Package 'mand'

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Type Package

Title Multivariate Analysis for Neuroimaging Data

Version 3.0

Description Provides functions for multivariate analysis and visualization of neuroimaging data. The package contains the functions and example data used in the book 'Multivariate Analysis for Neuroimaging Data' by Kawaguchi (2021, ISBN: 978-0367255329). It includes utilities for image visualization, image data matrix construction, basis reconstruction, multicomponent visualization, predictive modeling, simulation, and multiblock analysis. Version 3.0 preserves the public interfaces used in the accompanying package vignettes.

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`mand-package` *Multivariate Analysis for Neuroimaging Data Package*

Description

A Package for implementation of multivariate data analysis for neuroimaging data.

Author(s)

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References

Kawaguchi, A. (2021). Multivariate Analysis for Neuroimaging Data. CRC Press.

atlas *Atlas set*

Description

The data is the atlas image data. An image whose element is "ROIid" is stored for each atlas.

Usage

```
data(atlas)
```

Format

A list of array

atlasdatasets *Atlas data set*

Description

The data is the atlas data. Various atlases are stored. Each matrix has "ROIid" and "ROIname" as column names.

Usage

```
data(atlasdatasets)
```

Format

A list of matrix

atlastable *Result report with atlas data*

Description

This function refers to the results obtained by the analysis in an atlas image, and reports a summary of the results for each anatomical region.

Usage

```
atlastable(x, y, atlasdataset = NULL, ROIids = NULL, ...)
```

Arguments

x	A three-dimensional atlas image.
y	an array for the result image.
atlasdataset	a matrix or data.frame. The colnames should include "ROIid" and "ROIname".
ROIids	a vector indicating ROI id shown in the result.
...	further arguments passed to or from other methods.

Details

`atlastable` requires the atlas image and data frame including the ROI id and the name.

Examples

```
data(diffimg)
data(atlasdatasets)
data(atlas)
atlasname = "aal3"
atlasdataset = atlasdatasets[[atlasname]]
tmpatlas = atlas[[atlasname]]
atlastable(tmpatlas, diffimg, atlasdataset=atlasdataset, ROIids = c(1:2, 41:44))
```

---

baseimg *Base Brain Data*

Description

The data is the base brain data. This is an average image of a healthy person, and is used when generating artificial data.

Usage

```
data(baseimg)
```

Format

A array

basisprod *Product Radial Basis Function*

Description

This is a function to product the output for the rbfunc function with data matrix for a dimension reduction.

Usage

```
basisprod(A, B)
```

Arguments

A	a list or a matrix correponding to the output for the rbfunc function with the argument hispec=FALSE or data matrix, respectivey.
B	a list or a matrix.

Details

basisprod requires one list and one matrix.

Examples

```
imagedim1=c(10,10,10)

B1 = rbfunc(imagedim=imagedim1, seppix=4, hispec=TRUE)
B2 = rbfunc(imagedim=imagedim1, seppix=4, hispec=FALSE)

n = 50
S = matrix(rnorm(n*prod(imagedim1)), nrow = n, ncol = prod(imagedim1))

SB1 = S %*% B1
SB12 = tcrossprod(S, t(B1))
all(SB1-SB12 == 0)

SB2 = basisprod(S, B2)
all(SB1-SB2 == 0)

BS1 = t(B1) %*% t(S)
BS2 = basisprod(B2, S)
all(BS1-t(BS2) == 0)
```

coat *Coat Function*

Description

This is a function for plotting an image. The analysis result can be overcoated on the template.

Usage

```
coat(
  x,
  y = NULL,
  pseq = NULL,
  xyz = NULL,
  col.x = gray(0:64/64),
  col.y = NULL,
  breaks.y = NULL,
  zlim.x = NULL,
  zlim.y = NULL,
  rownum = 5,
  colnum = NULL,
  plane = c("axial", "coronal", "sagittal", "all")[1],
  xlab = "",
  ylab = "",
  axes = FALSE,
  oma = rep(0, 4),
  mar = rep(0, 4),
  bg = "black",
  paron = TRUE,
  cross.hair = FALSE,
  chxy = NULL,
  color.bar = TRUE,
  regionplot = FALSE,
  atlasdataset = NULL,
  regionname = c("atlas", "stat")[1],
  regionlegend = FALSE,
  atlasname = "",
  ROIids = 1:9,
  ...
)
```

Arguments

x	A three-dimensional background image.
y	image2 to be overcoated.
pseq	a vector plot sequence.

xyz	a vector position to be plotted.
col.x	a color vector for image1.
col.y	a color vector for image2.
breaks.y	a vector breaks value for y.
zlim.x	a vector plot limitation values for z of x.
zlim.y	a vector plot limitation values for z of y.
rownum	a numeric, the number of row for the plot.
colnum	a numeric, the number of colnum for the plot.
plane	a vector plot sequence.
xlab	a character for a label in the x axis.
ylab	a character for a label in the y axis.
axes	a logical. TRUE presents the axes.
oma	a vector for outer margin area.
mar	a vector for margin.
bg	a character for color of background.
paron	a logical. TRUE means par is used.
cross.hair	a logical.
chxy	a vector cross hair position to be plotted.
color.bar	a logical.
regionplot	a logical.
atlasdataset	a matrix or data.frame. colnames shold include "ROIid" and "ROIname".
regionname	a character.
regionlegend	a logical.
atlasname	a character.
ROIids	a vector
...	further arguments passed to or from other methods.

Details

coat requires a image array.

Examples

```
data(exbrain)
coat(exbrain)
```

diffimg *Difference Brain Data*

Description

The data is the difference brain data. This represents the difference between the average images of healthy subjects and patients with Alzheimer's disease, and is used when generating artificial data.

Usage

```
data(diffimg)
```

Format

A array

exbrain *Example Brain Data*

Description

The data are from a MRI gray matter brain data for one subject.

Usage

```
data(exbrain)
```

Format

A array

imgdatamat *Creat Data Matrix Function*

Description

This is a function that creates a data matrix for analysis from a file saved in image format.

Usage

```
imgdatamat(
  imgfnames,
  mask = NULL,
  ROI = FALSE,
  atlas = NULL,
  atlasdataset = NULL,
  ROIids = NULL,
  zeromask = FALSE,
  schange = FALSE,
  ...
)
```

Arguments

imgfnames	a vector for (nifti) file names to be used.
mask	a vector for brain mask data.
ROI	a logical for roi data set.
atlas	An optional three-dimensional atlas image.
atlasdataset	a matrix or data.frame. colnames shold include "ROIid" and "ROIname".
ROIids	a vector
zeromask	a logical for masking voxel with all zeros.
schange	a logical for change dimension.
...	further arguments passed to or from other methods.

Details

`imgdatamat` requires image file names.

Value

S	data matrix
brainpos	binary brain position.
imagedim	three dimensional vector for image dimension

Examples

```
# imgfnames1 = c("img1.nii", "img2.nii")
# imgdata = imgdatamat(imgfnames1)
```

mask *Brain Mask*

Description

The data is the brain mask. This is used to exclude extra-brain regions from the analysis.

Usage

```
data(mask)
```

Format

A array

multicoat *Multi Coat Function*

Description

This is a function for plotting an image. The analysis result can be overcoated on the template.

Usage

```
multicoat(imgs, y = NULL, row4imp = 6, col4imp = 1, trm = NULL, ...)
```

Arguments

imgs	A list of three-dimensional image arrays to be displayed.
y	image(s) to be overcoated. In the case of a single image, the same y images are overlaid on each x. In the case of a list of images equal to the number of x, each image is overlaid on each x.
row4imp	the number of rows per a image
col4imp	the number of columns per a image
trm	the index to trim the top and bottom of the slice
...	further arguments passed to or from other methods.

Details

multicoat requires a image array.

Examples

```
data(exbrain)
```

`multicompplot` *Multi components plot*

Description

This is a function that plots the vectorized image returned to its original dimensions by the multirec function.

Usage

```
multicompplot(
  object,
  x,
  comps = NULL,
  row4comp = 6,
  col4comp = 1,
  pseq4comp = NULL,
  ...
)
```

Arguments

`object`	an object of class "`multirec`." Usually, a result of a call to `multirec`
`x`	A three-dimensional template image.
`comps`	a component sequence to be plotted.
`row4comp`	the number of rows per a component
`col4comp`	the number of columns per a component
`pseq4comp`	the number of images per a component
`...`	further arguments passed to or from other methods.

Details

`multicompplot` requires the output result of `msma` function.

Examples

```
if (requireNamespace("msma", quietly = TRUE)) {
data(baseimg)
data(diffimg)
data(mask)
data(template)
img1 = simbrain(baseimg = baseimg, diffimg = diffimg, mask=mask)
B1 = rbfunc(imagedim=img1$imagedim, seppix=2, hispec=FALSE, mask=img1$brainpos)
SB1 = basisprod(img1$S, B1)
fit111 = msma::msma(SB1, comp=2)
ws = multirec(fit111, imagedim=img1$imagedim, B=B1, mask=img1$brainpos)
```

```
multicompplot(ws, template)
}
```

`multirec` *Multi components reconstruction*

Description

This is a function that returns the weight vector of multiple components obtained by the `msma` function applied after dimension reduction by the radial basis function to the same dimension as the original image.

Usage

```
multirec(
  object,
  imagedim,
  B = NULL,
  mask = NULL,
  midx = 1,
  comps = NULL,
  XY = c("X", "Y", "XY")[1],
  signflip = FALSE
)
```

Arguments

`object`	an object of class `msma`. Usually, a result of a call to `msma`
`imagedim`	a vector for original dimension.
`B`	a list or a matrix.
`mask`	a list or a matrix.
`midx`	a block number to be plotted.
`comps`	a component sequence to be plotted.
`XY`	a character, indicating "X" or "Y". "XY" for the scatter plots using X and Y scores from `msma`.
`signflip`	a logical if the sign in the block is flipped to pose the super as possitive.

Details

`multirec` requires the output result of `msma` function.

Examples

```
if (requireNamespace("msma", quietly = TRUE)) {
data(baseimg)
data(diffimg)
data(mask)
img1 = simbrain(baseimg = baseimg, diffimg = diffimg, mask=mask)
B1 = rbfunc(imagedim=img1$imagedim, seppix=2, hispec=FALSE, mask=img1$brainpos)
SB1 = basisprod(img1$S, B1)
fit111 = msma::msma(SB1, comp=2)
ws = multirec(fit111, imagedim=img1$imagedim, B=B1, mask=img1$brainpos)
}
```

---

ptest *Prediction Model Function*

Description

This is the function that creates and evaluates the predictive model.

Usage

```
ptest(
  object,
  Z = Z,
  newdata = NULL,
  testZ = NULL,
  regmethod = "glm",
  methods1 = c("boot", "boot632", "cv", "repeatedcv", "LOOCV", "LGOCV")[4],
  metric = "ROC",
  number1 = 10,
  repeats1 = 5,
  params = NULL
)
```

Arguments

object	a matrix indicating the explanatory variable(s), or an object of class msma, which is a result of a call to msma .
Z	a vector, response variable(s) for the construction of the prediction model. The length of Z is the number of subjects for the training.
newdata	a matrix for the prediction.
testZ	a vector, response variable(s) for the prediction evaluation. The length of testZ is the number of subjects for the validation.
regmethod	a character for the name of the prediction model. This corresponds to the method argument of the train function in the caret package.

methods1	a character for the name of the evaluation method.
metric	a character for the name of summary metric to select the optimal model.
number1	a number of folds or number of resampling iterations
repeats1	a number of repeats for the repeated cross-validation
params	a data frame with possible tuning values.

Details

ptest requires the output result of msma function.

Value

object	an object of class "msma", usually, a result of a call to msma
trainout	a predictive model output from the train function in the caret package with scores computed by the msma function as predictors
scorecvroc	the training evaluation measure and values of the tuning parameters
evalmeasure	evaluation measures and information criterion for the msma model
traincnfmat	a confusion matrix in training data
predcnfmat	a confusion matrix in test data

Examples

```
if (requireNamespace("msma", quietly = TRUE)) {
data(baseimg)
data(diffimg)
data(mask)
data(template)
img1 = simbrain(baseimg = baseimg, diffimg = diffimg, mask=mask)
B1 = rbfunc(imagedim=img1$imagedim, seppix=2, hispec=FALSE, mask=img1$brainpos)
SB1 = basisprod(img1$S, B1)
fit111 = msma::msma(SB1, comp=2)
predmodel = ptest(fit111, Z=img1$Z)
}
```

---

rbfunc *Radial Basis Function*

Description

This makes a radial basis function.

Usage

```
rbfunc(imagedim, seppix, hispec = FALSE, mask = NULL, brainpos = NULL)
```

Arguments

imagedim	a vector indicating image three dimension.
seppix	a numeric. distance between knots.
hispec	a logical. TRUE produces a matrix output. FALSE produces a list output to reduce the data memorry.
mask	a vector.
brainpos	a logical vector.

Details

rbfunc requires the dimensions of the original image to be applied and the knot interval. The output is obtained as a matrix, with the number of rows corresponding to the number of voxels in the original image and the number of columns determined by the knot spacing. By setting hispec = TRUE, you can get the output in list format with a smaller memory.

Examples

```
imagedim1=c(10,10,10)

B1 = rbfunc(imagedim=imagedim1, seppix=4, hispec=TRUE)
B2 = rbfunc(imagedim=imagedim1, seppix=4, hispec=FALSE)
```

---

rec *Reconstruction*

Description

This is a function that restores the vectorized image to its original dimensions, reduced in dimension by the radial basis function.

Usage

```
rec(Q, imagedim, B = NULL, mask = NULL)
```

Arguments

Q	a vector for reduced data.
imagedim	a vector for original dimension.
B	a list or a matrix indicating the basis function used in the dimension reduction.
mask	a list or a matrix indicating the mask image used in the dimension reduction.

Details

rec requires a vector to be converted to a array.

Examples

```
imagedim1=c(10,10,10)
recvec = rec(rnorm(prod(imagedim1)), imagedim1)
```

`sdevimg` *Standard Deviation Brain Data*

Description

The data is the standard deviation brain data. This represents the common standard deviation between the average images of healthy subjects and patients with Alzheimer's disease, and is used when generating artificial data.

Usage

```
data(sdevimg)
```

Format

A array

`simbrain` *Generate simulation data Function*

Description

This is a function for simulation data based on the real base brain image data and difference in brain between healty and disease groups.

Usage

```
simbrain(
  baseimg,
  diffimg,
  sdevimg = NULL,
  mask = NULL,
  n0 = 10,
  c1 = 0.5,
  sd1 = 0.01,
  rho = NULL,
  zeromask = FALSE,
  reduce = c("no", "rd1", "rd2")[1],
  output = c("rdata", "nifti")[1],
  seed = 1
)
```

Arguments

baseimg	an array for the basis image.
diffimg	an array for the difference image.
sdevimg	an array for the standard deviation image.
mask	an array for the mask image.
n0	a numeric, which is a sample size per group.
c1	a numeric, the strength of the difference
sd1	a numeric, standard deviation for the individual variation.
rho	a numeric, correlation coefficient in the noize
zeromask	a logical, whether mask the position with zero values for all subjects.
reduce	a vector.
output	a vector.
seed	a numeric for seed for random variables.

Details

simbrain requires a base brain image data and mean difference image data.

Value

S	data matrix
Z	binary group variable
brainpos	binary brain position.
imagedim	three dimensional vector for image dimension

Examples

```
data(baseimg)
data(diffimg)
sim1 = simbrain(baseimg = baseimg, diffimg = diffimg)
```

---

sizechange *Size change Function*

Description

TThis is a function that changes the resolution of the image.

Usage

```
sizechange(img1, simscale = NULL, refsize = NULL, ...)
```

Arguments

img1	a array or nifti class, which is a image data to be changed the size.
simscale	a numeric.
refsize	a vector with length 3, which is a size to be changed.
...	further arguments passed to or from other methods.

Details

sizechange requires the array data.

Examples

```
data(exbrain)
exbrain2 = sizechange(exbrain, simscale=1/2)
```

---

template *Brain Template*

Description

The data is the brain tempalte. This is an average brain image, and is mainly used for overlaying analysis results.

Usage

```
data(template)
```

Format

A array

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