Package ‘regmed’

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Type Package
Title Regularized Mediation Analysis
Version 2.0.4
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Description Mediation analysis for multiple mediators by penalized structural equation models with different types of penalties depending on whether there are multiple mediators and only one exposure and one outcome variable (using sparse group lasso) or multiple exposures, multiple mediators, and multiple outcome variables (using lasso, L1, penalties).
License GPL (>= 2)
Suggests testthat, rmarkdown
Depends R (>= 3.6.0), methods, graphics, glasso, igraph
Imports knitr, Rcpp, RcppArmadillo, lavaan
LinkingTo Rcpp, RcppArmadillo
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VignetteBuilder knitr
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Description

Mediation analysis for multiple mediators by penalized structural equation models with different types of penalties depending on whether there are multiple mediators and only one exposure and one outcome variable (using sparse group lasso) or multiple exposures, multiple mediators, and multiple outcome variables (using lasso, L1, penalties).

Details

The DESCRIPTION file:

Package: regmed
Type: Package
Title: Regularized Mediation Analysis
Version: 2.0.4
Date: 2021-04-12
Authors@R: c( person("Jason", "Sinnwell", email = "sinnwell.jason@mayo.edu", comment="c(ORCID="0000-0003-1964-5522"), role = c("aut"),),

Description: Mediation analysis for multiple mediators by penalized structural equation models with different types of penalties depending on whether there are multiple mediators and only one exposure and one outcome variable (using sparse group lasso) or multiple exposures, multiple mediators, and multiple outcome variables (using lasso, L1, penalties).

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Imports: knitr, Rcpp, RcppArmadillo, lavaan
LinkingTo: Rcpp, RcppArmadillo
NeedsCompilation: yes
VignetteBuilder: knitr
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- **summary.mvregmed** Summary of mvregmed object
medsim

Further information is available in the following vignettes:

regmed  Regularized Mediation Manual (source, pdf)

Author(s)

NA
Maintainer: NA

References


medsim  Simulated dataset for regmed package

Description

Example data simulated from 2 response (y) variables, 10 exposure (x) variables, and 200 mediators (med). The all variables are generated from multivariate standard normal, with varying degrees of association between exposure, mediators, and responses.

Usage

data("medsim")

Format

Three data frames with 100 observations each:

x  matrix with 10 columns of continuous exposure variables
y  matrix with 2 columns of continuous response variables
med numeric matrix of 200 columns of simulated mediators between exposures and responses
mvregmed.dat.check

Helper function to check x, y, mediator for input to mvregmed functions

Description
Assure that x, y, mediator are matrices, check column names and fill in if NULL, and reduce x, y, mediator so no missing values among all three matrices.

Usage
mvregmed.dat.check(x, y, mediator)

Arguments
- x: matrix with columns representing "exposure" variable (sometimes called instrumental variable)
- y: matrix with columns representing outcome variables
- mediator: matrix with columns representing mediator variables

Value
list with updated x, y, mediator

Author(s)
Daniel Schaid and Jason Sinnwell

See Also
mvregmed.fit mvregmed.grid

mvregmed.edges

For an object of class mvregmed, create edges for a graph object that can be used for plots, or for creating models input to lavaan function sem

Description
Using the names of the alpha, beta, and delta matrices in the fitted object, create directed edges

Usage
mvregmed.edges(fit, eps = 0.001)
mvregmed.fit

Arguments

fit The fit as an object of class mvregmed. This can be output from either mvregmed.fit or mvregmed.grid.bestfit.

eps Threshold to determine whether any of alpha, beta, or delta parameters are close to zero to be rounded to zero.

Value

an object of class mvregmed.edges, which is a list with all.edge which is a data.frame with directed edges that are the names of x, mediator, y that are in the fitted model. Also returns data frames for alpha, beta, delta (each data frame containing vertex labels, row/col indices from which parameters were selected, and coefficient values), as well as names of x, mediator, and y.

Author(s)

Daniel Schaid and Jason Sinnwell

References


See Also

mvregmed.fit plot.mvregmed.edges

mvregmed.fit Multivariate regularized mediation model

Description

Fit regularized mediation model for a specified lambda penalty value. Structural equation models for analysis of multiple exposures (x), multiple mediators, and multiple outcome variables (y) are fit with a lasso (L1) penalty on the model parameters. The model is x-[alpha] -> mediator-[beta] -> outcome, where alpha and beta are the parameters for the indirect effect of x on y, through the mediator. The model also allows a direct effect of x on y: x-[delta]->y.

Usage

mvregmed.fit(x, mediator, y, lambda, x.std = TRUE, med.std = TRUE, y.std = TRUE, max.outer = 5000, max.inner = 2, step.multiplier = 0.5, print.iter = FALSE)
Arguments

- **x**: matrix with columns representing "exposure" variable (sometimes called instrumental variable)
- **mediator**: matrix with columns representing mediator variables
- **y**: matrix with columns representing outcome variables
- **lambda**: lambda penalty parameter
- **x.std**: logical (TRUE/FALSE) whether to standardize x by dividing by standard deviation of x. Note that each column of x will be centered on its mean.
- **med.std**: logical (TRUE/FALSE) whether to standardize mediator by dividing by standard deviation of mediator. Note that each column of mediator will be centered on its mean.
- **y.std**: logical (TRUE/FALSE) whether to standardize y by dividing by standard deviation of y. Note that each column of y will be centered on its mean.
- **max.outer**: maximum number of outer loop iterations. The outer loop cycles over several inner loops.
- **max.inner**: maximum number of iterations for each inner loop. There is an inner loop for each parameter in the matrices alpha, beta, delta, and vary.
- **step.multiplier**: In inner loop, the step size is shrunk by the step.multiplier to assure that step size is not too large. Generally, the default of 0.5 works well.
- **print.iter**: print iteration number during fitting routine

Value

An object of class mvregmed

Author(s)

Daniel Schaid and Jason Sinnwell

References


See Also

mvregmed.grid

Examples

```r
data(medsim)
mvfit <- mvregmed.fit(x, med[,1:10], y, lambda=.1)
summary(mvfit)
```
mvregmed.graph.attributes

*Setup attributes of graph object for plotting*

Description

Setup attributes of graph object for plotting directed acyclic graph with graph attributes

Usage

```
mvregmed.graph.attributes(fit.edges, x.color = "palegreen",
y.color = "palevioletred", med.color = "skyblue", v.size = 30)
```

Arguments

- **fit.edges**: A data.frame of edges with 1st column a vertex directed to the vertex in the 2nd column. This is all.edge from the list that is output from mvregmed.edges
- **x.color**: Color of vertices for x variables
- **y.color**: Color of vertices for y variables
- **med.color**: Color of vertices for mediators
- **v.size**: Size of vertices for plotting

Details

User can use this as template for taking advantage of more igraph attributes.

Value

List with items 1) output from graph_from_edgelist (see igraph); 2) vertex names; 3) vertex size; 4) vertex colors

Author(s)

Daniel Schaid and Jason Sinnwell

References


See Also

mvregmed.edges graph_from_edgelist
mvregmed.grid

Fit a grid of mvregmed models over a vector of lambda penalty parameters

Description

For each lambda in an input vector of values, fit a penalized mvregmed model

Usage

mvregmed.grid(x, mediator, y, lambda.vec, max.outer = 5000, 
max.inner = 2, x.std = TRUE, med.std = TRUE, y.std = TRUE, 
step.multiplier = 0.5, print.iter = FALSE)

Arguments

x               matrix with columns representing "exposure" variable (sometimes called instrumental variable)
mediator         matrix with columns representing mediator variables
y               matrix with columns representing outcome variables
lambda.vec       Vector of values of penalty parameter lambda's
max.outer        maximum number of outer loop iterations. The outer loop cycles over several inner loops.
max.inner        maximum number of iterations for each inner loop. There is an inner loop for each parameter in the matrices alpha, beta, delta, and vary.
x.std            logical (TRUE/FALSE) whether to standardize x by dividing by standard deviation of x. Note that each column of x will be centered on its mean.
med.std          logical (TRUE/FALSE) whether to standardize mediator by dividing by standard deviation of mediator. Note that each column of mediator will be centered on its mean.
y.std            logical (TRUE/FALSE) whether to standardize y by dividing by standard deviation of y. Note that each column of y will be centered on its mean.
step.multiplier  In inner loop, the step size is shrunk by the step.multiplier to assure that step size is not too large. Generally, the default of 0.5 works well.
print.iter       print iteration number during fitting routine

Value

An object of class mvregmed.grid

Author(s)

Daniel Schaid and Jason Sinnwell
References


See Also

mvregmed.fit

Examples

data(medsim)
mvfit.grid <- mvregmed.grid(x, med[,1:10], y, lambda.vec=seq(.3, .04, by=-.01))
summary(mvfit.grid)
## plot(mvfit.grid)

mvregmed.grid.bestfit

Choose best fit model from a grid search based on minimum Bayesian Information Criterion

Description

Search over all models fit in a grid and choose model with min BIC as best model.

Usage

mvregmed.grid.bestfit(fit.grid)

Arguments

fit.grid An object of class mvregmed.grid, output from function mvregmed.grid

Value

An object of class mvregmed, a single best fitting model.

Author(s)

Daniel Schaid and Jason Sinnwell

References


See Also

mvregmed.grid
mvregmed.grid.data

Helper function to summarize fits of models across a grid of lambda values

Description

elper function to summarize fits of models across a grid of lambda values

Usage

mvregmed.grid.data(fit.lst, lambda.vec)

Arguments

fit.lst A list of model fits over a grid of lambda values; length of list is length of vector of lambdas.
lambda.vec A vector of penalty lambda values/

Details

Create a data.frame of summary information for each model fit in a grid.

Value

data.frame of summary information

Author(s)

Daniel Schaid and Jason Sinnwell

References


See Also

mvregmed.grid
mvregmed.grid.update  *Helper function to update parameters in a grid search*

**Description**

After a model is fit with a specific lambda, use the output of the fitted parameters as initial values for the next lambda value, thus using warm starts at each successive lambda value.

**Usage**

```
mvregmed.grid.update(fit.obj, inits)
```

**Arguments**

- **fit.obj**: A fitted model of class mvregmed.
- **inits**: Initial values from mvregmed.init that are subsequently updated with new values from fit.obj

**Value**

A list with the same components as output from mvregmed.init

**Author(s)**

Daniel Schaid and Jason Sinnwell

**References**


**See Also**

`mvregmed.init`

---

mvregmed.init  *Helper function to setup data and parameters for input to mvregmed.fit and mvregmed.grid*

**Description**

Helper function to setup data and parameters for input to mvregmed.fit and mvregmed.grid

**Usage**

```
mvregmed.init(dat.obj, x.std = TRUE, med.std = TRUE, y.std = TRUE)
```
mvregmed.lavaan.dat

Arguments

- **dat.obj**: A list that is output from mvregmed.dat.check that contains x, mediator, and y.
- **x.std**: logical (TRUE/FALSE) whether to standardize x by dividing by standard deviation of x. Note that each column of x will be centered on its mean.
- **med.std**: logical (TRUE/FALSE) whether to standardize mediator by dividing by standard deviation of mediator. Note that each column of mediator will be centered on its mean.
- **y.std**: logical (TRUE/FALSE) whether to standardize y by dividing by standard deviation of y. Note that each column of y will be centered on its mean.

Details

Center and scale (if declared) x, mediator and y. Then regress each mediator on all x to create residuals that are used to create the residual variance matrix for mediators. This variance matrix is penalized by glasso to obtain a matrix of full rank. Variance matrices for x and y variables are also created. Initial values of parameter matrices alpha, beta, and delta are created (all intial values = 0).

Value

A list of items used as input to model fitting.

Author(s)

Daniel Schaid and Jason Sinnwell

References


See Also

mvregmed.fit mvregmed.grid

mvregmed.lavaan.dat  Set up data to input to lavaan sem

Description

Set up data to input to lavaan structural equation model (sem)

Usage

mvregmed.lavaan.dat(x, mediator, y)
mvregmed.lavaan.model

Arguments

- x: matrix of exposure variables
- mediator: matrix of mediators
- y: matrix of outcome variables

Details

Use the function regmed.dat.check to standardize all variables and subset to subjects without missing data.

Value

A dataframe with updated x, mediator, and y

Author(s)

Daniel Schaid and Jason Sinnwell

References


Description

Set up a model statement (string formula) from mvregmed object for input to lavaan.

Usage

mvregmed.lavaan.model(fit.edge, fit.mvregmed)

Arguments

- fit.edge: Output from mvregmed.edges
- fit.mvregmed: A mvregmed object, either from mvregmed.fit or from mvregmed.grid.bestfit

Details

Loop through all relationships determined important from mrregmed edges object, and create model statement for lavaan, while also specifying covariances pre-estimated by mvregmed. See vignette for examples. The summary method for lavaan supersedes the summary from the lavaan package by simplifying the output to only return the coefficient table, as the covariance estimates were fixd from mvregmed.
Value

Text string to define a model as input to sem

Author(s)

Daniel Schaid and Jason Sinnwell

References


plot.mvregmed.grid

Plot penalty parameter lambda versus BIC for model fits

Description

Plot penalty parameter lambda versus BIC for model fits

Usage

## S3 method for class 'mvregmed.grid'
plot(x, xlab="lambda", ylab="BIC", pch="*", ...)

Arguments

x An object created by mvregmed.grid
xlab x axis label, by default set to 'lambda'
ylab y axis label, by default set to 'BIC' for this plot
pch plot character, by default set to a star (*)
... optional plot arguments

Author(s)

Daniel Schaid and Jason Sinnwell

References

**Description**

Creates 2 plots: (1) BIC vs. lambda, and (2) Coefficients Alpha and Beta of mediator vs. lambda.

**Usage**

```r
## S3 method for class 'regmed.grid'
plot(x, as.log=FALSE, ...)
```

**Arguments**

- `x` : regmed.grid object, returned by the `regmed.grid()` function
- `as.log` : Logical; if TRUE, plot lambda on the log scale
- `...` : optional arguments for plot method

**Value**

nothing is returned

**Author(s)**

Dan Schaid, Greg Jenkins, Jason Sinnwell

**See Also**

`regmed.grid`

**Examples**

```r
data(medsim)
fit.grid <- regmed.grid(x[,1], med[,1:10], y[,1],
lambda.vec= c(seq(from=1, to=0, by = -.1)), frac.lasso=.8)
summary(fit.grid)
```
For an object of class `regmed`, create edges for a graph object that can be used for plots, or for creating models input to `lavaan` function `sem`.

### Description

Using the names of the alpha, beta, and delta matrices in the fitted object, create directed edges.

### Usage

`regmed.edges(fit, type="mediators", eps = 0.001)`

### Arguments

- **fit**
  - The fit as an object of class `mvregmed`. This can be output from either `mvregmed.fit` or `mvregmed.grid.bestfit`.
- **type**
  - Character string specifying whether to only keep edges for mediators that have a non-zero coefficient with exposure and response variables ("mediator") or all edges ("all").
- **eps**
  - Threshold to determine whether any of alpha, beta, or delta parameters are close to zero to be rounded to zero.

### Value

A list with class `"regmed.edges"` containing `all.edge` which is a data.frame with directed edges that are the names of x, mediator, y that are in the fitted model, with the coefficient for that edge. The plot method will plot the edges using igraph plotting options.

### Author(s)

Daniel Schaid and Jason Sinnwell

### References


### See Also

`regmed.fit` `plot.regmed.edges`
This code regmed.fit is a function for fitting a regularized mediation model for a specified lambda penalty value.

**Description**

Fit regularized mediation model for a specified lambda penalty value. Structural equation models for analysis of multiple mediators are extended by creating a sparse group lasso penalized model such that the penalty considers the natural groupings of the pair of parameters that determine mediation, as well as encourages sparseness of the model parameters. The model is $x-[\alpha] \rightarrow$ mediator-$[\beta] \rightarrow$ outcome, where $\alpha$ and $\beta$ are the parameters for the indirect effect of $x$ on $y$, through the mediator. The model also allows a direct effect of $x$ on $y$: $x-[\delta] \rightarrow y$.

**Usage**

```r
gemed.fit(x, mediator, y, lambda, frac.lasso=0.8, x.std=TRUE, med.std=TRUE, max.outer=5000, max.inner=100, step.multiplier = 0.5, wt.delta = .5, print.iter=FALSE)
```

**Arguments**

- **x**: vector representing "exposure" variable (sometimes called instrumental variable)
- **mediator**: matrix of mediators, rows are observations, columns are different mediators
- **y**: vector representing outcome
- **lambda**: lambda penalty parameter
- **frac.lasso**: fraction of penalty (lambda) that is allocated to L1 penalty (lasso). The remaining fraction, (1-frac.lasso) is allocated to group-lasso penalty, where the group is the pair of parameters alpha and beta that determine mediation ($x-[\alpha] \rightarrow$ mediator-$[\beta] y$).
- **x.std**: logical (TRUE/FALSE) whether to standardize $x$ by dividing by standard deviation of $x$. Note that $x$ will be centered on its mean.
- **med.std**: logical (TRUE/FALSE) whether to standardize mediators by dividing each mediator by its standard deviation. Note that mediators will be centered on their means.
- **max.outer**: maximum number of outer loop iterations. The outer loop cycles over several inner loops.
- **max.inner**: maximum number of iterations for each inner loop. There is an inner loop for each pair of alpha-beta parameters for each mediator, an inner loop for direct effect (delta), and inner loops for residual variances for $x$ and for $y$.
- **step.multiplier**: a value between 0 and 1 for backtracking, to shrink step size. Value of 0.5 is typical default.
- **wt.delta**: a weight $\geq 0$ for how much weight should be given to shrinking delta parameter, by penalty lambda*wt.delta.
- **print.iter**: print iteration history during fitting routine
regmed.grid

Value

regmed object, with S3 methods available: plot, print, summary

Author(s)

Dan Schaid, Greg Jenkins, Jason Sinnwell

References


See Also

regmed.edges summary.regmed

Examples

data(medsim)
filter5 <- regmed.prefilter(x[,1], med, y[,1], k=5)
fit.regmed <- regmed.fit(x[,1], med[,1:5], y[,1], lambda = 0.2, frac.lasso=.8)
summary(fit.regmed)

regmed.grid  Regularized mediation models over a vector grid of lambda penalty values.

Description

Fit regularized mediation models over a vector grid of lambda penalty values. Structural equation models for analysis of multiple mediators are extended by creating a sparse group lasso penalized model such that the penalty considers the natural groupings of the pair of parameters that determine mediation, as well as encourages sparseness of the model parameters. The model is x-[alpha] -> mediator-[beta] -> outcome, where alpha and beta are the parameters for the indirect effect of x on y, through the mediator. The model also allows a direct effect of x on y: x-[delta] -> y.

Usage

regmed.grid(x, mediator, y, lambda.vec, frac.lasso=0.8, max.outer=5000,
max.inner=100, x.std=TRUE, med.std=TRUE, step.multiplier = 0.5,
wt.delta = .5, print.iter=FALSE)
Arguments

- **x**: vector representing "exposure" variable (sometimes called instrumental variable)
- **mediator**: matrix of mediators, rows are observations, columns are different mediators
- **y**: vector representing outcome
- **lambda.vec**: vector of lambda penalty parameters
- **frac.lasso**: fraction of penalty (lambda) that is allocated to L1 penalty (lasso). The remaining fraction, (1-frac.lasso) is allocated to group-lasso penalty, where the group is the pair of parameters alpha and beta that determine mediation (x [alpha] -> mediator -> [beta] y).
- **max.outer**: maximum number of outer loop iterations. The outer loop cycles over several inner loops.
- **max.inner**: maximum number of iterations for each inner loop. There is an inner loop for each pair of alpha-beta parameters for each mediator, an inner loop for direct effect (delta), and inner loops for residual variances for x and for y.
- **x.std**: logical (TRUE/FALSE) whether to standardize x by dividing by standard deviation of x. Note that x will be centered on its mean.
- **med.std**: logical (TRUE/FALSE) whether to standardize mediators by dividing each mediator by its standard deviation. Note that mediators will be centered on their means.
- **step.multiplier**: a value between 0 and 1 for backtracking, to shrink step size. Value of 0.5 is typical default.
- **wt.delta**: a weight >=0 for how much weight should be given to shrinking delta parameter, by penalty lambda*wt.delta.
- **print.iter**: print iteration history during fitting routine

Details

 Although outcome y is not required to be scaled by its standard deviation, it can be beneficial to scale y. This helps with setting range of lambda penalty parameters, because when all x, y, and mediators are scaled, it is reasonable to consider lambda values within the range of 0 to 1. See reference for details of algorithm.

Value

- regmed.grid object

Author(s)

- Dan Schaid, Jason Sinnwell

References

regmed.grid.bestfit

See Also

plot.regmed.grid regmed.fit

Examples

data(medsim)
fit.grid <- regmed.grid(x[,1], med[,1:5], y[,1],
lambda.vec= c(seq(from=1, to=0, by = -.1)),
frac.lasso=.8)
print(fit.grid)

regmed.grid.bestfit  Find best fitting regmed model from regmed.grid object.

Description

Find best fitting regmed model from regmed.grid object using minimum BIC to select model.

Usage

regmed.grid.bestfit(fit.grid)

Arguments

fit.grid  a regmed.grid object

Value

fit  best fit regmed object based on minimum BIC
grid  row out of grid.data of regmed.grid object corresponding to best fit

Author(s)

Dan Schaid, Greg Jenkins, Jason Sinnwell

References


See Also

regmed.grid
### regmed.lavaan.dat

**Set up data to input to lavaan sem**

#### Description

Set up data to input to lavaan structural equation model (sem)

#### Usage

```r
regmed.lavaan.dat(x, mediator, y)
```

#### Arguments

- `x` vector of exposure variables
- `mediator` matrix of mediator variables
- `y` vector of outcome variable

#### Details

Use the function `regmed.dat.check` to standardize all variables and subset to subjects without missing data

#### Value

A dataframe with updated x, mediator, and y

#### Author(s)

Dan Schaid, Jason Sinnwell

#### References


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### regmed.lavaan.model

**Create a lavaan model**

#### Description

Create a lavaan model for input to lavan::sem()

#### Usage

```r
regmed.lavaan.model(fit.edge, fit.regmed)
```
Arguments

- **fit.edge** object created by regmed.edges function
- **fit.regmed** object created by regmed.fit from which the fit.edge object was made

Details

The fit.regmed object is needed for the fixed covariance estimates to be put into the model statement. The summary method supersedes the default summary from the lavaan package to only return the table of coefficients, as the covariances are fixed from regmed.fit.

Value

- a character string that describes the mediation model in format of lavaan model

Author(s)

- Dan Schaid, Greg Jenkins, Jason Sinnwell

---

**regmed.prefilter**

*Prefilter to reduce the number of mediators for subsequent analyses*

Description

Use sure independence screening (Fan & Lv, 2008) to reduce the number of potential mediators when the number of potential mediators is large. This is based on ranking marginal correlations and then selecting the highest ranked values such that the number of parameters is less than the sample size. Because mediation depends on the two correlations, cor(x, med) and cor(med, y) we rank the absolute values of their products, |cor(x, med) * cor(med, y)|, and choose the highest k ranked values to determine which potential mediators to include in penalized mediation models. If k is not specified, the default value of k is n/2, where n is the sample size, because each mediator results in two parameters alpha and beta.

Usage

```r
regmed.prefilter(x, mediator, y, k = NULL, x.std = TRUE, med.std = TRUE, y.std=TRUE)
```

Arguments

- **x** vector representing "exposure" variable (sometimes called instrumental variable)
- **mediator** matrix of mediators, rows are observations, columns are different mediators
- **y** vector representing outcome
- **k** Number of potential mediators to select. Default is n/2, where n is sample size.
- **x.std** logical (TRUE/FALSE) whether to standardize x by dividing by standard deviation of x. Note that x will be centered on its mean.
med.std logical (TRUE/FALSE) whether to standardize mediators by dividing each mediator by its standard deviation. Note that mediators will be centered on their means.

y.std logical (TRUE/FALSE) whether to standardize y by dividing by standard deviation of y. Note that y will be centered on its mean.

Value

list with x, mediator, and y, after subsetting to no missing values, applying x.std and med.std, and subsetting mediators to k top choices.

Author(s)

Dan Schaid, Jason Sinnwell

References


See Also

regmed

Examples

data(medsim)
dim(med)
filtered <- regmed.prefilter(x[,1], med, y[,1], k=10)
dim(filtered$med)

---

summary.mvregmed Summary of mvregmed object

Description

Summary of non-zero parameter estimates. Optional epsilon (eps) parameter controls rounding to 0.

Usage

## S3 method for class 'mvregmed'
summary(object, eps=1e-3, ...)

**Arguments**

- **object**: mvregmed object returned from mvregmed.fit or mvregmed.grid.bestfit
- **eps**: parameters smaller than epsilon (eps) are rounded to zero.
- **...**: optional arguments

**Value**

Nothing is returned

**Author(s)**

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