Package 'iAR'

April 15, 2021

Type Package

Title Irregularly Observed Autoregressive Models

Version 0.1.0

Description Data sets, functions and scripts with examples to implement autoregressive models for irregularly observed time series. The models available in this package are the irregular autoregressive model (Eyheramendy et al.(2018) <doi:10.1093/mnras/sty2487>), the complex irregular autoregressive model (Elorrieta et al.(2019) <doi:10.1051/0004-6361/201935560>) and the bivariate irregular autoregressive model.

Encoding UTF-8

License GPL-2

Imports ggplot2,stats,Rdpack

Suggests arfima

Depends R (>= 3.5.0)

URL https://github.com/felipeelorrieta

LazyData true

RdMacros Rdpack

RoxygenNote 7.1.1

NeedsCompilation no

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Repository CRAN

Date/Publication 2021-04-15 11:30:02 UTC

R topics documented:

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agn *Active Galactic Nuclei*

Description

Time series of the AGN MCG-6-30-15 measured in the K-band between 2006 August and 2011 July with the ANDICAM camera mounted on the 1.3 m telescope at Cerro Tololo Inter-American Observatory (CTIO)

Usage

```
agn
```

Format

A data frame with 237 observations on the following 3 variables:

t heliocentric Julian Day - 2450000

m Flux $(10^{-15}$ ergs/s/cm^2 /A)$

merr measurement error standard deviations.

References

Lira P, Arévalo P, Uttley P, McHardy IMM, Videla L (2015). "Long-term monitoring of the archetype Seyfert galaxy MCG-6-30-15: X-ray, optical and near-IR variability of the corona, disc and torus." *Monthly Notices of the Royal Astronomical Society*, **454**(1), 368–379. ISSN 0035-8711, doi: 10.1093/mnras/stv1945, https://doi.org/10.1093/mnras/stv1945.

Examples

```
data(agn)
plot(agn$t,agn$m,type="l",ylab="",xlab="")
```

BIAR.fit	*Fitted Values of BIAR model*

Description

Fit a BIAR model to a bivariate irregularly observed time series.

Usage

```
BIAR.fit(x, y1, y2, t, yerr1, yerr2, zero.mean = "TRUE")
```

Arguments

x	An array with the parameters of the BIAR model. The elements of the array are, in order, the autocorrelation and the cross correlation parameter of the BIAR model.
y1	Array with the observations of the first time series of the BIAR process.
y2	Array with the observations of the second time series of the BIAR process.
t	Array with the irregular observational times.
yerr1	Array with the measurements error standard deviations of the first time series of the BIAR process.
yerr2	Array with the measurements error standard deviations of the second time series of the BIAR process.
zero.mean	logical; if true, the array y has zero mean; if false, y has a mean different from zero.

Value

A list with the following components:

- rho Estimated value of the contemporary correlation coefficient.
- innov.var Estimated value of the innovation variance.
- fitted Fitted values of the BIAR model.
- fitted.state Fitted state values of the BIAR model.

See Also

gentime, BIAR.sample, BIAR.phi.kalman, BIAR.kalman

Examples

```
n=80
set.seed(6714)
st<-gentime(n)
x=BIAR.sample(n=n,phi.R=0.9,phi.I=0.3,sT=st,rho=0.9)
y=x$y
y1=y/apply(y,1,sd)
yerr1=rep(0,n)
yerr2=rep(0,n)
biar=BIAR.kalman(y1=y1[1,],y2=y1[2,],t=st,delta1 = yerr1,delta2=yerr2)
biar
predbiar=BIAR.fit(x=c(biar$phiR,biar$phiI),y1=y1[1,],y2=y1[2,],t=st,yerr1
 = rep(0,length(y[1,])),yerr2=rep(0,length(y[1,])))
rho=predbiar$rho
print(rho)
yhat=predbiar$fitted
```

BIAR.kalman *Maximum Likelihood Estimation of the BIAR Model via Kalman Recursions*

Description

Maximum Likelihood Estimation of the BIAR model parameters phi.R and phi.I. The estimation procedure uses the Kalman Filter to find the maximum of the likelihood.

Usage

```
BIAR.kalman(
  y1,
  y2,
  t,
  delta1 = 0,
```

```
    delta2 = 0,
    zero.mean = "TRUE",
    niter = 10,
    seed = 1234
)
```

Arguments

y1	Array with the observations of the first time series of the BIAR process.
y2	Array with the observations of the second time series of the BIAR process.
t	Array with the irregular observational times.
delta1	Array with the measurements error standard deviations of the first time series of the BIAR process.
delta2	Array with the measurements error standard deviations of the second time series of the BIAR process.
zero.mean	logical; if true, the array y has zero mean; if false, y has a mean different from zero.
niter	Number of iterations in which the function nlminb will be repeated.
seed	a single value, interpreted as the seed of the random process.

Value

A list with the following components:

- phiR MLE of the autocorrelation coefficient of BIAR model (phi.R).
- phiI MLE of the cross-correlation coefficient of the BIAR model (phi.I).
- ll Value of the negative log likelihood evaluated in phi.R and phi.I.

See Also

gentime, BIAR.sample, BIAR.phi.kalman

Examples

```
n=80
set.seed(6714)
st<-gentime(n)
x=BIAR.sample(n=n,phi.R=0.9,phi.I=0,sT=st,rho=0)
y=x$y
y1=y/apply(y,1,sd)
biar=BIAR.kalman(y1=y1[1,],y2=y1[2,],t=st,delta1 = rep(0,length(y[1,])),
delta2=rep(0,length(y[1,])))
biar
```

BIAR.phi.kalman   *Minus Log Likelihood of the BIAR Model*

Description

This function return the negative log likelihood of the BIAR process given specific values of phi.R and phi.I

Usage

```
BIAR.phi.kalman(x, y1, y2, t, yerr1, yerr2, zero.mean = "TRUE")
```

Arguments

x	An array with the parameters of the BIAR model. The elements of the array are, in order, the real (phi.R) and the imaginary (phi.I) part of the coefficient of BIAR model.
y1	Array with the observations of the first time series of the BIAR process.
y2	Array with the observations of the second time series of the BIAR process.
t	Array with the irregular observational times.
yerr1	Array with the measurements error standard deviations of the first time series of the BIAR process.
yerr2	Array with the measurements error standard deviations of the second time series of the BIAR process.
zero.mean	logical; if true, the array y has zero mean; if false, y has a mean different from zero.

Value

Value of the negative log likelihood evaluated in phiR and phiI.

See Also

gentime, BIAR.sample

Examples

```
n=300
set.seed(6714)
st<-gentime(n)
x=BIAR.sample(n=n,phi.R=0.9,phi.I=0.3,sT=st)
y=x$y
y1=y[1,]
y2=y[2,]
yerr1=rep(0,n)
yerr2=rep(0,n)
BIAR.phi.kalman(x=c(0.8,0.2),y1=y1,y2=y2,t=st,yerr1=yerr1,yerr2=yerr2)
```

BIAR.sample   *Simulate from a BIAR Model*

Description

Simulates a BIAR Time Series Model

Usage

```
BIAR.sample(n, sT, phi.R, phi.I, delta1 = 0, delta2 = 0, rho = 0)
```

Arguments

n	Length of the output bivariate time series. A strictly positive integer.
sT	Array with observational times.
phi.R	Autocorrelation coefficient of BIAR model. A value between -1 and 1.
phi.I	Crosscorrelation coefficient of BIAR model. A value between -1 and 1.
delta1	Array with the measurements error standard deviations of the first time series of the bivariate process.
delta2	Array with the measurements error standard deviations of the second time series of the bivariate process.
rho	Contemporary correlation coefficient of BIAR model. A value between -1 and 1.

Details

The chosen phi.R and phi.I values must satisfy the condition $|phi.R + i\, phi.I| < 1$.

Value

A list with the following components:

- y Matrix with the simulated BIAR process.
- t Array with observation times.
- Sigma Covariance matrix of the process.

See Also

gentime

Examples

```
n=300
set.seed(6714)
st<-gentime(n)
x=BIAR.sample(n=n,phi.R=0.9,phi.I=0.3,sT=st)
plot(st,x$y[1,],type='l')
plot(st,x$y[2,],type='l')
x=BIAR.sample(n=n,phi.R=-0.9,phi.I=-0.3,sT=st)
plot(st,x$y[1,],type='l')
plot(st,x$y[2,],type='l')
```

CIAR.fit *Fitted Values of CIAR model*

Description

Fit a CIAR model to an irregularly observed time series.

Usage

```
CIAR.fit(x, y, t, standarized = "TRUE", c = 1)
```

Arguments

x	An array with the parameters of the CIAR model. The elements of the array are, in order, the real and the imaginary part of the phi parameter of the CIAR model.
y	Array with the time series observations.
t	Array with the irregular observational times.
standarized	logical; if true, the array y is standarized; if false, y contains the raw time series
c	Nuisance parameter corresponding to the variance of the imaginary part.

Value

A list with the following components:

- yhat Fitted values of the observable part of CIAR model.
- xhat Fitted values of both observable part and imaginary part of CIAR model.
- Lambda Lambda value estimated by the CIAR model at the last time point.
- Theta Theta array estimated by the CIAR model at the last time point.
- Sighat Covariance matrix estimated by the CIAR model at the last time point.
- Qt Covariance matrix of the state equation estimated by the CIAR model at the last time point.

References

Elorrieta, F, Eyheramendy, S, Palma, W (2019). "Discrete-time autoregressive model for unequally spaced time-series observations." *A\& A*, **627**, A120. doi: 10.1051/00046361/201935560, https://doi.org/10.1051/0004-6361/201935560.

See Also

gentime, CIAR.sample, CIAR.phi.kalman, CIAR.kalman

Examples

```
n=100
set.seed(6714)
st<-gentime(n)
x=CIAR.sample(n=n,phi.R=0.9,phi.I=0,sT=st,c=1)
y=x$y
y1=y/sd(y)
ciar=CIAR.kalman(y=y1,t=st)
ciar
yhat=CIAR.fit(x=c(ciar$phiR,ciar$phiI),y=y1,t=st)
```

CIAR.forecast	*Forecast from CIAR model*

Description

Forecast from models fitted by CIAR.kalman

Usage

```
CIAR.forecast(phi.R, phi.I, y1, st, n.ahead = 1)
```

Arguments

phi.R	Real part of the phi coefficient of CIAR model.
phi.I	Imaginary part of the phi coefficient of CIAR model.
y1	Array with the time series observations.
st	Array with the irregular observational times.
n.ahead	The number of steps ahead for forecast is required.

Value

A list with the following components:

- fitted Fitted values by the CIAR model.
- forecast Point Forecasts in the n.ahead times.
- Lambda Lambda value estimated by the CIAR model at the last time point.
- Sighat Covariance matrix estimated by the CIAR model at the last time point.

References

Elorrieta, F, Eyheramendy, S, Palma, W (2019). "Discrete-time autoregressive model for unequally spaced time-series observations." *A\& A*, **627**, A120. doi: 10.1051/00046361/201935560, https://doi.org/10.1051/0004-6361/201935560.

See Also

CIAR.sample, CIAR.kalman, CIAR.fit

Examples

```
#Simulated Data
n=100
set.seed(6714)
st<-gentime(n)
x=CIAR.sample(n=n,phi.R=0.9,phi.I=0,sT=st,c=1)
y=x$y
y1=y/sd(y)
n=length(y1)
p=trunc(n*0.99)
ytr=y1[1:p]
yte=y1[(p+1):n]
str=st[1:p]
ste=st[(p+1):n]
n.ahead=ste-str[p]

final<-matrix(0,length(n.ahead),4)
ciar=CIAR.kalman(y=ytr,t=str)
forCIAR<-CIAR.forecast(ciar$phiR,ciar$phiI,ytr,str,n.ahead=n.ahead)
```

CIAR.kalman   *Maximum Likelihood Estimation of the CIAR Model via Kalman Re-*
                           cursions

Description

Maximum Likelihood Estimation of the CIAR model parameters phi.R and phi.I. The estimation procedure uses the Kalman Filter to find the maximum of the likelihood.

Usage

```
CIAR.kalman(
  y,
  t,
  delta = 0,
  zero.mean = "TRUE",
  standarized = "TRUE",
```

```
  c = 1,
  niter = 10,
  seed = 1234
)
```

Arguments

y	Array with the time series observations.
t	Array with the irregular observational times.
delta	Array with the measurements error standard deviations.
zero.mean	logical; if true, the array y has zero mean; if false, y has a mean different from zero.
standarized	logical; if true, the array y is standarized; if false, y contains the raw time series.
c	Nuisance parameter corresponding to the variance of the imaginary part.
niter	Number of iterations in which the function nlminb will be repeated.
seed	a single value, interpreted as the seed of the random process.

Value

A list with the following components:

- phiR MLE of the Real part of the coefficient of CIAR model (phi.R).
- phiI MLE of the Imaginary part of the coefficient of the CIAR model (phi.I).
- ll Value of the negative log likelihood evaluated in phi.R and phi.I.

References

Elorrieta, F, Eyheramendy, S, Palma, W (2019). "Discrete-time autoregressive model for unequally spaced time-series observations." *A\& A*, **627**, A120. doi: 10.1051/00046361/201935560, https://doi.org/10.1051/0004-6361/201935560.

See Also

gentime, CIAR.sample, CIAR.phi.kalman

Examples

```
n=100
set.seed(6714)
st<-gentime(n)
x=CIAR.sample(n=n,phi.R=0.9,phi.I=0,sT=st,c=1)
y=x$y
y1=y/sd(y)
ciar=CIAR.kalman(y=y1,t=st)
ciar
Mod(complex(real=ciar$phiR,imaginary=ciar$phiI))
```

CIAR.phi.kalman *Minus Log Likelihood of the CIAR Model*

Description

This function return the negative log likelihood of the CIAR process given specific values of phi.R and phi.I

Usage

```
CIAR.phi.kalman(x, y, t, yerr, zero.mean = "TRUE", standarized = "TRUE", c = 1)
```

Arguments

x	An array with the parameters of the CIAR model. The elements of the array are, in order, the real (phi.R) and the imaginary (phi.I) part of the coefficient of CIAR model.
y	Array with the time series observations.
t	Array with the irregular observational times.
yerr	Array with the measurements error standard deviations.
zero.mean	logical; if true, the array y has zero mean; if false, y has a mean different from zero.
standarized	logical; if true, the array y is standarized; if false, y contains the raw time series.
c	Nuisance parameter corresponding to the variance of the imaginary part.

Value

Value of the negative log likelihood evaluated in phiR and phiI.

References

Elorrieta, F, Eyheramendy, S, Palma, W (2019). "Discrete-time autoregressive model for unequally spaced time-series observations." *A\& A*, **627**, A120. doi: 10.1051/00046361/201935560, https://doi.org/10.1051/0004-6361/201935560.

See Also

gentime, CIAR.sample

Examples

```
n=300
set.seed(6714)
st<-gentime(n)
x=CIAR.sample(n=n,phi.R=0.9,phi.I=0,sT=st,c=1)
y=x$y
yerr=rep(0,n)
CIAR.phi.kalman(x=c(0.8,0),y=y,t=st,yerr=yerr)
```

CIAR.sample   *Simulate from a CIAR Model*

Description

Simulates a CIAR Time Series Model

Usage

```
CIAR.sample(n, sT, phi.R, phi.I, rho = 0, c = 1)
```

Arguments

n	Length of the output time series. A strictly positive integer.
sT	Array with observational times.
phi.R	Real part of the coefficient of CIAR model. A value between -1 and 1.
phi.I	Imaginary part of the coefficient of CIAR model. A value between -1 and 1.
rho	Correlation between the real and the imaginary part of the process. A value between -1 and 1.
c	Nuisance parameter corresponding to the variance of the imaginary part.

Details

The chosen phi.R and phi.I values must satisfy the condition $|phi.R + i\ phi.I| < 1$.

Value

A list with the following components:

- yArray with the simulated real part of the CIAR process.
- t Array with observation times.
- Sigma Covariance matrix of the process.

References

Elorrieta, F, Eyheramendy, S, Palma, W (2019). "Discrete-time autoregressive model for unequally spaced time-series observations." *A\& A*, **627**, A120. doi: 10.1051/00046361/201935560, https://doi.org/10.1051/0004-6361/201935560.

See Also

gentime

Examples

```
n=300
set.seed(6714)
st<-gentime(n)
x=CIAR.sample(n=n,phi.R=0.9,phi.I=0,sT=st,c=1)
plot(st,x$y,type='l')
x=CIAR.sample(n=n,phi.R=-0.9,phi.I=0,sT=st,c=1)
plot(st,x$y,type='l')
```

---

clcep   *Classical Cepheid*

Description

Time series of a classical cepheid variable star obtained from HIPPARCOS.

Usage

```
clcep
```

Format

A data frame with 109 observations on the following 3 variables:

t heliocentric Julian Day

m magnitude

merr measurement error of the magnitude (in mag).

Details

The frequency computed by GLS for this light curve is 0.060033386. Catalogs and designations of this star: HD 1989: HD 305996 TYCHO-2 2000:TYC 8958-2333-1 USNO-A2.0:USNO-A2 0225-10347916 HIP: HIP-54101

Examples

```
data(clcep)
f1=0.060033386
foldlc(clcep,f1)
```

---

dmcep *Double Mode Cepheid.*

Description

Time series of a double mode cepheid variable star obtained from OGLE.

Usage

```
dmcep
```

Format

A data frame with 191 observations on the following 3 variables:

t heliocentric Julian Day

m magnitude

merr measurement error of the magnitude (in mag).

Details

The dominant frequency computed by GLS for this light curve is 0.7410152. The second frequency computed by GLS for this light curve is 0.5433353. OGLE-ID:175210

Examples

```
data(dmcep)
f1=0.7410152
foldlc(dmcep,f1)
fit=harmonicfit(dmcep,f1)
f2=0.5433353
foldlc(cbind(dmcep$t,fit$res,dmcep$merr),f2)
```

---

dscut *Delta Scuti*

Description

Time series of a Delta Scuti variable star obtained from HIPPARCOS.

Usage

```
dscut
```

Format

A data frame with 116 observations on the following 3 variables:

t heliocentric Julian Day

m magnitude

merr measurement error of the magnitude (in mag).

Details

The frequency computed by GLS for this light curve is 14.88558646. Catalogs and designations of this star: HD 1989: HD 199757 TYCHO-2 2000: TYC 7973-401-1 USNO-A2.0: USNO-A2 0450-39390397 HIP: HIP 103684

Examples

```
data(dscut)
f1=14.88558646
foldlc(dscut,f1)
```

---

eb   *Eclipsing Binaries (Beta Lyrae)*

Description

Time series of a Beta Lyrae variable star obtained from OGLE.

Usage

```
eb
```

Format

A data frame with 470 observations on the following 3 variables:

t heliocentric Julian Day

m magnitude

merr measurement error of the magnitude (in mag).

Details

The frequency computed by GLS for this light curve is 1.510571586. Catalogs and designations of this star:OGLE051951.22-694002.7

Examples

```
data(eb)
f1=1.510571586
foldlc(eb,f1)
```

---

foldlc   *Plotting folded light curves*

Description

This function plots a time series folded on its period.

Usage

```
foldlc(file, f1)
```

Arguments

file
: Matrix with the light curve observations. The first column must have the irregular times, the second column must have the brightness magnitudes and the third column must have the measurement errors.

f1
: Frequency (1/Period) of the light curve.

Value

A plot of the folded (phased) time series.

Examples

```
data(clcep)
f1=0.060033386
foldlc(clcep,f1)
```

---

gentime   *Generating Irregularly spaced times*

Description

Function to generate irregularly spaced times from a mixture of exponential distributions.

Usage

```
gentime(n, lambda1 = 130, lambda2 = 6.5, p1 = 0.15, p2 = 0.85)
```

Arguments

n
: A positive integer. Length of observations times.

lambda1
: Mean (1/rate) of the first exponential distribution.

lambda2
: Mean (1/rate) of the second exponential distribution.

p1
: Weight of the first exponential distribution.

p2
: Weight of the second exponential distribution.

Value

Array with irregularly spaced observations times

References

Eyheramendy S, Elorrieta F, Palma W (2018). "An irregular discrete time series model to iden-tify residuals with autocorrelation in astronomical light curves." *Monthly Notices of the Royal Astronomical Society*, **481**(4), 4311–4322. ISSN 0035-8711, doi: 10.1093/mnras/sty2487, https://academic.oup.com/mnras/article-pdf/481/4/4311/25906473/sty2487.pdf.

See Also

IAR.sample

Examples

```
st<-gentime(n=100)
```

---

harmonicfit   *Harmonic Fit to Time Series*

Description

This function fit an k-harmonic function to time series data.

Usage

```
harmonicfit(file, f1, nham = 4, weights = NULL, print = FALSE)
```

Arguments

file	A matrix with two columns. The first column corresponds to the observations times, and the second column corresponds to the measures.
f1	Frequency (1/Period) of the time series
nham	Number of harmonic components in the model
weights	An array with the weights of each observation
print	logical; if true, the summary of the harmonic fitted model will be printed. The default value is false.

Value

A list with the following components:

- res Residuals to the harmonic fit of the time series.
- t Observations times.
- R2 Adjusted R-Squared.
- MSE Mean Squared Error.

Examples

```
data(clcep)
f1=0.060033386
results=harmonicfit(file=clcep[,1:2],f1=f1)
results$R2
results$MSE
results=harmonicfit(file=clcep[,1:2],f1=f1,nham=3)
results$R2
results$MSE
results=harmonicfit(file=clcep[,1:2],f1=f1,weights=clcep[,3])
results$R2
results$MSE
```

IAR.gamma   *Maximum Likelihood Estimation of the IAR-Gamma model*

Description

Maximum Likelihood Estimation of the IAR-Gamma model.

Usage

```
IAR.gamma(y, sT)
```

Arguments

y	Array with the time series observations
sT	Array with the irregular observational times

Value

A list with the following components:

- phi MLE of the phi parameter of the IAR-Gamma model.
- mu MLE of the mu parameter of the IAR-Gamma model.
- sigma MLE of the sigma parameter of the IAR-Gamma model.
- ll Value of the negative log likelihood evaluated in phi, mu and sigma.

References

Eyheramendy S, Elorrieta F, Palma W (2018). "An irregular discrete time series model to identify residuals with autocorrelation in astronomical light curves." *Monthly Notices of the Royal Astronomical Society*, **481**(4), 4311–4322. ISSN 0035-8711, doi: 10.1093/mnras/sty2487, https://academic.oup.com/mnras/article-pdf/481/4/4311/25906473/sty2487.pdf.

See Also

gentime, IARg.sample, IAR.phi.gamma

Examples

```
n=300
set.seed(6714)
st<-gentime(n)
y<-IARg.sample(n,phi=0.9,st,sigma2=1,mu=1)
model<-IAR.gamma(y$y, sT=st)
phi=model$phi
muest=model$mu
sigmaest=model$sigma
```

IAR.kalman   *Maximum Likelihood Estimation of the IAR Model via Kalman Recursions*

Description

Maximum Likelihood Estimation of the IAR model parameter phi. The estimation procedure uses the Kalman Filter to find the maximum of the likelihood.

Usage

```
IAR.kalman(y, sT, delta = 0, zero.mean = "TRUE", standarized = "TRUE")
```

Arguments

y	Array with the time series observations.
sT	Array with the irregular observational times.
delta	Array with the measurements error standard deviations.
zero.mean	logical; if true, the array y has zero mean; if false, y has a mean different from zero.
standarized	logical; if true, the array y is standarized; if false, y contains the raw time series

Value

A list with the following components:

- phi MLE of the phi parameter of the IAR model.
- ll Value of the negative log likelihood evaluated in phi.

References

Eyheramendy S, Elorrieta F, Palma W (2018). "An irregular discrete time series model to identify residuals with autocorrelation in astronomical light curves." *Monthly Notices of the Royal Astronomical Society*, **481**(4), 4311–4322. ISSN 0035-8711, doi: 10.1093/mnras/sty2487, https://academic.oup.com/mnras/article-pdf/481/4/4311/25906473/sty2487.pdf.

See Also

gentime, IAR.sample, arima,IAR.phi.kalman

Examples

```
set.seed(6714)
st<-gentime(n=100)
y<-IAR.sample(phi=0.99,n=100,st)
y<-y$series
phi=IAR.kalman(y=y,sT=st)$phi
print(phi)
```

IAR.loglik   *Maximum Likelihood Estimation of the IAR Model*

Description

Maximum Likelihood Estimation of the IAR Model.

Usage

```
IAR.loglik(y, sT, delta = 0, include.mean = "FALSE", standarized = "TRUE")
```

Arguments

y	Array with the time series observations.
sT	Array with the irregular observational times.
delta	Array with the measurements error standard deviations.
include.mean	logical; if true, the array y has zero mean; if false, y has a mean different from zero.
standarized	logical; if true, the array y is standarized; if false, y contains the raw time series.

Value

A list with the following components:

- phi MLE of the phi parameter of the IAR model.
- ll Value of the negative log likelihood evaluated in phi.

References

Eyheramendy S, Elorrieta F, Palma W (2018). "An irregular discrete time series model to identify residuals with autocorrelation in astronomical light curves." *Monthly Notices of the Royal Astronomical Society*, **481**(4), 4311–4322. ISSN 0035-8711, doi: 10.1093/mnras/sty2487, https://academic.oup.com/mnras/article-pdf/481/4/4311/25906473/sty2487.pdf.

See Also

gentime, IAR.sample, arima, IAR.phi.loglik

Examples

```
#Generating IAR sample
set.seed(6714)
st<-gentime(n=100)
y<-IAR.sample(phi=0.99,n=100,st)
y<-y$series
#Compute Phi
phi=IAR.loglik(y=y,sT=st)$phi
print(phi)
#Compute the standard deviation of innovations
n=length(y)
d=c(0,diff(st))
phi1=phi**d
yhat=phi1*as.vector(c(0,y[1:(n-1)]))
plot(st,y,type='l')
lines(st,yhat,col='red')
sigma=var(y)
nu=c(sigma,sigma*(1-phi1**(2))[-1])
tau<-nu/sigma
sigmahat<-mean(c((y-yhat)**2/tau))
nuhat<-sigmahat*(1-phi1**(2))
nuhat2<-sqrt(nuhat)
#Equally spaced models
require(arfima)
fit2<-arfima(y,order=c(1,0,0))
fit<-arima(y,order=c(1,0,0),include.mean=FALSE)
syarf<-tacvfARFIMA(phi=fit2$modes[[1]]$phi,dfrac=fit2$modes[[1]]$dfrac,
sigma2=fit2$modes[[1]]$sigma,maxlag=20)[1]
syar<-fit$sigma/(1-fit$coef[1]**2)
print(sigmahat)
print(syar)
print(syarf)
carf<-fit2$modes[[1]]$sigma/syarf
car<-(1-fit$coef[1]**2)
ciar<-(1-phi1**(2))
#Compute the standard deviation of innovations (regular case)
sigma=var(y)
nuhat3=sqrt(sigma*ciar)
searf<-sqrt(sigma*carf)
sear<-sqrt(sigma*car)
#Plot the standard deviation of innovations
plot(st[-1], nuhat3[-1], t="n", axes=FALSE,xlab='Time',ylab='Standard Deviation of Innovations')
axis(1)
axis(2)
segments(x0=st[-1], y0=nuhat3[-1], y1=0, col=8)
points(st, nuhat3, pch=20, col=1, bg=1)
abline(h=sd(y),col='red',lwd=2)
abline(h=sear,col='blue',lwd=2)
```

```
abline(h=searf,col='green',lwd=2)
abline(h=mean(nuhat3[-1]),col='black',lwd=2)
```

IAR.phi.gamma *Minus Log Likelihood IAR-Gamma Model*

Description

This function return the negative log likelihood of the IAR-Gamma given specific values of phi, mu and sigma.

Usage

```
IAR.phi.gamma(x, y, sT)
```

Arguments

x	An array with the parameters of the IAR-Gamma model. The first element of the array corresponding to the phi parameter, the second to the level parameter mu, and the last one to the scale parameter sigma.
y	Array with the time series observations.
sT	Array with the irregular observational times.

Value

Value of the negative log likelihood evaluated in phi, mu and sigma.

References

Eyheramendy S, Elorrieta F, Palma W (2018). "An irregular discrete time series model to identify residuals with autocorrelation in astronomical light curves." *Monthly Notices of the Royal Astronomical Society*, **481**(4), 4311–4322. ISSN 0035-8711, doi: 10.1093/mnras/sty2487, https://academic.oup.com/mnras/article-pdf/481/4/4311/25906473/sty2487.pdf.

See Also

gentime, IARg.sample

Examples

```
n=300
set.seed(6714)
st<-gentime(n)
y<-IARg.sample(n,phi=0.9,st,sigma2=1,mu=1)
IAR.phi.gamma(x=c(0.9,1,1),y=y$y,sT=st)
```

IAR.phi.kalman   *Minus Log Likelihood of the IAR Model estimated via Kalman Recursions*

Description

This function return the negative log likelihood of the IAR process given a specific value of phi.

Usage

```
IAR.phi.kalman(x, y, yerr, t, zero.mean = "TRUE", standarized = "TRUE")
```

Arguments

x	A given phi coefficient of the IAR model.
y	Array with the time series observations.
yerr	Array with the measurements error standard deviations.
t	Array with the irregular observational times.
zero.mean	logical; if true, the array y has zero mean; if false, y has a mean different from zero.
standarized	logical; if true, the array y is standarized; if false, y contains the raw time series.

Value

Value of the negative log likelihood evaluated in phi.

References

Eyheramendy S, Elorrieta F, Palma W (2018). "An irregular discrete time series model to identify residuals with autocorrelation in astronomical light curves." *Monthly Notices of the Royal Astronomical Society*, **481**(4), 4311–4322. ISSN 0035-8711, doi: 10.1093/mnras/sty2487, https://academic.oup.com/mnras/article-pdf/481/4/4311/25906473/sty2487.pdf.

See Also

gentime, IAR.sample

Examples

```
set.seed(6714)
st<-gentime(n=100)
y<-IAR.sample(phi=0.99,n=100,st)
y<-y$series
IAR.phi.loglik(x=0.8,y=y,sT=st)
```

IAR.phi.loglik *Minus Log Likelihood of the IAR Model*

Description

This function return the negative log likelihood of the IAR Model for a specific value of phi.

Usage

```
IAR.phi.loglik(
  x,
  y,
  sT,
  delta = 0,
  include.mean = "FALSE",
  standarized = "TRUE"
)
```

Arguments

x	A given phi coefficient of the IAR model.
y	Array with the time series observations.
sT	Array with the irregular observational times.
delta	Array with the measurements error standard deviations.
include.mean	logical; if true, the array y has zero mean; if false, y has a mean different from zero.
standarized	logical; if true, the array y was standarized; if false, y contains the raw data

Value

Value of the negative log likelihood evaluated in phi.

References

Eyheramendy S, Elorrieta F, Palma W (2018). "An irregular discrete time series model to identify residuals with autocorrelation in astronomical light curves." *Monthly Notices of the Royal Astronomical Society*, **481**(4), 4311–4322. ISSN 0035-8711, doi: 10.1093/mnras/sty2487, https://academic.oup.com/mnras/article-pdf/481/4/4311/25906473/sty2487.pdf.

See Also

gentime, IAR.sample

Examples

```
set.seed(6714)
st<-gentime(n=100)
y<-IAR.sample(phi=0.99,n=100,st)
y<-y$series
IAR.phi.loglik(x=0.8,y=y,sT=st)
```

IAR.phi.t   *Minus Log Likelihood IAR-T Model*

Description

This function return the negative log likelihood of the IAR-T given specific values of phi and sigma.

Usage

```
IAR.phi.t(x, y, sT, nu = 3)
```

Arguments

x	An array with the parameters of the IAR-T model. The first element of the array corresponding to the phi parameter and the second element to the scale parameter sigma
y	Array with the time series observations
sT	Array with the irregular observational times
nu	degrees of freedom

Value

Value of the negative log likelihood evaluated in phi,sigma and nu.

References

Eyheramendy S, Elorrieta F, Palma W (2018). "An irregular discrete time series model to identify residuals with autocorrelation in astronomical light curves." *Monthly Notices of the Royal Astronomical Society*, **481**(4), 4311–4322. ISSN 0035-8711, doi: 10.1093/mnras/sty2487, https://academic.oup.com/mnras/article-pdf/481/4/4311/25906473/sty2487.pdf.

See Also

gentime, IARg.sample

Examples

```
n=300
set.seed(6714)
st<-gentime(n) #Unequally spaced times
y<-IARt.sample(n,0.9,st,sigma2=1,nu=3)
IAR.phi.t(x=c(0.9,1),y=y$y,sT=st)
```

IAR.sample   *Simulate from an IAR(1) Model*

Description

Simulates an IAR(1) Time Series Model.

Usage

```
IAR.sample(phi, n = 100, sT)
```

Arguments

phi	A coefficient of IAR(1) model. A value between 0 and 1
n	Length of the output time series. A strictly positive integer.
sT	Array with observational times.

Value

A list with the following components:

- times Array with observation times.
- series Array with simulated IAR(1) data.

References

Eyheramendy S, Elorrieta F, Palma W (2018). "An irregular discrete time series model to iden-tify residuals with autocorrelation in astronomical light curves." *Monthly Notices of the Royal Astronomical Society*, **481**(4), 4311–4322. ISSN 0035-8711, doi: 10.1093/mnras/sty2487, https://academic.oup.com/mnras/article-pdf/481/4/4311/25906473/sty2487.pdf.

See Also

gentime

Examples

```
set.seed(6714)
st<-gentime(n=100)
y<-IAR.sample(phi=0.99,n=100,st)
y<-y$series
plot(st,y,type='l')
```

IAR.t   *Maximum Likelihood Estimation of the IAR-T model*

Description

Maximum Likelihood Estimation of the IAR-T model.

Usage

```
IAR.t(y, sT, nu = 3)
```

Arguments

y	Array with the time series observations
sT	Array with the irregular observational times
nu	degrees of freedom

Value

A list with the following components:

- phi MLE of the phi parameter of the IAR-T model.
- sigma MLE of the sigma parameter of the IAR-T model.
- ll Value of the negative log likelihood evaluated in phi and sigma.

References

Eyheramendy S, Elorrieta F, Palma W (2018). "An irregular discrete time series model to identify residuals with autocorrelation in astronomical light curves." *Monthly Notices of the Royal Astronomical Society*, **481**(4), 4311–4322. ISSN 0035-8711, doi: 10.1093/mnras/sty2487, https://academic.oup.com/mnras/article-pdf/481/4/4311/25906473/sty2487.pdf.

See Also

gentime, IARt.sample, IAR.phi.t

Examples

```
n=300
set.seed(6714)
st<-gentime(n)
y<-IARt.sample(n,0.9,st,sigma2=1,nu=3)
model<-IAR.t(y$y, sT=st)
phi=model$phi
sigmaest=model$sigma
```

IAR.Test   *Test for the significance of the autocorrelation estimated by the IAR*
                                  model in periodic irregularly observed time series

---

Description

This function perform a test for the significance of the autocorrelation estimated by the IAR model. This test is based on the residuals of the periodical time series fitted with an harmonic model using an incorrect period.

Usage

```
IAR.Test(y, sT, f, phi, plot = "TRUE", xlim = c(-1, 0))
```

Arguments

y	Array with the time series observations
sT	Array with the irregular observational times
f	Frequency (1/Period) of the raw time series
phi	autocorrelation estimated by IAR.loglik
plot	logical; if true, the function return a density plot of the distribution of the bad fitted examples; if false, this function does not return a plot
xlim	The x-axis limits (x1, x2) of the plot. Only works if plot='TRUE'. See plot.default for more details

Details

The null hypothesis of the test is: The autocorrelation estimated in the time series belongs to the distribution of the coefficients estimated for the residuals of the data fitted using wrong periods. Therefore, if the hypothesis is rejected, it can be concluded that the residuals of the harmonic model do not remain a time dependency structure.The statistic of the test is log(phi) which was contrasted with a normal distribution with parameters corresponding to the log of the mean and the variance of the phi computed for the residuals of the bad fitted light curves.

Value

A list with the following components:

- phi MLE of the phi parameter of the IAR model.
- norm Mean and variance of the normal distribution of the bad fitted examples.
- z0 Statistic of the test (log(phi)).
- pvalue P-value computed for the test.

References

Eyheramendy S, Elorrieta F, Palma W (2018). "An irregular discrete time series model to iden-
tify residuals with autocorrelation in astronomical light curves." *Monthly Notices of the Royal
Astronomical Society*, **481**(4), 4311–4322. ISSN 0035-8711, doi: 10.1093/mnras/sty2487, https:
//academic.oup.com/mnras/article-pdf/481/4/4311/25906473/sty2487.pdf.

See Also

clcep, harmonicfit, IAR.loglik, IAR.Test2

Examples

```
data(clcep)
f1=0.060033386
results=harmonicfit(file=clcep,f1=f1)
y=results$res/sqrt(var(results$res))
sT=results$t
res3=IAR.loglik(y,sT,standarized='TRUE')[1]
res3$phi
require(ggplot2)
test<-IAR.Test(y=clcep[,2],sT=clcep[,1],f1,res3$phi,plot='TRUE',xlim=c(-10,0.5))
test
```

IAR.Test2   *Test for the significance of the autocorrelation estimated by the IAR
                                   model*

Description

This function perform a test for the significance of the autocorrelation estimated by the IAR model.
This test is based in to take N disordered samples of the original data (Useful for non-periodic time
series or when the period is unknown).

Usage

```
IAR.Test2(y, sT, iter = 100, phi, plot = "TRUE", xlim = c(-1, 0))
```

Arguments

y	Array with the time series observations
sT	Array with the irregular observational times
iter	Number of disordered samples of the original data (N)
phi	autocorrelation estimated by `IAR.loglik`
plot	logical; if true, the function return a density plot of the distribution of the bad fitted examples; if false, this function does not return a plot
xlim	The x-axis limits (x1, x2) of the plot. Only works if plot='TRUE'. See `plot.default` for more details

Details

The null hypothesis of the test is: The coefficient phi estimated for the time series belongs to the distribution of the coefficients estimated on the disordered data, which are assumed to be uncorrelated. Therefore, if the hypothesis is accepted, it can be concluded that the observations of the time series are uncorrelated.The statistic of the test is log(phi) which was contrasted with a normal distribution with parameters corresponding to the log of the mean and the variance of the phi computed for the N samples of the disordered data. This test differs for `IAR.Test` in that to perform this test it is not necessary to know the period of the time series.

Value

A list with the following components:

- phi MLE of the phi parameter of the IAR model.
- norm Mean and variance of the normal distribution of the disordered data.
- z0 Statistic of the test (log(phi)).
- pvalue P-value computed for the test.

References

Eyheramendy S, Elorrieta F, Palma W (2018). "An irregular discrete time series model to identify residuals with autocorrelation in astronomical light curves." *Monthly Notices of the Royal Astronomical Society*, **481**(4), 4311–4322. ISSN 0035-8711, doi: 10.1093/mnras/sty2487, https://academic.oup.com/mnras/article-pdf/481/4/4311/25906473/sty2487.pdf.

See Also

`Planets`,`IAR.loglik`, `IAR.Test`

Examples

```
data(Planets)
t<-Planets[,1]
res<-Planets[,2]
y=res/sqrt(var(res))
res3=IAR.loglik(y,t,standarized='TRUE')[1]
```

```
res3$phi
set.seed(6713)
require(ggplot2)
test<-IAR.Test2(y=y,sT=t,phi=res3$phi,plot='TRUE',xlim=c(-9.6,-9.45))
```

IARg.sample   *Simulate from an IAR-Gamma Model*

Description

Simulates an IAR-Gamma Time Series Model.

Usage

```
IARg.sample(n, phi, st, sigma2 = 1, mu = 1)
```

Arguments

n	Length of the output time series. A strictly positive integer.
phi	A coefficient of IAR-Gamma model. A value between 0 and 1.
st	Array with observational times.
sigma2	Scale parameter of the IAR-Gamma process. A positive value.
mu	Level parameter of the IAR-Gamma process. A positive value.

Value

A list with the following components:

- y Array with simulated IAR-Gamma process.
- st Array with observation times.

References

Eyheramendy S, Elorrieta F, Palma W (2018). "An irregular discrete time series model to iden-
tify residuals with autocorrelation in astronomical light curves." *Monthly Notices of the Royal
Astronomical Society*, **481**(4), 4311–4322. ISSN 0035-8711, doi: 10.1093/mnras/sty2487, https:
//academic.oup.com/mnras/article-pdf/481/4/4311/25906473/sty2487.pdf.

See Also

gentime

Examples

```
n=300
set.seed(6714)
st<-gentime(n)
y<-IARg.sample(n,phi=0.9,st,sigma2=1,mu=1)
plot(st,y$y,type='l')
hist(y$y,breaks=20)
```

IARt.sample   *Simulate from an IAR-T Model*

Description

Simulates an IAR-T Time Series Model.

Usage

```
IARt.sample(n, phi, st, sigma2 = 1, nu = 3)
```

Arguments

n	Length of the output time series. A strictly positive integer.
phi	A coefficient of IAR-T model. A value between 0 and 1.
st	Array with observational times.
sigma2	Scale parameter of the IAR-T process. A positive value.
nu	degrees of freedom.

Value

A list with the following components:

- y Array with simulated IAR-t process.
- st Array with observation times.

References

Eyheramendy S, Elorrieta F, Palma W (2018). "An irregular discrete time series model to identify residuals with autocorrelation in astronomical light curves." *Monthly Notices of the Royal Astronomical Society*, **481**(4), 4311–4322. ISSN 0035-8711, doi: 10.1093/mnras/sty2487, https://academic.oup.com/mnras/article-pdf/481/4/4311/25906473/sty2487.pdf.

See Also

gentime

Examples

```
n=300
set.seed(6714)
st<-gentime(n)
y<-IARt.sample(n,0.9,st,sigma2=1,nu=3)
plot(st,y$y,type='l')
hist(y$y,breaks=20)
```

Planets   *Transit of an extrasolar planet*

Description

Time series corresponding to the residuals of the parametric model fitted by Jordan et al (2013) for a transit of an extrasolar planet.

Usage

```
Planets
```

Format

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

t Time from mid-transit (hours).

r Residuals of the parametric model fitted by Jordan et al (2013).

References

Jordán A, Espinoza N, Rabus M, Eyheramendy S, Sing DK, Désert J, Bakos GÁ, Fortney JJ, López-Morales M, Maxted PFL, Triaud AHMJ, Szentgyorgyi A (2013). "A Ground-based Optical Transmission Spectrum of WASP-6b." *The Astrophysical Journal*, **778**, 184. doi: 10.1088/0004637X/778/2/184, 1310.6048, https://doi.org/10.1088/0004-637X/778/2/184.

Examples

```
data(Planets)
plot(Planets[,1],Planets[,2],xlab='Time from mid-transit (hours)',ylab='Noise',pch=20)
```

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