Package ‘DFA’

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Type Package

Title Detrended Fluctuation Analysis

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Description Containing the Detrended Fluctuation Analysis (DFA), Detrended Cross-Correlation Analysis (DCCA), Detrended Cross-Correlation Coefficient (rhoDCCA), Delta Amplitude Detrended Cross-Correlation Coefficient (DeltarhoDCCA), log amplitude Detrended Fluctuation Analysis (DeltalogDFA), and the Activity Balance Index, it also includes two DFA automatic methods for identifying crossover points and a Deltalog automatic method for identifying reference channels.

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Encoding UTF-8

LazyData true

Depends stats, R (>= 3.5.0)

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BugReports https://github.com/victormesquita40/DFA/issues

NeedsCompilation no

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Contents

`ABI` *Activity balance index (ABI)*

Description

This function estimates the Activity balance index (ABI), which is a transformation of the self-similarity parameter (SSP), also known as scaling exponent or alpha.

Usage

```
ABI(x)
```

Arguments

`x`	the estimated self-similarity parameter (SSP)

Details

ABI = exp(-abs(SSP-1)/exp(-2))

Value

The estimated Activity balance index (ABI) is a real number between zero and one.

Author(s)

Ian Meneghel Danilevicz

References

Danilevicz, I.M., van Hees, V.T., van der Heide, F., Jacob, L., Landré, B., Benadjaoud, M.A., Sabia, S. (2023). Measures of fragmentation of rest activity patterns: mathematical properties and interpretability based on accelerometer real life data. Research square. 10.21203/rs.3.rs-3543711/v1.

Examples

```
# Estimate Activity balance index of a very known time series available on R base: the sunspot.year.

library(DFA)
alpha = SSP(sunspot.year, scale = 1.2)
abi = ABI(alpha)
```

AUC — *Area Under the Curve*

Description

Applies the Area Under the Curve on the log-log curve.

Usage

```
AUC(x,data)
```

Arguments

`x`	Vector of the decimal logarithm of the boxes sizes.
`data`	A data frame of different decimal logarithm of the DFA calculated in each boxe.

Details

Compute the Area Under the Curve to a data frame. The method returns the curve with higher AUC.

Value

`position`	Position of the DFA curve with higher Area Under the Curve (AUC).
`Area`	Respective Area Under the Curve (AUC) computed by trapezoidal rule for the channel with higher AUC.

Note

All of log-log curve contained in the data frame must have the same sample size.

Author(s)

Victor Barreto Mesquita

References

https://www.khanacademy.org/math/ap-calculus-ab/ab-integration-new/ab-6-2/a/understanding-the-trape

https://en.wikipedia.org/wiki/Trapezoidal_rule

Examples

```
# Example with a data frame with different DFA exponents ranging from short 0.1 to long 0.9.
# The functions returns the channel with higher AUC and its respective area.

library(DFA)
#library(latex2exp) # it is necessary for legend of the plot function

data("lrcorrelation")

#plot(lrcorrelation$`log10(boxes)`,lrcorrelation$`log10(DFA(alpha = 0.9))`
#     ,xlab=TeX("$log_{10}(n)$"),ylab=TeX("$log_{10}F_{DFA}(n)$"),col="black"
#     ,pch=19, ylim= c(-0.8,1.2))
#lines(lrcorrelation$`log10(boxes)`,lrcorrelation$`log10(DFA(alpha = 0.8))`,type="p"
#      ,col="blue", pch=19)
#lines(lrcorrelation$`log10(boxes)`,lrcorrelation$`log10(DFA(alpha = 0.7))`,type="p"
#      ,col="red", pch=19)
#lines(lrcorrelation$`log10(boxes)`,lrcorrelation$`log10(DFA(alpha = 0.6))`,type="p"
#      ,col="green", pch=19)
#lines(lrcorrelation$`log10(boxes)`,lrcorrelation$`log10(DFA(alpha = 0.5))`,type="p"
#      ,col="brown", pch=19)
#lines(lrcorrelation$`log10(boxes)`,lrcorrelation$`log10(DFA(alpha = 0.4))`,type="p"
#      ,col="yellow", pch=19)
#lines(lrcorrelation$`log10(boxes)`,lrcorrelation$`log10(DFA(alpha = 0.3))`,type="p"
#      ,col="orange", pch=19)
#lines(lrcorrelation$`log10(boxes)`,lrcorrelation$`log10(DFA(alpha = 0.2))`,type="p"
#      ,col="pink", pch=19)
#lines(lrcorrelation$`log10(boxes)`,lrcorrelation$`log10(DFA(alpha = 0.1))`,type="p"
#      ,col="magenta", pch=19)

#legend("bottom", legend=c(TeX("$\alpha_{DFA} = 0.9$"),TeX("$\alpha_{DFA} = 0.8$")
#                          ,TeX("$\alpha_{DFA} = 0.7$"),TeX("$\alpha_{DFA} = 0.6$")
#                          ,TeX("$\alpha_{DFA} = 0.5$"),TeX("$\alpha_{DFA} = 0.4$")
#                          ,TeX("$\alpha_{DFA} = 0.3$"),TeX("$\alpha_{DFA} = 0.2$")
#                          ,TeX("$\alpha_{DFA} = 0.1$"))
#       , col=c("black","blue","red","green","brown","yellow","orange","pink","magenta")
#       , pch=c(19,19,19,19,19,19,19,19,19)
#       , cex = 0.55
#       , ncol = 5
#)

x = lrcorrelation$`log10(boxes)`

data = lrcorrelation

AUC(x,data)
```

DCCA *Detrended Cross-Correlation Analysis (DCCA)*

Description

Applies the Detrended Cross-Correlation Analysis (DCCA) to nonstationary time series.

Usage

```
DCCA(file,file2,scale = 2^(1/8),box_size = 4,m=1)
```

Arguments

`file`	Univariate time series (must be a vector or data frame)
`file2`	Univariate time series (must be a vector or data frame)
`scale`	Specifies the ratio between successive box sizes (by default `scale = 2^(1/8)`)
`box_size`	Vector of box sizes (must be used in conjunction with `scale = "F"`)
`m`	An integer of the polynomial order for the detrending (by default `m=1`).

Details

The Detrended Cross-Correlation Analysis method (DCCA) can be computed in a geometric scale or for different choices of boxes sizes.

Value

`boxe`	Size n of the overlapping boxes.
`DFA1`	DFA of the first time series (`file`).
`DFA2`	DFA of the second time series (`file2`).
`DCCA`	Detrended Cross-Correlation function.

Note

The time series `file` and `file2` must have the same sample size.

Author(s)

Victor Barreto Mesquita

References

N. Xu, P. Shang, S. Kamae Modeling traffic flow correlation using DFA and DCCA Nonlinear Dynam., 61 (2010), pp. 207-216

B. Podobnik, D. Horvatic, A. Petersen, H.E. Stanley Cross-correlations between volume change and price change PNAS, 106 (52) (2009), pp. 22079-22084

R. Ursilean, A.-M. Lazar Detrended cross-correlation analysis of biometric signals used in a new authentication method Electr. Electron. Eng., 1 (2009), pp. 55-58

Examples

```
#The following examples using the database of financial time series
#collected during the United States bear market of 2007-2009.

library(DFA)
data("NYA2008")
data("IXIC2008")
file = NYA2008
file2= IXIC2008

DCCA(file,file2,scale = 2^(1/8),box_size = c(4,8,16),m=1)


# Example with different polynomial fit order.

library(DFA)
data("NYA2008")
data("LSE.L2008")
file = NYA2008
file2= LSE.L2008

DCCA(file,file2,scale = 2^(1/8),box_size = c(4,8,16),m=2)


# Example using different choice of overlapping boxes sizes.

library(DFA)
data("NYA2008")
data("IXIC2008")
file = NYA2008
file2= IXIC2008

DCCA(file,file2,scale = "F",box_size = c(4,8,16),m=1)
```

`DeltaDFA` *log-amplitude Detrended Fluctuation Analysis (DeltaDFA)*

Description

Applies the log-amplitude Detrended Fluctuation Analysis (DFA) to nonstationary time series.

Usage

```
DeltaDFA(file,file2,scale = 2^(1/8),box_size = 4,m=1)
```

Arguments

`file`	Univariate time series (must be a vector or data frame)

`file2`	Univariate time series (must be a vector or data frame)
`scale`	Specifies the ratio between successive box sizes (by default `scale = 2^(1/8)`)
`box_size`	Vector of box sizes (must be used in conjunction with `scale = "F"`)
`m`	An integer of the polynomial order for the detrending (by default `m=1`).

Details

The DFA log-amplitude fluctuation can be computed in a geometric scale or for different choices of boxes sizes.

Value

`boxe`	Size n of the overlapping boxes.
`DeltaDFA`	log-amplitude Detrended Fluctuation function defined as the difference between the DFA decimal logarithmic of the first time series (`file`) and the DFA decimal logarithmic of the second time series (`file2`)

Note

The time series `file` and `file2` must have the same sample size.

Author(s)

Victor Barreto Mesquita

References

G. F. Zebende, F. M. Oliveira Filho, J. A. L. Cruz, Auto-correlationin the motor/imaginary human eeg signals: A vision about the fdfafluctuations, PloS one 12 (9) (2017).

F. Oliveira Filho, J. L. Cruz, G. Zebende, Analysis of the eeg bio-signalsduring the reading task by dfa method, Physica A: Statistical Mechanicsand its Applications 525 (2019) 664-671.

S. R. Hirekhan, R. R. Manthalkar, The detrended fluctuation and cross-correlation analysis of eeg signals, International Journal of IntelligentSystems Design and Computing 2 (2) (2018) .

Examples

```
#The following examples using the database of financial time series
#collected during the United States bear market of 2007-2009.

library(DFA)
data("NYA2008")
data("IXIC2008")
file = NYA2008
file2= IXIC2008

DeltaDFA(file,file2,scale = 2^(1/8),box_size = c(4,8,16),m=1)


# Example with different polynomial fit order.
```

```
library(DFA)
data("NYA2008")
data("LSE.L2008")
file = NYA2008
file2= LSE.L2008

DeltaDFA(file,file2,scale = 2^(1/8),box_size = c(4,8,16),m=2)


# Example using differente choice of overlapping boxes sizes.

library(DFA)
data("NYA2008")
data("IXIC2008")
file = NYA2008
file2= IXIC2008

DeltaDFA(file,file2,scale = "F",box_size = c(4,8,16),m=1)
```

Deltarho *Delta Amplitude Detrended Cross-Correlation Coefficient (DeltarhoDCCA)*

Description

Applies the Detrended Cross-Correlation Coefficient Difference (Deltarho) to nonstationary time series.

Usage

```
Deltarho(file,file2,file3,file4,scale = 2^(1/8),box_size = 4,m=1)
```

Arguments

`file`	Univariate time series (must be a vector or data frame)
`file2`	Univariate time series (must be a vector or data frame)
`file3`	Univariate time series (must be a vector or data frame)
`file4`	Univariate time series (must be a vector or data frame)
`scale`	Specifies the ratio between successive box sizes (by default `scale = 2^(1/8)`)
`box_size`	Vector of box sizes (must be used in conjunction with `scale = "F"`)
`m`	An integer of the polynomial order for the detrending (by default `m=1`).

Details

The Deltarho can be computed in a geometric scale or for different choices of boxes sizes.

Value

`boxe`	Size n of the overlapping boxes.
`DFA1`	DFA of the first time series (`file`).
`DFA2`	DFA of the second time series (`file2`).
`DFA3`	DFA of the third time series (`file3`).
`DFA4`	DFA of the fourth time series (`file4`).
`DCCA`	Detrended Cross-Correlation function between the first time series (`file`) and the second time series (`file2`).
`DCCA2`	Detrended Cross-Correlation function between the third time series (`file3`) and the fourth time series (`file4`).
`rhoDCCA`	Detrended Cross-Correlation Coefficient function, defined as the ratio between the `DCCA` and two DFA (`DFA1,DFA2`).
`rhoDCCA2`	Detrended Cross-Correlation Coefficient function, defined as the ratio between the `DCCA2` and two DFA (`DFA3,DFA4`).

Note

The time series `file`,`file2`,`file3` and `file4` must have the same sample size.

Author(s)

Victor Barreto Mesquita

References

SILVA, Marcus Fernandes da et al. Quantifying cross-correlation between ibovespa and brazilian blue-chips: The dcca approach. Physica A: Statistical Mechanics and its Applications, v. 424,2015.

Examples

```
#The following examples using the database of financial time series
#collected during the United States bear market of 2007-2009.

library(DFA)
data("NYA2008")
data("IXIC2008")
data("LSE.L2008")
data("SSEC2008")

file = NYA2008
file2= IXIC2008
file3 = LSE.L2008
file4 = SSEC2008

Deltarho(file,file2,file3,file4,scale = 2^(1/8),box_size = c(4,8,16),m=1)


# Example with different polynomial fit order.
```

```
library(DFA)
data("NYA2008")
data("IXIC2008")
data("LSE.L2008")
data("SSEC2008")

file = NYA2008
file2 = LSE.L2008
file3= IXIC2008
file4 = SSEC2008

Deltarho(file,file2,file3,file4,scale = 2^(1/8),box_size = c(4,8,16),m=2)



# Example using different choice of overlapping boxes sizes.

library(DFA)
data("NYA2008")
data("IXIC2008")
data("LSE.L2008")
data("SSEC2008")

file = NYA2008
file2= IXIC2008
file3 = LSE.L2008
file4 = SSEC2008

Deltarho(file,file2,file3,file4,scale = "F",box_size = c(4,8,16),m=1)
```

DFA *Detrended Fluctuation Analysis (DFA)*

Description

Applies the Detrended Fluctuation Analysis (DFA) to nonstationary time series.

Usage

```
DFA(file,scale = 2^(1/8),box_size = 4,m=1)
```

Arguments

`file`	Univariate time series (must be a vector or data frame)
`scale`	Specifies the ratio between successive box sizes (by default `scale = 2^(1/8)`)
`box_size`	Vector of box sizes (must be used in conjunction with `scale = "F"`)
`m`	An integer of the polynomial order for the detrending (by default `m=1`).

Details

The DFA fluctuation can be computed in a geometric scale or for different choices of boxes sizes.

Value

`boxe`	Size n of the overlapping boxes.
`DFA`	Detrended Fluctuation function.

Note

The time series `file` and `file2` must have the same sample size.

Author(s)

Victor Barreto Mesquita

References

C.-K. Peng, S.V. Buldyrev, S. Havlin, M. Simons, H.E. Stanley, A.L. Goldberger Phys. Rev. E, 49 (1994), p. 1685

H.E. Stanley, L.A.N. Amaral, A.L. Goldberger, S. Havlin, P.Ch. Ivanov, C.-K. Peng Physica A, 270 (1999), p. 309

P.C. Ivanov, A. Bunde, L.A.N. Amaral, S. Havlin, J. Fritsch-Yelle, R.M. Baevsky, H.E. Stanley, A.L. Goldberger Europhys. Lett., 48 (1999), p. 594

P. Talkner, R.O. Weber Phys. Rev. E, 62 (2000), p. 150

M. Ausloos, K. Ivanova Physica A, 286 (2000), p. 353

H.E. Hurst, R.P. Black, Y.M. Simaika Long-Term Storage, An Experimental Study, Constable, London (1965)

Examples

```
#The following examples using the database of financial time series
#collected during the United States bear market of 2007-2009.

library(DFA)
data("NYA2008")
file = NYA2008

DFA(file,scale = 2^(1/8),box_size = c(4,8,16),m=1)


# Example with different polynomial fit order.

library(DFA)
data("LSE.L2008")
file = LSE.L2008

DFA(file,scale = 2^(1/8),box_size = c(4,8,16),m=2)
```

```
# Example using different choice of overlapping boxes sizes.

library(DFA)
data("NYA2008")
file = NYA2008

DFA(file,scale = "F",box_size = c(4,8,16),m=1)
```

DFA_aux *Detrended Fluctuation Analysis Auxiliary function*

Description

Function, which is used as an auxiliary function with DFA, to store data between each iteration and thus decrease the computation time speed to compute the alpha coefficient.

Usage

```
DFA_aux(j, box_size, ninbox2, file, y_k, m, N)
```

Arguments

j	J-th iteration
box_size	Vector of box sizes (must be used in conjunction with scale = "F")
ninbox2	The number of windows
file	Univariate time series (must be a vector or data frame)
y_k	Vector with the fit's output stored.
m	An integer of the polynomial order for the detrending (by default m=1).
N	The time series size

Details

The DFA fluctuation can be computed in a geometric scale or for different choices of boxes sizes.

Value

boxe	Size n of the overlapping boxes.
DFA	Detrended Fluctuation function.

Note

The time series file and file2 must have the same sample size.

Author(s)

Victor Barreto Mesquita

References

C.-K. Peng, S.V. Buldyrev, S. Havlin, M. Simons, H.E. Stanley, A.L. Goldberger Phys. Rev. E, 49 (1994), p. 1685

H.E. Stanley, L.A.N. Amaral, A.L. Goldberger, S. Havlin, P.Ch. Ivanov, C.-K. Peng Physica A, 270 (1999), p. 309

P.C. Ivanov, A. Bunde, L.A.N. Amaral, S. Havlin, J. Fritsch-Yelle, R.M. Baevsky, H.E. Stanley, A.L. Goldberger Europhys. Lett., 48 (1999), p. 594

P. Talkner, R.O. Weber Phys. Rev. E, 62 (2000), p. 150

M. Ausloos, K. Ivanova Physica A, 286 (2000), p. 353

H.E. Hurst, R.P. Black, Y.M. Simaika Long-Term Storage, An Experimental Study, Constable, London (1965)

Examples

```
#There is not directy usage of this function,
# because it must be used in parallel with the DFA function.
```

`EEGsignal` *A single DFA dataframe with the decimal log fluctuation curve.*

Description

The data contains the log fluctuation channel curve calculated for an epileptic subject extracted in the Physionet platform.

Usage

```
data("EEGsignal")
```

Format

A data frame with 91 observations on the following 2 variables.

'`log10(boxes)`' a numeric vector referring to the decimal logarithm of the boxes sizes.

'`log10(DFA)`' a numeric vector referring to the decimal logarithm of the Detrended Fluctuation Analysis (DFA) calculated in each boxe.

References

https://physionet.org/content/chbmit/1.0.0/chb01/#files-panel

Examples

```
data(EEGsignal)
data("EEGsignal")
x<-EEGsignal$`log10(boxes)`
y<-EEGsignal$`log10(DFA)`
plot(x,y)
```

`euclidean` *euclidean method for detection of crossover points*

Description

Applies the euclidean method for detection of crossover points on the log-log curve.

Usage

```
euclidean(x,y,npoint)
```

Arguments

`x`	Vector of the decimal logarithm of the boxes sizes.
`y`	Vector of the decimal logarithm of the DFA calculated in each boxe.
`npoint`	Number of crossover points calculated on the log-log curve.

Value

`position`	Position of the crossover point identified by the euclidean method.
`sugestion_before`	Sugestion for the position of the second crossover point identified by the euclidean method and calculated in the area before the first crossover point.
`sugestion_after`	Sugestion for the position of the second crossover point identified by the euclidean method and calculated in the area after the first crossover point.

Author(s)

Victor Barreto Mesquita

References

https://en.wikipedia.org/wiki/Distance_from_a_point_to_a_line

Examples

```
# Example with crossover point fixed in position=20.

library(DFA)
data(lrcorrelation)
x<-lrcorrelation$`log10(boxes)`
y<-c(lrcorrelation$`log10(DFA(alpha = 0.1))`[1:20],lrcorrelation$`log10(DFA(alpha = 0.3))`[21:40])
plot(x,y,xlab="log10(boxes)",ylab="log10(DFA)",pch=19)
fit<- lm(y[1:20] ~ x[1:20])
fit2<-lm(y[21:40] ~ x[21:40])
abline(fit,col="blue")
abline(fit2,col="red")
euclidean(x,y,npoint=1)

# Example with crossover point fixed in position=13 and 26.
library(DFA)
data(lrcorrelation)
x<-lrcorrelation$`log10(boxes)`
y<-c(lrcorrelation$`log10(DFA(alpha = 0.2))`[1:13],lrcorrelation$`log10(DFA(alpha = 0.6))`[14:26]
  ,lrcorrelation$`log10(DFA(alpha = 0.9))`[27:40])
plot(x,y,xlab="log10(boxes)",ylab="log10(DFA)",pch=19)
fit<- lm(y[1:13] ~ x[1:13])
fit2<-lm(y[14:26] ~ x[14:26])
fit3<-lm(y[27:40] ~ x[27:40])
abline(fit,col="blue")
abline(fit2,col="red")
abline(fit3,col="brown")
euclidean(x,y,npoint=2)
```

`IXIC2008` *Time series referring to the adjusted closing price of the NASDAQ Composite (^IXIC) during the United States bear market of 2007−2009*

Description

Univariate vector of time series referring to the adjusted closing price of the NASDAQ Composite (^IXIC) during the United States bear market of 2007−2009, considered the worst bear market this side of the Great Depression. The crash, which unfolded from Oct. 9, 2007 to March 9, 2009, obliterated more than half of the total value of the U.S. stock market. During this period, the S&P 500 lost approximately a half of its value and threatened the very existence of iconic companies from General Motors to Merrill Lynch.

Usage

```
data("IXIC2008")
```

Format

The format is: num [1:332] 2811 2772 2805 2780 2763 ...

Source

Yahoo Finance

References

https://www.investopedia.com/terms/b/bearmarket.asp

Examples

```
library(DFA)
data("IXIC2008")
```

`lrcorrelation` *data frame with log fluctuation channel curve simulated following an ARFIMA process*

Description

The data contains the data frame with log fluctuation channel curve simulated following an ARFIMA process with different DFA exponents ranging from short 0.1 to long 0.9 .

Usage

```
data("lrcorrelation")
```

Format

A data frame with 40 observations on the following 10 variables.

'`log10(boxes)`' a numeric vector referring to the decimal logarithm of the boxes sizes.

'`log10(DFA(alpha = 0.1))`' a numeric vector referring to the decimal logarithm of the Detrended Fluctuation Analysis (DFA) with DFA exponent equal 0.1 and calculated in each boxe.

'`log10(DFA(alpha = 0.2))`' a numeric vector referring to the decimal logarithm of the Detrended Fluctuation Analysis (DFA) with DFA exponent equal 0.2 and calculated in each boxe.

'`log10(DFA(alpha = 0.3))`' a numeric vector referring to the decimal logarithm of the Detrended Fluctuation Analysis (DFA) with DFA exponent equal 0.3 and calculated in each boxe.

'`log10(DFA(alpha = 0.4))`' a numeric vector referring to the decimal logarithm of the Detrended Fluctuation Analysis (DFA) with DFA exponent equal 0.4 and calculated in each boxe.

'`log10(DFA(alpha = 0.5))`' a numeric vector referring to the decimal logarithm of the Detrended Fluctuation Analysis (DFA) with DFA exponent equal 0.5 and calculated in each boxe.

'`log10(DFA(alpha = 0.6))`' a numeric vector referring to the decimal logarithm of the Detrended Fluctuation Analysis (DFA) with DFA exponent equal 0.6 and calculated in each boxe.

'`log10(DFA(alpha = 0.7))`' a numeric vector referring to the decimal logarithm of the Detrended Fluctuation Analysis (DFA) with DFA exponent equal 0.7 and calculated in each boxe.

'`log10(DFA(alpha = 0.8))`' a numeric vector referring to the decimal logarithm of the Detrended Fluctuation Analysis (DFA) with DFA exponent equal 0.8 and calculated in each boxe.

'`log10(DFA(alpha = 0.9))`' a numeric vector referring to the decimal logarithm of the Detrended Fluctuation Analysis (DFA) with DFA exponent equal 0.9 and calculated in each boxe.

Examples

```
library(DFA)
#library(latex2exp) # it is necessary for legend of the plot function
data(lrcorrelation)
plot(lrcorrelation$`log10(boxes)`,lrcorrelation$`log10(DFA(alpha = 0.9))`
     ,xlab="log10(n)",ylab="log10FDFA(n)",col="black"
     ,pch=19, ylim= c(-0.8,1.2))
lines(lrcorrelation$`log10(boxes)`,lrcorrelation$`log10(DFA(alpha = 0.8))`,type="p"
      ,col="blue", pch=19)
lines(lrcorrelation$`log10(boxes)`,lrcorrelation$`log10(DFA(alpha = 0.7))`,type="p"
      ,col="red", pch=19)
lines(lrcorrelation$`log10(boxes)`,lrcorrelation$`log10(DFA(alpha = 0.6))`,type="p"
      ,col="green", pch=19)
lines(lrcorrelation$`log10(boxes)`,lrcorrelation$`log10(DFA(alpha = 0.5))`,type="p"
      ,col="brown", pch=19)
lines(lrcorrelation$`log10(boxes)`,lrcorrelation$`log10(DFA(alpha = 0.4))`,type="p"
      ,col="yellow", pch=19)
lines(lrcorrelation$`log10(boxes)`,lrcorrelation$`log10(DFA(alpha = 0.3))`,type="p"
      ,col="orange", pch=19)
lines(lrcorrelation$`log10(boxes)`,lrcorrelation$`log10(DFA(alpha = 0.2))`,type="p"
      ,col="pink", pch=19)
lines(lrcorrelation$`log10(boxes)`,lrcorrelation$`log10(DFA(alpha = 0.1))`,type="p"
      ,col="magenta", pch=19)

#legend("bottom", legend=c(TeX("$\alpha_{DFA} = 0.9$"),TeX("$\alpha_{DFA} = 0.8$")
#                          ,TeX("$\alpha_{DFA} = 0.7$"),TeX("$\alpha_{DFA} = 0.6$")
#                          ,TeX("$\alpha_{DFA} = 0.5$"),TeX("$\alpha_{DFA} = 0.4$")
#                          ,TeX("$\alpha_{DFA} = 0.3$"),TeX("$\alpha_{DFA} = 0.2$")
#                          ,TeX("$\alpha_{DFA} = 0.1$"))
#       , col=c("black","blue","red","green","brown","yellow","orange","pink","magenta")
#       , pch=c(19,19,19,19,19,19,19,19,19)
#       , cex = 0.55
#       , ncol = 5
#)
```

`LSE.L2008` *Time series referring to the adjusted closing price of the London Stock Exchange Group plc (LSE.L) during the period which the United States faced the bear market of 2007–2009.*

Description

Univariate vector of time series referring to the adjusted closing price of the London Stock Exchange Group plc (LSE.L) during the period which the United States faced the bear market of 2007−2009, considered the worst bear market this side of the Great Depression. The crash, which unfolded from Oct. 9, 2007 to March 9, 2009, obliterated more than half of the total value of the U.S. stock market. During this period, the S&P 500 lost approximately a half of its value and threatened the very existence of iconic companies from General Motors to Merrill Lynch.

Usage

```
data("LSE.L2008")
```

Format

The format is: num [1:332] 1172 1176 1165 1163 1163 ...

Source

Yahoo Finance

References

https://www.investopedia.com/terms/b/bearmarket.asp

Examples

```
library(DFA)
data("LSE.L2008")
```

NYA2008 — *Time series referring to the adjusted closing price of the NYSE COMPOSITE (^NYA) during the United States bear market of 2007−2009*

Description

Univariate vector of time series referring to the adjusted closing price of the NYSE COMPOSITE (^NYA) during the United States bear market of 2007−2009, considered the worst bear market this side of the Great Depression. The crash, which unfolded from Oct. 9, 2007 to March 9, 2009, obliterated more than half of the total value of the U.S. stock market. During this period, the S&P 500 lost approximately a half of its value and threatened the very existence of iconic companies from General Motors to Merrill Lynch.

Usage

```
data("NYA2008")
```

Format

The format is: num [1:332] 10264 10245 10301 10216 10125 ...

Source

Yahoo Finance

References

https://www.investopedia.com/terms/b/bearmarket.asp

Examples

```
library(DFA)
data("NYA2008")
```

`rhoDCCA` *Detrended Cross-Correlation Coefficient (rhoDCCA)*

Description

Applies the Detrended Cross-Correlation Coefficient (rhoDCCA) to nonstationary time series.

Usage

```
rhoDCCA(file,file2,scale = 2^(1/8),box_size = 4,m=1)
```

Arguments

`file`	Univariate time series (must be a vector or data frame)
`file2`	Univariate time series (must be a vector or data frame)
`scale`	Specifies the ratio between successive box sizes (by default `scale = 2^(1/8)`)
`box_size`	Vector of box sizes (must be used in conjunction with `scale = "F"`)
`m`	An integer of the polynomial order for the detrending (by default `m=1`).

Details

The Detrended Cross-Correlation Coefficient (rhoDCCA) can be computed in a geometric scale or for different choices of boxes sizes.

Value

`boxe`	Size n of the overlapping boxes.
`DFA1`	DFA of the first time series (`file`).
`DFA2`	DFA of the second time series (`file2`).
`DCCA`	Detrended Cross-Correlation function.
`rhoDCCA`	Detrended Cross-Correlation Coefficient function, defined as the ratio between the `DCCA` and two DFA (`DFA1,DFA2`).

Note

The time series `file` and `file2` must have the same sample size.

Author(s)

Victor Barreto Mesquita

References

Zebende G.F. DCCA cross-correlation coefficient: Quantifying level of cross-correlation Physica A, 390 (4) (2011), pp. 614-618

Vassoler R.T., Zebende G.F. DCCA cross-correlation coefficient apply in time series of air temperature and air relative humidity Physica A, 391 (7) (2012), pp. 2438-2443

Guedes E.F., Zebende G.F., da Cunha Lima I.C. Quantificacao dos Efeitos do Cambio na Producao da Industria de Transformacao Baiana: uma abordagem via coeficiente de correlacao cruzada rho dcca Conjuntura & Planejamento, 1 (192) (2017), pp. 75-89

Examples

```
#The following examples using the database of financial time series
#collected during the United States bear market of 2007-2009.

library(DFA)
data("NYA2008")
data("IXIC2008")
file = NYA2008
file2= IXIC2008

rhoDCCA(file,file2,scale = 2^(1/8),box_size = c(4,8,16),m=1)


# Example with different polynomial fit order.

library(DFA)
data("NYA2008")
data("LSE.L2008")
file = NYA2008
file2= LSE.L2008

rhoDCCA(file,file2,scale = 2^(1/8),box_size = c(4,8,16),m=2)


# Example using different choice of overlapping boxes sizes.

library(DFA)
data("NYA2008")
data("IXIC2008")
file = NYA2008
file2= IXIC2008

rhoDCCA(file,file2,scale = "F",box_size = c(4,8,16),m=1)
```

`secant` *secant method for detection of crossover points*

Description

Applies the secant method for detection of crossover points on the log-log curve.

Usage

```
secant(x,y,npoint,size_fit)
```

Arguments

`x`	Vector of the decimal logarithm of the boxes sizes.
`y`	Vector of the decimal logarithm of the DFA calculated in each boxe.
`npoint`	Number of crossover points calculated on the log-log curve.
`size_fit`	Number of points of the two semi-curved fitted in the extremes of the log-log curve.

Value

`position`	Position of the crossover point identified by the secant method.

Author(s)

Victor Barreto Mesquita

Examples

```
# Example with the data referring to the log fluctuation
#channel curve data calculated for an epileptic subject
#extracted in the Physionet platform.

library(DFA)
data("EEGsignal")
x<-EEGsignal$`log10(boxes)`
y<-EEGsignal$`log10(DFA)`
plot(x,y,xlab="log10(boxes)",ylab="log10(DFA)")

secant(x,y,npoint=2,size_fit=8)

# Example with crossover point fixed in position=20.

library(DFA)
```

```
part1 <- seq(1,20)
part2 <- seq(20,1)
y = c(part1,part2)
x<-seq(1,40)
plot(x,y)
secant(x,y,npoint=1,size_fit=8)
```

SSEC2008 *Time series referring to the adjusted closing price of the SSE Composite Index (^SSEC) during the period which the United States faced the bear market of 2007−2009.*

Description

Univariate vector of time series referring to the adjusted closing price of the SSE Composite Index (^SSEC) during the period which the United States faced the bear market of 2007−2009, considered the worst bear market this side of the Great Depression. The crash, which unfolded from Oct. 9, 2007 to March 9, 2009, obliterated more than half of the total value of the U.S. stock market. During this period, the S&P 500 lost approximately a half of its value and threatened the very existence of iconic companies from General Motors to Merrill Lynch.

Usage

```
data("SSEC2008")
```

Format

The format is: num [1:332] 5771 5913 5903 6030 6092 ...

Source

Yahoo Finance

References

https://www.investopedia.com/terms/b/bearmarket.asp

Examples

```
library(DFA)
data("SSEC2008")
```

SSP *Self-similarity parameter (SSP)*

Description

This function estimates the self-similarity parameter (SSP), also known as scaling exponent or alpha.

Usage

```
SSP(file,scale = 2^(1/8),box_size = 4,m=1)
```

Arguments

`file`	Univariate time series (must be a vector or data frame)
`scale`	Specifies the ratio between successive box sizes (by default scale = 2^(1/8))
`box_size`	Vector of box sizes (must be used in conjunction with scale = "F")
`m`	An integer of the polynomial order for the detrending (by default m=1)

Details

The DFA fluctuation can be computed in a geometric scale or for different choices of boxes sizes.

Value

Estimated alpha is a real number between zero and two.

Note

It is not possible estimating alpha for multiple time series at once.

Author(s)

Ian Meneghel Danilevicz and Victor Barreto Mesquita

References

C.-K. Peng, S.V. Buldyrev, S. Havlin, M. Simons, H.E. Stanley, A.L. Goldberger Phys. Rev. E, 49 (1994), p. 1685

Mesquita, V., Filho, F., Rodrigues, P. (2020). Detection of crossover points in detrended fluctuation analysis: An application to EEG signals of patients with epilepsy. Bioinformatics. 10.1093/bioinformatics/btaa955.

Examples

```
# Estimate self-similarity of a very known time series available on R base: the sunspot.year.
# Then the spend time with each method is compared.
library(DFA)
SSP(sunspot.year, scale = 2)
SSP(sunspot.year, scale = 1.2)

time1 = system.time(SSP(sunspot.year, scale = 1.2))
time2 = system.time(SSP(sunspot.year, scale = 2))

time1
time2
```

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