Package 'gluvarpro'

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Type Package

Title Glucose Variability Measures from Continuous Glucose Monitoring Data

Version 1.0

Imports ggplot2, pracma, scales, stats, tidyr, zoo

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Description Calculate different glucose variability measures,
including average measures of glycemia, measures of glycemic variability and measures of glycemic risk,
from continuous glucose monitoring data obtained from diabetic patients.
Boris P. Kovatchev, Erik Otto, Daniel Cox, Linda Gonder-Frederick, and William Clarke (2006) <doi:10.2337/dc06-1085>.
Jean-Pierre Le Floch, Philippe Escuyer, Eric Baudin, Dominique Baudon, and Leon Perlemuter (1990) <doi:10.2337/diacare.13.2.172>.
C.M. McDonnell, S.M. Donath, S.I. Vidmar, G.A. Werther, and F.J. Cameron (2005) <doi:10.1089/dia.2005.7.253>.
Everitt, Brian (1998) <doi:10.1111/j.1751-5823.2011.00149_2.x>.
Becker, R. A., Chambers, J. M. and Wilks, A. R. (1988) <doi:10.2307/2234167>.
Dougherty, R. L., Edelman, A. and Hyman, J. M. (1989) <doi:10.1090/S0025-5718-1989-0962209-1>.
Tukey, J. W. (1977) <doi:10.1016/0377-2217(86)90209-2>.
F. John Service (2013) <doi:10.2337/db12-1396>.
Edmond A. Ryan, Tami Shandro, Kristy Green, Breay W. Paty, Peter A. Senior, David Bigam, A.M. James Shapiro, and Marie-Christine Vantyghem (2004) <doi:10.2337/diabetes.53.4.955>.
Seniz Sevimer Tuncan, Mehmet Uzunlulu, Ozge telci caklili, Hasan Huseyin Mutlu, and Aytekin Oguz (2016) <doi:10.5152/cjms.2016.109>.
Sarah E. Siegelaar, Frits Holleman, Joost B. L. Hoekstra, and J. Hans DeVries (2010) <doi:10.1210/er.2009-0021>.
Gabor Marics, Zsofia Lendvai, Csaba Lodi, Levente Koncz, David Zakarias, Gyorgy Schuster, Borbala Mikos, Csaba Hermann, Attila J. Szabo, and Peter Toth-Heyn (2015) <doi:10.1186/s12938-015-0035-3>.

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Depends R (>= 2.10)

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NeedsCompilation no

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R topics documented:

`adrrgvp` *adrrgvp (average daily risk range).*

Description

Average daily risk range is a measure of glycemic risk that is based on risk values obtained from glucose levels that are mathematically transformed to give equal weight to hyperglycemic and hypoglycemic excursions. The *adrrgvp* is scored based on risk categories: Low risk, 0–19; moderate risk, 20–40; and high risk, 40 and above.

Usage

```
adrrgvp(x, t = 24)
```

Arguments

x	Data-set with data frame format containing three columns: date: date of the observation with format *yyyy/mm/dd*. time: time of the observation with 24 hour format *hh:mm:ss*. glucose: glucose value of the observation in [mg/dl].
t	Interval for calculating the measurement. Permitted values are 4, 6, 8, 12 and 24 hours. Default value of 24 hours.

Value

A data frame containing the adrr values.

Author(s)

Sergio Contador.

References

Boris P. Kovatchev, Erik Otto, Daniel Cox, Linda Gonder-Frederick, and William Clarke. Evaluation of a new measure of blood glucose variability in diabetes. Diabetes Care, 29(11):2433–2438, 2006.

See Also

bgigvp(x, t = 24)

Examples

```
data("datagvp1")
adrrgvp(datagvp1)
```

---

aucgvp *aucgvp (area under curve).*

Description

Area under curve is an average measure of glycemia that quantifies the average exposure to hypoglycemia and hyperglycemia events. The integral trapezoidal cumulative function is used to calculate the area. The area under a curve between two points can be found by doing a definite integral between the two points. To find the area under the curve y = f(x) between x = a and x = b, integrate y = f(x) between the limits of a and b.

Usage

```
aucgvp(x, t = 24, tdown = 70, tup = 180)
```

Arguments

x	Data-set with data frame format containing three columns: date: date of the observation with format *yyyy/mm/dd*. time: time of the observation with 24 hour format *hh:mm:ss*. glucose: glucose value of the observation in [mg/dl].
t	Interval for calculate measure. Permitted values are 4, 6, 8, 12 and 24 hours. Default value of 24 hours.
tdown	Target range low with default value of 70 [mg/dl].
tup	Target range high with default value of 180 [mg/dl].

Value

A data frame containing the lauc, hauc and auc values.

Author(s)

Sergio Contador.

References

Jean-Pierre Le Floch, Philippe Escuyer, Eric Baudin, Dominique Baudon, and Leon Perlemuter. Blood glucose area under the curve: Methodological aspects. Diabetes Care, 13(2):172–175, 1990.

Examples

```
data("datagvp1")
aucgvp(datagvp1)
```

---

bgigvp *bgigvp (blood glucose index).*

Description

Blood glucose index is a measure of glycemic risk based on the same normalizing transformation as the *adrrgvp* measure but is specifically designed to be sensitive to hypoglycemia (*lbgi*) and hyperglycemia (*hbgi*), respectively, and to have zero correlation with their opposite ranges on the blood glucose scale.

Usage

```
bgigvp(x, t = 24)
```

Arguments

x	Data-set with data frame format containing three columns: date: date of the observation with format *yyyy/mm/dd*. time: time of the observation with 24 hour format *hh:mm:ss*. glucose: glucose value of the observation in [mg/dl].
t	Interval for calculating the measurement. Permitted values are 4, 6, 8, 12 and 24 hours. Default value of 24 hours.

Value

A data frame containing the lbgi, hbgi and bgi values.

Author(s)

Sergio Contador.

References

Boris P. Kovatchev, Erik Otto, Daniel Cox, Linda Gonder-Frederick, and William Clarke. Evaluation of a new measure of blood glucose variability in diabetes. Diabetes Care, 29(11):2433–2438, 2006.

See Also

adrrgvp(x, t = 24)

Examples

```
data("datagvp1")
bgigvp(datagvp1)
```

---

congagvp *congagvp (continuous overall net glycemic action).*

Description

Continuous overall net glycemic action is a measure of glycemic variability specifically developed for use on continuous glucose monitoring data. It is calculated as the standard deviation of the sum of the differences between a current observation and an observation n hours previously. Because conga does not require arbitrary glucose cutoffs or arbitrary defined rises and falls, it seems to be a more objective manner to define glucose variability than *mvgvp* or *magegvp*.

Usage

```
congagvp(x, t = 24, ts = 15, h = 1)
```

Arguments

x	Data-set with data frame format containing three columns: date: date of the observation with format *yyyy/mm/dd*. time: time of the observation with 24 hour format *hh:mm:ss*. glucose: glucose value of the observation in [mg/dl].
t	Interval for calculating the measurement. Permitted values are 4, 6, 8, 12 and 24 hours. Default value of 24 hours.
ts	Sampling time of glucose values. Permitted values are 5 and 15 minutes. Default value of 15 minutes.
h	Type of measure calculated. Permitted values are from 1 to 24 hours, with differences of 1 hour. Default value of 1 hour.

Value

A data frame containing the conga values.

Author(s)

Sergio Contador.

References

C.M. McDonnell, S.M. Donath, S.I. Vidmar, G.A. Werther, and F.J. Cameron. A novel approach to continuous glucose analysis utilizing glycemic variation. Diabetes Technology \& Therapeutics, 7(2):253–263, 2005.

Examples

```
data("datagvp1")
congagvp(datagvp1)
```

---

cvgvp *cvgvp (percentage coefficient of variation).*

Description

Percentage coefficient of variation is a measure of glycemic variability defined as the ratio of the standard deviation to the mean.

Usage

```
cvgvp(x, t = 24)
```

Arguments

x	Data-set with data frame format containing three columns: date: date of the observation with format *yyyy/mm/dd*. time: time of the observation with 24 hour format *hh:mm:ss*. glucose: glucose value of the observation in [mg/dl].
t	Interval for calculating the measurement. Permitted values are 4, 6, 8, 12 and 24 hours. Default value of 24 hours.

Value

A data frame containing the cv values.

Author(s)

Sergio Contador.

References

Everitt, Brian (1998). The Cambridge Dictionary of Statistics. Cambridge, UK New York: Cambridge University Press.

See Also

meangvp(x, t = 24)

sdgvp(x, t = 24)

Examples

```
data("datagvp1")
cvgvp(datagvp1)
```

---

datagvp1 *data-set from Freestyle Libre continuous glucose monitoring.*

Description

Data from type 1 diabetic patient acquired through Freestyle Libre continuous glucose monitoring.

Usage

```
data("datagvp1")
```

Format

Data-set with data frame format containing three columns:

date: date of the observation with format *yyyy/mm/dd*.

time: time of the observation with 24 hour format *hh:mm:ss*.

glucose: glucose value of the observation in [mg/dl].

Details

Data-set with 6 complete days of data acquired with sampling time of 15 minutes. There are 576 observations in total.

Source

Hospital Universitario Principe de Asturias de Alcala de Henares, Madrid, Spain.

Examples

```
data("datagvp1")
datagvp1
```

---

datagvp2 *data-set from Medtronic continuous glucose monitoring.*

Description

Data from type 1 diabetic patient acquired through Medtronic continuous glucose monitoring.

Usage

```
data("datagvp2")
```

Format

Data-set with data frame format containing three columns:

date: date of the observation with format *yyyy/mm/dd*.

time: time of the observation with 24 hour format *hh:mm:ss*.

glucose: glucose value of the observation in [mg/dl].

Details

Data-set with 36 complete days of data acquired with sampling time of 5 minutes. There are a total of 10368 observations, 10 with NA values of glucose.

Source

School of Electrical Engineering and Computer Science, Ohio University, Ohio, United States.

References

Cindy Marling and Razvan Bunescu. The OhioT1DM Dataset for Blood Glucose Level Prediction - DRAFT.

Examples

```
data("datagvp2")
datagvp2
```

`datagvp3` *data-set from Freestyle Libre continuous glucose monitoring.*

Description

Data from type 1 diabetic patient acquired through Freestyle Libre continuous glucose monitoring.

Usage

```
data("datagvp3")
```

Format

Data-set with data frame format containing three columns:

date: date of the observation with format *yyyy/mm/dd*.

time: time of the observation with 24 hour format *hh:mm:ss*.

glucose: glucose value of the observation in [mg/dl].

Details

Data-set with 476 complete days of data acquired with sampling time of 15 minutes. There are 45696 observations in total.

Source

Hospital Universitario Principe de Asturias de Alcala de Henares, Madrid, Spain.

Examples

```
data("datagvp3")
datagvp3
```

`fillgvp` *fillgvp (fill glucose values from continuous glucose monitoring).*

Description

Generic functions for replacing NA values with interpolated values, performing linear or cubic spline interpolation of given data points.

Usage

```
fillgvp(x, method = "linear", n = 4)
```

Arguments

`x`	Data-set with data frame format containing one column: glucose: glucose value of the observation in [mg/dl].
`method`	Missing values (NAs) are replaced by linear interpolation via *linear* or cubic spline interpolation via *cubic*, respectively. Default value is *linear*.
`n`	Maximum number of consecutive NAs to fill. Any longer gaps will be left unchanged. Default value is 4.

Value

A data frame containing glucose values.

Author(s)

Sergio Contador.

References

Becker, R. A., Chambers, J. M. and Wilks, A. R. (1988). The New S Language. Wadsworth & Brooks/Cole.

Dougherty, R. L., Edelman, A. and Hyman, J. M. (1989). Positivity-, monotonicity-, or convexity-preserving cubic and quintic Hermite interpolation. Mathematics of Computation, 52, 471–494.

Examples

```
data("datagvp1")
fillgvp(datagvp1)
```

iqrgvp *igrgvp (inter-quartile range).*

Description

Inter-quartile range is a measure of glycemic variability defined as the difference between 75th and 25th percentiles.

Usage

```
iqrgvp(x, t = 24)
```

Arguments

x	Data-set with data frame format containing three columns: date: date of the observation with format *yyyy/mm/dd*. time: time of the observation with 24 hour format *hh:mm:ss*. glucose: glucose value of the observation in [mg/dl].
t	Interval for calculating the measurement. Permitted values are 4, 6, 8, 12 and 24 hours. Default value of 24 hours.

Value

A data frame containing the iqr values.

Author(s)

Sergio Contador.

References

Tukey, J. W. (1977). Exploratory Data Analysis. Reading: Addison-Wesley.

Examples

```
data("datagvp1")
iqrgvp(datagvp1)
```

jigvp *jigvp (j index).*

Description

J index is a measure of glycemic variability that combines information of the standard deviation and the mean, and excludes severe and persistent hypoglycemia.

Usage

```
jigvp(x, t = 24)
```

Arguments

x	Data-set with data frame format containing three columns: date: date of the observation with format *yyyy/mm/dd*. time: time of the observation with 24 hour format *hh:mm:ss*. glucose: glucose value of the observation in [mg/dl].
t	Interval for calculating the measurement. Permitted values are 4, 6, 8, 12 and 24 hours. Default value of 24 hours.

Value

A data frame containing the ji values.

Author(s)

Sergio Contador.

References

F. John Service. Glucose variability. Diabetes, 62(5):1398–1404, 2013.

Examples

```
data("datagvp1")
jigvp(datagvp1)
```

ligvp *ligvp (lability index).*

Description

Lability index is a measure of glycemic variability that evaluates the metabolic lability and its possible improvement in patients candidates for islet transplantation.

Usage

```
ligvp(x, t = 24, ts = 15)
```

Arguments

x	Data-set with data frame format containing three columns: date: date of the observation with format *yyyy/mm/dd*. time: time of the observation with 24 hour format *hh:mm:ss*. glucose: glucose value of the observation in [mg/dl].
t	Interval for calculating the measurement. Permitted values are 4, 6, 8, 12 and 24 hours. Default value of 24 hours.
ts	Sampling time of glucose values. Permitted values are 5 and 15 minutes. Default value of 15 minutes.

Value

A data frame containing the li values.

Author(s)

Sergio Contador.

References

Edmond A. Ryan, Tami Shandro, Kristy Green, Breay W. Paty, Peter A. Senior, David Bigam, A.M. James Shapiro, and Marie-Christine Vantyghem. Assessment of the severity of hypoglycemia and glycemic lability in type 1 diabetic subjects undergoing islet transplantation. Diabetes, 53(4):955–962, 2004.

Examples

```
data("datagvp1")
ligvp(datagvp1)
```

magegvp *magegvp (mean amplitude of glycemic excursions).*

Description

Mean amplitude of glycemic excursions is a measure of glycemic variability that calculates changes in blood glucose that exceed multiples of the standard deviation, and that are in hypoglycemic and hyperglycemic values. It is based on the number of glycemic excursions, using glucose values that are above or below the limits of hypoglycemia and hyperglycemia.

Usage

```
magegvp(x, t = 24, n = 1)
```

Arguments

x	Data-set with data frame format containing three columns: date: date of the observation with format *yyyy/mm/dd*. time: time of the observation with 24 hour format *hh:mm:ss*. glucose: glucose value of the observation in [mg/dl].
t	Interval for calculating the measurement. Permitted values are 4, 6, 8, 12 and 24 hours. Default value of 24 hours.
n	Number of multiple values of standard deviation with default value of 1.

Value

A data frame containing the number of glycemic excursions ge, lmage, hmage and mage values.

Author(s)

Sergio Contador.

References

Seniz Sevimer Tuncan, Mehmet Uzunlulu, Ozge telci caklili, Hasan Huseyin Mutlu, and Aytekin Oguz. Evaluation of the glycemic fluctuation as defined as the mean amplitude of glycemic excursion in hospitalized patients with type 2 diabetes. 1, 11 2016.

Examples

```
data("datagvp1")
magegvp(datagvp1)
```

meangvp *meangvp (arithmetic mean).*

Description

Arithmetic mean is an average measure of glycemia that calculates the sum of a set of data values divided by the number of data values in the data-set.

Usage

```
meangvp(x, t = 24)
```

Arguments

x	Data-set with data frame format containing three columns: date: date of the observation with format *yyyy/mm/dd*. time: time of the observation with 24 hour format *hh:mm:ss*. glucose: glucose value of the observation in [mg/dl].
t	Interval for calculating the measurement. Permitted values are 4, 6, 8, 12 and 24 hours. Default value of 24 hours.

Value

A data frame containing the mean values.

Author(s)

Sergio Contador.

References

Becker, R. A., Chambers, J. M. and Wilks, A. R. (1988). The New S Language. Wadsworth & Brooks/Cole.

See Also

cvgvp(x, t = 24)

Examples

```
data("datagvp1")
meangvp(datagvp1)
```

mvgvp *mvgvp (m value).*

Description

M value is a measure of glycemic variability that quantifies the glycemic control of diabetic patients. It is a measure of the stability of the glucose excursions in comparison with an ideal glucose default value of 6.6 [mmol/l]-120 [mg/dl]. The m value is zero in healthy controls, rising with increasing glycemic variability or poorer glycemic control, making it difficult to distinguish between patients with either high mean glucose or high glucose variability. Moreover, because hypoglycemia has a greater impact on the m value than hyperglycemia, it is more a clinical than a mathematical indicator of glycemic control.

Usage

```
mvgvp(x, t = 24, gi = 120)
```

Arguments

x	Data-set with data frame format containing three columns: date: date of the observation with format *yyyy/mm/dd*. time: time of the observation with 24 hour format *hh:mm:ss*. glucose: glucose value of the observation in [mg/dl].
t	Interval for calculating the measurement. Permitted values are 4, 6, 8, 12 and 24 hours. Default value of 24 hours.
gi	Ideal glucose value with default value of 120 [mg/dl].

Value

A data frame containing the mv values.

Author(s)

Sergio Contador.

References

Sarah E. Siegelaar, Frits Holleman, Joost B. L. Hoekstra, and J. Hans DeVries. Glucose variability; does it matter? Endocrine Reviews, 31(2):171–182, 2010.

Examples

```
data("datagvp1")
mvgvp(datagvp1)
```

plotgvp *plotgvp (plot glucose values and glucose variability measures).*

Description

Generic function for plotting given data points.

Usage

```
plotgvp(x, col = "one", var = "glucose")
```

Arguments

x	Data-set with data frame format containing three columns: date: date of the observation with format *yyyy/mm/dd*. time: time of the observation with 24 hour format *hh:mm:ss*. glucose or variability measure: glucose value [mg/dl] or glucose variability measure.
col	Color for plotting data points. If data-set contains more than one day, it can be selected different colors (*multiple*) for each day of data or one color (*one*). Default value is *one* color.
var	Variable for plotting. Permitted values are *glucose*, *adrr*, *lauc*, *hauc*, *auc*, *lbgi*, *hbgi*, *bgi*, *conga*, *cv*, *iqr*, *ji*, *li*, *ge*, *lmage*, *hmage*, *mage*, *mean*, *mv*, *sd*, *lpstr*, *hpstr*, *npstr* and *pstr*. Default value is *glucose*.

Author(s)

Sergio Contador.

Examples

```
data("datagvp1")
plotgvp(datagvp1)
```

pstrgvp *pstrgvp (percentage spent below/above the target range).*

Description

Percentage spent below/above the target range is an average measure of glycemia that calculates the percentage of average time that the patient is in hypoglycemic and hyperglycemic ranges. This measure calculates the time-in-range measure (*npstr*) but does not give more weight to extremely low values (*lpstr*) nor to high values (*hpstr*). Arbitrary target range may not be optimal, so the ranges must to be chosen careful.

Usage

```
pstrgvp(x, t = 24, tdown = 70, tup = 180)
```

Arguments

x	Data-set with data frame format containing three columns: date: date of the observation with format *yyyy/mm/dd*. time: time of the observation with 24 hour format *hh:mm:ss*. glucose: glucose value of the observation in [mg/dl].
t	Interval for calculating the measurement. Permitted values are 4, 6, 8, 12 and 24 hours. Default value of 24 hours.
tdown	Target range low with default value of 70 [mg/dl].
tup	Target range high with default value of 180 [mg/dl].

Value

A data frame containing the lpstr, hpstr, npstr and pstr values.

Author(s)

Sergio Contador.

References

Gabor Marics, Zsofia Lendvai, Csaba Lodi, Levente Koncz, David Zakarias, Gyorgy Schuster, Borbala Mikos, Csaba Hermann, Attila J. Szabo, and Peter Toth-Heyn. Evaluation of an open access software for calculating glucose variability parameters of a continuous glucose monitoring system applied at pediatric intensive care unit. BioMedical Engineering OnLine, 14(1):37, Apr 2015.

Examples

```
data("datagvp1")
pstrgvp(datagvp1)
```

---

sdgvp *sdgvp (standard deviation).*

Description

Standard deviation is a measure of glycemic variability that quantify the amount of variation or dispersion of a set of data values.

Usage

```
sdgvp(x, t = 24)
```

Arguments

x	Data-set with data frame format containing three columns: date: date of the observation with format *yyyy/mm/dd*. time: time of the observation with 24 hour format *hh:mm:ss*. glucose: glucose value of the observation in [mg/dl].
t	Interval for calculating the measurement. Permitted values are 4, 6, 8, 12 and 24 hours. Default value of 24 hours.

Value

A data frame containing the sd values.

Author(s)

Sergio Contador.

References

Becker, R. A., Chambers, J. M. and Wilks, A. R. (1988). The New S Language. Wadsworth & Brooks/Cole.

See Also

cvgvp(x, t = 24)

Examples

```
data("datagvp1")
sdgvp(datagvp1)
```

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