Package: spectralAnalysis (via r-universe)

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Title Pre-Process, Visualize and Analyse Spectral Data

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Description Infrared, near-infrared and Raman spectroscopic data measured during chemical reactions, provide structural fingerprints by which molecules can be identified and quantified. The application of these spectroscopic techniques as inline process analytical tools (PAT), provides the pharmaceutical and chemical industry with novel tools, allowing to monitor their chemical processes, resulting in a better process understanding through insight in reaction rates, mechanistics, stability, etc. Data can be read into R via the generic spc-format, which is generally supported by spectrometer vendor software. Versatile pre-processing functions are available to perform baseline correction by linking to the 'baseline' package; noise reduction via the 'signal' package; as well as time alignment, normalization, differentiation, integration and interpolation. Implementation based on the S4 object system allows storing a pre-processing pipeline as part of a spectral data object, and easily transferring it to other datasets. Interactive plotting tools are provided based on the 'plotly' package. Non-negative matrix factorization (NMF) has been implemented to perform multivariate analyses on individual spectral datasets or on multiple datasets at once. NMF provides a parts-based representation of the spectral data in terms of spectral signatures of the chemical compounds and their relative proportions. See 'hNMF'-package for references on available methods. The functionality to read in spc-files was adapted from the 'hyperSpec' package.

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Imports baseline, BiocGenerics, data.table, ggplot2, graphics, jsonlite, magrittr, methods, nnls, NMF, plotly, plyr, dplyr, RColorBrewer, signal, stats, viridis, hNMF, zoo, pls

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Suggests testthat, knitr, rmarkdown, webshot, bookdown

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baselineCorrect *generic function to perfom baseline correction*

Description

generic function to perfom baseline correction

Usage

```
baselineCorrect(object, ...)

## S4 method for signature 'SpectraInTime'
baselineCorrect(object, method = "modpolyfit", degree = 4, ...)

## S4 method for signature 'SpectraInTimeComp'
baselineCorrect(object, ...)
```

Arguments

object	a S4 class object
...	other parameters passed to baseline
method	method of baseline correction, default value is to 'modpolyfit', see baseline.modpolyfit
degree	numeric value, degree of the polynomial used only if method is 'modpolyfit'

Value

SpectraInTime-class

Note

baseline correction in the wavelength domain by linking to the baseline

Examples

```
spectralEx           <-  getSpectraInTimeExample()
timeRange            <-  range( getTimePoints( spectralEx ) )
timesToSelect        <-  e(  seq( timeRange[1] , timeRange[2] , length.out = 5  )   )
baselineDefault      <-  baselineCorrect( spectralEx )
baselineHighPolynomial  <-  baselineCorrect( spectralEx,
  method = 'modpolyfit', degree = 4 )

# filtering with fast fourier transform, not so good on example
baselineLowpass         <-  baselineCorrect( spectralEx , method = "lowpass" )

# visual inspection

plot( spectralEx )
plot( baselineDefault[ timesToSelect , ] , type = "time"  )
```

```
plot( baselineHighPolynomial[ timesToSelect , ] , type = "time"  )
plot( baselineLowpass[ timesToSelect , ] , type = "time"  )
```

---

checkCompatible *Check object compatibility*

Description

Check wheter 2 objects are compatible before using them together e.g. in time aligment using a time file with matching experiment name.

Usage

```
checkCompatible(x, y, ...)

## S4 method for signature 'SpectraInTime,ProcessTimes'
checkCompatible(x, y)

## S4 method for signature 'ProcessTimes,SpectraInTime'
checkCompatible(x, y)
```

Arguments

x	first object
y	second object
...	additional parameters

Value

no output, produces an error when object are not compatible with each other

TRUE when the aer competible, otherwise it stops and prints a list of error messages

---

checkForRedundantSources
Check for redunt NMF source vectors

Description

Check if any of the source vectors in the initialized NMF model are redundant and should be omitted from the actual NMF analysis

Usage

```
checkForRedundantSources(seed)
```

Arguments

seed	nmfModel object containing initialization of the factor matrices

Value

boolean vector, indicating which source vector(s) are redundant

Author(s)

Nicolas Sauwen

---

checkIdenticalClass *check wether all elements of of the same class*

Description

check wether all elements of of the same class

Usage

```
checkIdenticalClass(listOfObjects, class)
```

Arguments

listOfObjects	a list of S4 objects to check
class	a class to compare with

Value

logical value TRUE if all objects are of the correct class

Author(s)

Adriaan Blommaert

`combineSpectralObjects` *Function to combine* `SpectraInTime-class` *objects containing 1 spectrum each*

Description

Function to combine `SpectraInTime-class` objects containing 1 spectrum each

Usage

```
combineSpectralObjects(objectList, timeRange, checkNames = TRUE)
```

Arguments

`objectList`	List of `SpectraInTime-class` objects to be combined
`timeRange`	Numeric value, equal to the maximum time of the measured spectra.
`checkNames`	Boolean - if `TRUE`, the experiment name of the spectral objects will be compared to see if these spectral objects belong to the same experiment

Value

`SpectraInTime-class`

Author(s)

Nicolas Sauwen

`computeNMFResidu` *NMF relative residual per observation*

Description

Compute relative residual per observation of an NMF fit to a spectral data set

Usage

```
computeNMFResidu(object, NMFResult)
```

Arguments

`object`	`SpectraInTime-class`
`NMFResult`	Fitted NMF model

Value

Dataframe, containing time (observation) vector and residual vector

Author(s)

nsauwen

`e` *Create an* `ElementsToSelect-class` *from a numeric vector or multiple numeric values or vectors*

Description

Create an `ElementsToSelect-class` from a numeric vector or multiple numeric values or vectors

Usage

```
e(x, ...)
```

Arguments

`x`	numeric vector
`...`	additional numeric vectors

Value

`ElementsToSelect-class` with unique elements

Examples

```
e( 1 , 5, 4.5  )
e( 1:10 , c(4 , 5 , 6 ) , 7 )
```

`ElementsToSelect-class` *Elements S4 class useful for closest elements subsetting*

Description

Elements S4 class useful for closest elements subsetting

Slots

`elements` numeric vector of elements

Author(s)

Adriaan Blommaert

firstSpectrum *Get the first spectrum*

Description

Get the first spectrum

Usage

```
firstSpectrum(object, ...)

## S4 method for signature 'SpectraInTime'
firstSpectrum(object)

## S4 method for signature 'numeric'
firstSpectrum(object)
```

Arguments

object	S4 object
...	additional parameters

Value

numeric vector containing observations first spectrum

getDefaultSumFunc *function to get default summary functions*

Description

function to get default summary functions

Usage

```
getDefaultSumFunc()
```

Value

character vector of functions

getDefaultTimeFormat *function to get default time format in the package*

Description

function to get default time format in the package

Usage

```
getDefaultTimeFormat()
```

Value

character vector specifiying a time format

character string iwth default time format

getDimensionReduction *generic function to extract* dimensionReduction-*slot*

Description

generic function to extract dimensionReduction-slot

Usage

```
getDimensionReduction(object, ...)
```

Arguments

object	a S4 class object
...	additional parameters

Value

dimension reduction slot of an object

getElements *generic function to extract* elements-*slot*

Description

generic function to extract elements-slot

Usage

```
getElements(object, ...)

## S4 method for signature 'ElementsToSelect'
getElements(object)
```

Arguments

object	a S4 class object
...	additional parameters

getExperimentName *generic function to extract* experimentName-*slot*

Description

generic function to extract experimentName-slot

Usage

```
getExperimentName(object, ...)

## S4 method for signature 'SpectraInTime'
getExperimentName(object)
```

Arguments

object	a S4 class object
...	additional parameters

Value

string containing experiment name

getExtraInfo *generic function to extract* extraInfo*-slot*

Description

generic function to extract extraInfo-slot

Usage

```
getExtraInfo(object, ...)

## S4 method for signature 'SpectraInTime'
getExtraInfo(object)
```

Arguments

object	a S4 class object
...	additional parameters

Value

list of extraInfo

getListOfSpectraExample *get example list of spectra*

Description

get example list of spectra

Usage

```
getListOfSpectraExample()
```

Value

list of SpectraInTime-class

getNMFInputMatrix *Get spectralData as input NMF model*

Description

Extract spectral input matrix from SpectraInTime-class and condition properly for NMF modeling

Usage

```
getNMFInputMatrix(object, method = "")
```

Arguments

object	object of the 'spectralData' class, such as a raw SPC file
method	name of the NMF method to be used.

Value

spectral matrix, with wavelengths as its rows and time points as its columns

Author(s)

Nicolas Sauwen

getPathProcessTimesExample *example path process times*

Description

example path process times

Usage

```
getPathProcessTimesExample()
```

Value

ProcessTimes-class

`getPreprocessing` *generic function to extract* `preprocessing`*-slot*

Description

generic function to extract `preprocessing`-slot

Usage

```
getPreprocessing(object, ...)

## S4 method for signature 'SpectraInTime'
getPreprocessing(object)
```

Arguments

`object`	a S4 class object
`...`	additional parameters

Value

list with preprocessing steps

`getProcessTimesExample` *get a minimal* `ProcessTimes-class` *example based on* `getSpectraInTimeExample`

Description

get a minimal `ProcessTimes-class` example based on `getSpectraInTimeExample`

Usage

```
getProcessTimesExample()
```

Value

`ProcessTimes-class`

Author(s)

Adriaan Blommaert

Examples

```
getProcessTimesExample()
```

getProcessTimesFrameExample *get mimimal example* ProcessTimesFrame-class

Description

get mimimal example ProcessTimesFrame-class

Usage

```
getProcessTimesFrameExample()
```

Value

ProcessTimes-class

Author(s)

Adriaan Blommaert

getRange *generic function to extract* range-*slot*

Description

generic function to extract range-slot

Usage

```
getRange(object, ...)

## S4 method for signature 'RangeToSubset'
getRange(object)
```

Arguments

object	a S4 class object
...	additional parameters

getSpectra *generic function to extract* spectra*-slot*

Description

generic function to extract spectra-slot

Usage

```
getSpectra(object, ...)

## S4 method for signature 'SpectraInTime'
getSpectra(object)

## S4 method for signature 'SpectraInTime'
getSpectra(object)
```

Arguments

object	a S4 class object
...	additional parameters

Value

matrix of spectra

getSpectraInTimeCompExample *Artificial example of* SpectraInTimeComp-class

Description

Example SpectraInTime-class with nmf result using random initialization with rank 2

Usage

```
getSpectraInTimeCompExample()
```

Value

SpectraInTimeComp-class

Author(s)

Adriaan Blommaert

Examples

```
test <-  getSpectraInTimeCompExample()
```

`getSpectraInTimeExample` *Artificial example* `SpectraInTime-class`

Description

exponential conversion from 2 concentrations with gaussion curves for spectra at different wavelength per compounds

Usage

```
getSpectraInTimeExample(showPlots = FALSE)
```

Arguments

`showPlots`	logical indicator to show plots

Value

`SpectraInTime-class`

Author(s)

Adriaan Blommaert

Examples

```
ex1  <-  getSpectraInTimeExample()
```

`getSpectralAxis` *generic function to extract* `spectralAxis`*-slot*

Description

generic function to extract `spectralAxis`-slot

Usage

```
getSpectralAxis(object, ...)

## S4 method for signature 'SpectraInTime'
getSpectralAxis(object)
```

Arguments

object	a S4 class object
...	additional parameters

Value

numeric vector containing wavelengths

---

getStartTime *generic function to extract* startTime-*slot*

Description

generic function to extract startTime-slot

Usage

```
getStartTime(object, ...)

## S4 method for signature 'SpectraInTime'
getStartTime(object)
```

Arguments

object	a S4 class object
...	additional parameters

Value

character vector with start time

---

getTimePoints *generic function to extract* timePoints-*slot*

Description

generic function to extract timePoints-slot

Usage

```
getTimePoints(object, ...)

## S4 method for signature 'SpectraInTime'
getTimePoints(object, timePointsAlt = FALSE, timeUnit = "seconds")
```

Arguments

object	a S4 class object
...	additional parameters
timePointsAlt	logical indicator to get alternative (shifted) instead of recorded time points, defaults to FALSE
timeUnit	unit to use , choose between: seconds , minutes or hours, defaults equal to seconds

Value

numberic vector containing timepoints

Examples

```
spectra    <-  getSpectraInTimeExample()
getTimePoints( spectra )
getTimePoints( spectra , timePointsAlt = TRUE  )
getTimePoints( spectra , timeUnit = "hours"  )
```

---

getUnits *generic function to extract* units-*slot*

Description

generic function to extract units-slot

Usage

```
getUnits(object, ...)

## S4 method for signature 'SpectraInTime'
getUnits(object)
```

Arguments

object	a S4 class object
...	additional parameters

Value

list of units

includeRedundantSources *Re-introduce redundant sources in NMF-model*

Description

Re-introduce redundant source vectors and corresponding zero abundances into final NMF result

Usage

```
includeRedundantSources(NMFResult, seed_orig, redundantSources)
```

Arguments

NMFResult	Fitted NMF model
seed_orig	Initial NMF model
redundantSources	boolean vector, obtained from checkForRedundantSources

Value

Final NMF model with redundant sources re-introduced

Author(s)

Nicolas Sauwen

initializeNMFModel *Initialize NMF model with initial spectral data*

Description

Initialize NMF model with initial spectral data

Usage

```
initializeNMFModel(initSpectralData, spectra, spectralAxis = NULL)
```

Arguments

initSpectralData	this can be a list of spectralData objects, containing the pure component spectra. It can also be either of the NMF factor matrices with initial values
spectra	spectral matrix, with wavelengths as its rows and time points as its columns
spectralAxis	vector of wavelength/spectralAxis values

Value

an object that inherents from the class NMF

`lastSpectrum` *Get the last spectrum*

Description

Get the last spectrum

Usage

```
lastSpectrum(object, ...)

## S4 method for signature 'numeric'
lastSpectrum(object)

## S4 method for signature 'SpectraInTime'
lastSpectrum(object)
```

Arguments

`object`	S4 object
`...`	additional parameters

Value

numeric vector containing values last spectrum

`loadAllSPCFiles` *Load all or a selection of SPC files from a given directory.*

Description

This function automatically recognizes all the files bearing an '.spc' extension and returns a list in which each element corresponds to a different xml file.

Usage

```
loadAllSPCFiles(directoryFiles, selectedFiles = NULL)
```

Arguments

directoryFiles	Character vector indicating the directory from which the files needs to be downloaded. Note that files with an other extension than '.spc' can be stored in this directory.
selectedFiles	Character vector listing which files of the chosen directory (as expressed by the 'directoryFiles' argument) should be processed. This argument is used when one wants to process a subset of the spc files of the selected directory only. Note that one should add the complete file name to this list, including the file extension! This is an optional argument with as default value NULL, meaning that by default all files of the selected directory are considered.

Value

A list is returned of which each element contains a processed SPC file

---

localBaselineCorrect *Local baseline correction*

Description

Substract a baseline either through 1 or 2 points

Usage

```
localBaselineCorrect(object, baseWavelengths = NULL)
```

Arguments

object	SpectraInTime-class
baseWavelengths	numeric vector of 1 or 2 wavelength use to draw a baseline trough, defaults to NULL when no baseline correction is performed

Value

SpectraInTime-class with baseline subset

Author(s)

Adriaan Blommaert

Examples

```
spectra             <-  getSpectraInTimeExample()
spectraConstCorrect  <-  localBaselineCorrect( spectra , baseWavelengths = 240  )
spectraLinCorrect    <-  localBaselineCorrect( spectra , c( 250 , 330 )  )

plot( spectra )
plot( spectraConstCorrect )
plot( spectraLinCorrect )
```

`nonNegativePreprocessing` *condition datamatrix to input in and condition properly for NMF*

Description

condition datamatrix to input in and condition properly for NMF

Usage

```
nonNegativePreprocessing(spectra, method = "")
```

Arguments

`spectra`	matrix of spectra
`method`	name of the NMF method to be used.

Details

put negative values to zero, transpose, an add small value zero row (wavelength with only zeros)

Value

matrix, with wavelengths as its rows and time points as its columns

---

`normalize` *generic normalization function*

Description

generic normalization function

Usage

```
normalize(object, ...)

## S4 method for signature 'SpectraInTime'
normalize(
  object,
  method = "normalize",
  spectralRange = r(-Inf, Inf),
  spectralAxisVal = NULL,
  scaleFunction = "sd",
  meanFunction = NULL
)

## S4 method for signature 'SpectraInTimeComp'
normalize(object, ...)
```

Arguments

object	a S4 class object
...	additional parameters
method	a method for normalization or peak correction , choose from: * normalize substract mean and divide by scale * peak scale by reference spectralAxisVal * integration scale by integrating over spectralAxisRange
spectralRange	range for integration if method = integration , defaults to complete range
spectralAxisVal	reference spectral axis value (wavelength or other) for peak regresssion
scaleFunction	scale function used when method = normalize defaults to sd
meanFunction	mean function used when method = normalize defaults to mean

Value

SpectraInTime-class

Examples

```
spectralEx           <-  getSpectraInTimeExample()
timeRange            <-  range( getTimePoints( spectralEx ))
timesToSelect        <-  e(  seq( timeRange[1] , timeRange[2] , length.out = 5  )   )

plot( spectralEx )
plot( spectralEx[ timesToSelect ,  ] , type = "time" )

normalizePeak       <-  normalize( spectralEx , method = "peak" , spectralAxisVal = 400 )
getPreprocessing( normalizePeak )

plot( normalizePeak[ timesToSelect ,  ] , type = "time" )
plot( normalizePeak )
```

```
normalizeIntegration  <-  normalize( spectralEx , method = "integration" )

plot( normalizeIntegration[ timesToSelect ,  ] , type = "time" )

normalizedUser <- normalize( spectralEx , method = "normalize" , mean = "median" , scale = "sd" )

plot( normalizedUser[ timesToSelect ,  ] , type = "time" )
```

`predictNNLS` *Based on previously obtained NMF result* `NMFResult`*, estimate coefficients for a new spectralData object* `object` *using non-negative least squares fitting. The result is returned as as an NMF model.*

Description

Based on previously obtained NMF result `NMFResult`, estimate coefficients for a new spectralData object `object` using non-negative least squares fitting. The result is returned as as an NMF model.

Usage

```
predictNNLS(object, NMFResult)
```

Arguments

`object`	`SpectraInTime-class`
`NMFResult`	Fitted NMF model

Value

Fitted non-negative least squares result in the form of an NMF model

Author(s)

nsauwen

`preprocess` *generic function to preprocess an S4 object*

Description

generic function to preprocess an S4 object

Usage

```
preprocess(object, with)

## S4 method for signature 'SpectraInTime,list'
preprocess(object, with)

## S4 method for signature 'SpectraInTime,SpectraInTime'
preprocess(object, with)

## S4 method for signature 'SpectraInTimeComp,ANY'
preprocess(object, with)
```

Arguments

object	a S4 class object
with	an other object containing preprocessing information: other S4 object, list or expression

Value

SpectraInTime-class

ProcessTimes-class *S4 Class key process times*

Description

S4 Class key process times

Slots

`experimentName` character vector with name of the experiment

`timeHeatingAboveMin` time when experiment above minimum temperature

`timeStartReaction` time start reaction (end of heating ramp)

`timeEndProcess` time timeEndProcess time end of the process, when cooling down starts

`Tset` the maximum temperature to indicate `timeStartReaction`

`comments` character vector of comments when `NA` values are produced

Author(s)

Adriaan Blommaert

ProcessTimesFrame-class *ProcessTimes-class*

Description

S4 Class key process times in a data frame, every line is convertable to a ProcessTimes-class

Value

ProcessTimes-class

Slots

processTimes data.frame with every line process times of an experiment

Author(s)

Adriaan Blommaert

r *create a RangeToSubset-class object from 2 elements or from a vector*

Description

create a RangeToSubset-class object from 2 elements or from a vector

Usage

```
r(x, y)

## S4 method for signature 'numeric,numeric'
r(x, y)

## S4 method for signature 'RangeToSubset,missing'
r(x, y)
```

Arguments

x	numeric value or vector of numeric values
y	numeric value missing when x is a vector of values

Value

RangeToSubset-class

RangeToSubset-class *RangeToSubset-class*

Description

Allows for subsetting a range of actual values instead of a range of indicators

Slots

`range` numeric vector with min and max value

Author(s)

Adriaan Blommaert

readProcessTimes *read .csv file as process times*

Description

read .csv file as process times

Usage

```
readProcessTimes(path, timeFormat = "%Y-%m-%d %H:%M:%OS")
```

Arguments

`path`	to the file containing process times information
`timeFormat`	character specifying time format `as.POSIXct`

Value

`ProcessTimesFrame-class`

`ProcessTimes-class`

Examples

```
readProcessTimes( getPathProcessTimesExample() , timeFormat =  "%Y-%m-%d %H:%M:%S" )
```

readSPC *Read-in of a SPC file.*

Description

This function is an adaptation of the 'read.spc' function of the 'hyperSpec' package : Claudia Beleites and Valter Sergo: 'hyperSpec: a package to handle hyperspectral data sets in R, R package version 0.98-20161118. http://hyperspec.r-forge.r-project.org.

Usage

```
readSPC(filename, keys.log2data = TRUE, keys.hdr2data = FALSE)
```

Arguments

filename	Character vector expressing the name of the SPC file (just the name, not the directory).
keys.log2data	Logical vector indicating whether the full information (consisting of additional information on the experimental conditions) needs to be parsed from the SPC file or not (TRUE indicates that the full information should be parsed from the SPC file). The default value is FALSE.
keys.hdr2data	a character vector of header object to add to backgroundInformation

Value

SpectraInTime-class

removeRedundantSources *Remove redundant sources from the initial NMF model*

Description

Remove redundant sources from the initial NMF model

Usage

```
removeRedundantSources(seed, redundantSources)
```

Arguments

seed	nmfModel object containing initialization of the factor matrices
redundantSources	boolean vector, obtained from checkForRedundantSources

Value

nmfModel object with redundant sources removed from initial factor matrices

Author(s)

Nicolas Sauwen

`runNMF` *Actual NMF analysis*

Description

Actual NMF analysis

Usage

```
runNMF(
  spectra,
  rank,
  method = "PGNMF",
  seed = NULL,
  nruns = 10,
  checkDivergence = TRUE,
  timePointsList = NULL,
  subsamplingFactor = 3,
  maxIter = 1000
)
```

Arguments

`spectra`	spectral input matrix, with wavelengths as its rows and time points as its columns
`rank`	number of NMF components to be found
`method`	name of the NMF method to be used, consult the help of the 'nmf' function from the NMF package for the methods available by default
`seed`	nmfModel object containing initialization of the factor matrices
`nruns`	number of NMF runs. It is recommended to run the NMF analyses multiple times when random seeding is used, to avoid a suboptimal solution
`checkDivergence`	Boolean indicating whether divergence checking should be performed, defaults to `TRUE`
`timePointsList`	list of time point vectors of the individual experiments
`subsamplingFactor`	subsampling factor used during NMF analysis
`maxIter`	maximum number of iterations per NMF run

Value

Resulting NMF model (in accordance with the NMF package definition)

Author(s)

Nicolas Sauwen

`saveSpectra` *read or save a* `SpectraInTime-class` *from or to a* `.txt` *file*

Description

read or save a `SpectraInTime-class` from or to a `.txt` file

Usage

```
saveSpectra(object, directory, precision = 32)

readSpectra(file)
```

Arguments

`object`	object to save
`directory`	directory to save object
`precision`	number of significant digits controlling precission
`file`	to be read

Value

the path to which the file is saved

`SpectraInTime-class`

Note

experiment name is used to save the experiment

default time formats are assumed to convert to `SpectraInTime-class`

some data precession is lost because of internal conversion to JSON format

Author(s)

Adriaan Blommaert

Examples

```
spectra         <-  getSpectraInTimeExample()
saveSpectra(  spectra , directory )
experimentName  <-  getExperimentName( spectra )
file            <-  file.path( directory , paste0( experimentName , ".txt")  )
spectraRead     <-  readSpectra( file )
```

`scaleNMFResult` *Apply fixed scaling to NMF model*

Description

Apply fixed scaling to NMF model matrices by normalizing the basis vectors

Usage

```
scaleNMFResult(NMFResult)
```

Arguments

`NMFResult`	Fitted NMF model

Value

NMFResult Rescaled NMF model

Author(s)

Nicolas Sauwen

`setExperimentName<-` *set the experiment name*

Description

set the experiment name

Usage

```
setExperimentName(object) <- value

## S4 replacement method for signature 'SpectraInTime'
setExperimentName(object) <- value

## S4 replacement method for signature 'SpectraInTime'
setTimePointsAlt(object) <- value
```

Arguments

object	a S4 class object
value	a vector of time points

Value

SpectraInTime-class with modified experiment name

---

setTimePointsAlt<- *set time alternative time axis*

Description

set time alternative time axis

Usage

```
setTimePointsAlt(object) <- value
```

Arguments

object	a S4 class object
value	a vector of time points

Value

SpectraInTime-class with modified timePointsAlt axis

---

smooth *generic smoothing function*

Description

smoothing is applied along the spectral axis, not the time axis

Usage

```
smooth(object, ...)

## S4 method for signature 'SpectraInTime'
smooth(
  object,
  method = "sg",
  order = 3,
  window = order + 7 - order%%2,
  derivative = 0,
  dim = "spectralAxis"
)

## S4 method for signature 'SpectraInTimeComp'
smooth(object, ...)
```

Arguments

object	a S4 class object
...	additional parameters
method	character vector smoothing method, options are 'sg' (= default, Savitsky-Golay filter) or 'mean'.
order	numeric value, order of the polynomial used to interpolate (only used when method = 'sg'), should be larger than derivative order, defaults to 3 + derivative
window	width of the smoothing default value slightly higher than in the signal package, the user might consider a large value, otherwise smoothing has little effect
derivative	derivative to be taken (only used when method = 'sg'), defaults to 0
dim	character string, specifying along which dimension smoothing should be applied. Options are "spectralAxis" (= default) or "time"

Value

SpectraInTime-class

Note

equal distances between wavelenght intervals are assumed

Examples

```
spectralEx     <-  getSpectraInTimeExample()
smoothDefault   <-  smooth( spectralEx )
timeRange       <-  range( getTimePoints( spectralEx ))
timesToSelect   <-  e( seq( timeRange[1] , timeRange[2] , length.out = 5  )  )
smoothALot      <-  smooth( spectralEx ,  order = 2 , window = 301  )
derivative1     <-  smooth( spectralEx , derivative = 1 )
derivative2     <-  smooth( spectralEx , derivative = 2 )
```

SpectraInTimeComp-class *SpectraInTimeComp-class (time resolved spectra)*

Description

Spectral-time data for 1 experiment with dimension reduction techique NMF and/or PCA decomposition included

Usage

```
## S4 method for signature 'SpectraInTimeComp'
getDimensionReduction(object, type = NULL)
```

Arguments

object	of class SpectraInTimeComp-class
type	type of regression method specified, if NULL the entire slot is returned as a list

Slots

dimensionReduction list containing dimension reduction techique, either PCA or NMF, but only one per kind.

Author(s)

Adriaan Blommaert

Examples

```
 #  generate example
exampleSpectra     <-  getSpectraInTimeCompExample()

 # methods
    PCAResult      <-  getDimensionReduction( exampleSpectra, type = "PCA" )
    NMFResult      <-  getDimensionReduction( exampleSpectra, type = "NMF" )

    dimensionReductions  <-  getDimensionReduction( exampleSpectra )
    str(dimensionReductions  )

 # subsetting works by reducing to \code{\link{SpectraInTime-class}}
 subsetting     <-  exampleSpectra[1:3 , r(400, 450)]
 # preprocessing methods also reduce the object to \code{\link{SpectraInTime-class}}
```

`spectralIntegration` *Integrate spectraInTime object*

Description

The integrated value over a user-specified spectral range is calculated (trapezium rule) per time point, afterwards smoothing over time can be applied

Usage

```
spectralIntegration(
  object,
  spectralRange,
  smoothingValue = 0,
  timeUnit = "seconds"
)
```

Arguments

`object`	`SpectraInTime-class`
`spectralRange`	numeric vector of 2 elements i.e. integration limits
`smoothingValue`	numeric value between 0 and 1, amount of `lowess`-smoothing, default to `0` i.e no smoothing. Note that smoothing is applied after integration
`timeUnit`	character value, choose between: `second` , `minutes` and `hours`, defaults to `seconds`

Value

`data.frame` with variables `time` and `integratedValue`

Examples

```
spectra                 <-  getSpectraInTimeExample()
defaults             <-  spectralIntegration( spectra , c(200 , 300) , timeUnit = "hours" )
unsmoothedTrend       <-  spectralIntegration( spectra , c(200 , 300) , timeUnit = "hours" )
smoothedTrend            <-  spectralIntegration( spectra , c(200 , 300) ,
  smoothingValue = 0.5 , timeUnit = "hours" )
```

spectralNMF *Perform Non-Negative Matrix factorization on spectral data*

Description

Perform Non-Negative Matrix factorization on spectral data

Usage

```
spectralNMF(
  object,
  rank,
  method = "PGNMF",
  initSpectralData = NULL,
  nruns = 10,
  subsamplingFactor = 1,
  checkDivergence = TRUE,
  maxIter = 1000,
  includeRefs = FALSE
)
```

Arguments

object	SpectraInTime-class
rank	number of NMF components to be found
method	name of the NMF method to be used. "PGNMF" (default), "HALSacc" and "semiNMF" are methods derived from the hNMF package. All methods from the NMF package are also available.
initSpectralData	this can be a list of spectralData objects, containing the pure component spectra. It can also be either of the NMF factor matrices with initial values
nruns	number of NMF runs. It is recommended to run the NMF analyses multiple times when random seeding is used, to avoid a suboptimal solution
subsamplingFactor	subsampling factor used during NMF analysis
checkDivergence	Boolean indicating whether divergence checking should be performed
maxIter	maximum number of iterations per NMF run
includeRefs	boolean, indicating whether references should be included in the input matrix for the NMF analysis

Value

SpectraInTimeComp-class which includeds a scaled NMF model (in accordance with the NMF package definition)

SpectraInTimeComp-class

Author(s)

Nicolas Sauwen

Examples

```
spectralExample    <-  getSpectraInTimeExample()
nmfResult         <-  spectralNMF( spectralExample , rank = 2 , subsamplingFactor = 5 )
 nmfObject         <-  getDimensionReduction( nmfResult , type = "NMF")$NMF
 nmfTrends         <-  t( NMF::coef( nmfObject ) )
matplot( nmfTrends , type = "l" , x = getTimePoints( spectralExample , timeUnit = "hours" ),
  xlab = "time in hours"  )
```

`spectralNMFList` *Perform Non-Negative Matrix factorization on list of SPC files*

Description

Perform Non-Negative Matrix factorization on list of SPC files

Usage

```
spectralNMFList(
  objectList,
  rank,
  method = "PGNMF",
  initSpectralData = NULL,
  nruns = 10,
  subsamplingFactor = 3,
  checkDivergence = TRUE,
  maxIter = 1000
)
```

Arguments

`objectList`	list of SPC files
`rank`	number of NMF components to be found
`method`	name of the NMF method to be used, consult the help of the 'nmf' function from the NMF package for the methods available by default
`initSpectralData`	list of SPC files containing pure component spectra
`nruns`	number of NMF runs.
`subsamplingFactor`	subsampling factor used during NMF analysis
`checkDivergence`	Boolean indicating whether divergence checking should be performed
`maxIter`	maximum number of iterations per NMF run

Value

list of SpectraInTimeComp-class

Author(s)

Nicolas Sauwen

Examples

```
spectralData    <-  getListOfSpectraExample()
spectraWithNmf  <-  spectralNMFList( spectralData , rank = 2 )
```

`spectralPLSCalibration` *Compute PLS model*

Description

Compute PLS model

Usage

```
spectralPLSCalibration(objectList, UPLC_DF, ncomp = 10)
```

Arguments

`objectList`	list of SPC files
`UPLC_DF`	dataframe with UPLC data, which should contain the following columns: experiment, time, and 1 column per compound
`ncomp`	number of PLS components, defaults to 10

Value

PLS model, as obtained from `plsr`

Author(s)

Nicolas Sauwen

spectralPlsPrediction *Perform PLS prediction*

Description

Perform PLS prediction

Usage

```
spectralPlsPrediction(spectralObject, plsModel, nComp)
```

Arguments

spectralObject	SpectraInTime-class
plsModel	PLS model as obtained from spectralPLSCalibration
nComp	Number of components

Value

SpectraInTimeComp-class which includes PLS model + prediction

Author(s)

Nicolas Sauwen

subset-methods *Subsetting* SpectraInTime-class

Description

Subsetting SpectraInTime-class

Usage

```
## S4 method for signature 'SpectraInTime,ANY,ANY'
x[i, j, ..., drop = ""]

## S4 method for signature 'SpectraInTime,missing,ANY'
x[i, j, ..., drop = ""]

## S4 method for signature 'SpectraInTime,ANY,missing'
x[i, j, ..., drop = ""]

## S4 method for signature 'SpectraInTime,missing,missing'
x[i, j, ..., drop = ""]
```

```
## S4 method for signature 'SpectraInTimeComp,ANY,ANY'
x[i, j, ..., drop = ""]

## S4 method for signature 'SpectraInTimeComp,missing,ANY'
x[i, j, ..., drop = ""]

## S4 method for signature 'SpectraInTimeComp,ANY,missing'
x[i, j, ..., drop = ""]
```

Arguments

x	object to subset
i	subsetting rows (timePoints)
j	subsetting columns (spectral axis)
...	additional parameters • timeUnit unit at which subsetting should be done choose between seconds , minutes or hours defaults to seconds • timePointsAlt logical indicators whater alternative timePoints should be used
drop	for consistancy, not used

Value

SpectraInTime-class

Examples

```
### subsetting [ time , spectral axis, options ]

spectralEx               <-  getSpectraInTimeExample()
spectraSubset            <-  spectralEx[ r( 1000 , 30000 ) , r(130 , 135 ) ]
spectraSubsetTime        <-  spectralEx[ r( 1000 , 30000 ) ,  ]
spectraSubsetSpectralVals  <-  spectralEx[  ,  r(130 , 135 ) ]
spectraSubsetHours      <-  spectralEx[ r( 1 , 3 ) , r(130 , 135 ) , timeUnit = "hours" ]
closestSpectralVals     <- spectralEx[ , e( 150, 4, 300, 500 ) ] # remark only unique values
spectraSubsetLogical     <-  spectralEx[ getTimePoints( spectralEx ) > 300   ,
getSpectralAxis( spectralEx ) <= 500 ]
```

---

timeAlign *Time align first object, using info in the second object*

Description

Time align first object, using info in the second object

Usage

```
timeAlign(x, y, ...)

## S4 method for signature 'SpectraInTime,ProcessTimes'
timeAlign(x, y, cutCooling = FALSE, cutBeforeMinTemp = FALSE)

## S4 method for signature 'list,ProcessTimesFrame'
timeAlign(x, y, cutCooling = FALSE, cutBeforeMinTemp = FALSE)

## S4 method for signature 'list,character'
timeAlign(
  x,
  y,
  cutCooling = FALSE,
  cutBeforeMinTemp = FALSE,
  timeFormat = "%Y-%m-%d %H:%M:%S"
)
```

Arguments

x	and S4 object to be aligned
y	object to use time information from
...	additional arguments
cutCooling	logical indicator if TRUE observation after cooling starts are cut off, defaults to FALSE
cutBeforeMinTemp	logical indicator if TRUE observation before minimum temperature are cut off, defaults to FALSE
timeFormat	character vector specifying time format as.POSIXct

Value

SpectraInTime-class or list of spectra depending on input

Examples

```
 spectra            <-  getSpectraInTimeExample()
 listOfSpectra      <-  getListOfSpectraExample()
 processTimes       <-  getProcessTimesExample()
 processTimesFrame  <-  getProcessTimesFrameExample()
 pathProcessTimes   <-  getPathProcessTimesExample()

ex1  <-  timeAlign( x = spectra , y = processTimes ,
 cutCooling = TRUE , cutBeforeMinTemp = TRUE )
ex2  <-  timeAlign( x = listOfSpectra , y = processTimesFrame ,
 cutCooling = TRUE , cutBeforeMinTemp = TRUE )
ex3  <-  timeAlign( x = listOfSpectra , y = pathProcessTimes,
 cutCooling = TRUE , cutBeforeMinTemp = TRUE  , timeFormat =  "%Y-%m-%d %H:%M:%OS" )
```

upsampleNMFResult *Upsample NMF result to original temporal resolution*

Description

Upsample NMF result to original temporal resolution

Usage

```
upsampleNMFResult(NMFResult, timePoints, subsamplingFactor, shift = 0)
```

Arguments

NMFResult	Fitted NMF model
timePoints	Original time points
subsamplingFactor	Subsampling factor
shift	Integer that correctly shifts subsampling index when applying NMF to multiple experiments

Value

Upsampled NMF model

Author(s)

Nicolas Sauwen

wavelengthAlign *Wavelength align spectral data*

Description

Align SpectraInTime objects with differing wavelength axes to a common wavelength axis using cubic spline interpolation.

Usage

```
wavelengthAlign(ref, toAlign)

## S4 method for signature 'SpectraInTime,SpectraInTime'
wavelengthAlign(ref, toAlign)

## S4 method for signature 'SpectraInTime,list'
wavelengthAlign(ref, toAlign)
```

Arguments

ref	SpectraInTime-class object with the reference wavelength vector
toAlign	SpectraInTime-class object(s) to be aligned. This can either be a single SpectraInTime object or a list of SpectraInTime objects. In case of a list, all objects in the list should have the same wavelength axis.

Value

List of aligned SpectraInTime objects, including the reference object.

one or a list of SpectraInTime-class

Examples

```
  spectra            <-  getSpectraInTimeExample()
  listOfSpectra      <-  getListOfSpectraExample()

# Dummy alignment of spectrum with itself:
  ex1                <-  wavelengthAlign( ref = spectra , toAlign = spectra )
# Alignment of list of spectra with a reference spectrum:
  ex2                <-  wavelengthAlign( ref = spectra , toAlign = listOfSpectra )
```

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