Package 'growthPheno'

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Title Plotting, Smoothing and Growth Trait Extraction for Longitudinal Data

Depends R (>= 3.5.0)

Imports dae, ggplot2, stats, stringi, readxl, Hmisc, GGally, RColorBrewer, reshape, grid

Suggests testthat, R.rsp

VignetteBuilder R.rsp

Description Assists in producing longitudinal or profile plots of measured traits. These allow checks to be made for anomalous data and growth patterns in the data to be explored. Smoothing of growth trends for individual plants using smoothing splines is available for removing transient effects. There are tools for diagnosing the adequacy of trait smoothing, either using this package or other packages, such as those that fit nonlinear growth models. A range of per-unit (pot, plant, plot) growth traits can be extracted from longitudinal data, including single time-point smoothed trait values and their growth rates, interval growth rates and other growth statistics, such as maximum growth. The package is particularly suited to preparing data from high-throughput phenotyping facilities, such as imaging data from a Lemna-Tec Scananalyzer 3D (see <https://www.youtube.com/watch?v=MRAF_mAEa7E/> for more information). The package 'growthPheno' can also be installed from <http://chris.brien.name/rpackages/>.

License GPL (>=2)

URL http://chris.brien.name

RoxygenNote 5.0.1

NeedsCompilation no

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R topics documented:

anom	*Tests if any values in a vector are anomalous in being outside specified limits*

Description

Test whether any values in x are less than the value of lower, if it is not NULL, or are greater than the value of upper, if it is not NULL, or both.

Usage

```
anom(x, lower=NULL, upper=NULL, na.rm = TRUE)
```

Arguments

x	A [vector](#) containing the values to be tested.
lower	A [numeric](#) such that values in x below it are considered to be anomalous.
upper	A [numeric](#) such that values in x above it are considered to be anomalous.
na.rm	A [logical](#) indicating whether NA values should be stripped before the testing proceeds.

Value

A [logical](#) indicating whether any values have been found to be outside the limits specified by lower or upper or both.

Author(s)

Chris Brien

Examples

```
data(exampleData)
anom.val <- anom(longi.dat$Area.smooth.AGR, lower=2.5)
```

---

calcLagged	*Replaces the values in a vector with the result of applying an operation to it and a lagged value*

Description

Replaces the values in x with the result of applying an operation to it and the value that is lag positions either before it or after it in x, depending on whether lag is positive or negative. For positive lag the first lag values will be NA, while for negative lag the last lag values will be NA. When operation is NULL, the values are moved lag positions down the vector.

Usage

```
calcLagged(x, operation = NULL, lag = 1)
```

Arguments

x	A [vector](#) containing the values on which the calculations are to be made.
operation	A [character](#) giving the operation to be performed on pairs of values in x. If operation is NULL then the values are moved lag positions down the vector.
lag	A integer specifying, for the second value in the pair to be operated on, the number positions it is ahead of or behind the current value.

Value

A [vector](#) containing the result of applying operation to values in x. For positive lag the first lag values will be NA, while for negative lag the last lag values will be NA.

Author(s)

Chris Brien

See Also

[Ops](Ops)

Examples

```
data(exampleData)
longi.dat$Days.diffs <- calcLagged(longi.dat$xDays, operation ="-")
```

---

calcTimes	*Calculates for a set of times, the time intervals after an origin time and the position of each within a time interval*

Description

For the column specified in imageTimes, having converted it to POSIXct if not already converted, calculates for each value the number of intervalUnits between the time and the startTime. Then the number of timePositions within the intervals is calculated for the values in imageTimes. The function difftimes is used in doing the calculations, but the results are converted to numeric. For example intervals could correspond to the number of Days after Planting and the timePositions to the hour within each day.

Usage

```
calcTimes(data, imageTimes = NULL, timeFormat = "%Y-%m-%d %H:%M",
          intervals = "Time.after.Planting..d.", startTime = NULL,
          intervalUnit = "days", timePositions = NULL)
```

Arguments

data	A data.frame containing any columns specified by imageTimes, intervals and timePositions.
imageTimes	A character giving the name of the column that contains the time that each cart was imaged. Note that in importing data into R, spaces and nonalphanumeric characters in names are converted to full stops. If imageTimes is NULL then no calculations are done.
timeFormat	A character giving the POSIXct format of characters containing times, in particular imageTimes and startTime. Note that if fractions of seconds are required options(digits.secs) must be used to set the number of decimal places and timeFormat must use %OS for seconds in timeFormat.
intervals	A character giving the name of the column in data containing, as a numeric or a factor, the calculated times after startTime to be plotted on the x-axis. It is given as the number of intervalUnits between the two times. If startTime is NULL then intervals is not calculated.
startTime	A character giving the time, in the POSIXct format specified by timeFormat, to be subtracted from imageTimes to caclualte intervals. For example, it might be the day of planting or treatment. If startTime is NULL then intervals is not calculated.

intervalUnit   A [character](#) giving the name of the unit in which the values of the intervals should be expressed. It must be one of "secs", "mins", "hours" or "days".

timePositions   A [character](#) giving the name of the column in data containing, as a [numeric](#), the value of the time position within an interval (for example, the time of imaging during the day expressed in hours plus a fraction of an hour). If timePositions is NULL then it is not calculated.

Value

A data.frame, being the unchaged data data.frame when imageTimes is NULL or containing either intervals and/or timePositions depending on which is not NULL.

Author(s)

Chris Brien

See Also

[as.POSIXct](#), [imagetimesPlot](#).

Examples

```
data(exampleData)
raw.dat <- calcTimes(data = raw.dat,
                     imageTimes = "Snapshot.Time.Stamp", timePositions = "Hour")
```

---

cumulate	*Calculates the cumulative sum, ignoring the first element if exclude.1st is TRUE*

Description

Uses cumsum to calculate the cumulative sum, ignoring the first element if exclude.1st is TRUE.

Usage

```
cumulate(x, exclude.1st = FALSE, na.rm = FALSE, ...)
```

Arguments

x   A [vector](#) containing the values to be cumulated.

exclude.1st   A [logical](#) indicating whether or not the first value of the cumulative sum is to be NA.

na.rm   A [logical](#) indicating whether NA values should be stripped before the computation proceeds

...   allows passing of arguments to other functions; not used at present.

Value

A [vector](#) containing the cumulative sum.

Author(s)

Chris Brien

See Also

cumsum

Examples

```
data(exampleData)
Area.cum <- cumulate(longi.dat$Area)
```

---

designFactors   *Adds the factors and covariates for a blocked, split-plot design*

Description

Add the following factors and covariates to a date frame containing imaging data from the Plant Accelerator: Zones, xZones, SHZones, ZLane, ZMainplots, Subplots and xMainPosn. It checks that the numbers of levels of the factors are consistent with the observed numbers of carts and observations.

Usage

```
designFactors(data, insertName = NULL, designfactorMethod = "LanePosition",
        nzones = 6, nlanesperzone = 4, nmainplotsperlane = 11, nsubplotspermain = 2)
```

Arguments

data   A data.frame to which are to be added the design factors and covariates and
                    which must contain the following columns:

                    Smarthouse, Snapshot.ID.Tag, XDays, xPosn and,

                    if designfactorMethod = "LanePosition", Lane and Position.

insertName   A character giving the name of the column in the data.frame after which the
                    new factors and covariates are to be inserted. If NULL, they are added after the
                    last column.

designfactorMethod

                    A character giving the method to use to obtain the columns for the design fac-
                    tors Zones, ZLane, Mainplots and Subplots. For LanePosition, it is assumed
                    that (i) Lane can be divided into Zones and ZLane, each with nzones and nlanes-
                    perzone levels, respectively, and (ii) Position can be divided into Mainplots and
                    Subplots, each with nmainplotsperlane and nmainplotsperlane levels, respec-
                    tively. The factor SHZones is formed by combining Smarthouse and Zones and
                    ZMainplots is formed by combining ZLane and Mainplots. For StandardOrder,
                    the factors Zones, ZLane, Mainplots, Subplots are generated in standard order,
                    with the levels of Subplots changing for every observation and the levels of sub-
                    sequent changing only after all combinations of the levels of the factors to its
                    right have been cycled through.

nzones   A numeric giving the number of zones in a smarthouse.

nlanesperzone   A numeric giving the number of lanes in each zone.

nmainplotsperlane

>   A numeric giving the number of mainplots in each lane.

nsubplotspermain

>   A numeric giving the number of subplots in a main plot.

Details

The factors Zones, ZLane, ZMainplots and Subplots are derived for each Smarthouse based on the values of `nzones`, `nlanesperzone`, `nmainplotsperlane`, `nsubplotspermain`, Zones being the blocks in the split-plot design. Thus, the number of carts in each Smarthouse must be the product of these values and the number of observations must be the product of the numbers of smarthouse, carts and imagings for each cart. If this is not the case, it may be able to be achieved by including in `data` rows for extra observations that have values for the Snapshot.ID.Tag, Smarthouse, Lane, Position and Time.after.Planting..d. and the remaining columns for these rows have missing values (NA) Then SHZones is formed by combining Smarthouse and Zones and the covariates xZones and xMainPosn calculated. The covariate xZones is calculated from Zones and xMainPosn is formed from the mean of xPosn for each main plot.

Value

A data.frame including the columns:

1. Smarthouse: factor with levels for the Smarthouse

2. Zones: factor dividing the Lanes into groups, usually of 4 lanes

3. xZones: numeric corresponding to Zones, centred by subtracting the mean of the unique positions

4. SHZones: factor for the combinations of Smarthouse and Zones

5. ZLane: factor for the lanes within a Zone

6. ZMainplots: factor for the main plots within a Zone

7. Subplots: factor for the subplots

8. xMainPosn: numeric for the main-plot positions within a Lane, centred by subtracting the mean of the unique positions

Author(s)

Chris Brien

Examples

```
data(exampleData)
longi.dat <- designFactors(longi.prime.dat, insertName = "xDays",
                           nzones = 1, nlanesperzone = 1, nmainplotsperlane = 10,
                           designfactorMethod="StandardOrder")
```

---

exampleData   *A small data set to use in function examples*

Description

Imaging data for 20 of the plants from an experiment in a Smarthouse in the Plant Accelerator. It is used as a small example in the documentation for growthPheno.

Usage

```
data(exampleData)
```

Format

Four data.frames: raw.dat (280 rows by 33 columns), longi.prime.dat (280 rows by 45 columns), longi.dat (280 rows by 63 columns), cart.dat (20 rows by 14 columns).

---

fitSpline   *Produce the fits from a natural cubic smoothing spline applied to a response in a* data.frame, *and growth rates can be computed using derivatives*

Description

Uses smooth.spline to fit a spline to all the values of response stored in data.

The amount of smoothing can be controlled by df and the smoothing.method provides for direct amd logarithmic smoothing. If df = NULL, the amount of smoothing is controlled by the default arguments and those you supply for smooth.spline. The method of Huang (2001) for correcting the fitted spline for estimation bias at the end-points will be applied if correctBoundaries is TRUE.

The derivatives of the fitted spline can also be obtained, and the Absolute and Relative Growth Rates (AGR and RGR) computed using them, provided correctBoundaries is FALSE. Otherwise, growth rates can be obtained by difference using [splitContGRdiff](#).

By default, smooth.spline will issue an error if there are not at least four distinct x-values. On the other hand, fitSplines issues a warning and sets all smoothed values and derivatives to NA. The handling of missing values in the observations is controlled via na.x.action and na.y.action.

Usage

```
fitSpline(data, response, x, df=NULL, smoothing.method = "direct",
          correctBoundaries = FALSE,
          deriv=NULL, suffices.deriv=NULL, RGR=NULL, AGR=NULL,
          na.x.action="exclude", na.y.action = "exclude", ...)
```

Arguments

data	A [data.frame](#) containing the column to be smoothed.
response	A [character](#) giving the name of the column in data that is to be smoothed.
x	A [character](#) giving the name of the column in data that contains the values of the predictor variable.
df	A [numeric](#) specifying the desired equivalent number of degrees of freedom of the smooth (trace of the smoother matrix). Lower values result in more smoothing. If df = NULL, the amount of smoothing is controlled by the default arguments for and those that you supply to smooth.spline.
smoothing.method	A [character](#) giving the smoothing method to use. The two possibilites are (i) "direct", for directly smoothing the observed response, and (ii) "logarithmic", for smoothing the log-transformed response and then back-transforming by taking the exponential of the fitted values.
correctBoundaries	A [logical](#) indicating whether the fitted spline values are to have the method of Huang (2001) applied to them to correct for estimation bias at the end-points. Note that deriv must be NULL for correctBoundaries to be set to TRUE.
deriv	A numeric specifying one or more orders of derivatives that are required.
suffices.deriv	A [character](#) giving the characters to be appended to the names of the derivatives. If NULL and the derivative is to be retained then smooth.dv is appended.
RGR	A [character](#) giving the character to be appended to the smoothed response to create the RGR name, but only when smoothing.method is direct and the RGR is required. When smoothing.method is direct and the RGR is required RGR must not be NULL and deriv must include one so that the first derivative is available for calculating it. When smoothing.method is logarithmic, the RGR is the backtransformed first derivative and so, to obtain it, merely include 1 in deriv and any suffix for it in suffices.deriv. Leave RGR set to NULL.
AGR	A [character](#) giving the character to be appended to the smoothed response to create the AGR name, but only when smoothing.method is logarithmic and the AGR is required. When smoothing.method is logarithmic and the AGR is required AGR must not be NULL and deriv must include one so that the first derivative is available for calculating it. When smoothing.method is direct, the AGR is the backtransformed first derivative and so, to obtain it, merely include 1 in deriv and any suffix for it in suffices.deriv. Leave AGR set to NULL.
na.x.action	A [character](#) string that specifies the action to be taken when values of x are NA. The possible values are fail, exclude or omit. For exclude and omit, predictions and derivatives will only be obtained for nonmissing values of x. The difference between these two codes is that for exclude the returned data.frame will have as many rows as data, the missing values have been incorporated.
na.y.action	A [character](#) string that specifies the action to be taken when values of y, or the response, are NA. The possible values are fail, exclude, omit, allx, trimx, ltrimx or rtrimx. For all options, except fail, missing values in y will be removed before smoothing. For exclude and omit, predictions and derivatives will be obtained only for nonmissing values of x that do not have missing y values. Again, the difference between these two is that, only for exclude will the missing values be incorporated into the returned data.frame. For allx, predictions and derivatives will be obtained for all nonmissing x. For trimx,

they will be obtained for all nonmissing x between the first and last nonmissing y values that have been ordered for x; for ltrimx and utrimx either the lower or upper missing y values, respectively, are trimmed.

... allows for arguments to be passed to smooth.spline.

Value

A data.frame containing x and the fitted smooth. The names of the columns will be the value of x and the value of response with .smooth appended. The number of rows in the data.frame will be equal to the number of pairs that have neither a missing x or response and it will have the same order of codex as data. If deriv is not NULL, columns containing the values of the derivative(s) will be added to the data.frame; the name each of these columns will be the value of response with .smooth.dvf appended, where f is the order of the derivative, or the value of response with .smooth. and the corresponding element of suffices.deriv appended. If RGR is not NULL, the RGR is calculated as the ratio of value of the first derivative of the fitted spline and the fitted value for the spline.

Author(s)

Chris Brien

References

Huang, C. (2001). Boundary corrected cubic smoothing splines. *Journal of Statistical Computation and Simulation*, **70**, 107-121.

See Also

splitSplines, smooth.spline, predict.smooth.spline, splitContGRdiff

Examples

```
data(exampleData)
fit <- fitSpline(longi.dat, response="Area", , x="xDays", df = 4,
                 deriv=c(1,2), suffices.deriv=c("AGRdv","Acc"))
```

---

getTimesSubset　　　　　　　　*Forms a subset of* responses *in* data *that contains their values for the nominated times*

Description

Forms a subset of responses in data that contains their values for the nominated times.

Usage

```
getTimesSubset(responses, times.factor = "Days", data, which.times,
               suffix = NULL, include.times.factor = FALSE,
               include.individuals = FALSE, individuals = "Snapshot.ID.Tag")
```

Arguments

responses	A [character](#) giving the names of the columns in data whose values are to be subsetted.
times.factor	A [character](#) giving the name of the column in data containing the factor for times at which the data was collected. Its levels will be used to identify the subset and should be numeric values stored as characters.
data	A [data.frame](#) containing the column from which the growth rates are to be calculated.
which.times	A [vector](#) giving the times that are to be selected.
suffix	A [character](#) giving the suffix to be appended to responses to form the names of the columns containing the subset.
include.times.factor	
	A [logical](#) indicating whether or not to include the times.factor in the result, the name in the result having the suffix with a separating full appended.
include.individuals	
	A [logical](#) indicating whether or not to include the individuals column in the result.
individuals	A [character](#) giving the name of the column in data containing an identifier for each individual.

Value

A [data.frame](#) containing the subset of responses ordered by as many of the initial columns of data as are required to uniquely identify each row (see [order](#) for more information). The names of the columns for responses and times.factor in the subset are the concatenation of their names in data and suffix separated by a full stop.

Author(s)

Chris Brien

Examples

```
data(exampleData)
AreaLast <- getTimesSubset("Area.smooth", data = longi.dat,
                           which.times = c(42), suffix = "last")
```

---

growthPheno-deprecated

Deprecated Functions in the Package asremlPlus

Description

These functions have been renamed and deprecated in growthPheno:

1. getDates -> [getTimesSubset](#)
2. anomPlot -> [plotAnom](#)
3. corrPlot -> [plotCorrmatrix](#)
4. imagetimesPlot -> [plotImagetimes](#)
5. longiPlot -> [plotLongitudinal](#)

Usage

```
getDates(...)
anomPlot(...)
corrPlot(...)
imagetimesPlot(...)
longiPlot(...)
```

Arguments

...	absorbs arguments passed from the old functions of the style foo.bar().

Author(s)

Chris Brien

---

growthPheno-pkg	*Plotting, Smoothing and Growth Trait Extraction for Longitudinal Data*

Description

Assists in producing longitudinal or profile plots of measured traits. These allow checks to be made for anomalous data and growth patterns in the data to be explored. Smoothing of growth trends for individual plants using smoothing splines is available for removing transient effects. There are tools for diagnosing the adequacy of trait smoothing, either using this package or other packages, such as those that fit nonlinear growth models. A range of per-unit (pot, plant, plot) growth traits can be extracted from longitudinal data, including single time-point smoothed trait values and their growth rates, interval growth rates and other growth statistics, such as maximum growth. The package is particularly suited to preparing data from high-throughput phenotyping facilities, such as imaging data from a Lemna-Tec Scananalyzer 3D (see <https://www.youtube.com/watch?v=MRAF_mAEa7E/> for more information). The package 'growthPheno' can also be installed from <http://chris.brien.name/rpackages/>.

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For an overview of the use of these functions and an example see below.

(i) Data

[exampleData](#)	A small data set to use in function examples.
[RiceRaw.dat](#)	Data for an experiment to investigate a rice germplasm panel.
[tomato.dat](#)	Longitudinal data for an experiment to investigate tomato response to mycorrhizal fungi and zinc.

(ii) Data frame manipulation

[designFactors](#)	Adds the factors and covariates for a blocked, split-plot design.

getTimesSubset	Forms a subset of 'responses' in 'data' that contains their values for the nominated times.
importExcel	Imports an Excel imaging file and allows some renaming of variables.
longitudinalPrime	Selects a set variables to be retained in a data frame of longitudinal data.
twoLevelOpcreate	Creates a data.frame formed by applying, for each response, abinary operation to the values of two different treatments.

(iii) Plots

plotAnom	Identifies anomalous individuals and produces longitudinal plots without them and with just them.
plotCorrmatrix	Calculates and plots correlation matrices for a set of responses.
plotDeviationsBoxes	Produces boxplots of the deviations of the observed values from the smoothed values over values of x.
plotImagetimes	Plots the time within an interval versus the interval. For example, the hour of the day carts are imaged against the days after planting (or some other number of days after an event).
plotLongitudinal	Plots longitudinal data for a set of indiividuals
plotMedianDeviations	Calculates and plots the median of the deviations of the smoothed values from the observed values.
probeSmoothing	Compares, for a set of specified values of df and different smoothing methods, a response and the smooths of it, possibly along with growth rates calculated from the smooths.

(iii) Smoothing

fitSpline	Produce the fits from a natural cubic smoothing spline applied to a response in a 'data.frame', and growth rates can be computed using derivatives.
splitSplines	Adds the fits, and optionally growth rates computed from derivatives, after fitting natural cubic smoothing splines to subsets of a response to a 'data.frame'.

(iv) Growth rate and WUI calculation

fitSpline	Produce the fits from a natural cubic smoothing spline applied to a response in a 'data.frame', and growth rates can be computed using derivatives.
GrowthRates	Calculates growth rates (AGR, PGR, RGRdiff) between pairs of values in a vector.
intervalGRaverage	Calculates the growth rates for a specified time interval by taking weighted averages of growth rates for times within the interval.
intervalGRdiff	Calculates the growth rates for a specified time interval.

splitContGRdiff	Adds the growth rates calculated continuously over time for subsets of a response to a 'data.frame'.
splitSplines	Adds the fits, and optionally growth rates computed from derivatives, after fitting natural cubic smoothing splines to subsets of a response to a 'data.frame'.
WUI	Calculates the Water Use Index (WUI).
intervalWUI	Calculates water use indices (WUI) over a specified time interval to a data.frame.

(v) General calculations

anom	Tests if any values in a vector are anomalous in being outside specified limits.
calcLagged	Replaces the values in a vector with the result of applying an operation to it and a lagged value.
calcTimes	Calculates for a set of times, the time intervals after an origin time and the position of each within a time interval
cumulate	Calculates the cumulative sum, ignoring the first element if exclude.1st is TRUE.
intervalValueCalculate	Calculates a single value that is a function of an individual's values for a response over a specified time interval.
splitValueCalculate	Calculates a single value that is a function of an individual's values for a response.

(vi) Principal variates analysis (PVA)

intervalPVA.data.frame	Selects a subset of variables using PVA, based on the observed values within a specified time interval
PVA.data.frame	Selects a subset of variables stored in a data.frame using PVA.
PVA.matrix	Selects a subset of variables using PVA based on a correlation matrix.
rcontrib.data.frame	Computes a measure of how correlated each variable in a set is with the other variable, conditional on a nominated subset of them.
rcontrib.matrix	Computes a measure of how correlated each variable in a set is with the other variable, conditional on a nominated subset of them.

Overview

This package can be used to analyse growth data using splines to smooth the trend of individual plant traces over time and then to extract traits for further analysis. This process is called smoothing and extraction of traits (SET) by Brien et al. (2020), who detail the use of 'growthPheno' for carrying out the method.

The package 'growthPheno' has tools that aid in choosing the degree of smoothing and the selection of traits. There are also functions for importing and orgainizing the data that are generally

applicable, although they do have defaults that make them particularly adapted to data from a high-throughput phenotyping facility based on a Lemna-Tec Scananalyzer 3D system.

Data suitable for use with this package consists of columns of data obtained from a set of units (pots, carts or plots) over time. There should be a unique identifier for each unit, which by default is `Snapshot.ID.Tag`, and variable giving the Days after Planting for each measurement, by default `Time.after.Planting..d..` In some cases, it is expected that there will be a column labelled `Snapshot.Time.Stamp`, which reflects the imaging time from which a particular data value was obtained. For imaging data, the carts/pots may be arranged in a grid of Lanes × Positions.

The vignettes `Tomato` and `Rice` illustrate this process, the former being the example presented in Brien et al. (2020). Use `vignette("Tomato",package = "growthPheno")` or `vignette("Rice",package = "growthPheno")` to access either of the vignettes.

Author(s)

NA

Maintainer: NA

References

Brien, C., Jewell, N., Garnett, T., Watts-Williams, S. J., & Berger, B. (2020). Smoothing and extraction of traits in the growth analysis of noninvasive phenotypic data. *Plant Methods*, **16**, 36. doi: 10.1186/s13007020005776.

See Also

dae

GrowthRates	*Calculates growth rates (AGR, PGR, RGRdiff) between pairs of values in a vector*

Description

Calculates either the Absolute Growth Rate (AGR), Proportionate Growth Rate (PGR) or Relative Growth Rate (RGR) between pairs of time points, the second of which is `lag` positions before the first. in `x`.

Usage

```
AGRdiff(x, time.diffs, lag=1)
PGR(x, time.diffs, lag=1)
RGRdiff(x, time.diffs, lag=1)
```

Arguments

x	A numeric from which the growth rates are to be calculated.
time.diffs	a numeric giving the time differences between successive values in x.
lag	A integer specifying, for the second value in the pair to be operated on, the number positions it is ahead of the current value.

Details

The AGRdiff is calculated as the difference between a pair of values divided by the time.diffs. The PGR is calculated as the ratio of a value to a second value which is lag values ahead of the first in x and the ratio raised to the power of the reciprocal of time.diffs. The RGRdiff is calculated as the log of the PGR and so is equal to the difference between the logarithms of a pair of values divided by the time.diffs. The differences and ratios are obtained using calcLagged with lag = 1.

Value

A numeric containing the growth rates which is the same length as x and in which the first lag values NA.

Author(s)

Chris Brien

See Also

intervalGRaverage, intervalGRdiff, splitContGRdiff, splitSplines, calcLagged

Examples

```
data(exampleData)
longi.dat$Area.AGR <- with(longi.dat, AGRdiff(Area, time.diffs = Days.diffs))
```

---

importExcel   *Imports an Excel imaging file and allows some renaming of variables*

Description

Uses readxl to import a sheet of imaging data produced by the Lemna Tec Scanalyzer. Basically, the data consists of imaging data obtained from a set of pots or carts over time. There should be a column, which by default is called Snapshot.ID.Tag, containing a unique identifier for each cart and a column, which by default is labelled Snapshot.Time.Stamp, containing the time of imaging for each observation in a row of the sheet. Also, if startTime is not NULL, calcTimes is called to calculate, or recalculate if already present, timeAfterStart from imageTimes by subtracting a supplied startTime.

Using cameraType, keepCameraType, labsCamerasViews and prefix2suffix, some flexibility is provided for renaming the columns with imaging data. For example, if the column names are prefixed with 'RGB_SV1', 'RGB_SV2' or 'RGB_TV', the 'RGB_' can be removed and the 'SV1', 'SV2' or 'TV' become suffices.

Usage

```
importExcel(file, sheet="raw data", sep = ",",
            cartId = "Snapshot.ID.Tag",
            imageTimes = "Snapshot.Time.Stamp",
            timeAfterStart = "Time.after.Planting..d.",
            cameraType = "RGB", keepCameraType = FALSE,
            labsCamerasViews = NULL, prefix2suffix = TRUE,
```

```
                       startTime = NULL,
                       timeFormat = "%Y-%m-%d %H:%M",
                       plotImagetimes = TRUE, ...)
```

Arguments

file	A [character](#) giving the path and name of the file containing the data.
sheet	A [character](#) giving the name of the sheet containing the data, that must include columns whose names are as specified by cartId, which uniquely indexes the carts in the experiment, and imageTimes, which reflects the time of the imaging from which a particular data value was obtained. It is also assumed that a column whose name is specified by timeAfterStart is in the sheet or that it will be calculated from imageTimes using the value of startTime supplied in the function call.
sep	A [character](#) giving the separator used in a csv file.
cartId	A [character](#) giving the name of the column that contains the unique Id for each cart. Note that in importing data into R, spaces and nonalphanumeric characters in names are converted to full stops.
imageTimes	A [character](#) giving the name of the column that contains the time that each cart was imaged. Note that in importing data into R, spaces and nonalphanumeric characters in names are converted to full stops.
timeAfterStart	A [character](#) giving the name of the column that contains or is to contain the difference between imageTimes and startTime. The function calcTimes is called to calculate the differences. For example, it might contain the number of days after planting. Note that in importing data into R, spaces and nonalphanumeric characters in names are converted to full stops.
cameraType	A [character](#) string nominating the abbreviation used for the cameraType. A warning will be given if no variable names include this cameraType.
keepCameraType	A logical specifying whether to retain the cameraType in the variables names. It will be the start of the prefix or suffix and separated from the remander of the prefix or suffix by an underscore (_).
labsCamerasViews	
	A named [character](#) whose elements are new labels for the camera-view combinations and the name of each element is the old label for the camera-view combination in the data being imported. If labsCamerasViews is NULL, all column names beginning with cameraType are classed as imaging variables and the unique prefixes amongst them determined. If no imaging variables are found then no changes are made. Note that if you want to include a recognisable cameraType in a camier-view label, it should be at the start of the the label in labsCamerasViews and separated from the rest of the label by an underscore (_).
prefix2suffix	A logical specifying whether the variables names with prefixed camera-view labels are to have those prefixes transferred to become suffices. The prefix is assumed to be all the characters up to the first full stop (.) in the variable name and must contain cameraType to be moved. It is generally assumed that the characters up to the first underscore (_) are the camera type and this is removed if keepCameraType is FALSE. If there is no underscore (_), the whole prefix is moved. If labsCamerasViews is NULL, all column names beginning with cameraType are classed as imaging variables and the unique prefixes amongst them determined. If no imaging variables are found then no changes are made.

startTime   A character giving the time of planting, in the POSIXct format timeFormat, to
                  be subtracted from imageTimes in recalculating timeAfterStart. If startTime
                  is NULL then timeAfterStart is not recalculated.

timeFormat   A character giving the POSIXct format of characters containing times, in par-
                  ticular imageTimes and startTime.

plotImagetimes   A logical indicating whether a plot of the imaging times against the recalcu-
                  lated Time.After.Planting..d.. It aids in checking Time.After.Planting..d.
                  and what occurred in imaging the plants.

...   allows for arguments to be passed to plotImagetimes. However, if intervals
                  is passed an error will occur; use timeAfterStart instead.

Value

A data.frame containing the data.

Author(s)

Chris Brien

See Also

as.POSIXct, calcTimes, plotImagetimes

Examples

```
filename <- system.file("extdata/rawdata.xlsx", package = "growthPheno",
                        mustWork = TRUE)
raw.dat <- importExcel(file = filename,
                       startTime  = "2015-02-11 0:00 AM")



camview.labels <- c("SF0", "SL0", "SU0", "TV0")
names(camview.labels) <- c("RGB_Side_Far_0", "RGB_Side_Lower_0",
                           "RGB_Side_Upper_0", "RGB_TV_0")
filename <- system.file("extdata/raw19datarow.csv", package = "growthPheno",
                        mustWork = TRUE)
raw.19.dat <- suppressWarnings(importExcel(file = filename,
                                           cartId = "Snapshot.ID.Tags",
                                           startTime = "06/10/2017 0:00 AM",
                                           timeFormat = "%d/%m/%Y %H:M",
                                           labsCamerasViews = camview.labels,
                                           plotImagetimes = FALSE))
```

---

intervalGRaverage   *Calculates the growth rates for a specified time interval by taking*
                           weighted averages of growth rates for times within the interval

---

Description

Using previously calculated growth rates over time, calculates the Absolute Growth Rates for a
specified interval using the weighted averages of AGRs for each time point in the interval (AGR)
and the Relative Growth Rates for a specified interval using the weighted geometric means of RGRs
for each time point in the interval (RGR).

Usage

```
intervalGRaverage(responses, individuals = "Snapshot.ID.Tag",
                  which.rates = c("AGR","RGR"), suffices.rates=c("AGR","RGR"),
                  start.time, end.time, times.factor = "Days", suffix.interval,
                  data, sep=".", na.rm=TRUE)
```

Arguments

responses
: A [character](#) giving the names of the responses for which there are columns in data that contain the growth rates that are to be averaged. The names of the growth rates should have either AGR or RGR appended to the responses names.

individuals
: A [character](#) giving the name(s) of the factor(s) that define the subsets of the data for which each subset corresponds to the responses for an individual.

which.rates
: A [character](#) giving the growth rates that are to be averaged to obtain growth rates for an interval. It should be a combination "AGR" and "RGR".

suffices.rates
: A [character](#) giving the suffices to be appended to response to form the names of the columns containing the calculated the growth rates and in which growth rates are to be stored. Their elements will be matched with those of which.rates.

start.time
: A [numeric](#) giving the times, in terms of levels of times.factor, that will give a single value for each Snapshot.ID.Tag and that will be taken as the observation at the start of the interval for which the growth rate is to be calculated.

end.time
: A [numeric](#) giving the times, in terms of levels of times.factor, that will give a single value for each Snapshot.ID.Tag and that will be taken as the observation at the end of the interval for which the growth rate is to be calculated.

times.factor
: A [character](#) giving the name of the column in data containing the factor for times at which the data was collected. Its levels will be used in calculating growth rates and should be numeric values stored as characters.

suffix.interval
: A [character](#) giving the suffix to be appended to response.suffices.rates to form the names of the columns containing the calculated the growth rates.

data
: A [data.frame](#) containing the columns from which the growth rates are to be calculated.

sep
: A [character](#) giving the separator to use when the levels of individuals are combined. This is needed to avoid using a [character](#) that occurs in a factor to delimit levels when the levels of individuals are combined to identify subsets.

na.rm
: A [logical](#) indicating whether NA values should be stripped before the calculation of weighted means proceeds.

Details

The AGR for an interval is calculated as the weighted mean of the AGRs for times within the interval. The RGR is calculated as the weighted geometric mean of the RGRs for times within the interval; in fact the exponential is taken of the weighted means of the logs of the RGRs. The weights are obtained from the times.factor. They are taken as the sum of half the time subintervals before and after each time, except for the end points; the end points are taken to be the subintervals at the start and end of the interval.

Value

A [data.frame](#) with the growth rates. The name of each column is the concatenation of (i) one of responses, (ii) one of AGR, PGR or RGR, or the appropriate element of suffices.rates, and (iii) suffix.interval, the three components being separated by full stops.

Author(s)

Chris Brien

See Also

[intervalGRdiff](#), [intervalWUI](#), [splitValueCalculate](#), [getTimesSubset](#), [GrowthRates](#), [splitSplines](#), [splitContGRdiff](#)

Examples

```
data(exampleData)
longi.dat <- splitSplines(longi.dat, response="Area", x="xDays",
                          INDICES = "Snapshot.ID.Tag",
                          df = 4, deriv=1, suffices.deriv="AGRdv", RGR="RGRdv")
Area.smooth.GR <- intervalGRaverage("Area.smooth", which.rates = c("AGR","RGR"),
                                    suffices.rates = c("AGRdv","RGRdv"),
                                    start.time = 31, end.time = 35,
                                    suffix.interval = "31to35",
                                    data = longi.dat)
```

---

intervalGRdiff   *Calculates the growth rates for a specified time interval*

Description

Using the values of the responses, calculates the specified combination of the Absolute Growth Rates using differences (AGR), the Proportionate Growth Rates (PGR) and Relative Growth Rates using log differences (RGR) between two nominated time points.

Usage

```
intervalGRdiff(responses, individuals = "Snapshot.ID.Tag",
               which.rates = c("AGR","PGR","RGR"), suffices.rates=NULL,
               times.factor = "Days", start.times, end.times, suffix.interval,
               data)
```

Arguments

responses	A [character](#) giving the names of the columns in data from which the growth rates are to be calculated.
individuals	A [character](#) giving the name(s) of the factor(s) that define the subsets of the data for which each subset corresponds to the responses for an individual.
which.rates	A [character](#) giving the growth rates that are to be calculated. It should be a combination "AGR", "PGR" and "RGR".

suffices.rates A [character](#) giving the characters to be appended to the names of the responses in constructing the names of the columns containing the calculated growth rates. The order of the suffices in suffices.rates should correspond to the order of the elements of which.rates.

times.factor A [character](#) giving the name of the column in data containing the factor for times at which the data was collected. Its levels will be used in calculating growth rates and should be numeric values stored as characters.

start.times A [numeric](#) giving the times, in terms of levels of times.factor, that will give a single value for each Snapshot.ID.Tag and that will be taken as the observation at the start of the interval for which the growth rate is to be calculated.

end.times A [numeric](#) giving the times, in terms of levels of times.factor, that will give a single value for each Snapshot.ID.Tag and that will be taken as the observation at the end of the interval for which the growth rate is to be calculated.

suffix.interval

A [character](#) giving the suffix to be appended to response to form the names of the columns containing the calculated the growth rates.

data A [data.frame](#) containing the column from which the growth rates are to be calculated.

Details

The AGR is calculated as the difference between the values of response at the end.times and start.times divided by the difference between end.times and start.times. The PGR is calculated as the ratio of response at the end.times to that at start.times and the ratio raised to the power of the reciprocal of the difference between end.times and start.times. The RGR is calculated as the log of the PGR and so is equal to the difference between the logarithms of response at the end.times and start.times divided by the difference between end.times and start.times.

Value

A [data.frame](#) with the growth rates. The name of each column is the concatenation of (i) one of responses, (ii) one of AGR, PGR or RGR, or the appropriate element of suffices.rates, and (iii) suffix.interval, the three components being separated by full stops.

Author(s)

Chris Brien

See Also

[intervalGRaverage](#), [intervalWUI](#), [getTimesSubset](#), [GrowthRates](#), [splitSplines](#), [splitContGRdiff](#)

Examples

```
data(exampleData)
Area.smooth.GR <- intervalGRdiff("Area.smooth", which.rates = c("AGR","RGR"),
                                 start.times = 31, end.times = 35,
                                 suffix.interval = "31to35",
                                 data = longi.dat)
```

intervalPVA.data.frame

Selects a subset of variables using Principal Variable Analysis (PVA),
based on the observed values within a specified time interval

Description

Principal Variable Analysis (PVA) (Cumming and Wooff, 2007) selects a subset from a set of the variables such that the variables in the subset are as uncorrelated as possible, in an effort to ensure that all aspects of the variation in the data are covered. Here, all observations in a specified time interval are used for calculation the correlations on which the selection is based.

Usage

```
## S3 method for class 'data.frame'
intervalPVA(obj, responses, times.factor = "Days", start.time, end.time,
            nvarselect = NULL, p.variance = 1, include = NULL,
            plot = TRUE, ...)
```

Arguments

obj	A [data.frame](#) containing the columns of variables from which the selection is to be made.
responses	A [character](#) giving the names of the columns in data from which the variables are to be selected.
times.factor	A [character](#) giving the name of the column in data containing the factor for times at which the data was collected. Its levels will be used to identify the subset and should be numeric values stored as characters.
start.time	A numeric giving the time, in terms of a level of times.factor, at which the time interval begins; observations at this time and up to and including end.time will be included.
end.time	A numeric giving the time, in terms of levels of times.factor, at the end of the interval; observations after this time will not be included.
nvarselect	A [numeric](#) specifying the number of variables to be selected, which includes those listed in include. If nvarselect = 1, as many variables are selected as is need to satisfy p.variance.
p.variance	A [numeric](#) specifying the minimum proportion of the variance that the selected variables must account for,
include	A [character](#) giving the names of the columns in data for the variables whose selection is mandatory.
plot	A [logical](#) indicating whether a plot of the cumulative proportion of the variance explained is to be produced.
...	allows passing of arguments to other functions.

Details

The variable that is most correlated with the other variables is selected first for inclusion. The partial correlation for each of the remaining variables, given the first selected variable, is calculated and the most correlated of these variables is selects for inclusion next. Then the partial correlations are adjust for the second included variables. This process is repeated until the specified criteria have been satisfied. The possibilities are to:

1. the default (nvarselect = NULL and p.variance = 1) select all variables in increasing order of amount of information they provide;

2. select exactly nvarselect variables;

3. select just enough variables, up to a maximum of nvarselect variables, to explain at least p.variance*100 per cent of the total variance.

Value

A `data.frame` giving the results of the variable selection. It will contain the columns Variable, Selected, h.partial, Added.Propn and Cumulative.Propn.

Author(s)

Chris Brien

References

Cumming, J. A. and D. A. Wooff (2007) Dimension reduction via principal variables. *Computational Statistics and Data Analysis*, **52**, 550–565.

See Also

`PVA`, `rcontrib`

Examples

```
data(exampleData)
responses <- c("Area","Area.SV","Area.TV", "Image.Biomass", "Max.Height","Centre.Mass",
               "Density", "Compactness.TV", "Compactness.SV")
results <-  intervalPVA(longi.dat, responses,
                        start.time = "31", end.time = "31",
                        p.variance=0.9, plot = FALSE)
```

---

intervalValueCalculate

Calculates a single value that is a function of an individual's values for a response over a specified time interval

---

Description

Splits the values of a response into subsets corresponding individuals and applies a function that calculates a single value from each individual's observations during a specified time interval. It includes the ability to calculate the observation number that is closest to the calculated value of the function and the assocated values of a `factor` or `numeric`.

Usage

```
intervalValueCalculate(response, weights=NULL, individuals = "Snapshot.ID.Tag",
                       FUN = "max", which.obs = FALSE, which.values = NULL,
                       start.time=NULL, end.time=NULL, times.factor = "Days",
                       suffix.interval=NULL, data, sep=".", na.rm=TRUE, ...)
```

Arguments

response   A [character](#) giving the name of the column in data from which the values of
                  FUN are to be calculated.

weights   A [character](#) giving the name of the column in data containing the weights to
                  be supplied as w to FUN.

individuals   A [character](#) giving the name(s) of the factor(s) that define the subsets of the
                  data for which each subset corresponds to the response value for an individual.

FUN   A [character](#) giving the name of the function that calculates the value for each
                  subset.

which.obs   A [logical](#) indicating whether or not to determine the observation number cor-
                  responding to the observed value that is closest to the value of the function,
                  in addition to the value of the function itself. That is, FUN need not return an
                  observed value of the reponse, e.g. quantile.

which.values   A [character](#) giving the name of the [factor](#) or [numeric](#) whose values are as-
                  sociated with the response values and whose value is to be returned for the
                  observation number whose response value corresponds to the observed value
                  closest to the value of the function. That is, FUN need not return an observed
                  value of the reponse, e.g. quantile. In the case of multiple observed response
                  values satisfying this condition, the value of the which.values vector for the
                  first of these is returned.

start.time   A [numeric](#) giving the times, in terms of levels of times.factor, that will give
                  a single value for each Snapshot.ID.Tag and that will be taken as the obser-
                  vation at the start of the interval for which the growth rate is to be calculated.
                  If start.time is NULL, the interval will start with the first observation. In the
                  case of multiple observed response values satisfying this condition, the first is
                  returned.

end.time   A [numeric](#) giving the times, in terms of levels of times.factor, that will give
                  a single value for each Snapshot.ID.Tag and that will be taken as the observa-
                  tion at the end of the interval for which the growth rate is to be calculated. If
                  end.time is NULL, the interval will end with the last observation.

times.factor   A [character](#) giving the name of the column in data containing the factor for
                  times at which the data was collected. Its levels should be numeric values stored
                  as characters.

suffix.interval

                  A [character](#) giving the suffix to be appended to response to form the name of
                  the column containing the calculated values. If it is NULL then nothing will be
                  appended.

data   A [data.frame](#) containing the column from which the function is to be calcu-
                  lated.

na.rm   A [logical](#) indicating whether NA values should be stripped before the calcula-
                  tion proceeds.
```

sep             A [character](#) giving the separator to use when the levels of individuals are combined. This is needed to avoid using a [character](#) that occurs in a factor to delimit levels when the levels of individuals are combined to identify subsets.

...             allows for arguments to be passed to FUN.

## Value

A [data.frame](#), with the same number of rows as there are individuals, containing a column for the individuals and a column with the values of the function for the individuals. It is also possible to determine observaton numbers or the values of another column in data for the response values that are closest to the FUN results, using either or both of which.obs and which.values. If which.obs is TRUE, a column with observation numbers is included in the [data.frame](#). If which.values is set to the name of a [factor](#) or a [numeric](#),a column containing the levels of that [factor](#) or the values of that [numeric](#) is included in the [data.frame](#).

The name of the column with the values of the function will be result of concatenating the response, FUN and, if it is not NULL, suffix.interval, each separated by a full stop. If which.obs is TRUE, the column name for the obervations numbers will have .obs added after FUN into the column name for the function values; if which.values is specified, the column name for these values will have a full stop followed by which.values added after FUN into the column name for the function values.

## Author(s)

Chris Brien

## See Also

[intervalGRaverage](#), [intervalGRdiff](#), [intervalWUI](#), [splitValueCalculate](#), [getTimesSubset](#)

## Examples

```
data(exampleData)
Area.smooth.max <- intervalValueCalculate("Area.smooth",
                                          start.time = 31, end.time = 35,
                                          suffix.interval = "31to35",
                                          data = longi.dat)
AGR.max.dat <- intervalValueCalculate("Area.smooth.AGR", FUN="max",
                                      start.time = 31, end.time = 35,
                                      suffix.interval = "31to35",
                                      which.values = "Days", which.obs = TRUE,
                                      data=longi.dat)
```

---

intervalWUI   *Calculates water use indices (WUI) over a specified time interval to a data.frame*

Description

Calculates the Water Use Index (WUI) between two time points for a set of responses.

Usage

```
intervalWUI(responses, water.use = "Water.Use",
            individuals = "Snapshot.ID.Tag", times.factor = "Days",
            start.times, end.times, suffix.interval = NULL,
            data, include.total.water = FALSE, na.rm = FALSE)
```

Arguments

responses   A [character](#) giving the names of the columns in data from which the growth
                 rates are to be calculated.

water.use   A [character](#) giving the names of the column in data which contains the water
                 use values.

individuals   A [character](#) giving the name(s) of the factor(s) that define the subsets of the
                 data for which each subset corresponds to the responses for an individual.

times.factor   A [character](#) giving the name of the column in data containing the factor for
                 times at which the data was collected. Its levels will be used in identifying the
                 intervals and should be numeric values stored as characters.

start.times   A numeric giving the times, in terms of levels of times.factor, that will give a
                 single value for each Snapshot.ID.Tag and that will be taken as the observation
                 at the start of the interval for which the growth rate is to be calculated.

end.times   A numeric giving the times, in terms of levels of times.factor, that will give a
                 single value for each Snapshot.ID.Tag and that will be taken as the observation
                 at the end of the interval for which the growth rate is to be calculated.

suffix.interval

                 A [character](#) giving the suffix to be appended to response to form the names
                 of the columns containing the calculated the growth rates.

data   A [data.frame](#) containing the column from which the growth rates are to be
                 calculated.

include.total.water

                 A [logical](#) indicating whether or not to include a column in the results for the
                 total of water.use for the interval for each individual.

na.rm   A [logical](#) indicating whether NA values should be stripped before the calcula-
                 tion proceeds.

Details

The WUI is calculated as the difference between the values of a response at the end.times and
start.times divided by the sum of the water use after start.times until end.times. Thus, the
water use up to start.times is not included.

Value

A [data.frame](#) containing the WUIs, the name of each column being the concatenation of one of
responses, WUI and, if not NULL, suffix.interval, the three components being separated by a
full stop. If the total water is to be included, the name of the column will be the concatenation of
water.use, Total and the suffix, each separated by a full stop('.').

Author(s)

Chris Brien

See Also

[intervalGRaverage](), [intervalGRdiff](), [splitValueCalculate](), [getTimesSubset](), [GrowthRates]()

Examples

```
data(exampleData)
Area.smooth.WUI <- intervalWUI("Area", water.use = "Water.Loss",
                               start.times = 31, end.times = 35,
                               suffix = "31to35",
                               data = longi.dat, include.total.water = TRUE)
```

---

longitudinalPrime	*Selects a set variables to be retained in a data frame of longitudinal data*

Description

Forms the prime traits by selecting a subset of the traits in a data.frame of imaging data produced by the Lemna Tec Scanalyzer. The imaging traits to be retained are specified using the traits and labsCamerasViews arguments. Some imaging traits are divided by 1000 to convert them from pixels to kilopixels. Also added are factors and explanatory variates that might be of use in an analysis.

Usage

```
longitudinalPrime(data, cartId = "Snapshot.ID.Tag",
                  imageTimes = "Snapshot.Time.Stamp",
                  timeAfterStart = "Time.after.Planting..d.",
                  idcolumns = c("Genotype.ID","Treatment.1"),
                  traits = list(all = c("Area",
                                        "Boundary.Points.To.Area.Ratio",
                                        "Caliper.Length", "Compactness",
                                        "Convex.Hull.Area"),
                                side = c("Center.Of.Mass.Y",
                                         "Max.Dist.Above.Horizon.Line")),
                  labsCamerasViews = list(all = c("SV1", "SV2", "TV"),
                                          side = c("SV1", "SV2")),
                  smarthouse.lev = NULL,
                  calcWaterLoss = TRUE, pixelsPERcm)
```

Arguments

data
A [data.frame]() containing the columns specified by cartId, imageTimes, timeAfterStart, idcolumns, traits and cameras along with the following columns:

Smarthouse, Lane, Position, Weight.Before, Weight.After, Water.Amount, Projected.Shoot.Area..pixels.

The defaults for the arguments to longitudinalPrime requires a [data.frame]() containing the following columns, although not necessarily in the order given here:

Smarthouse, Lane, Position, Weight.Before, Weight.After, Water.Amount, Projected.Shoot.Area..pixels., Area.SV1, Area.SV2, Area.TV,

Boundary.Points.To.Area.Ratio.SV1, Boundary.Points.To.Area.Ratio.SV2, Boundary.Points.To.Area.Ratio.TV, Caliper.Length.SV1, Caliper.Length.SV2, Caliper.Length.TV, Compactness.SV1, Compactness.SV2, Compactness.TV, Convex.Hull.Area.SV1, Convex.Hull.Area.SV2, Convex.Hull.Area.TV, Center.Of.Mass.Y.SV1, Center.Of.Mass.Y.SV2, Max.Dist.Above.Horizon.Line.SV1, Max.Dist.Above.Horizon.Line.SV2.

cartId	A [character](#) giving the name of the column that contains the unique Id for each cart.
imageTimes	A [character](#) giving the name of the column that contains the time that each cart was imaged.
timeAfterStart	A [character](#) giving the name of the column that contains the time after some nominated starting time e.g. the number of days after planting.
idcolumns	A [character](#) vector giving the names of the columns that identify differences between the plants or carts e.g. Genotype.ID, Treatment.1, Treatment.2.
traits	A [character](#) or a [list](#) whose components are [character](#)s. Each [character](#) gives the names of the columns for imaging traits whose values are required for each of the camera-view combinations given in the corresponding [list](#) component of labsCamerasViews. If labsCamerasViews or a component of labsCamerasViews is NULL, then the contents of traits or the coresponding component of traits are merely treated as the names of columns to be retained.
labsCamerasViews	A [character](#) or a [list](#) whose components are [character](#)s. Each [character](#) gives the labels of the camera-view combinations for which is required values of each of the imaging traits in the corresponding [character](#) of traits. It is assumed that the camera-view labels are appended to the trait names and separated from the trait names by a full stop (.). If labsCamerasViews or a component of labsCamerasViews is NULL, then the contents of the traits or the coresponding component of traits are merely treated as the names of columns to be retained.
smarthouse.lev	A [character](#) vector giving the levels to use for the Smarthouse factor. If NULL then the unique values in Smarthouse will be used.
calcWaterLoss	A [logical](#) indicating whether to calculate the Water.Loss. If it is FALSE, Water.Before, Water.After and Water.Amount will not be in the returned [data.frame](#). They can be copied across by listing them in a component of traits and set the corresponding component of cameras to NULL.
pixelsPERcm	A [numeric](#) giving the number of pixels per cm for the images. *No longer used.*

Details

The columns are copied from data, except for those columns in the list under **Value** that have '(calculated)' appended.

Value

A [data.frame](#) containing the columns specified by cartId, imageTimes, timeAfterStart, idcolumns, traits and cameras. The defaults will result in the following columns:

1. Smarthouse: factor with levels for the Smarthouse

2. Lane: factor for lane number in a smarthouse

3. Position: factor for east/west position in a lane

4. Days: factor for the number of Days After Planting (DAP)

5. `cartId`: unique code for each cart

6. `imageTimes`: time at which an image was taken in POSIXct format

7. Reps: factor indexing the replicates for each combination of the factors in `idcolumns` (calculated)

8. xPosn: numeric for the Positions within a Lane (calculated)

9. Hour: hour of the day, to 2 decimal places, at which the image was taken (calculated)

10. xDays: numeric for the DAP that is centred by subtracting the mean of the unique days (calculated)

11. `idcolumns`: the columns listed in `idcolumns` that have been converted to factors

12. Weight.Before: weight of the pot before watering (only if `calcWaterLoss` is `TRUE`)

13. Weight.After: weight of the pot after watering (only if `calcWaterLoss` is `TRUE`)

14. Water.Amount: the weight of the water added (= Water.After - Water.Before) (calculated)

15. Water.Loss: the difference between Weight.Before for the current imaging and the Weight.After for the previous imaging (calculated unless `calcWaterLoss` is `FALSE`)

16. Area: the Projected.Shoot.Area..pixels. divided by 1000 (calculated)

17. Area.SV1: the Projected.Shoot.Area from Side View 1 divided by 1000 (calculated)

18. Area.SV2: the Projected.Shoot.Area from Side View 2 divided by 1000 (calculated)

19. Area.TV: the Projected.Shoot.Area from Top View divided by 1000 (calculated)

20. Boundary.To.Area.Ratio.SV1

21. Boundary.To.Area.Ratio.SV2

22. Boundary.To.Area.Ratio.TV

23. Caliper.Length.SV1

24. Caliper.Length.SV2

25. Caliper.Length.TV

26. Compactness.SV1 from Side View 1

27. Compactness.SV2 from Side View 2

28. Compactness.TV: from Top View

29. Convex.Hull.Area.SV1: area of Side View 1 Convex Hull divided by 1000 (calculated)

30. Convex.Hull.Area.SV2: area of Side View 2 Convex Hull divided by 1000 (calculated)

31. Convex.Hull.TV: Convex.Hull.Area.TV divided by 1000 (calculated)

32. Center.Of.Mass.Y.SV1: Centre of Mass from Side View 1

33. Center.Of.Mass.Y.SV2: Centre of Mass from Side View 2

34. Max.Dist.Above.Horizon.Line.SV1: the Max.Dist.Above.Horizon.Line.SV1 converted to cm using `pixelsPERcm` (calculated)

35. Max.Dist.Above.Horizon.Line.SV2: the Max.Dist.Above.Horizon.Line.SV2 converted to cm using `pixelsPERcm` (calculated)

Author(s)

Chris Brien

Examples

```
data(exampleData)
longiPrime.dat <- longitudinalPrime(data=raw.dat, smarthouse.lev=1)

longiPrime.dat <- longitudinalPrime(data=raw.dat, smarthouse.lev=1,
                                    traits = list(a = "Area", c = "Compactness"),
                                    labsCamerasViews = list(all = c("SV1", "SV2", "TV"),
                                                            t = "TV"))

longiPrime.dat <- longitudinalPrime(data=raw.dat, smarthouse.lev=1,
                                    traits = c("Area.SV1", "Area.SV2", "Area.TV",
                                               "Compactness.TV"),
                                    labsCamerasViews = NULL)

longiPrime.dat <- longitudinalPrime(data=raw.dat, smarthouse.lev=1,
                                    calcWaterLoss = FALSE,
                                    traits = list(img = c("Area", "Compactness"),
                                                  H20 = c("Weight.Before","Weight.After",
                                                          "Water.Amount")),
                                    labsCamerasViews = list(all = c("SV1", "SV2", "TV"),
                                                            H2O = NULL))
```

---

plotAnom	*Identifies anomalous individuals and produces longitudinal plots without them and with just them*

Description

Uses intervalValueCalculate and the function anom to identify anomalous individuals. The user can elect to print the anomalous individuals, a longitudinal profile plot without the anomalous individuals and/or a longitudinal profile plot with only the anomalous individuals. The plots are produced using ggplot. The plot can be facetted so that a grid of plots is produced.

Usage

```
plotAnom(data, x="xDays+24.16666667", response="Area.smooth.RGR",
         individuals="Snapshot.ID.Tag",
         breaks=seq(12, 36, by=2), vertical.line=NULL,
         groupsFactor=NULL, lower=NULL, upper=NULL,
         start.time=NULL, end.time=NULL, times.factor = "Days",
         suffix.interval=NULL,
         columns.retained=c("Snapshot.ID.Tag", "Smarthouse", "Lane",
                            "Position", "Treatment.1", "Genotype.ID"),
         whichPrint=c("anomalous","innerPlot","outerPlot"), na.rm=TRUE, ...)
```

Arguments

data	A data.frame containing the data to be tested and plotted.
x	A character giving the variable to be plotted on the x-axis.
response	A character specifying the response variable that is to be tested and plotted on the y-axis.

individuals	A [character](#) giving the name(s) of the factor(s) that define the subsets of the data for which each subset corresponds to the response value for an individual.
breaks	A [numeric](#) vector giving the breaks to be plotted on the x-axis scale.
vertical.line	A [numeric](#) giving position on the x-axis at which a vertical line is to be drawn. If NULL, no line is drawn.
groupsFactor	A [factor](#) giving the name of a factor that defines groups of individuals between which the test for anomalous individuals can be varied by setting values for one or more of lower, upper, start.time and end.time to be NULL, a single value or a set of values whose number equals the number of levels of groupsFactor. If NULL or only a dingle value is supplied, the test is the same for all individuals.
lower	A [numeric](#) such that values in response below it are considered to be anomalous. If NULL, there is no testing for values below the lower bound.
upper	A [numeric](#) such that values in response above it are considered to be anomalous. If NULL, there is no testing for values above the upper bound.
start.time	A [numeric](#) giving the start of the time interval, in terms of a level of times.factor, during which testing for anomalous values is to occur. If NULL, the interval will start with the first observation.
end.time	A [numeric](#) giving the end of the time interval, in terms of a level of times.factor, during which testing for anomalous values is to occur. If NULL, the interval will end with the last observation.
times.factor	A [character](#) giving the name of the column in data containing the factor for times at which the data was collected. Its levels should be numeric values stored as characters.
suffix.interval	A [character](#) giving the suffix to be appended to response to form the name of the column containing the calculated values. If it is NULL then nothing will be appended.
columns.retained	A [character](#) giving the names of the columns in data that are to be retained in the data.frame of anomalous individuals.
whichPrint	A [character](#) indicating what is to be printed. If anomalous is included, the columns.retained are printed for the anomalous individuals.
na.rm	A [logical](#) indicating whether NA values should be stripped before the testing proceeds.
...	allows for arguments to be passed to [plotLongitudinal](#).

Value

A [list](#) with three components:

1. data, a data frame resulting from the [merge](#) of data and the [logical](#) identifying whether or not an individual is anomalous;

2. innerPlot, an object of class ggplot storing the longitudinal plot of the individuals that are not anomalous;

3. outerPlot, an object of class ggplot storing the longitudinal plot of only the individuals that are anomalous.

The name of the column indicating anomalous individuals will be result of concatenating the response, anom and, if it is not NULL, suffix.interval, each separated by a full stop. The ggplot objects can be plotted using print and can be modified by adding ggplot functions before printing. If there are no observations to plot, NULL will be returned for the plot.

Author(s)

Chris Brien

See Also

anom, intervalValueCalculate, ggplot.

Examples

```
data(exampleData)
anomalous <- plotAnom(longi.dat, response="Area.smooth.AGR",
                      lower=2.5, start.time=40,
                      x = "xDays+35.42857143", vertical.line=29,
                      breaks=seq(28, 42, by=2),
                      whichPrint=c("innerPlot"),
                      y.title="Area.smooth.AGR")
```

---

plotCorrmatrix   *Calculates and plots correlation matrices for a set of responses*

Description

Having calculated the correlations a heat map indicating the magnitude of the correlations is produced using ggplot. In this heat map, the darker the red in a cell then the closer the correlation is to -1, while the deeper the blue in the cell, then the closer the correlation is to 1. A matrix plot of all pairwise combinations of the variables can be produced. The matrix plot contains a scatter diagram for each pair, as well as the value of the correlation coefficient. The argument pairs.sets can be used to restrict the pairs in the matrix plot to those combinations within each set.

Usage

```
plotCorrmatrix(data, responses, which.plots = c("heatmap","matrixplot"),
               title = NULL, labels = NULL, labelSize = 4, pairs.sets = NULL,
               show.sig = FALSE, axis.text.size = 20, ggplotFuncs = NULL,
               printPlot = TRUE, ...)
```

Arguments

data	A data.frame containing the columns of variables to be correlated.
responses	A character giving the names of the columns in data containing the variables to be correlated.
which.plots	A character specifying the plots of the correlations to be produced. The possibilities are one or both of heatmap and matrixplot.
title	Title for the plots.

labels	A [character](#) specifying the labels to be used in the plots. If labels is NULL, responses is used for the labels.
labelSize	A [numeric](#) giving the size of the labels in the matrixplot.
pairs.sets	A [list](#) each of whose components is a [numeric](#) giving the position of the variable names in responses that are to be included in the set. All pairs of variables in this pairs.set will be included in a matrixplot.
show.sig	A [logical](#) indicating whether or not to give asterisks on the heatmap indicating the correlations are significantly different from zero.
axis.text.size	A [numeric](#) giving the size of the labels on the axes of the heatmap.
ggplotFuncs	A [list](#), each element of which contains the results of evaluating a [ggplot](#) function. It is created by calling the [list](#) function with a [ggplot](#) function call for each element. These functions are applied in creating the ggplot object.
printPlot	A [logical](#) indicating whether or not to print the plot.
...	allows passing of arguments to other functions; not used at present.

Details

The correlations and their p-values are producced using [rcorr](#) from the Hmisc package. The heatmap is produced using [ggplot](#) and the matrixplot is produced using [GGally](#).

Value

The heatmap plot, if produced, as an object of class "ggplot", which can be plotted using print; otherwise NULL is returned.

Author(s)

Chris Brien

See Also

[rcorr](#), [GGally](#), [ggplot](#).

Examples

```
data(exampleData)
responses <- c("Area","Area.SV","Area.TV", "Image.Biomass", "Max.Height","Centre.Mass",
               "Density", "Compactness.TV", "Compactness.SV")
plotCorrmatrix(longi.dat, responses, pairs.sets=list(c(1:4),c(5:7)))
```

---

plotDeviationsBoxes	*Produces boxplots of the deviations of the observed values from the smoothed values over values of x.*

Description

Produces boxplots of the deviations of the observed values from the smoothed values over values of x.

Usage

```
plotDeviationsBoxes(data, observed, smoothed, x.factor,
                    x.title = NULL, y.titles = NULL,
                    facet.x = ".", facet.y = ".", labeller = NULL,
                    df, deviations.plots = "absolute",
                    ggplotFuncs = NULL, printPlot = TRUE, ...)
```

Arguments

data	A [data.frame](#) containing the observed and smoothed values from which the deviations are to be computed.
observed	A `character` specifying the response variable for which the observed values are supplied.
smoothed	A `character` specifying the smoothed response variable, corresponding to `observed`, for which values are supplied.
x.factor	A [character](#) giving the [factor](#) to be plotted on the x-axis.
x.title	Title for the x-axis. If NULL then set to xname.
y.titles	A [character](#) giving the titles for the y-axis, one for each plot specified deviations.plots.
facet.x	A [data.frame](#) giving the variable to be used to form subsets to be plotted in separate columns of plots. Use `"."` if a split into columns is not wanted. For which.plots set to methodcompare or dfcompare facet.x is ignored.
facet.y	A [data.frame](#) giving the variable to be used to form subsets to be plotted in separate rows of plots. Use `"."` if a split into columns is not wanted.
labeller	A [ggplot function](#) for labelling the facets of a plot produced using the [ggplot](#) function. For more information see [ggplot](#).
df	A [numeric](#) specifying the smoothing degrees of freedom used in producing the response.smoothed and which is to be used in labelling the plot.
deviations.plots	A [character](#) specifying whether absolute and/or relative deviations are to be plotted.
ggplotFuncs	A [list](#), each element of which contains the results of evaluating a [ggplot](#) function. It is created by calling the [list](#) function with a [ggplot](#) function call for each element. These functions are applied in creating the ggplot object for plotting.
printPlot	A [logical](#) indicating whether or not to print the plots.
...	allows passing of arguments to [plotLongitudinal](#).

Value

A list whose components are named absolute and relative; a component will contain an object of class "ggplot" when the plot has been requested using the deviations.plots argument and a NULL otherwise. The objects can be plotted using print.

Author(s)

Chris Brien

See Also

plotMedianDeviations, probeSmoothing, ggplot.

Examples

```
data(exampleData)

plotDeviationsBoxes(longi.dat, observed = "Area", smoothed = "Area.smooth",
                    x.factor="Days", facet.x = ".", facet.y= ".", df =5)
```

---

plotImagetimes | *Plots the position of a time within an interval against the interval for each cart*

Description

Uses ggplot to produce a plot of the time position within an interval against the interval. For example, one might plot the hour of the day carts are imaged against the days after planting (or some other number of days after an event). A line is produced for each value of groupVariable and the colour is varied according to the value of the colourVariable. Each Smarthouse is plotted separately. It aids in checking whether delays occurred in imaging the plants.

Usage

```
plotImagetimes(data, intervals = "Time.after.Planting..d.", timePositions = "Hour",
               groupVariable = "Snapshot.ID.Tag", colourVariable = "Lane",
               ggplotFuncs = NULL, printPlot = TRUE)
```

Arguments

data	A data.frame containing any columns specified by intervals, timePositions, groupVariable and colourVariable.
intervals	A character giving the name of the column in data containing, as a numeric or a factor, the calculated times to be plotted on the x-axis. For example, it could be the days after planting or treatment.
timePositions	A character giving the name of the column in data containing, as a numeric, the value of the time position within an interval (for example, the time of imaging during the day expressed in hours plus a fraction of an hour).
groupVariable	A character giving the name of the column in data containing the variable to be used to group the plotting.
colourVariable	A character giving the name of the column in data containing the variable to be used to colour the plotting.
ggplotFuncs	A list, each element of which contains the results of evaluating a ggplot function. It is created by calling the list function with a ggplot function call for each element. These functions are applied in creating the ggplot object.
printPlot	A logical indicating whether or not to print the plot.

Value

An object of class "ggplot", which can be plotted using print.

Author(s)

Chris Brien

See Also

[ggplot](#), [calcTimes](#).

Examples

```
data(exampleData)
library(ggplot2)
longi.dat <- calcTimes(longi.dat, imageTimes = "Snapshot.Time.Stamp",
                       timePositions = "Hour")
plotImagetimes(data = longi.dat, intervals = "Days", timePositions = "Hour",
               ggplotFuncs=list(scale_colour_gradient(low="grey20", high="black"),
                                geom_line(aes(group=Snapshot.ID.Tag, colour=Lane))))
```

---

plotLongitudinal   *Plots longitudinal data for a set of indiividuals*

Description

Produce profile or longitudinal plots of a response using ggplot. A line is drawn for the data for each individual and the plot can be facetted so that a grid of plots is produced. For each facet a line for the medians over time can be added, along with the vaue of the outer whiskers (median +/- 1.5 * IQR).

Usage

```
plotLongitudinal(data, x = "xDays+44.5", response = "Area",
                 individuals = "Snapshot.ID.Tag", title = NULL,
                 x.title = "Days", y.title = "Area (kpixels)",
                 facet.x = "Treatment.1", facet.y = "Smarthouse",
                 labeller = NULL, colour = "black",
                 colour.column = NULL, colour.values = NULL,
                 alpha = 0.1, addMediansWhiskers = FALSE,
                 xname = "xDays", ggplotFuncs = NULL,
                 printPlot = TRUE)
```

Arguments

data	A [data.frame](#) containing the data to be plotted.
x	A [character](#) giving the variable to be plotted on the x-axis.
response	A character specifying the response variable that is to be plotted on the y-axis.
individuals	A [character](#) giving the name(s) of the [factor](#)(s) that define the subsets of the data for which each subset corresponds to the response values for an individual.
x.title	Title for the x-axis.
y.title	Title for the y-axis.

title	Title for the plot.
facet.x	A [data.frame](#) giving the variable to be used to form subsets to be plotted in separate columns of plots. Use "." if a split into columns is not wanted.
facet.y	A [data.frame](#) giving the variable to be used to form subsets to be plotted in separate rows of plots. Use "." if a split into columns is not wanted.
labeller	A [ggplot function](#) for labelling the facets of a plot produced using the [ggplot](#) function. For more information see [ggplot](#).
colour	A [character](#) specifying a single colour to use in drawing the lines for the profiles. If colouring according to the values of a variable is required then use colour.column.
colour.column	A [character](#) giving the name of a column in data over whose values the colours of the lines are to be varied. The colours can be specified using colour.values .
colour.values	A [character](#) vector specifying the values of the colours to use in drawing the lines for the profiles. If this is a named vector, then the values will be matched based on the names. If unnamed, values will be matched in order (usually alphabetical) with the limits of the scale.
alpha	A [numeric](#) specifying the degrees of transparency to be used in plotting. It is a ratio in which the denominator specifies the number of points (or lines) that must be overplotted to give a solid cover.
addMediansWhiskers	
	A [logical](#) indicating whether plots over time of the medians and outer whiskers are to be added to the plot. The outer whiskers are related to the whiskers on a box-and-whisker and are defined as the median plus (and minus) 1.5 times the interquartile range (IQR). Points lying outside the whiskers are considered to be potential outliers.
xname	A [character](#) giving the name of the [numeric](#) that contains the values of the predictor variable from which x is derived, it being that x may incorporate an expression.
ggplotFuncs	A [list](#), each element of which contains the results of evaluating a [ggplot](#) function. It is created by calling the [list](#) function with a [ggplot](#) function call for each element. These functions are applied in creating the ggplot object.
printPlot	A [logical](#) indicating whether or not to print the plot.

Value

An object of class "[ggplot](#)", which can be plotted using print.

Author(s)

Chris Brien

See Also

[ggplot](#), [labeller](#).

Examples

```
data(exampleData)
plotLongitudinal(data = longi.dat, response = "Area.smooth")

plt <- plotLongitudinal(data = longi.dat, response = "Area.smooth", x.title = "DAP",
                        y.title = "Area.smooth", x="xDays+35.42857143", printPlot=FALSE)
plt <- plt + ggplot2::geom_vline(xintercept=29, linetype="longdash", size=1) +
             ggplot2::scale_x_continuous(breaks=seq(28, 42, by=2)) +
             ggplot2::scale_y_continuous(limits=c(0,750))
print(plt)

plotLongitudinal(data = longi.dat, response = "Area.smooth", x.title = "DAP",
                 y.title = "Area.smooth", x="xDays+35.42857143",
               ggplotFuncs = list(ggplot2::geom_vline(xintercept=29, linetype="longdash",
                                                      size=1),
                                  ggplot2::scale_x_continuous(breaks=seq(28, 42, by=2)),
                                   ggplot2::scale_y_continuous(limits=c(0,750))))
```

---

plotMedianDeviations	*Calculates and plots the median of the deviations of the smoothed values from the observed values.*

Description

Calculates and plots the median of the deviations of the supplied smoothed values from the supplied observed values for traits and combinations of different smoothing methods and smoothing degrees of freedom, possibly for subsets of factor combinations. The requisite values can be generated using `probeSmoothing` with both `which.plots` and `deviations.plots` set to none. The results of smoothing methods applied externally to growthPheno can be included via the `extra.smooths` argument. Envelopes of the median value of a trait for each factor combination can be added.

Usage

```
plotMedianDeviations(data, response, response.smoothed,
                     x = NULL, xname="xDays",
                     individuals = "Snapshot.ID.Tag",
                     x.title = NULL, y.titles = NULL,
                     facet.x = "Treatment.1", facet.y = "Smarthouse",
                     labeller = NULL,
                     trait.types = c("response", "AGR", "RGR"),
                     propn.types = c(0.1, 0.5, 0.75), propn.note = TRUE,
                     alpha.med.devn = 0.5,
                     smoothing.methods = "direct", df, extra.smooths = NULL,
                     ggplotFuncsMedDevn = NULL, printPlot = TRUE, ...)
```

Arguments

data   A `data.frame` containing the observed and smoothed values from which the deviations are to be computed. There should be a column of smoothed values for each combination of `smoothing.methods`, `df` and the types specified by `trait.types`. In addition, there should be a column of values for each element of `extra.smooths` in combination with the elements of `trait.types`.

Also, there should be a column of observed values for the types specified by
trait.typesThe naming of the columns for smoothed traits should follow the
convention that a name is made up, in the order sepcified, of a response.smoothed,
the trait.type if not a response only, a smoothing.method or an extra.smooths
and, if a smoothing.method, a df; each component should be separated by a pe-
riod (.).

response   A [character](#) specifying the response variable for which the observed values
                  are supplied. Depending on the setting of trait.types, the observed values of
                  related trait.types may also need to be be supplied.

response.smoothed

                  A [character](#) specifying the name of the column containing the values of the
                  smoothed response variable, corresponding to response and obtained for the
                  combinations of smoothing.methods and df, usually using smoothing splines.
                  Depending on the setting of trait.types, the smoothed values of related trait.types
                  may also need to be be supplied.

x   A [character](#) giving the variable to be plotted on the x-axis; it may incorporate
                  an expression. If x is NULL then xname is used.

xname   A [character](#) giving the name of the [numeric](#) that contains the values from
                  which x is derived, it being that x may incorporate an expression.

individuals   A [character](#) giving the name(s) of the [factor](#)(s) that define the subsets of the
                  data for which each subset corresponds to the response values for an individ-
                  ual.

x.title   A [character](#) giving the title for the x-axis. If NULL then set to xname.

y.titles   A [character](#) giving the titles for the y-axis, one for each trait specified by
                  trait.types. If NULL then set to the traits derived for response from trait.types.

facet.x   A [data.frame](#) giving the variable to be used to form subsets to be plotted in
                  separate columns of plots. Use "." if a split into columns is not wanted. For
                  which.plots set to methodcompare or dfcompare facet.x is ignored.

facet.y   A [data.frame](#) giving the variable to be used to form subsets to be plotted in
                  separate rows of plots. Use "." if a split into columns is not wanted.

labeller   A [ggplot function](#) for labelling the facets of a plot produced using the [ggplot](#)
                  function. For more information see [ggplot](#).

trait.types   A [character](#) giving the traits types that are to be plotted. While AGR and RGR are
                  commonly used, the names can be arbitrary, except that response is a special
                  case that indicates that the original response is to be plotted.

propn.types   A [numeric](#) giving the proportion of the medians the values of each of the trait.types
                  that are to be plotted in the median deviations plots. If set to NULL, the plots of
                  the proprotions are omitted.

propn.note   A [logical](#) indicating whether a note giving the proportion of the median values
                  plotted in the compare.medians plots.

alpha.med.devn   A [numeric](#) specifying the degrees of transparency to be used in plotting a me-
                  dian deviations plot. It is a ratio in which the denominator specifies the number
                  of points (or lines) that must be overplotted to give a solid cover.

smoothing.methods

                  A [character](#) giving the smoothing method used in producing the response.smoothed
                  and which is to be used in labelling the plot.

df   A [numeric](#) specifying the smoothing degrees of freedom used in producing the
                  response.smoothed and which is to be used in labelling the plot.

extra.smooths   A [character](#) specifying one or more smoothing.method labels that have been
                 used in naming of columns of smooths of the response obtained by methods
                 other than the smoothing spline methods provided by growthPheno. Depending
                 on the setting of trait.types, the smoothed values of related trait types must
                 also be supplied, with names constructed according to the convention described
                 under data.

ggplotFuncsMedDevn
                 A [list](#), each element of which contains the results of evaluating a [ggplot](#) func-
                 tion. It is created by calling the [list](#) function with a [ggplot](#) function call for
                 each element. These functions are applied in creating the ggplot object.

printPlot   A [logical](#) indicating whether or not to print the plot.

...   allows passing of arguments to [plotLongitudinal](#).

Value

A [list](#) that consists of two components: (i) a componence named plots that stores a [list](#) of
the median deviations plots, one for each trait.types; (ii) a component named med.dev.dat that
stores the [data.frame](#) containing the median deviations that have been plotted. Each plot in the
plots [list](#) is in an object of class "[ggplot](#)", which can be plotted using print.

Author(s)

Chris Brien

See Also

[plotDeviationsBoxes](#), [probeSmoothing](#), [ggplot](#).

Examples

```
data(exampleData)
vline <- list(ggplot2::geom_vline(xintercept=20, linetype="longdash", size=1),
              ggplot2::scale_x_continuous(breaks=seq(12, 36, by=2)))
traits <- probeSmoothing(data = longi.dat, response = "Area",
                         df = c(4:7), x="xDays+24.16666667",
                         facet.x = ".", facet.y = ".",
                         which.plots = "none",
                         deviations.plots = "none",
                         propn.types = NULL)
med <- plotMedianDeviations(data = traits,
                            response = "Area", response.smoothed = "Area.smooth",
                            x="xDays+24.16666667", xname = "xDays",
                            df = c(4,7), x.title = "DAP",
                            facet.x = ".", facet.y = ".",
                            trait.types = "response", propn.types = 0.05,
                            ggplotFuncsMedDevn = vline)
```

---

probeDF	*Compares, for a set of specified values of df, a response and the smooths of it, possibly along with growth rates calculated from the smooths*

Description

Takes a response and, for each individual, uses splitSplines to smooth its values for each individual using the degrees of freedom values in df. Provided get.rates is TRUE, both the Absolute Growth Rates (AGR) and the Relative Growth Rates (RGR) are calculated for each smooth, either using differences or first derivatives. A combination of the unsmoothed and smoothed values, as well as the AGR and RGR, can be plotted for each value in df. Note that the arguments that modify the plots apply to all plots that are produced. The handling of missing values is controlled via na.x.action and na.y.action

Usage

```
probeDF(data, response = "Area", xname="xDays", individuals="Snapshot.ID.Tag",
        na.x.action="exclude", na.y.action = "exclude",
        df, smoothing.scale = "identity", correctBoundaries = FALSE,
        get.rates = TRUE, rates.method="differences",
        times.factor = "Days", x = NULL, x.title = NULL,
        facet.x = "Treatment.1", facet.y =   "Smarthouse", labeller = NULL,
        colour = "black", colour.column=NULL, colour.values=NULL, alpha = 0.1,
        which.traits = c("response", "AGR", "RGR"),
        which.plots = "smoothedonly",
        deviations.boxplots = "none",
        ggplotFuncs = NULL,
        ...)
```

Arguments

data	A data.frame containing the data.
response	A character specifying the response variable to be supplied to smooth.spline and that is to be plotted on the y-axis.
xname	A character giving the name of the numeric that contains the values of the predictor variable to be supplied to smooth.spline and from which x is derived.
individuals	A character giving the name(s) of the factor(s) that define the subsets of the data for which each subset corresponds to the response values for an individual.
na.x.action	A character string that specifies the action to be taken when values of x are NA. The possible values are fail, exclude or omit. For exclude and omit, predictions and derivatives will only be obtained for nonmissing values of x. The difference between these two codes is that for exclude the returned data.frame will have as many rows as data, the missing values have been incorporated.
na.y.action	A character string that specifies the action to be taken when values of y, or the response, are NA. The possible values are fail, exclude, omit, allx, trimx, ltrimx or rtrimx. For all options, except fail, missing values in y will be removed before smoothing. For exclude and omit, predictions and derivatives will be obtained only for nonmissing values of x that do not have missing y

values. Again, the difference between these two is that, only for exclude will the missing values be incorporated into the returned data.frame. For allx, predictions and derivatives will be obtained for all nonmissing x. For trimx, they will be obtained for all nonmissing x between the first and last nonmissing y values that have been ordered for x; for ltrimx and utrimx either the lower or upper missing y values, respectively, are trimmed.

df	A [numeric](#) specifying the set of degrees of freedom to be probed.
smoothing.scale	
	A [character](#) giving the scale on which smoothing is to be performed. The two possibilites are "identity", for directly smoothing the observed response, and "logarithmic", for smoothing the log-transformed response.
correctBoundaries	
	A [logical](#) indicating whether the fitted spline values are to have the method of Huang (2001) applied to them to correct for estimation bias at the end-points. Note that if rates.method is set to "derivatives" then it is not possible to have correctBoundaries set to TRUE.
get.rates	A [logical](#) specifying whether or not the growth rates (AGR and RGR) are to be computed and stored.
rates.method	A [character](#) specifying the method to use in calculating the growth rates. The two possibilities are "differences" and "derivates".
times.factor	A [character](#) giving the name of the column in data containing the factor for times at which the data was collected. Its levels will be used in calculating growth rates and should be numeric values stored as characters.
x	A [character](#) giving the variable to be plotted on the x-axis; it may incorporate an expression. If x is NULL then xname is used.
x.title	Title for the x-axis. If NULL then set to times.factor.
facet.x	A [data.frame](#) giving the variable to be used to form subsets to be plotted in separate columns of plots. Use "." if a split into columns is not wanted.
facet.y	A [data.frame](#) giving the variable to be used to form subsets to be plotted in separate rows of plots. Use "." if a split into columns is not wanted.
labeller	A [ggplot function](#) for labelling the facets of a plot produced using the [ggplot](#) function. For more information see [ggplot](#).
colour	A [character](#) specifying a single colour to use in drawing the lines for the profiles. If colouring according to the values of a variable is required then use colour.column.
colour.column	A [character](#) giving the name of a column in data over whose values the colours of the lines are to be varied. The colours can be specified using colour.values .
colour.values	A [character](#) vector specifying the values of the colours to use in drawing the lines for the profiles. If this is a named vector, then the values will be matched based on the names. If unnamed, values will be matched in order (usually alphabetical) with the limits of the scale.
alpha	A [numeric](#) specifying the degrees of transparency to be used in plotting. It is a ratio in which the denominator specifies the number of points (or lines) that must be overplotted to give a solid cover.
which.traits	A [character](#) giving the traits that are to be produced. One of more of response, AGR and RGR. If all, all three traits are produced. The unsmoothed growth rates are not calculated if only smoothed plots are requested.

which.plots   A [character](#) giving the plots that are to be produced. If none, no plots are produced. If smoothedonly, plots of the smoothed traits are plotted. If bothseparatetly, plots of the unsmoothed trait followed by the smoothed trait are produced for each trait. If compare, a combined plot of the unsmoothed trait and the smoothed trait is produced for each value of df.

deviations.boxplots

A [character](#) specifying whether boxplots of the absolute and/or relative deviations of the values of a trait from their smoothed values are to be produced (observed - smoothed). If none, no plots are produced. The argument which.traits controls the traits for which boxplots are produced.

ggplotFuncs   A [list](#), each element of which contains the results of evaluating a [ggplot](#) function. It is created by calling the [list](#) function with a [ggplot](#) function call for each element. Note that these functions are applied to all three plots produced.

...   allows passing of arguments to [plotLongitudinal](#).

Value

A [data.frame](#) containing individuals, times.factor, facet.x, facet.y, xname, response, and, for each df, the smoothed response, the AGR and the RGR. It is returned invisibly. The names of the new data are constructed by joining elements separated by full stops (.). In all cases, the last element is the value of df. For the smoothed response, the other elements are response and "smooth"; for AGR and RGR, the other elements are the name of the smoothed response and either "AGR" or "RGR".

Author(s)

Chris Brien

See Also

[splitSplines](#), [splitContGRdiff](#), [smooth.spline](#), [ggplot](#).

Examples

```
## Not run:
data(exampleData)
vline <- list(ggplot2::geom_vline(xintercept=20, linetype="longdash", size=1),
              ggplot2::scale_x_continuous(breaks=seq(12, 36, by=2)))
probeDF(data = longi.dat, response = "Area", df = c(4,7), x="xDays+24.16666667",
        ggplotFuncs=vline)

## End(Not run)
```

---

probeSmoothing   *Compares, for a set of specified values of df and different smoothing methods, a response and the smooths of it, possibly along with growth rates calculated from the smooths*

Description

Takes a response and, for each individual, uses [splitSplines](#) to smooth its values for each individual using the degrees of freedom values in df. Provided get.rates is TRUE, both the Absolute Growth Rates (AGR) and the Relative Growth Rates (RGR) are calculated for each smooth, either using differences or first derivatives. A combination of the unsmoothed and smoothed values, as well as the AGR and RGR, can be plotted for each value in smoothing methods in combination with df. Note that the arguments that modify the plots apply to all plots that are produced. The handling of missing values is controlled via na.x.action and na.y.action

Usage

```
probeSmoothing(data, response = "Area", x = NULL, xname="xDays",
               times.factor = "Days", individuals="Snapshot.ID.Tag",
               na.x.action="exclude", na.y.action = "exclude",
               df, smoothing.methods = "direct", correctBoundaries = FALSE,
               get.rates = TRUE, rates.method="differences",
               facet.x = "Treatment.1", facet.y =   "Smarthouse",
               labeller = NULL, x.title = NULL,
               colour = "black", colour.column=NULL,
               colour.values=NULL, alpha = 0.1,
               trait.types = c("response", "AGR", "RGR"),
               propn.types = c(0.1, 0.5, 0.75), propn.note = TRUE,
               which.plots = "smoothedonly",
               deviations.plots = "none", alpha.med.devn = 0.5,
               ggplotFuncs = NULL, ggplotFuncsMedDevn = NULL,
               ...)
```

Arguments

data	A [data.frame](#) containing the data.
response	A character specifying the response variable to be supplied to [smooth.spline](#) and that is to be plotted on the y-axis.
x	A [character](#) giving the variable to be plotted on the x-axis; it may incorporate an expression, it being that x may incorporate an expression. If x is NULL then xname is used.
xname	A [character](#) giving the name of the [numeric](#) that contains the values of the predictor variable to be supplied to [smooth.spline](#) and from which x is derived.
times.factor	A [character](#) giving the name of the column in data containing the factor for times at which the data was collected. Its levels will be used in calculating growth rates and should be numeric values stored as characters.
individuals	A [character](#) giving the name(s) of the [factor](#)(s) that define the subsets of the data for which each subset corresponds to the response values for an individual.
na.x.action	A character string that specifies the action to be taken when values of x are NA. The possible values are fail, exclude or omit. For exclude and omit, predictions and derivatives will only be obtained for nonmissing values of x. The difference between these two codes is that for exclude the returned data.frame will have as many rows as data, the missing values have been incorporated.
na.y.action	A character string that specifies the action to be taken when values of y, or the response, are NA. The possible values are fail, exclude, omit, allx, trimx,

	ltrimx or rtrimx. For all options, except fail, missing values in y will be removed before smoothing. For exclude and omit, predictions and derivatives will be obtained only for nonmissing values of x that do not have missing y values. Again, the difference between these two is that, only for exclude will the missing values be incorporated into the returned data.frame. For allx, predictions and derivatives will be obtained for all nonmissing x. For trimx, they will be obtained for all nonmissing x between the first and last nonmissing y values that have been ordered for x; for ltrimx and utrimx either the lower or upper missing y values, respectively, are trimmed.
df	A [numeric](#) specifying the set of degrees of freedom to be probed.
smoothing.methods	A [character](#) giving one or more methods to use for smoothing. Currently, the two possibilites are (i) ″direct″, for directly smoothing the observed response, and (ii) ″logarithmic″, for smoothing the log-transformed response, followed by taking exponentials of the fitted values to back-trasnform them.
correctBoundaries	A [logical](#) indicating whether the fitted spline values are to have the method of Huang (2001) applied to them to correct for estimation bias at the end-points. Note that if rates.method is set to ″derivatives″ then it is not possible to have correctBoundaries set to TRUE.
get.rates	A [logical](#) specifying whether or not the growth rates (AGR and RGR) are to be computed and stored.
rates.method	A [character](#) specifying the method to use in calculating the growth rates. The two possibilities are ″differences″ and ″derivates″.
facet.x	A [data.frame](#) giving the variable to be used to form subsets to be plotted in separate columns of plots. Use ″.″ if a split into columns is not wanted. For which.plots set to methodscompare or dfcompare , facet.x is ignored.
facet.y	A [data.frame](#) giving the variable to be used to form subsets to be plotted in separate rows of plots. Use ″.″ if a split into columns is not wanted.
labeller	A [ggplot function](#) for labelling the facets of a plot produced using the [ggplot](#) function. For more information see [ggplot](#).
x.title	Title for the x-axis. If NULL then set to times.factor.
colour	A [character](#) specifying a single colour to use in drawing the lines for the profiles. If colouring according to the values of a variable is required then use colour.column.
colour.column	A [character](#) giving the name of a column in data over whose values the colours of the lines are to be varied. The colours can be specified using colour.values .
colour.values	A [character](#) vector specifying the values of the colours to use in drawing the lines for the profiles. If this is a named vector, then the values will be matched based on the names. If unnamed, values will be matched in order (usually alphabetical) with the limits of the scale.
alpha	A [numeric](#) specifying the degrees of transparency to be used in plotting. It is a ratio in which the denominator specifies the number of points (or lines) that must be overplotted to give a solid cover.
trait.types	A [character](#) giving the trait.types that are to be produced. One of more of response, AGR and RGR. If all, all three traits are produced. The unsmoothed growth rates are not calculated if only smoothed plots are requested.

propn.types   A [numeric](#) giving the proportion of the median values of each of the trait.types
                 that are to be plotted in the compare.medians plots of the deviations of the ob-
                 served values from the smoothed values. If set to NULL, the plots of the propro-
                 tions of the median values of the traits are omitted.

propn.note   A [logical](#) indicating whether a note giving the proportion of the median values
                 plotted in the compare.medians plots.

which.plots   A [character](#) giving the plots that are to be produced. If none, no plots are pro-
                 duced. If smoothedonly, plots of the smoothed traits are plotted. If bothseparately,
                 plots of the unsmoothed trait followed by the smoothed traits are produced for
                 each trait. If methodscompare, a combined plot of the smoothed traits for each
                 smoothing.methods is produced, for each value of df. If methods+rawcompare,
                 the unsmoothed trait is added to the combined plot. if dfcompare, a combined
                 plot of the smoothed trait for each df is produced, for each smoothing.methods.
                 If df+rawcompare, the unsmoothed trait is added to the combined plot.

deviations.plots

                 A [character](#) is either none or any combination of absolute.boxplots, relative.boxplots
                 and compare.medians. If none, no plots are produced. Boxplots of the absolute
                 and relative deviations are specified by absolute.boxplots and relative.boxplots.
                 The absolute deviations are the values of a trait minus their smoothed values
                 (observed - smoothed); the relative deviations are the absolute deviations di-
                 vided by the smoothed values of the trait. The option compare.medians results
                 in a plot that compares the medians of the deviations over the times.factor
                 for each combination of the smoothing.methods and the df. The argument
                 trait.types controls the traits for which boxplots are produced.

alpha.med.devn   A [numeric](#) specifying the degrees of transparency to be used in plotting a me-
                 dian deviations plot. It is a ratio in which the denominator specifies the number
                 of points (or lines) that must be overplotted to give a solid cover.

ggplotFuncs   A [list](#), each element of which contains the results of evaluating a [ggplot](#) func-
                 tion. It is created by calling the [list](#) function with a [ggplot](#) function call for
                 each element. Note that these functions are applied to all three plots produced.

ggplotFuncsMedDevn

                 A [list](#), each element of which contains the results of evaluating a [ggplot](#) func-
                 tion. It is created by calling the [list](#) function with a [ggplot](#) function call for
                 each element. Note that these functions are applied to the compare.median
                 deviations plots only.

...   allows passing of arguments to [plotLongitudinal](#).

Value

A [data.frame](#) containing individuals, times.factor, facet.x, facet.y, xname, response,
and, for each df, the smoothed response, the AGR and the RGR. It is returned invisibly. The names
of the new data are constructed by joining elements separated by full stops (.). In all cases, the
last element is the value of df. For the smoothed response, the other elements are response and
"smooth"; for AGR and RGR, the other elements are the name of the smoothed response and either
"AGR" or "RGR".

Author(s)

Chris Brien

See Also

splitSplines, splitContGRdiff, smooth.spline, ggplot.

Examples

```
data(exampleData)
vline <- list(ggplot2::geom_vline(xintercept=20, linetype="longdash", size=1),
              ggplot2::scale_x_continuous(breaks=seq(12, 36, by=2)))
probeSmoothing(data = longi.dat, response = "Area", df = c(4,7), x="xDays+24.16666667",
               ggplotFuncs=vline)
```

PVA   *Selects a subset of variables using Principal Variable Analysis (PVA)*

Description

Principal Variable Analysis (PVA) (Cumming and Wooff, 2007) selects a subset from a set of the variables such that the variables in the subset are as uncorrelated as possible, in an effort to ensure that all aspects of the variation in the data are covered.

Usage

```
PVA(obj, ...)
```

Arguments

obj	A data.frame containing the columns of variables from which the selection is to be made.
...	allows passing of arguments to other functions

Details

PVA is the generic function for the PVA method. Use methods("PVA") to get all the methods for the PVA generic.

PVA.data.frame is a method for a data.frame.

PVA.matrix is a method for a matrix.

Value

A data.frame giving the results of the variable selection. It will contain the columns Variable, Selected, h.partial, Added.Propn and Cumulative.Propn.

Author(s)

Chris Brien

References

Cumming, J. A. and D. A. Wooff (2007) Dimension reduction via principal variables. *Computational Statistics and Data Analysis*, **52**, 550–565.

See Also

PVA.data.frame, PVA.matrix, intervalPVA, rcontrib

PVA.data.frame   *Selects a subset of variables stored in a data.frame using Principal*
                               Variable Analysis (PVA)

Description

Principal Variable Analysis (PVA) (Cumming and Wooff, 2007) selects a subset from a set of the variables such that the variables in the subset are as uncorrelated as possible, in an effort to ensure that all aspects of the variation in the data are covered.

Usage

```
## S3 method for class 'data.frame'
PVA(obj, responses, nvarselect = NULL, p.variance = 1, include = NULL,
    plot = TRUE, ...)
```

Arguments

obj	A data.frame containing the columns of variables from which the selection is to be made.
responses	A character giving the names of the columns in data from which the variables are to be selected.
nvarselect	A numeric specifying the number of variables to be selected, which includes those listed in include. If nvarselect = 1, as many variables are selected as is need to satisfy p.variance.
p.variance	A numeric specifying the minimum proportion of the variance that the selected variables must account for,
include	A character giving the names of the columns in data for the variables whose selection is mandatory.
plot	A logical indicating whether a plot of the cumulative proportion of the variance explained is to be produced.
...	allows passing of arguments to other functions

Details

The variable that is most correlated with the other variables is selected first for inclusion. The partial correlation for each of the remaining variables, given the first selected variable, is calculated and the most correlated of these variables is selects for inclusion next. Then the partial correlations are adjust for the second included variables. This process is repeated until the specified criteria have been satisfied. The possibilities are:

1. the default (nvarselect = NULL and p.variance = 1), which selects all variables in increasing order of amount of information they provide;

2. to select exactly nvarselect variables;

3. to select just enough variables, up to a maximum of nvarselect variables, to explain at least p.variance*100 per cent of the total variance.

Value

A [data.frame](#) giving the results of the variable selection. It will contain the columns Variable, Selected, h.partial, Added.Propn and Cumulative.Propn.

Author(s)

Chris Brien

References

Cumming, J. A. and D. A. Wooff (2007) Dimension reduction via principal variables. *Computational Statistics and Data Analysis*, **52**, 550–565.

See Also

[PVA](#), [PVA.matrix](#), [intervalPVA.data.frame](#), [rcontrib](#)

Examples

```
data(exampleData)
responses <- c("Area","Area.SV","Area.TV", "Image.Biomass", "Max.Height","Centre.Mass",
               "Density", "Compactness.TV", "Compactness.SV")
results <-  PVA(longi.dat, responses, p.variance=0.9, plot = FALSE)
```

PVA.matrix	*Selects a subset of variables using Principal Variable Analysis (PVA) based on a correlation matrix*

Description

Principal Variable Analysis (PVA) (Cumming and Wooff, 2007) selects a subset from a set of the variables such that the variables in the subset are as uncorrelated as possible, in an effort to ensure that all aspects of the variation in the data are covered.

Usage

```
## S3 method for class 'matrix'
PVA(obj, responses, nvarselect = NULL, p.variance = 1, include = NULL,
    plot = TRUE, ...)
```

Arguments

obj	A [matrix](#) containing the correlation matrix for the variables from which the selection is to be made.
responses	A [character](#) giving the names of the rows and columns in obj, being the names of the variables from which the selection is to be made.
nvarselect	A [numeric](#) specifying the number of variables to be selected, which includes those listed in include. If nvarselect = 1, as many variables are selected as is need to satisfy p.variance.
p.variance	A [numeric](#) specifying the minimum proportion of the variance that the selected variables must account for,

include	A [character](#) giving the names of the columns in data for the variables whose selection is mandatory.
plot	A [logical](#) indicating whether a plot of the cumulative proportion of the variance explained is to be produced.
...	allows passing of arguments to other functions

Details

The variable that is most correlated with the other variables is selected first for inclusion. The partial correlation for each of the remaining variables, given the first selected variable, is calculated and the most correlated of these variables is selects for inclusion next. Then the partial correlations are adjust for the second included variables. This process is repeated until the specified criteria have been satisfied. The possibilities are:

1. the default (nvarselect = NULL and p.variance = 1), which selects all variables in increasing order of amount of information they provide;

2. to select exactly nvarselect variables;

3. to select just enough variables, up to a maximum of nvarselect variables, to explain at least p.variance*100 per cent of the total variance.

Value

A [data.frame](#) giving the results of the variable selection. It will contain the columns Variable, Selected, h.partial, Added.Propn and Cumulative.Propn.

Author(s)

Chris Brien

References

Cumming, J. A. and D. A. Wooff (2007) Dimension reduction via principal variables. *Computational Statistics and Data Analysis*, **52**, 550–565.

See Also

[PVA](#), [PVA.data.frame](#), [intervalPVA.data.frame](#), [rcontrib](#)

Examples

```
data(exampleData)
responses <- c("Area","Area.SV","Area.TV", "Image.Biomass", "Max.Height","Centre.Mass",
               "Density", "Compactness.TV", "Compactness.SV")
R <- Hmisc::rcorr(as.matrix(longi.dat[responses]))$r
results <-  PVA(R, responses, p.variance=0.9, plot = FALSE)
```

---

rcontrib	*Computes a measure of how correlated each variable in a set is with the other variable, conditional on a nominated subset of them*

Description

A measure of how correlated a variable is with those in a set is given by the square root of the sum of squares of the correlation coefficients between the variables and the other variables in the set (Cumming and Wooff, 2007). Here, the partial correlation between the subset of the variables listed in response that are not listed in include is calculated from the partial correlation matrix for the subset, adjusting for those variables in include. This is useful for manually deciding which of the variables not in include should next be added to it.

Usage

```
rcontrib(obj, ...)
```

Arguments

obj   A [data.frame](#) containing the columns of variables from which the correlation measure is to be calculated.

...   allows passing of arguments to other functions

Details

rcontrib is the generic function for the rcontrib method. Use methods("rcontrib") to get all the methods for the rcontrib generic.

[rcontrib.data.frame](#) is a method for a [data.frame](#).

[rcontrib.matrix](#) is a method for a [matrix](#).

Value

A [numeric](#) giving the correlation measures.

Author(s)

Chris Brien

References

Cumming, J. A. and D. A. Wooff (2007) Dimension reduction via principal variables. *Computational Statistics and Data Analysis*, **52**, 550–565.

See Also

[PVA](#), [intervalPVA](#)

---

rcontrib.data.frame   *Computes a measure of how correlated each variable in a set is with*
                             the other variable, conditional on a nominated subset of them

---

Description

A measure of how correlated a variable is with those in a set is given by the square root of the sum
of squares of the correlation coefficients between the variables and the other variables in the set
(Cumming and Wooff, 2007). Here, the partial correlation between the subset of the variables listed
in `response` that are not listed in `include` is calculated from the partial correlation matrix for the
subset, adjusting for those variables in `include`. This is useful for manually deciding which of the
variables not in `include` should next be added to it.

Usage

```
## S3 method for class 'data.frame'
rcontrib(obj, responses, include = NULL, ...)
```

Arguments

`obj`	A [data.frame](#) containing the columns of variables from which the correlation measure is to be calculated.
`responses`	A [character](#) giving the names of the columns in `data` from which the correlation measure is to be calculated.
`include`	A [character](#) giving the names of the columns in `data` for the variables for which other variables are to be adjusted.
`...`	allows passing of arguments to other functions.

Value

A [numeric](#) giving the correlation measures.

Author(s)

Chris Brien

References

Cumming, J. A. and D. A. Wooff (2007) Dimension reduction via principal variables. *Computational Statistics and Data Analysis*, **52**, 550–565.

See Also

[rcontrib](#), [rcontrib.matrix](#), [PVA](#), [intervalPVA.data.frame](#)

Examples

```
data(exampleData)
responses <- c("Area","Area.SV","Area.TV", "Image.Biomass", "Max.Height","Centre.Mass",
               "Density", "Compactness.TV", "Compactness.SV")
h <-  rcontrib(longi.dat, responses, include = "Area")
```

---

rcontrib.matrix	*Computes a measure of how correlated each variable in a set is with the other variable, conditional on a nominated subset of them*

Description

A measure of how correlated a variable is with those in a set is given by the square root of the sum of squares of the correlation coefficients between the variables and the other variables in the set (Cumming and Wooff, 2007). Here, the partial correlation between the subset of the variables listed in response that are not listed in include is calculated from the partial correlation matrix for the subset, adjusting for those variables in include. This is useful for manually deciding which of the variables not in include should next be added to it.

Usage

```
## S3 method for class 'matrix'
rcontrib(obj, responses, include = NULL, ...)
```

Arguments

obj	A [matrix](#) containing the correlations of the variables from which the correlation measure is to be calculated.
responses	A [character](#) giving the names of the columns in data from which the correlation measure is to be calculated.
include	A [character](#) giving the names of the columns in data for the variables for which other variables are to be adjusted.
...	allows passing of arguments to other functions.

Value

A [numeric](#) giving the correlation measures.

Author(s)

Chris Brien

References

Cumming, J. A. and D. A. Wooff (2007) Dimension reduction via principal variables. *Computational Statistics and Data Analysis*, **52**, 550–565.

See Also

[rcontrib](#), [rcontrib.data.frame](#), [PVA](#), [intervalPVA.data.frame](#)

Examples

```
data(exampleData)
responses <- c("Area","Area.SV","Area.TV", "Image.Biomass", "Max.Height","Centre.Mass",
               "Density", "Compactness.TV", "Compactness.SV")
R <- Hmisc::rcorr(as.matrix(longi.dat[responses]))$r
h <- rcontrib(R, responses, include = "Area")
```

RiceRaw.dat   *Data for an experiment to investigate a rice germplasm panel*

Description

The data is from an experiment in a Smarthouse in the Plant Accelerator. It is described in Al-Tamimi et al. (2016). It is used in growthPheno-pkg as an executable example to illustrate the use of growthPheno.

Usage

```
data(RiceRaw.dat)
```

Format

A data.frame containing 1120 observations on 15 variables.

Source

Al-Tamimi N, Brien C, Oakey H, Berger B, Saade S, Ho YS, Schmockel SM, Tester M, Negrao S: Data from: Salinity tolerance loci revealed in rice using high-throughput non-invasive phenotyping. Retrieved from: doi: 10.5061/dryad.3118j.

References

Al-Tamimi, N, Brien, C.J., Oakey, H., Berger, B., Saade, S., Ho, Y. S., Schmockel, S. M., Tester, M. and Negrao, S. (2016) New salinity tolerance loci revealed in rice using high-throughput non-invasive phenotyping. *Nature Communications*, **7**, 13342. Retrieved from doi: 10.1038/ncomms13342.

---

splitContGRdiff   *Adds the growth rates calculated continuously over time for subsets of*
                              a response to a data.frame

Description

Uses AGRdiff, PGR and RGRdiff to calculate growth rates continuously over time for subsets of the values of response and stores the results in data. The subsets are those values with the same levels combinations of the factors listed in INDICES.

Usage

```
splitContGRdiff(data, responses, INDICES,
                which.rates = c("AGR","PGR","RGR"), suffices.rates=NULL,
                times.factor = "Days")
```

Arguments

data	A [data.frame](#) containing the columns for which growth rates are to be calculated.
responses	A [character](#) giving the names of the columns in data for which growth rates are to be calculated.
INDICES	A [character](#) giving the name(s) of the [factor](#)(s) that define the subsets of response for which growth rates are to be calculated continuously. If the columns corresponding to INDICES are not [factor](#)(s) then they will be coerced to [factor](#)(s). The subsets are formed using [by](#).
which.rates	A [character](#) giving the growth rates that are to be calculated. It should be a combination "AGR", "PGR" and "RGR".
times.factor	A [character](#) giving the name of the column in data containing the factor for times at which the data was collected. Its levels will be used in calculating growth rates and should be numeric values stored as characters.
suffices.rates	A [character](#) giving the characters to be appended to the names of the responses to provide the names of the columns containing the calculated growth rates. The order of the suffices in suffices.rates should correspond to the order of the elements of which.rates. If NULL, the values of which.rates are used.

Value

A [data.frame](#) containing data to which has been added a column for the differences between the times.factor, if it is not already in data, and columns with growth rates. The name of the column for times.factor differences will be the times.factor with ".diff" appended and, for each of the growth-rate columns will be the value of response with one of ".AGR", ".PGR" or "RGR" or the corresponding value from suffices.GR appended.

Author(s)

Chris Brien

See Also

[fitSpline](#), [splitSplines](#)

Examples

```
data(exampleData)
longi.dat <- splitContGRdiff(longi.dat, response="Area.smooth",
                             INDICES = "Snapshot.ID.Tag", which.rates=c("AGR", "RGR"))
```

---

splitSplines	*Adds the fits, and optionally growth rates computed from derivatives, after fitting natural cubic smoothing splines to subsets of a response to a* data.frame

---

Description

Uses [fitSpline](#) to fit a spline to a subset of the values of response and stores the fitted values in data. The subsets are those values with the same levels combinations of the factors listed in INDICES. The degree of smoothing is controlled by df and the smoothing.method provides for direct amd logarithmic smoothing.

The derivatives of the fitted spline can also be obtained, and the Absolute and Relative Growth Rates (AGR and RGR) computed using them, provided correctBoundaries is FALSE. Otherwise, growth rates can be obtained by difference using [splitContGRdiff](#).

By default, smooth.spline will issue an error if there are not at least four distinct x-values. On the other hand, [fitSpline](#) issues a warning and sets all smoothed values and derivatives to NA. The handling of missing values in the observations is controlled via na.x.action and na.y.action.

Usage

```
splitSplines(data, response, x, INDICES, df = NULL, smoothing.method = "direct",
             correctBoundaries = FALSE,
             deriv = NULL, suffices.deriv=NULL, RGR=NULL, AGR=NULL, sep=".",
             na.x.action="exclude", na.y.action = "exclude", ...)
```

Arguments

data	A [data.frame](#) containing the column to be smoothed.
response	A [character](#) giving the name of the column in data that is to be smoothed.
x	A [character](#) giving the name of the column in data that contains the values of the predictor variable.
INDICES	A [character](#) giving the name(s) of the [factor](#)(s) that define the subsets of response that are to be smoothed separately. If the columns corresponding to INDICES are not [factor](#)(s) then they will be coerced to [factor](#)(s). The subsets are formed using [split](#).
df	A [numeric](#) specifying the desired equivalent number of degrees of freedom of the smooth (trace of the smoother matrix). Lower values result in more smoothing. If df = NULL, ordinary leave-one-out cross-validation is used to determine the amount of smooth.
smoothing.method	
	A [character](#) giving the smoothing method to use. The two possibilites are (i) "direct", for directly smoothing the observed response, and (ii) "logarithmic", for smoothing the log-transformed response and then back-transforming by taking the exponential of the fitted values.
correctBoundaries	
	A [logical](#) indicating whether the fitted spline values are to have the method of Huang (2001) applied to them to correct for estimation bias at the end-points. Note that deriv must be NULL for correctBoundaries to be set to TRUE.
deriv	A numeric specifying one or more orders of derivatives that are required.
suffices.deriv	A [character](#) giving the characters to be appended to the names of the derivatives. If NULL and the derivative is to be retained then smooth.dv is appended.
RGR	A [character](#) giving the character to be appended to the smoothed response to create the RGR name, but only when smoothing.method is direct and the RGR is required. When smoothing.method is direct and the RGR is required RGR must not be NULL and deriv must include one so that the first derivative

	is available for calculating it. When smoothing.method is logarithmic, the RGR is the backtransformed first derivative and so, to obtain it, merely include 1 in deriv and any suffix for it in suffices.deriv. Leave RGR set to NULL.
AGR	A [character](#) giving the character to be appended to the smoothed response to create the AGR name, but only when smoothing.method is logarithmic and the AGR is required. When smoothing.method is logarithmic and the AGR is required AGR must not be NULL and deriv must include one so that the first derivative is available for calculating it. When smoothing.method is direct, the AGR is the backtransformed first derivative and so, to obtain it, merely include 1 in deriv and any suffix for it in suffices.deriv. Leave AGR set to NULL.
sep	A [character](#) giving the separator to use when the levels of INDICES are combined. This is needed to avoid using a [character](#) that occurs in a factor to delimit levels when the levels of INDICES are combined to identify subsets.
na.x.action	A [character](#) string that specifies the action to be taken when values of x are NA. The possible values are fail, exclude or omit. For exclude and omit, predictions and derivatives will only be obtained for nonmissing values of x. The difference between these two codes is that for exclude the returned data.frame will have as many rows as data, the missing values have been incorporated.
na.y.action	A [character](#) string that specifies the action to be taken when values of y, or the response, are NA. The possible values are fail, exclude, omit, allx, trimx, ltrimx or rtrimx. For all options, except fail, missing values in y will be removed before smoothing. For exclude and omit, predictions and derivatives will be obtained only for nonmissing values of x that do not have missing y values. Again, the difference between these two is that, only for exclude will the missing values be incorporated into the returned data.frame. For allx, predictions and derivatives will be obtained for all nonmissing x. For trimx, they will be obtained for all nonmissing x between the first and last nonmissing y values that have been ordered for x; for ltrimx and utrimx either the lower or upper missing y values, respectively, are trimmed.
...	allows for arguments to be passed to smooth.spline.

Value

A [data.frame](#) containing data to which has been added a column with the fitted smooth, the name of the column being response with .smooth appended to it. If deriv is not NULL, columns containing the values of the derivative(s) will be added to data; the name each of these columns will be the value of response with .smooth.dvf appended, where f is the order of the derivative, or the value of response with .smooth. and the corresponding element of suffices.deriv appended. If RGR is not NULL, the RGR is calculated as the ratio of value of the first derivative of the fitted spline and the fitted value for the spline. Any pre-existing smoothed and derivative columns in data will be replaced. The ordering of the data.frame for the x values will be preserved as far as is possible; the main difficulty is with the handling of missing values by the function merge. Thus, if missing values in x are retained, they will occur at the bottom of each subset of INDICES and the order will be problematic when there are missing values in y and na.y.action is set to omit.

Author(s)

Chris Brien

References

Huang, C. (2001). Boundary corrected cubic smoothing splines. *Journal of Statistical Computation and Simulation*, **70**, 107-121.

See Also

`fitSpline`, `smooth.spline`, `predict.smooth.spline`, `splitContGRdiff`, `split`

Examples

```
data(exampleData)
longi.dat <- splitSplines(longi.dat, response="Area", x="xDays",
                          INDICES = "Snapshot.ID.Tag",
                          df = 4, deriv=1, suffices.deriv="AGRdv", RGR="RGRdv")
```

---

splitValueCalculate	*Calculates a single value that is a function of an individual's values for a response*

Description

Splits the values of a response into subsets corresponding individuals and applies a function that calculates a single value from each individual's observations. It includes the ability to calculate the observation number that is closest to the calculated value of the function and the assocated values of a `factor` or `numeric`.

Usage

```
splitValueCalculate(response, weights=NULL, individuals = "Snapshot.ID.Tag",
                    FUN = "max", which.obs = FALSE, which.values = NULL,
                    data, na.rm=TRUE, sep=".", ...)
```

Arguments

response	A `character` giving the name of the column in `data` from which the values of FUN are to be calculated.
weights	A `character` giving the name of the column in `data` containing the weights to be supplied as w to FUN.
individuals	A `character` giving the name(s) of the `factor`(s) that define the subsets of the `data` for which each subset corresponds to the `response` value for an individual.
FUN	A `character` giving the name of the `function` that calculates the value for each subset.
which.obs	A `logical` indicating whether or not to determine the observation number corresponding to the observed value that is closest to the value of the function, in addition to the value of the function itself. That is, FUN need not return an observed value of the `reponse`, e.g. `quantile`. In the case of multiple observed response values satisfying this condition, the first is returned.

which.values	A [character](#) giving the name of the [factor](#) or [numeric](#) whose values are associated with the response values and whose value is to be returned for the observation number whose response value corresponds to the observed value closest to the value of the function. That is, FUN need not return an observed value of the reponse, e.g. quantile. In the case of multiple observed response values satisfying this condition, the value of the which.values vector for the first of these is returned.
data	A [data.frame](#) containing the column from which the function is to be calculated.
na.rm	A [logical](#) indicating whether NA values should be stripped before the calculation proceeds.
sep	A [character](#) giving the separator to use when the levels of individuals are combined. This is needed to avoid using a [character](#) that occurs in a factor to delimit levels when the levels of individuals are combined to identify subsets.
...	allows for arguments to be passed to FUN.

Value

A [data.frame](#), with the same number of rows as there are individuals, containing a column for the individuals and a column with the values of the function for the individuals. It is also possible to determine observaton numbers or the values of another column in data for the response values that are closest to the FUN results, using either or both of which.obs and which.values. If which.obs is TRUE, a column with observation numbers is included in the [data.frame](#). If which.values is set to the name of a [factor](#) or a [numeric](#),a column containing the levels of that [factor](#) or the values of that [numeric](#) is included in the [data.frame](#).

The name of the column with the values of the function will be formed by concatenating the response and FUN, separated by a full stop. If which.obs is TRUE, the column name for the obervations numbers will have .obs added after FUN into the column name for the function values; if which.values is specified, the column name for these values will have a full stop followed by which.values added after FUN into the column name for the function values.

Author(s)

Chris Brien

See Also

[intervalValueCalculate](#), [splitContGRdiff](#), [splitSplines](#)

Examples

```
data(exampleData)
Area.smooth.max.dat <- splitValueCalculate("Area.smooth", data = longi.dat)
AGR.max.dat <- splitValueCalculate("Area.smooth.AGR", FUN="max", data=longi.dat,
                                    which.values = "Days", which.obs = TRUE)
sPSA.dec1.dat <- splitValueCalculate("Area.smooth", FUN="quantile", data=longi.dat,
                                    which.values = "Days", probs = 0.1)
```

---

tomato.dat	*Longitudinal data for an experiment to investigate tomato response to mycorrhizal fungi and zinc*

Description

The data is from an experiment in a Smarthouse in the Plant Accelerator and is decribed by Watts-Williams et al. (2019). The experiment involves 32 plants, each placed in a pot in a cart, and the carts were assigned 8 treatments using a randomized complete-block design. The main response is Projected Shoot Area (Area for short), being the sum of the plant pixels from three images. The eight treatments were the combinations of 4 Zinc (Zn) levels by two Arbuscular Mycorrhiza Fungi (AMF) levls. Each plant was imaged on 35 different days after planting (DAPs). It is used to explore the analysis of growth dynamics.

Usage

```
data(tomato.dat)
```

Format

A data.frame containing 14784 observations on 33 variables. The names of the columns in the data.frame are:

Column	Name	Class	Description
1	Lane	factor	the Lane in the 2 Lane x 16 Positions grid.
2	Position	factor	the Position in the 2 Lane x 16 Positions grid.
3	DAP	factor	the numbers of days after planting on which the current data was observed.
4	Snapshot.ID.Tag	character	a unique identifier for each cart in the experiment.
5	xDAP	numeric	a centered numbic covariate for DAP.
6	Days.diffs	numeric	the number of Days between this and the previous observations (all one for this experiment).
7	xPosn	numeric	a centered numeric covaariate for Positions.
8	Block	factor	the block of the randomized complete-block design to which the current cart belonged.
9	Cart	factor	the number of the cart within a block.
10	AMF	factor	the AMF treatment (- AMF, +AMF) assigned to the cart.
11	Zn	factor	the Zinc level (0, 10, 40, 90) assigned to the cart.
12	Treatments	factor	the combined factor formed from AMF and Zn with levels: (-,0; -,10; -,40; -,90; +,0; +,10; +,40; +,90).
12	Weight.After	numeric	the weight of the cart after watering.
13	Water.Amount	numeric	the amount of water added to the cart.
14	Water.Loss	numeric	the amount of water lost since the previous watering.
15	Area	numeric	the total number of plant pixels in three plant images.

References

Watts-Williams SJ, Jewell N, Brien C, Berger B, Garnett T, Cavagnaro TR (2019) Using high-throughput phenotyping to explore growth responses to mycorrhizal fungi and zinc in three plant

species. *Plant Phenomics*, **2019**, 12.

---

twoLevelOpcreate	*Creates a data.frame formed by applying, for each response, a binary operation to the paired values of two different treatments*

Description

Takes pairs of values for a set of responses indexed by a two-level `treatment.factor` and calculates, for each of pair, the result of applying a binary `operation` to their values for the two levels of the `treatment.factor`. The level of the `treatment.factor` designated the `control` will be on the right of the binary operator and the value for the other level will be on the left.

Usage

```
twoLevelOpcreate(responses, data, treatment.factor = "Treatment.1",
                 suffices.treatment = c("Cont","Salt"), control = 1,
                 columns.suffixed = NULL,
                 operations = "/", suffices.results="OST",
                 columns.retained = c("Snapshot.ID.Tag","Smarthouse","Lane",
                                   "Zones","xZones","SHZones","ZLane",
                                   "ZMainplots","xMainPosn", "Genotype.ID"),
                 by = c("Smarthouse","Zones","ZMainplots"))
```

Arguments

responses
: A [character](#) giving the names of the columns in data that contain the responses to which the binary operations are to be applied.

data
: A [data.frame](#) containing the columns specified by `treatment.factor`, `columns.retained` and responses.

treatment.factor
: A [factor](#) with two levels corresponding to what is to be designated the `control` and treated observations .

suffices.treatment
: A [character](#) giving the characters to be appended to the names of the responses and `columns.suffixed` in constructing the names of the columns containing the responses and `columns.suffixed` for each level of the `treatment.factor`. The order of the suffices in `suffices.treatment` should correspond to the order of the levels of `treatment.factor`.

control
: A [numeric](#), equal to either 1 or 2, that specifies the level of `treatment.factor` that is the control treatment. The value for the `control` level will be on the right of the binary operator.

columns.suffixed
: A [character](#) giving the names of the `columns.retained` in data that are to be have the values for each treatment retained and whose names are to be suffixed using `suffices.treatment`. Generally, this is done when `columns.retained` has different values for different levels of the `treatment.factor`.

operations   A [character](#) giving the binary operations to perform on the values for the two
                different levels of the treatment.factor. It should be either of length one, in
                which case the same operation will be performed for all columns specified in
                response.GR, or equal in length to response.GR so its elements correspond to
                those of response.GR.

suffices.results

                A [character](#) giving the characters to be appended to the names of the responses
                in constructing the names of the columns containing the results of applying the
                operations. The order of the suffices in suffices.results should correspond
                to the order of the operators in operations.

columns.retained

                A [character](#) giving the names of the columns in data that are to be retained in
                the data.frame being created. These are usually [factor](#)s that index the results
                of applying the operations and that might be used subsequently.

by   A [character](#) giving the names of the columns in data whose combinations will
                be unique for the observation for each treatment. It is used by [merge](#) when com-
                bining the values of the two treatments in separate columns in the data.frame
                to be returned.

Value

A [data.frame](#) containing the following columns and the values of the :

1. those from data nominated in columns.retained;

2. those containing the treated values of the columns whose names are specified in responses;
   the treated values are those having the other level of treatment.factor to that specified by
   control;

3. those containing the control values of the columns whose names are specified in responses;
   the control values are those having the level of treatment.factor specified by control;

4. those containing the values calculated using the binary operations; the names of these
   columns will be constructed from responses by appending suffices.results to them.

Author(s)

Chris Brien

Examples

```
data(exampleData)
responses <- c("Area.smooth.AGR","Area.smooth.RGR")
cols.retained <-  c("Snapshot.ID.Tag","Smarthouse","Lane","Position",
                    "Days","Snapshot.Time.Stamp", "Hour", "xDays",
                    "Zones","xZones","SHZones","ZLane","ZMainplots",
                    "xMainPosn", "Genotype.ID")
longi.SIIT.dat <-
  twoLevelOpcreate(responses, longi.dat, suffices.treatment=c("C","S"),
                   operations = c("-", "/"),
                   suffices.results = c("diff", "SIIT"),
                   columns.retained = cols.retained,
                   by = c("Smarthouse","Zones","ZMainplots","Days"))
longi.SIIT.dat <- with(longi.SIIT.dat,
                          longi.SIIT.dat[order(Smarthouse,Zones,ZMainplots,Days),])
```

WUI	*Calculates the Water Use Index (WUI)*

Description

Calculates the Water Use Index, returning NA if the water use is zero.

Usage

```
WUI(response, water)
```

Arguments

response	A [numeric](#) giving the value of the response achieved.
water	A [numeric](#) giving the amount of water used.

Value

A [numeric](#) containing the water divided by the response, unless water is zero in which caseNA is returned.

Author(s)

Chris Brien

Examples

```
data(exampleData)
Area.WUE <- with(longi.dat, WUI(Area.AGR, Water.Loss))
```

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