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Title Penalized Likelihood Factor Analysis via Nonconvex Penalty

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Depends Matrix

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Description Computes the penalized maximum likelihood estimates of factor loadings and unique variances for various tuning parameters. The pathwise coordinate descent along with EM algorithm is used. This package also includes a graphical tool which outputs path diagrams, heatmaps, goodness-of-fit indices and model selection criteria for each regularization parameter (Yamamoto, M., Hirose, K. and Nagata, H., 2017 <doi:10.1007/s41237-016-0007-3>). The user can change the regularization parameter interactively with a built-in self-contained HTML viewer (no additional packages required), which is helpful to find a suitable value of regularization parameter. As a penalty, we can choose either the minimax concave penalty (Hirose, K. and Yamamoto, M., 2015 <doi:10.1007/s11222-014-9458-0>; Hirose, K. and Yamamoto, M., 2014 <doi:10.1016/j.csda.2014.05.011>) or the product-based elastic net penalty (Hirose, K. and Terada, Y., 2023 <doi:10.1007/s11336-022-09868-4>).

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`fanc` *Penalized Likelihood Factor Analysis via Nonconvex Penalties*

Description

Computes solution paths of penalized maximum likelihood estimates for factor analysis or probabilistic principal component analysis. The available penalties are MC+, the product-based elastic net (prenet), and the elastic net.

Usage

```
fanc(x, factors, n.obs, rho, gamma, cor.factor=FALSE, normalize=TRUE,
     normalize.penalty=FALSE, covmat, type="MC", model="FA", control=list())

## S3 method for class 'fanc'
print(x, digits=max(3, getOption("digits") - 3),
                     num.result=20, ...)
```

Arguments

`x`	A numeric data matrix.
`factors`	The number of factors.
`n.obs`	The number of observations. This is required to calculate model-selection criteria and goodness-of-fit indices when only `covmat` is supplied. If it is omitted, model fitting is performed but these indices are unavailable.

rho	Values of rho. This may be a scalar or a matrix with one column for each gamma value.
gamma	Values of gamma.
cor.factor	Logical; if TRUE, factor correlations are estimated. The default is FALSE.
normalize	Logical; if TRUE, each variable is normalized. The default is TRUE.
normalize.penalty	Logical; if TRUE, variable-specific penalty weights are calculated. The default is FALSE.
covmat	A covariance matrix, used when the data matrix x is unavailable.
type	Penalty type: "MC", "prenet", or "enet". The default is "MC".
model	Model type: "FA" for factor analysis or "PPCA" for probabilistic principal component analysis. The default is "FA".
control	A list of control parameters. See 'Details'.
digits	Number of digits used by the print method.
num.result	Retained for compatibility with earlier versions; it currently does not change the printed output.
...	Reserved for compatibility; currently unused.

Details

The control argument can contain the following components:

length.rho Number of rho candidates.

length.gamma Number of gamma candidates.

max.rho Maximum rho. For prenet and enet, a scalar is repeated for every gamma. Alternatively, supply one value per gamma. Other lengths are invalid.

max.gamma Maximum finite gamma.

min.gamma Minimum gamma.

eta Non-negative tuning parameter used to prevent improper solutions.

ncand.initial Number of candidate initial loading matrices. The default is 10.

ncand.initial.prenet Number of candidate initial values for the prenet penalty. The default is 100.

maxit.em Maximum number of EM iterations.

maxit.cd Maximum number of coordinate-descent iterations.

maxit.bfgs Maximum number of BFGS iterations.

maxit.initial Maximum number of iterations used when choosing initial values.

start Starting-value strategy, either "warm" or "cold".

Delta Ratio of the minimum rho to the maximum rho.

min.uniquevar Minimum unique variance.

tol.em Convergence tolerance for the EM algorithm.

tol.cd Convergence tolerance for coordinate descent.

`tol.bfgs` Convergence tolerance for BFGS.

`min.rhozero` Logical; if `TRUE`, the minimum rho is zero.

`zita` Hyper-parameter for factor correlations.

`progress` Logical; if `TRUE`, fitting progress is displayed.

`openmp` Logical; if `TRUE`, OpenMP parallel computation is requested.

`num.threads` Number of OpenMP threads.

`gamma.ebic` Gamma used in the extended BIC.

Value

An object of class `"fanc"`. Important components include:

`loadings`	Factor-loading matrices for every rho and gamma.
`uniquenesses`	Unique variances for every rho and gamma.
`Phi`	Factor-correlation matrices.
`rho`	Matrix of rho values.
`gamma`	Vector of gamma values.
`df`, `dfnonzero`	Degrees of freedom.
`AIC`, `BIC`, `CAIC`, `EBIC`	Model-selection criteria based on reparametrized degrees of freedom.
`AIC_dfnonzero`, `BIC_dfnonzero`, `CAIC_dfnonzero`, `EBIC_dfnonzero`	Model-selection criteria based on active parameters.
`GFI`, `AGFI`, `CFI`, `RMSEA`, `SRMR`	Goodness-of-fit indices.
`AGFI_dfnonzero`, `CFI_dfnonzero`, `RMSEA_dfnonzero`	Goodness-of-fit indices based on active parameters.
`factors`	Number of factors.
`cor.factor`	Whether factor correlations were estimated.
`x`	The original data matrix, or `NULL` when only `covmat` was supplied.
`convergence`	Convergence indicators for the fitting algorithms.
`type`, `model`	Penalty and model types.

When only `covmat` is supplied and `n.obs` is omitted, the model-selection criteria and goodness-of-fit indices are `NULL`.

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References

Hirose, K. and Yamamoto, M. (2015). *Sparse estimation via nonconcave penalized likelihood in a factor analysis model*, *Statistics and Computing*, 25, 633–648.

See Also

out, select, and plot.fanc.

Examples

```
set.seed(0)
loadings0 <- matrix(c(rep(0.8, 5), rep(0, 5),
                      rep(0, 5), rep(0.8, 5)), 10, 2)
common.factors0 <- matrix(rnorm(50 * 2), 50, 2)
unique.factors0 <- matrix(rnorm(50 * 10, sd=sqrt(0.36)), 50, 10)
x <- common.factors0 %*% t(loadings0) + unique.factors0

fit <- fanc(x, 2)
print(fit)
out(fit, rho=0.1, gamma=Inf)
select(fit, criterion="BIC", gamma=Inf)

## Not run:
plot(fit)
plot(fit, file="fanc-viewer.html")

## End(Not run)
```

---

out *Extract a Result from a "fanc" Object*

Description

Extracts the fitted model at specified values of rho and gamma from a "fanc" object.

Usage

```
out(x, rho, gamma, scores=FALSE, df.method="active")
```

Arguments

x	Fitted "fanc" model object.
gamma	The value of gamma.
rho	The value of rho.
scores	Logical flag for outputting factor scores. The original data matrix must have been supplied to fanc. The default is FALSE.
df.method	Two types of degrees of freedom are supported. If "reparametrization", the degrees of freedom of the MC+ are reparametrized based on the degrees of freedom of the lasso. If "active", the degrees of freedom are the number of nonzero parameters.

Value

loadings	factor loadings
uniquenesses	unique variances
Phi	Factor-correlation matrix, when factor correlations were estimated.
scores	Factor scores, when scores=TRUE.
df	Degrees of freedom under the selected df.method.
criteria	Values of AIC, BIC, CAIC and EBIC, when available.
goodness.of.fit	Values of GFI, AGFI, CFI, RMSEA and SRMR, when available.
rho	The selected value of rho.
gamma	The selected value of gamma.

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References

Hirose, K. and Yamamoto, M. (2015). *Sparse estimation via nonconcave penalized likelihood in a factor analysis model*,
Statistics and Computing, 25, 633–648.

See Also

fanc and plot.fanc objects.

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plot.fanc *Plot a Solution Path from a "fanc" Object*

Description

This function plots the solution paths or heatmaps from a "fanc" object. By default it opens a self-contained, interactive HTML viewer in the browser or RStudio viewer pane (no additional packages required). The viewer has sliders for rho and gamma, buttons that jump to the model selected by AIC, BIC, CAIC or EBIC, and an overview mode showing every rho along the path at once. All data and code are embedded in the page, so it runs without a server and can be saved and shared as a single file via the file argument.

Usage

```
## S3 method for class 'fanc'
plot(x, Window.Height=500, type=NULL, df.method="active",
                    viewer=c("auto", "html", "base"), file=NULL,
                    rho.index=1, gamma.index=1, ...)
```

Arguments

x	Fitted "fanc" model object.
Window.Height	Maximum plot height in pixels for the HTML viewer. It does not change the internal layout of base R plots. It must be between 250 and 2000. The default is 500.
type	Two plot types are supported. If "path", the path diagram is depicted. If "heatmap", the heatmap is depicted. When NULL, a path diagram is used when there are fewer than 50 variables and fewer than seven factors; otherwise a heatmap is used. Explicitly requesting "path" with seven or more factors is allowed but produces a warning because the diagram may be difficult to read.
df.method	Two types of degrees of freedom are supported. If "reparametrization", the degrees of freedom of the MC+ are reparametrized based on the degrees of freedom of the lasso. If "active", the degrees of freedom are the number of nonzero parameters.
viewer	Viewer backend. "auto" opens the interactive HTML viewer in an interactive session (or whenever file is supplied) and otherwise falls back to a base R plot. "html" always builds the HTML viewer. "base" draws the selected indices with base graphics. Long labels in base R plots are reduced or abbreviated to fit the available space. Rendering non-ASCII labels depends on the fonts supported by the active graphics device.
file	Optional path for the generated HTML file. When NULL (default) a temporary file is used. Supplying a path writes a permanent, self-contained .html file that can be opened on any computer (no R required).
rho.index	Initial index of the rho value.
gamma.index	Initial index of the gamma value.
...	Reserved for compatibility; currently unused.

Value

For viewer="html" the path to the generated HTML file (invisibly); otherwise NULL (invisibly). Called for the side effect of drawing or opening the viewer.

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References

Hirose, K. and Yamamoto, M. (2015). *Sparse estimation via nonconcave penalized likelihood in a factor analysis model*,
Statistics and Computing, 25, 633–648.

See Also

fanc and out objects.

select *Select a Model from a "fanc" Object*

Description

Selects the value of rho that minimizes a model-selection criterion, optionally at a specified value of gamma.

Usage

```
select(x, criterion=c("BIC","AIC","CAIC","EBIC"),
 gamma,  scores=FALSE, df.method="active")
```

Arguments

x	Fitted "fanc" model object.
criterion	The criterion by which to select the tuning parameter rho. One of "AIC", "BIC", "CAIC", or "EBIC". Default is "BIC".
gamma	The value of gamma.
scores	Logical flag for outputting factor scores. The original data matrix must have been supplied to fanc. The default is FALSE.
df.method	Two types of degrees of freedom are supported. If "active", the degrees of freedom are the number of nonzero parameters. If "reparametrization", the degrees of freedom of the MC+ are reparametrized based on the degrees of freedom of the lasso.

Value

loadings	factor loadings
uniquenesses	unique variances
Phi	Factor-correlation matrix, when factor correlations were estimated.
scores	Factor scores, when scores=TRUE.
df	Degrees of freedom under the selected df.method.
AIC, BIC, CAIC, EBIC	The value of the selected criterion.
goodness.of.fit	Values of GFI, AGFI, CFI, RMSEA and SRMR, when available.
rho	The selected value of rho.
gamma	The selected value of gamma.

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References

Hirose, K. and Yamamoto, M. (2015). *Sparse estimation via nonconcave penalized likelihood in a factor analysis model*,
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See Also

`fanc` and `plot.fanc` objects.

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