

# Package: bamdit (via r-universe)

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**Type** Package

**Title** Bayesian Meta-Analysis of Diagnostic Test Data

**Version** 3.4.2

**Date** 2024-09-20

**Depends** R (>= 4.0.0)

**Imports** rjags (>= 4.0.0), R2jags (>= 0.04-03), stats, ggplot2, ggExtra, MASS, grid, gridExtra

**SystemRequirements** JAGS (>= 4.3.0) (see <http://mcmc-jags.sourceforge.net>)

**Description** Provides a new class of Bayesian meta-analysis models that incorporates a model for internal and external validity bias. In this way, it is possible to combine studies of diverse quality and different types. For example, we can combine the results of randomized control trials (RCTs) with the results of observational studies (OS).

**License** GPL (>= 2)

**Repository** CRAN

**RoxygenNote** 7.3.2

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**LazyData** true

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## Contents

bamdit-package . . . . .	2
bsroc . . . . .	3
ct . . . . .	5

diabetes	6
ep	7
glas	7
gould	8
metadiag	9
mri	15
plot.metadiag	16
plotcompare	18
plotcredibility	20
plotdata	21
plotsesp	23
plotw	23
print.metadiag	24
rapt	25
safdar05	26
scheidler	27
skin	27
skin2	28
summary.metadiag	29

<b>Index</b>	<b>30</b>
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bamdit-package

*Bayesian Meta-Analysis of Diagnostic Test Data*

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## Description

Bayesian meta-analysis of diagnostic test data based on a scale mixtures bivariate random-effects model. This package was developed with the aim of simplifying the use of meta-analysis models that up to now have demanded great statistical expertise in Bayesian meta-analysis. The package implements a series of innovative statistical techniques including: the BSROC (Bayesian Summary ROC) curve, the BAUC (Bayesian AUC), predictive surfaces, the use of prior distributions that avoid boundary estimation problems of component of variance and correlation parameters, analysis of conflict of evidence and robust estimation of model parameters. In addition, the package comes with several published examples of meta-analysis that can be used for illustration or further research in this area.

## Details

Package:	bamdit
Type:	Package
Version:	3.4.2
Date:	2024-09-20
License:	GPL (>= 2)
LazyLoad:	yes

**Author(s)**

**Maintainer:** Pablo Emilio Verde <pabloemilio.verde@hhu.de>

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 bsroc

*bsroc*


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**Description**

This function plots the observed data in the ROC (Receiving Operating Characteristics) space with the Bayesian SROC (Summary ROC) curve. The predictive curves are approximated using a parametric model.

**Usage**

```
bsroc(
  m,
  level = c(0.05, 0.5, 0.95),
  title = "Bayesian SROC Curve",
  fpr.x = seq(0.01, 0.95, 0.01),
  partial.AUC = TRUE,
  xlim.bsroc = c(0, 1),
  ylim.bsroc = c(0, 1),
  lower.auc = 0,
  upper.auc = 0.95,
  col.fill.points = "blue",
  results.bauc = TRUE,
  results.bsroc = FALSE,
  plot.post.bauc = FALSE,
  bins = 30,
  scale.size.area = 10
)
```

**Arguments**

<code>m</code>	The object generated by <code>metadiag</code> .
<code>level</code>	Credibility levels of the predictive curve
<code>title</code>	Optional parameter for setting a title in the plot.
<code>fpr.x</code>	Grid of values where the conditional distribution is calculated.
<code>partial.AUC</code>	Automatically calculate the AUC for the observed range of FPRs, default is TRUE.
<code>xlim.bsroc</code>	Graphical limits of the x-axis for the BSROC curve plot.
<code>ylim.bsroc</code>	Graphical limits of the y-axis for the BSROC curve plot.
<code>lower.auc</code>	Lower limit of the AUC.
<code>upper.auc</code>	Upper limit of the AUC.

col.fill.points           Color used to fill points, default is blue.

results.bauc            Print results of the Bayesian Area Under the Curve, default value is TRUE.

results.bsroc           Print results of the Bayesian SROC curve, default value is FALSE.

plot.post.bauc         The BSROC and the posterior of the BAUC are plotted in the same page, default is FALSE.

bins                    Histograms' bins.

scale.size.area         Scale area for the plotted points, default = 10.

## References

Verde P. E. (2010). Meta-analysis of diagnostic test data: A bivariate Bayesian modeling approach. *Statistics in Medicine*. 29(30):3088-102. doi: 10.1002/sim.4055.

Verde P. E. (2018). bamdit: An R Package for Bayesian Meta-Analysis of Diagnostic Test Data. *Journal of Statistical Software*. Volume 86, issue 10, pages 1–32.

## See Also

[metadiag](#).

## Examples

```
## execute analysis
## Not run:
# Example: data from Glas et al. (2003).....

data(glas)
glas.t <- glas[glas$marker == "Telomerase", 1:4]
glas.m1 <- metadiag(glas.t, re = "normal", link = "logit")
bsroc(glas.m1)
bsroc(glas.m1, plot.post.bauc = TRUE)

# Example: data from Scheidler et al. (1997)
# In this example the range of the observed FPR is less than 20%.
# Calculating the BSROC curve makes no sense! You will get a warning message!

data(mri)
mri.m <- metadiag(mri)
bsroc(mri.m)

## End(Not run)
```

ct

*Diagnosis of appendicitis with computer tomography scans***Description**

This data frame corresponds to 51 clinical studies reporting the accuracy of computer tomography (CT) scans for the diagnosis of appendicitis.

**Format**

A matrix with 51 rows and 17 columns. Each row represents study results, the columns are:

**tp** number of true positives.

**n1** number of patients with disease.

**fp** number of false positives.

**n2** number of patients without disease.

**Author** First author and year.

**country** Country: EU = 1, others/USA = 2.

**hosp** Type of hospital: 1 = university, 2 = others.

**inclus** Inclusion criteria: 1 = Suspected, 2 = appendectomy.

**indfind** Other CT findings included: 1 = no, 2 = yes.

**design** Study design: 1 = prospective, 2 = retrospective.

**contr** Contrast medium: 1 = no, 2 = yes.

**localis** Localisation: 1 = one area, 2 = more than one area.

**child** Children included: 1 = no, 2 = yes.

**fup.na** Followup: 0 = no, 1 = yes.

**refer.na** Valid reference: 0 = no, 1 = yes.

**sample.na** Sample: 0 = selected, 1 = consecutive/random.

**gender.na** Gender, female: 0 = less than 50%; 1 = more than 50%.

**Details**

This data frame corresponds to 51 clinical studies reporting the accuracy of computer tomography (CT) scans for the diagnosis of appendicitis.

**Source**

The data were obtained from

Ohmann C, Verde PE, Gilbers T, Franke C, Fuerst G, Sauerland S, Boehner H. (2006) Systematic review of CT investigation in suspected acute appendicitis. *Final Report; Coordination Centre for Clinical Trials, Heinrich-Heine University*. Moorenstr. 5, D-40225 Duesseldorf Germany.

## References

Verde P. E. (2010). Meta-analysis of diagnostic test data: A bivariate Bayesian modeling approach. *Statistics in Medicine*. **29**, 3088-3102.

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diabetes	<i>Systematic review which compares the accuracy of HbA1c vs FPG in diabetes</i>
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## Description

This data frame contains results of diagnostic accuracy of 38 studies which reported comparison of sensitivity and specificity between HbA1c vs FPG in a population based screening for type 2 diabetes.

## Format

A data frame with 38 rows and 9 columns. Each row represents study results, the columns are:

**Study** Name of the first author.

**TP\_HbA1c** Number of true positive cases for HbA1c.

**FP\_HbA1c** Number of false positive cases for HbA1c.

**FN\_HbA1c** Number of false negative cases for HbA1c.

**TN\_HbA1c** Number of true negative cases for HbA1c.

**TP\_FPG** Number of true positive cases for FPG.

**FP\_FPG** Number of false positive cases for FPG.

**FN\_FPG** Number of false negative cases for FPG.

**TN\_FPG** Number of true negative cases for FPG.

## Details

This data frame contains results of diagnostic accuracy of 38 studies which reported comparison of sensitivity and specificity between HbA1c vs FPG in a population-based screening for type 2 diabetes.

## Source

Hoyer, A., Kuss, O. Meta-analysis for the comparison of two diagnostic test: a new approach based on copulas. *Stat. Med.* 2018; 37:739-748

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ep	<i>Ectopic pregnancy vs. all other pregnancies data</i>
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**Description**

Ectopic pregnancy vs. all other pregnancies data Table III Mol et al. 1998

**Format**

A matrix with 21 rows and 8 columns. Each row represents study results, the columns are:

**tp** number of true positives.

**n1** number of patients with disease.

**fp** number of false positives.

**n2** number of patients without disease.

**d1** Prospective vs. retrospective.

**d2** Cohort vs. case-control

**d3** Consecutive sampling patients series vs. non-consecutive.

**Source**

Table III Mol et al. 1998

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glas	<i>Tumor markers in the diagnosis of primary bladder cancer.</i>
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**Description**

Outcome of individual studies evaluating urine markers

**Format**

A matrix with 46 rows and 7 columns. Each row represents study results, the columns are:

**tp** number of true positives.

**n1** number of patients with disease.

**fp** number of false positives.

**n2** number of patients without disease.

**author** first author of the study.

**cutoff** cutoff in U/ml.

**marker** test method used in the study.

**Source**

The data were obtained from

Glas AS, Roos D, Deutekom M, Zwindermann AH, Bossuyt PM, Kurth KH. (2003) Tumor markers in the diagnosis of primary bladder cancer. A systematic review. *Journal of Urology*; **169**:1975-82.

**References**

Verde P. E. (2010). Meta-analysis of diagnostic test data: A bivariate Bayesian modeling approach. *Statistics in Medicine*. **29**, 3088-3102.

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gould

*Accuracy of Positron Emission Tomography for Diagnosis of Pulmonary Nodules and Mass Lesions*

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**Description**

Data from a Meta-Analysis of Studies Quality of FDG-PET for Diagnosis of SPNs and Mass Lesions

**Format**

A matrix with 31 rows and 6 columns. Each row represents study results, the columns are:

**tp** number of true positives.

**n1** number of patients with disease.

**fp** number of false positives.

**n2** number of patients without disease.

**author** first author of the study.

**year** publication date.

**Source**

The data were obtained from

Gould MK, Maclean CC, Kushner WG, Rydzak CE, Owens Dk. (2001) Accuracy of positron emission tomography for diagnosis of pulmonary nodules and mass lesions: a meta-analysis. *The Journal of the American Medical Association*; **285**:914-24.



## Description

This function performs a Bayesian meta-analysis of diagnostic test data by fitting a bivariate random effects model. The number of true positives and false positives are modeled with two conditional Binomial distributions and the random-effects are based on a bivariate scale mixture of Normals. Computations are done by calling JAGS (Just Another Gibbs Sampler) to perform MCMC (Markov Chain Monte Carlo) sampling and returning an object of the class *mcmc.list*.

## Usage

```
metadiag(  
  data,  
  two.by.two = FALSE,  
  re = "normal",  
  re.model = "DS",  
  link = "logit",  
  mean.mu.D = 0,  
  mean.mu.S = 0,  
  sd.mu.D = 1,  
  sd.mu.S = 1,  
  sigma.D.upper = 10,  
  sigma.S.upper = 10,  
  mean.Fisher.rho = 0,  
  sd.Fisher.rho = 1/sqrt(2),  
  df = 4,  
  df.estimate = FALSE,  
  df.lower = 3,  
  df.upper = 20,  
  split.w = FALSE,  
  n.1.new = 50,  
  n.2.new = 50,  
  nr.chains = 2,  
  nr.iterations = 10000,  
  nr.adapt = 1000,  
  nr.burnin = 1000,  
  nr.thin = 1,  
  be.quiet = FALSE,  
  r2jags = TRUE  
)
```

## Arguments

**data** Either a data frame with at least 4 columns containing the true positives (tp), number of patients with disease (n1), false positives (fp), number of patients

	without disease (n2), or for two.by.two = TRUE a data frame where each line contains the diagnostic results as a two by two table, where the column names are: TP, FP, TN, FN.
two.by.two	If TRUE indicates that the diagnostic results are given as: TP, FP, TN, FN.
re	Random effects distribution for the resulting model. Possible values are <i>normal</i> for bivariate random effects and <i>sm</i> for scale mixtures.
re.model	If re.model = "DS" indicates that the sum and differences of TPR and FPR are modeled as random effects and re.model = "SeSp" indicates that the Sensitivity and Specificity are modeled as random effects. The default value is re.model = "DS".
link	The link function used in the model. Possible values are <i>logit</i> , <i>cloglog</i> <i>probit</i> .
mean.mu.D	prior Mean of D, default value is 0.
mean.mu.S	prior Mean of S, default value is 0.
sd.mu.D	prior Standard deviation of D, default value is 1 (the prior of mu.D is a logistic distribution).
sd.mu.S	prior Standard deviation of S, default value is 1 (the prior of mu.S is a logistic distribution).
sigma.D.upper	Upper bound of the uniform prior of sigma.S, default value is 10.
sigma.S.upper	Upper bound of the uniform prior of sigma.S, default value is 10.
mean.Fisher.rho	Mean of rho in the Fisher scale default value is 0.
sd.Fisher.rho	Standard deviation of rho in the Fisher scale, default value is 1/sqrt(2).
df	If de.estimate = FALSE, then df is the degrees of freedom for the scale mixture distribution, default value is 4.
df.estimate	Estimate the posterior of df. The default value is FALSE.
df.lower	Lower bound of the prior of df. The default value is 3.
df.upper	Upper bound of the prior of df. The default value is 30.
split.w	Split the w parameter in two independent weights one for each random effect. The default value is FALSE.
n.1.new	Number of patients with disease in a predictive study default is 50.
n.2.new	Number of patients with non-disease in a predictive study default is 50.
nr.chains	Number of chains for the MCMC computations, default 5.
nr.iterations	Number of iterations after adapting the MCMC, default is 10000. Some models may need more iterations.
nr.adapt	Number of iterations in the adaptation process, default is 1000. Some models may need more iterations during adaptation.
nr.burnin	Number of iteration discard for burn-in period, default is 1000. Some models may need a longer burnin period.
nr.thin	Thinning rate, it must be a positive integer, the default value 1.
be.quiet	Do not print warning message if the model does not adapt default value is FALSE. If you are not sure about the adaptation period choose be.quiet=TRUE.
r2jags	Which interface is used to link R to JAGS (rjags and R2jags) default value is R2Jags TRUE.

## Details

Installation of JAGS: It is important to note that R 3.3.0 introduced a major change in the use of toolchain for Windows. This new toolchain is incompatible with older packages written in C++. As a consequence, if the installed version of JAGS does not match the R installation, then the `rjags` package will spontaneously crash. Therefore, if a user works with R version  $\geq 3.3.0$ , then JAGS must be installed with the installation program `JAGS-4.2.0-Rtools33.exe`. For users who continue using R 3.2.4 or an earlier version, the installation program for JAGS is the default installer `JAGS-4.2.0.exe`.

## Value

This function returns an object of the class `metadiag`. This object contains the MCMC output of each parameter and hyper-parameter in the model, the data frame used for fitting the model, the link function, type of random effects distribution and the splitting information for conflict of evidence analysis.

The results of the object of the class `metadiag` can be extracted with `R2jags` or with `rjags`. In addition a summary, a print and a plot functions are implemented for this type of object.

## References

Verde P. E. (2010). Meta-analysis of diagnostic test data: A bivariate Bayesian modeling approach. *Statistics in Medicine*. 29(30):3088-102. doi: 10.1002/sim.4055.

Verde P. E. (2018). `bamdit`: An R Package for Bayesian Meta-Analysis of Diagnostic Test Data. *Journal of Statistical Software*. Volume 86, issue 10, pages 1–32.

## Examples

```
## Not run:

# Example: data from Glas et al. (2003).....
library(bamdit)
data("glas")
glas.t <- glas[glas$marker == "Telomerase", 1:4]

glas.t <- glas[glas$marker == "Telomerase", 1:4]

# Simple visualization ...

plotdata(glas.t,                # Data frame
          two.by.two = FALSE    # Data is given as: (tp, n1, fp, n2)
          )

glas.m1 <- metadiag(glas.t,      # Data frame
                    two.by.two = FALSE, # Data is given as: (tp, n1, fp, n2)
                    re = "normal",     # Random effects distribution
                    re.model = "DS",    # Random effects on D and S
                    link = "logit",     # Link function
                    sd.Fisher.rho = 1.7, # Prior standard deviation of correlation
                    nr.burnin = 1000,   # Iterations for burnin
```

```

        nr.iterations = 10000, # Total iterations
        nr.chains = 2,         # Number of chains
        r2jags = TRUE)        # Use r2jags as interface to jags

summary(glas.m1, digit=3)

plot(glas.m1,                # Fitted model
     level = c(0.5, 0.75, 0.95), # Credibility levels
     parametric.smooth = TRUE) # Parametric curve

# Plot results: based on a non-parametric smoother of the posterior predictive rates .....

plot(glas.m1,                # Fitted model
     level = c(0.5, 0.75, 0.95), # Credibility levels
     parametric.smooth = FALSE) # Non-parametric curve

# Using the pipe command in the package dplyr .....

library(dplyr)

glas.t %>%
  metadiag(re = "normal", re.model = "SeSp") %>%
  plot(parametric.smooth = FALSE, color.pred.points = "red")

# Visualization of posteriors of hyper-parameters .....
library(ggplot2)
library(GGally)
library(R2jags)
attach.jags(glas.m1)
hyper.post <- data.frame(mu.D, mu.S, sigma.D, sigma.S, rho)
ggpairs(hyper.post,          # Data frame
        title = "Hyper-Posteriors", # title of the graph
        lower = list(continuous = "density") # contour plots
        )

#.....

# List of different statistical models:
# 1) Different link functions: logit, cloglog and probit

# 2) Different parametrization of random effects in the link scale:
#     DS = "differences of TPR and FPR"
#     SeSp = "Sensitivity and Specificity"

# 3) Different random effects distributions:
#     "normal" or "sm = scale mixtures".

```

```

# 4) For the scale mixture random effects:
#   split.w = TRUE => "split the weights".

# 5) For the scale mixture random effects:
#   df.estimate = TRUE => "estimate the degrees of freedom".

# 6) For the scale mixture random effects:
#   df.estimate = TRUE => "estimate the degrees of freedom".

# 7) For the scale mixture random effects:
#   df = 4 => "fix the degrees of freedom to a particular value".
#   Note that df = 1 fits a Cauchy bivariate distribution to the random effects.

# logit-normal-DS
m <- metadiag(glas.t, re = "normal", re.model = "DS", link = "logit")
summary(m)
plot(m)

# cloglog-normal-DS
summary(metadiag(glas.t, re = "normal", re.model = "DS", link = "cloglog"))

# probit-normal-DS
summary(metadiag(glas.t, re = "normal", re.model = "DS", link = "probit"))
# logit-normal-SeSp
summary(metadiag(glas.t, re = "normal", re.model = "SeSp", link = "logit"))

# cloglog-normal-SeSp
summary(metadiag(glas.t, re = "normal", re.model = "SeSp", link = "cloglog"))
# probit-normal-SeSp
summary(metadiag(glas.t, re = "normal", re.model = "SeSp", link = "probit"))

# logit-sm-DS
summary(metadiag(glas.t, re = "sm", re.model = "DS", link = "logit", df = 1))

# cloglog-sm-DS
summary(m<-metadiag(glas.t, re = "sm", re.model = "DS", link = "cloglog", df = 1))
plot(m, parametric.smooth = FALSE)

# probit-sm-DS
summary(m<-metadiag(glas.t, re = "sm", re.model = "DS", link = "probit", df = 1))
plot(m, parametric.smooth = FALSE)

# logit-sm-SeSp
summary(m<-metadiag(glas.t, re = "sm", re.model = "SeSp", link = "logit", df = 1))
plot(m, parametric.smooth = FALSE, level = c(0.5, 0.9))

# cloglog-sm-SeSp
summary(m<-metadiag(glas.t, re = "sm", re.model = "SeSp", link = "cloglog", df = 1))
plot(m, parametric.smooth = FALSE, level = c(0.5, 0.9))

# probit-sm-SeSp
summary(m<-metadiag(glas.t, re = "sm", re.model = "SeSp", link = "probit", df = 1))
plot(m, parametric.smooth = FALSE, level = c(0.5, 0.9))

```

```

# logit-sm-DS-df
summary(m<-metadiag(glas.t, re = "sm", re.model = "DS", link = "logit",
  df.estimate = TRUE))
plot(m, parametric.smooth = FALSE, level = c(0.5, 0.9))

# cloglog-sm-DS-df
summary(m<-metadiag(glas.t, re = "sm", re.model = "DS", link = "cloglog",
  df.estimate = TRUE))
plot(m, parametric.smooth = FALSE, level = c(0.5, 0.9))

# probit-sm-DS-df
summary(m<-metadiag(glas.t, re = "sm", re.model = "DS", link = "probit",
  df.estimate = TRUE))
plot(m, parametric.smooth = FALSE, level = c(0.5, 0.9))

# logit-sm-SeSp-df
summary(m<-metadiag(glas.t, re = "sm", re.model = "SeSp", link = "probit",
  df.estimate = TRUE))
plot(m, parametric.smooth = FALSE, level = c(0.5, 0.9))

# cloglog-sm-SeSp-df
summary(m<-metadiag(glas.t, re = "sm", re.model = "SeSp", link = "cloglog",
  df.estimate = TRUE))
plot(m, parametric.smooth = FALSE, level = c(0.5, 0.9))

# probit-sm-SeSp-df
summary(m<-metadiag(glas.t, re = "sm", re.model = "SeSp", link = "probit",
  df.estimate = TRUE))
plot(m, parametric.smooth = FALSE, level = c(0.5, 0.9))

# split.w .....

# logit-sm-DS
summary(m<- metadiag(glas.t, re = "sm", re.model = "DS", link = "logit", split.w = TRUE, df = 10))
plot(m)

# cloglog-sm-DS
summary(m<-metadiag(glas.t, re = "sm", re.model = "DS", link = "cloglog", split.w = TRUE, df = 4))
plot(m)

# probit-sm-DS
summary(m<-metadiag(glas.t, re = "sm", re.model = "DS", link = "probit", split.w = TRUE, df = 4))
plot(m, parametric.smooth = FALSE)

# logit-sm-SeSp
summary(m<-metadiag(glas.t, re = "sm", re.model = "SeSp", link = "logit", split.w = TRUE, df = 1))
plot(m, parametric.smooth = FALSE, level = c(0.5, 0.9))
plotw(m)

# cloglog-sm-SeSp
summary(m<-metadiag(glas.t, re = "sm", re.model = "SeSp", link = "cloglog", split.w = TRUE, df = 1))
plot(m, parametric.smooth = FALSE, level = c(0.5, 0.9))

```

```
plotw(m)

# probit-sm-SeSp
summary(m<-metadiag(glas.t, re = "sm", re.model = "SeSp", link = "probit", split.w = TRUE, df = 1))
plot(m, parametric.smooth = FALSE, level = c(0.5, 0.9))
plotw(m)

# logit-sm-DS-df
summary(m<-metadiag(glas.t, re = "sm", re.model = "DS", link = "logit", split.w = TRUE,
  df.estimate = TRUE))
plot(m, parametric.smooth = FALSE, level = c(0.5, 0.9))
plotw(m)

# cloglog-sm-DS-df
summary(m<-metadiag(glas.t, re = "sm", re.model = "DS", link = "cloglog", split.w = TRUE,
  df.estimate = TRUE))
plot(m, parametric.smooth = FALSE, level = c(0.5, 0.9))
plotw(m)

# probit-sm-DS-df
summary(m<-metadiag(glas.t, re = "sm", re.model = "DS", link = "probit", split.w = TRUE,
  df.estimate = TRUE))
plot(m, parametric.smooth = FALSE, level = c(0.5, 0.9))
plotw(m)

# logit-sm-SeSp-df
summary(m<-metadiag(glas.t, re = "sm", re.model = "SeSp", link = "probit", split.w = TRUE,
  df.estimate = TRUE))
plot(m, parametric.smooth = FALSE, level = c(0.5, 0.9))
plotw(m)

# cloglog-sm-SeSp-df
summary(m<-metadiag(glas.t, re = "sm", re.model = "SeSp", link = "cloglog", split.w = TRUE,
  df.estimate = TRUE))
plot(m, parametric.smooth = FALSE, level = c(0.5, 0.9))
plotw(m)

# probit-sm-SeSp-df
summary(m<-metadiag(glas.t, re = "sm", re.model = "SeSp", link = "probit", split.w = TRUE,
  df.estimate = TRUE))
plot(m, parametric.smooth = FALSE, level = c(0.5, 0.9))
plotw(m)

## End(Not run)
```

**Description**

Diagnosis of lymph node metastasis with magnetic resonance imaging

**Format**

A matrix with 10 rows and 4 columns. Each row represents study results, the columns are:

**tp** true positives

**n1** number of patients with disease

**fp** false positives

**n2** number of patients without disease

**Source**

The data were obtained from

Scheidler J, Hricak H, Yu KK, Subak L, Segal MR. (1997) Radiological evaluation of lymph node metastases in patients with cervical cancer: a meta-analysis. *The Journal of the American Medical Association*; **278**:1096-1101.

**References**

Verde P. E. (2010). Meta-analysis of diagnostic test data: A bivariate Bayesian modeling approach. *Statistics in Medicine*. **29**, 3088-3102.

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plot.metadiag

*Generic plot function for metadiag object in bamdit*

---

**Description**

This function plots the observe data in the ROC (Receiving Operating Characteristics) space with the posterior predictive contours. The predictive curves are approximated using a non-parametric smoother or with a parametric model. For the parametric model the current implementation supports only a logistic link function. The marginal posterior predictive distributions are plotted outside the ROC space.

**Usage**

```
## S3 method for class 'metadiag'  
plot(  
  x,  
  parametric.smooth = TRUE,  
  level = c(0.5, 0.75, 0.95),  
  limits.x = c(0, 1),  
  limits.y = c(0, 1),  
  kde2d.n = 25,  
  color.line = "red",
```



```

    title = paste("Posterior Predictive Contours (50%, 75% and 95%)"),
    marginals = TRUE,
    bin.hist = 30,
    color.hist = "lightblue",
    S = 500,
    color.pred.points = "lightblue",
    color.data.points = "blue",
    ...
)

```

### Arguments

x	The object generated by the metadiag function.
parametric.smooth	Indicates if the predictive curve is a parametric or non-parametric.
level	Credibility levels of the predictive curve. If parametric.smooth = FALSE, then the probability levels are estimated from the nonparametric surface.
limits.x	Numeric vector of length 2 specifying the x-axis limits. The default value is c(0, 1).
limits.y	Numeric vector of length 2 specifying the x-axis limits. The default value is c(0, 1).
kde2d.n	The number of grid points in each direction for the non-parametric density estimation. Can be scalar or a length-2 inter vector.
color.line	Color of the predictive contour line.
title	Optional parameter for setting a title in the plot.
marginals	Plot the posterior marginal predictive histograms.
bin.hist	Number of bins of the marginal histograms.
color.hist	Color of the histograms.
S	Number of predictive rates to be plotted.
color.pred.points	Color of the posterior predictive rates.
color.data.points	Color of the data points.
...	...

### See Also

[metadiag](#).

### Examples

```

## Not run:
library(bamdit)
data("glas")

```

```

glas.t <- glas[glas$marker == "Telomerase", 1:4]
glas.m1 <- metadiag(glas.t,           # Data frame
                   re = "normal",    # Random effects distribution
                   re.model = "DS",  # Random effects on D and S
                   link = "logit",   # Link function
                   sd.Fisher.rho = 1.7, # Prior standard deviation of correlation
                   nr.burnin = 1000,  # Iterations for burnin
                   nr.iterations = 10000, # Total iterations
                   nr.chains = 2,     # Number of chains
                   r2jags = TRUE)     # Use r2jags as interface to jags

plot(glas.m1,           # Fitted model
     level = c(0.5, 0.75, 0.95), # Credibility levels
     parametric.smooth = TRUE)   # Parametric curve

# Plot results: based on a non-parametric smoother of the posterior predictive rates .....

plot(glas.m1,           # Fitted model
     level = c(0.5, 0.75, 0.95), # Credibility levels
     parametric.smooth = FALSE)  # Non-parametric curve

# Using the pipe command in the package dplyr and changing some colors .....

library(dplyr)

glas.t %>%
  metadiag(re = "normal", re.model = "SeSp") %>%
  plot(parametric.smooth = FALSE,
       S = 100,
       color.data.points = "green",
       color.pred.points = "blue",
       color.line = "black")

## End(Not run)

```

---

plotcompare

*plotcompare*


---

## Description

This function compares the predictive posterior surfaces of two fitted models.

## Usage

```

plotcompare(
  m1,
  m2,
  level = 0.95,

```

```

    title = paste("Comparative Predictive Posterior Contours"),
    m1.name = "Model.1",
    m2.name = "Model.2",
    group = NULL,
    limits.x = c(0, 1),
    limits.y = c(0, 1),
    group.colors = c("blue", "red")
  )

```

### Arguments

m1	A model fitted to the data. This is an object generated by the metadiag function.
m2	A second model fitted to the data. This is an object generated by the metadiag function.
level	Credibility level of the predictive curves.
title	The title of the plot.
m1.name	Label of the model 1.
m2.name	Label of the model 2.
group	An optional argument, which is a variable name indicating a group factor. This argument is used to compare results from two subgroups.
limits.x	A vector with the limits of the horizontal axis.
limits.y	A vector with the limits of the vertical axis.
group.colors	A character vector with two color names.

### See Also

[metadiag](#).

### Examples

```

## execute analysis
## Not run:

# Comparing results from two models same data

data(glas)
glas.t <- glas[glas$marker == "Telomerase", 1:4]
glas.m1 <- metadiag(glas.t)
glas.m2 <- metadiag(glas.t, re = "sm")
plotcompare(m1 = glas.m1, m2 = glas.m2)

# Comparing results from two models fitted to two subgroups of data:
# studies with retrospective design and studies with prospective design

data("ct")
ct$design = factor(ct$design, labels = c("Prospective", "Retrospective"))

m1.ct <- metadiag(ct[ct$design=="Prospective", ])

```

```

m2.ct <- metadiag(ct[ct$design=="Retrospective", ])

plotcompare(m1.ct, m2.ct,m1.name = "Retrospective design",
m2.name = "Prospective design",group = "design",
limits.x = c(0, 0.75), limits.y = c(0.65, 1))

## End(Not run)

```

---

plotcredibility

*Generic plot function for metadiag object in bamdit*


---

### Description

This function plots the observe data in the ROC (Receiving Operating Characteristics) space with the posterior credibility contours.

### Usage

```

plotcredibility(
  x,
  parametric.smooth = TRUE,
  level = c(0.5, 0.75, 0.95),
  limits.x = c(0, 1),
  limits.y = c(0, 1),
  color.line = "red",
  color.data.points = "blue",
  title = paste("Posterior Credibility Contours (50%, 75% and 95%)"),
  ...
)

```

### Arguments

<code>x</code>	The object generated by the metadiag function.
<code>parametric.smooth</code>	Indicates if the predictive curve is a parametric or non-parametric.
<code>level</code>	Credibility levels of the predictive curve. If <code>parametric.smooth = FALSE</code> , then the probability levels are estimated from the nonparametric surface.
<code>limits.x</code>	Numeric vector of length 2 specifying the x-axis limits. The default value is <code>c(0, 1)</code> .
<code>limits.y</code>	Numeric vector of length 2 specifying the x-axis limits. The default value is <code>c(0, 1)</code> .
<code>color.line</code>	Color of the predictive contour line.
<code>color.data.points</code>	Color of the data points.

```

title      Optional parameter for setting a title in the plot.
...

```

### See Also

[metadiag](#).

### Examples

```

## Not run:
library(bamdit)
data("glas")
glas.t <- glas[glas$marker == "Telomerase", 1:4]
glas.m1 <- metadiag(glas.t,          # Data frame
                   re = "normal",    # Random effects distribution
                   re.model = "DS",  # Random effects on D and S
                   link = "logit",   # Link function
                   sd.Fisher.rho = 1.7, # Prior standard deviation of correlation
                   nr.burnin = 1000,  # Iterations for burnin
                   nr.iterations = 10000, # Total iterations
                   nr.chains = 2,     # Number of chains
                   r2jags = TRUE)     # Use r2jags as interface to jags

plotcredibility(glas.m1,          # Fitted model
                level = c(0.5, 0.75, 0.95), # Credibility levels
                parametric.smooth = TRUE) # Parametric curve

## End(Not run)

```

---

plotdata

*Basic function to plot the data of meta-analysis of diagnostic test*

---

### Description

This function plots the true positive rates vs the false positive rates of each study included in the meta-analysis. Study results are displayed by circles, the diameter of each circle is proportional to the sample size of the study (or table). If subgroups are displayed each group is represented by different colours. This function use the package *ggplot2*.

### Usage

```

plotdata(
  data,
  two.by.two = FALSE,
  group = NULL,
  x.lo = 0,

```

```

x.up = 1,
y.lo = 0,
y.up = 1,
alpha.p = 0.7,
max.size = 15
)

```

### Arguments

data	Either a data frame with at least 4 columns containing the true positives (tp), number of patients with disease (n1), false positives (fp), number of patients without disease (n2), or for two.by.two = TRUE a data frame where each line contains the diagnostic results as a two by two table, where the column names are: TP, FP, TN, FN.
two.by.two	If TRUE indicates that the diagnostic results are given as: TP, FP, TN, FN.
group	a variable name indicating a group factor
x.lo	lower limit of the x-axis
x.up	upper limit of the x-axis
y.lo	lower limit of the y-axis
y.up	upper limit of the y-axis
alpha.p	transparency of the points
max.size	scale parameter of the maximum size

### Examples

```

## execute analysis
## Not run:

data(ct)
ct$design <- with(ct, factor(design,
                          labels = c("Prospective", "Retrospective")))

plotdata(ct,          # Data frame
         group = "design", # Grouping variable
         y.lo = 0.75,    # Lower limit of y-axis
         x.up = 0.75,    # Upper limit of x-axis
         alpha.p = 0.5,  # Transparency of the balls
         max.size = 5)   # Scale the circles

## End(Not run)

```

---

plotsesp	<i>plotsesp()</i> plot the posterior densities for Se and Sp
----------	--

---

**Description**

plotsesp() plot the posterior densities for Se and Sp

**Usage**

```
plotsesp(m, binwidth.p = 0.03, CI.level = 0.95)
```

**Arguments**

m	The object generated by the metadiag function.
binwidth.p	Histograms binwidth, default is 0.03.
CI.level	Level of the posterior interval default is 0.95.

**See Also**

[metadiag](#).

**Examples**

```
## execute analysis
## Not run:
data(ep)
m1.ep <- metadiag(ep[,1:4])

plotsesp(m = m1.ep)

## End(Not run)
```

---

plotw	<i>Plot for the conflict of evidence parameters w1 and w2</i>
-------	---

---

**Description**

Conflict of evidence plot: this plot displays the posterior distribution of the study's weights  $w_1$  and  $w_2$ . These weights indicate potential conflict of evidence of the studies. The weight  $w_1$  indicates deviations with respect to the specificity and  $w_2$  to the sensitivity.

**Usage**

```
plotw(  
  m,  
  group = NULL,  
  title = "Posterior quantiles (25%, 50%, 75%)",  
  group.colors = c("blue", "red")  
)
```

**Arguments**

<code>m</code>	The object generated by <code>metadiag</code> . The model object must be fitted with the options: <code>re = "sm"</code> and <code>split.w = TRUE</code> .
<code>group</code>	An optional argument which is a variable name indicating a group factor. If set, then the plot is colored by groups.
<code>title</code>	The title of the plot.
<code>group.colors</code>	A character vector with two color names.

**See Also**

[metadiag](#).

**Examples**

```
## execute analysis  
## Not run:  
data(ep)  
ep$design = factor(ep$d1, labels = c("prospective", "retrospective"))  
m.ep <- metadiag(ep, re = "sm", re.model = "SeSp",  
                split.w = TRUE,  
                df.estimate = TRUE)  
  
plotw(m.ep)  
#Relationship between conflict and study design  
plotw(m.ep, group = "design")  
  
## End(Not run)
```

---

print.metadiag

*Generic print function for metadiag object in bamdit*

---

**Description**

Generic print function for metadiag object in bamdit



**Usage**

```
## S3 method for class 'metadiag'
print(x, digits = 3, ...)
```

**Arguments**

x	The object generated by the function metadiag.
digits	The number of significant digits printed. The default value is 3.
...	...

---

 rapt

*Systematic reviews of clinical decision tools for acute abdominal pain*


---

**Description**

This data frame corresponds to 13 clinical studies reporting the accuracy of doctors added with decision tools.

**Format**

A data frame with 13 rows and 13 columns. Each row represents study results, the columns are:

**Author** Name of the first author and year of publication  
**tp.dr** Number of true positive cases for unadded doctors.  
**fp.dr** Number of false positive cases for unadded doctors.  
**fn.dr** Number of false negative cases for unadded doctors.  
**tn.dr** Number of true negative cases for unadded doctors.  
**tp.tools** Number of true positive cases for doctors with decision tools.  
**fp.tools** Number of false positive cases for doctors with decision tools.  
**fn.tools** Number of false negative cases for doctors with decision tools.  
**tn.tools** Number of true negative cases for doctors with decision tools.  
**tool** Diagnostic tool.  
**n.dr** Total number of cases for unadded doctors.  
**n.tools** Total number of cases for doctors with decision tools.  
**design** Study design.

**Details**

This data frame contains results of diagnostic accuracy of 13 studies which reported comparison of sensitivity and specificity between doctors using diagnostic tools vs doctors without decision tools.

**Source**

Health Technol Assess. 2006 Nov;10(47):1-167, iii-iv. Systematic reviews of clinical decision tools for acute abdominal pain. Liu JL1, Wyatt JC, Deeks JJ, Clamp S, Keen J, Verde P, Ohmann C, Wellwood J, Dawes M, Altman DG.

**References**

Health Technol Assess. 2006 Nov;10(47):1-167, iii-iv. Systematic reviews of clinical decision tools for acute abdominal pain. Liu JL1, Wyatt JC, Deeks JJ, Clamp S, Keen J, Verde P, Ohmann C, Wellwood J, Dawes M, Altman DG.

---

safdar05

*Diagnosis of Intravascular Device-Related Bloodstream Infection*

---

**Description**

Outcome of individual studies evaluating intravascular device-related bloodstream infection

**Format**

A matrix with 78 rows and 8 columns. Each row represents study results, the columns are:

**tp** number of true positives.

**n1** number of patients with disease.

**fp** number of false positives.

**n2** number of patients without disease.

**author** first author of the study.

**year** publication date.

**technique** diagnostic technique used in the study.

**duration** duration of catheterization: short term or long term or both.

**Source**

The data were obtained from

Safdar N, Fine JP, Maki DG. (2005) Meta-analysis: methods for diagnosing intravascular device-related bloodstream infection. *Ann Intern Med.*; **142**:451-66.

---

scheidler	<i>Radiological evaluation of lymph node metastases in patients with cervical cancer: a meta-analysis.</i>
-----------	--

---

### Description

This data frame summarizes the tables 1-3 of Scheidler et al. 1997.

### Format

A matrix with 46 rows and 7 columns. Each row represents study results, the columns are:

**tp** true positives.

**n1** number of patients with disease.

**fp** false positives.

**n2** number of patients without disease.

**author** first author of the study.

**year** publication date.

**test** test method used in the study.

### Source

The data were obtained from

Scheidler J, Hricak H, Yu KK, Subak L, Segal MR. (1997) Radiological evaluation of lymph node metastases in patients with cervical cancer: a meta-analysis. *The Journal of the American Medical Association*; **278**:1096-1101.

### References

Verde P. E. (2010). Meta-analysis of diagnostic test data: A bivariate Bayesian modeling approach. *Statistics in Medicine*. **29**, 3088-3102.

---

skin	<i>Accuracy of Computer-Aided Diagnosis of Melanoma: A Meta-analysis.</i>
------	---

---

### Description

This data frame contains results 70 studies investigated computer-aided diagnosis of melanoma

**Format**

A matrix with 70 rows and 15 columns. Each row represents a study's results, the columns are:

"TP" number of true positives.

"TN" number of true negatives.

"FP" number of false positives.

"FN" number of false negative.

"study\_ID" Study identification

"test\_set\_source" Public or proprietary.

"method" Diagnostic technique used in the study: computer vision; deep learning or hardware-based.

"test\_set\_independent" yes or no.

"SAMPLE\_SELECTION\_BR" QUADAS-2, Patient selection bias.

"INDEX\_TEST\_BR" QUADAS-2, Index test description/application bias.

"REFERENCE\_STANDARD\_BR" QUADAS-2, Reference standard bias.

"FLOW\_AND\_TIMING\_BR" QUADAS-2, Patient flow and timing bias.

"SAMPLE\_SELECTION\_AP" QUADAS-2, Patient selection bias.

"INDEX\_TEST\_AP" QUADAS-2, Index test description/application bias.

"REFERENCE\_STANDARD\_AP" QUADAS-2, Reference standard bias.

**Source**

The data were obtained from

Dick V, Sinz C, Mittlböck M, Kittler H, Tschandl P. Accuracy of Computer-Aided Diagnosis of Melanoma: A Meta-analysis. *JAMA Dermatol.* 2019 Nov 1;155 11:1291-1299. doi: 10.1001/jamadermatol.2019.1375. PMID: 31215969; PMCID: PMC6584889.

---

skin2

*Accuracy of Computer-Aided Diagnosis of Melanoma: A Comparative Meta-analysis.*

---

**Description**

This data frame contains results 14 comparative diagnostic studies: CAD vs Dermatologists

**Format**

A matrix with 14 rows and 12 columns. Each row represents a study's results, the columns are:

"**study**" Study name and year

"**TP\_CAD**" number of true positives CAD.

"**TN\_CAD**" number of true negatives CAD.

"**FP\_CAD**" number of false positives CAD.

"**FN\_CAD**" number of false negative CAD.

"**TP\_Dermatologists**" number of true positives Dermatologists.

"**TN\_Dermatologists**" number of true negatives Dermatologists.

"**FP\_Dermatologists**" number of false positives Dermatologists.

"**FN\_Dermatologists**" number of false negative Dermatologists.

"**test\_set\_source**" The database was public domain or proprietary.

"**cad\_method**" Computer-Aided Diagnostic Technique: computer vision; deep learning or hardware-based.

"**test\_set\_independent**" yes or no.

**Source**

The data were obtained from

Dick V, Sinz C, Mittlböck M, Kittler H, Tschandl P. Accuracy of Computer-Aided Diagnosis of Melanoma: A Meta-analysis. JAMA Dermatol. 2019 Nov 1;155 11:1291-1299. doi: 10.1001/jamadermatol.2019.1375. PMID: 31215969; PMCID: PMC6584889.

---

summary.metadiag

*Generic summary function for metadiag object in bamdit*

---

**Description**

Generic summary function for metadiag object in bamdit

**Usage**

```
## S3 method for class 'metadiag'
summary(object, digits = 3, ...)
```

**Arguments**

object	The object generated by the metadiag function.
digits	The number of significant digits printed. The default value is 3.
...	...

# Index

## \* datasets

- ct, [5](#)
- diabetes, [6](#)
- ep, [7](#)
- glas, [7](#)
- gould, [8](#)
- mri, [15](#)
- rapt, [25](#)
- safdar05, [26](#)
- scheidler, [27](#)
- skin, [27](#)
- skin2, [28](#)

## \* file

- bsroc, [3](#)
- plotcompare, [18](#)
- plotsesp, [23](#)
- plotw, [23](#)

- bamdit (bamdit-package), [2](#)
- bamdit-package, [2](#)
- bsroc, [3](#)

- ct, [5](#)

- diabetes, [6](#)

- ep, [7](#)

- glas, [7](#)
- gould, [8](#)

- metadiag, [4](#), [9](#), [17](#), [19](#), [21](#), [23](#), [24](#)
- mri, [15](#)

- plot.metadiag, [16](#)
- plotcompare, [18](#)
- plotcredibility, [20](#)
- plotdata, [21](#)
- plotsesp, [23](#)
- plotw, [23](#)
- print.metadiag, [24](#)

- rapt, [25](#)

- safdar05, [26](#)
- scheidler, [27](#)
- skin, [27](#)
- skin2, [28](#)
- summary.metadiag, [29](#)