

# Package ‘MetCirc’

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**Type** Package

**Title** Navigating mass spectral similarity in high-resolution MS/MS  
metabolomics data metabolomics data

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**Author** Thomas Naake <thomasnaake@gmail.com>,  
Johannes Rainer <johannes.rainer@eurac.edu> and Emmanuel Gaquerel  
<emmanuel.gaquerel@ibmp-cnrs.unistra.fr>

**Maintainer** Thomas Naake <thomasnaake@gmail.com>

**VignetteBuilder** knitr

**Depends** R (>= 4.4), amap (>= 0.8), circlize (>= 0.4.16), scales (>= 1.3.0), shiny (>= 1.8.1.1), Spectra (>= 1.15.3)

**Imports** ggplot2 (>= 3.5.1), MsCoreUtils (>= 1.17.0), S4Vectors (>= 0.43.1)

**Suggests** BiocGenerics, graphics (>= 4.4), grDevices (>= 4.4), knitr  
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**biocViews** ShinyApps, Metabolomics, MassSpectrometry, Visualization

**Description** MetCirc comprises a workflow to interactively explore high-resolution MS/MS metabolomics data. MetCirc uses the Spectra object infrastructure defined in the package Spectra that stores MS/MS spectra. MetCirc offers functionality to calculate similarity between precursors based on the normalised dot product, neutral losses or user-defined functions and visualise similarities in a circular layout. Within the interactive framework the user can annotate MS/MS features based on their similarity to (known) related MS/MS features.

**License** GPL (>= 3)

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|            |                                                               |
|------------|---------------------------------------------------------------|
| cart2Polar | <i>Calculate polar coordinates from cartesian coordinates</i> |
|------------|---------------------------------------------------------------|

---

**Description**

cart2Polar calculates polar coordinates from cartesian coordinates.

**Usage**

```
cart2Polar(x, y)
```

**Arguments**

|   |                                |
|---|--------------------------------|
| x | numeric cartesian x coordinate |
| y | numeric cartesian y coordinate |

**Details**

cart2Polar is employed to translate cartesian coordinates into polar coordinates especially in interactive shiny applications when using hovering and clicking features.

**Value**

cart2Polar returns a list of polar coordinates r and theta

**Author(s)**

Thomas Naake, <thomasnaake@gmail.com>

**Examples**

```
x <- 1; y <- 1  
cart2Polar(x, y)
```

---

|              |                                      |
|--------------|--------------------------------------|
| circosLegend | <i>Plot a legend for circos plot</i> |
|--------------|--------------------------------------|

---

**Description**

circosLegend plots a legend for circos plot using group names.

**Usage**

```
circosLegend(groupname, highlight = TRUE, colour = NULL, cex = 1)
```

**Arguments**

|           |                                                                                                                                                                                                                 |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| groupname | character vector containing "group" and "name" to display that is a unique identifier of the features, "group" and "name" have to be separated by "_" where "group" is the first and "name" is the last element |
| highlight | logical, should colours be adjusted to highlight settings?                                                                                                                                                      |
| colour    | NULL or character, colour defines the colours which are used for plotting, if NULL default colours are used                                                                                                     |
| cex       | numeric, parameter that controls size of the legend in the plot                                                                                                                                                 |

**Details**

Internal use in shinyCircos or outside of shinyCircos to reproduce figures.

**Value**

The function will open a new plot and display colours together with labels.

**Author(s)**

Thomas Naake, <thomasnaake@gmail.com>

**Examples**

```
data("spectra", package = "MetCirc")

## create similarity matrix
similarityMat <- Spectra::compareSpectra(sps_tissue[1:10],
  FUN = MsCoreUtils::ndotproduct, ppm = 20, m = 0.5, n = 2)
rownames(similarityMat) <- colnames(similarityMat) <- sps_tissue$name[1:10]

linkDf <- createLinkDf(similarityMatrix = similarityMat,
  sps = sps_tissue[1:10],
  condition = c("SPL", "LIM", "ANT", "STY"), lower = 0.01, upper = 1)

## cut link data.frame (here: only display links between groups)
linkDf_cut <- cutLinkDf(linkDf, type = "inter")
groupname <- c(as.character(linkDf_cut[, "spectrum1"]),
  as.character(linkDf_cut[, "spectrum2"]))
groupname <- unique(groupname)

## plot legend
circosLegend(groupname, highlight = TRUE, colour = NULL, cex = 1)
```

---

compartmentTissue*Example data for 'MetCirc': 'compartmentTissue'*

---

**Description**

The 'data.frame' 'compartmentTissue' is used in the subsection 'Preparing the tissue data set for analysis' in the vignette of 'MetCirc'. In 'compartmentTissue', information on the organ-localisation of each MS/MS spectrum is stored.

**Format**

'data.frame'

**Value**

'data.frame'

**Author(s)**

Thomas Naake, <thomasnaake@gmail.com>

**Source**

internal

---

convertExampleDF*Example data for 'MetCirc': convertExampleDF*

---

**Description**

'convertExampleDF' is a 'data.frame' which comprises information on a specific metabolite per row stating the average retention time, average m/z, the name of the metabolite, the adduct ion name and the spectrum reference file name. The function 'allocatePrecursor2mz' uses 'data.frame's of the kind of 'sd01\\_outputXCMS' and 'sd02\\_deconvoluted' to create a 'data.frame' of the kind of 'convertExampleDF'. Allocation of precursor ions to candidate m/z values is based on minimal distance of m/z and deviance of retention time based on an objective function. See '?allocatePrecursor2mz' for further information.

**Format**

'data.frame'

**Value**

'data.frame'

**Author(s)**

Thomas Naake, <thomasnaake@gmail.com>

**Source**

internal

---

|                    |                                                            |
|--------------------|------------------------------------------------------------|
| convertMsp2Spectra | <i>Convert MSP data frame into object of class Spectra</i> |
|--------------------|------------------------------------------------------------|

---

**Description**

Convert msp data frame into object of class [Spectra()]

**Usage**

```
convertMsp2Spectra(msp)
```

**Arguments**

|     |                                                                                    |
|-----|------------------------------------------------------------------------------------|
| msp | data.frame that mimicks the .msp file format, see Details for further information. |
|-----|------------------------------------------------------------------------------------|

**Details**

msp is a data frame of a .msp file, a typical data file for MS/MS libraries. The data frame has two columns and contains in the first column the entries "NAME:", "PRECURSORMZ:" (or "EXACTMASS:"), "RETENTIONTIME:", Num Peaks:" and information on fragments and peak areas/intensities and will extract the respective information in the second column.

**Value**

convertMsp2Spectra returns an object of class 'Spectra'

**Author(s)**

Thomas Naake, <thomasnaake@gmail.com>

**Examples**

```
data("convertMsp2Spectra", package = "MetCirc")
convertMsp2Spectra(msp = msp2spectra)
```

---

createLink0df*Create a link matrix*

---

## Description

Create a link matrix which links every feature in similarity matrix with another.

## Usage

```
createLink0df(similarityMatrix, sps, condition)
```

## Arguments

|                  |                                                                                                             |
|------------------|-------------------------------------------------------------------------------------------------------------|
| similarityMatrix | matrix, a similarity matrix that contains the NDP similarity measure between all precursors in the data set |
| sps              | Spectra object                                                                                              |
| condition        | character, which conditions should be included?                                                             |

## Details

createLink0df creates a matrix from a similarity matrix which includes all connections between features in the similarity matrix, but exclude links which have a similarity of exactly 0.

## Value

createLink0df returns a 'matrix' that gives per each row information on linked features

## Author(s)

Thomas Naake, <thomasnaake@googlemail.com>

## Examples

```
data("spectra", package = "MetCirc")
data("similarityMat", package = "MetCirc")
link0df <- createLink0df(similarityMatrix = similarityMat,
  sps = sps_tissue, condition = c("SPL", "LIM", "ANT", "STY"))
```

---

|              |                                                                      |
|--------------|----------------------------------------------------------------------|
| createLinkDf | <i>Create a data frame which contains features to link (indices)</i> |
|--------------|----------------------------------------------------------------------|

---

## Description

Create a data frame which contains features to link (indices).

## Usage

```
createLinkDf(similarityMatrix, sps, condition, lower, upper)
```

## Arguments

|                  |                                                                                                          |
|------------------|----------------------------------------------------------------------------------------------------------|
| similarityMatrix | matrix, a similarity matrix that contains the similarity measure between all precursors in the data set  |
| sps              | Spectra object containing spectral data corresponding to features in similarityMatrix                    |
| condition        | character vector containing the conditions/samples for which a linkDf is created                         |
| lower            | numeric(1), threshold value for similarity values, linked features below this value will not be included |
| upper            | numeric(1), threshold value for similarity values, linked features above this value will not be included |

## Details

lower and upper are numerical values and truncate spectra based on their similarity. The function createLinkDf is a wrapper for the functions createLink0df and thresholdLinkDf.

## Value

createLinkDf returns a data.frame that gives per each row information on linked features

## Author(s)

Thomas Naake, <thomasnaake@gmail.com>

## Examples

```
data("spectra", package = "MetCirc")
data("similarityMat", package = "MetCirc")
link0df <- createLink0df(similarityMatrix = similarityMat,
  sps = sps_tissue, condition = c("SPL", "LIM", "ANT", "STY"))
createLinkDf(similarityMatrix = similarityMat, sps = sps_tissue,
  condition = c("SPL", "LIM", "ANT", "STY"), lower = 0.5, upper = 1)
```



---

|           |                                                   |
|-----------|---------------------------------------------------|
| cutLinkDf | Create a cut data frame with information on links |
|-----------|---------------------------------------------------|

---

## Description

Create a cut link data frame

## Usage

```
cutLinkDf(linkDf, type = c("all", "inter", "intra"))
```

## Arguments

|        |                                                                    |
|--------|--------------------------------------------------------------------|
| linkDf | data.frame, that gives per each row information on linked features |
| type   | character, one of "all", "inter" or "intra"                        |

## Details

This function is used to truncate features from linkDf. If type = "all", linkDf will not be changed; if type = "inter" the returned linkDf will only contain entries of links which are between groups and not inside groups; contrary to that, if type = "intra" the returned linkDf will only contain entries of links which are inside groups and not between groups.

## Value

cutLinkDf returns a data.frame that gives per each row information on linked features

## Author(s)

Thomas Naake, <thomasnaake@gmail.com>

## Examples

```
data("spectra", package = "MetCirc")
data("similarityMat", package = "MetCirc")
linkDf <- createLinkDf(similarityMatrix = similarityMat,
  sps = sps_tissue, condition = c("SPL", "LIM", "ANT", "STY"),
  lower = 0.75, upper = 1)
cutLinkDf(linkDf = linkDf, type = "all")
```

---

|                  |                                         |
|------------------|-----------------------------------------|
| getLinkDfIndices | <i>Get indices in linkDf of feature</i> |
|------------------|-----------------------------------------|

---

## Description

Gets indices in linkDf of feature

## Usage

```
getLinkDfIndices(groupnamesselected, linkDf)
```

## Arguments

|                    |                                                                                                                                                                                                                                                             |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| groupnamesselected | character vector with groupname of selected feature, vector containing "group" and "name" to display, that is a unique identifier of the features, "group" and "name" have to be separated by "_" where "group" is the first and "name" is the last element |
| linkDf             | data.frame, in each row there is information about features to be connected                                                                                                                                                                                 |

## Details

Internal use for function highlight

## Value

getLinkDfIndices returns indices concerning linkDf to which groupnamesselected connects

## Author(s)

Thomas Naake, <thomasnaake@gmail.com>

## Examples

```
## Not run: getLinkDfIndices(groupnamesselected, linkMatrix)
```

---

**highlight***Add links and highlight sectors*

---

**Description**

A function to add links and highlight sectors to an initialised and plotted circize plot with one track.

**Usage**

```
highlight(  
  groupname,  
  ind,  
  linkDf,  
  colour = NULL,  
  transparency = 0.4,  
  links = TRUE  
)
```

**Arguments**

|              |                                                                                                                                                                                                                 |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| groupname    | character vector containing "group" and "name" to display that is a unique identifier of the features, "group" and "name" have to be separated by "_" where "group" is the first and "name" is the last element |
| ind          | numeric, indices which will be highlighted                                                                                                                                                                      |
| linkDf       | data.frame, in each row there is information about features to be connected                                                                                                                                     |
| colour       | NULL or character, colour defines the colours which are used for plotting, if 'NULL' default colours are used                                                                                                   |
| transparency | numeric, defines the transparency of the colours                                                                                                                                                                |
| links        | logical, should links of unselected features be plotted                                                                                                                                                         |

**Details**

Internal use for shinyCircos or outside of shinyCircos to reproduce the figure.

**Value**

The function will update an existing plot by highlighting a specified sector and connected links.

**Author(s)**

Thomas Naake, <thomasnaake@gmail.com>

## Examples

```
data("spectra", package = "MetCirc")

## create similarity matrix
similarityMat <- Spectra::compareSpectra(sps_tissue[1:10],
  FUN = MsCoreUtils::ndotproduct, ppm = 20, m = 0.5, n = 2)
rownames(similarityMat) <- colnames(similarityMat) <- sps_tissue$name[1:10]

## order similarityMat according to retentionTime and update rownames
simM <- orderSimilarityMatrix(similarityMat, sps = sps_tissue[1:10],
  type = "retentionTime")

## create link matrix
linkDf <- createLinkDf(similarityMatrix = simM, sps = sps_tissue,
  condition = c("SPL", "LIM", "ANT", "STY"), lower = 0.01, upper = 1)

## cut link matrix (here: only display links between groups)
linkDf_cut <- cutLinkDf(linkDf, type = "inter")

## set circlize parameters
circos.clear()
circos.par(gap.degree = 0, cell.padding = c(0.0, 0, 0.0, 0),
  track.margin = c(0.0, 0))
groupname <- c(as.character(linkDf_cut[, "spectrum1"]),
  as.character(linkDf_cut[, "spectrum2"]))
groupname <- unique(groupname)

## here: set indSelected arbitrarily
indSelected <- c(2,3)

## actual plotting
plotCircos(groupname, linkDf_cut, initialize = TRUE,
  featureNames = TRUE, cexFeatureNames = 0.2, groupSector = TRUE,
  groupName = FALSE, links = FALSE, highlight = TRUE)

## highlight
highlight(groupname = groupname, ind = indSelected, linkDf = linkDf_cut,
  colour = NULL, transparency = 0.4, links = TRUE)
```

---

minFragCart2Polar

*Calculate the nearest feature in polar coordinates given cartesian coordinates*


---

## Description

Calculates the nearest feature in polar coordinates given cartesian coordinates.

## Usage

```
minFragCart2Polar(x, y, degreeOfFeatures)
```

**Arguments**

x                    numeric, cartesian x coordinate  
 y                    numeric, cartesian y coordinate  
 degreeOfFeatures    list of positions of features

**Details**

minFragCart2Polar is employed to find the feature with the smallest distance from given cartesian coordinates.

**Value**

minFragCart2Polar returns the index of the feature that has the smallest distance to the given coordinates. As minFragCart2Polar is used in shinyCircos for the track 1 only polar r coordinates between 0.8 and 1 will be used to find the feature with smallest distance.

**Author(s)**

Thomas Naake, <thomasnaake@gmail.com>

**Examples**

```

library("MsCoreUtils")
data("spectra", package = "MetCirc")

## create similarity matrix
similarityMat <- Spectra::compareSpectra(sps_tissue[1:10],
  FUN = MsCoreUtils::ndotproduct, ppm = 20, m = 0.5, n = 2)
rownames(similarityMat) <- colnames(similarityMat) <- sps_tissue$name[1:10]

linkDf <- createLinkDf(similarityMatrix = similarityMat,
  sps = sps_tissue[1:10],
  condition = c("SPL", "LIM", "ANT", "STY"), lower = 0.5, upper = 1)

## cut link data.frame (here: only display links between groups)
linkDf_cut <- cutLinkDf(linkDf, type = "inter")
groupname <- c(as.character(linkDf_cut[, "spectrum1"]),
  as.character(linkDf_cut[, "spectrum2"]))
groupname <- unique(groupname)

## set circlize parameters
circos.clear()
circos.par(gap.degree = 0, cell.padding = c(0.0, 0, 0.0, 0),
  track.margin = c(0.0, 0))
plotCircos(groupname, NULL, initialize = TRUE, featureNames = FALSE,
  groupName = FALSE, groupSector = FALSE, links = FALSE, highlight = FALSE)
x <- 1
y <- 0
degreeFeatures <- lapply(groupname,
  function(x)

```

```
mean(circlize:::get.sector.data(x)[c("start.degree", "end.degree")]))
minFragCart2Polar(x, y, degreeOfFeatures = degreeFeatures)
```

---

msp2spectra

*Example data for 'MetCirc': 'msp2spectra'*


---

### Description

'convertMsp2Spectra' contains the object 'msp2spectra' that is a data frame in .MSP format, a typical format for MS/MS library building. Each entry consists of the metabolite name (NAME), the precursor mz (PRECURSORMZ), the retention time (RETENTIONTIME), number of peaks (Num Peaks), together with fragments and their intensity values. In the example used in the function 'convertMsp2Spectra' the 'data.frame' 'msp2spectra' is used to construct an object of class 'MSpectra'.

### Format

'data.frame'

### Value

'data.frame'

### Author(s)

Thomas Naake, <thomasnaake@gmail.com>

### Source

[http://prime.psc.riken.jp/Metabolomics\\_Software/MS-DIAL/](http://prime.psc.riken.jp/Metabolomics_Software/MS-DIAL/), truncated .MSP file of GNPS MS/MS Negative (contains 22 entries): [http://prime.psc.riken.jp/Metabolomics\\_Software/MS-DIAL/MSMS-GNPS-Curated-Neg.msp](http://prime.psc.riken.jp/Metabolomics_Software/MS-DIAL/MSMS-GNPS-Curated-Neg.msp)

---

neutralloss

*Calculate similarity based on neutral losses*


---

### Description

Calculate similarity based on neutral losses (NLS)

### Usage

```
neutralloss(x, y, m = 0.5, n = 2, na.rm = TRUE, ...)
```

**Arguments**

|       |                                                                                        |
|-------|----------------------------------------------------------------------------------------|
| x     | Spectra object from Spectra containing intensity and m/z values, first MS/MS spectrum  |
| y     | Spectra object from Spectra containing intensity and m/z values, second MS/MS spectrum |
| m     | numeric(1), exponent to calculate peak intensity-based weights                         |
| n     | numeric(1), exponent to calculate m/z-based weights                                    |
| na.rm | logical(1), if NA values should be removed                                             |
| ...   | further arguments                                                                      |

**Details**

Similarities of spectra based on neutral losses are calculated according to the following formula:

$$NLS = \frac{\sum (W_{S1,i} \cdot W_{S2,i})^2}{\sum (W_{S1,i}^2) \cdot \sum (W_{S2,i}^2)}$$

,  
with  $W = [peakintensity]^m \cdot [NL]^n$  and  $NL = |m/z - precursor m/z|$ . For further information see Li et al. (2015): Navigating natural variation in herbivory-induced secondary metabolism in coyote tobacco populations using MS/MS structural analysis. PNAS, E4147–E4155.

In here, the precursor m/z is taken by the m/z feature with the highest intensity.

neutralloss returns a numeric value ranging between 0 and 1, where 0 indicates no similarity between the two MS/MS features, while 1 indicates that the MS/MS features are identical. Prior to calculating

$$W_{S1}$$

or

$$W_{S2}$$

, all intensity values are divided by the maximum intensity value.

**Value**

neutralloss returns a numeric similarity coefficient between 0 and 1

**Author(s)**

Thomas Naake, <thomasnaake@gmail.com>

**Examples**

```
data("spectra", package = "MetCirc")
Spectra::compareSpectra(sps_tissue[1:10], FUN = neutralloss, m = 0.5, n = 2)
```

---

`orderSimilarityMatrix` *Order columns and rows of a similarity matrix according to m/z, retention time and clustering*

---

## Description

Internal function for shiny application. May also be used outside of shiny to reconstruct figures.

## Usage

```
orderSimilarityMatrix(
  similarityMatrix,
  sps,
  type = c("retentionTime", "mz", "clustering"),
  group = FALSE
)
```

## Arguments

|                               |                                                                                                                                                                                                                                                                                                                                                    |
|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>similarityMatrix</code> | matrix, <code>similarityMatrix</code> contains pair-wise similarity coefficients which give information about the similarity between precursors                                                                                                                                                                                                    |
| <code>sps</code>              | Spectra object containing spectra that are compared in <code>similarityMatrix</code>                                                                                                                                                                                                                                                               |
| <code>type</code>             | character(1), one of "retentionTime", "mz", or "clustering"                                                                                                                                                                                                                                                                                        |
| <code>group</code>            | logical(1), if TRUE group separated by "_" will be cleaved from rownames/colnames of <code>similarityMatrix</code> and matched against names of <code>sps</code> ( <code>sps\$name</code> ), if FALSE rownames/colnames of <code>similarityMatrix</code> are taken as are and matched against names of <code>sps</code> ( <code>sps\$name</code> ) |

## Details

`orderSimilarityMatrix` takes a similarity matrix, Spectra object (`sps`, containing information on m/z and retention time), and a character vector as arguments. It will then reorder rows and columns of the `similarityMatrix` object such, that it orders rows and columns of `similarityMatrix` according to m/z, retention time or clustering in each group.

`orderSimilarityMatrix` is employed in the `shinyCircos` function to create `similarityMatrix` objects which will allow to switch between different types of ordering in between groups (sectors) in the circos plot. It may be used as well externally, to reproduce plots outside of the reactive environment (see vignette for a workflow).

## Value

matrix, `orderSimilarityMatrix` returns a similarity matrix with ordered rownames according to the character vector type



**Author(s)**

Thomas Naake, <thomasnaake@googlemail.com>

**Examples**

```
data("spectra", package = "MetCirc")
similarityMat <- Spectra::compareSpectra(sps_tissue[1:10],
  FUN = MsCoreUtils::ndotproduct, ppm = 10)
rownames(similarityMat) <- colnames(similarityMat) <- sps_tissue$name[1:10]

## order according to retention time
orderSimilarityMatrix(similarityMatrix = similarityMat,
  sps = sps_tissue, type = "retentionTime", group = FALSE)
```

---

plotCircos

---

*Circular plot to visualize similarity*


---

**Description**

Circular plot to visualize similarity.

**Usage**

```
plotCircos(
  groupname,
  linkDf,
  initialize = c(TRUE, FALSE),
  featureNames = c(TRUE, FALSE),
  cexFeatureNames = 0.3,
  groupSector = c(TRUE, FALSE),
  groupName = c(TRUE, FALSE),
  links = c(TRUE, FALSE),
  highlight = c(TRUE, FALSE),
  colour = NULL,
  transparency = 0.2
)
```

**Arguments**

|              |                                                                                                                                                                                                                 |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| groupname    | character vector containing "group" and "name" to display that is a unique identifier of the features, "group" and "name" have to be separated by "_" where "group" is the first and "name" is the last element |
| linkDf       | data.frame containing linked features in each row, has five columns (group1, spectrum1, group2, spectrum2, similarity)                                                                                          |
| initialize   | logical, should plot be initialized?                                                                                                                                                                            |
| featureNames | logical, should feature names be displayed?                                                                                                                                                                     |

|                 |                                                                                                             |
|-----------------|-------------------------------------------------------------------------------------------------------------|
| cexFeatureNames | numeric size of feature names                                                                               |
| groupSector     | logical, should groups be displayed with background colours?                                                |
| groupName       | logical, should group names (e.g. compartment names or individual names) be displayed?                      |
| links           | logical, should links be plotted?                                                                           |
| highlight       | logical, highlight is set to TRUE by default                                                                |
| colour          | NULL or character, colour defines the colours which are used for plotting, if NULL default colours are used |
| transparency    | numeric, defines the transparency of the colours                                                            |

### Details

Internal use for shinyCircos or used outside of shinyCircos to reproduce figure

### Value

The function will initialize a circlize plot and/or will plot features of a circlize plot.

### Author(s)

Thomas Naake, <thomasnaake@gmail.com>

### Examples

```
library("MsCoreUtils")
data("spectra", package = "MetCirc")

## create similarity matrix
similarityMat <- Spectra::compareSpectra(sps_tissue[1:10],
  FUN = MsCoreUtils::ndotproduct, ppm = 20, m = 0.5, n = 2)
rownames(similarityMat) <- colnames(similarityMat) <- sps_tissue$name[1:10]

## order similarityMat according to retentionTime
simM <- orderSimilarityMatrix(similarityMat, sps = sps_tissue[1:10],
  type = "retentionTime")

## create link data.frame
linkDf <- createLinkDf(similarityMatrix = simM, sps = sps_tissue,
  condition = c("SPL", "LIM", "ANT", "STY"), lower = 0.01, upper = 1)
## cut link data.frame (here: only display links between groups)
linkDf_cut <- cutLinkDf(linkDf, type = "inter")

## set circlize paramters
circos.clear()
circos.par(gap.degree = 0, cell.padding = c(0.0, 0, 0.0, 0),
  track.margin = c(0.0, 0))
groupname <- c(as.character(linkDf_cut[, "spectrum1"]),
  as.character(linkDf_cut[, "spectrum2"]))
groupname <- unique(groupname)
```

```
## actual plotting
plotCircos(groupname, linkDf_cut, initialize = TRUE,
  featureNames = TRUE, cexFeatureNames = 0.3, groupSector = TRUE,
  groupName = FALSE, links = FALSE, highlight = FALSE, colour = NULL,
  transparency = 0.2)
```

---

|             |                               |
|-------------|-------------------------------|
| plotSpectra | <i>Plot pair-wise spectra</i> |
|-------------|-------------------------------|

---

### Description

plotSpectra plots a spectra of a subject and query spectra. plotSpectra uses ggplot plotting functionality.

### Usage

```
plotSpectra(sps, subject, query)
```

### Arguments

|         |                                                                                             |
|---------|---------------------------------------------------------------------------------------------|
| sps     | Spectra object                                                                              |
| subject | character, name of spectra that is aligned against, character with preceding sample name    |
| query   | character, name of spectra that is aligned to subject, character with preceding sample name |

### Details

Internally, all intensities are normalized to 100%.

### Value

ggplot2 plot

### Author(s)

Thomas Naake, <thomasnaake@googlemail.com>

### Examples

```
data("spectra", package = "MetCirc")
plotSpectra(sps = sps_tissue, subject = "SPL_1", query = "SPL_2")
```

```
printInformationSelect
```

*Display information on connected features of selected features*

---

## Description

Displays information on connected features of selected features.

## Usage

```
printInformationSelect(  
  select,  
  sps = NULL,  
  linkDfInd,  
  linkDf,  
  similarityMatrix,  
  roundDigits = 2  
)
```

## Arguments

|                               |                                                                                                                                                                                         |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>select</code>           | character, obtained from <code>groupname</code> , character of selected feature                                                                                                         |
| <code>sps</code>              | Spectra object containing spectra that are compared in <code>similarityMatrix</code>                                                                                                    |
| <code>linkDfInd</code>        | numeric indices of selected features                                                                                                                                                    |
| <code>linkDf</code>           | <code>data.frame</code> that contains information of linked features for given thresholds                                                                                               |
| <code>similarityMatrix</code> | matrix that is used to get information on the degree of similarity, <code>similarityMatrix</code> is an ordered version of a similarity matrix, see <code>?orderSimilarityMatrix</code> |
| <code>roundDigits</code>      | <code>numeric(1)</code> , how many digits should be displayed?                                                                                                                          |

## Details

`printInformationSelect` is for internal use.

## Value

character that is in HTML format

## Author(s)

Thomas Naake, <thomasnaake@googlemail.com>

**Examples**

```

data("spectra", package = "MetCirc")
sps_tissue@metadata$names <- rep("Unknown", 259)
sps_tissue@metadata$information <- rep("Unknown", 259)
sps_tissue@metadata$classes <- rep("Unknown", 259)
sps_tissue@metadata$adduct <- rep("Unknown", 259)
similarityMat <- Spectra::compareSpectra(sps_tissue[1:10],
  FUN = MsCoreUtils::ndotproduct, ppm = 20, m = 0.5, n = 2)
rownames(similarityMat) <- colnames(similarityMat) <- sps_tissue$name[1:10]
linkDf <- createLinkDf(similarityMatrix = similarityMat,
  sps = sps_tissue[1:10],
  condition = c("SPL", "LIM", "ANT", "STY"), lower = 0.01, upper = 1)

## cut link data.frame (here: only display links between groups)
linkDf_cut <- cutLinkDf(linkDf, type = "inter")
groupname <- c(as.character(linkDf_cut[, "spectrum1"]),
  as.character(linkDf_cut[, "spectrum2"]))
groupname <- unique(groupname)

## arbitrarily select a feature
ind <- 2
linkDfInds <- getLinkDfIndices(groupname[ind], linkDf_cut)
MetCirc:::printInformationSelect(select = groupname[ind],
  sps = sps_tissue[1:10], linkDfInd = linkDfInds,
  linkDf = linkDf_cut, similarityMatrix = similarityMat)

```

---

recordPlotFill\_degreeFeatures

*Record a plot of filled features and the degree of features*


---

**Description**

recordPlotFill\_degreeFeatures records a plot of filled features and returns the degree of features.

**Usage**

```
recordPlotFill_degreeFeatures(type_match, ...)
```

**Arguments**

|            |                                             |
|------------|---------------------------------------------|
| type_match | character, ordered vector according to type |
| ...        | further arguments passed to plotCircos      |

**Details**

Helper function for shinyCircos.

**Value**

list of length 2, entry plotFill is of recordedplot and entry degreeFeatures is a list of vectors of numeric(1)

**Author(s)**

Thomas Naake, <thomasnaake@gmail.com>

**Examples**

```
type_match <- c("a_1", "a_2", "a_3", "b_1", "b_2", "b_3", "c_1", "c_2")
MetCirc:::recordPlotFill_degreeFeatures(type_match)
```

---

|                     |                                                                       |
|---------------------|-----------------------------------------------------------------------|
| recordPlotHighlight | <i>Return a recordedplot of plotCircos plot with highlight = TRUE</i> |
|---------------------|-----------------------------------------------------------------------|

---

**Description**

recordPlotHighlight returns a recordedplot object of plotCircos with highlight = TRUE

**Usage**

```
recordPlotHighlight(type_match, ...)
```

**Arguments**

|            |                                             |
|------------|---------------------------------------------|
| type_match | character, ordered vector according to type |
| ...        | further arguments passed to plotCircos      |

**Details**

Helper function for shinyCircos.

**Value**

recordedplot

**Author(s)**

Thomas Naake, <thomasnaake@gmail.com>

**Examples**

```
type_match <- c("a_1", "a_2", "a_3", "b_1", "b_2", "b_3", "c_1", "c_2")
MetCirc:::recordPlotHighlight(type_match)
```

---

|               |                                     |
|---------------|-------------------------------------|
| replayPlotAdd | <i>Plot plotCircos or highlight</i> |
|---------------|-------------------------------------|

---

## Description

replayPlotAdd plots additional plots on a plot, either plots plotCircos or highlight.

## Usage

```
replayPlotAdd(
  orderMatch = "mz",
  onCircle = FALSE,
  linkDf,
  mz_match,
  rt_match,
  clust_match,
  ind,
  indMz,
  indRT,
  indCluster
)
```

## Arguments

|             |                                                                                                                                                                         |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| orderMatch  | character(1), either "mz", "retentionTime", or "clustering"                                                                                                             |
| onCircle    | logical, are coordinates on circle. If FALSE and no features are selected (length(ind) == 0), then filled plots are replayed, otherwise highlighted plots are replayed. |
| linkDf      | data.frame that contains information of linked features for given thresholds                                                                                            |
| mz_match    | character, ordered vector according to m/z                                                                                                                              |
| rt_match    | character, ordered vector according to retention time                                                                                                                   |
| clust_match | character, ordered vector according to clustering                                                                                                                       |
| ind         | numeric, indices of clicked features                                                                                                                                    |
| indMz       | numeric, indices of clicked features for "mz" ordering                                                                                                                  |
| indRT       | numeric, indices of clicked features for "retentionTime" ordering                                                                                                       |
| indCluster  | numeric, indices of clicked features for "clustering" ordering                                                                                                          |

## Details

Helper function for shinyCircos.

## Value

Depending on onCircle and indMz either returns plotCircos or highlight

**Author(s)**

Thomas Naake, <thomasnaake@googlemail.com>

**Examples**

```
data("spectra", package = "MetCirc")
similarityMat <- Spectra::compareSpectra(sps_tissue[1:10],
  FUN = MsCoreUtils::ndotproduct, ppm = 10, m = 0.5, n = 2)
rownames(similarityMat) <- colnames(similarityMat) <- sps_tissue$name[1:10]

## order according to m/z
mz_match <- MetCirc:::typeMatch_link0(similarityMatrix = similarityMat,
  sps = sps_tissue, type = "mz",
  condition = c("SPL", "LIM", "ANT", "STY"))
linkDf <- mz_match[["link0df"]]
mz_match <- mz_match[["type_match"]]

## order according to retention time
rt_match <- MetCirc:::typeMatch_link0(similarityMatrix = similarityMat,
  sps = sps_tissue, type = "retentionTime",
  condition = c("SPL", "LIM", "ANT", "STY"))
rt_match <- rt_match[["type_match"]]

## order according to clustering
clust_match <- MetCirc:::typeMatch_link0(similarityMatrix = similarityMat,
  sps = sps_tissue, type = "clustering",
  condition = c("SPL", "LIM", "ANT", "STY"))
clust_match <- clust_match[["type_match"]]
circos.initialize(mz_match,##, levels = mz_match),
  xlim = matrix(rep(c(0,1), length(mz_match)), ncol = 2, byrow = TRUE))
#circos.trackPlotRegion(factor(mz_match, levels = mz_match), ylim = c(0,1))
MetCirc:::replayPlotAdd(orderMatch = "mz", onCircle = FALSE, linkDf = linkDf,
  mz_match = mz_match, rt_match = rt_match, clust_match = clust_match,
  ind = 1, indMz = NULL, indRT = NULL, indCluster = NULL)
```

---

replayPlotOrder

*Wrapper for replayPlot*


---

**Description**

replayPlotOrder will call replayPlot from grDevices with a recordedplot object based on orderMatch.

**Usage**

```
replayPlotOrder(orderMatch = "mz", onCircle = FALSE, plot_l, ind)
```



**Arguments**

|            |                                                                                                                                                                         |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| orderMatch | character, either "mz", "retentionTime" or "clustering"                                                                                                                 |
| onCircle   | logical, are coordinates on circle. If FALSE and no features are selected (length(ind) == 0), then filled plots are replayed, otherwise highlighted plots are replayed. |
| plot_l     | list with plots                                                                                                                                                         |
| ind        | numeric, indices of clicked features                                                                                                                                    |

**Details**

Helper function for shinyCircos.

**Value**

replayedplot

**Author(s)**

Thomas Naake, <thomasnaake@googlemail.com>

**Examples**

```
type_match <- c("a_1", "a_2", "a_3", "b_1", "b_2", "b_3", "c_1", "c_2")
plotCircos(type_match, NULL, initialize = TRUE, featureNames = TRUE,
  groupSector = TRUE, groupName = FALSE, links = FALSE,
  highlight = TRUE)
p <- recordPlot()
plot.new()
plot_l <- list(highlightMz = p)
MetCirc::replayPlotOrder(orderMatch = "mz", onCircle = TRUE,
  plot_l = plot_l, ind = NULL)
```

---

sd01\_outputXCMS

---

*Example data for 'MetCirc': 'sd01\_outputXCMS'*


---

**Description**

'sd01\_outputXCMS' is the output file from the package 'XCMS' using the data from Li et al. (2015). See Li et al. (2015) for further details.

**Format**

'data.frame'

**Value**

'data.frame'

**Author(s)**

Thomas Naake, <thomasnaake@gmail.com>

**Source**

Li et al. (2015)

---

|                   |                                                      |
|-------------------|------------------------------------------------------|
| sd02_deconvoluted | <i>Example data for 'MetCirc': sd02_deconvoluted</i> |
|-------------------|------------------------------------------------------|

---

**Description**

'sd02\_deconvoluted' contains MS/MS data from Li et al. (2015). It is a 'data.frame' which hosts m/z values, retention time, intensity and the respective precursor m/z values. 'sd02\_deconvoluted' originates from Li et al. (2015). See Li et al. (2015) for further information.

**Format**

'data.frame'

**Value**

'data.frame'

**Author(s)**

Thomas Naake, <thomasnaake@gmail.com>

**Source**

Li et al. (2015)

---

|        |                                           |
|--------|-------------------------------------------|
| select | <i>Select variable based on condition</i> |
|--------|-------------------------------------------|

---

**Description**

select returns mz, rt or clust depending on condition.

**Usage**

```
select(condition, mz, rt, clust)
```

**Arguments**

|           |                                                             |
|-----------|-------------------------------------------------------------|
| condition | character(1), either "mz", "retentionTime", or "clustering" |
| mz        | object to return if condition == "mz"                       |
| rt        | object to return if condition == "retentionTime"            |
| clust     | object to return if condition == "clustering"               |

**Details**

Helper function for shinyCircos, replayPlotOrder and replayPlotAdd.

**Value**

mz, rt or clust depending on condition

**Author(s)**

Thomas Naake <thomasnaake@gmail.com>

**Examples**

```
mz <- 1
rt <- 2
clust <- 3
MetCirc::select(condition = "mz", mz = mz, rt = rt, clust = clust)
```

---

shinyCircos

---

*Interactive visualisation of similarity and navigation of MS/MS features*


---

**Description**

Visualise the similarity of MS/MS features in a reactive context. See Details the vignette for further descriptions on how to use shinyCircos.

**Usage**

```
shinyCircos(similarityMatrix, sps, condition, ...)
```

**Arguments**

|                  |                                                                                                                                        |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| similarityMatrix | matrix, similarityMatrix contains pair-wise similarity coefficients which give information about the similarity between MS/MS features |
| sps              | Spectra, sps will be used to display information about the selected feature and will store information of annotation                   |
| condition        | character vector, specifies which conditions/samples are displayed                                                                     |
| ...              | further arguments passed to shinyCircos, e.g. cexFeatureNames to pass to plotCircos to set font size in plotCircos of feature names    |

## Details

The function is based on the shiny and circlize package. The user can choose interactively thresholds, type of links (between or within groups), display information about MS/MS features, permanently select MS/MS features and export selected precursors. The Spectra object stores annotation information about the MS/MS features. Names of features within the similarityMatrix have to be found as entries in Spectra. sps\$name are used as identifiers and colnames/rownames from similarityMatrix are cleaved by the group identifier (separated by "\_"). Annotation information is taken from spectra from the columns "names", "information", "classes" and "adduct" in the slot metadata of spectra. After exiting the application, the annotation will be written to the respective columns in the slot metadata. If one or several of these columns is already present in metadata, the column(s) will be used as the source of annotation information.

## Value

character, shinyCircos returns a character vector with the permanently selected precursors and an object with the MSpectra object containing the annotation.

## Author(s)

Thomas Naake, <thomasnaake@googlemail.com>

## Examples

```
data("spectra", package = "MetCirc")
similarityMat <- Spectra::compareSpectra(sps_tissue[1:10],
  FUN = MsCoreUtils::ndotproduct, ppm = 10, m = 0.5, n = 2)
rownames(similarityMat) <- colnames(similarityMat) <- sps_tissue$name[1:10]
## Not run:
shinyCircos(similarityMatrix = similarityMat,
  sps = sps_tissue, condition = c("SPL", "LIM", "ANT", "STY"))

## End(Not run)
```

---

similarityMat

*Example data for 'MetCirc': 'similarityMat'*

---

## Description

'similarityMat' is a 'matrix' containing the pair-wise similarity scores derived from the 'idMSM-Stissueproject' data set. See the vignette for a workflow to reproduce the object 'similarityMat'.

## Format

'matrix'

## Value

'matrix'

**Author(s)**

Thomas Naake, <thomasnaake@gmail.com>

**Source**

```
data("spectra", package = "MetCirc") similarityMat <- Spectra::compareSpectra(sps_tissue, fun =
ndotproduct, ppm = 10) rownames(similarityMat) <- colnames(similarityMat) <- sps_tissue$name
save(similarityMat, file = "similarityMat.RData", compress = "xz")
```

---

|                  |                                                        |
|------------------|--------------------------------------------------------|
| spectraCondition | <i>Get MS/MS spectra that are present in condition</i> |
|------------------|--------------------------------------------------------|

---

**Description**

spectraCondition returns the names of Spectra that are present in condition, corresponding to the slot metadata.

**Usage**

```
spectraCondition(sps, condition)
```

**Arguments**

|           |                                                                         |
|-----------|-------------------------------------------------------------------------|
| sps       | Spectra object of Spectra package                                       |
| condition | character, vector with conditions found as columns in the metadata slot |

**Details**

Helper function in createLink0df and shinyCircos.

**Value**

list, named list with character vector as entries that contains the names of the MS/MS entries in spectra that are present in the condition (tissues, stress conditions, time points, etc.)

**Author(s)**

Thomas Naake <thomasnaake@gmail.com>

**Examples**

```
data("spectra", package = "MetCirc")
MetCirc::spectraCondition(sps = sps_tissue,
  condition = c("SPL", "LIM", "ANT", "STY"))
```

sps\_tissue

*Example data for 'MetCirc': 'sps\_tissue'***Description**

'sps\_tissue' is a 'Spectra' object derived from the 'idMSMStissueproject' data set. See the vignette for a workflow to reproduce the object 'spectra'.

**Format**

'matrix'

**Value**

'matrix'

**Author(s)**

Thomas Naake, <thomasnaake@gmail.com>

**Source**

```
data("idMSMStissueproject", package = "MetCirc") ## get all MS/MS spectra
tissue <- tissue[tissue[, "id"] == id_uniq, "id"]
id_uniq <- unique(tissue[, "id"])

## obtain precursor m/z from id_uniq
prec_mz <- lapply(strsplit(as.character(id_uniq), split = "_"),
  "[", 1) >> unlist() >> as.numeric()

## obtain m/z from fragments per precursor m/z
mz_l <- lapply(id_uniq, function(id_i) tissue[tissue[, "id"] == id_i, "mz"])

## obtain corresponding intensity values
int_l <- lapply(id_uniq, function(id_i) tissue[tissue[, "id"] == id_i, "intensity"])

## order m/z and intensity values
int_l <- lapply(seq_along(int_l), function(i) int_l[[i]][order(mz_l[[i]])])
mz_l <- lapply(seq_along(mz_l), function(i) sort(mz_l[[i]]))

## obtain retention time by averaging all retention time values
rt <- lapply(id_uniq, function(id_i) tissue[tissue[, "id"] == id_i, "rt"]) >> lapply(mean) >> unlist()

## create list of Spectra objects and concatenate
sps_l <- lapply(seq_len(length(mz_l)), function(i)
  spd <- S4Vectors::DataFrame( name = as.character(i), rtime = rt[i], msLevel = 2L, precursorMz =
    prec_mz[i])
  spd$mz <- list(mz_l[[i]])
  spd$intensity <- list(int_l[[i]])
  Spectra::Spectra(spd))
sps_tissue <- Reduce(c, sps_l)

## combine list of spectrum2 objects to MSpectra object, ## use SPL, LIM, ANT, STY for further analysis
sps_tissue@metadata <- data.frame( compartmentTissue[, c("SPL", "LIM", "ANT", "STY")])

save(sps_tissue, file = "spectra.RData", compress = "xz")
```

---

|                 |                                                               |
|-----------------|---------------------------------------------------------------|
| thresholdLinkDf | <i>Threshold a data frame containing information on links</i> |
|-----------------|---------------------------------------------------------------|

---

## Description

Threshold a link data frame based on lower and upper similarity values. The function will return the links that lie within the defined bounds.

## Usage

```
thresholdLinkDf(link0df, lower = 0.75, upper = 1)
```

## Arguments

|         |                                                                                                       |
|---------|-------------------------------------------------------------------------------------------------------|
| link0df | data.frame, a link data frame that gives per each row information on linked features                  |
| lower   | numeric, threshold value for similarity values, below this value linked features will not be returned |
| upper   | numeric, threshold value for similarity values, above this value linked features will not be returned |

## Details

lower and upper are numerical values and truncate mass spectra based on their similarity values.

## Value

thresholdLinkDf returns a data.frame that gives per each row information on linked features which are linked within certain thresholds.

## Author(s)

Thomas Naake, <thomasnaake@googlemail.com>

## Examples

```
data("spectra", package = "MetCirc")
data("similarityMat", package = "MetCirc")
link0df <- createLink0df(similarityMatrix = similarityMat,
  sps_tissue, condition = c("SPL", "LIM", "ANT", "STY"))
thresholdLinkDf(link0df = link0df, lower = 0.5, upper = 1)
```

---

|        |                                             |
|--------|---------------------------------------------|
| tissue | <i>Example data for 'MetCirc': 'tissue'</i> |
|--------|---------------------------------------------|

---

**Description**

The 'data.frame' 'tissue' is used in the subsection 'Preparing the tissue data set for analysis' in the vignette of 'MetCirc'. MS/MS data are merged across floral organs in this 'data.frame'.

**Format**

'data.frame'

**Value**

'data.frame'

**Author(s)**

Thomas Naake, <thomasnaake@gmail.com>

**Source**

internal

---

|                 |                                           |
|-----------------|-------------------------------------------|
| typeMatch_link0 | <i>Get typeMatch and link0 data frame</i> |
|-----------------|-------------------------------------------|

---

**Description**

typeMatch\_link0 returns a list with accessors "link0df" and "type\_match"

**Usage**

typeMatch\_link0(similarityMatrix, sps, type, condition)

**Arguments**

- similarityMatrix  
matrix with pairwise similarity values
- sps  
Spectra object
- type  
character(1), either "mz", "retentionTime", "clustering"
- condition  
character

**Details**

Helper function for shinyCircos.



**Value**

list of length 2, entry `link0df` is a `data.frame` and entry `type_match` is a character vector

**Author(s)**

Thomas Naake, <thomasnaake@gmail.com>

**Examples**

```
data("spectra", package = "MetCirc")
similarityMat <- Spectra::compareSpectra(sps_tissue[1:10],
  FUN = MsCoreUtils::ndotproduct, ppm = 10, m = 0.5, n = 2)
rownames(similarityMat) <- colnames(similarityMat) <- sps_tissue$name[1:10]

## order according to retention time
MetCirc:::typeMatch_link0(similarityMatrix = similarityMat,
  sps = sps_tissue, type = "mz",
  condition = c("SPL", "LIM", "ANT", "STY"))
```

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