Package 'fuzzyreg'

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Title Fuzzy Linear Regression

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Description Estimators for fuzzy linear regression. The functions estimate parameters of fuzzy linear regression models with crisp or fuzzy independent variables (triangular fuzzy numbers are supported). Implements multiple methods for parameter estimation and algebraic operations with triangular fuzzy numbers. Includes functions for summarising, printing and plotting the model fit. Calculates predictions from the model and total error of fit.
Diamond (1988) <doi:10.1016/0020-0255(88)90047-3>,
Hung & Yang (2006) <doi:10.1016/j.fss.2006.08.004>,
Lee & Tanaka (1999) <doi:10.15807/jorsj.42.98>,
Nasrabadi, Nasrabadi & Nasrabady (2005) <doi:10.1016/j.amc.2004.02.008>,
Tanaka, Hayashi & Watada (1989) <doi:10.1016/0377-2217(89)90431-1>.

Depends R (>= 3.4.0),

License GPL-3

Encoding UTF-8

LazyData true

Imports limSolve, quadprog, stats, graphics, grDevices

RoxygenNote 6.1.1

Suggests testthat, FuzzyNumbers

BuildVignettes true

NeedsCompilation no

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R topics documented:

`bats` *Temperature Data of Hibernating Bats and Climate at Site*

Description

Body surface temperature of multiple species of hibernating bats and mean annual surface temperature at the hibernation site.

Usage

```
data(bats)
```

Format

A data frame with 528 rows and two variables:

`MAST` numeric Mean annual surface temperature at the site in degrees Celsius

`temperature` numeric Body surface temperature of hibernating bats in degrees Celsius

Source

Martinkova, N., Pikula, J., Zukal, J., Kovacova, V., Bandouchova, H., Bartonicka, T., Botvinkin, A.D., Brichta, J., Dundarova, H., Kokurewicz, T., Irwin, N.R., Linhart, P., Orlov, O.L., Piacek, V., Skrabanek, P., Tiunov, M.P. and Zahradnikova, A., Jr. (2018) Hibernation temperature-dependent *Pseudogymnoascus destructans* infection intensity in Palearctic bats. *Virulence* 9: 1734-1750.

Hijmans, R.J., Cameron, S.E., Parra, J.L., Jones, P.G. and Jarvis, A. (2005) Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology* 25: 1965-1978.

Examples

```
data(bats)
# remove outlier
dat <- bats[!(bats$MAST < 0 & bats$temperature > 7), ]
fit <- fuzzylm(temperature ~ MAST, data = dat, method = "plrls", h = 0.01, k1 = 5)
plot(fit, res = 30, col = "orange")
```

---

diamond — *Fuzzy Linear Regression using the Fuzzy Least Squares Method*

Description

The function calculates fuzzy regression coeficients using the fuzzy least squares (FLS) method proposed by Diamond (1988) for non-symmetric triangular fuzzy numbers.

Usage

```
diamond(x, y)
```

Arguments

x	two column matrix with the second column representing independent variable observations. The first column is related to the intercept, so it consists of ones. Missing values not allowed.
y	matrix of dependent variable observations. The first column contains the central tendency, the second column the left spread and the third column the right spread of non-symmetric triangular fuzzy numbers. Missing values not allowed.

Details

The FLS method for the fuzzy linear regression fits a simple model.

Value

Returns a `fuzzylm` object that includes the model coefficients, limits for data predictions from the model and the input data.

References

Diamond, P. (1988) Fuzzy least squares. *Information Sciences* 46(3): 141-157.

See Also

fuzzylm

Examples

```
data(fuzzydat)
x <- fuzzydat$dia[, 1, drop = FALSE]
x <- cbind(rep(1, nrow(x)), x)
y <- fuzzydat$dia[, c(2,3,3)]
fls(x = x, y = y)
```

---

dom — *Real Value Degree of Membership to a Triangular Fuzzy Number*

Description

Calculates the degree of membership of a real number to a triangular fuzzy number. The fuzzy number is defined by its central value and the left and right spreads.

Usage

```
dom(x, TFN)
```

Arguments

x	a numeric vector.
TFN	a numeric vector of length 3.

Value

Returns a numeric in interval `[0,1]`.

Examples

```
x <- seq(from = 0, to = 2, length.out = 10)
A <- c(1, 1, 1)
dom(x, A)
```

fls *Fuzzy Linear Regression using the Fuzzy Least Squares Method*

Description

The function calculates fuzzy regression coeficients using the fuzzy least squares (FLS) method proposed by Diamond (1988) for non-symmetric triangular fuzzy numbers.

Usage

```
fls(x, y)
```

Arguments

`x`	two column matrix with the second column representing independent variable observations. The first column is related to the intercept, so it consists of ones. Missing values not allowed.
`y`	matrix of dependent variable observations. The first column contains the central tendency, the second column the left spread and the third column the right spread of non-symmetric triangular fuzzy numbers. Missing values not allowed.

Details

The FLS method for the fuzzy linear regression fits a simple model.

Value

Returns a `fuzzylm` object that includes the model coefficients, limits for data predictions from the model and the input data.

Note

Preferred use is through the `fuzzylm` wrapper function with argument `method = "fls"`.

References

Diamond, P. (1988) Fuzzy least squares. *Information Sciences* 46(3): 141-157.

See Also

`fuzzylm`

Examples

```
data(fuzzydat)
x <- fuzzydat$dia[, 1, drop = FALSE]
x <- cbind(rep(1, nrow(x)), x)
y <- fuzzydat$dia[, c(2,3,3)]
fls(x = x, y = y)
```

fuzzydat *Data For Fuzzy Linear Regression*

Description

Example data reported by the authors of the respective fuzzy linear regression methods for testing model fit performance.

Usage

```
data(fuzzydat)
```

Format

A list of data.frames.

Source

Diamond, P. (1988) Fuzzy least squares. *Information Sciences* 46(3): 141-157.

Hung, W.-L. and Yang, M.-S. (2006) An omission approach for detecting outliers in fuzzy regression models. *Fuzzy Sets and Systems* 157: 3109-3122.

Lee, H. and Tanaka, H. (1999) Fuzzy approximations with non-symmetric fuzzy parameters in fuzzy regression analysis. *Journal of the Operations Research Society Japan* 42: 98-112.

Nasrabadi, M. M., Nasrabadi, E. and Nasrabady, A. R. (2005) Fuzzy linear regression analysis: a multi-objective programming approach. *Applied Mathematics and Computation* 163: 245-251.

Tanaka H., Hayashi I. and Watada J. (1989) Possibilistic linear regression analysis for fuzzy data. *European Journal of Operational Research* 40: 389-396.

Examples

```
data(fuzzydat)
fuzzylm(y ~ x, data = fuzzydat$lee)
fuzzylm(y ~ x, data = fuzzydat$dia, method = "fls", fuzzy.left.y = "yl", fuzzy.right.y = "yl")
```

---

fuzzylm *Fuzzy Linear Regression*

Description

A wrapper function that calculates fuzzy regression coeficients using a chosen method.

Usage

```
fuzzylm(formula, data, method = "plrls", fuzzy.left.x = NULL,
  fuzzy.right.x = NULL, fuzzy.left.y = NULL, fuzzy.right.y = NULL,
  ...)
```

Arguments

`formula`	a model formula.
`data`	a data.frame, containing the variables in formula.
`method`	method for fitting of the fuzzy linear model.
`fuzzy.left.x`	character string vector specifying column name(s) with the left spread of the fuzzy independent variable(s).
`fuzzy.right.x`	character string vector specifying column name(s) with the right spread of the fuzzy independent variable(s).
`fuzzy.left.y`	character string vector specifying column name(s) with the left spread of the fuzzy dependent variable.
`fuzzy.right.y`	character string vector specifying column name(s) with the right spread of the fuzzy dependent variable.
`...`	additional parameters used by specific methods.

Details

The implemented methods include `plrls` for fitting the fuzzy linear regression from the crisp input data (Lee and Tanaka 1999), and `fls` (Diamond 1988), `oplr` (Hung and Yang 2006), `moflr` (Nasrabadi et al. 2005) and `plr` (Tanaka et al. 1989) methods for triangular fuzzy numbers.

Value

Returns a `fuzzylm` object that includes the model coefficients, limits for data predictions from the model and the input data.

References

Diamond, P. (1988) Fuzzy least squares. *Information Sciences* 46(3): 141-157.

Hung, W.-L. and Yang, M.-S. (2006) An omission approach for detecting outliers in fuzzy regression models. *Fuzzy Sets and Systems* 157: 3109-3122.

Lee, H. and Tanaka, H. (1999) Fuzzy approximations with non-symmetric fuzzy parameters in fuzzy regression analysis. *Journal of the Operations Research Society Japan* 42: 98-112.

Nasrabadi, M. M., Nasrabadi, E. and Nasrabady, A. R. (2005) Fuzzy linear regression analysis: a multi-objective programming approach. *Applied Mathematics and Computation* 163: 245-251.

Tanaka H., Hayashi I. and Watada J. (1989) Possibilistic linear regression analysis for fuzzy data. *European Journal of Operational Research* 40: 389-396.

See Also

`plot`, `predict`, `summary`

Examples

```
data(fuzzydat)
fuzzylm(y ~ x, data = fuzzydat$lee, method = "plrls")
## Not run:
# returns an error due to the incorrect number of spreads
fuzzylm(y ~ x, data = fuzzydat$dia, method = "fls", fuzzy.left.y = "yl")
## End(Not run)
# use the same column name for the left and right spread, when the method requests
# non-symmetric fuzzy numbers, but the data specify symmetric fuzzy numbers
fuzzylm(y ~ x, data = fuzzydat$dia, method = "fls", fuzzy.left.y = "yl", fuzzy.right.y = "yl")
```

---

hung — *Fuzzy Linear Regression Using the Possibilistic Linear Regression with Omission Method*

Description

The function calculates fuzzy regression coeficients using the possibilistic linear regression with an outlier omission approach method (OPLR) developed by Hung and Yang (2006) that combines the least squares approach (fitting of a central tendency) with the possibilistic approach (fitting of spreads) when approximating an observed linear dependence by a fuzzy linear model.

Usage

```
hung(x, y, h = 0)
```

Arguments

x	matrix with the independent variables observations. The first column is related to the intercept, so it consists of ones. Missing values not allowed.
y	two column matrix of the dependent variable values and the respective spread. Method assumes symmetric triangular fuzzy input, so the second spread (if present) is ignored. Missing values not allowed.
h	a scalar value in interval `[0,1]`, specifying the h-level.

Details

The function input expects symmetric fuzzy response and crisp predictors. The prediction returns symmetric triangular fuzzy number coefficients. The OPLR method can detect one outlier in the data that is farther than `1.5 * IQR` from either quartile.

The h-level is a degree of fitting chosen by the decision maker.

Value

Returns a `fuzzylm` object that includes the model coefficients, limits for data predictions from the model and the input data.

References

Hung, W.-L. and Yang, M.-S. (2006) An omission approach for detecting outliers in fuzzy regression models. *Fuzzy Sets and Systems* 157: 3109-3122.

See Also

fuzzylm

Examples

```
data(fuzzydat)
fuzzylm(y ~ x, fuzzydat$hun, "oplr", , , "yl")
```

---

lee — *Fuzzy Linear Regression using the Possibilistic Linear Regression with Least Squares Method*

Description

The function calculates fuzzy regression coeficients using the possibilistic linear regression with least squares method developed by Lee and Tanaka (1999) that combines the least squares approach (fitting of a central tendency) with the possibilistic approach (fitting of spreads) when approximating an observed linear dependence by a fuzzy linear model.

Usage

```
lee(x, y, h = 0, k1 = 1, k2 = 1, epsilon = 1e-05)
```

Arguments

x	two column matrix with the second column representing independent variable observations. The first column is related to the intercept, so it consists of ones. Missing values not allowed.
y	one column matrix of dependent variable values, missing values not allowed.
h	a scalar value in interval [0,1], specifying the h-level.
k1	weight coefficient for the centeral tendency.
k2	weight coefficient for the spreads.
epsilon	small positive number that supports search for the optimal solution.

Details

The function input expects crisp numbers of both the explanatory and response variables, and the prediction returns non-symmetric triangular fuzzy number coefficients.

The h-level is a degree of fitting chosen by the decision maker.

Value

Returns a `fuzzylm` object that includes the model coefficients, limits for data predictions from the model and the input data.

References

Lee, H. and Tanaka, H. (1999) Fuzzy approximations with non-symmetric fuzzy parameters in fuzzy regression analysis. *Journal of the Operations Research Society Japan* 42: 98-112.

See Also

`fuzzylm`

Examples

```
x <- matrix(c(rep(1, 15), rep(1:3, each = 5)), ncol = 2)
y <- matrix(c(rnorm(5, 1), rnorm(5, 2), rnorm(5, 3)), ncol = 1)
plrls(x = x, y = y)
```

---

moflr — *Fuzzy Linear Regression Using the Multi-Objective Fuzzy Linear Regression Method*

Description

This function calculates fuzzy regression coeficients using the multi-objective fuzzy linear regression (MOFLR) method developed by Nasrabadi et al. (2005) that combines the least squares approach (fitting of a central tendency) with the possibilistic approach (fitting of spreads) when approximating an observed linear dependence by a fuzzy linear model.

Usage

```
moflr(x, y, omega = 0.5, sc = 1e-05)
```

Arguments

`x`	matrix of *n* independent variable values, followed by *n* spreads. First column is exptected to consist of ones, representing intercept. Missing values not allowed.
`y`	two column matrix of dependent variable values and the respective spread. Method assumes symmetric triangular fuzzy input, so the second spread (if present) is ignored. Missing values not allowed.
`omega`	a scalar that specifies weight that determines trade-off of between outliers penalization and data fitting in interval `[0,1]`, where high values of `omega` decrease the penalization of outliers.
`sc`	scaling constant used to input random spreads for the intercept, necessary for computational stability.

Details

The function input expects both the response and the predictors in form of symmetric fuzzy numbers. The prediction returns symmetric triangular fuzzy number coefficients. The Nasrabadi et al.'s method can process datasets with multiple outliers. Values `omega>0.5` decrease weight of outliers on the solution.

Value

Returns a `fuzzylm` object that includes the model coefficients, limits for data predictions from the model and the input data.

Note

Preferred use is through the `fuzzylm` wrapper function with argument `method = "moflr"`.

References

Nasrabadi, M. M., Nasrabadi, E. and Nasrabady, A. R. (2005) Fuzzy linear regression analysis: a multi-objective programming approach. *Applied Mathematics and Computation* 163: 245-251.

See Also

`fuzzylm`

Examples

```
data(fuzzydat)
fuzzylm(y~x, fuzzydat$nas, "moflr", "xl", , "yl")
```

`nasrabadi` *Fuzzy Linear Regression Using the Multi-Objective Fuzzy Linear Regression Method*

Description

This function calculates fuzzy regression coeficients using the multi-objective fuzzy linear regression (MOFLR) method developed by Nasrabadi et al. (2005) that combines the least squares approach (fitting of a central tendency) with the possibilistic approach (fitting of spreads) when approximating an observed linear dependence by a fuzzy linear model.

Usage

```
nasrabadi(x, y, omega = 0.5, sc = 1e-05)
```

Arguments

x	matrix of *n* independent variable values, followed by *n* spreads. First column is exptected to consist of ones, representing intercept. Missing values not allowed.
y	two column matrix of dependent variable values and the respective spread. Method assumes symmetric triangular fuzzy input, so the second spread (if present) is ignored. Missing values not allowed.
omega	a scalar that specifies weight that determines trade-off of between outliers penalization and data fitting in interval `[0,1]`, where high values of `omega` decrease the penalization of outliers.
sc	scaling constant used to input random spreads for the intercept, necessary for computational stability.

Details

The function input expects both the response and the predictors in form of symmetric fuzzy numbers. The prediction returns symmetric triangular fuzzy number coefficients. The Nasrabadi et al.'s method can process datasets with multiple outliers. Values `omega>0.5` decrease weight of outliers on the solution.

Value

Returns a `fuzzylm` object that includes the model coefficients, limits for data predictions from the model and the input data.

References

Nasrabadi, M. M., Nasrabadi, E. and Nasrabady, A. R. (2005) Fuzzy linear regression analysis: a multi-objective programming approach. *Applied Mathematics and Computation* 163: 245-251.

See Also

`fuzzylm`

Examples

```
data(fuzzydat)
fuzzylm(y~x, fuzzydat$nas, "moflr", "xl", , "yl")
```

---

oplr — *Fuzzy Linear Regression Using the Possibilistic Linear Regression with Omission Method*

Description

The function calculates fuzzy regression coeficients using the possibilistic linear regression with an outlier omission approach method (OPLR) developed by Hung and Yang (2006) that combines the least squares approach (fitting of a central tendency) with the possibilistic approach (fitting of spreads) when approximating an observed linear dependence by a fuzzy linear model.

Usage

```
oplr(x, y, h = 0)
```

Arguments

`x`	matrix with the independent variables observations. The first column is related to the intercept, so it consists of ones. Missing values not allowed.
`y`	two column matrix of the dependent variable values and the respective spread. Method assumes symmetric triangular fuzzy input, so the second spread (if present) is ignored. Missing values not allowed.
`h`	a scalar value in interval `[0,1]`, specifying the h-level.

Details

The function input expects symmetric fuzzy response and crisp predictors. The prediction returns symmetric triangular fuzzy number coefficients. The OPLR method can detect one outlier in the data that is farther than `1.5 * IQR` from either quartile.

The h-level is a degree of fitting chosen by the decision maker.

Value

Returns a `fuzzylm` object that includes the model coefficients, limits for data predictions from the model and the input data.

Note

Preferred use is through the `fuzzylm` wrapper function with argument `method = "oplr"`.

References

Hung, W.-L. and Yang, M.-S. (2006) An omission approach for detecting outliers in fuzzy regression models. *Fuzzy Sets and Systems* 157: 3109-3122.

See Also

`fuzzylm`

Examples

```
data(fuzzydat)
fuzzylm(y ~ x, fuzzydat$hun, "oplr", , , "yl")
```

plot.fuzzylm *Plot Fuzzy Linear Regression*

Description

Plots the data and the central tendency with spreads of a fuzzy linear regression. For multiple regression, allows choice of which variable to display. Optionally colors the polygon for the regression.

Usage

```
## S3 method for class 'fuzzylm'
plot(x, y = NULL, which = 1, res = 2,
  col.fuzzy = NA, length = 0.05, angle = 90, main = "method",
  xlab = NULL, ylab = NULL, ...)
```

Arguments

`x`	a `fuzzylm` object.
`y`	NULL for plotting a `fuzzylm` object.
`which`	an integer or character string specifying which explanatory variable to plot.
`res`	an integer `>= 2` specifying resolution of shading for the regression plot. Minimum resolution for shading the plot is 3.
`col.fuzzy`	color for shading of the regression plot.
`length`	length of the edges of the arrow head (in inches).
`angle`	angle from the shaft of the arrow to the edge of the arrow head.
`main`	a main title for the plot. Default title specifies method used to fit the model.
`xlab`	a label for the x axis, defaults to a description of x.
`ylab`	a label for the y axis, defaults to a description of y.
`...`	additional graphical parameters.

Details

Silently plots the data. Fuzzy numbers are plotted with points for the central value and arrows specifying spreads.

Examples

```
data(fuzzydat)
f = fuzzylm(y ~ x, fuzzydat$lee)
plot(f)
plot(f, res = 20, col.fuzzy = "red")
```

plr — *Fuzzy Linear Regression Using the Possibilistic Linear Regression Method*

Description

The function calculates fuzzy regression coeficients using the possibilistic linear regression method (PLR) developed by Tanaka et al. (1989). Specifically, the `min` problem is implemented in this function.

Usage

```
plr(x, y, h = 0)
```

Arguments

`x`	matrix of n independent variable observations. The first column is related to the intercept, so it consists of ones. Missing values not allowed.
`y`	two column matrix of dependent variable values and the respective spread. Method assumes symmetric triangular fuzzy input, so the second spread (if present) is ignored. Missing values not allowed.
`h`	a scalar value in interval `[0,1]`, specifying the h-level.

Details

The function input expects the response in form of a symmetric fuzzy number and the predictors as crisp numbers. The prediction returns symmetric triangular fuzzy number coefficients. The h-level is a degree of fitting chosen by the decision maker.

Value

Returns a `fuzzylm` object that includes the model coefficients, limits for data predictions from the model and the input data.

Note

Preferred use is through the `fuzzylm` wrapper function with argument `method = "plr"`.

References

Tanaka H., Hayashi I. and Watada J. (1989) Possibilistic linear regression analysis for fuzzy data. *European Journal of Operational Research* 40: 389-396.

See Also

`fuzzylm`

Examples

```
data(fuzzydat)
fuzzylm(y ~ x, fuzzydat$tan, "plr", , , "yl", "yr")
```

---

plrls — *Fuzzy Linear Regression using the Possibilistic Linear Regression with Least Squares Method*

Description

The function calculates fuzzy regression coeficients using the possibilistic linear regression with least squares method developed by Lee and Tanaka (1999) that combines the least squares approach (fitting of a central tendency) with the possibilistic approach (fitting of spreads) when approximating an observed linear dependence by a fuzzy linear model.

Usage

```
plrls(x, y, h = 0, k1 = 1, k2 = 1, epsilon = 1e-05)
```

Arguments

`x`	two column matrix with the second column representing independent variable observations. The first column is related to the intercept, so it consists of ones. Missing values not allowed.
`y`	one column matrix of dependent variable values, missing values not allowed.
`h`	a scalar value in interval `[0,1]`, specifying the h-level.
`k1`	weight coefficient for the centeral tendency.
`k2`	weight coefficient for the spreads.
`epsilon`	small positive number that supports search for the optimal solution.

Details

The function input expects crisp numbers of both the explanatory and response variables, and the prediction returns non-symmetric triangular fuzzy number coefficients.

The h-level is a degree of fitting chosen by the decision maker.

Value

Returns a `fuzzylm` object that includes the model coefficients, limits for data predictions from the model and the input data.

Note

Preferred use is through the `fuzzylm` wrapper function with argument `method = "plrls"`.

References

Lee, H. and Tanaka, H. (1999) Fuzzy approximations with non-symmetric fuzzy parameters in fuzzy regression analysis. *Journal of the Operations Research Society Japan* 42: 98-112.

See Also

fuzzylm

Examples

```
x <- matrix(c(rep(1, 15), rep(1:3, each = 5)), ncol = 2)
y <- matrix(c(rnorm(5, 1), rnorm(5, 2), rnorm(5, 3)), ncol = 1)
plrls(x = x, y = y)
```

---

predict.fuzzylm *Predict Method for Fuzzy Linear Regression*

Description

Predicts the central tendency and spreads from a fuzzy linear regression model.

Usage

```
## S3 method for class 'fuzzylm'
predict(object, newdata, ...)
```

Arguments

object	a fuzzylm object.
newdata	an optional data frame in which to look for variables with which to predict. If omitted, the fitted values are used.
...	further arguments passed to or from other methods.

Value

fuzzylm object with newdata replacing the slot x and predictions in triangular fuzzy number format representing the central values and left and right spreads replacing the slot y.

Examples

```
data(fuzzydat)
f <- fuzzylm(y ~ x, data = fuzzydat$lee)
predict(f)
```

print.fuzzylm *Prints Fuzzy Linear Regression Result*

Description

Prints the call and coefficients from the `fuzzylm` object.

Usage

```
## S3 method for class 'fuzzylm'
print(x, ...)
```

Arguments

`x`	a `fuzzylm` object.
`...`	further arguments passed to or from other methods.

Examples

```
x <- rep(1:3, each = 5)
y <- c(rnorm(5, 1), rnorm(5, 2), rnorm(5, 3))
dat <- data.frame(x = x, y = y)
f <- fuzzylm(y ~ x, dat)
f
```

print.summary.fuzzylm *Prints Fuzzy Linear Regression Summary*

Description

Prints the models for the central tendency and spreads from the `fuzzylm` object.

Usage

```
## S3 method for class 'summary.fuzzylm'
print(x, ...)
```

Arguments

`x`	a summary of a `fuzzylm` object.
`...`	further arguments passed to or from other methods.

Examples

```
x <- rep(1:3, each = 5)
y <- c(rnorm(5, 1), rnorm(5, 2), rnorm(5, 3))
dat <- data.frame(x = x, y = y)
f <- fuzzylm(y ~ x, dat)
sum.f <- summary(f)
sum.f
```

---

prodFuzzy — *Product of Two Triangular Fuzzy Numbers*

Description

Calculates product of two triangular fuzzy numbers defined as a central value, left and right spread.

Usage

```
prodFuzzy(x, y)
```

Arguments

x	a numeric vector of length three, specifying a triangular fuzzy number as its central value, left and right spread.
y	a numeric vector of length three, specifying a triangular fuzzy number as its central value, left and right spread.

Value

Returns a numeric vector, representing a triangular fuzzy number.

Examples

```
x <- c(1, 0.2, 0.2)
  y <- c(2, 0.2, 0.2)
  prodFuzzy(x = x, y = y)
```

prodSfuzzy *Product of a Scalar and a Triangular Fuzzy Number*

Description

Calculates product of a real number scalar and a triangular fuzzy number defined as a central value, left and right spread.

Usage

```
prodSfuzzy(x, y)
```

Arguments

x	numeric vector of length one.
y	a numeric vector of length three, specifying a triangular fuzzy number as its central value, left and right spread.

Details

Note that if `x < 0` the left and right spread will be reversed.

Value

Returns a numeric vector, representing a triangular fuzzy number.

Examples

```
x <- 2
y <- c(2, 0.2, 0.2)
prodSfuzzy(x = x, y = y)
x <- -2
prodSfuzzy(x = x, y = y)
```

sumFuzzy *Sum of Two Triangular Fuzzy Numbers*

Description

Calculates a sum of two triangular fuzzy numbers defined as a central value, left and right spread.

Usage

```
sumFuzzy(x, y)
```

Arguments

`x`	a numeric vector of length three, specifying a triangular fuzzy number as its central value, left and right spread.
`y`	a numeric vector of length three, specifying a triangular fuzzy number as its central value, left and right spread.

Value

Returns a numeric vector, representing a triangular fuzzy number.

Examples

```
x <- c(1, 0.1, 0.2)
y <- c(2, 0.2, 0.2)
sumFuzzy(x = x, y = y)
```

`summary.fuzzylm` *Summarizes Fuzzy Linear Regression*

Description

Calculates the summary from the `fuzzylm` object.

Usage

```
## S3 method for class 'fuzzylm'
summary(object, ...)
```

Arguments

`object`	a `fuzzylm` object.
`...`	additional parameters passed to and from other methods.

Value

Returns a list with models for the central tendency and spreads from the fuzzy linear regression.

Examples

```
data(fuzzydat)
f <- fuzzylm(y ~ x, fuzzydat$lee)
sum.f <- summary(f)
sum.f
```

`tanaka` *Fuzzy Linear Regression Using the Possibilistic Linear Regression Method*

Description

The function calculates fuzzy regression coeficients using the possibilistic linear regression method (PLR) developed by Tanaka et al. (1989). Specifically, the `min` problem is implemented in this function.

Usage

```
tanaka(x, y, h = 0)
```

Arguments

`x`	matrix of *n* independent variable observations. The first column is related to the intercept, so it consists of ones. Missing values not allowed.
`y`	two column matrix of dependent variable values and the respective spread. Method assumes symmetric triangular fuzzy input, so the second spread (if present) is ignored. Missing values not allowed.
`h`	a scalar value in interval `[0,1]`, specifying the h-level.

Details

The function input expects the response in form of a symmetric fuzzy number and the predictors as crisp numbers. The prediction returns symmetric triangular fuzzy number coefficients. The h-level is a degree of fitting chosen by the decision maker.

Value

Returns a `fuzzylm` object that includes the model coefficients, limits for data predictions from the model and the input data.

References

Tanaka H., Hayashi I. and Watada J. (1989) Possibilistic linear regression analysis for fuzzy data. *European Journal of Operational Research* 40: 389-396.

See Also

`fuzzylm`

Examples

```
data(fuzzydat)
fuzzylm(y ~ x, fuzzydat$tan, "plr", , , "yl", "yr")
```

TEF — *Total Error of Fit of Fuzzy Regression Model*

Description

Calculates total error of fit of a fuzzy regression model based on the concept of difference in membership functions of triangular fuzzy numbers between the estimated and observed fuzzy dependent variables.

Usage

```
TEF(object, sc = 1e-06, ...)
```

Arguments

`object`	a `fuzzylm` object.
`sc`	scaling constant used for numerical stability when spreads are equal to zero.
`...`	additional arguments passed to the `integrate` function.

Details

The `TFN1` and `TFN2` can be other objects that can be coerced to matrices with three columns.

Value

A numeric vector with pairwise differences between the triangular fuzzy numbers.

References

Kim B. and Bishu R. R. (1998) Evaluation of fuzzy linear regression models by comparing membership functions. *Fuzzy Sets and Systems* 100: 343-352.

See Also

`fuzzylm`

Examples

```
data(fuzzydat)
f <- fuzzylm(y ~ x, fuzzydat$lee)
TEF(f)
```

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