

# Package ‘regmed’

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**Type** Package

**Title** Regularized Mediation Analysis

**Version** 2.1.0

**Date** 2023-1-20

**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 ( $\geq 2$ )

**Suggests** testthat, rmarkdown

**Depends** R ( $\geq 4.1.0$ ), methods, graphics, glasso, igraph

**Imports** knitr, Rcpp, RcppArmadillo, lavaan, gtools

**LinkingTo** Rcpp, RcppArmadillo

**NeedsCompilation** yes

**VignetteBuilder** knitr

**URL** <https://cran.r-project.org/package=regmed>

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regmed-package	<i>Regularized Mediation Analysis</i>
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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:      2.1.0
Date:         2023-1-20
Authors@R:   c( person("Jason", "Sinnwell", email = "sinnwell.jason@mayo.edu", comment=c(ORCID="0000-0003-
Description:  Mediation analysis for multiple mediators by penalized structural equation models with different types o
License:      GPL (>= 2)
Suggests:    testthat, rmarkdown
Depends:     R (>= 4.1.0), methods, graphics, glasso, igraph
Imports:     knitr, Rcpp, RcppArmadillo, lavaan, gtools
LinkingTo:   Rcpp, RcppArmadillo
NeedsCompilation: yes
VignetteBuilder: knitr

```

URL: <https://cran.r-project.org/package=regmed>  
 Author: Jason Sinnwell [aut, cre] (<<https://orcid.org/0000-0003-1964-5522>>), Daniel Schaid [aut] (<<https://orcid.org/0000-0003-1964-5522>>)  
 Maintainer: Jason Sinnwell <[sinnwell.jason@mayo.edu](mailto:sinnwell.jason@mayo.edu)>

## Index of help topics:

medsim	Simulated dataset for regmed package
mvregmed.dat.check	Helper function to check x, y, mediator for input to mvregmed functions
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
mvregmed.fit	Multivariate regularized mediation model
mvregmed.graph.attributes	Setup attributes of graph object for plotting
mvregmed.grid	Fit a grid of mvregmed models over a vector of lambda penalty parameters
mvregmed.grid.bestfit	Choose best fit model from a grid search based on minimum Bayesian Information Criterion
mvregmed.grid.data	Helper function to summarize fits of models across a grid of lambda values
mvregmed.grid.update	Helper function to update parameters in a grid search
mvregmed.init	Helper function to setup data and parameters for input to mvregmed.fit and mvregmed.grid
mvregmed.lavaan.dat	Set up data to input to lavaan sem
mvregmed.lavaan.model	Setup a model for input to lavaan
plot.mvregmed.grid	Plot penalty parameter lambda versus BIC for model fits
plot.regmed.grid	Plots for regmed.grid object.
regmed-package	Regularized Mediation Analysis
regmed.edges	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
regmed.fit	Regularized Mediation model for a specified lambda penalty value.
regmed.grid	Regularized mediation models over a vector grid of lambda penalty values.
regmed.grid.bestfit	Find best fitting regmed model from regmed.grid object.
regmed.lavaan.dat	Set up data to input to lavaan sem
regmed.lavaan.model	Create a lavaan model
regmed.prefilter	Prefilter to reduce the number of mediators for subsequent analyses
summary.mvregmed	Summary of mvregmed object

Further information is available in the following vignettes:

regmed Regularized\_Mediation\_Examples (source)

### Author(s)

NA

Maintainer: NA

### References

Schaid, DJ, Sinnwell JP. (2020) Penalized Models for Analysis of Multiple Mediators. *Genet Epidemiol* 44:408-424.

Schaid DS, Dikilitas O, Sinnwell JP, Kullo I (2022). Penalized mediation models for multivariate data. *Genet Epidemiol* 46:32-50.

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medsim

*Simulated dataset for regmed package*

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### 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	<i>Helper function to check x, y, mediator for input to mvregmed functions</i>
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---

**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, max.cor=0.99)
```

**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
max.cor	maximum correlation within y, x, or mediators, so fitting is more robust

**Value**

list with updated x, y, mediator

**Author(s)**

Daniel Schaid and Jason Sinnwell

**See Also**

[mvregmed.fit](#) [mvregmed.grid](#)

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mvregmed.edges	<i>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</i>
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**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)
```

**Arguments**

<code>fit</code>	The fit as an object of class <code>mvregmed</code> . This can be output from either <code>mvregmed.fit</code> or <code>mvregmed.grid.bestfit</code> .
<code>eps</code>	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**

Schaid DS, Dikilitas O, Sinnwell JP, Kullo I (2022). Penalized mediation models for multivariate data. *Genet Epidemiol* 46:32-50.

**See Also**

[mvregmed.fit](#) [plot.mvregmed.edges](#)

---

`mvregmed.fit`

*Multivariate regularized mediation model*

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**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  $x \rightarrow [\alpha] \rightarrow \text{mediator} \rightarrow [\beta] \rightarrow \text{outcome}$ , 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:  $x \rightarrow [\delta] \rightarrow y$ .

**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, max.cor=0.99)
```

**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
max.cor	maximum correlation within y, x, or mediators, so fitting is more robust

**Value**

An object of class mvregmed

**Author(s)**

Daniel Schaid and Jason Sinnwell

**References**

Schaid DJ, Dikilitas O, Sinnwell JP, Kullo I (2022). Penalized Mediation Models for Multivariate Data. *Genet Epidemiol* 46:32-50.

**See Also**

[mvregmed.grid](#)

**Examples**

```
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

<code>fit.edges</code>	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
<code>x.color</code>	Color of vertices for x variables
<code>y.color</code>	Color of vertices for y variables
<code>med.color</code>	Color of vertices for mediators
<code>v.size</code>	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

Schaid DS, Dikilitas O, Sinnwell JP, Kullo I (2022). Penalized mediation models for multivariate data. Genet Epidemiol 46:32-50.

## See Also

[mvregmed.edges](#) [graph\\_from\\_edgelist](#)



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mvregmed.grid	<i>Fit a grid of mvregmed models over a vector of lambda penalty parameters</i>
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---

### 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, max.cor=0.99)
```

### 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
max.cor	maximum correlation within y, x, or mediators, so fitting is more robust

### Value

An object of class mvregmed.grid

### Author(s)

Daniel Schaid and Jason Sinnwell

**References**

Schaid DS, Dikilitas O, Sinnwell JP, Kullo I (2022). Penalized mediation models for multivariate data. *Genet Epidemiol* 46:32-50.

**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**

Schaid DS, Dikilitas O, Sinnwell JP, Kullo I (2022). Penalized mediation models for multivariate data. *Genet Epidemiol* 46:32-50.

**See Also**

[mvregmed.grid](#)

---

mvregmed.grid.data	<i>Helper function to summarize fits of models across a grid of lambda values</i>
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---

**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**

Schaid DS, Dikilitas O, Sinnwell JP, Kullo I (2022). Penalized mediation models for multivariate data. Genet Epidemiol 46:32-50.

**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**

Schaid DS, Dikilitas O, Sinnwell JP, Kullo I (2022). Penalized mediation models for multivariate data. *Genet Epidemiol* 46:32-50.

**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)
```

**Arguments**

<code>dat.obj</code>	A list that is output from <code>mvregmed.dat.check</code> that contains <code>x</code> , mediator, and <code>y</code> .
<code>x.std</code>	logical (TRUE/FALSE) whether to standardize <code>x</code> by dividing by standard deviation of <code>x</code> . Note that each column of <code>x</code> will be centered on its mean.
<code>med.std</code>	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.
<code>y.std</code>	logical (TRUE/FALSE) whether to standardize <code>y</code> by dividing by standard deviation of <code>y</code> . Note that each column of <code>y</code> 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 initial values = 0).

**Value**

A list of items used as input to model fitting.

**Author(s)**

Daniel Schaid and Jason Sinnwell

**References**

Schaid DS, Dikilitas O, Sinnwell JP, Kullo I (2022). Penalized mediation models for multivariate data. *Genet Epidemiol* 46:32-50.

**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, max.cor=0.99)
```

**Arguments**

x	matrix of exposure variables
mediator	matrix of mediators
y	matrix of outcome variables
max.cor	maximum correlation within mediators, so that fitting is more robust

**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**

Schaid DS, Dikilitas O, Sinnwell JP, Kullo I (2022). Penalized mediation models for multivariate data. *Genet Epidemiol* 46:32-50.

---

`mvregmed.lavaan.model` *Setup a model for input to lavaan*

---

**Description**

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

**Usage**

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

**Arguments**

<code>fit.edge</code>	Output from <code>mvregmed.edges</code>
<code>fit.mvregmed</code>	A <code>mvregmed</code> object, either from <code>mvregmed.fit</code> or from <code>mvregmed.grid.bestfit</code>

**Details**

Loop through all relationships determined important from `mvregmed.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 fixed from `mvregmed`.

**Value**

Text string to define a model as input to sem

**Author(s)**

Daniel Schaid and Jason Sinnwell

**References**

Schaid DS, Dikilitas O, Sinnwell JP, Kullo I (2022). Penalized mediation models for multivariate data. Genet Epidemiol 46:32-50.

---

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**

Schaid DS, Dikilitas O, Sinnwell JP, Kullo I (2022). Penalized mediation models for multivariate data. Genet Epidemiol 46:32-50.

---

plot.regmed.grid      *Plots for regmed.grid object.*

---

### Description

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

### Usage

```
## 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

```
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)
```



---

regmed.edges	<i>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</i>
--------------	---

---

### 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

Schaid DS, Dikilitas O, Sinnwell JP, Kullo I (2022). Penalized mediation models for multivariate data. Genet Epidemiol 46:32-50.

### See Also

[regmed.fit](#) [plot.regmed.edges](#)

regmed.fit

*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**

```
regmed.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, max.cor=0.99)
```

**Arguments**

<code>x</code>	vector representing "exposure" variable (sometimes called instrumental variable)
<code>mediator</code>	matrix of mediators, rows are observations, columns are different mediators
<code>y</code>	vector representing outcome
<code>lambda</code>	lambda penalty parameter
<code>frac.lasso</code>	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 $\rightarrow$ [beta] $y$ ).
<code>x.std</code>	logical (TRUE/FALSE) whether to standardize $x$ by dividing by standard deviation of $x$ . Note that $x$ will be centered on its mean.
<code>med.std</code>	logical (TRUE/FALSE) whether to standardize mediators by dividing each mediator by its standard deviation. Note that mediators will be centered on their means.
<code>max.outer</code>	maximum number of outer loop iterations. The outer loop cycles over several inner loops.
<code>max.inner</code>	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 $y$ .
<code>step.multiplier</code>	a value between 0 and 1 for backtracking, to shrink step size. Value of 0.5 is typical default.
<code>wt.delta</code>	a weight $\geq 0$ for how much weight should be given to shrinking delta parameter, by penalty $\lambda \cdot \text{wt.delta}$ .
<code>print.iter</code>	print iteration history during fitting routine
<code>max.cor</code>	maximum correlation within mediators, so that fitting is more robust

**Value**

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

**Author(s)**

Dan Schaid, Greg Jenkins, Jason Sinnwell

**References**

Schaid, DJ, Sinnwell JP. (2020) Penalized Models for Analysis of Multiple Mediators. Genet Epidemiol 44:408-424.

**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  $x - [\alpha] \rightarrow \text{mediator} - [\beta] \rightarrow \text{outcome}$ , 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**

```
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, max.cor=0.99)
```

**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 $\geq 0$ for how much weight should be given to shrinking delta parameter, by penalty $\lambda * wt.delta$ .
print.iter	print iteration history during fitting routine
max.cor	maximum correlation within mediators, so fitting is more robust

**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**

Schaid, DJ, Sinnwell JP. (2020) Penalized Models for Analysis of Multiple Mediators. Genet Epidemiol 44:408-424.

**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**

Schaid, DJ, Sinnwell JP. (2020) Penalized Models for Analysis of Multiple Mediators. Genet Epidemiol 44:408-424.

**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**

```
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**

Schaid, DJ, Sinnwell JP. (2020) Penalized Models for Analysis of Multiple Mediators. *Genet Epidemiol* 44:408-424.

---

regmed.lavaan.model      *Create a lavaan model*

---

**Description**

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

**Usage**

```
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.pfilter      *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,  $\text{cor}(x, \text{med})$  and  $\text{cor}(\text{med}, y)$  we rank the absolute values of their products,  $|\text{cor}(x, \text{med}) * \text{cor}(\text{med}, y)|$ , 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**

```
regmed.pfilter(x, mediator, y, k = NULL, x.std = TRUE,
  med.std = TRUE, y.std=TRUE, max.cor=0.99)
```

**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.
max.cor	maximum correlation within mediators, so that fitting is more robust

**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**

Fan, J., & Lv, J. (2008). Sure independence screening for ultrahigh dimensional feature space. *J. R. Statist. Soc.B*, 70, 849-911. Schaid, DJ, Sinnwell JP. (2020) Penalized Models for Analysis of Multiple Mediators. *Genet Epidemiol* 44:408-424.

**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)**

Daniel Schaid and Jason Sinnwell

**References**

Schaid DS, Dikilitas O, Sinnwell JP, Kullo I (2022). Penalized mediation models for multivariate data. *Genet Epidemiol* 46:32-50.

**See Also**

[mvregmed.fit](#) [mvregmed.grid.bestfit](#)

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