

# Package ‘smacof’

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**Title** Flexible Multidimensional Scaling and 'smacof' Extensions

**Version** 1.5-3

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**Description** Flexible multidimensional scaling (MDS) methods and extensions to the package 'smacof'. This package contains various functions, wrappers, methods and classes for fitting, plotting and displaying a large number of different flexible MDS models (some as of yet unpublished). These are: Torgerson scaling (Torgerson, 1958, ISBN:978-0471879459) with powers, Sammon mapping (Sammon, 1969, <doi:10.1109/T-C.1969.222678>) with ratio and interval optimal scaling, Multiscale MDS (Ramsay, 1977, <doi:10.1007/BF02294052>) with ratio and interval optimal scaling, S-stress MDS (ALSCAL; Takane, Young & De Leeuw, 1977, <doi:10.1007/BF02293745>) with ratio and interval optimal scaling, elastic scaling (McGee, 1966, <doi:10.1111/j.2044-8317.1966.tb00367.x>) with ratio and interval optimal scaling, r-stress MDS (De Leeuw, Groenen & Mair, 2016, <https://rpubs.com/deleeuw/142619>) with ratio, interval and non-metric optimal scaling, power-stress MDS (POST-MDS; Buja & Swayne, 2002 <doi:10.1007/s00357-001-0031-0>) with ratio and interval optimal scaling, restricted power-stress (Rusch, Mair & Hornik, 2021, <doi:10.1080/10618600.2020.1869027>) with ratio and interval optimal scaling, approximate power-stress with ratio optimal scaling (Rusch, Mair & Hornik, 2021, <doi:10.1080/10618600.2020.1869027>), Box-Cox MDS (Chen & Buja, 2013, <https://jmlr.org/papers/v14/chen13a.html>), local MDS (Chen & Buja, 2009, <doi:10.1198/jasa.2009.0111>), curvilinear component analysis (Demartines & Hérault, 1997, <doi:10.1109/72.554199>) and curvilinear distance analysis (Lee, Lendasse & Verleysen, 2004, <doi:10.1016/j.neucom.2004.01.007>). There also are experimental models (e.g., sparsified MDS and sparsified POST-MDS). Some functions are suitably flexible to allow any other sensible combination of explicit power transformations for weights, distances and input proximities with implicit ratio, interval or non-metric optimal scaling of the input proximities. Most functions use a Majorization-Minimization algorithm. Currently the methods are only available for one-mode data (symmetric dissimilarity matrices).

**Depends** R (>= 3.5.0), smacof (>= 1.10-4)

**Imports** MASS, minqa, plotrix, ProjectionBasedClustering, weights, vegan

**License** GPL-2 | GPL-3

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**BugReports**

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alscal *ALSCAL - MDS via S-Stress Minimization*

**Description**

An implementation to minimize s-stress by majorization with ratio and interval optimal scaling.

**Usage**

```
alscal(
  delta,
  type = "ratio",
  weightmat,
  init = NULL,
  ndim = 2,
  acc = 1e-06,
  itmax = 10000,
  verbose = FALSE,
  principal = FALSE
)
```

**Arguments**

- delta           dist object or a symmetric, numeric data.frame or matrix of distances
- type            what type of MDS to fit. Currently one of "ratio" or "interval". Default is "ratio".
- weightmat       a matrix of finite weights
- init            starting configuration
- ndim            dimension of the configuration; defaults to 2
- acc             numeric accuracy of the iteration. Default is 1e-6.

itmax	maximum number of iterations. Default is 10000.
verbose	should iteration output be printed; if > 1 then yes
principal	If 'TRUE', principal axis transformation is applied to the final configuration

### Value

a 'smacofP' object (inheriting from 'smacofB', see [smacofSym](#)). It is a list with the components

- delta: Observed untransformed dissimilarities
- tdelta: Observed explicitly transformed (squared) dissimilarities, normalized
- dhat: Explicitly transformed dissimilarities (dhats), optimally scaled and normalized
- confdist: Configuration dissimilarities
- conf: Matrix of fitted configuration
- stress: Default stress (stress 1; sqrt of explicitly normalized stress)
- spp: Stress per point
- ndim: Number of dimensions
- model: Name of smacof model
- niter: Number of iterations
- nobj: Number of objects
- type: Type of MDS model
- weightmat: weighting matrix as supplied
- stress.m: Default stress (stress-1<sup>2</sup>)
- tweightmat: transformed weighting matrix (here NULL)

### See Also

[rStressMin](#)

### Examples

```
dis<-smacof::kinshipdelta
res<-alscal(as.matrix(dis),type="interval",itmax=1000)
res
summary(res)
plot(res)
```

---

`apStressMin`*Approximate Power Stress MDS*

---

**Description**

An implementation to minimize approximate power stress by majorization with ratio or interval optimal scaling. This approximates the power stress objective in such a way that it can be fitted with SMACOF without distance transformations. See Rusch et al. (2021) for details.

**Usage**

```
apStressMin(  
  delta,  
  kappa = 1,  
  lambda = 1,  
  nu = 1,  
  type = "ratio",  
  weightmat = 1 - diag(nrow(delta)),  
  init = NULL,  
  ndim = 2,  
  acc = 1e-06,  
  itmax = 10000,  
  verbose = FALSE,  
  principal = FALSE  
)
```

```
apowerstressMin(  
  delta,  
  kappa = 1,  
  lambda = 1,  
  nu = 1,  
  type = "ratio",  
  weightmat = 1 - diag(nrow(delta)),  
  init = NULL,  
  ndim = 2,  
  acc = 1e-06,  
  itmax = 10000,  
  verbose = FALSE,  
  principal = FALSE  
)
```

```
apostmds(  
  delta,  
  kappa = 1,  
  lambda = 1,  
  nu = 1,  
  type = "ratio",
```

```
weightmat = 1 - diag(nrow(delta)),
init = NULL,
ndim = 2,
acc = 1e-06,
itmax = 10000,
verbose = FALSE,
principal = FALSE
)

apstressMin(
  delta,
  kappa = 1,
  lambda = 1,
  nu = 1,
  type = "ratio",
  weightmat = 1 - diag(nrow(delta)),
  init = NULL,
  ndim = 2,
  acc = 1e-06,
  itmax = 10000,
  verbose = FALSE,
  principal = FALSE
)

apstressmids(
  delta,
  kappa = 1,
  lambda = 1,
  nu = 1,
  type = "ratio",
  weightmat = 1 - diag(nrow(delta)),
  init = NULL,
  ndim = 2,
  acc = 1e-06,
  itmax = 10000,
  verbose = FALSE,
  principal = FALSE
)
```

### Arguments

delta	dist object or a symmetric, numeric data.frame or matrix of distances
kappa	power of the transformation of the fitted distances; defaults to 1
lambda	the power of the transformation of the proximities; defaults to 1
nu	the power of the transformation for weightmat; defaults to 1
type	what type of MDS to fit. Only "ratio" currently.
weightmat	a binary matrix of finite nonnegative weights.

init	starting configuration
ndim	dimension of the configuration; defaults to 2
acc	numeric accuracy of the iteration. Default is 1e-6.
itmax	maximum number of iterations. Default is 10000.
verbose	should iteration output be printed; if > 1 then yes
principal	If 'TRUE', principal axis transformation is applied to the final configuration

### Value

a 'smacofP' object (inheriting from 'smacofB', see [smacofSym](#)). It is a list with the components

- delta: Observed, untransformed dissimilarities
- tdelta: Observed explicitly transformed dissimilarities, normalized
- dhat: Explicitly transformed dissimilarities (dhats), optimally scaled and normalized
- confdist: Configuration dissimilarities
- conf: Matrix of fitted configuration
- stress: Default stress (stress 1; sqrt of explicitly normalized stress)
- spp: Stress per point
- ndim: Number of dimensions
- model: Name of smacof model
- niter: Number of iterations
- nobj: Number of objects
- type: Type of MDS model
- weightmat: weighting matrix as supplied
- stress.m: Default stress ( $\text{stress}-1^2$ )
- tweightmat: transformed weighting matrix (here  $\text{weightmat}^{\text{nu}}$ )

### Note

Internally we calculate the approximation parameters  $\text{upsilon}=\text{nu}+2*\text{lambda}*(1-(1/\text{kappa}))$  and  $\text{tau}=\text{lambda}/\text{kappa}$ . They are not output.

### References

Rusch, Mair, Hornik (2021). Cluster Optimized Proximity Scaling. JCGS <doi:10.1080/10618600.2020.1869027>

### Examples

```
dis<-smacof::kinshipdelta
res<-apStressMin(as.matrix(dis),kappa=2,lambda=1.5,itmax=1000)
res
summary(res)
plot(res)
plot(res,"Shepard")
plot(res,"transplot")
```

---

 BankingCrisesDistances

*Banking Crises Distances*


---

### Description

Matrix of Jaccard distances between 70 countries (Hungary and Greece were combined to be the same observation) based on their binary time series of having had a banking crises in a year from 1800 to 2010 or not. See `data(bankingCrises)` in package `Ecdat` for more info. The last column is Reinhart & Rogoffs classification as a low (3), middle- (2) or high-income country (1).

### Format

A 69 x 70 matrix.

### Source

`data(bankingCrises)` in library(`Ecdat`)

---

bcmnds

*Box-Cox MDS*


---

### Description

This function minimizes the Box-Cox Stress of Chen & Buja (2013) via gradient descent. This is a ratio metric scaling method. The transformations are not straightforward to interpret but  $\mu$  is associated with fitted distances in the configuration and  $\lambda$  with the dissimilarities. Concretely for fitted distances (attraction part) it is  $BC_{\mu+\lambda}(d(X))$  and for the repulsion part it is  $\delta^{\lambda} BC_{\mu}(d(X))$  with BC being the one-parameter Box-Cox transformation.

### Usage

```
bcmnds(
  delta,
  mu = 1,
  lambda = 1,
  rho = 0,
  type = "ratio",
  ndim = 2,
  weightmat = 1 - diag(nrow(delta)),
  itmax = 2000,
  init = NULL,
  verbose = 0,
  addD0 = 1e-04,
  principal = FALSE,
```



```
    normconf = FALSE
  )

bcStressMin(
  delta,
  mu = 1,
  lambda = 1,
  rho = 0,
  type = "ratio",
  ndim = 2,
  weightmat = 1 - diag(nrow(delta)),
  itmax = 2000,
  init = NULL,
  verbose = 0,
  addD0 = 1e-04,
  principal = FALSE,
  normconf = FALSE
)

bcstressMin(
  delta,
  mu = 1,
  lambda = 1,
  rho = 0,
  type = "ratio",
  ndim = 2,
  weightmat = 1 - diag(nrow(delta)),
  itmax = 2000,
  init = NULL,
  verbose = 0,
  addD0 = 1e-04,
  principal = FALSE,
  normconf = FALSE
)

boxcoxmds(
  delta,
  mu = 1,
  lambda = 1,
  rho = 0,
  type = "ratio",
  ndim = 2,
  weightmat = 1 - diag(nrow(delta)),
  itmax = 2000,
  init = NULL,
  verbose = 0,
  addD0 = 1e-04,
  principal = FALSE,
```

```

    normconf = FALSE
)

```

### Arguments

delta	dissimilarity or distance matrix, dissimilarity or distance data frame or 'dist' object
mu	mu parameter. Should be 0 or larger for everything working ok. If $\mu < 0$ it works but I find the MDS model is strange and normalized stress tends towards 0 regardless of fit. Use normalized stress at your own risk in that case.
lambda	lambda parameter. Must be larger than 0.
rho	the rho parameter, power for the weights (called nu in the original article).
type	what type of MDS to fit. Only "ratio" currently.
ndim	the dimension of the configuration
weightmat	a matrix of finite weights. Not implemented.
itmax	number of optimizing iterations, defaults to 2000.
init	initial configuration. If NULL a classical scaling solution is used.
verbose	prints progress if $> 3$ .
addD0	a small number that's added for $D(X)=0$ for numerical evaluation of worst fit (numerical reasons, see details). If $\text{addD0}=0$ the normalized stress for $\mu \neq 0$ and $\mu + \lambda \neq 0$ is correct, but will give useless normalized stress for $\mu = 0$ or $\mu + \lambda = 0$ .
principal	If 'TRUE', principal axis transformation is applied to the final configuration
normconf	normalize the configuration to $\sum(\text{delta}^2)=1$ (as in the power stresses). Default is FALSE. Note that then the distances in confdist do not match manually calculated ones.

### Details

For numerical reasons with certain parameter combinations, the normalized stress uses a configuration as worst result where every  $d(X)$  is  $0 + \text{addD0}$ . The same number is not added to the delta so there is a small inaccuracy of the normalized stress (but negligible if  $\min(\text{delta}) \gg \text{addD0}$ ). Also, for  $\mu < 0$  or  $\mu + \lambda < 0$  the normalization cannot generally be trusted (in the worst case of  $D(X)=0$  one would have an  $0^{(-a)}$ ).

### Value

an object of class 'bcmds' (also inherits from 'smacofP'). It is a list with the components

- delta: Observed, untransformed dissimilarities
- tdelta: Observed explicitly transformed dissimilarities, normalized
- dhat: Explicitly transformed dissimilarities (dhats)
- confdist: Configuration dissimilarities
- conf: Matrix of fitted configuration

- stress: Default stress (stress 1; sqrt of explicitly normalized stress)
- ndim: Number of dimensions
- model: Name of MDS model
- type: Must be "ratio" here.
- niter: Number of iterations
- nobj: Number of objects
- pars: hyperparameter vector theta
- weightmat: 1-diagonal matrix. For compatibility with smacofP classes.
- parameters, pars, theta: The parameters supplied
- call the call

and some additional components

- stress.m: default stress is the explicitly normalized stress on the normalized, transformed dissimilarities
- mu: mu parameter (for attraction)
- lambda: lambda parameter (for repulsion)
- rho: rho parameter (for weights)

### Author(s)

Lisha Chen & Thomas Rusch

### Examples

```
dis<-smacof::kinshipdelta
res<-bcmads(dis,mu=2,lambda=1.5,rho=0)
res
summary(res)
plot(res)
```

---

bcsdistance

*Calculates the blended Chi-square distance matrix between n vectors*

---

### Description

The pairwise blended chi-distance of two vectors  $x$  and  $y$  is  $\sqrt{\text{sum}(\frac{(x[i]-y[i])^2}{2*(ax[i]+by[i])})})}$ , with originally  $a$  in  $[0,1]$  and  $b=1-a$  as in Lindsay (1994) (but we allow any non-negative  $a$  and  $b$ ). The function calculates this for all pairs of rows of a matrix or data frame  $x$ .

### Usage

```
bcsdistance(x, a = 0.5, b = 1 - a)
```

**Arguments**

- x            an n times p numeric matrix or data frame. Note that the values of x must be non-negative.
- a            first blending weight. Must be non-negative and should be in [0,1] if a blended chi-square distance as in Lindsay (1994) is sought. Defaults to 0.5.
- b            second blending weight. Must be non-negative and should be 1-a if a blended chi-square distance as in Lindsay (1994) is sought. Defaults to 1-a.

**Value**

a symmetric n times n matrix of pairwise blended chi-square distance (between rows of x) with 0 in the main diagonal. It is an object of class distance and matrix with attributes "method", "type" and "par", the latter returning the a and b values.

**References**

Lindsay (1994). Efficiency versus robustness: the case for minimum Hellinger distance and related methods. *Annals of Statistics*, 22 (2), 1081-1114. <doi:10.1214/aos/1176325512>

---

biplotmds.bcnds            *S3 method for bcnds objects*

---

**Description**

S3 method for bcnds objects

**Usage**

```
## S3 method for class 'bcnds'
biplotmds(object, extvar, scale = TRUE)
```

**Arguments**

- object        An object of class smacofP
- extvar        Data frame with external variables.
- scale         if 'TRUE' external variables are standardized internally.

**Details**

If a model for individual differences is provided, the external variables are regressed on the group stimulus space configurations. For objects returned from 'biplotmds' we use the plot method in [biplotmds](#). In the biplot called with plot() only the relative length of the vectors and their direction matters. Using the vecscale argument in plot() the user can control for the relative length of the vectors. If 'vecscale = NULL', the 'vecscale()' function from the 'candisc' package is used which tries to automatically calculate the scale factor so that the vectors approximately fill the same space as the configuration. In this method vecscale should usually be smaller than the one used in smacof by a factor of 0.1. Note that in the biplot object, the configuration is always normalized (which it may not necessarily be in the bcnds object).

**Value**

Returns an object belonging to classes 'mlm' and 'mdsbi'. See 'lm' for details. R2vec: Vector containing the R2 values. See also [biplotmds](#) for the plot method.

---

biplotmds.lmds	<i>S3 method for lmds objects</i>
----------------	-----------------------------------

---

**Description**

S3 method for lmds objects

**Usage**

```
## S3 method for class 'lmds'
biplotmds(object, extvar, scale = TRUE)
```

**Arguments**

object	An object of class smacofP
extvar	Data frame with external variables.
scale	if 'TRUE' external variables are standardized internally.

**Details**

If a model for individual differences is provided, the external variables are regressed on the group stimulus space configurations. For objects returned from 'biplotmds' we use the plot method in [biplotmds](#). In the biplot called with plot() only the relative length of the vectors and their direction matters. Using the vecscale argument in plot() the user can control for the relative length of the vectors. If 'vecscale = NULL', the 'vecscale()' function from the 'candisc' package is used which tries to automatically calculate the scale factor so that the vectors approximately fill the same space as the configuration. In this method vecscale should usually be smaller than the one used in smacof by a factor of 0.1. Note that in the biplot object, the configuration is always normalized (which it may not necessarily be in the lmds object).

**Value**

Returns an object belonging to classes 'mlm' and 'mdsbi'. See 'lm' for details. R2vec: Vector containing the R2 values. See also [biplotmds](#) for the plot method.

---

biplotmds.smacofP      *S3 method for smacofP objects*

---

### Description

S3 method for smacofP objects

### Usage

```
## S3 method for class 'smacofP'  
biplotmds(object, extvar, scale = TRUE)
```

### Arguments

object	An object of class smacofP
extvar	Data frame with external variables.
scale	if 'TRUE' external variables are standardized internally.

### Details

If a model for individual differences is provided, the external variables are regressed on the group stimulus space configurations. For objects returned from 'biplotmds' we use the plot method in [biplotmds](#). In the biplot called with plot() only the relative length of the vectors and their direction matters. Using the vecscale argument in plot() the user can control for the relative length of the vectors. If 'vecscale = NULL', the 'vecscale()' function from the 'candisc' package is used which tries to automatically calculate the scale factor so that the vectors approximately fill the same space as the configuration. In this method vecscale should usually be smaller than the one used in smacof by a factor of 0.1.

### Value

Returns an object belonging to classes 'mlm' and 'mdsbi'. See 'lm' for details. R2vec: Vector containing the R2 values. See also [biplotmds](#) for the plot method.

### Examples

```
## see smacof::biplotmds for more  
res <- powerStressMin(morse, kappa=0.5, lambda=2)  
fitbi <- biplotmds(res, morsescales[,2:3])  
plot(fitbi, main = "MDS Biplot", vecscale = 0.03)
```

---

bootmds.smacofP      *MDS Bootstrap for smacofP objects*

---

### Description

Performs a bootstrap on an MDS solution. It works for derived dissimilarities only, i.e. generated by the call `dist(data)`. The original data matrix needs to be provided, as well as the type of dissimilarity measure used to compute the input dissimilarities.

### Usage

```
## S3 method for class 'smacofP'
bootmds(
  object,
  data,
  method.dat = "pearson",
  nrep = 100,
  alpha = 0.05,
  verbose = FALSE,
  ...
)
```

### Arguments

<code>object</code>	Object of class <code>smacofP</code> if used as method or another object inheriting from <code>smacofB</code> (needs to be called directly as <code>bootmds.smacofP</code> then).
<code>data</code>	Initial data (before dissimilarity computation).
<code>method.dat</code>	Dissimilarity computation used as MDS input. This must be one of "pearson", "spearman", "kendall", "euclidean", "maximum", "manhattan", "canberra", "binary".
<code>nrep</code>	Number of bootstrap replications.
<code>alpha</code>	Alpha level for confidence ellipsoids.
<code>verbose</code>	If 'TRUE', bootstrap index is printed out.
<code>...</code>	Additional arguments needed for dissimilarity computation as specified in <a href="#">sim2diss</a> .

### Details

In order to examine the stability solution of an MDS, a bootstrap on the raw data can be performed. This results in confidence ellipses in the configuration plot. The ellipses are returned as list which allows users to produce (and further customize) the plot by hand. See [bootmds](#) for more.

**Value**

An object of class 'smacofboot', see [bootmds](#). With values

- cov: Covariances for ellipse computation
- bootconf: Configurations bootstrap samples
- stressvec: Bootstrap stress values
- bootci: Stress bootstrap percentile confidence interval
- spp: Stress per point (based on stress.en)
- stab: Stability coefficient

**Examples**

```
##see ?smacof::bootmds for more
data <- na.omit(smacof::PVQ40[,1:5])
diss <- dist(t(data)) ## Euclidean distances
fit <- rStressMin(diss,r=0.5,itmax=1000) ## 2D ratio MDS
set.seed(123)
resboot <- bootmds(fit, data, method.dat = "euclidean", nrep = 10) #run for more nrep
resboot
plot(resboot) #see ?smacof::bootmds for more on the plot method
```

---

clca

---

*Curvilinear Component Analysis (CLCA)*


---

**Description**

A wrapper to run curvilinear component analysis via [CCA](#) and returning a 'smacofP' object. Note this functionality is rather rudimentary.

**Usage**

```
clca(
  delta,
  Epochs = 20,
  alpha0 = 0.5,
  lambda0,
  ndim = 2,
  weightmat = 1 - diag(nrow(delta)),
  init = NULL,
  acc = 1e-06,
  itmax = 10000,
  verbose = 0,
  method = "euclidean",
  principal = FALSE
)
```



**Arguments**

<code>delta</code>	dist object or a symmetric, numeric data.frame or matrix of distances.
<code>Epochs</code>	Scalar; gives the number of passes through the data.
<code>alpha0</code>	(scalar) initial step size, 0.5 by default
<code>lambda0</code>	the boundary/neighbourhood parameter(s) (called <code>lambda_y</code> in the original paper). It is supposed to be a numeric scalar. It defaults to the 90% quantile of <code>delta</code> .
<code>ndim</code>	dimension of the configuration; defaults to 2
<code>weightmat</code>	not used
<code>init</code>	starting configuration, not used
<code>acc</code>	numeric accuracy of the iteration; not used
<code>itmax</code>	maximum number of iterations. Not used.
<code>verbose</code>	should iteration output be printed; not used
<code>method</code>	Distance calculation; currently not used.
<code>principal</code>	If 'TRUE', principal axis transformation is applied to the final configuration

**Details**

This implements CCA as in Demartines & Hérault (1997). A different take on the ideas of curvilinear component analysis is available in the experimental functions [spmids](#) and [spmids](#).

**Value**

a 'smacofP' object. It is a list with the components

- `delta`: Observed, untransformed dissimilarities
- `tdelta`: Observed explicitly transformed dissimilarities, normalized
- `dhat`: Explicitly transformed dissimilarities (dhats), optimally scaled and normalized
- `confdist`: Configuration dissimilarities
- `conf`: Matrix of fitted configuration
- `stress`: Default stress (stress-1; sqrt of explicitly normalized stress)
- `spp`: Stress per point
- `ndim`: Number of dimensions
- `model`: Name of model
- `niter`: Number of iterations (training length)
- `nobj`: Number of objects
- `type`: Type of MDS model. Only ratio here.
- `weightmat`: weighting matrix as supplied
- `stress.m`: Default stress ( $\text{stress-1}^2$ )
- `tweightmat`: transformed weighting matrix; it is `weightmat` here.

**Examples**

```
dis<-smacof::morse
res<-clca(dis,lambda0=0.4)
res
summary(res)
plot(res)
```

---

clda

---

*Curvilinear Distance Analysis (CLDA)*


---

**Description**

A function to run curvilinear distance analysis via [CCA](#) and returning a 'smacofP' object. Note this functionality is rather rudimentary.

**Usage**

```
clda(
  delta,
  Epochs = 20,
  alpha0 = 0.5,
  lambda0,
  ndim = 2,
  weightmat = 1 - diag(nrow(delta)),
  init = NULL,
  acc = 1e-06,
  itmax = 10000,
  verbose = 0,
  method = "euclidean",
  principal = FALSE,
  epsilon,
  k,
  path = "shortest",
  fragmentedOK = FALSE
)
```

**Arguments**

delta	dist object or a symmetric, numeric data.frame or matrix of distances. Will be turned into geodesic distances.
Epochs	Scalar; gives the number of passes through the data.
alpha0	(scalar) initial step size, 0.5 by default
lambda0	the boundary/neighbourhood parameter(s) (called lambda_y in the original paper). It is supposed to be a numeric scalar. It defaults to the 90% quantile of delta.

ndim	dimension of the configuration; defaults to 2
weightmat	not used
init	starting configuration, not used
acc	numeric accuracy of the iteration; not used
itmax	maximum number of iterations. Not used.
verbose	should iteration output be printed; not used
method	Distance calculation; currently not used.
principal	If 'TRUE', principal axis transformation is applied to the final configuration
epsilon	Shortest dissimilarity retained.
k	Number of shortest dissimilarities retained for a point. If both 'epsilon' and 'k' are given, 'epsilon' will be used.
path	Method used in 'stepacross' to estimate the shortest path, with alternatives '"shortest"' and '"extended"'.
fragmentedOK	What to do if dissimilarity matrix is fragmented. If 'TRUE', analyse the largest connected group, otherwise stop with error.

### Details

This implements CLDA as CLCA with geodesic distances. The geodesic distances are calculated via 'vegan::isomapdist', see [isomapdist](#) for a documentation of what these distances do. 'clda' is just a wrapper for 'clca' applied to the geodesic distances obtained via isomapdist.

### Value

a 'smacofP' object. It is a list with the components

- delta: Observed, untransformed dissimilarities
- tdelta: Observed explicitly transformed dissimilarities, normalized
- dhat: Explicitly transformed dissimilarities (dhats), optimally scaled and normalized
- confdist: Configuration dissimilarities
- conf: Matrix of fitted configuration
- stress: Default stress (stress-1; sqrt of explicitly normalized stress)
- spp: Stress per point
- ndim: Number of dimensions
- model: Name of model
- niter: Number of iterations (training length)
- nobj: Number of objects
- type: Type of MDS model. Only ratio here.
- weightmat: weighting matrix as supplied
- stress.m: Default stress (stress-1<sup>2</sup>)
- tweightmat: transformed weighting matrix; it is weightmat here.

**Examples**

```
dis<-smacof::morse
res<-clda(dis,lambda0=0.4,k=4)
res
summary(res)
plot(res)
```

---

 cmds

*Classical Scaling*


---

**Description**

Classical Scaling

**Usage**

```
cmds(Do)
```

**Arguments**

Do                   dissimilarity matrix

---

cmdscale

*Wrapper to cmdscale for S3 class*


---

**Description**

Wrapper to cmdscale for S3 class

**Usage**

```
cmdscale(d, k = 2, eig = FALSE, ...)
```

**Arguments**

d                   a distance structure such as that returned by 'dist' or a full symmetric matrix containing the dissimilarities

k                   the maximum dimension of the space which the data are to be represented in

eig                 indicates whether eigenvalues should be returned. Defaults to TRUE.

...                 additional parameters passed to cmdscale. See [cmdscale](#)

**Details**

overloads stats::cmdscale turns on the liosting and adds slots and class attributes for which there are methods.

**Value**

Object of class 'cmdscalex' and 'cmdscale' extending `cmdscale`. This wrapper always returns the results of `cmdscale` as a list, adds column labels to the `$points` and adds extra elements (`conf=points`, `delta=d`, `confdist=dist(conf)`, `dhat=d`) and the call to the list, and assigns S3 class 'cmdscalex' and 'cmdscale'.

**Examples**

```
dis<-as.matrix(smacof::kinshipdelta)
res<-cmdscale(dis)
```

---

conf_adjust	<i>conf_adjust: a function to procrustes adjust two matrices</i>
-------------	--

---

**Description**

`conf_adjust`: a function to procrustes adjust two matrices

**Usage**

```
conf_adjust(conf1, conf2, verbose = FALSE, eps = 1e-12, itmax = 100)
```

**Arguments**

<code>conf1</code>	reference configuration, a numeric matrix
<code>conf2</code>	another configuration, a numeric matrix
<code>verbose</code>	should adjustment be output; default to FALSE
<code>eps</code>	numerical accuracy
<code>itmax</code>	maximum number of iterations

**Value**

a list with 'ref.conf' being the reference configuration, 'other.conf' the adjusted configuration and 'comparison.conf' the comparison configuration

---

 corpsepaint

*Corpse Paint*


---

**Description**

A matrix of gray scale images of people in "corpse paint", a black-and-white make-up, plus a surprise.

**Format**

A 8100 x 32 matrix

**Details**

The images are gray scale 8 bit, i.e., 0-255 unique gray values scaled to be between 0 and 1. There are 32 total images with pixel size of 90 x 90 that have been vectorized to 32 columns labeled as "F1" through "F32". An image *i* can be reconstructed with `matrix(corpsepaint[,i],ncol=90,nrow=90)`

**Examples**

```
oldpar<-par(no.readonly=TRUE)
par(mfrow=c(4,8))
for(i in 1:ncol(corpsepaint)){
  p1<-matrix(corpsepaint[,i],ncol=90,nrow=90,byrow=FALSE)
  image(p1,col=gray.colors(256),main=colnames(corpsepaint)[i])
}
par(oldpar)
```

---

 doubleCenter

*Double centering of a matrix*


---

**Description**

Double centering of a matrix

**Usage**

```
doubleCenter(x)
```

**Arguments**

*x*                    numeric matrix

**Value**

the double centered matrix

---

elscal                      *Elastic Scaling SMACOF*

---

### Description

An implementation to minimize elastic scaling stress by majorization with ratio and interval optimal scaling. Uses a repeat loop.

### Usage

```
elscal(
  delta,
  type = c("ratio", "interval"),
  weightmat,
  init = NULL,
  ndim = 2,
  acc = 1e-06,
  itmax = 10000,
  verbose = FALSE,
  principal = FALSE
)
```

### Arguments

delta	dist object or a symmetric, numeric data.frame or matrix of distances
type	what type of MDS to fit. Currently one of "ratio" and "interval". Default is "ratio".
weightmat	a matrix of finite weights
init	starting configuration
ndim	dimension of the configuration; defaults to 2
acc	numeric accuracy of the iteration. Default is 1e-6.
itmax	maximum number of iterations. Default is 10000.
verbose	should iteration output be printed; if > 1 then yes
principal	If 'TRUE', principal axis transformation is applied to the final configuration

### Value

a 'smacofP' object (inheriting from smacofB, see [smacofSym](#)). It is a list with the components

- delta: Observed untransformed dissimilarities
- tdelta: Observed explicitly transformed dissimilarities, normalized
- dhat: Explicitly transformed dissimilarities (dhats), optimally scaled and normalized
- confdist: Configuration dissimilarities, NOT normalized
- conf: Matrix of fitted configuration, NOT normalized

- stress: Default stress (stress 1; sqrt of explicitly normalized stress)
- spp: Stress per point (based on stress.en)
- ndim: Number of dimensions
- model: Name of smacof model
- niter: Number of iterations
- nobj: Number of objects
- type: Type of MDS model
- weightmat: weighting matrix as supplied
- tweightmat: transformed weighting matrix (here weightmat/delta^2)
- stress.m: Default stress (stress-1^2)

### See Also

[rStressMin](#)

### Examples

```
dis<-smacof::kinshipdelta
res<-elscal(as.matrix(dis),itmax=1000)
res
summary(res)
plot(res)
```

---

enorm

*Explicit Normalization Normalizes distances*

---

### Description

Explicit Normalization Normalizes distances

### Usage

```
enorm(x, w = 1)
```

### Arguments

x	numeric matrix
w	weight

### Value

a constant



---

 icExploreGen

*Exploring initial configurations in an agnostic way*


---

## Description

Allows to user to explore the effect of various starting configurations when fitting an MDS model. This is a bit more general than the icExplore function in smacof, as we allow any PS model to be used as the model is either setup by call or by a prefitted object (for the models in cops and stops we do not have a single UI function which necessitates this). Additionally, one can supply their own configurations and not just random ones.

## Usage

```
icExploreGen(
  object,
  mdscall = NULL,
  conflist,
  nrep = 100,
  ndim,
  returnfit = FALSE,
  min = -5,
  max = 5,
  verbose = FALSE
)
```

## Arguments

object	A fitted object of class 'smacofP', 'smacofB' or 'smacof'. If supplied this takes precedence over the call argument. If given this is added to the output and may be the optimal one.
mdscall	Alternatively to a fitted object, one can pass a syntactically valid call for any of the MDS functions cops, stops or smacof that find a configuration (not the ones that do parameter selection like pcops or stops). If object and call is given, object takes precedence.
conflist	Optional list of starting configurations.
nrep	If conflist is not supplied, how many random starting configurations should be used.
ndim	Dimensions of target space.
returnfit	Should all fitted MDS be returned. If FALSE (default) none is returned.
min	lower bound for the uniform distribution to sample from
max	upper bound for the uniform distribution to sample from
verbose	If >0 prints the fitting progress.

**Details**

If no configuration list is supplied, then nrep configurations are simulated. They are drawn from a ndim-dimensional uniform distribution with minimum min and maximum max. We recommend to use the route via supplying a fitted model as these are typically starting from a Torgerson configuration and are likely quite good.

**Value**

an object of class 'icexplore', see [icExplore](#) for more. There is a plot method in package 'smacof'.

**Examples**

```
dis<-kinshipdelta

## Version 1: Using a fitted object (recommended)
res1<-rStressMin(dis,type="ordinal",itmax=100)
resm<-icExploreGen(res1,nrep=5)

## Version 2: Using a call object and supplying conflist
conflist<-list(res1$init,jitter(res1$init,1),jitter(res1$init,1),jitter(res1$init,1))
c1 <- call("smds",delta=dis,tau=0.2,itmax=100)
resm<-icExploreGen(mdsCall=c1,conflist=conflist,returnfit=TRUE)

plot(resm)
```

---

jackmds.smacofP

*MDS Jackknife for smacofP objects*


---

**Description**

These functions perform an MDS Jackknife and plot the corresponding solution.

**Usage**

```
## S3 method for class 'smacofP'
jackmds(object, eps = 1e-06, itmax = 100, verbose = FALSE)
```

**Arguments**

object	Object of class smacofP if used as method or another object inheriting from smacofB (needs to be called directly as jackmds.smacofP then).
eps	Convergence criterion
itmax	Maximum number of iterations
verbose	If 'TRUE', intermediate stress is printed out.

## Details

In order to examine the stability solution of an MDS, a Jackknife on the configurations can be performed (see de Leeuw & Meulman, 1986) and plotted. The plot shows the jackknife configurations which are connected to their centroid. In addition, the original configuration (transformed through Procrustes) is plotted. The Jackknife function itself returns also a stability measure (as ratio of between and total variance), a measure for cross validity, and the dispersion around the original smacof solution.

## Value

An object of class 'smacofJK', see [jackmids](#). With values

- smacof.conf: Original configuration
- jackknife.confboot: An array of n-1 configuration matrices for each Jackknife MDS solution
- comparison.conf: Centroid Jackknife configurations (comparison matrix)
- cross: Cross validity
- stab: Stability coefficient
- disp: Dispersion
- loss: Value of the loss function (just used internally)
- ndim: Number of dimensions
- call: Model call
- niter: Number of iterations
- nobj: Number of objects

## Examples

```
dats <- na.omit(smacof::PVQ40[,1:5])
diss <- dist(t(dats)) ## Euclidean distances
fit <- rStressMin(diss,type="ordinal",r=0.4,itmax=1000) ## 2D ordinal MDS

res.jk <- jackmids(fit)
plot(res.jk, col.p = "black", col.l = "gray")
plot(res.jk, hclpar = list(c = 80, l = 40))
plot(res.jk, hclpar = list(c = 80, l = 40), plot.lines = FALSE)
```

---

koller

*Responses to the SCC scale and CSII scale (n=1013).*

---

## Description

1013 respondents answered the items of the consumer susceptibility top interpersonal influence (CSII) and the self-concept clarity (SCC) scale. The answers are on a five-point-Likert scale with 1 meaning "fully agree" and 5 meaning "fully disagree". Note that on scc the 10th item is reversed coded to align with the other items.

**Format**

A 1013 x 24 data frame.

**Source**

Koller, Floh, Zauner, Rusch (2013) "Persuasibility and the Self – Investigating Heterogeneity among Consumers". *Australasian Marketing Journal*, 21, 94-104.

---

lmds

*Local MDS*


---

**Description**

This function minimizes the Local MDS Stress of Chen & Buja (2006) via gradient descent. This is a ratio metric scaling method.

**Usage**

```
lmds(
  delta,
  k = 2,
  tau = 1,
  type = "ratio",
  ndim = 2,
  weightmat = 1 - diag(nrow(delta)),
  itmax = 5000,
  init = NULL,
  verbose = 0,
  principal = FALSE,
  normconf = FALSE
)
```

**Arguments**

delta	dissimilarity or distance matrix, dissimilarity or distance data frame or 'dist' object
k	the k neighbourhood parameter
tau	the penalty parameter (suggested to be in [0,1])
type	what type of MDS to fit. Only "ratio" currently.
ndim	the dimension of the configuration
weightmat	a matrix of finite weights. Not implemented.
itmax	number of optimizing iterations, defaults to 5000.
init	initial configuration. If NULL a classical scaling solution is used.
verbose	prints info if > 0 and progress if > 1.
principal	If 'TRUE', principal axis transformation is applied to the final configuration
normconf	normalize the configuration to $\sum(\text{delta}^2)=1$ (as in the power stresses). Note that then the distances in confdist do not match the manually calculated ones.

## Details

Note that  $k$  and  $\tau$  are not independent. It is possible for normalized stress to become negative if the  $\tau$  and  $k$  combination is so that the absolute repulsion for the found configuration dominates the local stress substantially less than the repulsion term does for the solution of  $D(X)=\Delta$ , so that the local stress difference between the found solution and perfect solution is nullified. This can typically be avoided if  $\tau$  is between 0 and 1. If not, set  $k$  and or  $\tau$  to a smaller value.

## Value

an object of class 'lmds' (also inherits from 'smacofP'). See [powerStressMin](#). It is a list with the components as in power stress

- delta: Observed, untransformed dissimilarities
- tdelta: Observed explicitly transformed dissimilarities, normalized
- dhat: Explicitly transformed dissimilarities (dhats)
- confdist: Configuration dissimilarities
- conf: Matrix of fitted configuration
- stress: Default stress (stress 1; sqrt of explicitly normalized stress)
- ndim: Number of dimensions
- model: Name of MDS model
- type: Is "ratio" here.
- niter: Number of iterations
- nobj: Number of objects
- pars: explicit transformations hyperparameter vector theta
- weightmat: 1-diagonal matrix (for compatibility with smacof classes)
- parameters, pars, theta: The parameters supplied
- call the call

and some additional components

- stress.m: default stress is the explicitly normalized stress on the normalized, transformed dissimilarities
- tau: tau parameter
- k: k parameter

## Author(s)

Lisha Chen & Thomas Rusch

## Examples

```
dis<-smacof::kinshipdelta
res<- lmds(dis,k=2,tau=0.1)
res
summary(res)
plot(res)
```

---

mkBmat	<i>Auxfunction1</i>
--------	---------------------

---

**Description**

only used internally

**Usage**

mkBmat(x)

**Arguments**

x                    matrix

---

mkPower	<i>Take matrix to a power</i>
---------	-------------------------------

---

**Description**

Take matrix to a power

**Usage**

mkPower(x, r)

**Arguments**

x                    matrix  
r                    numeric (power)

**Value**

a matrix

---

multiscale

*Multiscale SMACOF*


---

### Description

An implementation for maximum likelihood MDS aka multiscale that minimizes the multiscale stress by majorization with ratio and interval optimal scaling. Uses a repeat loop. Note that since this done via the route of r-sytress, the multiscale stress is approximate and only accurate for  $\kappa > 0$ .

### Usage

```
multiscale(
  delta,
  type = c("ratio", "interval"),
  weightmat,
  init = NULL,
  ndim = 2,
  acc = 1e-06,
  itmax = 10000,
  verbose = FALSE,
  kappa = 0.1,
  principal = FALSE
)
```

### Arguments

delta	dist object or a symmetric, numeric data.frame or matrix of distances. Warning: these will get transformed to the log scale, so make sure that $\log(\text{delta}) \geq 0$ .
type	what optimal scaling type of MDS to fit. Currently one of "ratio" or "interval". Default is "ratio".
weightmat	a matrix of finite weights
init	starting configuration
ndim	dimension of the configuration; defaults to 2
acc	numeric accuracy of the iteration. Default is 1e-6.
itmax	maximum number of iterations. Default is 10000.
verbose	should iteration output be printed; if > 1 then yes
kappa	As this is not exactly multiscale but an r-stress approximation, we have multiscale only for $\kappa > 0$ . This argument can therefore be used to make the approximation more accurate by making it smaller. Default is 0.1.
principal	If 'TRUE', principal axis transformation is applied to the final configuration

**Value**

a 'smacofP' object (inheriting from 'smacofB', see [smacofSym](#)). It is a list with the components

- delta: Observed dissimilarities
- tdelta: Observed explicitly transformed (log) dissimilarities, normalized
- dhat: Explicitly transformed dissimilarities (dhats), optimally scaled and normalized
- confdist: Configuration dissimilarities, NOT normalized
- conf: Matrix of fitted configuration, NOT normalized
- stress: Default stress (stress 1; sqrt of explicitly normalized stress)
- spp: Stress per point
- ndim: Number of dimensions
- model: Name of smacof model
- niter: Number of iterations
- nobj: Number of objects
- type: Type of MDS model
- weightmat: weighting matrix
- stress.m: Default stress ( $\text{stress}-1^2$ )

**Warning**

The input delta will internally get transformed to the log scale, so make sure that  $\log(\text{delta}) \geq 0$  otherwise it throws an error. It is often a good idea to use  $1+\text{delta}$  in this case.

**See Also**

[rStressMin](#)

**Examples**

```
dis<-smacof::kinshipdelta
res<-multiscale(as.matrix(dis),type="interval",itmax=1000)
res
summary(res)
plot(res)
```



---

multistart                      *Multistart MDS function*

---

### Description

For different starting configurations, this function fits a series of PS models given in object or call and returns the one with the lowest stress overall. The starting configurations can be supplied or are generated internally.

### Usage

```
multistart(
  object,
  mdscall = NULL,
  ndim = 2,
  conflist,
  nstarts = 108,
  return.all = FALSE,
  verbose = TRUE,
  min = -5,
  max = 5
)
```

### Arguments

object	A fitted object of class 'smacofP', 'smacofB' or 'smacof'. If supplied this takes precedence over the call argument. If given this is added to the output and may be the optimal one.
mdscall	Alternatively to a fitted object, one can pass a syntactically valid call for any of the MDS functions cops, stops or smacof that find a configuration (not the ones that do parameter selection like pcops or stops). If object and call is given, object takes precedence.
ndim	Dimensions of target space.
conflist	Optional list of starting configurations.
nstarts	If conflist is not supplied, how many random starting configurations should be used. The default is 108, which implies that at least one of the stress is within the lowest 1 percent of all stresses with probability of 1/3 or within the lowest 5 percent of stresses with probability 0.996
return.all	Should all fitted MDS be returned. If FALSE (default) only the optimal one is returned.
verbose	If >0 prints the fitting progress.
min	lower bound for the uniform distribution to sample from
max	upper bound for the uniform distribution to sample from

**Details**

If no configuration list is supplied, then `nstarts` configurations are simulated. They are drawn from a `ndim`-dimensional uniform distribution with minimum `min` and maximum `max`. We recommend to use the route via supplying a fitted model as these are typically starting from a Torgerson configuration and are likely quite good.

One can simply extract `$best` and save that and work with it right away.

**Value**

if `'return.all=FALSE'`, a list with the best fitted model as `'$best'` (minimal badness-of-fit of all fitted models) and `'$stressvec'` the stresses of all models. If `'return.all=TRUE'` a list with slots

- `best`: The object resulting from the fit that had the overall lowest objective function value (usually stress)
- `stressvec`: The vector of objective function values
- `models`: A list of all the fitted objects.

**Examples**

```
dis<-smacof::kinshipdelta

## Version 1: Using a fitted object (recommended)
res1<-rStressMin(delta=dis,type="ordinal",itmax=100)
resm<-multistart(res1,nstarts=2)
## best model
res2<-resm$best
#it's starting configuration
res2$init

## Version 2: Using a call object and supplying conflist
conflist<-list(res2$init,jitter(res2$init,1))
c1 <- call("rStressMin",delta=dis,type="ordinal",itmax=100)
resm<-multistart(mdsCall=c1,conflist=conflist,return.all=TRUE)
```

---

pdist

*Squared p-distances*

---

**Description**

Squared p-distances

**Usage**

`pdist(x, p)`

**Arguments**

x	numeric matrix
p	p>0 the Minkoswki distance

**Value**

squared Minkowski distance matrix

---

permtest.smacofP	<i>Permutation test for smacofP objects</i>
------------------	---

---

**Description**

Performs a permutation test on an MDS solution. It works with a smacofP object alone and also for derived dissimilarities, i.e. generated by the call `dist(data)`. The original data matrix needs to be provided, as well as the type of dissimilarity measure used to compute the input dissimilarities.

**Usage**

```
## S3 method for class 'smacofP'
permtest(
  object,
  data,
  method.dat = "pearson",
  nrep = 100,
  verbose = FALSE,
  ...
)
```

**Arguments**

object	Object of class smacofP if used as method or another object inheriting from smacof (needs to be called directly as permtest.smacofP then).
data	Optional: Initial data; if provided permutations are performed on the data matrix (see details)
method.dat	Dissimilarity computation used as MDS input. This must be one of "pearson", "spearman", "kendall", "euclidean", "maximum", "manhattan", "canberra", "binary". If data is provided, then this must be provided as well.
nrep	Number of permutations.
verbose	If TRUE, bootstrap index is printed out.
...	Additional arguments needed for dissimilarity computation as specified in <a href="#">sim2diss</a> .

## Details

This routine permutes  $m$  dissimilarity values, where  $m$  is the number of lower diagonal elements in the corresponding dissimilarity matrix. For each sample a symmetric, nonmetric SMACOF of dimension 'ndim' is computed and the stress values are stored in 'stressvec'. Using the fitted stress value, the p-value is computed. Subsequently, the empirical cumulative distribution function can be plotted using the plot method.

If the MDS fit provided on derived proximities of a data matrix, this matrix can be passed to the 'permtest' function. Consequently, the data matrix is subject to permutations. The proximity measure used for MDS fit has to match the one used for the permutation test. If a correlation similarity is provided, it is converted internally into a dissimilarity using 'sim2diss' with corresponding arguments passed to the ... argument.

## Value

An object of class 'smacofPerm', see [permtest](#) for details and methods. It has values

- stressvec: Vector containing the stress values of the permutation samples
- stress.obs: Stress (observed sample)
- pval: Resulting p-value
- call: Model call
- nrep: Number of permutations
- nobj: Number of objects

## Examples

```
##see ?smacof::permtest for more
## permuting the dissimilarity matrix (full)
#' data(kinshipdelta)
fitkin <- rStressMin(kinshipdelta, ndim = 2, r=0.5,itmax=10) #use higher itmax
set.seed(222)
res.perm <- permtest(fitkin,nrep=5) #use higher nrep in reality
res.perm
plot(res.perm)
## permuting the data matrix
GOPdtm[GOPdtm > 1] <- 1    ## use binary version
diss1 <- dist(t(GOPdtm[,1:10]), method = "binary") ## Jaccard distance
fitgop1 <- alscale(diss1,type="interval",itmax=10) #use higher itmax
fitgop1
set.seed(123)
permtest(fitgop1, GOPdtm[,1:10], nrep = 5, method.dat = "binary")
```

---

`plot.smacofP`*S3 plot method for smacofP objects*

---

**Description**

S3 plot method for smacofP objects

**Usage**

```
## S3 method for class 'smacofP'
plot(
  x,
  plot.type = "confplot",
  plot.dim = c(1, 2),
  bubscale = 1,
  col,
  label.conf = list(label = TRUE, pos = 3, col = 1, cex = 0.8),
  hull.conf = list(hull = FALSE, col = 1, lwd = 1, ind = NULL),
  shepard.x = NULL,
  identify = FALSE,
  type = "p",
  cex = 0.5,
  pch = 20,
  asp = 1,
  main,
  xlab,
  ylab,
  xlim,
  ylim,
  col.hist = NULL,
  legend = TRUE,
  legpos,
  loess = TRUE,
  shepard.lin = TRUE,
  ...
)
```

**Arguments**

<code>x</code>	an object of class <code>smacofP</code>
<code>plot.type</code>	String indicating which type of plot to be produced: "confplot", "resplot", "Shepard", "stressplot", "transplot", "bubbleplot" (see details)
<code>plot.dim</code>	dimensions to be plotted in confplot; defaults to <code>c(1, 2)</code>
<code>bubscale</code>	Scaling factor (size) for the bubble plot
<code>col</code>	vector of colors for the points

label.conf	List with arguments for plotting the labels of the configurations in a configuration plot (logical value whether to plot labels or not, label position, label color)
hull.conf	Option to add convex hulls to a configuration plot. Hull index needs to be provided.
shepard.x	Shepard plot only: original data (e.g. correlation matrix) can be provided for plotting on x-axis
identify	If 'TRUE', the 'identify()' function is called internally that allows to add configuration labels by mouse click
type	What type of plot should be drawn (see also 'plot')
cex	Symbol size.
pch	Plot symbol
asp	Aspect ratio; defaults to 1 so distances between x and y are represented accurately; can lead to slightly weird looking plots if the variance on one axis is much smaller than on the other axis; use NA if the standard type of R plot is wanted where the ylim and xlim arguments define the aspect ratio - but then the distances seen are no longer accurate
main	plot title
xlab	label of x axis
ylab	label of y axis
xlim	scale of x axis
ylim	scale of y axis
col.hist	Color of the borders of the histogram.
legend	Flag whether legends should be drawn for plots that have legends
legpos	Position of legend in plots with legends
loess	if TRUE a loess fit (by Tukey's rescending M-Estimator) of configuration distances explained by delta is added to the Shepard plot
shepard.lin	Shepard plot only: if TRUE the Shepard plot is linearized so $d^{\kappa} \sim \delta^{\lambda}$ . If FALSE $d \sim \delta^{\lambda}$
...	Further plot arguments passed: see 'plot.smacof' and 'plot' for detailed information.

### Details

- Configuration plot (plot.type = "confplot"): Plots the MDS configuration.
- Residual plot (plot.type = "resplot"): Plots the dhats  $f(T(\delta))$  against the transformed fitted distances  $T(d(X))$ .
- (Linearized) Shepard diagram (plot.type = "Shepard"): Is shep.lin=TRUE a diagram with the transformed observed normalized dissimilarities ( $T(\delta)$  on x) against the transformed fitted distance ( $T(d(X))$  on y) as well as a loess curve and a regression line corresponding to type (linear without intercept for ratio, linear for interval and isotonic for ordinal). If shep.lin=FALSE it uses the untransformed delta. Note that the regression line corresponds to the optimal scaling results (dhat) only up to a linear transformation.

- Transformation Plot (plot.type = "transplot"): Diagram with normalized observed dissimilarities (delta, light grey) and the normalized explicitly transformed dissimilarities (T(Delta), darker) against the untransformed fitted distances (d(X)) together with a nonlinear regression curve corresponding to the explicit transformation (fitted power transformation). This is most useful for ratio models with power transformations as the transformations can be read of directly. For other MDS models and stresses, it still gives a quick way to assess how the explicit transformations worked.
- Stress decomposition plot (plot.type = "stressplot"): Plots the stress contribution in of each observation. Note that it rescales the stress-per-point (SPP) from the corresponding function to percentages (sum is 100). The higher the contribution, the worse the fit.
- Bubble plot (plot.type = "bubbleplot"): Combines the configuration plot with the point stress contribution. The larger the bubbles, the worse the fit.
- histogram ('plot.type = "histogram"': gives a weighted histogram of the dissimilarities (weighted with tweightmat if exists else with weightmat). For optional arguments, see 'wtd.hist'.

### Value

no return value; just plots for class 'smacofP' (see details)

### Examples

```
dis<-as.matrix(smacof::kinshipdelta)
res<-powerStressMin(dis)
plot(res)
plot(res, "Shepard")
plot(res, "resplot")
plot(res, "transplot")
plot(res, "stressplot")
plot(res, "bubbleplot")
plot(res, "histogram")
```

---

powerStressFast

*Power stress minimization by NEWUOA (nloptr)*

---

### Description

An implementation to minimize power stress by a derivative-free trust region optimization algorithm (NEWUOA). Much faster than majorizing as used in powerStressMin but perhaps less accurate.

### Usage

```
powerStressFast(
  delta,
  kappa = 1,
  lambda = 1,
  nu = 1,
```

```

weightmat = 1 - diag(nrow(delta)),
init = NULL,
ndim = 2,
acc = 1e-06,
itmax = 10000,
verbose = FALSE
)

```

### Arguments

delta	dist object or a symmetric, numeric data.frame or matrix of distances
kappa	power of the transformation of the fitted distances; defaults to 1
lambda	the power of the transformation of the proximities; defaults to 1
nu	the power of the transformation for weightmat; defaults to 1
weightmat	a matrix of finite weights
init	starting configuration
ndim	dimension of the configuration; defaults to 2
acc	The smallest value of the trust region radius that is allowed. If not defined, then 1e-6 will be used.
itmax	maximum number of iterations. Default is 10000.
verbose	should iteration output be printed; if > 1 then yes

### Value

a 'smacofP' object (inheriting from 'smacofB', see [smacofSym](#)). It is a list with the components

- delta: Observed dissimilarities, not normalized
- obsdiss: Observed dissimilarities, normalized
- confdist: Configuration dissimilarities, NOT normalized
- conf: Matrix of fitted configuration, NOT normalized
- stress: Default stress (stress 1, square root of the explicitly normalized stress on the normalized, transformed dissimilarities)
- spp: Stress per point (based on stress.en)
- ndim: Number of dimensions
- model: Name of smacof model
- niter: Number of iterations
- nobj: Number of objects
- type: Type of MDS model

and some additional components

- gamma: Empty
- stress.m: default stress for the COPS and STOP. Defaults to the explicitly normalized stress on the normalized, transformed dissimilarities



- stress.en: explicitly stress on the normalized, transformed dissimilarities and normalized transformed distances
- deltaorig: observed, untransformed dissimilarities
- weightmat: weighting matrix

### See Also

[smacofSym](#)

### Examples

```
dis<-smacof::kinshipdelta
res<-powerStressFast(as.matrix(dis),kappa=2,lambda=1.5)
res
summary(res)
plot(res)
```

---

powerStressMin

*Power Stress SMACOF*

---

### Description

An implementation to minimize power stress by majorization with ratio or interval optimal scaling. Usually more accurate but slower than powerStressFast. Uses a repeat loop.

### Usage

```
powerStressMin(
  delta,
  kappa = 1,
  lambda = 1,
  nu = 1,
  type = "ratio",
  weightmat = 1 - diag(nrow(delta)),
  init = NULL,
  ndim = 2,
  acc = 1e-06,
  itmax = 10000,
  verbose = FALSE,
  principal = FALSE
)
```

```
powerstressMin(
  delta,
  kappa = 1,
  lambda = 1,
```

```
nu = 1,  
type = "ratio",  
weightmat = 1 - diag(nrow(delta)),  
init = NULL,  
ndim = 2,  
acc = 1e-06,  
itmax = 10000,  
verbose = FALSE,  
principal = FALSE  
)  
  
postmds(  
delta,  
kappa = 1,  
lambda = 1,  
nu = 1,  
type = "ratio",  
weightmat = 1 - diag(nrow(delta)),  
init = NULL,  
ndim = 2,  
acc = 1e-06,  
itmax = 10000,  
verbose = FALSE,  
principal = FALSE  
)  
  
pstressMin(  
delta,  
kappa = 1,  
lambda = 1,  
nu = 1,  
type = "ratio",  
weightmat = 1 - diag(nrow(delta)),  
init = NULL,  
ndim = 2,  
acc = 1e-06,  
itmax = 10000,  
verbose = FALSE,  
principal = FALSE  
)  
  
pStressMin(  
delta,  
kappa = 1,  
lambda = 1,  
nu = 1,  
type = "ratio",  
weightmat = 1 - diag(nrow(delta)),
```

```

    init = NULL,
    ndim = 2,
    acc = 1e-06,
    itmax = 10000,
    verbose = FALSE,
    principal = FALSE
)

pstressmds(
  delta,
  kappa = 1,
  lambda = 1,
  nu = 1,
  type = "ratio",
  weightmat = 1 - diag(nrow(delta)),
  init = NULL,
  ndim = 2,
  acc = 1e-06,
  itmax = 10000,
  verbose = FALSE,
  principal = FALSE
)

```

### Arguments

delta	dist object or a symmetric, numeric data.frame or matrix of distances
kappa	power of the transformation of the fitted distances; defaults to 1
lambda	the power of the transformation of the proximities; defaults to 1
nu	the power of the transformation for weightmat; defaults to 1
type	what type of MDS to fit. One of "ratio" or "interval". Default is "ratio".
weightmat	a matrix of finite weights or dist object
init	starting configuration
ndim	dimension of the configuration; defaults to 2
acc	numeric accuracy of the iteration. Default is 1e-6.
itmax	maximum number of iterations. Default is 10000.
verbose	should iteration output be printed; if > 1 then yes
principal	If 'TRUE', principal axis transformation is applied to the final configuration

### Value

a 'smacofP' object (inheriting from 'smacofB', see [smacofSym](#)). It is a list with the components

- delta: Observed, untransformed dissimilarities
- tdelta: Observed explicitly transformed dissimilarities, normalized
- dhat: Explicitly transformed dissimilarities (dhats), optimally scaled and normalized

- confdist: Configuration dissimilarities
- conf: Matrix of fitted configuration
- stress: Default stress (stress 1; sqrt of explicitly normalized stress)
- spp: Stress per point
- ndim: Number of dimensions
- model: Name of smacof model
- niter: Number of iterations
- nobj: Number of objects
- type: Type of MDS model
- weightmat: weighting matrix as supplied
- stress.m: Default stress (stress-1<sup>2</sup>)
- tweightmat: transformed weighingmatrix (here weightmat<sup>nu</sup>)

### See Also

[smacofSym](#)

### Examples

```
dis<-smacof::kinshipdelta
res<-powerStressMin(dis,type="ratio",kappa=2,lambda=1.5,itmax=1000)
res
summary(res)
plot(res)
```

---

procruster

*procruster: a procrustes function*

---

### Description

procruster: a procrustes function

### Usage

```
procruster(x)
```

### Arguments

x                    numeric matrix

### Value

a matrix

---

rpowerStressMin	<i>Restricted Power Stress SMACOF</i>
-----------------	---------------------------------------

---

**Description**

An implementation to minimize restricted power stress by majorization with ratio or interval optimal scaling. Restricted means that the same power is used for both dissimilarities and fitted distances. Uses a repeat loop.

**Usage**

```
rpowerStressMin(  
  delta,  
  expo = 1,  
  nu = 1,  
  type = "ratio",  
  weightmat,  
  init = NULL,  
  ndim = 2,  
  acc = 1e-06,  
  itmax = 10000,  
  verbose = FALSE,  
  principal = FALSE  
)
```

```
rpowerstressMin(  
  delta,  
  expo = 1,  
  nu = 1,  
  type = "ratio",  
  weightmat,  
  init = NULL,  
  ndim = 2,  
  acc = 1e-06,  
  itmax = 10000,  
  verbose = FALSE,  
  principal = FALSE  
)
```

```
rpostmds(  
  delta,  
  expo = 1,  
  nu = 1,  
  type = "ratio",  
  weightmat,  
  init = NULL,  
  ndim = 2,
```

```
    acc = 1e-06,  
    itmax = 10000,  
    verbose = FALSE,  
    principal = FALSE  
  )
```

```
rpstressMin(  
  delta,  
  expo = 1,  
  nu = 1,  
  type = "ratio",  
  weightmat,  
  init = NULL,  
  ndim = 2,  
  acc = 1e-06,  
  itmax = 10000,  
  verbose = FALSE,  
  principal = FALSE  
)
```

```
rpStressMin(  
  delta,  
  expo = 1,  
  nu = 1,  
  type = "ratio",  
  weightmat,  
  init = NULL,  
  ndim = 2,  
  acc = 1e-06,  
  itmax = 10000,  
  verbose = FALSE,  
  principal = FALSE  
)
```

```
rpstressmnds(  
  delta,  
  expo = 1,  
  nu = 1,  
  type = "ratio",  
  weightmat,  
  init = NULL,  
  ndim = 2,  
  acc = 1e-06,  
  itmax = 10000,  
  verbose = FALSE,  
  principal = FALSE  
)
```

**Arguments**

delta	dist object or a symmetric, numeric data.frame or matrix of distances
expo	power of the transformation of the fitted distances and dissimilarities; defaults to 1
nu	the power of the transformation for weightmat; defaults to 1
type	what type of MDS to fit. One of "ratio" or "interval". Default is "ratio".
weightmat	a matrix of finite weights
init	starting configuration
ndim	dimension of the configuration; defaults to 2
acc	numeric accuracy of the iteration. Default is 1e-6.
itmax	maximum number of iterations. Default is 10000.
verbose	should iteration output be printed; if > 1 then yes
principal	If 'TRUE', principal axis transformation is applied to the final configuration

**Value**

a 'smacofP' object (inheriting from 'smacofB', see [smacofSym](#)). It is a list with the components

- delta: Observed, untransformed dissimilarities
- tdelta: Observed explicitly transformed dissimilarities, normalized
- dhat: Explicitly transformed dissimilarities (dhats), optimally scaled and normalized
- confdist: Configuration dissimilarities
- conf: Matrix of fitted configuration
- stress: Default stress (stress 1; sqrt of explicitly normalized stress)
- spp: Stress per point
- ndim: Number of dimensions
- model: Name of smacof model
- niter: Number of iterations
- nobj: Number of objects
- type: Type of MDS model
- weightmat: weighting matrix as supplied
- stress.m: Default stress ( $\text{stress} \cdot 1^2$ )
- tweightmat: transformed weighting matrix (here  $\text{weightmat}^{\text{nu}}$ )
- parameters, pars, theta: The parameter vector of the explicit transformations

**Examples**

```
dis<-smacof::kinshipdelta
res<-rpowerStressMin(as.matrix(dis),expo=1.7,itmax=1000)
res
summary(res)
plot(res)
```

---

`rStressMin`*R stress SMACOF*

---

**Description**

An implementation to minimize r-stress by majorization with ratio, interval and ordinal optimal scaling. Uses a repeat loop.

**Usage**

```
rStressMin(  
  delta,  
  r = 0.5,  
  type = c("ratio", "interval", "ordinal"),  
  ties = "primary",  
  weightmat = 1 - diag(nrow(delta)),  
  init = NULL,  
  ndim = 2,  
  acc = 1e-06,  
  itmax = 10000,  
  verbose = FALSE,  
  principal = FALSE  
)
```

```
rstressMin(  
  delta,  
  r = 0.5,  
  type = c("ratio", "interval", "ordinal"),  
  ties = "primary",  
  weightmat = 1 - diag(nrow(delta)),  
  init = NULL,  
  ndim = 2,  
  acc = 1e-06,  
  itmax = 10000,  
  verbose = FALSE,  
  principal = FALSE  
)
```

```
rstressmids(  
  delta,  
  r = 0.5,  
  type = c("ratio", "interval", "ordinal"),  
  ties = "primary",  
  weightmat = 1 - diag(nrow(delta)),  
  init = NULL,  
  ndim = 2,  
  acc = 1e-06,
```



```

    itmax = 10000,
    verbose = FALSE,
    principal = FALSE
  )

  rstress(
    delta,
    r = 0.5,
    type = c("ratio", "interval", "ordinal"),
    ties = "primary",
    weightmat = 1 - diag(nrow(delta)),
    init = NULL,
    ndim = 2,
    acc = 1e-06,
    itmax = 10000,
    verbose = FALSE,
    principal = FALSE
  )

```

### Arguments

<code>delta</code>	dist object or a symmetric, numeric data.frame or matrix of distances
<code>r</code>	power of the transformation of the fitted distances (corresponds to $\kappa/2$ in power stress); defaults to 0.5 for standard stress
<code>type</code>	what type of MDS to fit. Currently one of "ratio", "interval" or "ordinal". Default is "ratio".
<code>ties</code>	the handling of ties for ordinal (nonmetric) MDS. Possible are "primary" (default), "secondary" or "tertiary".
<code>weightmat</code>	a matrix of finite weights.
<code>init</code>	starting configuration
<code>ndim</code>	dimension of the configuration; defaults to 2
<code>acc</code>	numeric accuracy of the iteration. Default is 1e-6.
<code>itmax</code>	maximum number of iterations. Default is 10000.
<code>verbose</code>	should iteration output be printed; if > 1 then yes
<code>principal</code>	If 'TRUE', principal axis transformation is applied to the final configuration

### Value

a 'smacofP' object (inheriting from 'smacofB', see [smacofSym](#)). It is a list with the components

- `delta`: Observed, untransformed dissimilarities
- `tdelta`: Observed explicitly transformed dissimilarities, normalized
- `dhat`: Explicitly transformed dissimilarities (dhats), optimally scaled and normalized
- `confdist`: Configuration dissimilarities
- `conf`: Matrix of fitted configuration

- stress: Default stress (stress 1; sqrt of explicitly normalized stress)
- spp: Stress per point
- ndim: Number of dimensions
- model: Name of smacof model
- niter: Number of iterations
- nobj: Number of objects
- type: Type of MDS model
- weightmat: weighting matrix as supplied
- stress.m: Default stress (stress-1<sup>2</sup>)
- tweightmat: transformed weighting matrix (here NULL)

### See Also

[smacofSym](#)

### Examples

```
dis<-smacof::kinshipdelta
res<-rStressMin(as.matrix(dis),type="ordinal",r=1,itmax=1000)
res
summary(res)
plot(res)
```

---

sammon

*Wrapper to sammon for S3 class*

---

### Description

Wrapper to sammon for S3 class

### Usage

```
sammon(d, y = NULL, k = 2, ...)
```

### Arguments

d	a distance structure such as that returned by 'dist' or a full symmetric matrix. Data are assumed to be dissimilarities or relative distances, but must be positive except for self-distance. This can contain missing values.
y	An initial configuration. If NULL, <a href="#">cmdscale</a> is used to provide the classical solution. (If there are missing values in 'd', an initial configuration must be provided.) This must not have duplicates.
k	The dimension of the configuration
...	Additional parameters passed to sammon, see <a href="#">sammon</a>

**Details**

Overloads MASS::sammon and adds new slots and class attributes for which there are methods.

**Value**

Object of class 'sammonx' inheriting from `sammon`. This wrapper adds an extra slot to the list with the call, adds column labels to the \$points, adds slots `conf=points`, `delta=d`, `dhat=normalized` dissimilarities, `confdist=distance` between points in `conf`, `stress.m=stress`, `stress=sqrt(stress.m)` and assigns S3 classes 'sammonx', 'sammon' and 'cmdscalex'.

**Examples**

```
dis<-as.matrix(smacof::kinshipdelta)
res<-sammon(dis)
```

---

sammonmap

*Sammon Mapping SMACOF*

---

**Description**

An implementation to minimize Sammon stress by majorization with ratio and interval optimal scaling. Uses a repeat loop.

**Usage**

```
sammonmap(
  delta,
  type = c("ratio", "interval"),
  weightmat,
  init = NULL,
  ndim = 2,
  acc = 1e-06,
  itmax = 10000,
  verbose = FALSE,
  principal = FALSE
)
```

**Arguments**

<code>delta</code>	dist object or a symmetric, numeric data.frame or matrix of distances
<code>type</code>	what type of MDS to fit. Currently one of "ratio" and "interval". Default is "ratio".
<code>weightmat</code>	a matrix of finite weights
<code>init</code>	starting configuration
<code>ndim</code>	dimension of the configuration; defaults to 2
<code>acc</code>	numeric accuracy of the iteration. Default is 1e-6.

itmax	maximum number of iterations. Default is 10000.
verbose	should iteration output be printed; if > 1 then yes
principal	If 'TRUE', principal axis transformation is applied to the final configuration

### Value

a 'smacofP' object (inheriting from smacofB, see [smacofSym](#)). It is a list with the components

- delta: Observed dissimilarities
- tdelta: Observed explicitly transformed dissimilarities, normalized
- dhat: Observed dissimilarities (dhats), optimally scaled and normalized
- confdist: Configuration dissimilarities
- conf: Matrix of fitted configuration
- stress: Default stress (stress 1; sqrt of explicitly normalized stress)
- spp: Stress per point (based on stress.en)
- ndim: Number of dimensions
- model: Name of smacof model
- niter: Number of iterations
- nobj: Number of objects
- type: Type of MDS model
- weightmat: weighting matrix as supplied
- stress.m: default stress ( $\text{stress}-1^2$ )
- tweightmat: weighting matrix after transformation (here  $\text{weightmat}/\text{delta}$ )

### See Also

[rStressMin](#)

### Examples

```
dis<-smacof::kinshipdelta
res<-sammonmap(as.matrix(dis),itmax=1000)
res
summary(res)
plot(res)
```

---

scale_adjust	<i>Adjusts a configuration</i>
--------------	--------------------------------

---

**Description**

Adjusts a configuration

**Usage**

```
scale_adjust(conf, ref, scale = c("sd", "std", "proc", "none"))
```

**Arguments**

conf	a configuration
ref	a reference configuration (only for scale="proc")
scale	Scale adjustment. "std" standardizes each column of the configurations to mean=0 and sd=1, "sd" scales the configuration by the maximum standard deviation of any column, "proc" adjusts the fitted configuration to the reference

**Value**

The scale adjusted configuration.

---

secularEq	<i>Secular Equation</i>
-----------	-------------------------

---

**Description**

Secular Equation

**Usage**

```
secularEq(a, b)
```

**Arguments**

a	matrix
b	matrix

---

smacofxDeleteOne      *Helper function to conduct jackknife MDS*

---

### Description

Function deletes every object row and columns once and fits the MDS in object and returns the configuration. The deleted row is set to 0 in the configuration. Is meant for smacofx functions, but should also work for every smacof models.

### Usage

```
smacofxDeleteOne(
  object,
  delta,
  weightmat,
  init,
  ndim,
  type,
  verbose = FALSE,
  itmaxi = 10000
)
```

### Arguments

object	Object of class smacofP if used as method or another object inheriting from smacofB. Note we assume the MDS model was fitted on a symmetric matrix/data frame or dist object
delta	the data (symmetric matrix, data frame or dist object)
weightmat	weighting matrix
init	starting configuration
ndim	target dimension of the mds
type	type of MDS
verbose	print progress
itmaxi	maximum iterations of the MDS procedure

### Value

An array of size n with n configurations

---

spmdda	<i>Sparse (POST-)Multidimensional Distance Analysis (SPMDDA or SMDDA) either as self-organizing or not</i>
--------	--

---

### Description

An implementation of a sparsified version of (POST-)MDS by pseudo-majorization with ratio, interval and ordinal optimal scaling for geodesic distances and optional power transformations. This is inspired by curvilinear distance analysis but works differently: It finds an initial weightmatrix where  $w_{ij}(X^0)=0$  if  $d_{ij}(X^0)>\tau$  and fits a POST-MDS with these weights. Then in each successive iteration step, the weightmat is recalculated so that  $w_{ij}(X^{(n+1)})=0$  if  $d_{ij}(X^{(n+1)})>\tau$ . Right now the zero weights are not found by the correct optimization, but we're working on that.

### Usage

```
spmdda(
  delta,
  lambda = 1,
  kappa = 1,
  nu = 1,
  tau,
  type = "ratio",
  ties = "primary",
  epsilon,
  k,
  path = "shortest",
  fragmentedOK = FALSE,
  weightmat = 1 - diag(nrow(delta)),
  init = NULL,
  ndim = 2,
  acc = 1e-06,
  itmax = 10000,
  verbose = FALSE,
  principal = FALSE
)
```

```
smda(
  delta,
  tau = stats::quantile(delta, 0.9),
  type = c("ratio"),
  ties = "primary",
  epsilon,
  k,
  path = "shortest",
  fragmentedOK = FALSE,
  weightmat = 1 - diag(nrow(delta)),
  init = NULL,
```

```
    ndim = 2,  
    acc = 1e-06,  
    itmax = 10000,  
    verbose = FALSE,  
    principal = FALSE  
  )  
  
so_spmdda(  
  delta,  
  kappa = 1,  
  lambda = 1,  
  nu = 1,  
  tau = max(delta),  
  epochs = 10,  
  type = c("ratio"),  
  ties = "primary",  
  epsilon,  
  k,  
  path = "shortest",  
  fragmentedOK = FALSE,  
  weightmat = 1 - diag(nrow(delta)),  
  init = NULL,  
  ndim = 2,  
  acc = 1e-06,  
  itmax = 10000,  
  verbose = FALSE,  
  principal = FALSE  
)  
  
so_smda(  
  delta,  
  tau = max(delta),  
  epochs = 10,  
  type = c("ratio"),  
  ties = "primary",  
  epsilon,  
  k,  
  path = "shortest",  
  fragmentedOK = FALSE,  
  weightmat = 1 - diag(nrow(delta)),  
  init = NULL,  
  ndim = 2,  
  acc = 1e-06,  
  itmax = 10000,  
  verbose = FALSE,  
  principal = FALSE  
)
```



**Arguments**

delta	dist object or a symmetric, numeric data.frame or matrix of distances
lambda	exponent of the power transformation of the dissimilarities; defaults to 1, which is also the setup of 'smdda'
kappa	exponent of the power transformation of the fitted distances; defaults to 1, which is also the setup of 'smdda'.
nu	exponent of the power of the weighting matrix; defaults to 1 which is also the setup for 'clca'.
tau	the boundary/neighbourhood parameter(s) (called lambda in the original paper). For 'spmdda' and 'smdda' it is supposed to be a numeric scalar (if a sequence is supplied the maximum is taken as tau) and all the transformed fitted distances exceeding tau are set to 0 via the weightmat (assignment can change between iterations). It defaults to the 90% quantile of the enormed (power transformed) geodesic distances of delta. For 'so_pclca' tau is supposed to be either a user supplied decreasing sequence of taus or if a scalar the maximum tau from which a decreasing sequence of taus is generated automatically as 'seq(from=tau,to=tau/epochs,length.out=epochs)' and then used in sequence.
type	what type of MDS to fit. Currently one of "ratio", "interval" or "ordinal". Default is "ratio".
ties	the handling of ties for ordinal (nonmetric) MDS. Possible are "primary" (default), "secondary" or "tertiary".
epsilon	Shortest dissimilarity retained.
k	Number of shortest dissimilarities retained for a point. If both 'epsilon' and 'k' are given, 'epsilon' will be used.
path	Method used in 'stepacross' to estimate the shortest path, with alternatives "'shortest'" and "'extended'".
fragmentedOK	What to do if dissimilarity matrix is fragmented. If 'TRUE', analyse the largest connected group, otherwise stop with error.
weightmat	a matrix of finite weights.
init	starting configuration
ndim	dimension of the configuration; defaults to 2
acc	numeric accuracy of the iteration. Default is 1e-6.
itmax	maximum number of iterations. Default is 10000.
verbose	should iteration output be printed; if > 1 then yes
principal	If 'TRUE', principal axis transformation is applied to the final configuration
epochs	for 'so_pclca' and tau being scalar, it gives the number of passes through the data. The sequence of taus created is 'seq(tau,tau/epochs,length.out=epochs)'. If tau is of length >1, this argument is ignored.

## Details

In 'spmdda' the logic is that we first transform to geodesic distance, then apply the explicit power transformation and then the implicit optimal scaling. There is a wrapper 'smdda' where the exponents are 1, which is standard SMDDA but extend to allow optimal scaling. The neighborhood parameter tau is kept fixed in 'spmdda' and 'smdda'. The functions 'so\_spmdda' and 'so\_smda' implement a self-organising principle where the is repeatedly fitted for a decreasing sequence of taus.

The solution is found by "quasi-majorization", which mean that the majorization is only working properly after a burn-in of a few iterations when the assignment which distances are ignored no longer changes. Due to that it can be that in the beginning the stress may not decrease monotonically and that there's a chance it might never.

The geodesic distances are calculated via 'vegan::isomapdist', see [isomapdist](#) for a documentation of what these distances do. The functions of '(p)smdda' are just a wrapper for '(p)clca' applied to the geodesic distances obtained via isomapdist.

If tau is too small it may happen that all distances for one i to all j are zero and then there will be an error, so make sure to set a larger tau.

In the standard functions 'spmdda' and 'smdda' we keep tau fixed throughout. This means that if tau is large enough, then the result is the same as the corresponding MDS. In the original publication the idea was that of a self-organizing map which decreased tau over epochs (i.e., passes through the data). This can be achieved with our function 'so\_spmdda' 'so\_smda' which creates a vector of decreasing tau values, calls the function 'spmdda' with the first tau, then supplies the optimal configuration obtained as the init for the next call with the next tau and so on.

## Value

a 'smacofP' object (inheriting from 'smacofB', see [smacofSym](#)). It is a list with the components

- delta: Observed, untransformed dissimilarities
- tdelta: Observed explicitly transformed dissimilarities, normalized
- dhat: Explicitly transformed dissimilarities (dhats), optimally scaled and normalized
- confdist: Configuration dissimilarities
- conf: Matrix of fitted configuration
- stress: Default stress (stress 1; sqrt of explicitly normalized stress)
- spp: Stress per point
- ndim: Number of dimensions
- model: Name of smacof model
- niter: Number of iterations
- nobj: Number of objects
- type: Type of MDS model
- weightmat: weighting matrix as supplied
- stress.m: Default stress ( $\text{stress} - 1^2$ )
- tweightmat: transformed weighting matrix; it is weightmat but containing all the 0s for the distances set to 0.

**Examples**

```

dis<-smacof::morse
res<-spmdda(dis,kappa=2,lambda=2,tau=0.4,k=5,itmax=500) #use higher itmax
res
#already many parameters
coef(res)

res2<-smdda(dis,type="interval",tau=0.4,epsilon=1,itmax=500) #use higher itmax
res2
summary(res)
oldpar<-par(mfrow=c(1,2))
plot(res)
plot(res2)
par(oldpar)

##which d_{ij}(X) exceeded tau at convergence (i.e., have been set to 0)?
res$tweightmat
res2$tweightmat

## Self-organizing map style (as in the original publication)
#run the som-style (p)smdda
sommod1<-so_spmdda(dis,tau=2,k=5,kappa=0.5,lambda=2,epochs=10,verbose=1)
sommod2<-so_smdda(dis,tau=2.5,epsilon=1,epochs=10,verbose=1)
sommod1
sommod2

```

---

spmds

*Sparsified (POST-) Multidimensional Scaling (SPMDS or SMDS) either as self-organizing or not*


---

**Description**

An implementation of a sparsified version of (POST-)MDS by pseudo-majorization with ratio, interval and ordinal optimal scaling for dissimilarities and optional power transformations. This is inspired by curvilinear component analysis but works differently: It finds an initial weightmatrix where  $w_{ij}(X^0)=0$  if  $d_{ij}(X^0)>\tau$  and fits a POST-MDS with these weights. Then in each successive iteration step, the weightmat is recalculated so that  $w_{ij}(X^{(n+1)})=0$  if  $d_{ij}(X^{(n+1)})>\tau$ .

**Usage**

```

spmds(
  delta,
  lambda = 1,
  kappa = 1,
  nu = 1,
  tau,

```

```
type = "ratio",
ties = "primary",
weightmat = 1 - diag(nrow(delta)),
init = NULL,
ndim = 2,
acc = 1e-06,
itmax = 10000,
verbose = FALSE,
principal = FALSE
)
```

```
smds(
  delta,
  tau = stats::quantile(delta, 0.9),
  type = "ratio",
  ties = "primary",
  weightmat = 1 - diag(nrow(delta)),
  init = NULL,
  ndim = 2,
  acc = 1e-06,
  itmax = 10000,
  verbose = FALSE,
  principal = FALSE
)
```

```
so_spmds(
  delta,
  kappa = 1,
  lambda = 1,
  nu = 1,
  tau = max(delta),
  epochs = 10,
  type = "ratio",
  ties = "primary",
  weightmat = 1 - diag(nrow(delta)),
  init = NULL,
  ndim = 2,
  acc = 1e-06,
  itmax = 10000,
  verbose = FALSE,
  principal = FALSE
)
```

```
so_smds(
  delta,
  tau = max(delta),
  epochs = 10,
  type = "ratio",
```

```

    ties = "primary",
    weightmat = 1 - diag(nrow(delta)),
    init = NULL,
    ndim = 2,
    acc = 1e-06,
    itmax = 10000,
    verbose = FALSE,
    principal = FALSE
)

```

### Arguments

delta	dist object or a symmetric, numeric data.frame or matrix of distances
lambda	exponent of the power transformation of the dissimilarities; defaults to 1, which is also the setup of 'smds'
kappa	exponent of the power transformation of the fitted distances; defaults to 1, which is also the setup of 'smds'.
nu	exponent of the power of the weighting matrix; defaults to 1 which is also the setup for 'smds'.
tau	the boundary/neighbourhood parameter(s) (called lambda in the original paper). For 'spmds' and 'smds' it is supposed to be a numeric scalar (if a sequence is supplied the maximum is taken as tau) and all the transformed fitted distances exceeding tau are set to 0 via the weightmat (assignment can change between iterations). It defaults to the 90% quantile of delta. For 'so_spmds' tau is supposed to be either a user supplied decreasing sequence of taus or if a scalar the maximum tau from which a decreasing sequence of taus is generated automatically as 'seq(from=tau,to=tau/epochs,length.out=epochs)' and then used in sequence.
type	what type of MDS to fit. Currently one of "ratio", "interval" or "ordinal". Default is "ratio".
ties	the handling of ties for ordinal (nonmetric) MDS. Possible are "primary" (default), "secondary" or "tertiary".
weightmat	a matrix of finite weights.
init	starting configuration. If NULL (default) we fit a full rstress model.
ndim	dimension of the configuration; defaults to 2
acc	numeric accuracy of the iteration. Default is 1e-6.
itmax	maximum number of iterations. Default is 10000.
verbose	should iteration output be printed; if > 1 then yes
principal	If 'TRUE', principal axis transformation is applied to the final configuration
epochs	for 'so_spmds' and tau being scalar, it gives the number of passes through the data. The sequence of taus created is 'seq(tau,tau/epochs,length.out=epochs)'. If tau is of length >1, this argument is ignored.

## Details

There is a wrapper 'smds' where the exponents are 1, which is standard SMDS but extend to allow optimal scaling. The neighborhood parameter tau is kept fixed in 'spmds' and 'smds'. The functions 'so\_spmds' and 'so\_smds' implement a self-organising principle, where the SMDS is repeatedly fitted for a decreasing sequence of taus.

The solution is found by "quasi-majorization", which means that the majorization is only real majorization once the weightmat no longer changes. This typically happens after a few iterations. Due to that it can be that in the beginning the stress may not decrease monotonically and that there's a chance it might never.

If tau is too small it may happen that all distances for one i to all j are zero and then there will be an error, so make sure to set a larger tau.

In the standard functions 'spmds' and 'smds' we keep tau fixed throughout. This means that if tau is large enough, then the result is the same as the corresponding MDS. In the original publication the idea was that of a self-organizing map which decreased tau over epochs (i.e., passes through the data). This can be achieved with our function 'so\_spmds' 'so\_smds' which creates a vector of decreasing tau values, calls the function 'spmds' with the first tau, then supplies the optimal configuration obtained as the init for the next call with the next tau and so on.

## Value

a 'smacofP' object (inheriting from 'smacofB', see [smacofSym](#)). It is a list with the components

- delta: Observed, untransformed dissimilarities
- tdelta: Observed explicitly transformed dissimilarities, normalized
- dhat: Explicitly transformed dissimilarities (dhats), optimally scaled and normalized
- confdist: Configuration dissimilarities
- conf: Matrix of fitted configuration
- stress: Default stress (stress 1; sqrt of explicitly normalized stress)
- spp: Stress per point
- ndim: Number of dimensions
- model: Name of smacof model
- niter: Number of iterations
- nobj: Number of objects
- type: Type of MDS model
- weightmat: weighting matrix as supplied
- stress.m: Default stress ( $\text{stress} - 1^2$ )
- tweightmat: transformed weighting matrix; it is weightmat but containing all the 0s for the distances set to 0.

**Examples**

```

dis<-smacof::morse
res<-spmnds(dis,type="interval",kappa=2,lambda=2,tau=0.3,itmax=100) #use higher itmax
res2<-smds(dis,type="interval",tau=0.3,itmax=500) #use higher itmax
res
res2
summary(res)
oldpar<-par(mfrow=c(1,2))
plot(res)
plot(res2)
par(oldpar)

##which d_{ij}(X)^kappa exceeded tau at convergence (i.e., have been set to 0)?
res$tweightmat
res2$tweightmat

## Self-organizing map style (as in the clca publication)
#run the som-style (p)smds
sommod1<-so_spmnds(dis, tau=1, kappa=0.5, lambda=2, epochs=10, verbose=1)
sommod2<-so_smds(dis, tau=1, epochs=10, verbose=1)
sommod1
sommod2

```

---

spp

*Calculating stress per point*


---

**Description**

Calculating stress per point

**Usage**

```
spp(dhat, confdist, weightmat)
```

**Arguments**

dhat	a dist object or symmetric matrix of dissimilarities
confdist	a dist object or symmetric matrix of fitted distances
weightmat	dist objetc or symmetric matrix of weights

**Value**

a list

---

sqdist	<i>Squared distances</i>
--------	--------------------------

---

**Description**

Squared distances

**Usage**

sqdist(x)

**Arguments**

x                    numeric matrix

**Value**

squared distance matrix



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