabel	set to FALSE to include stratification variable names and equal signs in labels for strata levels

dotchart	set to TRUE to output a dotchart in the latex table being generated.
group	for conTest and ordTest, a numeric or factor variable with length the same as x
tab	for catTest, a frequency table such as that created by table()

Value

summary.formula returns a data frame or list depending on method. plot.summary.formula.reverse returns the number of pages of plots that were made.

Side Effects

plot.summary.formula.reverse creates a function Key and Key2 in frame 0 that will draw legends.

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References

Harrell FE (2007): Statistical tables and plots using S and LaTeX. Document available from https://hbiostat.org/R/Hmisc/summary.pdf.

See Also

mChoice, smean.sd, summarize, label, strata, dotchart2, print.char.matrix, update, formula, cut2, llist, format.default, latex, latexTranslate bpplt, summaryM, summary

Examples

```
options(digits=3)
set.seed(173)
sex <- factor(sample(c("m","f"), 500, rep=TRUE))
age <- rnorm(500, 50, 5)
treatment <- factor(sample(c("Drug","Placebo"), 500, rep=TRUE))

# Generate a 3-choice variable; each of 3 variables has 5 possible levels
symp <- c('Headache','Stomach Ache','Hangnail',
          'Muscle Ache','Depressed')
symptom1 <- sample(symp, 500,TRUE)
symptom2 <- sample(symp, 500,TRUE)
symptom3 <- sample(symp, 500,TRUE)
Symptoms <- mChoice(symptom1, symptom2, symptom3, label='Primary Symptoms')
table(Symptoms)

# Note: In this example, some subjects have the same symptom checked
# multiple times; in practice these redundant selections would be NAs
```

```
# mChoice will ignore these redundant selections

#Frequency table sex*treatment, sex*Symptoms
summary(sex ~ treatment + Symptoms, fun=table)
# could also do summary(sex ~ treatment +
#  mChoice(symptom1,symptom2,symptom3), fun=table)


#Compute mean age, separately by 3 variables
summary(age ~ sex + treatment + Symptoms)


f <- summary(treatment ~ age + sex + Symptoms, method="reverse", test=TRUE)
f
# trio of numbers represent 25th, 50th, 75th percentile
print(f, long=TRUE)
plot(f)
plot(f, conType='bp', prtest='P')
bpplt()    # annotated example showing layout of bp plot

#Compute predicted probability from a logistic regression model
#For different stratifications compute receiver operating
#characteristic curve areas (C-indexes)
predicted <- plogis(.4*(sex=="m")+.15*(age-50))
positive.diagnosis <- ifelse(runif(500)<=predicted, 1, 0)
roc <- function(z) {
   x <- z[,1];
   y <- z[,2];
   n <- length(x);
   if(n<2)return(c(ROC=NA));
   n1 <- sum(y==1);
   c(ROC= (mean(rank(x)[y==1])-(n1+1)/2)/(n-n1) );
 }
y <- cbind(predicted, positive.diagnosis)
options(digits=2)
summary(y ~ age + sex, fun=roc)


options(digits=3)
summary(y ~ age + sex, fun=roc, method="cross")

#Use stratify() to produce a table in which time intervals go down the
#page and going across 3 continuous variables are summarized using
#quartiles, and are stratified by two treatments

set.seed(1)
d <- expand.grid(visit=1:5, treat=c('A','B'), reps=1:100)
d$sysbp <- rnorm(100*5*2, 120, 10)
label(d$sysbp) <- 'Systolic BP'
d$diasbp <- rnorm(100*5*2, 80,  7)
d$diasbp[1] <- NA
d$age    <- rnorm(100*5*2, 50, 12)
g <- function(y) {
```

```
  N <- apply(y, 2, function(w) sum(!is.na(w)))
  h <- function(x) {
    qu <- quantile(x, c(.25,.5,.75), na.rm=TRUE)
    names(qu) <- c('Q1','Q2','Q3')
    c(N=sum(!is.na(x)), qu)
}
  w <- as.vector(apply(y, 2, h))
  names(w) <- as.vector( outer(c('N','Q1','Q2','Q3'), dimnames(y)[[2]],
                               function(x,y) paste(y,x)))
  w
}
#Use na.rm=FALSE to count NAs separately by column
s <- summary(cbind(age,sysbp,diasbp) ~ visit + stratify(treat),
             na.rm=FALSE, fun=g, data=d)
#The result is very wide.  Re-do, putting treatment vertically
x <- with(d, factor(paste('Visit', visit, treat)))
summary(cbind(age,sysbp,diasbp) ~ x, na.rm=FALSE, fun=g, data=d)

#Compose LaTeX code directly
g <- function(y) {
  h <- function(x) {
    qu <- format(round(quantile(x, c(.25,.5,.75), na.rm=TRUE),1),nsmall=1)
    paste('{\\scriptsize',sum(!is.na(x)),
          ')} \\hfill{\\scriptsize ', qu[1], '} \\textbf{', qu[2],
          '} {\\scriptsize ', qu[3],'}', sep='')
  }
  apply(y, 2, h)
}
s <- summary(cbind(age,sysbp,diasbp) ~ visit + stratify(treat),
             na.rm=FALSE, fun=g, data=d)
# latex(s, prn=FALSE)
## need option in latex to not print n
#Put treatment vertically
s <- summary(cbind(age,sysbp,diasbp) ~ x, fun=g, data=d, na.rm=FALSE)
# latex(s, prn=FALSE)

#Plot estimated mean life length (assuming an exponential distribution)
#separately by levels of 4 other variables.  Repeat the analysis
#by levels of a stratification variable, drug.  Automatically break
#continuous variables into tertiles.
#We are using the default, method='response'
## Not run:
life.expect <- function(y) c(Years=sum(y[,1])/sum(y[,2]))
attach(pbc)
require(survival)
S <- Surv(follow.up.time, death)
s2 <- summary(S ~ age + albumin + ascites + edema + stratify(drug),
                        fun=life.expect, g=3)


#Note: You can summarize other response variables using the same
#independent variables using e.g. update(s2, response~.), or you
#can change the list of independent variables using e.g.
```

```
#update(s2, response ~.- ascites) or update(s2, .~.-ascites)
#You can also print, typeset, or plot subsets of s2, e.g.
#plot(s2[c('age','albumin'),]) or plot(s2[1:2,])


s2    # invokes print.summary.formula.response


#Plot results as a separate dot chart for each of the 3 strata levels
par(mfrow=c(2,2))
plot(s2, cex.labels=.6, xlim=c(0,40), superposeStrata=FALSE)


#Typeset table, creating s2.tex
w <- latex(s2, cdec=1)
#Typeset table but just print LaTeX code
latex(s2, file="")    # useful for Sweave


#Take control of groups used for age.  Compute 3 quartiles for
#both cholesterol and bilirubin (excluding observations that are missing
#on EITHER ONE)


age.groups <- cut2(age, c(45,60))
g <- function(y) apply(y, 2, quantile, c(.25,.5,.75))
y <- cbind(Chol=chol,Bili=bili)
label(y) <- 'Cholesterol and Bilirubin'
#You can give new column names that are not legal S names
#by enclosing them in quotes, e.g. 'Chol (mg/dl)'=chol


s <- summary(y ~ age.groups + ascites, fun=g)


par(mfrow=c(1,2), oma=c(3,0,3,0))   # allow outer margins for overall
for(ivar in 1:2) {                  # title
  isub <- (1:3)+(ivar-1)*3          # *3=number of quantiles/var.
  plot(s3, which=isub, main='',
       xlab=c('Cholesterol','Bilirubin')[ivar],
       pch=c(91,16,93))            # [, closed circle, ]
  }
mtext(paste('Quartiles of', label(y)), adj=.5, outer=TRUE, cex=1.75)
#Overall (outer) title


prlatex(latex(s3, trios=TRUE))
# trios -> collapse 3 quartiles


#Summarize only bilirubin, but do it with two statistics:
#the mean and the median.  Make separate tables for the two randomized
#groups and make plots for the active arm.
```

```
g <- function(y) c(Mean=mean(y), Median=median(y))


for(sub in c("D-penicillamine", "placebo")) {
  ss <- summary(bili ~ age.groups + ascites + chol, fun=g,
                subset=drug==sub)
  cat('\n',sub,'\n\n')
  print(ss)


  if(sub=='D-penicillamine') {
    par(mfrow=c(1,1))
    plot(s4, which=1:2, dotfont=c(1,-1), subtitles=FALSE, main='')
    #1=mean, 2=median     -1 font = open circle
    title(sub='Closed circle: mean;  Open circle: median', adj=0)
    title(sub=sub, adj=1)
  }


  w <- latex(ss, append=TRUE, fi='my.tex',
             label=if(sub=='placebo') 's4b' else 's4a',
             caption=paste(label(bili),' {\\em (',sub,')}', sep=''))
  #Note symbolic labels for tables for two subsets: s4a, s4b
  prlatex(w)
}


#Now consider examples in 'reverse' format, where the lone dependent
#variable tells the summary function how to stratify all the
#'independent' variables.  This is typically used to make tables
#comparing baseline variables by treatment group, for example.


s5 <- summary(drug ~ bili + albumin + stage + protime + sex +
                     age + spiders,
              method='reverse')
#To summarize all variables, use summary(drug ~., data=pbc)
#To summarize all variables with no stratification, use
#summary(~a+b+c) or summary(~.,data=\dots)


options(digits=1)
print(s5, npct='both')
#npct='both' : print both numerators and denominators
plot(s5, which='categorical')
Key(locator(1))  # draw legend at mouse click
par(oma=c(3,0,0,0))  # leave outer margin at bottom
plot(s5, which='continuous')
Key2()           # draw legend at lower left corner of plot
                 # oma= above makes this default key fit the page better
```

```
options(digits=3)
w <- latex(s5, npct='both', here=TRUE)
# creates s5.tex


#Turn to a different dataset and do cross-classifications on possibly
#more than one independent variable.  The summary function with
#method='cross' produces a data frame containing the cross-
#classifications.  This data frame is suitable for multi-panel
#trellis displays, although `summarize' works better for that.


attach(prostate)
size.quartile <- cut2(sz, g=4)
bone <- factor(bm,labels=c("no mets","bone mets"))


s7 <- summary(ap>1 ~ size.quartile + bone, method='cross')
#In this case, quartiles are the default so could have said sz + bone


options(digits=3)
print(s7, twoway=FALSE)
s7   # same as print(s7)
w <- latex(s7, here=TRUE)   # Make s7.tex


library(trellis,TRUE)
invisible(ps.options(reset=TRUE))
trellis.device(postscript, file='demo2.ps')


dotplot(S ~ size.quartile|bone, data=s7, #s7 is name of summary stats
                 xlab="Fraction ap>1", ylab="Quartile of Tumor Size")
#Can do this more quickly with summarize:
# s7 <- summarize(ap>1, llist(size=cut2(sz, g=4), bone), mean,
#                 stat.name='Proportion')
# dotplot(Proportion ~ size | bone, data=s7)


summary(age ~ stage, method='cross')
summary(age ~ stage, fun=quantile, method='cross')
summary(age ~ stage, fun=smean.sd, method='cross')
summary(age ~ stage, fun=smedian.hilow, method='cross')
summary(age ~ stage, fun=function(x) c(Mean=mean(x), Median=median(x)),
        method='cross')
#The next statements print real two-way tables
summary(cbind(age,ap) ~ stage + bone,
        fun=function(y) apply(y, 2, quantile, c(.25,.75)),
        method='cross')
options(digits=2)
summary(log(ap) ~ sz + bone,
```

```
        fun=function(y) c(Mean=mean(y), quantile(y)),
        method='cross')


#Summarize an ordered categorical response by all of the needed
#cumulative proportions
summary(cumcategory(disease.severity) ~ age + sex)


## End(Not run)
```

---

summaryM *Summarize Mixed Data Types vs. Groups*

Description

summaryM summarizes the variables listed in an S formula, computing descriptive statistics and optionally statistical tests for group differences. This function is typically used when there are multiple left-hand-side variables that are independently against by groups marked by a single right-hand-side variable. The summary statistics may be passed to print methods, plot methods for making annotated dot charts and extended box plots, and latex methods for typesetting tables using LaTeX. The html method uses htmlTable::htmlTable to typeset the table in html, by passing information to the latex method with html=TRUE. This is for use with Quarto/RMarkdown. The print methods use the print.char.matrix function to print boxed tables when options(prType=) has not been given or when prType='plain'. For plain tables, print calls the internal function printsummaryM. When prType='latex' the latex method is invoked, and when prType='html' html is rendered. In Quarto/RMarkdown, proper rendering will result even if results='asis' does not appear in the chunk header. When rendering in html at the console due to having options(prType='html') the table will be rendered in a viewer.

The plot method creates plotly graphics if options(grType='plotly'), otherwise base graphics are used. plotly graphics provide extra information such as which quantile is being displayed when hovering the mouse. Test statistics are displayed by hovering over the mean.

Continuous variables are described by three quantiles (quartiles by default) when printing, or by the following quantiles when plotting expended box plots using the bpplt function: 0.05, 0.125, 0.25, 0.375, 0.5, 0.625, 0.75, 0.875, 0.95. The box plots are scaled to the 0.025 and 0.975 quantiles of each continuous left-hand-side variable. Categorical variables are described by counts and percentages.

The left hand side of formula may contain mChoice ("multiple choice") variables. When test=TRUE each choice is tested separately as a binary categorical response.

The plot method for method="reverse" creates a temporary function Key as is done by the xYplot and Ecdf.formula functions. After plot runs, you can type Key() to put a legend in a default location, or e.g. Key(locator(1)) to draw a legend where you click the left mouse button. This key is for categorical variables, so to have the opportunity to put the key on the graph you will probably want to use the command plot(object, which="categorical"). A second function Key2 is created if continuous variables are being plotted. It is used the same as Key. If the which argument is not specified to plot, two pages of plots will be produced. If you don't define par(mfrow=) yourself, plot.summaryM will try to lay out a multi-panel graph to best fit all the individual charts for continuous variables.

Usage

```
summaryM(formula, groups=NULL, data=NULL, subset, na.action=na.retain,
         overall=FALSE, continuous=10, na.include=FALSE,
         quant=c(0.025, 0.05, 0.125, 0.25, 0.375, 0.5, 0.625,
                 0.75, 0.875, 0.95, 0.975),
         nmin=100, test=FALSE,
         conTest=conTestkw, catTest=catTestchisq,
         ordTest=ordTestpo)

## S3 method for class 'summaryM'
print(...)

printsummaryM(x, digits, prn = any(n != N),
      what=c('proportion', '%'), pctdig = if(what == '%') 0 else 2,
      npct = c('numerator', 'both', 'denominator', 'none'),
      exclude1 = TRUE, vnames = c('labels', 'names'), prUnits = TRUE,
      sep = '/', abbreviate.dimnames = FALSE,
     prefix.width = max(nchar(lab)), min.colwidth, formatArgs=NULL, round=NULL,
      prtest = c('P','stat','df','name'), prmsd = FALSE, long = FALSE,
      pdig = 3, eps = 0.001, prob = c(0.25, 0.5, 0.75), prN = FALSE, ...)

## S3 method for class 'summaryM'
plot(x, vnames = c('labels', 'names'),
     which = c('both', 'categorical', 'continuous'), vars=NULL,
     xlim = c(0,1),
     xlab = 'Proportion',
     pch = c(16, 1, 2, 17, 15, 3, 4, 5, 0), exclude1 = TRUE,
     main, ncols=2,
     prtest = c('P', 'stat', 'df', 'name'), pdig = 3, eps = 0.001,
     conType = c('bp', 'dot', 'raw'), cex.means = 0.5, cex=par('cex'),
     height='auto', width=700, ...)

## S3 method for class 'summaryM'
latex(object, title =
      first.word(deparse(substitute(object))),
      file=paste(title, 'tex', sep='.'), append=FALSE, digits,
      prn = any(n != N), what=c('proportion', '%'),
      pctdig = if(what == '%') 0 else 2,
      npct = c('numerator', 'both', 'denominator', 'slash', 'none'),
      npct.size = if(html) mspecs$html$smaller else 'scriptsize',
      Nsize = if(html) mspecs$html$smaller else 'scriptsize',
      exclude1 = TRUE,
      vnames=c("labels", "names"), prUnits = TRUE, middle.bold = FALSE,
      outer.size = if(html) mspecs$html$smaller else "scriptsize",
      caption, rowlabel = "", rowsep=html,
      insert.bottom = TRUE, dcolumn = FALSE, formatArgs=NULL, round=NULL,
      prtest = c('P', 'stat', 'df', 'name'), prmsd = FALSE,
      msdsize = if(html) function(x) x else NULL, brmsd=FALSE,
```

```
      long = FALSE, pdig = 3, eps = 0.001,
      auxCol = NULL, table.env=TRUE, tabenv1=FALSE, prob=c(0.25, 0.5, 0.75),
      prN=FALSE, legend.bottom=FALSE, html=FALSE,
      mspecs=markupSpecs, ...)

## S3 method for class 'summaryM'
html(object, ...)
```

Arguments

formula	An S formula with additive effects. There may be several variables on the right hand side separated by "+", or the numeral 1, indicating that there is no grouping variable so that only margin summaries are produced. The right hand side variable, if present, must be a discrete variable producing a limited number of groups. On the left hand side there may be any number of variables, separated by "+", and these may be of mixed types. These variables are analyzed separately by the grouping variable.
groups	if there is more than one right-hand variable, specify groups as a character string containing the name of the variable used to produce columns of the table. The remaining right hand variables are combined to produce levels that cause separate tables or plots to be produced.
x	an object created by summaryM. For conTestkw a numeric vector, and for ordTestpo, a numeric or factor variable that can be considered ordered
data	name or number of a data frame. Default is the current frame.
subset	a logical vector or integer vector of subscripts used to specify the subset of data to use in the analysis. The default is to use all observations in the data frame.
na.action	function for handling missing data in the input data. The default is a function defined here called na.retain, which keeps all observations for processing, with missing variables or not.
overall	Setting overall=TRUE makes a new column with overall statistics for the whole sample. If test=TRUE these marginal statistics are ignored in doing statistical tests.
continuous	specifies the threshold for when a variable is considered to be continuous (when there are at least continuous unique values). factor variables are always considered to be categorical no matter how many levels they have.
na.include	Set na.include=TRUE to keep missing values of categorical variables from being excluded from the table.
nmin	For categories of the response variable in which there are less than or equal to nmin non-missing observations, the raw data are retained for later plotting in place of box plots.
test	Set to TRUE to compute test statistics using tests specified in conTest and catTest.
conTest	a function of two arguments (grouping variable and a continuous variable) that returns a list with components P (the computed P-value), stat (the test statistic, either chi-square or F), df (degrees of freedom), testname (test name), namefun ("chisq", "fstat"), statname (statistic name), an optional component latexstat (LaTeX representation of statname), an optional component

plotmathstat (for R - the plotmath representation of statname, as a character string), and an optional component note that contains a character string note about the test (e.g., "test not done because n < 5"). conTest is applied to continuous variables on the right-hand-side of the formula when method="reverse". The default uses the spearman2 function to run the Wilcoxon or Kruskal-Wallis test using the F distribution.

catTest — a function of a frequency table (an integer matrix) that returns a list with the same components as created by conTest. By default, the Pearson chi-square test is done, without continuity correction (the continuity correction would make the test conservative like the Fisher exact test).

ordTest — a function of a frequency table (an integer matrix) that returns a list with the same components as created by conTest. By default, the Proportional odds likelihood ratio test is done.

... — For Key and Key2 these arguments are passed to key, text, or mtitle. For print methods these are optional arguments to print.char.matrix. For latex methods these are passed to latex.default. For html the arguments are passed the latex.summaryM, and the arguments may not include file. For print the arguments are passed to printsummaryM or latex.summaryM depending on options(prType=).

object — an object created by summaryM

quant — vector of quantiles to use for summarizing continuous variables. These must be numbers between 0 and 1 inclusive and must include the numbers 0.5, 0.25, and 0.75 which are used for printing and for plotting quantile intervals. The outer quantiles are used for scaling the x-axes for such plots. Specify outer quantiles as 0 and 1 to scale the x-axes using the whole observed data ranges instead of the default (a 0.95 quantile interval). Box-percentile plots are drawn using all but the outer quantiles.

prob — vector of quantiles to use for summarizing continuous variables. These must be numbers between 0 and 1 inclusive and have previously been included in the quant argument of summaryM. The vector must be of length three. By default it contains 0.25, 0.5, and 0.75.

Warning: specifying 0 and 1 as two of the quantiles will result in computing the minimum and maximum of the variable. As for many random variables the minimum will continue to become smaller as the sample size grows, and the maximum will continue to get larger. Thus the min and max are not recommended as summary statistics.

vnames — By default, tables and plots are usually labeled with variable labels (see the label and sas.get functions). To use the shorter variable names, specify vnames="name".

pch — vector of plotting characters to represent different groups, in order of group levels.

abbreviate.dimnames — see print.char.matrix

prefix.width — see print.char.matrix

min.colwidth — minimum column width to use for boxes printed with print.char.matrix. The default is the maximum of the minimum column label length and the minimum length of entries in the data cells.

formatArgs — a list containing other arguments to pass to format.default such as scientific, e.g., formatArgs=list(scientific=c(-5,5)). For print.summary.formula.reverse and format.summary.formula.reverse, formatArgs applies only to statistics computed on continuous variables, not to percents, numerators, and denominators. The round argument may be preferred.

digits — number of significant digits to print. Default is to use the current value of the digits system option.

what — specifies whether proportions or percentages are to be printed or LaTeX'd

pctdig — number of digits to the right of the decimal place for printing percentages or proportions. The default is zero if what='%', so percents will be rounded to the nearest percent. The default is 2 for proportions.

prn — set to TRUE to print the number of non-missing observations on the current (row) variable. The default is to print these only if any of the counts of non-missing values differs from the total number of non-missing values of the left-hand-side variable.

prN — set to TRUE to print the number of non-missing observations on rows that contain continuous variables.

npct — specifies which counts are to be printed to the right of percentages. The default is to print the frequency (numerator of the percent) in parentheses. You can specify "both" to print both numerator and denominator as a fraction, "denominator", "slash" to typeset horizontally using a forward slash, or "none".

npct.size — the size for typesetting npct information which appears after percents. The default is "scriptsize".

Nsize — When a second row of column headings is added showing sample sizes, Nsize specifies the LaTeX size for these subheadings. Default is "scriptsize".

exclude1 — By default, summaryM objects will be printed, plotted, or typeset by removing redundant entries from percentage tables for categorical variables. For example, if you print the percent of females, you don't need to print the percent of males. To override this, set exclude1=FALSE.

prUnits — set to FALSE to suppress printing or latexing units attributes of variables, when method='reverse' or 'response'

sep — character to use to separate quantiles when printing tables

prtest — a vector of test statistic components to print if test=TRUE was in effect when summaryM was called. Defaults to printing all components. Specify prtest=FALSE or prtest="none" to not print any tests. This applies to print, latex, and plot methods.

round — Specify round to round the quantiles and optional mean and standard deviation to round digits after the decimal point. Set round='auto' to try an automatic choice.

prmsd — set to TRUE to print mean and SD after the three quantiles, for continuous variables

msdsize — defaults to NULL to use the current font size for the mean and standard deviation if prmsd is TRUE. Set to a character string or function to specify an alternate LaTeX font size.

brmsd	set to TRUE to put the mean and standard deviation on a separate line, for html
long	set to TRUE to print the results for the first category on its own line, not on the same line with the variable label
pdig	number of digits to the right of the decimal place for printing P-values. Default is 3. This is passed to format.pval.
eps	P-values less than eps will be printed as < eps. See format.pval.
auxCol	an optional auxiliary column of information, right justified, to add in front of statistics typeset by latex.summaryM. This argument is a list with a single element that has a name specifying the column heading. If this name includes a newline character, the portions of the string before and after the newline form respectively the main heading and the subheading (typically set in smaller font), respectively. See the extracolheads argument to latex.default. auxCol is filled with blanks when a variable being summarized takes up more than one row in the output. This happens with categorical variables.
table.env	set to FALSE to use tabular environment with no caption
tabenv1	set to TRUE in the case of stratification when you want only the first stratum's table to be in a table environment. This is useful when using hyperref.
which	Specifies whether to plot results for categorical variables, continuous variables, or both (the default).
vars	Subscripts (indexes) of variables to plot for plotly graphics. Default is to plot all variables of each type (categorical or continuous).
conType	For drawing plots for continuous variables, extended box plots (box-percentile-type plots) are drawn by default, using all quantiles in quant except for the outermost ones which are using for scaling the overall plot based on the non-stratified marginal distribution of the current response variable. Specify conType='dot' to draw dot plots showing the three quartiles instead. For extended box plots, means are drawn with a solid dot and vertical reference lines are placed at the three quartiles. Specify conType='raw' to make a strip chart showing the raw data. This can only be used if the sample size for each right-hand-side group is less than or equal to nmin.
cex.means	character size for means in box-percentile plots; default is .5
cex	character size for other plotted items
height, width	dimensions in pixels for the plotly subplot object containing all the extended box plots. If height="auto", plot.summaryM will set height based on the number of continuous variables and ncols or for dot charts it will use Hmisc::plotlyHeightDotchart. At present height is ignored for extended box plots due to vertical spacing problem with plotly graphics.
xlim	vector of length two specifying x-axis limits. This is only used for plotting categorical variables. Limits for continuous variables are determined by the outer quantiles specified in quant.
xlab	x-axis label
main	a main title. This applies only to the plot for categorical variables.
ncols	number of columns for plotly graphics for extended box plots. Defaults to 2. Recommendation is for 1-2.

caption	character string containing LaTeX table captions.
title	name of resulting LaTeX file omitting the .tex suffix. Default is the name of the summary object. If caption is specied, title is also used for the table's symbolic reference label.
file	name of file to write LaTeX code to. Specifying file="" will cause LaTeX code to just be printed to standard output rather than be stored in a permanent file.
append	specify TRUE to add code to an existing file
rowlabel	see latex.default (under the help file latex)
rowsep	if html is TRUE, instructs the function to use a horizontal line to separate variables from one another. Recommended if brmsd is TRUE. Ignored for LaTeX.
middle.bold	set to TRUE to have LaTeX use bold face for the middle quantile
outer.size	the font size for outer quantiles
insert.bottom	set to FALSE to suppress inclusion of definitions placed at the bottom of LaTeX tables. You can also specify a character string containing other text that overrides the automatic text. At present such text always appears in the main caption for LaTeX.
legend.bottom	set to TRUE to separate the table caption and legend. This will place table legends at the bottom of LaTeX tables.
html	set to TRUE to typeset with html
mspecs	list defining markup syntax for various languages, defaults to Hmisc markupSpecs which the user can use as a starting point for editing
dcolumn	see latex

Value

a list. plot.summaryM returns the number of pages of plots that were made if using base graphics, or plotly objects created by plotly::subplot otherwise. If both categorical and continuous variables were plotted, the returned object is a list with two named elements Categorical and Continuous each containing plotly objects. Otherwise a plotly object is returned. The latex method returns attributes legend and nstrata.

Side Effects

plot.summaryM creates a function Key and Key2 in frame 0 that will draw legends, if base graphics are being used.

Author(s)

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References

Harrell FE (2004): Statistical tables and plots using S and LaTeX. Document available from https://hbiostat.org/R/Hmisc/summary.pdf.

See Also

mChoice, label, dotchart3, print.char.matrix, update, formula, format.default, latex, latexTranslate, bpplt, tabulr, bpplotM, summaryP

Examples

```
options(digits=3)
set.seed(173)
sex <- factor(sample(c("m","f"), 500, rep=TRUE))
country <- factor(sample(c('US', 'Canada'), 500, rep=TRUE))
age <- rnorm(500, 50, 5)
sbp <- rnorm(500, 120, 12)
label(sbp) <- 'Systolic BP'
units(sbp) <- 'mmHg'
treatment <- factor(sample(c("Drug","Placebo"), 500, rep=TRUE))
treatment[1]
sbp[1] <- NA

# Generate a 3-choice variable; each of 3 variables has 5 possible levels
symp <- c('Headache','Stomach Ache','Hangnail',
          'Muscle Ache','Depressed')
symptom1 <- sample(symp, 500,TRUE)
symptom2 <- sample(symp, 500,TRUE)
symptom3 <- sample(symp, 500,TRUE)
Symptoms <- mChoice(symptom1, symptom2, symptom3, label='Primary Symptoms')
table(as.character(Symptoms))

# Note: In this example, some subjects have the same symptom checked
# multiple times; in practice these redundant selections would be NAs
# mChoice will ignore these redundant selections

f <- summaryM(age + sex + sbp + Symptoms ~ treatment, test=TRUE)
f
# trio of numbers represent 25th, 50th, 75th percentile
print(f, long=TRUE)
plot(f)    # first specify options(grType='plotly') to use plotly
plot(f, conType='dot', prtest='P')
bpplt()    # annotated example showing layout of bp plot

# Produce separate tables by country
f <- summaryM(age + sex + sbp + Symptoms ~ treatment + country,
              groups='treatment', test=TRUE)
f

## Not run:
getHdata(pbc)
s5 <- summaryM(bili + albumin + stage + protime + sex +
               age + spiders ~ drug, data=pbc)

print(s5, npct='both')
# npct='both' : print both numerators and denominators
plot(s5, which='categorical')
```

```
Key(locator(1))  # draw legend at mouse click
par(oma=c(3,0,0,0))  # leave outer margin at bottom
plot(s5, which='continuous')  # see also bpplotM
Key2()           # draw legend at lower left corner of plot
                 # oma= above makes this default key fit the page better

options(digits=3)
w <- latex(s5, npct='both', here=TRUE, file='')

options(grType='plotly')
pbc <- upData(pbc, moveUnits = TRUE)
s <- summaryM(bili + albumin + alk.phos + copper + spiders + sex ~
              drug, data=pbc, test=TRUE)
# Render html
options(prType='html')
s   # invokes print.summaryM
a <- plot(s)
a$Categorical
a$Continuous
plot(s, which='con')

## End(Not run)
```

---

summaryP *Multi-way Summary of Proportions*

Description

summaryP produces a tall and thin data frame containing numerators (freq) and denominators (denom) after stratifying the data by a series of variables. A special capability to group a series of related yes/no variables is included through the use of the ynbind function, for which the user specials a final argument label used to label the panel created for that group of related variables.

If options(grType='plotly') is not in effect, the plot method for summaryP displays proportions as a multi-panel dot chart using the lattice package's dotplot function with a special panel function. Numerators and denominators of proportions are also included as text, in the same colors as used by an optional groups variable. The formula argument used in the dotplot call is constructed, but the user can easily reorder the variables by specifying formula, with elements named val (category levels), var (classification variable name), freq (calculated result) plus the overall cross-classification variables excluding groups. If options(grType='plotly') is in effect, the plot method makes an entirely different display using Hmisc::dotchartpl with plotly if marginVal is specified, whereby a stratification variable causes more finely stratified estimates to be shown slightly below the lines, with smaller and translucent symbols if data has been run through addMarginal. The marginal summaries are shown as the main estimates and the user can turn off display of the stratified estimates, or view their details with hover text.

The ggplot method for summaryP does not draw numerators and denominators but the chart is more compact than using the plot method with base graphics because ggplot2 does not repeat category names the same way as lattice does. Variable names that are too long to fit in panel strips are renamed (1), (2), etc. and an attribute "fnvar" is added to the result; this attribute is a character

string defining the abbreviations, useful in a figure caption. The ggplot2 object has labels for points plotted, used by plotly::ggplotly as hover text (see example).

The latex method produces one or more LaTeX tabulars containing a table representation of the result, with optional side-by-side display if groups is specified. Multiple tabulars result from the presence of non-group stratification factors.

Usage

```
summaryP(formula, data = NULL, subset = NULL,
         na.action = na.retain, sort=TRUE,
         asna = c("unknown", "unspecified"), ...)
## S3 method for class 'summaryP'
plot(x, formula=NULL, groups=NULL,
         marginVal=NULL, marginLabel=marginVal,
         refgroup=NULL, exclude1=TRUE,  xlim = c(-.05, 1.05),
         text.at=NULL, cex.values = 0.5,
         key = list(columns = length(groupslevels), x = 0.75,
                    y = -0.04, cex = 0.9,
                    col = lattice::trellis.par.get('superpose.symbol')$col,
                    corner=c(0,1)),
         outerlabels=TRUE, autoarrange=TRUE,
         col=colorspace::rainbow_hcl, ...)
## S3 method for class 'summaryP'
ggplot(data, mapping, groups=NULL, exclude1=TRUE,
           xlim=c(0, 1), col=NULL, shape=NULL, size=function(n) n ^ (1/4),
           sizerange=NULL, abblen=5, autoarrange=TRUE, addlayer=NULL,
           ..., environment)
## S3 method for class 'summaryP'
latex(object, groups=NULL, exclude1=TRUE, file='', round=3,
                           size=NULL, append=TRUE, ...)
```

Arguments

formula	a formula with the variables for whose levels proportions are computed on the left hand side, and major classification variables on the right. The formula need to include any variable later used as groups, as the data summarization does not distinguish between superpositioning and paneling. For the plot method, formula can provide an overall to the default formula for dotplot().
data	an optional data frame. For ggplot.summaryP data is the result of summaryP.
subset	an optional subsetting expression or vector
na.action	function specifying how to handle NAs. The default is to keep all NAs in the analysis frame.
sort	set to FALSE to not sort category levels in descending order of global proportions
asna	character vector specifying level names to consider the same as NA. Set asna=NULL to not consider any.
x	an object produced by summaryP

groups — a character string containing the name of a superpositioning variable for obtaining further stratification within a horizontal line in the dot chart.

marginVal — if options(grType='plotly') is in effect and the data given to summaryP were run through addMarginal, specifies the category name that represents marginal summaries (usually "All").

marginLabel — specifies a different character string to use than the value of marginVal. For example, if marginal proportions were computed over all regions, one may specify marginVal="All", marginLabel="All Regions". marginLabel is only used for formatting graphical output.

refgroup — used when doing a plotly chart and a two-level group variable was used, resulting in the half-width confidence interval for the difference in two proportions to be shown, and the actual confidence limits and the difference added to hover text. See dotchartpl for more details.

exclude1 — By default, ggplot, plot, and latex methods for summaryP remove redundant entries from tables for variables with only two levels. For example, if you print the proportion of females, you don't need to print the proportion of males. To override this, set exclude1=FALSE.

xlim — x-axis limits. Default is c(0,1).

text.at — specify to leave unused space to the right of each panel to prevent numerators and denominators from touching data points. text.at is the upper limit for scaling panels' x-axes but tick marks are only labeled up to max(xlim).

cex.values — character size to use for plotting numerators and denominators

key — a list to pass to the auto.key argument of dotplot. To place a key above the entire chart use auto.key=list(columns=2) for example.

outerlabels — by default if there are two conditioning variables besides groups, the latticeExtra package's useOuterStrips function is used to put strip labels in the margins, usually resulting in a much prettier chart. Set to FALSE to prevent usage of useOuterStrips.

autoarrange — If TRUE, the formula is re-arranged so that if there are two conditioning (paneling) variables, the variable with the most levels is taken as the vertical condition.

col — a vector of colors to use to override defaults in ggplot. When options(grType='plotly'), see dotchartpl.

shape — a vector of plotting symbols to override ggplot defaults

mapping, environment — not used; needed because of rules for generics

size — for ggplot, a function that transforms denominators into metrics used for the size aesthetic. Default is the fourth root function so that the area of symbols is proportional to the square root of sample size. Specify NULL to not vary point sizes. size=sqrt is a reasonable alternative. Set size to an integer to categorize the denominators into size quantile groups using cut2. Unless size is an integer, the legend for sizes uses the minimum and maximum denominators and 6-tiles using quantile(..., type=1) so that actually occurring sample sizes are used as labels. size is overridden to NULL if the range in denominators is less than 10 or the ratio of the maximum to the minimum is less than 1.2. For latex, size is an optional font size such as "small"

sizerange	a 2-vector specifying the range argument to the ggplot2 scale_size_... function, which is the range of sizes allowed for the points according to the denominator. The default is sizerange=c(.7, 3.25) but the lower limit is increased according to the ratio of maximum to minimum sample sizes.
abblen	labels of variables having only one level and having their name longer than abblen characters are abbreviated and documented in fnvar (described elsewhere here). The default abblen=5 is good for labels plotted vertically. If labels are rotated using theme a better value would be 12.
...	used only for plotly graphics and these arguments are passed to dotchartpl
object	an object produced by summaryP
file	file name, defaults to writing to console
round	number of digits to the right of the decimal place for proportions
append	set to FALSE to start output over
addlayer	a ggplot layer to add to the plot object

Value

summaryP produces a data frame of class "summaryP". The plot method produces a lattice object of class "trellis". The latex method produces an object of class "latex" with an additional attribute nglouplevels specifying the number of levels of any groups variable and an attribute nstrata specifying the number of strata.

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See Also

bpplotM, summaryM, ynbind, pBlock, ggplot, colorFacet

Examples

```
n <- 100
f <- function(na=FALSE) {
  x <- sample(c('N', 'Y'), n, TRUE)
  if(na) x[runif(100) < .1] <- NA
  x
}
set.seed(1)
d <- data.frame(x1=f(), x2=f(), x3=f(), x4=f(), x5=f(), x6=f(), x7=f(TRUE),
                age=rnorm(n, 50, 10),
                race=sample(c('Asian', 'Black/AA', 'White'), n, TRUE),
                sex=sample(c('Female', 'Male'), n, TRUE),
                treat=sample(c('A', 'B'), n, TRUE),
                region=sample(c('North America','Europe'), n, TRUE))
```

```
d <- upData(d, labels=c(x1='MI', x2='Stroke', x3='AKI', x4='Migraines',
                 x5='Pregnant', x6='Other event', x7='MD withdrawal',
                 race='Race', sex='Sex'))
dasna <- subset(d, region=='North America')
with(dasna, table(race, treat))
s <- summaryP(race + sex + ynbind(x1, x2, x3, x4, x5, x6, x7, label='Exclusions') ~
              region + treat, data=d)
# add exclude1=FALSE below to include female category
plot(s, groups='treat')
require(ggplot2)
ggplot(s, groups='treat')

plot(s, val ~ freq | region * var, groups='treat', outerlabels=FALSE)
# Much better looking if omit outerlabels=FALSE; see output at
# https://hbiostat.org/R/Hmisc/summaryFuns.pdf
# See more examples under bpplotM

## For plotly interactive graphic that does not handle variable size
## panels well:
## require(plotly)
## g <- ggplot(s, groups='treat')
## ggplotly(g, tooltip='text')

## For nice plotly interactive graphic:
## options(grType='plotly')
## s <- summaryP(race + sex + ynbind(x1, x2, x3, x4, x5, x6, x7,
##                                   label='Exclusions') ~
##               treat, data=subset(d, region='Europe'))
##
## plot(s, groups='treat', refgroup='A')  # refgroup='A' does B-A differences


# Make a chart where there is a block of variables that
# are only analyzed for males.  Keep redundant sex in block for demo.
# Leave extra space for numerators, denominators
sb <- summaryP(race + sex +
               pBlock(race, sex, label='Race: Males', subset=sex=='Male') ~
               region, data=d)
plot(sb, text.at=1.3)
plot(sb, groups='region', layout=c(1,3), key=list(space='top'),
     text.at=1.15)
ggplot(sb, groups='region')
## Not run:
plot(s, groups='treat')
# plot(s, groups='treat', outerlabels=FALSE) for standard lattice output
plot(s, groups='region', key=list(columns=2, space='bottom'))
require(ggplot2)
colorFacet(ggplot(s))

plot(summaryP(race + sex ~ region, data=d), exclude1=FALSE, col='green')

require(lattice)
# Make your own plot using data frame created by summaryP
```

```
useOuterStrips(dotplot(val ~ freq | region * var, groups=treat, data=s,
        xlim=c(0,1), scales=list(y='free', rot=0), xlab='Fraction',
        panel=function(x, y, subscripts, ...) {
          denom <- s$denom[subscripts]
          x <- x / denom
          panel.dotplot(x=x, y=y, subscripts=subscripts, ...) }))

# Show marginal summary for all regions combined
s <- summaryP(race + sex ~ region, data=addMarginal(d, region))
plot(s, groups='region', key=list(space='top'), layout=c(1,2))

# Show marginal summaries for both race and sex
s <- summaryP(ynbind(x1, x2, x3, x4, label='Exclusions', sort=FALSE) ~
              race + sex, data=addMarginal(d, race, sex))
plot(s, val ~ freq | sex*race)

## End(Not run)
```

---

summaryRc *Graphical Summarization of Continuous Variables Against a Response*

Description

summaryRc is a continuous version of summary.formula with method='response'. It uses the plsmo function to compute the possibly stratified lowess nonparametric regression estimates, and plots them along with the data density, with selected quantiles of the overall distribution (over strata) of each x shown as arrows on top of the graph. All the x variables must be numeric and continuous or nearly continuous.

Usage

```
summaryRc(formula, data=NULL, subset=NULL,
          na.action=NULL, fun = function(x) x,
          na.rm = TRUE, ylab=NULL, ylim=NULL, xlim=NULL,
          nloc=NULL, datadensity=NULL,
          quant = c(0.05, 0.1, 0.25, 0.5, 0.75,
                    0.90, 0.95), quantloc=c('top','bottom'),
          cex.quant=.6, srt.quant=0,
          bpplot = c('none', 'top', 'top outside', 'top inside', 'bottom'),
          height.bpplot=0.08,
          trim=NULL, test = FALSE, vnames = c('labels', 'names'), ...)
```

Arguments

formula	An R formula with additive effects. The formula may contain one or more invocations of the stratify function whose arguments are defined below. This causes the entire analysis to be stratified by cross-classifications of the combined list of stratification factors. This stratification will be reflected as separate lowess curves.

data	name or number of a data frame. Default is the current frame.
subset	a logical vector or integer vector of subscripts used to specify the subset of data to use in the analysis. The default is to use all observations in the data frame.
na.action	function for handling missing data in the input data. The default is a function defined here called na.retain, which keeps all observations for processing, with missing variables or not.
fun	function for transforming lowess estimates. Default is the identity function.
na.rm	TRUE (the default) to exclude NAs before passing data to fun to compute statistics, FALSE otherwise.
ylab	y-axis label. Default is label attribute of y variable, or its name.
ylim	y-axis limits. By default each graph is scaled on its own.
xlim	a list with elements named as the variable names appearing on the x-axis, with each element being a 2-vector specifying lower and upper limits. Any variable not appearing in the list will have its limits computed and possibly trimmed.
nloc	location for sample size. Specify nloc=FALSE to suppress, or nloc=list(x=,y=) where x,y are relative coordinates in the data window. Default position is in the largest empty space.
datadensity	see plsmo. Defaults to TRUE if there is a stratify variable, FALSE otherwise.
quant	vector of quantiles to use for summarizing the marginal distribution of each x. This must be numbers between 0 and 1 inclusive. Use NULL to omit quantiles.
quantloc	specify quantloc='bottom' to place at the bottom of each plot rather than the default
cex.quant	character size for writing which quantiles are represented. Set to 0 to suppress quantile labels.
srt.quant	angle for text for quantile labels
bpplot	if not 'none' will draw extended box plot at location given by bpplot, and quantiles discussed above will be suppressed. Specifying bpplot='top' is the same as specifying bpplot='top inside'.
height.bpplot	height in inches of the horizontal extended box plot
trim	The default is to plot from the 10th smallest to the 10th largest x if the number of non-NAs exceeds 200, otherwise to use the entire range of x. Specify another quantile to use other limits, e.g., trim=0.01 will use the first and last percentiles
test	Set to TRUE to plot test statistics (not yet implemented).
vnames	By default, plots are usually labeled with variable labels (see the label and sas.get functions). To use the shorter variable names, specify vnames="names".
...	arguments passed to plsmo

Value

no value is returned

Author(s)

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See Also

plsmo, stratify, label, formula, panel.bpplot

Examples

```
options(digits=3)
set.seed(177)
sex <- factor(sample(c("m","f"), 500, rep=TRUE))
age <- rnorm(500, 50, 5)
bp  <- rnorm(500, 120, 7)
units(age) <- 'Years'; units(bp) <- 'mmHg'
label(bp) <- 'Systolic Blood Pressure'
L <- .5*(sex == 'm') + 0.1 * (age - 50)
y <- rbinom(500, 1, plogis(L))
par(mfrow=c(1,2))
summaryRc(y ~ age + bp)
# For x limits use 1st and 99th percentiles to frame extended box plots
summaryRc(y ~ age + bp, bpplot='top', datadensity=FALSE, trim=.01)
summaryRc(y ~ age + bp + stratify(sex),
          label.curves=list(keys='lines'), nloc=list(x=.1, y=.05))
y2 <- rbinom(500, 1, plogis(L + .5))
Y <- cbind(y, y2)
summaryRc(Y ~ age + bp + stratify(sex),
          label.curves=list(keys='lines'), nloc=list(x=.1, y=.05))
```

---

summaryS *Summarize Multiple Response Variables and Make Multipanel Scatter or Dot Plot*

Description

Multiple left-hand formula variables along with right-hand side conditioning variables are reshaped into a "tall and thin" data frame if fun is not specified. The resulting raw data can be plotted with the plot method using user-specified panel functions for lattice graphics, typically to make a scatterplot or loess smooths, or both. The Hmisc panel.plsmo function is handy in this context. Instead, if fun is specified, this function takes individual response variables (which may be matrices, as in Surv objects) and creates one or more summary statistics that will be computed while the resulting data frame is being collapsed to one row per condition. The plot method in this case plots a multi-panel dot chart using the lattice dotplot function if panel is not specified to plot. There is an option to print selected statistics as text on the panels. summaryS pays special attention to Hmisc variable annotations: label, units. When panel is specified in addition to fun, a special

x-y plot is made that assumes that the x-axis variable (typically time) is discrete. This is used for example to plot multiple quantile intervals as vertical lines next to the main point. A special panel function mvarclPanel is provided for this purpose.

The plotp method produces corresponding plotly graphics.

When fun is given and panel is omitted, and the result of fun is a vector of more than one statistic, the first statistic is taken as the main one. Any columns with names not in textonly will figure into the calculation of axis limits. Those in textonly will be printed right under the dot lines in the dot chart. Statistics with names in textplot will figure into limits, be plotted, and printed. pch.stats can be used to specify symbols for statistics after the first column. When fun computed three columns that are plotted, columns two and three are taken as confidence limits for which horizontal "error bars" are drawn. Two levels with different thicknesses are drawn if there are four plotted summary statistics beyond the first.

mbarclPanel is used to draw multiple vertical lines around the main points, such as a series of quantile intervals stratified by x and paneling variables. If mbarclPanel finds a column of an aru-ment yother that is named "se", and if there are exactly two levels to a superpositioning variable, the half-height of the approximate 0.95 confidence interval for the difference between two point estimates is shown, positioned at the midpoint of the two point estimates at an x value. This assume normality of point estimates, and the standard error of the difference is the square root of the sum of squares of the two standard errors. By positioning the intervals in this fashion, a failure of the two point estimates to touch the half-confidence interval is consistent with rejecting the null hypothesis of no difference at the 0.05 level.

mbarclpl is the sfun function corresponding to mbarclPanel for plotp, and medvpl is the sfun replacement for medvPanel.

medvPanel takes raw data and plots median y vs. x, along with confidence intervals and half-interval for the difference in medians as with mbarclPanel. Quantile intervals are optional. Very transparent vertical violin plots are added by default. Unlike panel.violin, only half of the violin is plotted, and when there are two superpose groups they are side-by-side in different colors.

For plotp, the function corresponding to medvPanel is medvpl, which draws back-to-back spike histograms, optional Gini mean difference, optional SD, quantiles (thin line version of box plot with 0.05 0.25 0.5 0.75 0.95 quantiles), and half-width confidence interval for differences in medians. For quantiles, the Harrell-Davis estimator is used.

Usage

```
summaryS(formula, fun = NULL, data = NULL, subset = NULL,
         na.action = na.retain, continuous=10, ...)

## S3 method for class 'summaryS'
plot(x, formula=NULL, groups=NULL, panel=NULL,
           paneldoesgroups=FALSE, datadensity=NULL, ylab='',
           funlabel=NULL, textonly='n', textplot=NULL,
           digits=3, custom=NULL,
           xlim=NULL, ylim=NULL, cex.strip=1, cex.values=0.5, pch.stats=NULL,
           key=list(columns=length(groupslevels),
             x=.75, y=-.04, cex=.9,
             col=lattice::trellis.par.get('superpose.symbol')$col,
             corner=c(0,1)),
```

```
            outerlabels=TRUE, autoarrange=TRUE, scat1d.opts=NULL, ...)

## S3 method for class 'summaryS'
plotp(data, formula=NULL, groups=NULL, sfun=NULL,
            fitter=NULL, showpts=! length(fitter), funlabel=NULL,
            digits=5, xlim=NULL, ylim=NULL,
            shareX=TRUE, shareY=FALSE, autoarrange=TRUE, ...)

mbarclPanel(x, y, subscripts, groups=NULL, yother, ...)

medvPanel(x, y, subscripts, groups=NULL, violin=TRUE, quantiles=FALSE, ...)

mbarclpl(x, y, groups=NULL, yother, yvar=NULL, maintracename='y',
         xlim=NULL, ylim=NULL, xname='x', alphaSegments=0.45, ...)

medvpl(x, y, groups=NULL, yvar=NULL, maintracename='y',
       xlim=NULL, ylim=NULL, xlab=xname, ylab=NULL, xname='x',
       zeroline=FALSE, yother=NULL, alphaSegments=0.45,
       dhistboxp.opts=NULL, ...)
```

Arguments

formula	a formula with possibly multiple left and right-side variables separated by +. Analysis (response) variables are on the left and are typically numeric. For plot, formula is optional and overrides the default formula inferred for the reshaped data frame.
fun	an optional summarization function, e.g., smean.sd
data	optional input data frame. For plotp is the object produced by summaryS.
subset	optional subsetting criteria
na.action	function for dealing with NAs when constructing the model data frame
continuous	minimum number of unique values for a numeric variable to have to be considered continuous
...	ignored for summaryS and mbarclPanel, passed to strip and panel for plot. Passed to the density function by medvPanel. For plotp, are passed to plotlyM and sfun. For mbarclpl, passed to plotlyM.
x	an object created by summaryS. For mbarclPanel is an x-axis argument provided by lattice
groups	a character string or factor specifying that one of the conditioning variables is used for superpositioning and not paneling
panel	optional lattice panel function
paneldoesgroups	set to TRUE if, like panel.plsmo, the paneling function internally handles superpositioning for groups
datadensity	set to TRUE to add rug plots etc. using scat1d
ylab	optional y-axis label

funlabel	optional axis label for when fun is given
textonly	names of statistics to print and not plot. By default, any statistic named "n" is only printed.
textplot	names of statistics to print and plot
digits	used if any statistics are printed as text (including plotly hovertext), to specify the number of significant digits to render
custom	a function that customizes formatting of statistics that are printed as text. This is useful for generating plotmath notation. See the example in the tests directory.
xlim	optional x-axis limits
ylim	optional y-axis limits
cex.strip	size of strip labels
cex.values	size of statistics printed as text
pch.stats	symbols to use for statistics (not included the one one in columne one) that are plotted. This is a named vectors, with names exactly matching those created by fun. When a column does not have an entry in pch.stats, no point is drawn for that column.
key	lattice key specification
outerlabels	set to FALSE to not pass two-way charts through useOuterStrips
autoarrange	set to FALSE to prevent plot from trying to optimize which conditioning variable is vertical
scat1d.opts	a list of options to specify to scat1d
y, subscripts	provided by lattice
yother	passed to the panel function from the plot method based on multiple statistics computed
violin	controls whether violin plots are included
quantiles	controls whether quantile intervals are included
sfun	a function called by plotp.summaryS to compute and plot user-specified summary measures. Two functions for doing this are provided here: mbarclpl, medvpl.
fitter	a fitting function such as loess to smooth points. The smoothed values over a systematic grid will be evaluated and plotted as curves.
showpts	set to TRUE to show raw data points in additon to smoothed curves
shareX	TRUE to cause plotly to share a single x-axis when graphs are aligned vertically
shareY	TRUE to cause plotly to share a single y-axis when graphs are aligned horizontally
yvar	a character or factor variable used to stratify the analysis into multiple y-variables
maintracename	a default trace name when it can't be inferred
xname	x-axis variable name for hover text when it can't be inferred
xlab	x-axis label when it can't be inferred
alphaSegments	alpha saturation to draw line segments for plotly
dhistboxp.opts	list of options to pass to dhistboxp
zeroline	set to FALSE to suppress plotly zero line at x=0

Value

a data frame with added attributes for `summaryS` or a `lattice` object ready to render for `plot`

Author(s)

Frank Harrell

See Also

`summary`, `summarize`

Examples

```
# See tests directory file summaryS.r for more examples, and summarySp.r
# for plotp examples
require(survival)
n <- 100
set.seed(1)
d <- data.frame(sbp=rnorm(n, 120, 10),
                dbp=rnorm(n, 80, 10),
                age=rnorm(n, 50, 10),
                days=sample(1:n, n, TRUE),
                S1=Surv(2*runif(n)), S2=Surv(runif(n)),
                race=sample(c('Asian', 'Black/AA', 'White'), n, TRUE),
                sex=sample(c('Female', 'Male'), n, TRUE),
                treat=sample(c('A', 'B'), n, TRUE),
                region=sample(c('North America','Europe'), n, TRUE),
                meda=sample(0:1, n, TRUE), medb=sample(0:1, n, TRUE))

d <- upData(d, labels=c(sbp='Systolic BP', dbp='Diastolic BP',
            race='Race', sex='Sex', treat='Treatment',
            days='Time Since Randomization',
            S1='Hospitalization', S2='Re-Operation',
            meda='Medication A', medb='Medication B'),
            units=c(sbp='mmHg', dbp='mmHg', age='Year', days='Days'))

s <- summaryS(age + sbp + dbp ~ days + region + treat,  data=d)
# plot(s)   # 3 pages
plot(s, groups='treat', datadensity=TRUE,
     scat1d.opts=list(lwd=.5, nhistSpike=0))
plot(s, groups='treat', panel=lattice::panel.loess,
     key=list(space='bottom', columns=2),
     datadensity=TRUE, scat1d.opts=list(lwd=.5))

# To make a plotly graph when the stratification variable region is not
# present, run the following (showpts adds raw data points):
# plotp(s, groups='treat', fitter=loess, showpts=TRUE)

# Make your own plot using data frame created by summaryP
# xyplot(y ~ days | yvar * region, groups=treat, data=s,
#        scales=list(y='free', rot=0))
```

```
# Use loess to estimate the probability of two different types of events as
# a function of time
s <- summaryS(meda + medb ~ days + treat + region, data=d)
pan <- function(...)
   panel.plsmo(..., type='l', label.curves=max(which.packet()) == 1,
               datadensity=TRUE)
plot(s, groups='treat', panel=pan, paneldoesgroups=TRUE,
     scat1d.opts=list(lwd=.7), cex.strip=.8)

# Repeat using intervals instead of nonparametric smoother
pan <- function(...)  # really need mobs > 96 to est. proportion
  panel.plsmo(..., type='l', label.curves=max(which.packet()) == 1,
              method='intervals', mobs=5)

plot(s, groups='treat', panel=pan, paneldoesgroups=TRUE, xlim=c(0, 150))


# Demonstrate dot charts of summary statistics
s <- summaryS(age + sbp + dbp ~ region + treat, data=d, fun=mean)
plot(s)
plot(s, groups='treat', funlabel=expression(bar(X)))
# Compute parametric confidence limits for mean, and include sample
# sizes by naming a column "n"

f <- function(x) {
  x <- x[! is.na(x)]
  c(smean.cl.normal(x, na.rm=FALSE), n=length(x))
}
s <- summaryS(age + sbp + dbp ~ region + treat, data=d, fun=f)
plot(s, funlabel=expression(bar(X) %+-% t[0.975] %*% s))
plot(s, groups='treat', cex.values=.65,
     key=list(space='bottom', columns=2,
       text=c('Treatment A:','Treatment B:')))

# For discrete time, plot Harrell-Davis quantiles of y variables across
# time using different line characteristics to distinguish quantiles
d <- upData(d, days=round(days / 30) * 30)
g <- function(y) {
  probs <- c(0.05, 0.125, 0.25, 0.375)
  probs <- sort(c(probs, 1 - probs))
  y <- y[! is.na(y)]
  w <- hdquantile(y, probs)
  m <- hdquantile(y, 0.5, se=TRUE)
  se <- as.numeric(attr(m, 'se'))
  c(Median=as.numeric(m), w, se=se, n=length(y))
}
s <- summaryS(sbp + dbp ~ days + region, fun=g, data=d)
plot(s, panel=mbarclPanel)
plot(s, groups='region', panel=mbarclPanel, paneldoesgroups=TRUE)

# For discrete time, plot median y vs x along with CL for difference,
# using Harrell-Davis median estimator and its s.e., and use violin
# plots
```

```
s <- summaryS(sbp + dbp ~ days + region, data=d)
plot(s, groups='region', panel=medvPanel, paneldoesgroups=TRUE)

# Proportions and Wilson confidence limits, plus approx. Gaussian
# based half/width confidence limits for difference in probabilities
g <- function(y) {
  y <- y[!is.na(y)]
  n <- length(y)
  p <- mean(y)
  se <- sqrt(p * (1. - p) / n)
  structure(c(binconf(sum(y), n), se=se, n=n),
            names=c('Proportion', 'Lower', 'Upper', 'se', 'n'))
}
s <- summaryS(meda + medb ~ days + region, fun=g, data=d)
plot(s, groups='region', panel=mbarclPanel, paneldoesgroups=TRUE)
```

`symbol.freq` *Graphic Representation of a Frequency Table*

Description

This function can be used to represent contingency tables graphically. Frequency counts are represented as the heights of "thermometers" by default; you can also specify `symbol='circle'` to the function. There is an option to include marginal frequencies, which are plotted on a halved scale so as to not overwhelm the plot. If you do not ask for marginal frequencies to be plotted using `marginals=T`, `symbol.freq` will ask you to click the mouse where a reference symbol is to be drawn to assist in reading the scale of the frequencies.

`label` attributes, if present, are used for x- and y-axis labels. Otherwise, names of calling arguments are used.

Usage

```
symbol.freq(x, y, symbol = c("thermometer", "circle"),
            marginals = FALSE, orig.scale = FALSE,
            inches = 0.25, width = 0.15, subset, srtx = 0, ...)
```

Arguments

`x`	first variable to cross-classify
`y`	second variable
`symbol`	specify `"thermometer"` (the default) or `"circle"`
`marginals`	set to `TRUE` to add marginal frequencies (scaled by half) to the plot
`orig.scale`	set to `TRUE` when the first two arguments are numeric variables; this uses their original values for x and y coordinates)
`inches`	see `symbols`

width	see thermometers option in symbols
subset	the usual subsetting vector
srtx	rotation angle for x-axis labels
...	other arguments to pass to symbols

Author(s)

Frank Harrell

See Also

symbols

Examples

```
## Not run:
getHdata(titanic)
attach(titanic)
age.tertile <- cut2(titanic$age, g=3)
symbol.freq(age.tertile, pclass, marginals=T, srtx=45)
detach(2)

## End(Not run)
```

---

sys *Run Unix or Dos Depending on System*

Description

Runs unix or dos depending on the current operating system. For R, just runs system with optional concatenation of first two arguments which are assumed named command and text.

Usage

```
sys(command, text=NULL, output=TRUE)
# S-Plus: sys(\dots, minimized=FALSE)
```

Arguments

command	system command to execute
text	text to concatenate to system command, if any (typically options or file names or both)
output	set to FALSE to not return output of command as a character vector

Value

see unix or dos

Side Effects

executes system commands

See Also

unix, system

`t.test.cluster` *t-test for Clustered Data*

Description

Does a 2-sample t-test for clustered data.

Usage

```
t.test.cluster(y, cluster, group, conf.int = 0.95)
## S3 method for class 't.test.cluster'
print(x, digits, ...)
```

Arguments

`y`	normally distributed response variable to test
`cluster`	cluster identifiers, e.g. subject ID
`group`	grouping variable with two values
`conf.int`	confidence coefficient to use for confidence limits
`x`	an object created by `t.test.cluster`
`digits`	number of significant digits to print
`...`	unused

Value

a matrix of statistics of class `t.test.cluster`

Author(s)

Frank Harrell

References

Donner A, Birkett N, Buck C, Am J Epi 114:906-914, 1981.

Donner A, Klar N, J Clin Epi 49:435-439, 1996.

Hsieh FY, Stat in Med 8:1195-1201, 1988.

See Also

t.test

Examples

```
set.seed(1)
y <- rnorm(800)
group <- sample(1:2, 800, TRUE)
cluster <- sample(1:40, 800, TRUE)
table(cluster,group)
t.test(y ~ group)   # R only
t.test.cluster(y, cluster, group)
# Note: negate estimates of differences from t.test to
# compare with t.test.cluster
```

---

tabulr *Interface to Tabular Function*

Description

tabulr is a front-end to the tables package's tabular function so that the user can take advantage of variable annotations used by the Hmisc package, particular those created by the label, units, and upData functions. When a variable appears in a tabular function, the variable x is found in the data argument or in the parent environment, and the labelLatex function is used to create a LaTeX label. By default any units of measurement are right justified in the current LaTeX tabular field using hfill; use nofill to list variables for which units are not right-justified with hfill. Once the label is constructed, the variable name is preceeded by Heading("LaTeX label")*x in the formula before it is passed to tabular. nolabel can be used to specify variables for which labels are ignored.

tabulr also replaces trio with table_trio, N with table_N, and freq with table_freq in the formula.

table_trio is a function that takes a numeric vector and computes the three quartiles and optionally the mean and standard deviation, and outputs a LaTeX-formatted character string representing the results. By default, calculated statistics are formatted with 3 digits to the left and 1 digit to the right of the decimal point. Running table_options(left=l, right=r) will use l and r digits instead. Other options that can be given to table_options are prmsd=TRUE to add mean +/- standard deviation to the result, pn=TRUE to add the sample size, bold=TRUE to set the median in bold face, showfreq='all','low', 'high' used by the table_freq function, pctdec, specifying the number of places to the right of the decimal point for percentages (default is zero), and npct='both','numerator','denominator','none' used by table_formatpct to control what appears after the percent. Option pnformat may be specified to control the formatting for pn. The default is "(n=..)". Specify pnformat="non" to suppress "n=". pnwhen specifies when to print the number of observations. The default is "always". Specify pnwhen="ifna" to include n only if there are missing values in the vector being processed.

tabulr substitutes table_N for N in the formula. This is used to create column headings for the number of observations, without a row label.

table_freq analyzes a character variable to compute, for a single output cell, the percents, numerator, and denominator for each category, or optimally just the maximum or minimum, as specified by table_options(showfreq).

table_formatpct is a function that formats percents depending on settings of options in table_options.

nFm is a function that calls sprintf to format numeric values to have a specific number of digits to the left and to the right of the point.

table_latexdefs writes (by default) to the console a set of LaTeX definitions that can be invoked at any point thereafter in a knitr or sweave document by naming the macro, preceeded by a single slash. The blfootnote macro is called with a single LaTeX argument which will appear as a footnote without a number. keytrio invokes blfootnote to define the output of table_trio if mean and SD are not included. If mean and SD are included, use keytriomsd.

Usage

```
tabulr(formula, data = NULL, nolabel=NULL, nofill=NULL, ...)
table_trio(x)
table_freq(x)
table_formatpct(num, den)
nFm(x, left, right, neg=FALSE, pad=FALSE, html=FALSE)
table_latexdefs(file='')
```

Arguments

formula	a formula suitable for tabular except for the addition of .(variable name), .n(), trio.
data	a data frame or list. If omitted, the parent environment is assumed to contain the variables.
nolabel	a formula such as ~ x1 + x2 containing the list of variables for which labels are to be ignored, forcing use of the variable name
nofill	a formula such as ~ x1 + x2 contaning the list of variables for which units of measurement are not to be right-justified in the field using the LaTeX hfill directive
...	other arguments to tabular
x	a numeric vector
num	a single numerator or vector of numerators
den	a single denominator
left, right	number of places to the left and right of the decimal point, respectively
neg	set to TRUE if negative x values are allowed, to add one more space to the left of the decimal place
pad	set to TRUE to replace blanks with the LaTeX tilde placeholder
html	set to TRUE to make pad use an HTML space character instead of a LaTeX tilde space
file	location of output of table_latexdefs

Value

tabulr returns an object of class "tabular"

Author(s)

Frank Harrell

See Also

tabular, label, latex, summaryM

Examples

```
## Not run:
n <- 400
set.seed(1)
d <- data.frame(country=factor(sample(c('US','Canada','Mexico'), n, TRUE)),
                sex=factor(sample(c('Female','Male'), n, TRUE)),
                age=rnorm(n, 50, 10),
                sbp=rnorm(n, 120, 8))
d <- upData(d,
            preghx=ifelse(sex=='Female', sample(c('No','Yes'), n, TRUE), NA),
            labels=c(sbp='Systolic BP', age='Age', preghx='Pregnancy History'),
            units=c(sbp='mmHg', age='years'))
contents(d)
require(tables)
invisible(booktabs())  # use booktabs LaTeX style for tabular
g <- function(x) {
  x <- x[!is.na(x)]
  if(length(x) == 0) return('')
  paste(latexNumeric(nFm(mean(x), 3, 1)),
        ' \hfill{\smaller[2](', length(x), ')}', sep='')
}
tab <- tabulr((age + Heading('Females')*(sex == 'Female')*sbp)*
              Heading()*g + (age + sbp)*Heading()*trio ~
              Heading()*country*Heading()*sex, data=d)
# Formula after interpretation by tabulr:
# (Heading('Age\hfill {\smaller[2] years}') * age + Heading("Females")
# * (sex == "Female") * Heading('Systolic BP {\smaller[2] mmHg}') * sbp)
# * Heading() * g + (age + sbp) * Heading() * table_trio ~ Heading()
# * country * Heading() * sex
cat('\begin{landscape}\n')
cat('\begin{minipage}{\textwidth}\n')
cat('\keytrio\n')
latex(tab)
cat('\end{minipage}\end{landscape}\n')

getHdata(pbc)
pbc <- upData(pbc, moveUnits=TRUE)
# Convert to character to prevent tabular from stratifying
for(x in c('sex', 'stage', 'spiders')) {
  pbc[[x]] <- as.character(pbc[[x]])
```

```
  label(pbc[[x]]) <- paste(toupper(substring(x, 1, 1)), substring(x, 2), sep='')
}
table_options(pn=TRUE, showfreq='all')
tab <- tabulr((bili + albumin + protime + age) *
              Heading()*trio +
              (sex + stage + spiders)*Heading()*freq ~ drug, data=pbc)
latex(tab)

## End(Not run)
```

---

testCharDateTime *testCharDateTime*

Description

Test Character Variables for Dates and Times

Usage

```
testCharDateTime(x, p = 0.5, m = 0, convert = FALSE, existing = FALSE)
```

Arguments

x	input vector of any type, but interesting cases are for character x
p	minimum proportion of non-missing non-blank values of x for which the format is one of the formats described before considering x to be of that type
m	if greater than 0, a test is applied: the number of distinct illegal values of x (values containing a letter or underscore) must not exceed m, or type character will be returned. p is set to 1.0 when m > 0.
convert	set to TRUE to convert the variable under the dominant format. If all values are NA, type will be set to 'character'.
existing	set to TRUE to return a character string with the current type of variable without examining pattern matches

Details

For a vector x, if it is already a date-time, date, or time variable, the type is returned if convert=FALSE, or a list with that type, the original vector, and numna=0 is returned. Otherwise if x is not a character vector, a type of notcharacter is returned, or a list that includes the original x and type='notcharacter'. When x is character, the main logic is applied. The default logic (when m=0) is to consider x a date-time variable when its format is YYYY-MM-DD HH:MM:SS (:SS is optional) in more than 1/2 of the non-missing observations. It is considered to be a date if its format is YYYY-MM-DD or MM/DD/YYYY or DD-MMM-YYYY in more than 1/2 of the non-missing observations (MMM=3-letter month). A time variable has the format HH:MM:SS or HH:MM. Blank values of x (after trimming) are set to NA before proceeding.

Value

if convert=FALSE, a single character string with the type of x: "character", "datetime", "date", "time". If convert=TRUE, a list with components named type, x (converted to POSIXct, Date, or chron times format), and numna, the number of originally non-NA values of x that could not be converted to the predominant format. If there were any non-covertible dates/times, the returned vector is given an additional class special.miss and an attribute special.miss which is a list with original character values (codes) and observation numbers (obs). These are summarized by describe().

Author(s)

Frank Harrell

Examples

```
for(conv in c(FALSE, TRUE)) {
  print(testCharDateTime(c('2023-03-11', '2023-04-11', 'a', 'b', 'c'), convert=conv))
  print(testCharDateTime(c('2023-03-11', '2023-04-11', 'a', 'b'), convert=conv))
 print(testCharDateTime(c('2023-03-11 11:12:13', '2023-04-11 11:13:14', 'a', 'b'), convert=conv))
 print(testCharDateTime(c('2023-03-11 11:12', '2023-04-11 11:13', 'a', 'b'), convert=conv))
  print(testCharDateTime(c('3/11/2023', '4/11/2023', 'a', 'b'), convert=conv))
}
x <- c(paste0('2023-03-0', 1:9), 'a', 'a', 'a', 'b')
y <- testCharDateTime(x, convert=TRUE)$x
describe(y)  # note counts of special missing values a, b
```

---

tex *function for use in graphs that are used with the psfrag package in LaTeX*

Description

tex is a little function to save typing when including TeX commands in graphs that are used with the psfrag package in LaTeX to typeset any LaTeX text inside a postscript graphic. tex surrounds the input character string with '\tex[options]{}'. This is especially useful for getting Greek letters and math symbols in postscript graphs. By default tex returns a string with psfrag commands specifying that the string be centered, not rotated, and not specially enlarged or shrunk.

Usage

```
tex(string, lref='c', psref='c', scale=1, srt=0)
```

Arguments

string	a character string to be processed by psfrag in LaTeX.
lref	LaTeX reference point for string. See the psfrag documentation referenced below. Default is "c" for centered (this is also the default for psref).
psref	PostScript reference point.
scale	scall factor, default is 1
srt	rotation for string in degrees (default is zero)

Value

`tex` returns a modified character string.

Author(s)

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References

Grant MC, Carlisle (1998): The PSfrag System, Version 3. Full documentation is obtained by searching www.ctan.org for 'pfgguide.ps'.

See Also

postscript, par, ps.options, mgp.axis.labels, pdf, trellis.device, setTrellis

Examples

```
## Not run:
pdf('test.pdf')
x <- seq(0,15,length=100)
plot(x, dchisq(x, 5), xlab=tex('$x$'),
        ylab=tex('$f(x)$'), type='l')
title(tex('Density Function of the $\chi_{5}^{2}$ Distribution'))
dev.off()
# To process this file in LaTeX do something like
#\documentclass{article}
#\usepackage[scanall]{psfrag}
#\begin{document}
#\begin{figure}
#\includegraphics{test.ps}
#\caption{This is an example}
#\end{figure}
#\end{document}

## End(Not run)
```

`transace` *Additive Regression and Transformations using ace or avas*

Description

transace is ace packaged for easily automatically transforming all variables in a formula without a left-hand side. transace is a fast one-iteration version of transcan without imputation of NAs. The ggplot method makes nice transformation plots using ggplot2. Binary variables are automatically kept linear, and character or factor variables are automatically treated as categorical.

areg.boot uses areg or avas to fit additive regression models allowing all variables in the model (including the left-hand-side) to be transformed, with transformations chosen so as to optimize certain criteria. The default method uses areg whose goal it is to maximize R^2. method="avas" explicity tries to transform the response variable so as to stabilize the variance of the residuals. All-variables-transformed models tend to inflate R^2 and it can be difficult to get confidence limits for each transformation. areg.boot solves both of these problems using the bootstrap. As with the validate function in the **rms** library, the Efron bootstrap is used to estimate the optimism in the apparent R^2, and this optimism is subtracted from the apparent R^2 to optain a bias-corrected R^2. This is done however on the transformed response variable scale.

Tests with 3 predictors show that the avas and ace estimates are unstable unless the sample size exceeds 350. Apparent R^2 with low sample sizes can be very inflated, and bootstrap estimates of R^2 can be even more unstable in such cases, resulting in optimism-corrected R^2 that are much lower even than the actual R^2. The situation can be improved a little by restricting predictor transformations to be monotonic. On the other hand, the areg approach allows one to control overfitting by specifying the number of knots to use for each continuous variable in a restricted cubic spline function.

For method="avas" the response transformation is restricted to be monotonic. You can specify restrictions for transformations of predictors (and linearity for the response). When the first argument is a formula, the function automatically determines which variables are categorical (i.e., factor, category, or character vectors). Specify linear transformations by enclosing variables by the identify function (I()), and specify monotonicity by using monotone(variable). Monotonicity restrictions are not allowed with method="areg".

The summary method for areg.boot computes bootstrap estimates of standard errors of differences in predicted responses (usually on the original scale) for selected levels of each predictor against the lowest level of the predictor. The smearing estimator (see below) can be used here to estimate differences in predicted means, medians, or many other statistics. By default, quartiles are used for continuous predictors and all levels are used for categorical ones. See *Details* below. There is also a plot method for plotting transformation estimates, transformations for individual bootstrap re-samples, and pointwise confidence limits for transformations. Unless you already have a par(mfrow=) in effect with more than one row or column, plot will try to fit the plots on one page. A predict method computes predicted values on the original or transformed response scale, or a matrix of transformed predictors. There is a Function method for producing a list of R functions that perform the final fitted transformations. There is also a print method for areg.boot objects.

When estimated means (or medians or other statistical parameters) are requested for models fitted with areg.boot (by summary.areg.boot or predict.areg.boot), the "smearing" estimator of *Duan (1983)* is used. Here we estimate the mean of the untransformed response by computing the arithmetic mean of $ginverse(lp + residuals)$, where ginverse is the inverse of the nonparametric transformation of the response (obtained by reverse linear interpolation), lp is the linear predictor for an individual observation on the transformed scale, and residuals is the entire vector of residuals estimated from the fitted model, on the transformed scales (n residuals for n original observations). The smearingEst function computes the general smearing estimate. For efficiency smearingEst

recognizes that quantiles are transformation-preserving, i.e., when one wishes to estimate a quantile of the untransformed distribution one just needs to compute the inverse transformation of the transformed estimate after the chosen quantile of the vector of residuals is added to it. When the median is desired, the estimate is $ginverse(lp + \text{median}(residuals))$. See the last example for how `smearingEst` can be used outside of `areg.boot`.

`Mean` is a generic function that returns an R function to compute the estimate of the mean of a variable. Its input is typically some kind of model fit object. Likewise, `Quantile` is a generic quantile function-producing function. `Mean.areg.boot` and `Quantile.areg.boot` create functions of a vector of linear predictors that transform them into the smearing estimates of the mean or quantile of the response variable, respectively. `Quantile.areg.boot` produces exactly the same value as `predict.areg.boot` or `smearingEst`. `Mean` approximates the mapping of linear predictors to means over an evenly spaced grid of by default 200 points. Linear interpolation is used between these points. This approximate method is much faster than the full smearing estimator once `Mean` creates the function. These functions are especially useful in `nomogram` (see the example on hypothetical data).

Usage

```
transace(formula, trim=0.01, data=environment(formula))

## S3 method for class 'transace'
print(x, ...)

## S3 method for class 'transace'
ggplot(data, mapping, ..., environment, nrow=NULL)

areg.boot(x, data, weights, subset, na.action=na.delete,
          B=100, method=c("areg","avas"), nk=4, evaluation=100, valrsq=TRUE,
          probs=c(.25,.5,.75), tolerance=NULL)

## S3 method for class 'areg.boot'
print(x, ...)

## S3 method for class 'areg.boot'
plot(x, ylim, boot=TRUE, col.boot=2, lwd.boot=.15,
     conf.int=.95, ...)

smearingEst(transEst, inverseTrans, res,
            statistic=c('median','quantile','mean','fitted','lp'),
            q)

## S3 method for class 'areg.boot'
summary(object, conf.int=.95, values, adj.to,
        statistic='median', q, ...)

## S3 method for class 'summary.areg.boot'
print(x, ...)
```

```
## S3 method for class 'areg.boot'
predict(object, newdata,
        statistic=c("lp", "median",
                    "quantile", "mean", "fitted", "terms"),
        q=NULL, ...)

## S3 method for class 'areg.boot'
Function(object, type=c('list','individual'),
         ytype=c('transformed','inverse'),
         prefix='.', suffix='', pos=-1, ...)

Mean(object, ...)

Quantile(object, ...)

## S3 method for class 'areg.boot'
Mean(object, evaluation=200, ...)

## S3 method for class 'areg.boot'
Quantile(object, q=.5, ...)
```

Arguments

formula	a formula without a left-hand-side variable. Variables may be enclosed in `monotone()`, `linear()`, `categorical()` to make certain assumptions about transformations. `categorical` and `linear` need not be specified if they can be summized from the variable values.
x	for `areg.boot` x is a formula. For `print` or `plot`, an object created by `areg.boot` or `transace`. For `print.summary.areg.boot`, and object created by `summary.areg.boot`. For ggplot is the result of `transace`.
object	an object created by `areg.boot`, or a model fit object suitable for `Mean` or `Quantile`.
transEst	a vector of transformed values. In log-normal regression these could be predicted log(Y) for example.
inverseTrans	a function specifying the inverse transformation needed to change `transEst` to the original untransformed scale. `inverseTrans` may also be a 2-element list defining a mapping from the transformed values to untransformed values. Linear interpolation is used in this case to obtain untransform values.
trim	quantile to which to trim original and transformed values for continuous variables for purposes of plotting the transformations with `ggplot.transace`
nrow	the number of rows to graph for `transace` transformations, with the default chosen by `ggplot2`
data	data frame to use if x is a formula and variables are not already in the search list. For ggplot is a `transace` object.
environment, mapping	ignored

weights	a numeric vector of observation weights. By default, all observations are weighted equally.
subset	an expression to subset data if x is a formula
na.action	a function specifying how to handle NAs. Default is na.delete.
B	number of bootstrap samples (default=100)
method	"areg" (the default) or "avas"
nk	number of knots for continuous variables not restricted to be linear. Default is 4. One or two is not allowed. nk=0 forces linearity for all continuous variables.
evaluation	number of equally-spaced points at which to evaluate (and save) the nonparametric transformations derived by avas or ace. Default is 100. For Mean.areg.boot, evaluation is the number of points at which to evaluate exact smearing estimates, to approximate them using linear interpolation (default is 200).
valrsq	set to TRUE to more quickly do bootstrapping without validating R^2
probs	vector probabilities denoting the quantiles of continuous predictors to use in estimating effects of those predictors
tolerance	singularity criterion; list source code for the lm.fit.qr.bare function.
res	a vector of residuals from the transformed model. Not required when statistic="lp" or statistic="fitted".
statistic	statistic to estimate with the smearing estimator. For smearingEst, the default results in computation of the sample median of the model residuals, then smearingEst adds the median residual and back-transforms to get estimated median responses on the original scale. statistic="lp" causes predicted transformed responses to be computed. For smearingEst, the result (for statistic="lp") is the input argument transEst. statistic="fitted" gives predicted untransformed responses, i.e., $ginverse(lp)$, where ginverse is the inverse of the estimated response transformation, estimated by reverse linear interpolation on the tabulated nonparametric response transformation or by using an explicit analytic function. statistic="quantile" generalizes "median" to any single quantile q which must be specified. "mean" causes the population mean response to be estimated. For predict.areg.boot, statistic="terms" returns a matrix of transformed predictors. statistic can also be any R function that computes a single value on a vector of values, such as statistic=var. Note that in this case the function name is not quoted.
q	a single quantile of the original response scale to estimate, when statistic="quantile", or for Quantile.areg.boot.
ylim	2-vector of y-axis limits
boot	set to FALSE to not plot any bootstrapped transformations. Set it to an integer k to plot the first k bootstrap estimates.
col.boot	color for bootstrapped transformations
lwd.boot	line width for bootstrapped transformations
conf.int	confidence level (0-1) for pointwise bootstrap confidence limits and for estimated effects of predictors in summary.areg.boot. The latter assumes normality of the estimated effects.

values	a list of vectors of settings of the predictors, for predictors for which you want to overide settings determined from probs. The list must have named components, with names corresponding to the predictors. Example: values=list(x1=c(2,4,6,8), x2=c(-1,0,1)) specifies that summary is to estimate the effect on y of changing x1 from 2 to 4, 2 to 6, 2 to 8, and separately, of changing x2 from -1 to 0 and -1 to 1.
adj.to	a named vector of adjustment constants, for setting all other predictors when examining the effect of a single predictor in summary. The more nonlinear is the transformation of y the more the adjustment settings will matter. Default values are the medians of the values defined by values or probs. You only need to name the predictors for which you are overriding the default settings. Example: adj.to=c(x2=0,x5=10) will set x2 to 0 and x5 to 10 when assessing the impact of variation in the other predictors.
newdata	a data frame or list containing the same number of values of all of the predictors used in the fit. For factor predictors the 'levels' attribute do not need to be in the same order as those used in the original fit, and not all levels need to be represented. If newdata is omitted, you can still obtain linear predictors (on the transformed response scale) and fitted values (on the original response scale), but not "terms".
type	specifies how Function is to return the series of functions that define the transformations of all variables. By default a list is created, with the names of the list elements being the names of the variables. Specify type="individual" to have separate functions created in the current environment (pos=-1, the default) or in location defined by pos if where is specified. For the latter method, the names of the objects created are the names of the corresponding variables, prefixed by prefix and with suffix appended to the end. If any of pos, prefix, or suffix is specified, type is automatically set to "individual".
ytype	By default the first function created by Function is the y-transformation. Specify ytype="inverse" to instead create the inverse of the transformation, to be able to obtain originally scaled y-values.
prefix	character string defining the prefix for function names created when type="individual". By default, the function specifying the transformation for variable x will be named .x.
suffix	character string defining the suffix for the function names
pos	See assign.
...	arguments passed to other functions. Ignored for print.transace and ggplot.transace.

Details

As transace only does one iteration over the predictors, it may not find optimal transformations and it will be dependent on the order of the predictors in x.

ace and avas standardize transformed variables to have mean zero and variance one for each bootstrap sample, so if a predictor is not important it will still consistently have a positive regression coefficient. Therefore using the bootstrap to estimate standard errors of the additive least squares regression coefficients would not help in drawing inferences about the importance of the predictors. To do this, summary.areg.boot computes estimates of, e.g., the inter-quartile range effects

of predictors in predicting the response variable (after untransforming it). As an example, at each bootstrap repetition the estimated transformed value of one of the predictors is computed at the lower quartile, median, and upper quartile of the raw value of the predictor. These transformed x values are then multipled by the least squares estimate of the partial regression coefficient for that transformed predictor in predicting transformed y. Then these weighted transformed x values have the weighted transformed x value corresponding to the lower quartile subtracted from them, to estimate an x effect accounting for nonlinearity. The last difference computed is then the standardized effect of raising x from its lowest to its highest quartile. Before computing differences, predicted values are back-transformed to be on the original y scale in a way depending on `statistic` and `q`. The sample standard deviation of these effects (differences) is taken over the bootstrap samples, and this is used to compute approximate confidence intervals for effects andapproximate P-values, both assuming normality.

`predict` does not re-insert `NA`s corresponding to observations that were dropped before the fit, when `newdata` is omitted.

`statistic="fitted"` estimates the same quantity as `statistic="median"` if the residuals on the transformed response have a symmetric distribution. The two provide identical estimates when the sample median of the residuals is exactly zero. The sample mean of the residuals is constrained to be exactly zero although this does not simplify anything.

Value

`transace` returns a list of class `transace` containing these elements: `n` (number of non-missing observations used), `transformed` (a matrix containing transformed values), `rsq` (vector of R^2 with which each variable can be predicted from the others), `omitted` (row numbers of data that were deleted due to `NA`s), `trantab` (compact transformation lookups), `levels` (original levels of character and factor varibles if the input was a data frame), `trim` (value of `trim` passed to `transace`), `limits` (the limits for plotting raw and transformed variables, computed from `trim`), and `type` (a vector of transformation types used for the variables).

`areg.boot` returns a list of class '`areg.boot`' containing many elements, including (if `valrsq` is `TRUE`) `rsquare.app` and `rsquare.val`. `summary.areg.boot` returns a list of class '`summary.areg.boot`' containing a matrix of results for each predictor and a vector of adjust-to settings. It also contains the call and a '`label`' for the statistic that was computed. A `print` method for these objects handles the printing. `predict.areg.boot` returns a vector unless `statistic="terms"`, in which case it returns a matrix. `Function.areg.boot` returns by default a list of functions whose argument is one of the variables (on the original scale) and whose returned values are the corresponding transformed values. The names of the list of functions correspond to the names of the original variables. When `type="individual"`, `Function.areg.boot` invisibly returns the vector of names of the created function objects. `Mean.areg.boot` and `Quantile.areg.boot` also return functions.

`smearingEst` returns a vector of estimates of distribution parameters of class '`labelled`' so that `print.labelled` wil print a label documenting the estimate that was used (see `label`). This label can be retrieved for other purposes by using e.g. `label(obj)`, where obj was the vector returned by `smearingEst`.

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References

Harrell FE, Lee KL, Mark DB (1996): Stat in Med 15:361–387.

Duan N (1983): Smearing estimate: A nonparametric retransformation method. JASA 78:605–610.

Wang N, Ruppert D (1995): Nonparametric estimation of the transformation in the transform-both-sides regression model. JASA 90:522–534.

See avas, ace for primary references.

See Also

avas, ace, ols, validate, predab.resample, label, nomogram

Examples

```
# xtrans <- transace(~ monotone(age) + sex + blood.pressure + categorical(race.code))
# print(xtrans)  # show R^2s and a few other things
# ggplot(xtrans) # show transformations

# Generate random data from the model y = exp(x1 + epsilon/3) where
# x1 and epsilon are Gaussian(0,1)
set.seed(171)  # to be able to reproduce example
x1 <- rnorm(200)
x2 <- runif(200)  # a variable that is really unrelated to y]
x3 <- factor(sample(c('cat','dog','cow'), 200,TRUE))  # also unrelated to y
y  <- exp(x1 + rnorm(200)/3)
f  <- areg.boot(y ~ x1 + x2 + x3, B=40)
f
plot(f)
# Note that the fitted transformation of y is very nearly log(y)
# (the appropriate one), the transformation of x1 is nearly linear,
# and the transformations of x2 and x3 are essentially flat
# (specifying monotone(x2) if method='avas' would have resulted
# in a smaller confidence band for x2)


summary(f)


# use summary(f, values=list(x2=c(.2,.5,.8))) for example if you
# want to use nice round values for judging effects


# Plot Y hat vs. Y (this doesn't work if there were NAs)
plot(fitted(f), y)  # or: plot(predict(f,statistic='fitted'), y)


# Show fit of model by varying x1 on the x-axis and creating separate
# panels for x2 and x3.  For x2 using only a few discrete values
```

```
newdat <- expand.grid(x1=seq(-2,2,length=100),x2=c(.25,.75),
                      x3=c('cat','dog','cow'))
yhat <- predict(f, newdat, statistic='fitted')
# statistic='mean' to get estimated mean rather than simple inverse trans.
xYplot(yhat ~ x1 | x2, groups=x3, type='l', data=newdat)


## Not run:
# Another example, on hypothetical data
f <- areg.boot(response ~ I(age) + monotone(blood.pressure) + race)
# use I(response) to not transform the response variable
plot(f, conf.int=.9)
# Check distribution of residuals
plot(fitted(f), resid(f))
qqnorm(resid(f))
# Refit this model using ols so that we can draw a nomogram of it.
# The nomogram will show the linear predictor, median, mean.
# The last two are smearing estimators.
Function(f, type='individual')  # create transformation functions
f.ols <- ols(.response(response) ~ age +
             .blood.pressure(blood.pressure) + .race(race))
# Note: This model is almost exactly the same as f but there
# will be very small differences due to interpolation of
# transformations
meanr <- Mean(f)      # create function of lp computing mean response
medr  <- Quantile(f)  # default quantile is .5
nomogram(f.ols, fun=list(Mean=meanr,Median=medr))


# Create S functions that will do the transformations
# This is a table look-up with linear interpolation
g <- Function(f)
plot(blood.pressure, g$blood.pressure(blood.pressure))
# produces the central curve in the last plot done by plot(f)

## End(Not run)


# Another simulated example, where y has a log-normal distribution
# with mean x and variance 1.  Untransformed y thus has median
# exp(x) and mean exp(x + .5sigma^2) = exp(x + .5)
# First generate data from the model y = exp(x + epsilon),
# epsilon ~ Gaussian(0, 1)


set.seed(139)
n <- 1000
x <- rnorm(n)
y <- exp(x + rnorm(n))
f <- areg.boot(y ~ x, B=20)
plot(f)       # note log shape for y, linear for x.  Good!
xs <- c(-2, 0, 2)
d <- data.frame(x=xs)
```

```
predict(f, d, 'fitted')
predict(f, d, 'median')   # almost same; median residual=-.001
exp(xs)                   # population medians
predict(f, d, 'mean')
exp(xs + .5)              # population means


# Show how smearingEst works
res <- c(-1,0,1)          # define residuals
y <- 1:5
ytrans <- log(y)
ys <- seq(.1,15,length=50)
trans.approx <- list(x=log(ys), y=ys)
options(digits=4)
smearingEst(ytrans, exp, res, 'fitted')          # ignores res
smearingEst(ytrans, trans.approx, res, 'fitted') # ignores res
smearingEst(ytrans, exp, res, 'median')          # median res=0
smearingEst(ytrans, exp, res+.1, 'median')       # median res=.1
smearingEst(ytrans, trans.approx, res, 'median')
smearingEst(ytrans, exp, res, 'mean')
mean(exp(ytrans[2] + res))                       # should equal 2nd # above
smearingEst(ytrans, trans.approx, res, 'mean')
smearingEst(ytrans, trans.approx, res, mean)
# Last argument can be any statistical function operating
# on a vector that returns a single value
```

`transcan` *Transformations/Imputations using Canonical Variates*

Description

`transcan` is a nonlinear additive transformation and imputation function, and there are several functions for using and operating on its results. `transcan` automatically transforms continuous and categorical variables to have maximum correlation with the best linear combination of the other variables. There is also an option to use a substitute criterion - maximum correlation with the first principal component of the other variables. Continuous variables are expanded as restricted cubic splines and categorical variables are expanded as contrasts (e.g., dummy variables). By default, the first canonical variate is used to find optimum linear combinations of component columns. This function is similar to `ace` except that transformations for continuous variables are fitted using restricted cubic splines, monotonicity restrictions are not allowed, and `NA`s are allowed. When a variable has any `NA`s, transformed scores for that variable are imputed using least squares multiple regression incorporating optimum transformations, or `NA`s are optionally set to constants. Shrinkage can be used to safeguard against overfitting when imputing. Optionally, imputed values on the original scale are also computed and returned. For this purpose, recursive partitioning or multinomial logistic models can optionally be used to impute categorical variables, using what is predicted to be the most probable category.

By default, `transcan` imputes `NA`s with "best guess" expected values of transformed variables, back transformed to the original scale. Values thus imputed are most like conditional medians assuming

the transformations make variables' distributions symmetric (imputed values are similar to conditionl modes for categorical variables). By instead specifying `n.impute`, `transcan` does approximate multiple imputation from the distribution of each variable conditional on all other variables. This is done by sampling `n.impute` residuals from the transformed variable, with replacement (a la bootstrapping), or by default, using Rubin's approximate Bayesian bootstrap, where a sample of size n with replacement is selected from the residuals on n non-missing values of the target variable, and then a sample of size m with replacement is chosen from this sample, where m is the number of missing values needing imputation for the current multiple imputation repetition. Neither of these bootstrap procedures assume normality or even symmetry of residuals. For sometimes-missing categorical variables, optimal scores are computed by adding the "best guess" predicted mean score to random residuals off this score. Then categories having scores closest to these predicted scores are taken as the random multiple imputations (`impcat = "rpart"` is not currently allowed with `n.impute`). The literature recommends using `n.impute = 5` or greater. `transcan` provides only an approximation to multiple imputation, especially since it "freezes" the imputation model before drawing the multiple imputations rather than using different estimates of regression coefficients for each imputation. For multiple imputation, the `aregImpute` function provides a much better approximation to the full Bayesian approach while still not requiring linearity assumptions.

When you specify `n.impute` to `transcan` you can use `fit.mult.impute` to re-fit any model `n.impute` times based on `n.impute` completed datasets (if there are any sometimes missing variables not specified to `transcan`, some observations will still be dropped from these fits). After fitting `n.impute` models, `fit.mult.impute` will return the fit object from the last imputation, with `coefficients` replaced by the average of the `n.impute` coefficient vectors and with a component `var` equal to the imputation-corrected variance-covariance matrix using Rubin's rule. `fit.mult.impute` can also use the object created by the `mice` function in the **mice** library to draw the multiple imputations, as well as objects created by `aregImpute`. The following components of fit objects are also replaced with averages over the `n.impute` model fits: `linear.predictors`, `fitted.values`, `stats`, `means`, `icoef`, `scale`, `center`, `y.imputed`.

By specifying `fun` to `fit.mult.impute` you can run any function on the fit objects from completed datasets, with the results saved in an element named `funresults`. This facilitates running bootstrap or cross-validation separately on each completed dataset and storing all these results in a list for later processing, e.g., with the `rms` package `processMI` function. Note that for `rms`-type validation you will need to specify `fitargs=list(x=TRUE,y=TRUE)` to `fit.mult.impute` and to use special names for `fun` result components, such as `validate` and `calibrate` so that the result can be processed with `processMI`. When simultaneously running multiple imputation and resampling model validation you may not need values for `n.impute` or `B` (number of bootstraps) as high as usual, as the total number of repetitions will be `n.impute * B`.

`fit.mult.impute` can incorporate robust sandwich variance estimates into Rubin's rule if `robust=TRUE`.

For `ols` models fitted by `fit.mult.impute` with stacking, the R^2 measure in the stacked model fit is OK, and `print.ols` computes adjusted R^2 using the real sample size so it is also OK because `fit.mult.compute` corrects the stacked error degrees of freedom in the stacked fit object to reflect the real sample size.

The `summary` method for `transcan` prints the function call, R^2 achieved in transforming each variable, and for each variable the coefficients of all other transformed variables that are used to estimate the transformation of the initial variable. If `imputed=TRUE` was used in the call to transcan, also uses the `describe` function to print a summary of imputed values. If `long = TRUE`, also prints all imputed values with observation identifiers. There is also a simple function `print.transcan` which merely prints the transformation matrix and the function call. It has an optional argument `long`, which if

set to TRUE causes detailed parameters to be printed. Instead of plotting while transcan is running, you can plot the final transformations after the fact using plot.transcan or ggplot.transcan, if the option trantab = TRUE was specified to transcan. If in addition the option imputed = TRUE was specified to transcan, plot and ggplot will show the location of imputed values (including multiples) along the axes. For ggplot, imputed values are shown as red plus signs.

impute method for transcan does imputations for a selected original data variable, on the original scale (if imputed=TRUE was given to transcan). If you do not specify a variable to impute, it will do imputations for all variables given to transcan which had at least one missing value. This assumes that the original variables are accessible (i.e., they have been attached) and that you want the imputed variables to have the same names are the original variables. If n.impute was specified to transcan you must tell impute which imputation to use. Results are stored in .GlobalEnv when list.out is not specified (it is recommended to use list.out=TRUE).

The predict method for transcan computes predicted variables and imputed values from a matrix of new data. This matrix should have the same column variables as the original matrix used with transcan, and in the same order (unless a formula was used with transcan).

The Function function is a generic function generator. Function.transcan creates R functions to transform variables using transformations created by transcan. These functions are useful for getting predicted values with predictors set to values on the original scale.

The vcov methods are defined here so that imputation-corrected variance-covariance matrices are readily extracted from fit.mult.impute objects, and so that fit.mult.impute can easily compute traditional covariance matrices for individual completed datasets.

The subscript method for transcan preserves attributes.

The invertTabulated function does either inverse linear interpolation or uses sampling to sample qualifying x-values having y-values near the desired values. The latter is used to get inverse values having a reasonable distribution (e.g., no floor or ceiling effects) when the transformation has a flat or nearly flat segment, resulting in a many-to-one transformation in that region. Sampling weights are a combination of the frequency of occurrence of x-values that are within tolInverse times the range of y and the squared distance between the associated y-values and the target y-value (aty).

Usage

```
transcan(x, method=c("canonical","pc"),
         categorical=NULL, asis=NULL, nk, imputed=FALSE, n.impute,
         boot.method=c('approximate bayesian', 'simple'),
         trantab=FALSE, transformed=FALSE,
         impcat=c("score", "multinom", "rpart"),
         mincut=40,
         inverse=c('linearInterp','sample'), tolInverse=.05,
         pr=TRUE, pl=TRUE, allpl=FALSE, show.na=TRUE,
         imputed.actual=c('none','datadensity','hist','qq','ecdf'),
         iter.max=50, eps=.1, curtail=TRUE,
         imp.con=FALSE, shrink=FALSE, init.cat="mode",
         nres=if(boot.method=='simple')200 else 400,
         data, subset, na.action, treeinfo=FALSE,
         rhsImp=c('mean','random'), details.impcat='', ...)

## S3 method for class 'transcan'
```

```
summary(object, long=FALSE, digits=6, ...)

## S3 method for class 'transcan'
print(x, long=FALSE, ...)

## S3 method for class 'transcan'
plot(x, ...)

## S3 method for class 'transcan'
ggplot(data, mapping, scale=FALSE, ..., environment)

## S3 method for class 'transcan'
impute(x, var, imputation, name, pos.in, data,
       list.out=FALSE, pr=TRUE, check=TRUE, ...)

fit.mult.impute(formula, fitter, xtrans, data, n.impute, fit.reps=FALSE,
                dtrans, derived, fun, vcovOpts=NULL,
                robust=FALSE, cluster, robmethod=c('huber', 'efron'),
                method=c('ordinary', 'stack', 'only stack'),
                funstack=TRUE, lrt=FALSE,
                pr=TRUE, subset, fitargs)

## S3 method for class 'transcan'
predict(object, newdata, iter.max=50, eps=0.01, curtail=TRUE,
        type=c("transformed","original"),
        inverse, tolInverse, check=FALSE, ...)

Function(object, ...)

## S3 method for class 'transcan'
Function(object, prefix=".", suffix="", pos=-1, ...)

invertTabulated(x, y, freq=rep(1,length(x)),
                aty, name='value',
                inverse=c('linearInterp','sample'),
                tolInverse=0.05, rule=2)

## Default S3 method:
vcov(object, regcoef.only=FALSE, ...)

## S3 method for class 'fit.mult.impute'
vcov(object, regcoef.only=TRUE,
                intercepts='mid', ...)
```

Arguments

x	a matrix containing continuous variable values and codes for categorical variables. The matrix must have column names (dimnames). If row names are

present, they are used in forming the names attribute of imputed values if imputed = TRUE. x may also be a formula, in which case the model matrix is created automatically, using data in the calling frame. Advantages of using a formula are that categorical variables can be determined automatically by a variable being a factor variable, and variables with two unique levels are modeled asis. Variables with 3 unique values are considered to be categorical if a formula is specified. For a formula you may also specify that a variable is to remain untransformed by enclosing its name with the identify function, e.g. I(x3). The user may add other variable names to the asis and categorical vectors. For invertTabulated, x is a vector or a list with three components: the x vector, the corresponding vector of transformed values, and the corresponding vector of frequencies of the pair of original and transformed variables. For print, plot, ggplot, impute, and predict, x is an object created by transcan.

formula — any R model formula

fitter — any R, rms, modeling function (not in quotes) that computes a vector of coefficients and for which vcov will return a variance-covariance matrix. E.g., fitter = lm, glm, ols. At present models involving non-regression parameters (e.g., scale parameters in parametric survival models) are not handled fully.

xtrans — an object created by transcan, aregImpute, or mice

method — use method="canonical" or any abbreviation thereof, to use canonical variates (the default). method="pc" transforms a variable instead so as to maximize the correlation with the first principal component of the other variables. For fit.mult.impute, method specifies whether to use standard multiple imputation (the default method='ordinary') or whether to get final coefficients from stacking all completed datasets and fitting one model. Stacking is required if likelihood ratio tests accounting for imputation are to be done. method='stack' means to do regular MI and stacking, which results in more valid standard errors of coefficient estimates. method='only stack' means that model fits are not done on individual completed datasets, and standard errors will not be very accurate.

categorical — a character vector of names of variables in x which are categorical, for which the ordering of re-scored values is not necessarily preserved. If categorical is omitted, it is assumed that all variables are continuous (or binary). Set categorical="*" to treat all variables as categorical.

asis — a character vector of names of variables that are not to be transformed. For these variables, the guts of lm.fit method="qr" is used to impute missing values. You may want to treat binary variables asis (this is automatic if using a formula). If imputed = TRUE, you may want to use '"categorical"' for binary variables if you want to force imputed values to be one of the original data values. Set asis="*" to treat all variables asis.

nk — number of knots to use in expanding each continuous variable (not listed in asis) in a restricted cubic spline function. Default is 3 (yielding 2 parameters for a variable) if $n < 30$, 4 if $30 <= n < 100$, and 5 if $n \geq 100$ (4 parameters).

imputed — Set to TRUE to return a list containing imputed values on the original scale. If the transformation for a variable is non-monotonic, imputed values are not unique. transcan uses the approx function, which returns the highest value of the variable with the transformed score equalling the imputed score. imputed=TRUE

also causes original-scale imputed values to be shown as tick marks on the top margin of each graph when show.na=TRUE (for the final iteration only). For categorical predictors, these imputed values are passed through the jitter function so that their frequencies can be visualized. When n.impute is used, each NA will have n.impute tick marks.

n.impute — number of multiple imputations. If omitted, single predicted expected value imputation is used. n.impute=5 is frequently recommended.

boot.method — default is to use the approximate Bayesian bootstrap (sample with replacement from sample with replacement of the vector of residuals). You can also specify boot.method="simple" to use the usual bootstrap one-stage sampling with replacement.

trantab — Set to TRUE to add an attribute trantab to the returned matrix. This contains a vector of lists each with components x and y containing the unique values and corresponding transformed values for the columns of x. This is set up to be used easily with the approx function. You must specify trantab=TRUE if you want to later use the predict.transcan function with type = "original".

transformed — set to TRUE to cause transcan to return an object transformed containing the matrix of transformed variables

impcat — This argument tells how to impute categorical variables on the original scale. The default is impcat="score" to impute the category whose canonical variate score is closest to the predicted score. Use impcat="rpart" to impute categorical variables using the values of all other transformed predictors in conjunction with the rpart function. A better but somewhat slower approach is to use impcat="multinom" to fit a multinomial logistic model to the categorical variable, at the last iteraction of the transcan algorithm. This uses the multinom function in the **nnet** library of the **MASS** package (which is assumed to have been installed by the user) to fit a polytomous logistic model to the current working transformations of all the other variables (using conditional mean imputation for missing predictors). Multiple imputations are made by drawing multinomial values from the vector of predicted probabilities of category membership for the missing categorical values.

mincut — If imputed=TRUE, there are categorical variables, and impcat = "rpart", mincut specifies the lowest node size that will be allowed to be split. The default is 40.

inverse — By default, imputed values are back-solved on the original scale using inverse linear interpolation on the fitted tabulated transformed values. This will cause distorted distributions of imputed values (e.g., floor and ceiling effects) when the estimated transformation has a flat or nearly flat section. To instead use the invertTabulated function (see above) with the "sample" option, specify inverse="sample".

tolInverse — the multiplyer of the range of transformed values, weighted by freq and by the distance measure, for determining the set of x values having y values within a tolerance of the value of aty in invertTabulated. For predict.transcan, inverse and tolInverse are obtained from options that were specified to transcan by default. Otherwise, if not specified by the user, these default to the defaults used to invertTabulated.

pr — For transcan, set to FALSE to suppress printing R^2 and shrinkage factors. Set impute.transcan=FALSE to suppress messages concerning the number of NA values imputed. Set fit.mult.impute=FALSE to suppress printing variance inflation factors accounting for imputation, rate of missing information, and degrees of freedom.

pl — Set to FALSE to suppress plotting the final transformations with distribution of scores for imputed values (if show.na=TRUE).

allpl — Set to TRUE to plot transformations for intermediate iterations.

show.na — Set to FALSE to suppress the distribution of scores assigned to missing values (as tick marks on the right margin of each graph). See also imputed.

imputed.actual — The default is '"none"' to suppress plotting of actual vs. imputed values for all variables having any NA values. Other choices are '"datadensity"' to use datadensity to make a single plot, '"hist"' to make a series of back-to-back histograms, '"qq"' to make a series of q-q plots, or '"ecdf"' to make a series of empirical cdfs. For imputed.actual="datadensity" for example you get a rug plot of the non-missing values for the variable with beneath it a rug plot of the imputed values. When imputed.actual is not '"none"', imputed is automatically set to TRUE.

iter.max — maximum number of iterations to perform for transcan or predict. For predict, only one iteration is used if there are no NA values in the data or if imp.con was used.

eps — convergence criterion for transcan and predict. eps is the maximum change in transformed values from one iteration to the next. If for a given iteration all new transformations of variables differ by less than eps (with or without negating the transformation to allow for "flipping") from the transformations in the previous iteration, one more iteration is done for transcan. During this last iteration, individual transformations are not updated but coefficients of transformations are. This improves stability of coefficients of canonical variates on the right-hand-side. eps is ignored when rhsImp="random".

curtail — for transcan, causes imputed values on the transformed scale to be truncated so that their ranges are within the ranges of non-imputed transformed values. For predict, curtail defaults to TRUE to truncate predicted transformed values to their ranges in the original fit (xt).

imp.con — for transcan, set to TRUE to impute NA values on the original scales with constants (medians or most frequent category codes). Set to a vector of constants to instead always use these constants for imputation. These imputed values are ignored when fitting the current working transformation for asingle variable.

shrink — default is FALSE to use ordinary least squares or canonical variate estimates. For the purposes of imputing NAs, you may want to set shrink=TRUE to avoid overfitting when developing a prediction equation to predict each variables from all the others (see details below).

init.cat — method for initializing scorings of categorical variables. Default is '"mode"' to use a dummy variable set to 1 if the value is the most frequent value (this is the default). Use '"random"' to use a random 0-1 variable. Set to '"asis"' to use the original integer codes asstarting scores.

nres	number of residuals to store if n.impute is specified. If the dataset has fewer than nres observations, all residuals are saved. Otherwise a random sample of the residuals of length nres without replacement is saved. The default for nres is higher if boot.method="approximate bayesian".
data	Data frame used to fill the formula. For ggplot is the result of transcan with trantab=TRUE.
subset	an integer or logical vector specifying the subset of observations to fit
na.action	These may be used if x is a formula. The default na.action is na.retain (defined by transcan) which keeps all observations with any NA values. For impute.transcan, data is a data frame to use as the source of variables to be imputed, rather than using pos.in. For fit.mult.impute, data is mandatory and is a data frame containing the data to be used in fitting the model but before imputations are applied. Variables omitted from data are assumed to be available from frame1 and do not need to be imputed.
treeinfo	Set to TRUE to get additional information printed when impcat="rpart", such as the predicted probabilities of category membership.
rhsImp	Set to '"random"' to use random draw imputation when a sometimes missing variable is moved to be a predictor of other sometimes missing variables. Default is rhsImp="mean", which uses conditional mean imputation on the transformed scale. Residuals used are residuals from the transformed scale. When '"random"' is used, transcan runs 5 iterations and ignores eps.
details.impcat	set to a character scalar that is the name of a category variable to include in the resulting transcan object an element details.impcat containing details of how the categorical variable was multiply imputed.
...	arguments passed to scat1d. For ggplot.transcan, these arguments are passed to facet_wrap, e.g. ncol=2.
long	for summary, set to TRUE to print all imputed values. For print, set to TRUE to print details of transformations/imputations.
digits	number of significant digits for printing values by summary
scale	for ggplot.transcan set scale=TRUE to scale transformed values to [0,1] before plotting.
mapping, environment	not used; needed because of rules about generics
var	For impute, is a variable that was originally a column in x, for which imputated values are to be filled in. imputed=TRUE must have been used in transcan. Omit var to impute all variables, creating new variables in position pos (see assign).
imputation	specifies which of the multiple imputations to use for filling in NA values
name	name of variable to impute, for impute function. Default is character string version of the second argument (var) in the call to impute. For invertTabulated, is the name of variable being transformed (used only for warning messages).
pos.in	location as defined by assign to find variables that need to be imputed, when all variables are to be imputed automatically by impute.transcan (i.e., when no input variable name is specified). Default is position that contains the first variable to be imputed.

list.out — If var is not specified, you can set list.out=TRUE to have impute.transcan return a list containing variables with needed values imputed. This list will contain a single imputation. Variables not needing imputation are copied to the list as-is. You can use this list for analysis just like a data frame.

check — set to FALSE to suppress certain warning messages

newdata — a new data matrix for which to compute transformed variables. Categorical variables must use the same integer codes as were used in the call to transcan. If a formula was originally specified to transcan (instead of a data matrix), newdata is optional and if given must be a data frame; a model frame is generated automatically from the previous formula. The na.action is handled automatically, and the levels for factor variables must be the same and in the same order as were used in the original variables specified in the formula given to transcan.

fit.reps — set to TRUE to save all fit objects from the fit for each imputation in fit.mult.impute. Then the object returned will have a component fits which is a list whose i'th element is the i'th fit object.

dtrans — provides an approach to creating derived variables from a single filled-in dataset. The function specified as dtrans can even reshape the imputed dataset. An example of such usage is fitting time-dependent covariates in a Cox model that are created by "start,stop" intervals. Imputations may be done on a one record per subject data frame that is converted by dtrans to multiple records per subject. The imputation can enforce consistency of certain variables across records so that for example a missing value of sex will not be imputed as 'male' for one of the subject's records and 'female' as another. An example of how dtrans might be specified is dtrans=function(w) {w$age <- w$years + w$months/12; w} where months might havebeen imputed but years was never missing. An outline for using 'dtrans' to impute missing baseline variables in a longitudinal analysis appears in Details below.

derived — an expression containing R expressions for computing derived variables that are used in the model formula. This is useful when multiple imputations are done for component variables but the actual model uses combinations of these (e.g., ratios or other derivations). For a single derived variable you can specify for example derived=expression(ratio <- weight/height). For multiple derived variables use the form derived=expression({ratio <- weight/height; product <- weight*height}) or put the expression on separate input lines. To monitor the multiply-imputed derived variables you can add to the expression a command such as print(describe(ratio)). See the example below. Note that derived is not yet implemented.

fun — a function of a fit made on one of the completed datasets. Typical uses are bootstrap model validations. The result of fun for imputation i is placed in the ith element of a list that is returned in the fit.mult.impute object element named funresults. See the rms processMI function for help in processing these results for the cases of validate and calibrate.

vcovOpts — a list of named additional arguments to pass to the vcov method for fitter. Useful for orm models for retaining all intercepts (vcovOpts=list(intercepts='all')) instead of just the middle one.

robust	set to TRUE to have fit.mult.impute call the rms package robcov function on each fit on a completed dataset. When cluster is given, robust is forced to TRUE.
cluster	a vector of cluster IDs that is the same length of the number of rows in the dataset being analyzed. When specified, robust is assumed to be TRUE, and the rms robcov function is called with the cluster vector given as its second argument.
robmethod	see the robcov function's method argument
funstack	set to FALSE to not run fun on the stacked dataset, making an n.impute+1 element of funresults
lrt	set to TRUE to have method, fun, fitargs set appropriately automatically so that processMI can be used to get likelihood ratio tests. When doing this, fun may not be specified by the user.
fitargs	a list of extra arguments to pass to fitter, used especially with fun. When robust=TRUE the arguments x=TRUE, y=TRUE are automatically added to fitargs.
type	By default, the matrix of transformed variables is returned, with imputed values on the transformed scale. If you had specified trantab=TRUE to transcan, specifying type="original" does the table look-ups with linear interpolation to return the input matrix x but with imputed values on the original scale inserted for NA values. For categorical variables, the method used here is to select the category code having a corresponding scaled value closest to the predicted transformed value. This corresponds to the default impcat. Note: imputed values thus returned when type="original" are single expected value imputations even in n.impute is given.
object	an object created by transcan, or an object to be converted to R function code, typically a model fit object of some sort
prefix, suffix	When creating separate R functions for each variable in x, the name of the new function will be prefix placed in front of the variable name, and suffix placed in back of the name. The default is to use names of the form '.varname', where varname is the variable name.
pos	position as in assign at which to store new functions (for Function). Default is pos=-1.
y	a vector corresponding to x for invertTabulated, if its first argument x is not a list
freq	a vector of frequencies corresponding to cross-classified x and y if x is not a list. Default is a vector of ones.
aty	vector of transformed values at which inverses are desired
rule	see approx. transcan assumes rule is always 2.
regcoef.only	set to TRUE to make vcov.default delete positions in the covariance matrix for any non-regression coefficients (e.g., log scale parameter from psm or survreg)
intercepts	this is primarily for orm objects. Set to "none" to discard all intercepts from the covariance matrix, or to "all" or "mid" to keep all elements generated by orm (orm only outputs the covariance matrix for the intercept corresponding to the median). You can also set intercepts to a vector of subscripts for selecting particular intercepts in a multi-intercept model.

Details

The starting approximation to the transformation for each variable is taken to be the original coding of the variable. The initial approximation for each missing value is taken to be the median of the non-missing values for the variable (for continuous ones) or the most frequent category (for categorical ones). Instead, if `imp.con` is a vector, its values are used for imputing `NA` values. When using each variable as a dependent variable, `NA` values on that variable cause all observations to be temporarily deleted. Once a new working transformation is found for the variable, along with a model to predict that transformation from all the other variables, that latter model is used to impute `NA` values in the selected dependent variable if `imp.con` is not specified.

When that variable is used to predict a new dependent variable, the current working imputed values are inserted. Transformations are updated after each variable becomes a dependent variable, so the order of variables on `x` could conceivably make a difference in the final estimates. For obtaining out-of-sample predictions/transformations, `predict` uses the same iterative procedure as `transcan` for imputation, with the same starting values for fill-ins as were used by `transcan`. It also (by default) uses a conservative approach of curtailing transformed variables to be within the range of the original ones. Even when `method = "pc"` is specified, canonical variables are used for imputing missing values.

Note that fitted transformations, when evaluated at imputed variable values (on the original scale), will not precisely match the transformed imputed values returned in `xt`. This is because `transcan` uses an approximate method based on linear interpolation to back-solve for imputed values on the original scale.

Shrinkage uses the method of *Van Houwelingen and Le Cessie (1990)* (similar to *Copas, 1983*). The shrinkage factor is

$$\frac{1 - \frac{(1-R2)(n-1)}{n-k-1}}{R2}$$

where R2 is the apparent R^2d for predicting the variable, n is the number of non-missing values, and k is the effective number of degrees of freedom (aside from intercepts). A heuristic estimate is used for k: `A - 1 + sum(max(0,Bi - 1))/m + m`, where A is the number of d.f. required to represent the variable being predicted, the Bi are the number of columns required to represent all the other variables, and m is the number of all other variables. Division by m is done because the transformations for the other variables are fixed at their current transformations the last time they were being predicted. The $+m$ term comes from the number of coefficients estimated on the right hand side, whether by least squares or canonical variates. If a shrinkage factor is negative, it is set to 0. The shrinkage factor is the ratio of the adjusted R^2d to the ordinary R^2d. The adjusted R^2d is

$$1 - \frac{(1 - R2)(n-1)}{n-k-1}$$

which is also set to zero if it is negative. If `shrink=FALSE` and the adjusted R^2s are much smaller than the ordinary R^2s, you may want to run `transcan` with `shrink=TRUE`.

Canonical variates are scaled to have variance of 1.0, by multiplying canonical coefficients from `cancor` by $\sqrt{n-1}$.

When specifying a non-**rms** library fitting function to `fit.mult.impute` (e.g., `lm`, `glm`), running the result of `fit.mult.impute` through that fit's `summary` method will not use the imputation-adjusted variances. You may obtain the new variances using `fit$var` or `vcov(fit)`.

When you specify a **rms** function to `fit.mult.impute` (e.g. `lrm`, `ols`, `cph`, `psm`, `bj`, `Rq`, `Gls`, `Glm`), automatically computed transformation parameters (e.g., knot locations for `rcs`) that are estimated

for the first imputation are used for all other imputations. This ensures that knot locations will not vary, which would change the meaning of the regression coefficients.

Warning: even though `fit.mult.impute` takes imputation into account when estimating variances of regression coefficient, it does not take into account the variation that results from estimation of the shapes and regression coefficients of the customized imputation equations. Specifying `shrink=TRUE` solves a small part of this problem. To fully account for all sources of variation you should consider putting the `transcan` invocation inside a bootstrap or loop, if execution time allows. Better still, use `aregImpute` or a package such as as **mice** that uses real Bayesian posterior realizations to multiply impute missing values correctly.

It is strongly recommended that you use the **Hmisc** `naclus` function to determine is there is a good basis for imputation. `naclus` will tell you, for example, if systolic blood pressure is missing whenever diastolic blood pressure is missing. If the only variable that is well correlated with diastolic bp is systolic bp, there is no basis for imputing diastolic bp in this case.

At present, `predict` does not work with multiple imputation.

When calling `fit.mult.impute` with `glm` as the `fitter` argument, if you need to pass a `family` argument to `glm` do it by quoting the family, e.g., `family="binomial"`.

`fit.mult.impute` will not work with proportional odds models when regression imputation was used (as opposed to predictive mean matching). That's because regression imputation will create values of the response variable that did not exist in the dataset, altering the intercept terms in the model.

You should be able to use a variable in the formula given to `fit.mult.impute` as a numeric variable in the regression model even though it was a factor variable in the invocation of `transcan`. Use for example `fit.mult.impute(y ~ codes(x), lrm, trans)` (thanks to Trevor Thompson <trevor@hp5.eushc.org>).

Here is an outline of the steps necessary to impute baseline variables using the `dtrans` argument, when the analysis to be repeated by `fit.mult.impute` is a longitudinal analysis (using e.g. `Gls`).

1. Create a one row per subject data frame containing baseline variables plus follow-up variables that are assigned to windows. For example, you may have dozens of repeated measurements over years but you capture the measurements at the times measured closest to 1, 2, and 3 years after study entry
2. Make sure the dataset contains the subject ID
3. This dataset becomes the one passed to `aregImpute` as `data=`. You will be imputing missing baseline variables from follow-up measurements defined at fixed times.
4. Have another dataset with all the non-missing follow-up values on it, one record per measurement time per subject. This dataset should not have the baseline variables on it, and the follow-up measurements should not be named the same as the baseline variable(s); the subject ID must also appear
5. Add the dtrans argument to `fit.mult.impute` to define a function with one argument representing the one record per subject dataset with missing values filled it from the current imputation. This function merges the above 2 datasets; the returned value of this function is the merged data frame.
6. This merged-on-the-fly dataset is the one handed by `fit.mult.impute` to your fitting function, so variable names in the formula given to `fit.mult.impute` must matched the names created by the merge

Value

For transcan, a list of class 'transcan' with elements

call	(with the function call)
iter	(number of iterations done)
rsq, rsq.adj	containing the R^2s and adjusted R^2s achieved in predicting each variable from all the others
categorical	the values supplied for categorical
asis	the values supplied for asis
coef	the within-variable coefficients used to compute the first canonical variate
xcoef	the (possibly shrunk) across-variables coefficients of the first canonical variate that predicts each variable in-turn.
parms	the parameters of the transformation (knots for splines, contrast matrix for categorical variables)
fillin	the initial estimates for missing values (NA if variable never missing)
ranges	the matrix of ranges of the transformed variables (min and max in first and secondrow)
scale	a vector of scales used to determine convergence for a transformation.
formula	the formula (if x was a formula)

, and optionally a vector of shrinkage factors used for predicting each variable from the others. For asis variables, the scale is the average absolute difference about the median. For other variables it is unity, since canonical variables are standardized. For xcoef, row i has the coefficients to predict transformed variable i, with the column for the coefficient of variable i set to NA. If imputed=TRUE was given, an optional element imputed also appears. This is a list with the vector of imputed values (on the original scale) for each variable containing NAs. Matrices rather than vectors are returned if n.impute is given. If trantab=TRUE, the trantab element also appears, as described above. If n.impute > 0, transcan also returns a list residuals that can be used for future multiple imputation.

impute returns a vector (the same length as var) of class 'impute' with NA values imputed.

predict returns a matrix with the same number of columns or variables as were in x.

fit.mult.impute returns a fit object that is a modification of the fit object created by fitting the completed dataset for the final imputation. The var matrix in the fit object has the imputation-corrected variance-covariance matrix. coefficients is the average (over imputations) of the coefficient vectors, variance.inflation.impute is a vector containing the ratios of the diagonals of the between-imputation variance matrix to the diagonals of the average apparent (within-imputation) variance matrix. missingInfo is *Rubin's rate of missing information* and dfmi is *Rubin's degrees of freedom for a t-statistic* for testing a single parameter. The last two objects are vectors corresponding to the diagonal of the variance matrix. The class "fit.mult.impute" is prepended to the other classes produced by the fitting function.

When method is not 'ordinary', i.e., stacking is used, fit.mult.impute returns a modified fit object that is computed on all completed datasets combined, with most all statistics that are functions of the sample size corrected to the real sample size. Elements in the fit such as residuals will have length equal to the real sample size times the number of imputations.

fit.mult.impute stores intercepts attributes in the coefficient matrix and in var for orm fits.

Side Effects

prints, plots, and `impute.transcan` creates new variables.

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References

Kuhfeld, Warren F: The PRINQUAL Procedure. SAS/STAT User's Guide, Fourth Edition, Volume 2, pp. 1265–1323, 1990.

Van Houwelingen JC, Le Cessie S: Predictive value of statistical models. Statistics in Medicine 8:1303–1325, 1990.

Copas JB: Regression, prediction and shrinkage. JRSS B 45:311–354, 1983.

He X, Shen L: Linear regression after spline transformation. Biometrika 84:474–481, 1997.

Little RJA, Rubin DB: Statistical Analysis with Missing Data. New York: Wiley, 1987.

Rubin DJ, Schenker N: Multiple imputation in health-care databases: An overview and some applications. Stat in Med 10:585–598, 1991.

Faris PD, Ghali WA, et al:Multiple imputation versus data enhancement for dealing with missing data in observational health care outcome analyses. J Clin Epidem 55:184–191, 2002.

See Also

`aregImpute`, `impute`, `naclus`, `naplot`, `ace`, `avas`, `cancor`, `prcomp`, `rcspline.eval`, `lsfit`, `approx`, `datadensity`, `mice`, `ggplot`, `processMI`

Examples

```
## Not run:
x <- cbind(age, disease, blood.pressure, pH)
#cbind will convert factor object `disease' to integer
par(mfrow=c(2,2))
x.trans <- transcan(x, categorical="disease", asis="pH",
                    transformed=TRUE, imputed=TRUE)
summary(x.trans)  #Summary distribution of imputed values, and R-squares
f <- lm(y ~ x.trans$transformed)   #use transformed values in a regression
#Now replace NAs in original variables with imputed values, if not
#using transformations
age            <- impute(x.trans, age)
disease        <- impute(x.trans, disease)
blood.pressure <- impute(x.trans, blood.pressure)
pH             <- impute(x.trans, pH)
#Do impute(x.trans) to impute all variables, storing new variables under
#the old names
summary(pH)       #uses summary.impute to tell about imputations
```

```
                  #and summary.default to tell about pH overall
# Get transformed and imputed values on some new data frame xnew
newx.trans     <- predict(x.trans, xnew)
w              <- predict(x.trans, xnew, type="original")
age            <- w[,"age"]            #inserts imputed values
blood.pressure <- w[,"blood.pressure"]
Function(x.trans)  #creates .age, .disease, .blood.pressure, .pH()
#Repeat first fit using a formula
x.trans <- transcan(~ age + disease + blood.pressure + I(pH),
                    imputed=TRUE)
age <- impute(x.trans, age)
predict(x.trans, expand.grid(age=50, disease="pneumonia",
        blood.pressure=60:260, pH=7.4))
z <- transcan(~ age + factor(disease.code),  # disease.code categorical
              transformed=TRUE, trantab=TRUE, imputed=TRUE, pl=FALSE)
ggplot(z, scale=TRUE)
plot(z$transformed)

## End(Not run)


# Multiple imputation and estimation of variances and covariances of
# regression coefficient estimates accounting for imputation
set.seed(1)
x1 <- factor(sample(c('a','b','c'),100,TRUE))
x2 <- (x1=='b') + 3*(x1=='c') + rnorm(100)
y  <- x2 + 1*(x1=='c') + rnorm(100)
x1[1:20] <- NA
x2[18:23] <- NA
d <- data.frame(x1,x2,y)
n <- naclus(d)
plot(n); naplot(n)  # Show patterns of NAs
f  <- transcan(~y + x1 + x2, n.impute=10, shrink=FALSE, data=d)
options(digits=3)
summary(f)


f  <- transcan(~y + x1 + x2, n.impute=10, shrink=TRUE, data=d)
summary(f)


h <- fit.mult.impute(y ~ x1 + x2, lm, f, data=d)
# Add ,fit.reps=TRUE to save all fit objects in h, then do something like:
# for(i in 1:length(h$fits)) print(summary(h$fits[[i]]))


diag(vcov(h))


h.complete <- lm(y ~ x1 + x2, na.action=na.omit)
h.complete
diag(vcov(h.complete))
```

```
# Note: had the rms ols function been used in place of lm, any
# function run on h (anova, summary, etc.) would have automatically
# used imputation-corrected variances and covariances


# Example demonstrating how using the multinomial logistic model
# to impute a categorical variable results in a frequency
# distribution of imputed values that matches the distribution
# of non-missing values of the categorical variable


## Not run:
set.seed(11)
x1 <- factor(sample(letters[1:4], 1000,TRUE))
x1[1:200] <- NA
table(x1)/sum(table(x1))
x2 <- runif(1000)
z  <- transcan(~ x1 + I(x2), n.impute=20, impcat='multinom')
table(z$imputed$x1)/sum(table(z$imputed$x1))

# Here is how to create a completed dataset
d <- data.frame(x1, x2)
z <- transcan(~x1 + I(x2), n.impute=5, data=d)
imputed <- impute(z, imputation=1, data=d,
                  list.out=TRUE, pr=FALSE, check=FALSE)
sapply(imputed, function(x)sum(is.imputed(x)))
sapply(imputed, function(x)sum(is.na(x)))

## End(Not run)

# Do single imputation and create a filled-in data frame
z <- transcan(~x1 + I(x2), data=d, imputed=TRUE)
imputed <- as.data.frame(impute(z, data=d, list.out=TRUE))

# Example where multiple imputations are for basic variables and
# modeling is done on variables derived from these


set.seed(137)
n <- 400
x1 <- runif(n)
x2 <- runif(n)
y  <- x1*x2 + x1/(1+x2) + rnorm(n)/3
x1[1:5] <- NA
d <- data.frame(x1,x2,y)
w <- transcan(~ x1 + x2 + y, n.impute=5, data=d)
# Add ,show.imputed.actual for graphical diagnostics
## Not run:
g <- fit.mult.impute(y ~ product + ratio, ols, w,
                     data=data.frame(x1,x2,y),
                     derived=expression({
                       product <- x1*x2
```

```
                      ratio   <- x1/(1+x2)
                      print(cbind(x1,x2,x1*x2,product)[1:6,])}))

## End(Not run)


# Here's a method for creating a permanent data frame containing
# one set of imputed values for each variable specified to transcan
# that had at least one NA, and also containing all the variables
# in an original data frame.  The following is based on the fact
# that the default output location for impute.transcan is
# given by the global environment


## Not run:
xt <- transcan(~. , data=mine,
               imputed=TRUE, shrink=TRUE, n.impute=10, trantab=TRUE)
attach(mine, use.names=FALSE)
impute(xt, imputation=1) # use first imputation
# omit imputation= if using single imputation
detach(1, 'mine2')

## End(Not run)


# Example of using invertTabulated outside transcan
x    <- c(1,2,3,4,5,6,7,8,9,10)
y    <- c(1,2,3,4,5,5,5,5,9,10)
freq <- c(1,1,1,1,1,2,3,4,1,1)
# x=5,6,7,8 with prob. .1 .2 .3 .4 when y=5
# Within a tolerance of .05*(10-1) all y's match exactly
# so the distance measure does not play a role
set.seed(1)      # so can reproduce
for(inverse in c('linearInterp','sample'))
 print(table(invertTabulated(x, y, freq, rep(5,1000), inverse=inverse)))


# Test inverse='sample' when the estimated transformation is
# flat on the right.  First show default imputations
set.seed(3)
x <- rnorm(1000)
y <- pmin(x, 0)
x[1:500] <- NA
for(inverse in c('linearInterp','sample')) {
par(mfrow=c(2,2))
  w <- transcan(~ x + y, imputed.actual='hist',
                inverse=inverse, curtail=FALSE,
                data=data.frame(x,y))
  if(inverse=='sample') next
# cat('Click mouse on graph to proceed\n')
# locator(1)
}
```

```
## Not run:
# While running multiple imputation for a logistic regression model
# Run the rms package validate and calibrate functions and save the
# results in w$funresults
a <- aregImpute(~ x1 + x2 + y, data=d, n.impute=10)
require(rms)
g <- function(fit)
  list(validate=validate(fit, B=50), calibrate=calibrate(fit, B=75))
w <- fit.mult.impute(y ~ x1 + x2, lrm, a, data=d, fun=g,
                     fitargs=list(x=TRUE, y=TRUE))
# Get all validate results in it's own list of length 10
r <- w$funresults
val <- lapply(r, function(x) x$validate)
cal <- lapply(r, function(x) x$calibrate)
# See rms processMI and https://hbiostat.org/rmsc/validate.html#sec-val-mival

## End(Not run)

## Not run:
# Account for within-subject correlation using the robust cluster sandwich
# covariance estimate in conjunction with Rubin's rule for multiple imputation
# rms package must be installed
a <- aregImpute(..., data=d)
f <- fit.mult.impute(y ~ x1 + x2, lrm, a, n.impute=30, data=d, cluster=d$id)
# Get likelihood ratio chi-square tests accounting for missingness
a <- aregImpute(..., data=d)
h <- fit.mult.impute(y ~ x1 + x2, lrm, a, n.impute=40, data=d, lrt=TRUE)
processMI(h, which='anova')   # processMI is in rms

## End(Not run)
```

`translate` *Translate Vector or Matrix of Text Strings*

Description

Uses the UNIX tr command to translate any character in `old` in `text` to the corresponding character in `new`. If multichar=T or `old` and `new` have more than one element, or each have one element but they have different numbers of characters, uses the UNIX sed command to translate the series of characters in `old` to the series in `new` when these characters occur in `text`. If `old` or `new` contain a backslash, you sometimes have to quadruple it to make the UNIX command work. If they contain a forward slash, preceed it by two backslashes. Invokes the builtin chartr function if `multichar=FALSE`.

Usage

```
translate(text, old, new, multichar=FALSE)
```

Arguments

text	scalar, vector, or matrix of character strings to translate.
old	vector old characters
new	corresponding vector of new characters
multichar	See above.

Value

an object like text but with characters translated

See Also

grep

Examples

```
translate(c("ABC","DEF"),"ABCDEFG", "abcdefg")
translate("23.12","[.]","\\cdot ") # change . to \cdot
translate(c("dog","cat","tiger"),c("dog","cat"),c("DOG","CAT"))
# S-Plus gives  [1] "DOG"   "CAT"   "tiger" - check discrepency
translate(c("dog","cat2","snake"),c("dog","cat"),"animal")
# S-Plus gives  [1] "animal"  "animal2" "snake"
```

---

trunc.POSIXt *Return the floor, ceiling, or rounded value of date or time to specified unit.*

Description

truncPOSIXt returns the date truncated to the specified unit. ceil.POSIXt returns next ceiling of the date at the unit selected in units. roundPOSIXt returns the date or time value rounded to nearest specified unit selected in digits.

truncPOSIXt and roundPOSIXt have been extended from the base package functions trunc.POSIXt and round.POSIXt which in the future will add the other time units we need.

Usage

```
ceil(x, units,...)
## Default S3 method:
ceil(x, units, ...)
truncPOSIXt(x, units = c("secs", "mins", "hours", "days",
"months", "years"), ...)
## S3 method for class 'POSIXt'
ceil(x, units = c("secs", "mins", "hours", "days",
"months", "years"), ...)
roundPOSIXt(x, digits = c("secs", "mins", "hours", "days", "months", "years"))
```

Arguments

x	date to be ceilinged, truncated, or rounded
units	unit to that is is rounded up or down to.
digits	same as units but different name to be compatible with round generic.
...	further arguments to be passed to or from other methods.

Value

An object of class POSIXlt.

Author(s)

Charles Dupont

See Also

Date POSIXt POSIXlt DateTimeClasses

Examples

```
date <- ISOdate(1832, 7, 12)
ceil(date, units='months')  # '1832-8-1'
truncPOSIXt(date, units='years')     # '1832-1-1'
roundPOSIXt(date, digits='months')    # '1832-7-1'
```

---

typstAsis *Emit Raw Typst Markup Without Requiring* results='asis'

Description

Marks a character string as raw Typst source so that Quarto/knitr renders it directly – as real typeset Typst content – rather than displaying it as literal escaped text. This lets print/render methods that build Typst output (for example typst_describe, typst_describe_single, or the Typst branch of a print.X/latex.X method) return their result normally, with no results='asis' chunk option required anywhere in the calling document.

Usage

```
typstAsis(x)
```

Arguments

x	A character string (or vector, coerced via paste0) containing complete, valid Typst markup.

Details

`typstAsis` wraps `x` in a Pandoc raw-block fence (`` ````{=typst} ... ```` ``) and, when running inside a knitr/Quarto render, returns the result via `asis_output`. Returning an `asis_output` object as the visible top-level value of a chunk is what knitr's own `knit_print` dispatch recognizes as content to insert verbatim rather than escape – this is the mechanism, confirmed empirically, that requires no new `knit_print` method to be registered for any particular class: any function that ultimately returns `typstAsis(...)` as its result renders correctly, regardless of how deeply the string was built up inside helper functions.

The fence uses **four** backticks, not the usual three. This is deliberate: if `x` itself contains a triple-backtick sequence (for example, output from a helper that wraps captured `print` output in its own raw block, such as `typst_verbatim`), an ordinary three-backtick outer fence would be closed prematurely by that inner sequence, silently corrupting everything in the document that follows – confirmed directly as the cause of a real rendering failure during development. Pandoc's fenced-block matching only closes a fence with another fence of at least the same length, so a four-backtick outer fence cannot be broken by an inner three-backtick one.

When not running inside a knitr render (for example, when called interactively at the R console while developing or testing a `typst_*` function), `typstAsis` falls back to printing `x` via `cat` and returning it invisibly, so `typst_*` functions remain directly usable outside Quarto documents.

Important: `x` must already be genuine, complete Typst syntax. `typstAsis` does not translate or interpret its argument in any way – it only marks already-finished Typst markup so Pandoc passes it through untouched. This means `typstAsis` must *not* be used to wrap LaTeX-syntax math content that is meant to be parsed by Pandoc's own markdown reader and translated to Typst via texmath (for example, the equation content built by `latexrms` and its calling `latex.X` methods) – wrapping such content in a `{=typst}` raw block prevents Pandoc from ever recognizing it as math to translate, and it will be inserted unchanged, as literal LaTeX syntax, into a Typst document. That kind of content should instead be returned via a bare `asis_output` call, with no raw-block fence, so Pandoc's markdown/math parsing sees it directly.

Value

If called during a knitr/Quarto render, an object of class `knit_asis` (see `asis_output`), which knitr inserts into the rendered document verbatim. Otherwise, the fenced string is printed to the console via `cat` and returned invisibly.

See Also

`typstTranslate`, `asis_output`

Examples

```
## Not run:
# Inside a print/render method's typst branch:
typst_describe <- function(object, ...) {
  R <- c(typstFunctions$spikehist, ...)  # build up Typst content
  typstAsis(paste(R, collapse = '\n\n'))
}

# NOT appropriate: LaTeX-syntax math meant for texmath translation
```

```
# should use bare knitr::asis_output(), never typstAsis()

## End(Not run)
```

---

typstDotchart *Enhanced Dot Chart Rendered as Typst Markup*

Description

typstDotchart is a Typst-markup translation of latexDotchart, itself a translation of dotchart3. It produces a character string of Typst markup (a single #box(...) containing a sequence of #place() calls) that visually mimics dotchart3's output, for use in Typst/Quarto documents in place of a raster image. As with latexDotchart, the add and horizontal=FALSE options available in dotchart3 are not supported here.

Usage

```
typstDotchart(
  data,
  labels,
  groups = NULL,
  gdata = NA,
  xlab = "",
  auxdata,
  auxgdata = NULL,
  auxtitle,
  w = 4,
  h = 4,
  margin,
  lines = TRUE,
  dotsize = 0.075,
  size = "small",
  size.labels = "small",
  size.group.labels = "normalsize",
  ttlabels = FALSE,
  sort. = TRUE,
  xaxis = TRUE,
  lcolor = "gray",
  ...
)
```

Arguments

data	A numeric vector whose values are shown on the x-axis.
labels	A vector of labels for each point, corresponding to data. If omitted, names(data) are used, and if there are no names, integers prefixed by "#" are used.

groups	An optional categorical variable indicating how data values are grouped.
gdata	Data values for groups, typically summaries such as group medians.
xlab	X-axis title.
auxdata	A vector of auxiliary data, the same length as data. If present, printed outside the right margin of the chart – usually cell sizes.
auxgdata	Similar to auxdata but corresponding to gdata.
auxtitle	If auxdata is given, a column heading for it (e.g. "N").
w	Width of the chart, in inches.
h	Height of the chart, in inches.
margin	A 4-vector, in inches: margin to the left of the x-axis, below the y-axis, to the right of the x-axis, and above the y-axis. By default computed automatically based on label/auxdata widths.
lines	Set to FALSE to suppress the horizontal reference lines.
dotsize	Diameter of the filled dots, in inches.
size	Text size for the main chart text, as a LaTeX font-size command name (see Details).
size.labels	Text size for row labels.
size.group.labels	Text size for group labels.
ttlabels	Set to TRUE to render row labels in a monospace font.
sort.	Set to FALSE to keep the input order rather than sorting by data value.
xaxis	Set to FALSE to suppress the x-axis.
lcolor	Color for the horizontal reference lines. Default "gray".
...	Ignored.

Details

typstDotchart reuses latexDotchart's coordinate computation, sorting, and margin logic essentially unchanged – none of that is LaTeX-specific. Only the drawing primitives differ:

- Text (\put(x,y){\makebox(...)[just]{s}}) becomes a call to a small shared Typst helper, justified-text (expected to already be defined in the document via typstFunctions$justifiedText), which uses Typst's measure() function to compute the rendered width/height of s and offset the placement accordingly – the Typst equivalent of \makebox's own text-width-aware justification.
- Lines (\put(x,y){\line(dx,dy){len}}) become #place(dx:, dy:, line(length:, angle:)) calls, with color passed directly as line()'s stroke: argument rather than LaTeX's stateful \color{...} ... \color{black} wrapping – Typst needs no such state to be opened and closed.
- Dots (\put(x,y){\circle*{d}}) become #place(dx:, dy:, circle(radius:, fill: black)) calls. Since #place() anchors the *top-left* of a shape's bounding box rather than its center, both dx and dy are offset by -radius so the dot is actually centered on its target point.

Because Typst's `#place()` measures `dy` from the *top* of its container downward, while LaTeX's `picture` environment measures `y` from the *bottom* upward, the internal y-coordinate function is wrapped in a single top/bottom flip (`yt <- function(y) h - yt0(y)`) so every other line of coordinate logic below it can be used completely unchanged from `latexDotchart`.

The gap between x-axis tick marks and their labels was originally a fixed `0.15` inch offset from the axis line, with tick marks `0.05` inches long – an effective gap of `0.10` inches between the tick's far edge and the label. That gap has been reduced by 40% here (to `0.06` inches), giving a total label offset of `0.05 + 0.06 = 0.11` inches, confirmed by direct visual comparison against the original spacing.

`size`, `size.labels`, and `size.group.labels` keep `latexDotchart`'s original LaTeX font-size-command-name interface (e.g. `'small'`, `'normalsize'`, `'large'`) for familiarity, translated internally to approximate point sizes via a fixed lookup table based on standard LaTeX class default point sizes. This is an approximation – actual LaTeX point sizes depend on the base document font size – not a byte-exact equivalence.

This is a first-draft port. The individual drawing primitives (text justification via `measure()`, dot centering, horizontal/vertical lines, direct color arguments, the tick-label gap) have each been confirmed by standalone compile tests. The full function, exercised end to end on real grouped/auxdata input the way `latexDotchart`'s own examples do, has not yet been compile-tested at that scale.

Value

A single character string of Typst markup – one `#box(...)` containing the full sequence of placed drawing commands – suitable for passing to `typstAsis` (if it is the sole/final content being emitted) or for concatenating into a larger character vector alongside other Typst content.

See Also

`latexDotchart`, `dotchart3`, `typstTranslate`

Examples

```
## Not run:
z <- typstDotchart(c(.1, .2), c('a', 'bbAAb'), xlab = 'This Label',
                   auxdata = c(.1, .2), auxtitle = 'Zcriteria')
typstAsis(z)

## End(Not run)
```

---

typstTranslate *Translate a Character String for Typst Markup*

Description

Translates arbitrary character strings – variable labels, titles, captions, and similar free text – so they display correctly as literal text in Typst markup, with optional math-mode handling for superscripts and Greek letter names. This is the Typst analog of `latexTranslate` and `htmlTranslate`.

Usage

```
typstTranslate(object, greek = FALSE, na = "", ...)
```

Arguments

object	A character vector, or an object coercible to one via as.character, to be translated for display in Typst markup.
greek	Logical. If TRUE, whole-word matches of Greek letter names (alpha, beta, Gamma, etc.) are wrapped in Typst math mode so they render as the actual Greek glyph rather than the literal English name. Default is FALSE.
na	Character string to substitute for NA elements of object before translation. Default is ''.
...	Currently unused; present for signature compatibility with latexTranslate/htmlTranslate.

Details

typstTranslate is built entirely from vectorized base gsub calls rather than sedit, and is deliberately simpler than latexTranslate in several respects:

- Several characters latexTranslate escapes (|, %, &, >, the pound sign) have no special meaning in Typst markup and are left untouched here – carrying over LaTeX's escaping list unchanged would add noise, not correctness.
- Where LaTeX requires math mode for symbols such as \leq/\geq (they do not exist in text mode at all), Typst can use the literal Unicode character directly in ordinary text, so <= and >= translate straight to Unicode rather than opening a math span.
- Superscripts (^digits) are rendered with Typst's text-mode #super[] function rather than a bare math-mode span. A bare $^(3)$ span with no base inside the same span is invalid Typst syntax ("unexpected hat") unless something happens to merge a base into it, and even when made syntactically valid, pulling an ordinary word into math mode causes Typst to auto-italicize/treat it as bare variable letters rather than showing plain upright text. #super[] avoids both problems: it is valid immediately after any preceding content (or none), and does not restyle whatever precedes it.
- Greek letter names are recognized as whole words (via a single vectorized regex alternation, not a per-letter loop) and wrapped in $...$ so they render as the actual Greek glyph.

Characters that *are* escaped, because they are syntactically meaningful in Typst markup mode and could otherwise corrupt output or (in the case of <) cause an outright compile error, are # < _ @ ` * ~ and the backslash itself. < specifically needs this because Typst reads a bare < as the start of label-reference syntax (<name>); an unescaped value such as a P-value formatted as "<0.001" will otherwise break Typst compilation with an "unclosed label" error. _ and * are escaped unconditionally (not only where they would definitely cause trouble) because ordinary variable names and labels routinely contain underscores or asterisks, and Typst's emphasis/strong-text shorthand can trigger across unrelated stretches of text if these are left unescaped.

Math spans that end up touching with no text between them (which can happen, for example, when a Greek-letter substitution lands immediately next to another math-producing substitution) are merged into one continuous span. Typst reads two adjacent $...$$...$ spans as an *empty*

math block followed by bare text – a real compile error ("unexpected hat"), not merely a cosmetic issue – so this merge is applied unconditionally wherever it is safe to do so.

Not carried over from `latexTranslate`: the `pb` argument (auto-sizing `\left`/`\right` delimiters) and the `inn`/`out` extension arguments – Typst does not need LaTeX's delimiter-sizing workaround for ordinary text-mode brackets, and the extension hooks were not needed for current use cases.

Value

A character vector of the same length as `object`, containing valid Typst markup safe for direct insertion into Typst source (for example, inside a ```` ```{=typst} ```` raw block, or as the content of a native `#table()` cell).

See Also

`latexTranslate`, `htmlTranslate`, `typstAsis`

Examples

```
typstTranslate("P<0.001")                    # escapes the literal <
typstTranslate("Volume (cm^3)")               # #super[] superscript
typstTranslate("rho coefficient", greek=TRUE)  # real Greek rho glyph
typstTranslate("chi^2 statistic", greek=TRUE)  # merged math span
```

---

units *Units Attribute of a Vector*

Description

Sets or retrieves the `"units"` attribute of an object. For `units.default` replaces the builtin version, which only works for time series objects. If the variable is also given a `label`, subsetting (using `[.labelled`) will retain the `"units"` attribute. For a `Surv` object, `units` first looks for an overall `"units"` attribute, then it looks for `units` for the `time2` variable then for `time1`. When setting `"units"`, `value` is changed to lower case and any "s" at the end is removed.

Usage

```
units(x, ...)
## Default S3 method:
units(x, none='', ...)
## S3 method for class 'Surv'
units(x, none='', ...)
## Default S3 replacement method:
units(x) <- value
```

Arguments

x	any object
...	ignored
value	the units of the object, or ""
none	value to which to set result if no appropriate attribute is found

Value

the units attribute of x, if any; otherwise, the units attribute of the tspar attribute of x if any; otherwise the value none. Handling for Surv objects is different (see above).

See Also

label

Examples

```
require(survival)
fail.time <- c(10,20)
units(fail.time) <- "Day"
describe(fail.time)
S <- Surv(fail.time)
units(S)

label(fail.time) <- 'Failure Time'
units(fail.time) <- 'Days'
fail.time
```

---

upData *Update a Data Frame or Cleanup a Data Frame after Importing*

Description

cleanup.import will correct errors and shrink the size of data frames. By default, double precision numeric variables are changed to integer when they contain no fractional components. Infinite values or values greater than 1e20 in absolute value are set to NA. This solves problems of importing Excel spreadsheets that contain occasional character values for numeric columns, as S converts these to Inf without warning. There is also an option to convert variable names to lower case and to add labels to variables. The latter can be made easier by importing a CNTLOUT dataset created by SAS PROC FORMAT and using the sasdict option as shown in the example below. cleanup.import can also transform character or factor variables to dates.

upData is a function facilitating the updating of a data frame without attaching it in search position one. New variables can be added, old variables can be modified, variables can be removed or renamed, and "labels" and "units" attributes can be provided. Observations can be subsetted. Various checks are made for errors and inconsistencies, with warnings issued to help the user. Levels

of factor variables can be replaced, especially using the `list` notation of the standard `merge.levels` function. Unless `force.single` is set to `FALSE`, `upData` also converts double precision vectors to integer if no fractional values are present in a vector. `upData` is also used to process R workspace objects created by StatTransfer, which puts variable and value labels as attributes on the data frame rather than on each variable. If such attributes are present, they are used to define all the labels and value labels (through conversion to factor variables) before any label changes take place, and `force.single` is set to a default of `FALSE`, as StatTransfer already does conversion to integer.

Variables having labels but not classed `"labelled"` (e.g., data imported using the `haven` package) have that class added to them by `upData`.

The `dataframeReduce` function removes variables from a data frame that are problematic for certain analyses. Variables can be removed because the fraction of missing values exceeds a threshold, because they are character or categorical variables having too many levels, or because they are binary and have too small a prevalence in one of the two values. Categorical variables can also have their levels combined when a level is of low prevalence. A data frame listing actions take is return as attribute `"info"` to the main returned data frame.

Usage

```
cleanup.import(obj, labels, lowernames=FALSE,
               force.single=TRUE, force.numeric=TRUE, rmnames=TRUE,
               big=1e20, sasdict, print, datevars=NULL, datetimevars=NULL,
               dateformat='%F',
               fixdates=c('none','year'),
               autodate=FALSE, autonum=FALSE, fracnn=0.3,
               considerNA=NULL, charfactor=FALSE)

upData(object, ...,
       subset, rename, drop, keep, labels, units, levels, force.single=TRUE,
       lowernames=FALSE, caplabels=FALSE, classlab=FALSE, moveUnits=FALSE,
       charfactor=FALSE, print=TRUE, html=FALSE)

dataframeReduce(data, fracmiss=1, maxlevels=NULL,  minprev=0, print=TRUE)
```

Arguments

`obj`	a data frame or list
`object`	a data frame or list
`data`	a data frame
`force.single`	By default, double precision variables are converted to single precision (in S-Plus only) unless `force.single=FALSE`. `force.single=TRUE` will also convert vectors having only integer values to have a storage mode of integer, in R or S-Plus.
`force.numeric`	Sometimes importing will cause a numeric variable to be changed to a factor vector. By default, `cleanup.import` will check each factor variable to see if the levels contain only numeric values and `""`. In that case, the variable will be converted to numeric, with `""` converted to NA. Set `force.numeric=FALSE` to prevent this behavior.

rmnames	set to 'F' to not have 'cleanup.import' remove 'names' or '.Names' attributes from variables
labels	a character vector the same length as the number of variables in obj. These character values are taken to be variable labels in the same order of variables in obj. For upData, labels is a named list or named vector with variables in no specific order.
lowernames	set this to TRUE to change variable names to lower case. upData does this before applying any other changes, so variable names given inside arguments to upData need to be lower case if lowernames==TRUE.
big	a value such that values larger than this in absolute value are set to missing by cleanup.import
sasdict	the name of a data frame containing a raw imported SAS PROC CONTENTS CNTLOUT= dataset. This is used to define variable names and to add attributes to the new data frame specifying the original SAS dataset name and label.
print	set to TRUE or FALSE to force or prevent printing of the current variable number being processed. By default, such messages are printed if the product of the number of variables and number of observations in obj exceeds 500,000. For dataframeReduce set print to FALSE to suppress printing information about dropped or modified variables. Similar for upData.
datevars	character vector of names (after lowernames is applied) of variables to consider as a factor or character vector containing dates in a format matching dateformat. The default is "%F" which uses the yyyy-mm-dd format.
datetimevars	character vector of names (after lowernames is applied) of variables to consider to be date-time variables, with date formats as described under datevars followed by a space followed by time in hh:mm:ss format. chron is used to store date-time variables. If all times in the variable are 00:00:00 the variable will be converted to an ordinary date variable.
dateformat	for cleanup.import is the input format (see strptime)
fixdates	for any of the variables listed in datevars that have a dateformat that cleanup.import understands, specifying fixdates allows corrections of certain formatting inconsistencies before the fields are attempted to be converted to dates (the default is to assume that the dateformat is followed for all observation for datevars). Currently fixdates='year' is implemented, which will cause 2-digit or 4-digit years to be shifted to the alternate number of digits when dateform is the default "%F" or is "%y-%m-%d", "%m/%d/%y", or "%m/%d/%Y". Two-digits years are padded with 20 on the left. Set dateformat to the desired format, not the exceptional format.
autodate	set to TRUE to have cleanup.import determine and automatically handle factor or character vectors that mainly contain dates of the form YYYY-mm-dd, mm/dd/YYYY, YYYY, or mm/YYYY, where the later two are imputed to, respectively, July 3 and the 15th of the month. Takes effect when the fraction of non-dates (of non-missing values) is less than fracnn to allow for some free text such as "unknown". Attributes special.miss and imputed are created for the vector so that describe() will inform the user. Illegal values are converted to NAs and stored in the special.miss attribute.

autonum	set to TRUE to have cleanup.import examine (after autodate) character and factor variables to see if they are legal numerics exact for at most a fraction of fracnn of non-missing non-numeric values. Qualifying variables are converted to numeric, and illegal values set to NA and stored in the special.miss attribute to enhance describe output.
fracnn	see autodate and autonum
considerNA	for autodate and autonum, considers character values in the vector considerNA to be the same as NA. Leading and trailing white space and upper/lower case are ignored.
charfactor	set to TRUE to change character variables to factors if they have fewer than n/2 unique values. Null strings and blanks are converted to NAs.
...	for upData, one or more expressions of the form variable=expression, to derive new variables or change old ones.
subset	an expression that evaluates to a logical vector specifying which rows of object should be retained. The expressions should use the original variable names, i.e., before any variables are renamed but after lowernames takes effect.
rename	list or named vector specifying old and new names for variables. Variables are renamed before any other operations are done. For example, to rename variables age and sex to respectively Age and gender, specify rename=list(age="Age", sex="gender") or rename=c(age=...).
drop	a vector of variable names to remove from the data frame
keep	a vector of variable names to keep, with all other variables dropped
units	a named vector or list defining "units" attributes of variables, in no specific order
levels	a named list defining "levels" attributes for factor variables, in no specific order. The values in this list may be character vectors redefining levels (in order) or another list (see merge.levels if using S-Plus).
caplabels	set to TRUE to capitalize the first letter of each word in each variable label
classlab	set to TRUE (the old default behavior) to automatically have upData make variables having a "label" attribute have class of "labelled". Note that when the labels argument to upData is given, these create labelled-class variables as always.
moveUnits	set to TRUE to look for units of measurements in variable labels and move them to a "units" attribute. If an expression in a label is enclosed in parentheses or brackets it is assumed to be units if moveUnits=TRUE.
html	set to TRUE to print conversion information as html vertabim at 0.6 size. The user will need to put results='asis' in a knitr chunk header to properly render this output.
fracmiss	the maximum permissable proportion of NAs for a variable to be kept. Default is to keep all variables no matter how many NAs are present.
maxlevels	the maximum number of levels of a character or categorical or factor variable before the variable is dropped
minprev	the minimum proportion of non-missing observations in a category for a binary variable to be retained, and the minimum relative frequency of a category before it will be combined with other small categories

Value

a new data frame

Author(s)

Frank Harrell, Vanderbilt University

See Also

sas.get, data.frame, describe, label, read.csv, strptime, POSIXct,Date

Examples

```
## Not run:
dat <- read.table('myfile.asc')
dat <- cleanup.import(dat)

## End(Not run)
dat <- data.frame(a=1:3, d=c('01/02/2004',' 1/3/04',''))
cleanup.import(dat, datevars='d', dateformat='%m/%d/%y', fixdates='year')

dat <- data.frame(a=(1:3)/7, y=c('a','b1','b2'), z=1:3)
dat2 <- upData(dat, x=x^2, x=x-5, m=x/10,
               rename=c(a='x'), drop='z',
               labels=c(x='X', y='test'),
               levels=list(y=list(a='a',b=c('b1','b2'))))
dat2
describe(dat2)
dat <- dat2    # copy to original name and delete dat2 if OK
rm(dat2)
dat3 <- upData(dat, X=X^2, subset = x < (3/7)^2 - 5, rename=c(x='X'))

# Remove hard to analyze variables from a redundancy analysis of all
# variables in the data frame
d <- dataframeReduce(dat, fracmiss=.1, minprev=.05, maxlevels=5)
# Could run redun(~., data=d) at this point or include dataframeReduce
# arguments in the call to redun

# If you import a SAS dataset created by PROC CONTENTS CNTLOUT=x.datadict,
# the LABELs from this dataset can be added to the data.  Let's also
# convert names to lower case for the main data file
## Not run:
mydata2 <- cleanup.import(mydata2, lowernames=TRUE, sasdict=datadict)

## End(Not run)
```

upFirst *Change First Letters to Upper Case*

Description

Changes the first letter of each word in a string to upper case, keeping selected words in lower case. Words containing at least 2 capital letters are kept as-is.

Usage

```
upFirst(txt, lower = FALSE, alllower = FALSE)
```

Arguments

txt	a character vector
lower	set to TRUE to make only the very first letter of the string upper case, and to keep words with at least 2 capital letters in their original form
alllower	set to TRUE to make every word start with lower case unless it has at least 2 caps

References

https://en.wikipedia.org/wiki/Letter_case#Headings_and_publication_titles

Examples

```
upFirst(c('this and that','that is Beyond question'))
```

valueTags *Store Descriptive Information About an Object*

Description

Functions get or set useful information about the contents of the object for later use.

Usage

```
valueTags(x)
valueTags(x) <- value

valueLabel(x)
valueLabel(x) <- value

valueName(x)
valueName(x) <- value

valueUnit(x)
valueUnit(x) <- value
```

Arguments

x	an object
value	for valueTags<- a named list of value tags. a character vector of length 1, or NULL.

Details

These functions store the a short name of for the contents, a longer label that is useful for display, and the units of the contents that is useful for display.

valueTag is an accessor, and valueTag<- is a replacement function for all of the value's information.

valueName is an accessor, and valueName<- is a replacement function for the value's name. This name is used when a plot or a latex table needs a short name and the variable name is not useful.

valueLabel is an accessor, and valueLabel<- is a replacement function for the value's label. The label is used in a plots or latex tables when they need a descriptive name.

valueUnit is an accessor, and valueUnit<- is a replacement function for the value's unit. The unit is used to add unit information to the R output.

Value

valueTag returns NULL or a named list with each of the named values name, label, unit set if they exists in the object.

For valueTag<- returns list

For valueName, valueLable, and valueUnit returns NULL or character vector of length 1.

For valueName<-, valueLabel<-, and valueUnit returns value

Author(s)

Charles Dupont

See Also

names, attributes

Examples

```
age <- c(21,65,43)
y   <- 1:3
valueLabel(age) <- "Age in Years"
plot(age, y, xlab=valueLabel(age))


x1 <- 1:10
x2 <- 10:1
valueLabel(x2) <- 'Label for x2'
valueUnit(x2) <- 'mmHg'
x2
```

```
x2[1:5]
dframe <- data.frame(x1, x2)
Label(dframe)


##In these examples of llist, note that labels are printed after
##variable names, because of print.labelled
a <- 1:3
b <- 4:6
valueLabel(b) <- 'B Label'
```

---

varclus *Variable Clustering*

Description

Does a hierarchical cluster analysis on variables, using the Hoeffding D statistic, squared Pearson or Spearman correlations, or proportion of observations for which two variables are both positive as similarity measures. Variable clustering is used for assessing collinearity, redundancy, and for separating variables into clusters that can be scored as a single variable, thus resulting in data reduction. For computing any of the three similarity measures, pairwise deletion of NAs is done. The clustering is done by `hclust()`. A small function `naclus` is also provided which depicts similarities in which observations are missing for variables in a data frame. The similarity measure is the fraction of `NA`s in common between any two variables. The diagonals of this `sim` matrix are the fraction of NAs in each variable by itself. `naclus` also computes `na.per.obs`, the number of missing variables in each observation, and `mean.na`, a vector whose ith element is the mean number of missing variables other than variable i, for observations in which variable i is missing. The `naplot` function makes several plots (see the `which` argument).

So as to not generate too many dummy variables for multi-valued character or categorical predictors, `varclus` will automatically combine infrequent cells of such variables using `combine.levels`.

`plotMultSim` plots multiple similarity matrices, with the similarity measure being on the x-axis of each subplot.

`na.pattern` prints a frequency table of all combinations of missingness for multiple variables. If there are 3 variables, a frequency table entry labeled `110` corresponds to the number of observations for which the first and second variables were missing but the third variable was not missing.

Usage

```
varclus(x, similarity=c("spearman","pearson","hoeffding","bothpos","ccbothpos"),
        type=c("data.matrix","similarity.matrix"),
        method="complete",
        data=NULL, subset=NULL, na.action=na.retain,
        trans=c("square", "abs", "none"), ...)
## S3 method for class 'varclus'
print(x, abbrev=FALSE, ...)
## S3 method for class 'varclus'
plot(x, ylab, abbrev=FALSE, legend.=FALSE, loc, maxlen, labels, ...)
```

```
naclus(df, method)
naplot(obj, which=c('all','na per var','na per obs','mean na',
                    'na per var vs mean na'), ...)

plotMultSim(s, x=1:dim(s)[3],
            slim=range(pretty(c(0,max(s,na.rm=TRUE)))),
            slimds=FALSE,
            add=FALSE, lty=par('lty'), col=par('col'),
            lwd=par('lwd'), vname=NULL, h=.5, w=.75, u=.05,
            labelx=TRUE, xspace=.35)

na.pattern(x)
```

Arguments

x	a formula, a numeric matrix of predictors, or a similarity matrix. If x is a formula, model.matrix is used to convert it to a design matrix. If the formula excludes an intercept (e.g., ~ a + b -1), the first categorical (factor) variable in the formula will have dummy variables generated for all levels instead of omitting one for the first level. For plot and print, x is an object created by varclus. For na.pattern, x is a data table, data frame, or matrix. For plotMultSim, is a numeric vector specifying the ordered unique values on the x-axis, corresponding to the third dimension of s.
df	a data frame
s	an array of similarity matrices. The third dimension of this array corresponds to different computations of similarities. The first two dimensions come from a single similarity matrix. This is useful for displaying similarity matrices computed by varclus, for example. A use for this might be to show pairwise similarities of variables across time in a longitudinal study (see the example below). If vname is not given, s must have dimnames.
similarity	the default is to use squared Spearman correlation coefficients, which will detect monotonic but nonlinear relationships. You can also specify linear correlation or Hoeffding's (1948) D statistic, which has the advantage of being sensitive to many types of dependence, including highly non-monotonic relationships. For binary data, or data to be made binary, similarity="bothpos" uses as a similarity measure the proportion of observations for which two variables are both positive. similarity="ccbothpos" uses a chance-corrected measure which is the proportion of observations for which both variables are positive minus the product of the two marginal proportions. This difference is expected to be zero under independence. For diagonals, "ccbothpos" still uses the proportion of positives for the single variable. So "ccbothpos" is not really a similarity measure, and clustering is not done. This measure is useful for plotting with plotMultSim (see the last example).
type	if x is not a formula, it may be a data matrix or a similarity matrix. By default, it is assumed to be a data matrix.
method	see hclust. The default, for both varclus and naclus, is "compact" (for R it is "complete").

data	a data frame, data table, or list
subset	a standard subsetting expression
na.action	These may be specified if x is a formula. The default na.action is na.retain, defined by varclus. This causes all observations to be kept in the model frame, with later pairwise deletion of NAs.
trans	By default, when the similarity measure is based on Pearson's or Spearman's correlation coefficients, the coefficients are squared. Specify trans="abs" to take absolute values or trans="none" to use the coefficients as they stand.
...	for varclus these are optional arguments to pass to the dataframeReduce function. Otherwise, passed to plclust (or to dotchart or dotchart2 for naplot).
ylab	y-axis label. Default is constructed on the basis of similarity.
legend.	set to TRUE to plot a legend defining the abbreviations
loc	a list with elements x and y defining coordinates of the upper left corner of the legend. Default is locator(1).
maxlen	if a legend is plotted describing abbreviations, original labels longer than maxlen characters are truncated at maxlen.
labels	a vector of character strings containing labels corresponding to columns in the similar matrix, if the column names of that matrix are not to be used
obj	an object created by naclus
which	defaults to "all" meaning to have naplot make 4 separate plots. To make only one of the plots, use which="na per var" (dot chart of fraction of NAs for each variable), ,"na per obs" (dot chart showing frequency distribution of number of variables having NAs in an observation), "mean na" (dot chart showing mean number of other variables missing when the indicated variable is missing), or "na per var vs mean na", a scatterplot showing on the x-axis the fraction of NAs in the variable and on the y-axis the mean number of other variables that are NA when the indicated variable is NA.
abbrev	set to TRUE to abbreviate variable names for plotting or printing. Is set to TRUE automatically if legend=TRUE.
slim	2-vector specifying the range of similarity values for scaling the y-axes. By default this is the observed range over all of s.
slimds	set to slimds to TRUE to scale diagonals and off-diagonals separately
add	set to TRUE to add similarities to an existing plot (usually specifying lty or col)
lty, col, lwd	line type, color, or line thickness for plotMultSim
vname	optional vector of variable names, in order, used in s
h	relative height for subplot
w	relative width for subplot
u	relative extra height and width to leave unused inside the subplot. Also used as the space between y-axis tick mark labels and graph border.
labelx	set to FALSE to suppress drawing of labels in the x direction
xspace	amount of space, on a scale of 1:n where n is the number of variables, to set aside for y-axis labels

Details

`options(contrasts= c("contr.treatment", "contr.poly"))` is issued temporarily by `varclus` to make sure that ordinary dummy variables are generated for `factor` variables. Pass arguments to the `dataframeReduce` function to remove problematic variables (especially if analyzing all variables in a data frame).

Value

for `varclus` or `naclus`, a list of class `varclus` with elements `call` (containing the calling statement), `sim` (similarity matrix), `n` (sample size used if `x` was not a correlation matrix already - `n` is a matrix), `hclust`, the object created by `hclust`, `similarity`, and `method`. `naclus` also returns the two vectors listed under description, and `naplot` returns an invisible vector that is the frequency table of the number of missing variables per observation. `plotMultSim` invisibly returns the limits of similarities used in constructing the y-axes of each subplot. For `similarity="ccbothpos"` the `hclust` object is `NULL`.

`na.pattern` creates an integer vector of frequencies.

Side Effects

plots

Author(s)

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References

Sarle, WS: The VARCLUS Procedure. SAS/STAT User's Guide, 4th Edition, 1990. Cary NC: SAS Institute, Inc.

Hoeffding W. (1948): A non-parametric test of independence. Ann Math Stat 19:546–57.

See Also

`hclust`, `plclust`, `hoeffd`, `rcorr`, `cor`, `model.matrix`, `locator`, `na.pattern`, `cut2`, `combine.levels`

Examples

```
set.seed(1)
x1 <- rnorm(200)
x2 <- rnorm(200)
x3 <- x1 + x2 + rnorm(200)
x4 <- x2 + rnorm(200)
x <- cbind(x1,x2,x3,x4)
v <- varclus(x, similarity="spear")  # spearman is the default anyway
v    # invokes print.varclus
print(round(v$sim,2))
plot(v)
```

```
# Convert the dendrogram to be horizontal
v <- as.dendrogram(v$hclust)
plot(v, horiz=TRUE, axes=FALSE, xlab=expression(paste('Spearman ', rho^2)))
rh <- seq(0, 1, by=0.1)  # re-label x-axis re:similarity not distance
axis(1, at=1 - rh, labels=format(rh))

# plot(varclus(~ age + sys.bp + dias.bp + country - 1), abbrev=TRUE)
# the -1 causes k dummies to be generated for k countries
# plot(varclus(~ age + factor(disease.code) - 1))
#
#
# use varclus(~., data= fracmiss= maxlevels= minprev=) to analyze all
# "useful" variables - see dataframeReduce for details about arguments


df <- data.frame(a=c(1,2,3),b=c(1,2,3),c=c(1,2,NA),d=c(1,NA,3),
                 e=c(1,NA,3),f=c(NA,NA,NA),g=c(NA,2,3),h=c(NA,NA,3))
par(mfrow=c(2,2))
for(m in c("ward","complete","median")) {
  plot(naclus(df, method=m))
  title(m)
}
naplot(naclus(df))
n <- naclus(df)
plot(n); naplot(n)
na.pattern(df)

# plotMultSim example: Plot proportion of observations
# for which two variables are both positive (diagonals
# show the proportion of observations for which the
# one variable is positive).  Chance-correct the
# off-diagonals by subtracting the product of the
# marginal proportions.  On each subplot the x-axis
# shows month (0, 4, 8, 12) and there is a separate
# curve for females and males
d <- data.frame(sex=sample(c('female','male'),1000,TRUE),
                month=sample(c(0,4,8,12),1000,TRUE),
                x1=sample(0:1,1000,TRUE),
                x2=sample(0:1,1000,TRUE),
                x3=sample(0:1,1000,TRUE))
s <- array(NA, c(3,3,4))
opar <- par(mar=c(0,0,4.1,0))  # waste less space
for(sx in c('female','male')) {
  for(i in 1:4) {
    mon <- (i-1)*4
    s[,,i] <- varclus(~x1 + x2 + x3, sim='ccbothpos', data=d,
                      subset=d$month==mon & d$sex==sx)$sim
    }
  plotMultSim(s, c(0,4,8,12), vname=c('x1','x2','x3'),
              add=sx=='male', slimds=TRUE,
              lty=1+(sx=='male'))
  # slimds=TRUE causes separate  scaling for diagonals and
```

```
  # off-diagonals
}
par(opar)
```

---

vlab *vlab*

Description

Easily Retrieve Text Form of Labels/Units

Usage

```
vlab(x, name = NULL)
```

Arguments

x	a single variable name, unquoted
name	optional character string to use as variable name

Details

Uses the same search method as hlab returns label and units in a character string with units, if present, in brackets

Value

character string

Author(s)

Frank Harrell

See Also

hlab()

wtd.stats *Weighted Statistical Estimates*

Description

These functions compute various weighted versions of standard estimators. In most cases the weights vector is a vector the same length of x, containing frequency counts that in effect expand x by these counts. weights can also be sampling weights, in which setting normwt to TRUE will often be appropriate. This results in making weights sum to the length of the non-missing elements in x. normwt=TRUE thus reflects the fact that the true sample size is the length of the x vector and not the sum of the original values of weights (which would be appropriate had normwt=FALSE). When weights is all ones, the estimates are all identical to unweighted estimates (unless one of the non-default quantile estimation options is specified to wtd.quantile). When missing data have already been deleted for, x, weights, and (in the case of wtd.loess.noiter) y, specifying na.rm=FALSE will save computation time. Omitting the weights argument or specifying NULL or a zero-length vector will result in the usual unweighted estimates.

wtd.mean, wtd.var, and wtd.quantile compute weighted means, variances, and quantiles, respectively. wtd.Ecdf computes a weighted empirical distribution function. wtd.table computes a weighted frequency table (although only one stratification variable is supported at present). wtd.rank computes weighted ranks, using mid–ranks for ties. This can be used to obtain Wilcoxon tests and rank correlation coefficients. wtd.loess.noiter is a weighted version of loess.smooth when no iterations for outlier rejection are desired. This results in especially good smoothing when y is binary. wtd.quantile removes any observations with zero weight at the beginning. Previously, these were changing the quantile estimates.

num.denom.setup is a utility function that allows one to deal with observations containing numbers of events and numbers of trials, by outputting two observations when the number of events and non-events (trials - events) exceed zero. A vector of subscripts is generated that will do the proper duplications of observations, and a new binary variable y is created along with usual cell frequencies (weights) for each of the y=0, y=1 cells per observation.

Usage

```
wtd.mean(x, weights=NULL, normwt="ignored", na.rm=TRUE)
wtd.var(x, weights=NULL, normwt=FALSE, na.rm=TRUE,
        method=c('unbiased', 'ML'))
wtd.quantile(x, weights=NULL, probs=c(0, .25, .5, .75, 1),
             type=c('quantile','(i-1)/(n-1)','i/(n+1)','i/n'),
             normwt=FALSE, na.rm=TRUE)
wtd.Ecdf(x, weights=NULL,
         type=c('i/n','(i-1)/(n-1)','i/(n+1)'),
         normwt=FALSE, na.rm=TRUE)
wtd.table(x, weights=NULL, type=c('list','table'),
          normwt=FALSE, na.rm=TRUE)
wtd.rank(x, weights=NULL, normwt=FALSE, na.rm=TRUE)
wtd.loess.noiter(x, y, weights=rep(1,n),
                 span=2/3, degree=1, cell=.13333,
```

```
                  type=c('all','ordered all','evaluate'),
                  evaluation=100, na.rm=TRUE)
num.denom.setup(num, denom)
```

Arguments

x	a numeric vector (may be a character or category or factor vector for wtd.table)
num	vector of numerator frequencies
denom	vector of denominators (numbers of trials)
weights	a numeric vector of weights
normwt	specify normwt=TRUE to make weights sum to length(x) after deletion of NAs. If weights are frequency weights, then normwt should be FALSE, and if weights are normalization (aka reliability) weights, then normwt should be TRUE. In the case of the former, no check is made that weights are valid frequencies.
na.rm	set to FALSE to suppress checking for NAs
method	determines the estimator type; if 'unbiased' (the default) then the usual unbiased estimate (using Bessel's correction) is returned, if 'ML' then it is the maximum likelihood estimate for a Gaussian distribution. In the case of the latter, the normwt argument has no effect. Uses stats:cov.wt for both methods.
probs	a vector of quantiles to compute. Default is 0 (min), .25, .5, .75, 1 (max).
type	For wtd.quantile, type defaults to quantile to use the same interpolated order statistic method as quantile. Set type to "(i-1)/(n-1)","i/(n+1)", or "i/n" to use the inverse of the empirical distribution function, using, respectively, (wt - 1)/T, wt/(T+1), or wt/T, where wt is the cumulative weight and T is the total weight (usually total sample size). These three values of type are the possibilities for wtd.Ecdf. For wtd.table the default type is "list", meaning that the function is to return a list containing two vectors: x is the sorted unique values of x and sum.of.weights is the sum of weights for that x. This is the default so that you don't have to convert the names attribute of the result that can be obtained with type="table" to a numeric variable when x was originally numeric. type="table" for wtd.table results in an object that is the same structure as those returned from table. For wtd.loess.noiter the default type is "all", indicating that the function is to return a list containing all the original values of x (including duplicates and without sorting) and the smoothed y values corresponding to them. Set type="ordered all" to sort by x, and type="evaluate" to evaluate the smooth only at evaluation equally spaced points between the observed limits of x.
y	a numeric vector the same length as x
span, degree, cell, evaluation	see loess.smooth. The default is linear (degree=1) and 100 points to evaluation (if type="evaluate").

Details

The functions correctly combine weights of observations having duplicate values of x before computing estimates.

When normwt=FALSE the weighted variance will not equal the unweighted variance even if the weights are identical. That is because of the subtraction of 1 from the sum of the weights in the denominator of the variance formula. If you want the weighted variance to equal the unweighted variance when weights do not vary, use normwt=TRUE. The articles by Gatz and Smith discuss alternative approaches, to arrive at estimators of the standard error of a weighted mean.

wtd.rank does not handle NAs as elegantly as rank if weights is specified.

Value

wtd.mean and wtd.var return scalars. wtd.quantile returns a vector the same length as probs. wtd.Ecdf returns a list whose elements x and Ecdf correspond to unique sorted values of x. If the first CDF estimate is greater than zero, a point (min(x),0) is placed at the beginning of the estimates. See above for wtd.table. wtd.rank returns a vector the same length as x (after removal of NAs, depending on na.rm). See above for wtd.loess.noiter.

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References

Research Triangle Institute (1995): SUDAAN User's Manual, Release 6.40, pp. 8-16 to 8-17.

Gatz DF, Smith L (1995): The standard error of a weighted mean concentration–I. Bootstrapping vs other methods. Atmospheric Env 11:1185-1193.

Gatz DF, Smith L (1995): The standard error of a weighted mean concentration–II. Estimating confidence intervals. Atmospheric Env 29:1195-1200.

https://en.wikipedia.org/wiki/Weighted_arithmetic_mean

See Also

mean, var, quantile, table, rank, loess.smooth, lowess, plsmo, Ecdf, somers2, describe

Examples

```
set.seed(1)
x <- runif(500)
wts <- sample(1:6, 500, TRUE)
std.dev <- sqrt(wtd.var(x, wts))
wtd.quantile(x, wts)
death <- sample(0:1, 500, TRUE)
plot(wtd.loess.noiter(x, death, wts, type='evaluate'))
describe(~x, weights=wts)
# describe uses wtd.mean, wtd.quantile, wtd.table
xg <- cut2(x,g=4)
```

```
table(xg)
wtd.table(xg, wts, type='table')

# Here is a method for getting stratified weighted means
y <- runif(500)
g <- function(y) wtd.mean(y[,1],y[,2])
summarize(cbind(y, wts), llist(xg), g, stat.name='y')

# Empirically determine how methods used by wtd.quantile match with
# methods used by quantile, when all weights are unity
set.seed(1)
u <-  eval(formals(wtd.quantile)$type)
v <- as.character(1:9)
r <- matrix(0, nrow=length(u), ncol=9, dimnames=list(u,v))

for(n in c(8, 13, 22, 29))
  {
    x <- rnorm(n)
    for(i in 1:5) {
      probs <- sort( runif(9))
      for(wtype in u) {
        wq <- wtd.quantile(x, type=wtype, weights=rep(1,length(x)), probs=probs)
        for(qtype in 1:9) {
          rq <- quantile(x, type=qtype, probs=probs)
          r[wtype, qtype] <- max(r[wtype,qtype], max(abs(wq-rq)))
        }
      }
    }
  }

r

# Restructure data to generate a dichotomous response variable
# from records containing numbers of events and numbers of trials
num   <- c(10,NA,20,0,15)   # data are 10/12 NA/999 20/20 0/25 15/35
denom <- c(12,999,20,25,35)
w     <- num.denom.setup(num, denom)
w
# attach(my.data.frame[w$subs,])
```

`xtfrm.labelled` *Auxiliary Function Method for Sorting and Ranking*

Description

An auxiliary function method that is a workaround for bug in the implementation of xtfrm handles inheritance.

Usage

```
## S3 method for class 'labelled'
xtfrm(x)
```

Arguments

x	any object of class labelled.

See Also

xtfrm

---

xy.group *Mean x vs. function of y in groups of x*

Description

Compute mean x vs. a function of y (e.g. median) by quantile groups of x or by x grouped to have a given minimum number of observations. Deletes NAs in x and y before doing computations.

Usage

```
xy.group(x, y, m=150, g, fun=mean, result="list")
```

Arguments

x	a vector, may contain NAs
y	a vector of same length as x, may contain NAs
m	number of observations per group
g	number of quantile groups
fun	function of y such as median or mean (the default)
result	"list" (the default), or "matrix"

Value

if result="list", a list with components x and y suitable for plotting. if result="matrix", matrix with rows corresponding to x-groups and columns named n, x, and y.

See Also

cut2, cutGn, tapply

Examples

```
  ## Not run:
plot(xy.group(x, y, g=10)) #Plot mean y by deciles of x
xy.group(x, y, m=100, result="matrix") #Print table, 100 obs/group

## End(Not run)
```

---

xYplot *xyplot and dotplot with Matrix Variables to Plot Error Bars and Bands*

Description

A utility function Cbind returns the first argument as a vector and combines all other arguments into a matrix stored as an attribute called "other". The arguments can be named (e.g., Cbind(pressure=y,ylow,yhigh)) or a label attribute may be pre-attached to the first argument. In either case, the name or label of the first argument is stored as an attribute "label" of the object returned by Cbind. Storing other vectors as a matrix attribute facilitates plotting error bars, etc., as trellis really wants the x- and y-variables to be vectors, not matrices. If a single argument is given to Cbind and that argument is a matrix with column dimnames, the first column is taken as the main vector and remaining columns are taken as "other". A subscript method for Cbind objects subscripts the other matrix along with the main y vector.

The xYplot function is a substitute for xyplot that allows for simulated multi-column y. It uses by default the panel.xYplot and prepanel.xYplot functions to do the actual work. The method argument passed to panel.xYplot from xYplot allows you to make error bars, the upper-only or lower-only portions of error bars, alternating lower-only and upper-only bars, bands, or filled bands. panel.xYplot decides how to alternate upper and lower bars according to whether the median y value of the current main data line is above the median y for all groups of lines or not. If the median is above the overall median, only the upper bar is drawn. For bands (but not 'filled bands'), any number of other columns of y will be drawn as lines having the same thickness, color, and type as the main data line. If plotting bars, bands, or filled bands and only one additional column is specified for the response variable, that column is taken as the half width of a precision interval for y, and the lower and upper values are computed automatically as y plus or minus the value of the additional column variable.

When a groups variable is present, panel.xYplot will create a function in frame 0 (.GlobalEnv in R) called Key that when invoked will draw a key describing the groups labels, point symbols, and colors. By default, the key is outside the graph. For S-Plus, if Key(locator(1)) is specified, the key will appear so that its upper left corner is at the coordinates of the mouse click. For R/Lattice the first two arguments of Key (x and y) are fractions of the page, measured from the lower left corner, and the default placement is at x=0.05, y=0.95. For R, an optional argument to sKey, other, may contain a list of arguments to pass to draw.key (see xyplot for a list of possible arguments, under the key option).

When method="quantile" is specified, xYplot automatically groups the x variable into intervals containing a target of nx observations each, and within each x group computes three quantiles of y and plots these as three lines. The mean x within each x group is taken as the x-coordinate. This will make a useful empirical display for large datasets in which scatterdiagrams are too busy to see patterns of central tendency and variability. You can also specify a general function of a data vector

that returns a matrix of statistics for the method argument. Arguments can be passed to that function via a list methodArgs. The statistic in the first column should be the measure of central tendency. Examples of useful method functions are those listed under the help file for summary.formula such as smean.cl.normal.

xYplot can also produce bubble plots. This is done when size is specified to xYplot. When size is used, a function sKey is generated for drawing a key to the character sizes. See the bubble plot example. size can also specify a vector where the first character of each observation is used as the plotting symbol, if rangeCex is set to a single cex value. An optional argument to sKey, other, may contain a list of arguments to pass to draw.key (see xyplot for a list of possible arguments, under the key option). See the bubble plot example.

Dotplot is a substitute for dotplot allowing for a matrix x-variable, automatic superpositioning when groups is present, and creation of a Key function. When the x-variable (created by Cbind to simulate a matrix) contains a total of 3 columns, the first column specifies where the dot is positioned, and the last 2 columns specify starting and ending points for intervals. The intervals are shown using line type, width, and color from the trellis plot.line list. By default, you will usually see a darker line segment for the low and high values, with the dotted reference line elsewhere. A good choice of the pch argument for such plots is 3 (plus sign) if you want to emphasize the interval more than the point estimate. When the x-variable contains a total of 5 columns, the 2nd and 5th columns are treated as the 2nd and 3rd are treated above, and the 3rd and 4th columns define an inner line segment that will have twice the thickness of the outer segments. In addition, tick marks separate the outer and inner segments. This type of display (an example of which appeared in *The Elements of Graphing Data* by Cleveland) is very suitable for displaying two confidence levels (e.g., 0.9 and 0.99) or the 0.05, 0.25, 0.75, 0.95 sample quantiles, for example. For this display, the central point displays well with a default circle symbol.

setTrellis sets nice defaults for Trellis graphics, assuming that the graphics device has already been opened if using postscript, etc. By default, it sets panel strips to blank and reference dot lines to thickness 1 instead of the Trellis default of 2.

numericScale is a utility function that facilitates using xYplot to plot variables that are not considered to be numeric but which can readily be converted to numeric using as.numeric(). numericScale by default will keep the name of the input variable as a label attribute for the new numeric variable.

Usage

```
Cbind(...)

xYplot(formula, data = sys.frame(sys.parent()), groups,
       subset, xlab=NULL, ylab=NULL, ylim=NULL,
       panel=panel.xYplot, prepanel=prepanel.xYplot, scales=NULL,
       minor.ticks=NULL, sub=NULL, ...)

panel.xYplot(x, y, subscripts, groups=NULL,
             type=if(is.function(method) || method=='quantiles')
               'b' else 'p',
             method=c("bars", "bands", "upper bars", "lower bars",
                      "alt bars", "quantiles", "filled bands"),
             methodArgs=NULL, label.curves=TRUE, abline,
             probs=c(.5,.25,.75), nx=NULL,
```

```
              cap=0.015, lty.bar=1,
              lwd=plot.line$lwd, lty=plot.line$lty, pch=plot.symbol$pch,
              cex=plot.symbol$cex, font=plot.symbol$font, col=NULL,
              lwd.bands=NULL, lty.bands=NULL, col.bands=NULL,
              minor.ticks=NULL, col.fill=NULL,
              size=NULL, rangeCex=c(.5,3), ...)

prepanel.xYplot(x, y, ...)

Dotplot(formula, data = sys.frame(sys.parent()), groups, subset,
        xlab = NULL, ylab = NULL, ylim = NULL,
        panel=panel.Dotplot, prepanel=prepanel.Dotplot,
        scales=NULL, xscale=NULL, ...)

prepanel.Dotplot(x, y, ...)

panel.Dotplot(x, y, groups = NULL,
              pch  = dot.symbol$pch,
              col  = dot.symbol$col, cex = dot.symbol$cex,
              font = dot.symbol$font, abline, ...)

setTrellis(strip.blank=TRUE, lty.dot.line=2, lwd.dot.line=1)

numericScale(x, label=NULL, ...)
```

Arguments

`...`	for `Cbind` `...` is any number of additional numeric vectors. Unless you are using `Dotplot` (which allows for either 2 or 4 "other" variables) or `xYplot` with `method="bands"`, vectors after the first two are ignored. If drawing bars and only one extra variable is given in `...`, upper and lower values are computed as described above. If the second argument to `Cbind` is a matrix, that matrix is stored in the `"other"` attribute and arguments after the second are ignored. For bubble plots, name an argument `cex`. Also can be other arguments to pass to `labcurve`.
`formula`	a `trellis` formula consistent with `xyplot` or `dotplot`
`x`	x-axis variable. For `numericScale` `x` is any vector such as `as.numeric(x)` returns a numeric vector suitable for x- or y-coordinates.
`y`	a vector, or an object created by `Cbind` for `xYplot`. `y` represents the main variable to plot, i.e., the variable used to draw the main lines. For `Dotplot` the first argument to `Cbind` will be the main x-axis variable.
`data`, `subset`, `ylim`, `subscripts`, `groups`, `type`, `scales`, `panel`, `prepanel`, `xlab`, `ylab`	see `trellis.args`. `xlab` and `ylab` get default values from `"label"` attributes.
`xscale`	allows one to use the default `scales` but specify only the `x` component of it for `Dotplot`

`method` defaults to `"bars"` to draw error-bar type plots. See meaning of other values above. `method` can be a function. Specifying `method=quantile`, `methodArgs=list(probs=c(.5,.25,.` is the same as specifying `method="quantile"` without specifying `probs`.

`methodArgs` a list containing optional arguments to be passed to the function specified in `method`

`label.curves` set to `FALSE` to suppress invocation of `labcurve` to label primary curves where they are most separated or to draw a legend in an empty spot on the panel. You can also set `label.curves` to a list of options to pass to `labcurve`. These options can also be passed as `...` to `xYplot`. See the examples below.

`abline` a list of arguments to pass to `panel.abline` for each panel, e.g. `list(a=0, b=1, col=3)` to draw the line of identity using color 3. To make multiple calls to `panel.abline`, pass a list of unnamed lists as `abline`, e.g., `abline=list(list(h=0),list(v=1))`.

`probs` a vector of three quantiles with the quantile corresponding to the central line listed first. By default `probs=c(.5, .25, .75)`. You can also specify `probs` through `methodArgs=list(probs=...)`.

`nx` number of target observations for each `x` group (see `cut2` `m` argument). `nx` defaults to the minimum of 40 and the number of points in the current stratum divided by 4. Set `nx=FALSE` or `nx=0` if `x` is already discrete and requires no grouping.

`cap` the half-width of horizontal end pieces for error bars, as a fraction of the length of the x-axis

`lty.bar` line type for bars

`lwd`, `lty`, `pch`, `cex`, `font`, `col`
see `trellis.args`. These are vectors when `groups` is present, and the order of their elements corresponds to the different `groups`, regardless of how many bands or bars are drawn. If you don't specify `lty.bands`, for example, all band lines within each group will have the same `lty`.

`lty.bands`, `lwd.bands`, `col.bands`
used to allow `lty`, `lwd`, `col` to vary across the different band lines for different `groups`. These parameters are vectors or lists whose elements correspond to the added band lines (i.e., they ignore the central line, whose line characteristics are defined by `lty`, `lwd`, `col`). For example, suppose that 4 lines are drawn in addition to the central line. Specifying `lwd.bands=1:4` will cause line widths of 1:4 to be used for every group, regardless of the value of `lwd`. To vary characteristics over the `groups` use e.g. `lwd.bands=list(rep(1,4), rep(2,4))` or `list(c(1,2,1,2), c(3,4,3,4))`.

`minor.ticks` a list with elements `at` and `labels` specifying positions and labels for minor tick marks to be used on the x-axis of each panel, if any.

`sub` an optional subtitle

`col.fill` used to override default colors used for the bands in method='filled bands'. This is a vector when `groups` is present, and the order of the elements corresponds to the different `groups`, regardless of how many bands are drawn. The default colors for 'filled bands' are pastel colors matching the default colors superpose.line$col (plot.line$col)

size	a vector the same length as x giving a variable whose values are a linear function of the size of the symbol drawn. This is used for example for bubble plots.
rangeCex	a vector of two values specifying the range in character sizes to use for the size variable (lowest first, highest second). size values are linearly translated to this range, based on the observed range of size when x and y coordinates are not missing. Specify a single numeric cex value for rangeCex to use the first character of each observations's size as the plotting symbol.
strip.blank	set to FALSE to not make the panel strip backgrounds blank
lty.dot.line	line type for dot plot reference lines (default = 1 for dotted; use 2 for dotted)
lwd.dot.line	line thickness for reference lines for dot plots (default = 1)
label	a scalar character string to be used as a variable label after numericScale converts the variable to numeric form

Details

Unlike xyplot, xYplot senses the presence of a groups variable and automatically invokes panel.superpose instead of panel.xyplot. The same is true for Dotplot vs. dotplot.

Value

Cbind returns a matrix with attributes. Other functions return standard trellis results.

Side Effects

plots, and panel.xYplot may create temporary Key and sKey functions in the session frame.

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See Also

xyplot, panel.xyplot, summarize, label, labcurve, errbar, dotplot, reShape, cut2, panel.abline

Examples

```
# Plot 6 smooth functions.  Superpose 3, panel 2.
# Label curves with p=1,2,3 where most separated
d <- expand.grid(x=seq(0,2*pi,length=150), p=1:3, shift=c(0,pi))
xYplot(sin(x+shift)^p ~ x | shift, groups=p, data=d, type='l')
# Use a key instead, use 3 line widths instead of 3 colors
# Put key in most empty portion of each panel
```

```
xYplot(sin(x+shift)^p ~ x | shift, groups=p, data=d,
       type='l', keys='lines', lwd=1:3, col=1)
# Instead of implicitly using labcurve(), put a
# single key outside of panels at lower left corner
xYplot(sin(x+shift)^p ~ x | shift, groups=p, data=d,
       type='l', label.curves=FALSE, lwd=1:3, col=1, lty=1:3)
Key()

# Bubble plots
x <- y <- 1:8
x[2] <- NA
units(x) <- 'cm^2'
z <- 101:108
p <- factor(rep(c('a','b'),4))
g <- c(rep(1,7),2)
data.frame(p, x, y, z, g)
xYplot(y ~ x | p, groups=g, size=z)
 Key(other=list(title='g', cex.title=1.2))  # draw key for colors
sKey(.2,.85,other=list(title='Z Values', cex.title=1.2))
# draw key for character sizes

# Show the median and quartiles of height given age, stratified
# by sex and race.  Draws 2 sets (male, female) of 3 lines per panel.
# xYplot(height ~ age | race, groups=sex, method='quantiles')


# Examples of plotting raw data
dfr <- expand.grid(month=1:12, continent=c('Europe','USA'),
                   sex=c('female','male'))
set.seed(1)
dfr <- upData(dfr,
              y=month/10 + 1*(sex=='female') + 2*(continent=='Europe') +
                runif(48,-.15,.15),
              lower=y - runif(48,.05,.15),
              upper=y + runif(48,.05,.15))


xYplot(Cbind(y,lower,upper) ~ month,subset=sex=='male' & continent=='USA',
       data=dfr)
xYplot(Cbind(y,lower,upper) ~ month|continent, subset=sex=='male',data=dfr)
xYplot(Cbind(y,lower,upper) ~ month|continent, groups=sex, data=dfr); Key()
# add ,label.curves=FALSE to suppress use of labcurve to label curves where
# farthest apart


xYplot(Cbind(y,lower,upper) ~ month,groups=sex,
                              subset=continent=='Europe', data=dfr)
xYplot(Cbind(y,lower,upper) ~ month,groups=sex, type='b',
                              subset=continent=='Europe', keys='lines',
                              data=dfr)
# keys='lines' causes labcurve to draw a legend where the panel is most empty
```

```
xYplot(Cbind(y,lower,upper) ~ month,groups=sex, type='b', data=dfr,
                              subset=continent=='Europe',method='bands')
xYplot(Cbind(y,lower,upper) ~ month,groups=sex, type='b', data=dfr,
                              subset=continent=='Europe',method='upper')


label(dfr$y) <- 'Quality of Life Score'
# label is in Hmisc library = attr(y,'label') <- 'Quality\dots'; will be
# y-axis label
# can also specify Cbind('Quality of Life Score'=y,lower,upper)
xYplot(Cbind(y,lower,upper) ~ month, groups=sex,
       subset=continent=='Europe', method='alt bars',
        offset=grid::unit(.1,'inches'), type='b', data=dfr)
# offset passed to labcurve to label .4 y units away from curve
# for R (using grid/lattice), offset is specified using the grid
# unit function, e.g., offset=grid::unit(.4,'native') or
# offset=grid::unit(.1,'inches') or grid::unit(.05,'npc')


# The following example uses the summarize function in Hmisc to
# compute the median and outer quartiles.  The outer quartiles are
# displayed using "error bars"
set.seed(111)
dfr <- expand.grid(month=1:12, year=c(1997,1998), reps=1:100)
month <- dfr$month; year <- dfr$year
y <- abs(month-6.5) + 2*runif(length(month)) + year-1997
s <- summarize(y, llist(month,year), smedian.hilow, conf.int=.5)
xYplot(Cbind(y,Lower,Upper) ~ month, groups=year, data=s,
       keys='lines', method='alt', type='b')
# Can also do:
s <- summarize(y, llist(month,year), quantile, probs=c(.5,.25,.75),
               stat.name=c('y','Q1','Q3'))
xYplot(Cbind(y, Q1, Q3) ~ month, groups=year, data=s,
       type='b', keys='lines')
# Or:
xYplot(y ~ month, groups=year, keys='lines', nx=FALSE, method='quantile',
       type='b')
# nx=FALSE means to treat month as a discrete variable


# To display means and bootstrapped nonparametric confidence intervals
# use:
s <- summarize(y, llist(month,year), smean.cl.boot)
s
xYplot(Cbind(y, Lower, Upper) ~ month | year, data=s, type='b')
# Can also use Y <- cbind(y, Lower, Upper); xYplot(Cbind(Y) ~ ...)
# Or:
xYplot(y ~ month | year, nx=FALSE, method=smean.cl.boot, type='b')


# This example uses the summarize function in Hmisc to
# compute the median and outer quartiles.  The outer quartiles are
# displayed using "filled bands"
```

```
s <- summarize(y, llist(month,year), smedian.hilow, conf.int=.5)


# filled bands: default fill = pastel colors matching solid colors
# in superpose.line (this works differently in R)
xYplot ( Cbind ( y, Lower, Upper ) ~ month, groups=year,
     method="filled bands" , data=s, type="l")


# note colors based on levels of selected subgroups, not first two colors
xYplot ( Cbind ( y, Lower, Upper ) ~ month, groups=year,
     method="filled bands" , data=s, type="l",
     subset=(year == 1998 | year == 2000), label.curves=FALSE )


# filled bands using black lines with selected solid colors for fill
xYplot ( Cbind ( y, Lower, Upper ) ~ month, groups=year,
     method="filled bands" , data=s, label.curves=FALSE,
     type="l", col=1, col.fill = 2:3)
Key(.5,.8,col = 2:3) #use fill colors in key


# A good way to check for stable variance of residuals from ols
# xYplot(resid(fit) ~ fitted(fit), method=smean.sdl)
# smean.sdl is defined with summary.formula in Hmisc


# Plot y vs. a special variable x
# xYplot(y ~ numericScale(x, label='Label for X') | country)
# For this example could omit label= and specify
#    y ~ numericScale(x) | country, xlab='Label for X'


# Here is an example of using xYplot with several options
# to change various Trellis parameters,
# xYplot(y ~ x | z, groups=v, pch=c('1','2','3'),
#        layout=c(3,1),     # 3 panels side by side
#        ylab='Y Label', xlab='X Label',
#        main=list('Main Title', cex=1.5),
#        par.strip.text=list(cex=1.2),
#        strip=function(\dots) strip.default(\dots, style=1),
#        scales=list(alternating=FALSE))


#
# Dotplot examples
#


s <- summarize(y, llist(month,year), smedian.hilow, conf.int=.5)
```

```
setTrellis()            # blank conditioning panel backgrounds
Dotplot(month ~ Cbind(y, Lower, Upper) | year, data=s)
# or Cbind(\dots), groups=year, data=s


# Display a 5-number (5-quantile) summary (2 intervals, dot=median)
# Note that summarize produces a matrix for y, and Cbind(y) trusts the
# first column to be the point estimate (here the median)
s <- summarize(y, llist(month,year), quantile,
               probs=c(.5,.05,.25,.75,.95), type='matrix')
Dotplot(month ~ Cbind(y) | year, data=s)
# Use factor(year) to make actual years appear in conditioning title strips

# Plot proportions and their Wilson confidence limits
set.seed(3)
d <- expand.grid(continent=c('USA','Europe'), year=1999:2001,
                 reps=1:100)
# Generate binary events from a population probability of 0.2
# of the event, same for all years and continents
d$y <- ifelse(runif(6*100) <= .2, 1, 0)
s <- with(d,
          summarize(y, llist(continent,year),
                    function(y) {
                     n <- sum(!is.na(y))
                     s <- sum(y, na.rm=TRUE)
                     binconf(s, n)
                    }, type='matrix')
)

Dotplot(year ~ Cbind(y) | continent,  data=s, ylab='Year',
        xlab='Probability')


# Dotplot(z ~ x | g1*g2)
# 2-way conditioning
# Dotplot(z ~ x | g1, groups=g2); Key()
# Key defines symbols for g2


# If the data are organized so that the mean, lower, and upper
# confidence limits are in separate records, the Hmisc reShape
# function is useful for assembling these 3 values as 3 variables
# a single observation, e.g., assuming type has values such as
# c('Mean','Lower','Upper'):
# a <- reShape(y, id=month, colvar=type)
# This will make a matrix with 3 columns named Mean Lower Upper
# and with 1/3 as many rows as the original data
```

---

yearDays *Get Number of Days in Year or Month*

Description

Returns the number of days in a specific year or month.

Usage

```
yearDays(time)

monthDays(time)
```

Arguments

time	A POSIXt or Date object describing the month or year in question.

Author(s)

Charles Dupont

See Also

POSIXt, Date

---

ynbind *Combine Variables in a Matrix*

Description

ynbind column binds a series of related yes/no variables, allowing for a final argument label used to label the panel created for the group. labels for individual variables are collected into a vector attribute "labels" for the result; original variable names are used in place of labels for those variables without labels. A positive response is taken to be y, yes,present (ignoring case) or a logical TRUE value. By default, the columns are sorted be ascending order or the overall proportion of positives. A subsetting method is provided for objects of class "ynbind".

pBlock creates a matrix similarly labeled, from a general set of variables (without special handling of binaries), and sets to NA any observation not in subset so that when that block of variables is analyzed it will be only for that subset.

Usage

```
ynbind(..., label = deparse(substitute(...)),
       asna = c("unknown", "unspecified"), sort = TRUE)

pBlock(..., subset=NULL, label = deparse(substitute(...)))
```

Arguments

...	a series of vectors
label	a label for the group, to be attached to the resulting matrix as a "label" attribute, used by summaryP.
asna	a vector of character strings specifying levels that are to be treated the same as NA if present
sort	set to FALSE to not sort the columns by their proportions
subset	subset criteria - either a vector of logicals or subscripts

Value

a matrix of class "ynbind" or "pBlock" with "label" and "labels" attributes. For "pBlock", factor input vectors will have values converted to character.

Author(s)

Frank Harrell

See Also

summaryP

Examples

```
x1 <- c('yEs', 'no', 'UNKNOWN', NA)
x2 <- c('y', 'n', 'no', 'present')
label(x2) <- 'X2'
X <- ynbind(x1, x2, label='x1-2')
X[1:3,]

pBlock(x1, x2, subset=2:3, label='x1-2')
```

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