# Package ‘ECG’

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**Type** Package

**Title** Center of Gravity Methods

**Version** 0.5.2

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**Description** Implementation of the Centre of Gravity method and the Extrapolated Centre of Gravity method. It supports replicated observations.
Cameron, D.G., et al (1982) <doi:10.1366/0003702824638610>
JCGM (2008) <doi:10.59161/JCGM100-2008E>.

**Depends** R (>= 4.0), graphics (>= 3.4), stats (>= 3.4), MASS (>= 7.3)

**License** GPL (>= 3)

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**Repository** CRAN

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## Contents

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`ECG-package` *Center of Gravity Methods*

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## Description

Estimates the local minimum of a series or readings by the center of gravity and the extrapolated center of gravity.

## Details

| | |
|---|---|
| Package: | ECG |
| Type: | Package |
| Version: | 0.5.1 |
| Date: | 2024-10-01 |
| License: | GPL (>= 3) |

Define a series of readings of a series as a data frame object containing: (date of reading, independent variable, replicated observations for control, replicated observations for unknown) Then estimate the minimum by analysing its profile with the CGr method, Optionally estimate the extrapolated minimum by analysisng its profile with the ECGr method.

## Author(s)

H. Gasca-Aragon

Maintainer: H. Gasca-Aragon <hugo_gasca_aragon@hotmail.com>

## References

JCGM 100:2008. *Guide to the expression of uncertainty of measurement*.

Cameron et al. *Precision in Condensed Phase Vibrational Spectroscopy*, Applied Spectroscopy, Vol 36, Number 3, 1982.

## assess *Generic method for assessing an estimate against a reference value*

### Description

Generic method for assessing an estimate against a reference value by the En index.

### Usage

```
assess(x, y, x.B = list(u=0, dof=Inf), alpha=0.05)
```

### Arguments

| | |
|---|---|
| `x` | a Estimator object |
| `y` | a list with the reference value (x, u, dof) |
| `x.B` | a list with the estimate of uncertainty type B for the x object and its degrees of freedom |
| `alpha` | numeric, the level of significance used to compute the coverage factor and the expanded uncertainty |

### Value

the numeric value of the En index evaluation. This is a normalized error value with expanded uncertainty equals 1.0.

### Author(s)

H. Gasca-Aragon

## assess.CGdata *Evaluates the CGdata object estimation*

### Description

Evaluates the CGdata object estimation against a reference value by the En index.

### Usage

```
## S3 method for class 'CGdata'
assess(x, y, x.B=list(u=0, dof=Inf), alpha=x$input$alpha)
```

## Arguments

`x` a CGdata object

`y` a list with the reference value (x, u)

`x.B` a list with the estimate of uncertainty type B for the x object and its degrees of freedom

`alpha` a numeric, the level of significance to compute the coverage factor and expanded uncertainty

## Value

the numeric value of the En index evaluation. This is a normalized error value with expanded uncertainty equals 1.0.

## Author(s)

H. Gasca-Aragon

## Examples

```
require(ECG)

N<- 1000
set.seed(12345)
d1<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)+rnorm(5/2*N, 0, 0.01)
dat<- data.frame(x=1:length(d1),
y=100*(d1-min(d1))/(max(d1)-min(d1)))

CGres<- CGdata(dat)

X.ref <- list(x=1250, u=0, dof=Inf)

assess(CGres, y=X.ref)
```

---

# `assess.CGr` *Evaluates the CGr object estimation*

---

## Description

Evaluates the CGr object estimation against a reference value by the En index.

## Usage

```
## S3 method for class 'CGr'
assess(x, y, x.B = list(u=0, dof=Inf), alpha=x$input$alpha)
```

## Arguments

| | |
|---|---|
| x | a Estimator object |
| y | a list with the reference value (x, u, dof) |
| x.B | a list with the estimate of uncertainty type B for the x object and its degrees of freedom |
| alpha | numeric, the level of significance used to compute the coverage factor and the expanded uncertainty |

## Value

the numeric value of the En index evaluation.

## Author(s)

H. Gasca-Aragon

## Examples

```
require(ECG)
X.ref<- list(x=1250, u=0, dof=Inf)
N<- 1000
d0<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)
set.seed(12345)
d1<- d0+rnorm(5/2*N, 0, 0.01)
d2<- d0+rnorm(5/2*N, 0, 0.01)
dat<- data.frame(x=1:length(d1),
y1=100*(d1-min(d1))/(max(d1)-min(d1)),
y2=100*(d2-min(d2))/(max(d2)-min(d2)))

CGres<- CGr(dat, columns=c(2,3))
assess(CGres, X.ref)
```

# assess.ECGdata *Evaluates the ECGdata object estimation*

## Description

Evaluates the ECGdata object estimation against the reference value by the En index.

## Usage

```
## S3 method for class 'ECGdata'
assess(x, y, x.B = list(u=0, dof=Inf), alpha=x$input$alpha)
```

### Arguments

`x` a Estimator object

`y` a list with the reference value (x, u, dof)

`x.B` a list with the estimate of uncertainty type B for the x object and its degrees of freedom

`alpha` numeric, the level of significance used to compute the coverage factor and the expanded uncertainty

### Value

the numeric value of the En index evaluation.

### Author(s)

H. Gasca-Aragon

### Examples

```
require(ECG)
N<- 1000
set.seed(12345)
d1<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)+rnorm(5/2*N, 0, 0.01)
dat<- data.frame(x=1:length(d1),
y=100*(d1-min(d1))/(max(d1)-min(d1)))

ECGres<- ECGdata(dat)

X.ref <- list(x=1250, u=0, dof=Inf)
assess(ECGres, y=X.ref)
```

---

## assess.ECGr *Evaluates the ECGr object estimation*

---

### Description

Evaluates the ECGr object estimation against a reference value by the En index.

### Usage

```
## S3 method for class 'ECGr'
assess(x, y, x.B = list(u=0, dof=Inf), alpha=x$input$alpha)
```

## Arguments

| | |
|---|---|
| x | a Estimator object |
| y | a list with the reference value (x, u, dof) |
| x.B | a list with the estimate of uncertainty type B for the x object and its degrees of freedom |
| alpha | numeric, the level of significance used to compute the coverage factor and the expanded uncertainty |

## Value

the numeric value of the En index evaluation. This is a normalized error value with expanded uncertainty equals 1.0.

## Author(s)

H. Gasca-Aragon

## Examples

```
require(ECG)
X.ref<- list(x=pi/2, u=0, dof=Inf)
N<- 1000
d0<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)
set.seed(12345)
d1<- d0+rnorm(5/2*N, 0, 0.01)
d2<- d0+rnorm(5/2*N, 0, 0.01)
dat<- data.frame(x=1:length(d1),
y1=100*(d1-min(d1))/(max(d1)-min(d1)),
y2=100*(d2-min(d2))/(max(d2)-min(d2)))
ECGres<- ECGr(dat, min(dat$x), max(dat$x), columns=c(2,3),
responseLowerLimit=0, responseUpperLimit=100)
assess(ECGres, X.ref)
```

# CGdata *Creates a CGdata object*

## Description

Builds a CGdata (center of gravity) object for a series of single observations.

## Usage

```
CGdata(data, from=min(data$x), to=max(data$x), responseFraction = 0.5,
useConstantDelta = FALSE, fixedResponseFraction = 0.5,
useFixedResponseFraction = FALSE, replaceOutliers = TRUE,
responseLowerLimit = min(data$y), responseUpperLimit = max(data$y),
alpha = 0.05, signifDigits = 2, ...)
```

## Arguments

`data` a data frame structure containing (x, y) columns.

`from` a numeric value with the initial value of `x` to search for a local minimum.

`to` a numeric value with the final value of `x` to search for a local minimum.

`responseFraction` a real value with the fraction (0,1) of the maximum height to be considered in the analysis.

`useConstantDelta` a logic value, if true then it assumes the values of `x` increments at constant rate, otherwise it computes each increment.

`fixedResponseFraction` a numeric with the fraction of height to be used as a reference to normilize, default value is 0.5.

`useFixedResponseFraction` a logic value, if TRUE then it uses the value of `fixedResponseFraction` to normalize all the computations, otherwise it uses the value of `responseFraction` to normalize, default value is TRUE.

`replaceOutliers` a logic value, if true then it uses the value of `responseLowerLimit` and `responseUpperLimit` to replace outlier values. Default value is TRUE.

`responseLowerLimit` a real value to be used as the default to replace outlier values lower than expected.

`responseUpperLimit` a real value to be used as the default to replace outlier values larger than expected.

`alpha` a real value, it defines the level of error type I used to estimate the coverage factor `kp` and the expanded uncertainty, its default value is 0.05.

`signifDigits` an integer value, it defines the number of significant digits to be used for displaying the result and its uncertainty, default value is 2.

`...` additional parameters.

## Value

`x` numeric, the estimated value

`u` numeric, the estimated uncertainty associated to x

`moments` numeric vector, the estimated mean, variance, skweness and kurtosis

`input` list, contains the input parameters

`frame` list, contains the reference values of the analysis. This information is used to build a verbosed version of its plot. The content of the list is: `y.x.band.min` the local maximum found in the lower region of the analysis region.
`y.x.band.max` the local maximum found it the upper region of the analysis region.
`x.min.y` the value of `x` where the local minumum `y` occurrs.

x.max the value of x where the local maximum y.x.max occurs.
x.min the value of x where the locel maximum y.x.min occurs.
y.x.max the maximum height in the upper region of the analysis.
y.x.min the maximum height in the lower region of the analysis.
h the value of the index of x associated with f.i fraction of the data in the lower region of analysis.
k the value of the index of x associated with f.i fraction of the data in the upper region of analysis.
x.h the value of x associated with f.i fraction of the data in the lower region of analysis.
x.k the value of x associated with f.i fraction of the data in the upper region of analysis.

used.data.points the number of datapoints of x used to obtain the estimates, this is equal to k-h+1.

### Author(s)

H. Gasca-Aragon

### Examples

```
require(ECG)

N<- 1000
set.seed(12345)
d1<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)+rnorm(5/2*N, 0, 0.01)
dat<- data.frame(x=1:length(d1),
y=100*(d1-min(d1))/(max(d1)-min(d1)))

CGres <- CGdata(dat)
CGres
```

## CGr *Creates a CGr object*

### Description

Builds a CGr (center of gravity) object for a series of replicated observations.

### Usage

```
CGr(data, from=min(data$x), to=max(data$x), columns,  responseFraction = 0.50,
useConstantDelta=FALSE, fixedResponseFraction=0.5, useFixedResponseFraction=FALSE,
replaceOutliers=TRUE, responseLowerLimit=min(data[, columns]),
responseUpperLimit=max(data[, columns]), alpha=0.05,
kp=if(length(columns)<=1) qnorm(1-alpha/2) else
qt(1-alpha/2, length(columns)-1),
signifDigits=2, useRobustStatistics = TRUE, ...)
```

## Arguments

`data` a data frame structure containing (date, x, y1, ..., yn) columns, it may contain some other columns.

`from` a numeric value with the initial value of x to search for a local minimum.

`to` a numeric value with the final value of x to search for a local minimum.

`columns` a vector of indexes of the columns to be considered in the profile.

`responseFraction` numeric, fraction of the maximum height to be considered in the analysis,

`useConstantDelta` boolean flag, if true constant increment in the x values is assumed, otherwise the difference is computed for each increment of x.

`fixedResponseFraction` a numeric with the fraction of hieght to be used as a reference to normilize.

`useFixedResponseFraction` a logical value, if true then it uses the value of f.fixed to normalize all the computations, otherwise it uses the values of extrapolation sequence of fractions to normalize.

`replaceOutliers` a logic value, if true then it uses the value of `responseLowerLimit` and `responseUpperLimit` to replace outlier values. Default value is TRUE.

`responseLowerLimit` a real value to be used as the default to replace outlier values lower than expected, its default value is 0.

`responseUpperLimit` a real value to be used as the default to replace outlier values larger than expected, its default value is 1.

`alpha` a real value, define the level of significance for building confidence interval.

`kp` a real value, it defines the coverage factor to be used to estimate the expanded uncertainty. It is build based on the level of significance `alpha` and assumes a T distribution of the error terms with the degrees of freedom equals to the number of `columns` provided minus one, its default value is qnorm(1-`alpha`/2) for one column otherwise qt(1-`alpha`/2, length(`columns`)-1).

`signifDigits` number of significant digits used to display the result.

`useRobustStatistics` a logical value, if true then median and mad are used to estimate location and dispersion otherwise the mean and standard deviation are used.

`...` additional parameters.

## Value

`x` numeric, the estimated value

`u` numeric, the estimated uncertainty associated to x

`moments` numeric vector, the estimated mean, variance, skweness and kurtosis `input` list, contains the current input parameters, including the default values additional parameters passed through `...` are not included.

`frame` list, contains the reference values of the analysis. This information is used to build a verbosed version of its plot. The content of the list is: `y.x.band.min` the local maximum found in the lower region of the analysis region.
`y.x.band.max` the local maximum found it the upper region of the analysis region.
`x.min.y` the value of `x` where the local minumum `y` occurrs.
`x.max` the value of `x` where the local maximum `y.x.max` occurs.
`x.min` the value of `x` where the locel maximum `y.x.min` occurs.
`y.x.max` the maximum height in the upper region of the analysis.
`y.x.min` the maximum height in the lower region of the analysis.
`h` the value of the index of `x` associated with `f.i` fraction of the data in the lower region of analysis.
`k` the value of the index of `x` associated with `f.i` fraction of the data in the upper region of analysis.
`x.h` the value of `x` associated with `f.i` fraction of the data in the lower region of analysis.
`x.k` the value of `x` associated with `f.i` fraction of the data in the upper region of analysis.

`used.data.points` the number of datapoints of `x` used to obtain the estimates, this is equal to k-h+1.

## Author(s)

H. Gasca-Aragon

## Examples

```
require(ECG)

N<- 1000
set.seed(12345)
d1<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)+rnorm(5/2*N, 0, 0.01)
d2<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)+rnorm(5/2*N, 0, 0.01)
dat<- data.frame(x=1:length(d1),
y1=100*(d1-min(d1))/(max(d1)-min(d1)),
y2=100*(d2-min(d2))/(max(d2)-min(d2))
)

CGres<- CGr(dat, columns=c(2,3))
CGres
```

`ECGdata` *Creates a ECGdata object*

### Description

Builds a ECGdata object to estimate an extrapolation of the local minimum in the response for a series of single observations.

### Usage

```
ECGdata(data, from=min(data$x), to=max(data$x), useConstantDelta = FALSE,
maxResponseFraction = 0.5, minResponseFraction = 0.05,
byResponseFraction = -0.05, fixedResponseFraction = 0.5,
useFixedResponseFraction = FALSE, replaceOutliers = TRUE,
responseLowerLimit=min(data$y), responseUpperLimit=max(data$y),
 alpha = 0.05,  kp = qnorm(1-alpha/2), signifDigits = 2,
 useRobustStatistics = TRUE, ...)
```

### Arguments

`data` a data frame structure containing (x, y) columns.

`from` a numeric value with the initial value of x to search for a local minimum.

`to` a numeric value with the final value of x to search for a local minimum.

`useConstantDelta` a logical value, if true then it uses the mean value of the differences in x, otherwise, it uses the differences in x to estimate the expected value. in the analysis.

`maxResponseFraction` a real value with the fraction (0,1) of the maximum height to be considered in the analysis.

`minResponseFraction` a real value with the fraction (0,1) of the minimum height to be considered in the analysis.

`byResponseFraction` a real value with the fraction (0,1) of the decrement of height to be considered in the analysis. The extrapolation analysis uses the sequence: maxResponseFraction, maxResponseFraction+byResponseFraction, ..., minResponseFraction

`fixedResponseFraction` a numeric with the fraction of hieght to be used as a reference to normilize.

`useFixedResponseFraction` a logical value, if true then it uses the value of f.fixed to normalize all the computations, otherwise it uses the values of extrapolation sequence of fractions to normalize.

`replaceOutliers` a logic value, if true then it uses the value of `responseLowerLimit` and `responseUpperLimit` to replace outlier values. Default value is TRUE.

`responseLowerLimit`
: a real value to be used as the default to replace outlier values lower than expected, its default value is 0.

`responseUpperLimit`
: a real value to be used as the default to replace outlier values larger than expected, its default value is 1.

`alpha` a real value, define the level of significance for building confidence interval.

`kp` a real value, it defines the coverage factor to be used to estimate the expanded uncertainty. It is build based on the level of significance `alpha` and assumes normal distribution of the error terms, its default value is qnorm(1-`alpha`/2).

`signifDigits` number of significant digits used to display the result.

`useRobustStatistics`
: a logical value, if true then median and mad are used to estimate location and dispersion otherwise the mean and standard deviation are used.

`...` additional parameters.

## Details

The data at each step is a subset of the previous step hence the estimates are correlated. However by specifying useFixedResponseFraction=FALSE they are normalized against distinct fraction of the height.

## Value

`x` numeric, the estimated value

`u` numeric, the estimated uncertainty associated to x

`input` list, contains the input parameters

`frame` list, contains the reference values of the analysis. This information is used to build a verbosed version of its plot. The content of the list is:
`kp` the updated coverage factor considering the reduced degrees of freedom from using the model used. `y.x.band.min` the local maximum found in the lower region of the analysis region.
`x.max` the value of `x` where the local maximum `y.x.max` occurs.
`x.min` the value of `x` where the local maximum `y.x.min` occurs.
`solutions` a matrix with the solutions found for each analyzed fraction of the data.
The contained columns are:
the location estimate,
the standard uncertainty,
the response fraction used,
the value of the minimum response in the considered band,
the maximum response in the considered band, and
the number of data points used.
`type` an integer representing the degree of the polynomial model (0=constant model, 1=polynomial model of first degree, 2=polynomial model of second degree).
`model` a linear model summary object.

### Author(s)

H. Gasca-Aragon

### See Also

See Also as CGdata, print.ECGdata, plot.ECGdata

### Examples

```
require(ECG)
N<- 1000
set.seed(12345)
d1<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)+rnorm(5/2*N, 0, 0.01)
dat<- data.frame(x=1:length(d1),
y=100*(d1-min(d1))/(max(d1)-min(d1)))

ECGdata(dat)
ECGdata
```

## ECGr *Creates an ECGr object*

### Description

Builds an ECGr object to estimate an extrapolation of the local minimum in the response for a series of replicated observations.

### Usage

```
ECGr(data, from=min(data$x), to=max(data$x), columns, useConstantDelta=FALSE,
maxResponseFraction=0.5, minResponseFraction=0.05,
byResponseFraction=-0.05, fixedResponseFraction=0.5,
useFixedResponseFraction = FALSE, replaceOutliers = TRUE,
responseLowerLimit = min(data[, columns]),
responseUpperLimit = max(data[, columns]),
alpha=0.05, kp=if(length(columns)<=1) qnorm(1-alpha/2) else
qt(1-alpha/2, length(columns)-1),
signifDigits = 2, useRobustStatistics=TRUE, ...)
```

### Arguments

| | |
|---|---|
| `data` | a data frame structure containing (date, x, y1, ..., yn) columns, it may contain some other columns. |
| `from` | a numeric value with the initial value of x to search for a local minimum. |
| `to` | a numeric value with the final value of x to search for a local minimum. |
| `columns` | a vector of indexes of the columns to be considered in the profile. |

useConstantDelta
a logical value, if true then it uses the mean value of the differences in x, otherwise, it uses the differences in x to estimate the expected value. in the analysis.

maxResponseFraction
a real value with the fraction (0,1) of the maximum height to be considered in the analysis.

minResponseFraction
a real value with the fraction (0,1) of the minimum height to be considered in the analysis.

byResponseFraction
a real value with the fraction (0,1) of the decrement of height to be considered in the analysis. The extrapolation analysis uses the sequence: maxResponseFraction, maxResponseFraction+byResponseFraction, ..., minResponseFraction

fixedResponseFraction
a numeric with the fraction of hieght to be used as a reference to normilize.

useFixedResponseFraction
a logical value, if true then it uses the value of f.fixed to normalize all the computations, otherwise it uses the values of extrapolation sequence of fractions to normalize.

replaceOutliers
a logic value, if true then it uses the value of responseLowerLimit and responseUpperLimit to replace outlier values. Default value is TRUE.

responseLowerLimit
a real value to be used as the default to replace outlier values lower than expected, its default value is 0.

responseUpperLimit
a real value to be used as the default to replace outlier values larger than expected, its default value is 1.

alpha a real value, define the level of significance for building confidence interval.

kp a real value, it defines the coverage factor to be used to estimate the expanded uncertainty. It is build based on the level of significance alpha and assumes normal distribution of the error terms, its default value is qnorm(1-alpha/2).

signifDigits number of significant digits used to display the result.

useRobustStatistics
a logical value, if true then median and mad are used to estimate location and dispersion otherwise the mean and standard deviation are used.

... additional parameters.

## Value

x numeric, the estimated value

u numeric, the estimated uncertainty associated to x

input list, contains the input parameters

`frame` list, contains the reference values of the analysis. This information is used to build a verbosed version of its plot. The content of the list is:
`y` average of the response series. Depending on the `useRobustStatistics` value the average can be the mean or the median of the series indicated in the `columns` parameter. `u.y` average uncertainty of the response series. Depending on the `useRobustStatistics` value the average can be the standard deviation or the median absolute deviation of the series indicated in the `columns` parameter. `kp` the updated coverage factor considering the reduced degrees of freedom from using the model used.

`x.summary` the estimated location from the average of the series.
`u.x.summary` the estimated uncertainty associated to the estimated location from the average of the series.

`details` the matrix containing the results for considered fractions in the analysis. The columns are:
the estimated location, the estimated uncertainty, the minimum response value found,
the minimum value of the location estimates, the maximum value of the location estimates,
the estimated coverage factor.
`used.data.points` the number of data points used in the estimations.

## Author(s)

H. Gasca-Aragon

## See Also

See Also as `ECGdata`, `print.ECGr`, `plot.ECGr`

## Examples

```
require(ECG)
N<- 1000
set.seed(12345)
d1<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)+rnorm(5/2*N, 0, 0.01)
d2<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)+rnorm(5/2*N, 0, 0.01)
dat<- data.frame(x=1:length(d1),
y1=100*(d1-min(d1))/(max(d1)-min(d1)),
y2=100*(d2-min(d2))/(max(d2)-min(d2))
)
ECGres<- ECGr(dat, columns=c(2,3))
ECGres
```

## plot.CGdata *Plots a CGdata object*

### Description

Creates a plot of a series of single observations.

### Usage

```
## S3 method for class 'CGdata'
plot(x, from=x$input$from, to=x$input$to, xlab = expression(nu(cm^-1)),
 ylab = "Transmittance", add = FALSE, verbose = FALSE, ...)
```

### Arguments

| | |
|---|---|
| x | a CGdata object |
| from | lower limit point on the predictor value to be plotted |
| to | upper limit point on the predictor value to be plotted |
| xlab | a string or expression with the label for the x axis |
| ylab | a string or expression with the label for the y axis |
| add | a logical value, if true then the plot is added to an existing one, otherwise it creates a new plot |
| verbose | a logical value, if true then the plot displays intermediate steps to estimate the extreme point located between the from and to values |
| ... | additional parameters |

### Value

No return value, called for graphical display side effects

### Author(s)

H. Gasca-Aragon

### See Also

See Also as CGdata, print.CGdata

### Examples

```
require(ECG)

N<- 1000

set.seed(12345)
d1<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)+rnorm(5/2*N, 0, 0.01)
```

```
dat<- data.frame(x=1:length(d1),
y=100*(d1-min(d1))/(max(d1)-min(d1)))

CGres<- CGdata(dat)


plot(CGres, min(dat$x), max(dat$x), verbose = TRUE)
```

---

## plot.CGr *Plots a CGr object*

---

### Description

Creates a plot of a series of replicated data. It shows the summary of the series. Optionally it shows the limits of the range of analysis and the estimated local minimum computed as the center of gravity.

### Usage

```
## S3 method for class 'CGr'
plot(x, ...)
```

### Arguments

| | |
|---|---|
| x | a CGr object |
| ... | additional parameters |

### Value

No return value, called for graphical display.

### Author(s)

H. Gasca-Aragon

### See Also

See Also as CGr, print.CGr

### Examples

```
require(ECG)
N<- 1000
set.seed(12345)
d1<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)+rnorm(5/2*N, 0, 0.01)
d2<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)+rnorm(5/2*N, 0, 0.01)
dat<- data.frame(x=1:length(d1),
y1=100*(d1-min(d1))/(max(d1)-min(d1)),
y2=100*(d2-min(d2))/(max(d2)-min(d2))
)
CGres<- CGr(dat, columns=c(2,3))
plot(CGres)
```

## plot.ECGdata *Plots an ECGdata object*

### Description

Creates a plot for a series of single observations with the extrapolated center of gravity method.

### Usage

```
## S3 method for class 'ECGdata'
plot(x, xlim=range(x$frame$solution[,1]), ylim=c(0, max(x$frame$solution[,5])),
 xlab=expression(nu[i]), ylab=expression(f[i]), add=TRUE, ...)
```

### Arguments

| | |
|---|---|
| x | an ECGdata object |
| xlim | a range with the x limits for plotting purposes |
| ylim | a range with the y limits for plotting purposes |
| xlab | a string or expression with the label for the x axis |
| ylab | a string or expression with the label for the y axis |
| add | a logical value, if true then the plot is added to an existing one, otherwise it creates a new plot. |
| ... | additional parameters |

### Details

It plots the sequence of approximations for each fraction of the dataset, and it shows the estimated value while extrapolated at zero fraction. Use it in collaboration with CGdata::plot to show the data, the search frame, and the sequence of approximations.

### Value

No return value.

### Author(s)

H. Gasca-Aragon

### See Also

See Also as ECGdata, print.ECGdata, plot.ECGdata

## Examples

```
require(ECG)
N<- 1000
set.seed(12345)
d1<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)+rnorm(5/2*N, 0, 0.01)
dat<- data.frame(x=1:length(d1),
y=100*(d1-min(d1))/(max(d1)-min(d1)))

CGres <- CGdata(dat)
ECGres<- ECGdata(dat)


# use it alone, plot the sequence of approximations
plot(ECGres, add = FALSE)

# use it in collaboration with CGdata
# display the Center of Gravity approach for single observation
plot(CGres, min(dat$x), max(dat$x))
# then add the extrapolation sequence
plot(ECGres)
```

---

# `plot.ECGr` *Plots an ECGr object*

---

## Description

Creates a plot for a series of replicated observations with the extrapolated center of gravity method.

## Usage

```
## S3 method for class 'ECGr'
plot(x, add = TRUE, ...)
```

## Arguments

| | |
|---|---|
| `x` | an ECGr object. |
| `add` | a logical value, if true then the plot is added to an existing one, otherwise it creates a new plot. |
| `...` | additional parameters. |

## Details

It plots the sequence of approximations for each fraction of the dataset, and it shows the estimated value while extrapolated at zero fraction.

## Value

No return value. Used for graphical display.

## Author(s)

H. Gasca-Aragon

## See Also

See Also as ECGr, print.ECGr

## Examples

```
require(ECG)
N<- 1000
set.seed(12345)
d1<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)+rnorm(5/2*N, 0, 0.01)
d2<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)+rnorm(5/2*N, 0, 0.01)
dat<- data.frame(x=1:length(d1),
y1=100*(d1-min(d1))/(max(d1)-min(d1)),
y2=100*(d2-min(d2))/(max(d2)-min(d2))
)

# used alone
ECGres<- ECGr(dat, columns=c(2,3))
plot(ECGres, add = FALSE)

# used in colaboration with CGr
CGres<- CGr(dat, columns=c(2,3))

# display the Center of Gravity approach for replicated observations
plot(CGres, verbose = TRUE)
# then add the extrapolation sequence
plot(ECGres)
```

---

# print.CGdata *Displays the content of a CGdata object*

---

## Description

Displays the content of a CGdata object.

## Usage

```
## S3 method for class 'CGdata'
print(x, signifDigits=x$input$signifDigits, alpha=x$input$alpha, verbose=FALSE, ...)
```

## Arguments

`x` a CGdata object.

`signifDigits` a numeric value for the number of significant digits.

`alpha` a probability value taken as the significance level for building a symmetric confidence interval assuming a t distribution for `x$frame$used.data.points`-1 degrees of freedom.

`verbose` a boolean, if FALSE the description of the form
(value, expanded uncertainty) is provided. if TRUE the description is complemented providing:
the estimated coverage factor,
the estimated degrees of freedom,
the estimated coverage probability.

`...` additional parameters

## Value

No return value, called for displaying purposes/side effect.

## Author(s)

H. Gasca-Aragon

## See Also

objects to See Also as `CGdata`,

## Examples

```
require(ECG)

N<- 1000
set.seed(12345)
d1<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)+rnorm(5/2*N, 0, 0.01)
dat<- data.frame(x=1:length(d1),
y=100*(d1-min(d1))/(max(d1)-min(d1)))

CGres<- CGdata(dat)
CGres
print(CGres)
```

## print.CGr *Displays the content of a CGr object*

### Description

Displays the content of a CGr object.

### Usage

```
## S3 method for class 'CGr'
print(x, signifDigits=x$input$signifDigits,
alpha = x$input$alpha, verbose=FALSE, ...)
```

### Arguments

| | |
|---|---|
| `x` | a CGr object. |
| `signifDigits` | a numeric value for the number of significant digits. |
| `alpha` | a probability value taken as the significance level for building a symmetric confidence interval assuming a t distribution for `x$frame$used.data.points`-1 degrees of freedom. |
| `verbose` | a boolean, if FALSE the description of the form<br>(value, expanded uncertainty) is provided. if TRUE the description is complemented providing:<br>the estimated coverage factor,<br>the estimated degrees of freedom,<br>the estimated coverage probability. |
| `...` | additional parameters |

### Value

No return value.

### Author(s)

H. Gasca-Aragon

### Examples

```
require(ECG)
N<- 1000
set.seed(12345)
d1<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)+rnorm(5/2*N, 0, 0.01)
d2<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)+rnorm(5/2*N, 0, 0.01)
dat<- data.frame(x=1:length(d1),
y1=100*(d1-min(d1))/(max(d1)-min(d1)),
y2=100*(d2-min(d2))/(max(d2)-min(d2))
)
CGres<- CGr(dat, columns=c(2,3))
print(CGres)
```

## print.ECGdata *Displays the content of a ECGdata object*

### Description

Displays the content of a ECGdata object.

### Usage

```
## S3 method for class 'ECGdata'
print(x, signifDigits=x$input$signifDigits, alpha = x$input$alpha, verbose=FALSE, ...)
```

### Arguments

| | |
|---|---|
| `x` | an ECGdata object. |
| `signifDigits` | a numeric value for the number of significant digits. |
| `alpha` | a probability value taken as the significance level for building a symmetric confidence interval assuming a t distribution for `x$frame$used.data.points`-1 degrees of freedom. |
| `verbose` | a boolean, if FALSE the description of the form<br>(value, expanded uncertainty) is provided. if TRUE the description is complemented providing:<br>the estimated coverage factor,<br>the estimated degrees of freedom,<br>the estimated coverage probability. |
| `...` | additional parameters |

### Value

No return value. Used for textual displaying side effect.

### Author(s)

H. Gasca-Aragon

## Examples

```
require(ECG)
N<- 1000
set.seed(12345)
d1<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)+rnorm(5/2*N, 0, 0.01)
dat<- data.frame(x=1:length(d1),
y=100*(d1-min(d1))/(max(d1)-min(d1)))

ECGres<- ECGdata(dat)
ECGres
print(ECGres)
```

---

# `print.ECGr` *Displays the content of a ECGr object*

---

## Description

Displays the content of a ECGr object.

## Usage

```
## S3 method for class 'ECGr'
print(x, signifDigits=x$input$signifDigits,
alpha = x$input$alpha, verbose=FALSE, ...)
```

## Arguments

| | |
|---|---|
| `x` | an ECGr object. |
| `signifDigits` | a numeric value for the number of significant digits. |
| `alpha` | a probability value taken as the significance level for building a symmetric confidence interval assuming a t distribution for `x$frame$used.data.points`-1 degrees of freedom. |
| `verbose` | a boolean, if FALSE the description of the form<br>(value, expanded uncertainty) is provided. if TRUE the description is complemented providing:<br>the estimated coverage factor,<br>the estimated degrees of freedom,<br>the estimated coverage probability. |
| `...` | additional parameters |

## Value

No return value. Used for textual display purposes.

### Author(s)

H. Gasca-Aragon

### Examples

```
require(ECG)
N<- 1000
set.seed(12345)
d1<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)+rnorm(5/2*N, 0, 0.01)
d2<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)+rnorm(5/2*N, 0, 0.01)
dat<- data.frame(x=1:length(d1),
y1=100*(d1-min(d1))/(max(d1)-min(d1)),
y2=100*(d2-min(d2))/(max(d2)-min(d2))
)

ECGres<- ECGr(dat, columns=c(2,3))
ECGres
print(ECGres)

CGres<- CGr(dat, columns=c(2,3))
CGres
print(CGres)
```

## `toString.CGdata` *Converts a CGdata object into a string description*

### Description

Converts a CGdata object into a string description for displaying purposes.

### Usage

```
## S3 method for class 'CGdata'
toString(x, signifDigits=x$input$signifDigits, alpha=x$input$alpha, verbose=FALSE, ...)
```

### Arguments

`x` a CGdata object

`signifDigits` a numeric value for the number of significant digits.

`alpha` a probability value taken as the significance level for building a symmetric confidence interval assuming a t distribution for
`x$frame$used.data.points`-1 degrees of freedom.

`verbose` a boolean, if FALSE the description of the form
(value, expanded uncertainty) is provided. if TRUE the description is complemented providing:
the estimated coverage factor,
the estimated degrees of freedom,
the estimated coverage probability.

`...` additional parameters

### Value

a string description of the CGdata object.

### Author(s)

H. Gasca-Aragon

### Examples

```
require(ECG)
N<- 1000
d0<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)
set.seed(12345)
d1<- d0+rnorm(5/2*N, 0, 0.01)
dat<- data.frame(x=1:length(d1),
y=100*(d1-min(d1))/(max(d1)-min(d1)))

CGres<- CGdata(dat)
str.res <- toString(CGres)
print(nchar(str.res))
print(str.res)
```

## `toString.CGr` *Converts a CGr object into a string description*

### Description

Converts a CGr object into a string description for displaying purposes.

### Usage

```
## S3 method for class 'CGr'
toString(x, signifDigits=x$input$signifDigits, alpha=x$input$alpha, verbose=FALSE, ...)
```

### Arguments

`x` a CGr object

`signifDigits` a numeric value for the number of significant digits.

`alpha` a probability value taken as the significance level for building a symmetric confidence interval assuming a t distribution for `x$frame$used.data.points`-1 degrees of freedom.

| | |
|---|---|
| `verbose` | a boolean, if FALSE the description of the form<br>(value, expanded uncertainty) is provided. if TRUE the description is complemented providing:<br>the estimated coverage factor,<br>the estimated degrees of freedom,<br>the estimated coverage probability. |
| `...` | additional parameters |

## Value

a string description of the CGr object.

## Author(s)

H. Gasca-Aragon

## Examples

```
require(ECG)
X.ref<- list(x=pi/2, u=0)
N<- 1000
d0<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)

set.seed(12345)
d1<- d0+rnorm(5/2*N, 0, 0.01)
d2<- d0+rnorm(5/2*N, 0, 0.01)
dat<- data.frame(x=1:length(d1),
y1=100*(d1-min(d1))/(max(d1)-min(d1)),
y2=100*(d2-min(d2))/(max(d2)-min(d2)))

CGres<- CGr(dat, columns=c(2,3))
str.res <- toString(CGres)
print(nchar(str.res))
```

# `toString.ECGdata` *Converts a ECGdata object into a string description*

## Description

Converts a ECGdata object into a string description for displaying purposes.

## Usage

```
## S3 method for class 'ECGdata'
toString(x, signifDigits=x$input$signifDigits, alpha=x$input$alpha, verbose=FALSE, ...)
```

## Arguments

x an ECGdata object

signifDigits a numeric value for the number of significant digits.

alpha a probability value taken as the significance level for building a symmetric confidence interval assuming a t distribution for `x$frame$used.data.points`-1 degrees of freedom.

verbose a boolean, if FALSE the description of the form
(value, expanded uncertainty) is provided. if TRUE the description is complemented providing:
the estimated coverage factor,
the estimated degrees of freedom,
the estimated coverage probability.

... additional parameters

## Value

a string description of the ECGdata object.

## Author(s)

H. Gasca-Aragon

## Examples

```
require(ECG)
X.ref<- list(x=pi/2, u=0)
N<- 1000
d0<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)

set.seed(12345)
d1<- d0+rnorm(5/2*N, 0, 0.01)
dat<- data.frame(x=1:length(d1),
y=100*(d1-min(d1))/(max(d1)-min(d1)))

ECGres<- ECGdata(dat)
str.res <- toString(ECGres)
print(str.res)
```

# toString.ECGr *Converts an ECGr object into a string description*

## Description

Converts an ECGr object into a string description for displaying purposes.

## Usage

```
## S3 method for class 'ECGr'
toString(x, signifDigits=x$input$signifDigits, alpha=x$input$alpha,
verbose=FALSE, ...)
```

## Arguments

| | |
|---|---|
| `x` | a ECGr object |
| `signifDigits` | a numeric value for the number of significant digits. |
| `alpha` | a probability value taken as the significance level for building a symmetric confidence interval assuming a t distribution for `x$frame$used.data.points`-1 degrees of freedom. |
| `verbose` | a boolean, if FALSE the description of the form<br>(value, expanded uncertainty) is provided. if TRUE the description is complemented providing:<br>the estimated coverage factor,<br>the estimated degrees of freedom,<br>the estimated coverage probability. |
| `...` | addtional parameters |

## Value

a string description of the ECGr object.

## Author(s)

H. Gasca-Aragon

## Examples

```
require(ECG)
X.ref<- list(x=pi/2, u=0)
N<- 1000
d0<- 1-sin(seq(1:(5/2*N))/N*pi-pi*3/4)

set.seed(12345)
d1<- d0+rnorm(5/2*N, 0, 0.01)
d2<- d0+rnorm(5/2*N, 0, 0.01)
dat<- data.frame(x=1:length(d1),
y1=100*(d1-min(d1))/(max(d1)-min(d1)),
y2=100*(d2-min(d2))/(max(d2)-min(d2)))

ECGres<- ECGr(dat, columns=c(2,3))
str.res <- toString(ECGres)
print(nchar(str.res))
```

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