Package ‘iAR’

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Type Package

Title Irregularly Observed Autoregressive Models

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Maintainer Elorrieta Felipe <felipe.elorrieta@usach.cl>

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 (Elorrieta et al.(2021) <doi:10.1093/mnras/stab1216>).

License GPL-2

Depends R (>= 3.5.0)

Imports Rcpp (>= 1.0.7),ggplot2,stats, Rdpack

RdMacros Rdpack

Suggests arfima

URL https://github.com/felipeelorrieta

LinkingTo Rcpp,RcppArmadillo

RoxygenNote 7.1.2

LazyData true

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Author Elorrieta Felipe [aut, cre],
Ojeda Cesar [aut],
Eyheramendy Susana [aut],
Palma Wilfredo [aut]

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R topics documented:

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="")
```

BIARfit — *Fitted Values of BIAR model*

Description

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

Usage

```
BIARfit(phiValues, y1, y2, t, yerr1, yerr2, zeroMean = "TRUE")
```

Arguments

phiValues	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.
zeroMean	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.
- Lambda Lambda value estimated by the BIAR model at the last time point.
- Theta Theta array estimated by the BIAR model at the last time point.
- Sighat Covariance matrix estimated by the BIAR model at the last time point.
- Qt Covariance matrix of the state equation estimated by the BIAR model at the last time point.

References

Elorrieta F, Eyheramendy S, Palma W, Ojeda C (2021). "A novel bivariate autoregressive model for predicting and forecasting irregularly observed time series." *Monthly Notices of the Royal Astronomical Society*, **505**(1), 1105–1116. ISSN 0035-8711, doi: 10.1093/mnras/stab1216, https://academic.oup.com/mnras/article-pdf/505/1/1105/38391762/stab1216.pdf.

See Also

gentime, BIARsample, BIARphikalman, BIARkalman

Examples

```
n=80
set.seed(6714)
st<-gentime(n)
x=BIARsample(n=n,phiR=0.9,phiI=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=BIARkalman(y1=y1[1,],y2=y1[2,],t=st,delta1 = yerr1,delta2=yerr2)
biar
predbiar=BIARfit(phiValues=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
```

BIARkalman *Maximum Likelihood Estimation of the BIAR Model via Kalman Recursions*

Description

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

Usage

```
BIARkalman(
  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 (phiR).
- phiI MLE of the cross-correlation coefficient of the BIAR model (phiI).
- ll Value of the negative log likelihood evaluated in phiR and phiI.

References

Elorrieta F, Eyheramendy S, Palma W, Ojeda C (2021). "A novel bivariate autoregressive model for predicting and forecasting irregularly observed time series." *Monthly Notices of the Royal Astronomical Society*, **505**(1), 1105–1116. ISSN 0035-8711, doi: 10.1093/mnras/stab1216, https://academic.oup.com/mnras/article-pdf/505/1/1105/38391762/stab1216.pdf.

See Also

gentime, BIARsample, BIARphikalman

Examples

```
n=80
set.seed(6714)
st<-gentime(n)
x=BIARsample(n=n,phiR=0.9,phiI=0,st=st,rho=0)
y=x$y
y1=y/apply(y,1,sd)
biar=BIARkalman(y1=y1[1,],y2=y1[2,],t=st,delta1 = rep(0,length(y[1,])),
delta2=rep(0,length(y[1,])))
biar
```

BIARLL *Full Minus Log Likelihood of the BIAR Model*

Description

This function return the full negative log likelihood of the BIAR process given specific values of phiR and phiI

Usage

```
BIARLL(yest, phiValues, y1, y2, t, yerr1, yerr2, zeroMean = "TRUE")
```

Arguments

yest	An array with the estimate of a missing value in one or both time series of the bivariate process. This function recognizes a missing value with a NA. If the bivariate time series does not have a missing value, this value does not affect the computation of the likelihood.
phiValues	An array with the parameters of the BIAR model. The elements of the array are, in order, the real (phiR) and the imaginary (phiI) 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.
zeroMean	logical; if true, the array y has zero mean; if false, y has a mean different from zero.

Value

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

References

Elorrieta F, Eyheramendy S, Palma W, Ojeda C (2021). "A novel bivariate autoregressive model for predicting and forecasting irregularly observed time series." *Monthly Notices of the Royal Astronomical Society*, **505**(1), 1105–1116. ISSN 0035-8711, doi: 10.1093/mnras/stab1216, https://academic.oup.com/mnras/article-pdf/505/1/1105/38391762/stab1216.pdf.

See Also

gentime, BIARsample

Examples

```
n=100
set.seed(6714)
st<-gentime(n)
x=BIARsample(n=n,phiR=0.9,phiI=0.3,st=st)
y=x$y
y1=y[1,]
y2=y[2,]
yerr1=rep(0,n)
yerr2=rep(0,n)
BIARLL(yest=0,phiValues=c(0.8,0.2),y1=y1,y2=y2,t=st,yerr1=yerr1,yerr2=yerr2)
```

`BIARphikalman` *Minus Log Likelihood of the BIAR Model*

Description

This function return the negative log likelihood of the BIAR process given specific values of phiR and phiI

Usage

```
BIARphikalman(phiValues, y1, y2, t, yerr1, yerr2, zeroMean = "TRUE")
```

Arguments

`phiValues`	An array with the parameters of the BIAR model. The elements of the array are, in order, the real (phiR) and the imaginary (phiI) 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.
`zeroMean`	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.

References

Elorrieta F, Eyheramendy S, Palma W, Ojeda C (2021). "A novel bivariate autoregressive model for predicting and forecasting irregularly observed time series." *Monthly Notices of the Royal Astronomical Society*, **505**(1), 1105–1116. ISSN 0035-8711, doi: 10.1093/mnras/stab1216, `https://academic.oup.com/mnras/article-pdf/505/1/1105/38391762/stab1216.pdf`.

See Also

`gentime`, `BIARsample`

Examples

```
n=300
set.seed(6714)
st<-gentime(n)
x=BIARsample(n=n,phiR=0.9,phiI=0.3,st=st)
y=x$y
y1=y[1,]
y2=y[2,]
yerr1=rep(0,n)
yerr2=rep(0,n)
BIARphikalman(phiValues=c(0.8,0.2),y1=y1,y2=y2,t=st,yerr1=yerr1,yerr2=yerr2)
```

`BIARsample` *Simulate from a BIAR Model*

Description

Simulates a BIAR Time Series Model

Usage

```
BIARsample(n, st, phiR, phiI, delta1 = 0, delta2 = 0, rho = 0)
```

Arguments

n	Length of the output bivariate time series. A strictly positive integer.
st	Array with observational times.
phiR	Autocorrelation coefficient of BIAR model. A value between -1 and 1.
phiI	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 phiR and phiI values must satisfy the condition $|phiR + i phiI| < 1$.

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.

References

Elorrieta F, Eyheramendy S, Palma W, Ojeda C (2021). "A novel bivariate autoregressive model for predicting and forecasting irregularly observed time series." *Monthly Notices of the Royal Astronomical Society*, **505**(1), 1105–1116. ISSN 0035-8711, doi: 10.1093/mnras/stab1216, https://academic.oup.com/mnras/article-pdf/505/1/1105/38391762/stab1216.pdf.

See Also

gentime

Examples

```
n=300
set.seed(6714)
st<-gentime(n)
x=BIARsample(n=n,phiR=0.9,phiI=0.3,st=st)
plot(st,x$y[1,],type='l')
plot(st,x$y[2,],type='l')
x=BIARsample(n=n,phiR=-0.9,phiI=-0.3,st=st)
plot(st,x$y[1,],type='l')
plot(st,x$y[2,],type='l')
```

BIARsmoothing — *Smoothing and Forecasting from BIAR model*

Description

Estimation of missing values from models fitted by BIARkalman

Usage

```
BIARsmoothing(
  x,
  y1,
  y2,
  t,
  delta1 = 0,
  delta2 = 0,
  yini1 = 0,
  yini2 = 0,
  zero.mean = "TRUE",
  niter = 10,
  seed = 1234,
  nsmooth = 1
)
```

Arguments

`x`	An array with the parameters of the BIAR model. The elements of the array are, in order, the real (phiR) and the imaginary (phiI) 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.
`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.
`yini1`	a single value, initial value of the estimation of the missing value of the first time series of the BIAR process.
`yini2`	a single value, initial value of the estimation of the missing value 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.
`nsmooth`	a single value; If 1, only one time series of the BIAR process has a missing value. If 2, both time series of the BIAR process have a missing value.

Value

A list with the following components:

- fittedEstimation of the missing values of the BIAR process.
- llValue of the negative log likelihood evaluated in the fitted missing values.

References

Elorrieta F, Eyheramendy S, Palma W, Ojeda C (2021). “A novel bivariate autoregressive model for predicting and forecasting irregularly observed time series.” *Monthly Notices of the Royal Astronomical Society*, **505**(1), 1105–1116. ISSN 0035-8711, doi: 10.1093/mnras/stab1216, `https://academic.oup.com/mnras/article-pdf/505/1/1105/38391762/stab1216.pdf`.

See Also

`gentime`, `BIARsample`, `BIARLL`

Examples

```
set.seed(6713)
n=100
st<-gentime(n)
```

```
x=BIARsample(n=n,phiR=0.9,phiI=0.3,st=st,rho=0.9)
y=x$y
y1=y/apply(y,1,sd)
yerr1=rep(0,n)
yerr2=rep(0,n)
biar=BIARkalman(y1=y1[1,],y2=y1[2,],t=st,delta1 = yerr1,delta2=yerr2)
biar
napos=10
y0=y1
y1[1,napos]=NA
xest=c(biar$phiR,biar$phiI)
yest=BIARsmoothing(xest,y1=y1[1,],y2=y1[2,],t=st,delta1=yerr1,
delta2=yerr2,nsmooth=1)
yest$fitted
mse=(y0[1,napos]-yest$fitted)^2
print(mse)
par(mfrow=c(2,1))
plot(st,x$y[1,],type='l',xlim=c(st[napos-5],st[napos+5]))
points(st,x$y[1,],pch=20)
points(st[napos],yest$fitted*apply(y,1,sd)[1],col="red",pch=20)
plot(st,x$y[2,],type='l',xlim=c(st[napos-5],st[napos+5]))
points(st,x$y[2,],pch=20)
```

`CIARfit` *Fitted Values of CIAR model*

Description

Fit a CIAR model to an irregularly observed time series.

Usage

```
CIARfit(phiValues, y, t, standarized = "TRUE", c = 1)
```

Arguments

`phiValues`	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`, `CIARsample`, `CIARphikalman`,`CIARkalman`

Examples

```
n=100
set.seed(6714)
st<-gentime(n)
x=CIARsample(n=n,phiR=0.9,phiI=0,st=st,c=1)
y=x$y
y1=y/sd(y)
ciar=CIARkalman(y=y1,t=st)
ciar
yhat=CIARfit(phiValues=c(ciar$phiR,ciar$phiI),y=y1,t=st)
```

`CIARforecast` *Forecast from CIAR model*

Description

Forecast from models fitted by `CIARkalman`

Usage

```
CIARforecast(phiR, phiI, y1, st, nAhead)
```

Arguments

phiR	Real part of the phi coefficient of CIAR model.
phiI	Imaginary part of the phi coefficient of CIAR model.
y1	Array with the time series observations.
st	Array with the irregular observational times.
nAhead	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

CIARsample, CIARkalman, CIARfit

Examples

```
#Simulated Data
n=100
set.seed(6714)
st<-gentime(n)
x=CIARsample(n=n,phiR=0.9,phiI=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=CIARkalman(y=ytr,t=str)
forCIAR<-CIARforecast(ciar$phiR,ciar$phiI,ytr,str,nAhead=n.ahead)
```

CIARkalman *Maximum Likelihood Estimation of the CIAR Model via Kalman Recursions*

Description

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

Usage

```
CIARkalman(
  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 (phiR).
- phiI MLE of the Imaginary part of the coefficient of the CIAR model (phiI).
- ll 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, CIARsample, CIARphikalman

Examples

```
n=100
set.seed(6714)
st<-gentime(n)
x=CIARsample(n=n,phiR=0.9,phiI=0,st=st,c=1)
y=x$y
y1=y/sd(y)
ciar=CIARkalman(y=y1,t=st)
ciar
Mod(complex(real=ciar$phiR,imaginary=ciar$phiI))
```

CIARphikalman *Minus Log Likelihood of the CIAR Model*

Description

This function return the negative log likelihood of the CIAR process given specific values of phiR and phiI

Usage

```
CIARphikalman(x, y, t, yerr, zeroMean = "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 (phiR) and the imaginary (phiI) 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.
zeroMean	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, CIARsample

Examples

```
n=300
set.seed(6714)
st<-gentime(n)
x=CIARsample(n=n,phiR=0.9,phiI=0,st=st,c=1)
y=x$y
yerr=rep(0,n)
CIARphikalman(x=c(0.8,0),y=y,t=st,yerr=yerr)
```

CIARsample *Simulate from a CIAR Model*

Description

Simulates a CIAR Time Series Model

Usage

```
CIARsample(n, phiR, phiI, st, rho = 0L, c = 1L)
```

Arguments

n	Length of the output time series. A strictly positive integer.
phiR	Real part of the coefficient of CIAR model. A value between -1 and 1.
phiI	Imaginary part of the coefficient of CIAR model. A value between -1 and 1.
st	Array with observational times.
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 phiR and phiI values must satisfy the condition $lphiR + i phiIl < 1$.

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=CIARsample(n=n,phiR=0.9,phiI=0,st=st,c=1)
plot(st,x$y,type='l')
x=CIARsample(n=n,phiR=-0.9,phiI=0,st=st,c=1)
plot(st,x$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)
```

---

cvnovag — *ZTF g-band Cataclysmic Variable/Nova*

Description

Time series of a cataclysmic variable/nova object observed in the g-band of the ZTF survey and processed by the ALeRCE broker.ZTF Object code: ZTF18aayzpbr

Usage

```
cvnovag
```

Format

A data frame with 67 observations on the following 3 variables:

t heliocentric Julian Day - 2400000

m magnitude

merr measurement error standard deviations.

References

Förster F, Cabrera-Vives G, Castillo-Navarrete E, Estévez PA, Sánchez-Sáez P, Arredondo J, Bauer FE, Carrasco-Davis R, Catelan M, Elorrieta F, Eyheramendy S, Huijse P, Pignata G, Reyes E, Reyes I, Rodríguez-Mancini D, Ruz-Mieres D, Valenzuela C, Álvarez-Maldonado I, Astorga N, Borissova J, Clocchiatti A, Cicco DD, Donoso-Oliva C, Hernández-García L, Graham MJ, Jordán A, Kurtev R, Mahabal A, Maureira JC, Muñoz-Arancibia A, Molina-Ferreiro R, Moya A, Palma W, Pérez-Carrasco M, Protopapas P, Romero M, Sabatini-Gacitua L, Sánchez A, Martín JS, Sepúlveda-Cobo C, Vera E, Vergara JR (2021). "The Automatic Learning for the Rapid Classification of Events (ALeRCE) Alert Broker." *The Astronomical Journal*, **161**(5), 242. doi: 10.3847/15383881/abe9bc, `https://doi.org/10.3847/1538-3881/abe9bc`.

Examples

```
data(cvnovag)
plot(cvnovag$t,cvnovag$m,type="l",ylab="",xlab="",col="green")
```

`cvnovar` *ZTF r-band Cataclysmic Variable/Nova*

Description

Time series of a cataclysmic variable/nova object observed in the r-band of the ZTF survey and processed by the ALeRCE broker.ZTF Object code: ZTF18aayzpbr

Usage

```
cvnovar
```

Format

A data frame with 65 observations on the following 3 variables:

t heliocentric Julian Day - 2400000

m magnitude

merr measurement error standard deviations.

References

Förster F, Cabrera-Vives G, Castillo-Navarrete E, Estévez PA, Sánchez-Sáez P, Arredondo J, Bauer FE, Carrasco-Davis R, Catelan M, Elorrieta F, Eyheramendy S, Huijse P, Pignata G, Reyes E, Reyes I, Rodríguez-Mancini D, Ruz-Mieres D, Valenzuela C, Álvarez-Maldonado I, Astorga N, Borissova J, Clocchiatti A, Cicco DD, Donoso-Oliva C, Hernández-García L, Graham MJ, Jordán A, Kurtev R, Mahabal A, Maureira JC, Muñoz-Arancibia A, Molina-Ferreiro R, Moya A, Palma W, Pérez-Carrasco M, Protopapas P, Romero M, Sabatini-Gacitua L, Sánchez A, Martín JS, Sepúlveda-Cobo C, Vera E, Vergara JR (2021). "The Automatic Learning for the Rapid Classification of Events (ALeRCE) Alert Broker." *The Astronomical Journal*, **161**(5), 242. doi: 10.3847/15383881/abe9bc, `https://doi.org/10.3847/1538-3881/abe9bc`.

Examples

```
data(cvnovar)
plot(cvnovar$t,cvnovar$m,type="l",ylab="",xlab="",col="red")
```

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, plot = T)
```

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.
`plot`	logical; if TRUE, the function returns the plot of folded time series.

Value

A matrix whose first column has the folded (phased) observational times.

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,
  distribution = "expmixture",
  lambda1 = 130,
  lambda2 = 6.5,
  p1 = 0.15,
  p2 = 0.85,
  a = 0,
  b = 1
)
```

Arguments

n	A positive integer. Length of observation times.
distribution	Distribution of the observation times that will be generated. Default value is "expmixture" for a mixture of exponential distributions. Alternative distributions are "uniform", "exponential" and "gamma".
lambda1	Mean (1/rate) of the exponential distribution or the first exponential distribution in a mixture of exponential distributions.
lambda2	Mean (1/rate) of the second exponential distribution in a mixture of exponential distributions.
p1	Weight of the first exponential distribution in a mixture of exponential distributions.
p2	Weight of the second exponential distribution in a mixture of exponential distributions.
a	Shape parameter of a gamma distribution or lower limit of the uniform distribution.
b	Scale parameter of a gamma distribution or upper limit of the uniform distribution.

Value

Array with irregularly spaced observations 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

IARsample

Examples

```
st<-gentime(n=100)
st<-gentime(n=100,distribution="uniform")
st<-gentime(n=100,distribution="gamma",a=1,b=1)
st<-gentime(n=100,distribution="exponential",lambda1=1)
```

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,
  remove_trend = TRUE
)
```

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.
`remove_trend`	logical; if true, the linear trend of time series will be removed before the the harmonic model is fitted.

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.
- coef Summary of the coefficients estimated by the harmonic model.

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` *iAR: Irregularly Observed Autoregressive Models*

Description

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 (Elorrieta et al.(2021) <doi:10.1093/mnras/stab1216>)

BIAR functions

The foo functions ...

CIAR functions

The foo functions ...

IAR functions

heloo

`IARfit` *Fitted Values of IAR model*

Description

Fit an IAR model to an irregularly observed time series.

Usage

```
IARfit(phi, y, st, standarized = T, include.mean = F)
```

Arguments

`phi`	Estimated phi parameter by the iAR model.
`y`	Array with the time series observations.
`st`	Array with the irregular observational times.
`standarized`	logical; if true, the array y is standarized; if false, y contains the raw time series
`include.mean`	logical; if true, the array y has zero mean; if false, y has a mean different from zero.

Value

Fitted values of the iAR model

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`, `IARsample`, `IARloglik`, `IARkalman`

Examples

```
set.seed(6714)
st<-gentime(n=100)
y<-IARsample(phi=0.99,st=st,n=100)
y<-y$series
phi=IARloglik(y=y,st=st)$phi
fit=IARfit(phi=phi,y=y,st=st)
```

`IARgamma` *Maximum Likelihood Estimation of the IAR-Gamma model*

Description

Maximum Likelihood Estimation of the IAR-Gamma model.

Usage

```
IARgamma(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, IARgsample, IARphigamma

Examples

```
n=300
set.seed(6714)
st<-gentime(n)
y<-IARgsample(phi=0.9,st=st,n=n,sigma2=1,mu=1)
model<-IARgamma(y$y, st=st)
phi=model$phi
muest=model$mu
sigmaest=model$sigma
```

IARgfit *Fitted Values of IAR-Gamma model*

Description

Fit an IAR-Gamma model to an irregularly observed time series.

Usage

```
IARgfit(phi, mu, y, st)
```

Arguments

phi	Estimated phi parameter by the iAR-Gamma model.
mu	Estimated mu parameter by the iAR-Gamma model.
y	Array with the time series observations.
st	Array with the irregular observational times.

Value

Fitted values of the iAR-Gamma model

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, IARgsample, IARgamma

Examples

```
n=300
set.seed(6714)
st<-gentime(n)
y<-IARgsample(phi=0.9,st=st,n=n,sigma2=1,mu=1)
model<-IARgamma(y$y, st=st)
phi=model$phi
muest=model$mu
sigmaest=model$sigma
fit=IARgfit(phi=phi,mu=muest,y=y$y,st=st)
```

IARgsample — *Simulate from an IAR-Gamma Model*

Description

Simulates an IAR-Gamma Time Series Model.

Usage

```
IARgsample(phi, st, n = 100L, sigma2 = 1L, mu = 1L)
```

Arguments

phi	A coefficient of IAR-Gamma model. A value between 0 and 1.
st	Array with observational times.
n	Length of the output time series. A strictly positive integer.
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 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=100
set.seed(6714)
st<-gentime(n)
y<-IARgsample(phi=0.9,st=st,n=n,sigma2=1,mu=1)
plot(st,y$y,type='l')
hist(y$y,breaks=20)
```

`IARkalman` *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

```
IARkalman(y, st, delta = 0, zero.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.
`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, IARsample, arima,IARphikalman

Examples

```
set.seed(6714)
st<-gentime(n=100)
y<-IARsample(phi=0.99,st=st,n=100)
y<-y$series
phi=IARkalman(y=y,st=st)$phi
print(phi)
```

IARloglik *Maximum Likelihood Estimation of the IAR Model*

Description

Maximum Likelihood Estimation of the IAR Model.

Usage

```
IARloglik(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, IARsample, arima, IARphiloglik

Examples

```
#Generating IAR sample
set.seed(6714)
st<-gentime(n=100)
y<-IARsample(phi=0.99,st=st,n=100)
y<-y$series
#Compute Phi
phi=IARloglik(y=y,st=st)$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)
```

`IARphigamma` *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

```
IARphigamma(x_input, y, st)
```

Arguments

x_input	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, IARgsample

Examples

```
n=100
set.seed(6714)
st<-gentime(n)
y<-IARgsample(phi=0.9,st=st,n=n,sigma2=1,mu=1)
IARphigamma(x_input=c(0.9,1,1),y=y$y,st=st)
```

IARphikalman *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

```
IARphikalman(x, y, yerr, st, zeroMean = "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.
st	Array with the irregular observational times.
zeroMean	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, IARsample

Examples

```
set.seed(6714)
st<-gentime(n=100)
y<-IARsample(phi=0.99,st=st,n=100)
y<-y$series
yerr=rep(0,100)
IARphikalman(x=0.8,y=y,yerr=yerr,st=st)
```

IARphiloglik *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

```
IARphiloglik(x, y, st, delta_input, zeroMean = "TRUE", 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_input	Array with the measurements error standard deviations.
zeroMean	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, IARsample

Examples

```
set.seed(6714)
st<-gentime(n=100)
y<-IARsample(phi=0.99,st=st,n=100)
y<-y$series
IARphiloglik(x=0.8,y=y,st=st,delta_input=c(0))
```

IARphit *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

```
IARphit(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, IARgsample

Examples

```
n=300
set.seed(6714)
st<-gentime(n) #Unequally spaced times
y<-IARtsample(n,0.9,st,sigma2=1,nu=3)
IARphit(x=c(0.9,1),y=y$y,st=st)
```

`IARsample` *Simulate from an IAR Model*

Description

Simulates an IAR Time Series Model.

Usage

```
IARsample(phi, st, n = 100L)
```

Arguments

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

Value

A list with the following components:

- times Array with observation times.
- series Array with simulated IAR data.

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

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

IARsmoothing *Interpolation predictor of the iAR Model*

Description

One step interpolation predictor of the iAR Model

Usage

```
IARsmoothing(
  x,
  st,
  y,
  grid,
  delta = 0,
  zero.mean = "FALSE",
  standarized = "TRUE"
)
```

Arguments

x	A given phi coefficient of the IAR model.
st	Array with the irregular observational times.
y	Array with the time series observations.
grid	Array with the times in which the interpolation predictor will be computed.
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:

- yhatOne step interpolation predictor of the iAR model for each given time.
- gridTimes in which the interpolation predictor was computed.

References

Elorrieta F, Eyheramendy S, Palma W, Ojeda C (2021). "A novel bivariate autoregressive model for predicting and forecasting irregularly observed time series." *Monthly Notices of the Royal Astronomical Society*, **505**(1), 1105–1116. ISSN 0035-8711, doi: 10.1093/mnras/stab1216, `https://academic.oup.com/mnras/article-pdf/505/1/1105/38391762/stab1216.pdf`.

See Also

`gentime`, `IARsample`, `IARloglik`

Examples

```
n=300
set.seed(6713)
st<-gentime(n)
y<-IARsample(phi=0.9,st=st,n=n)
y<-y$series
phi=IARkalman(y=y,st=st)$phi
napos=10
y0=y
yest=IARsmoothing(x=phi,st=st[-napos],y=y[-napos],grid=st[napos])
print(yest)
```

`IARt` *Maximum Likelihood Estimation of the IAR-T model*

Description

Maximum Likelihood Estimation of the IAR-T model.

Usage

```
IARt(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`, `IARtsample`, `IARphit`

Examples

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

`IARTest` *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

```
IARTest(y, st, merr = 0, f, phi, plot = T, xlim = c(-1, 0))
```

Arguments

`y`	Array with the time series observations
`st`	Array with the irregular observational times
`merr`	Array with the variance of the measurement errors.
`f`	Frequency (1/Period) of the raw time series
`phi`	autocorrelation estimated by `IARloglik`
`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.
- bad A matrix with two columns. The first column contains the incorrect frequencies used to fit each harmonic model. The second column has the MLEs of the phi parameters of the IAR model that has been fitted to the residuals of the harmonic model fitted using the frequencies of the first column.
- 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 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

clcep, harmonicfit, IARloglik, IARTest2

Examples

```
data(clcep)
f1=0.060033386
results=harmonicfit(file=clcep,f1=f1)
y=results$res/sqrt(var(results$res))
st=results$t
res3=IARloglik(y,st,standarized='TRUE')[1]
res3$phi
require(ggplot2)
test<-IARTest(y=clcep[,2],st=clcep[,1],f=f1,phi=res3$phi,plot='TRUE',xlim=c(-10,0.5))
test
outbad <- ggplot(test$bad, aes(x = f0, y = bad)) + geom_line()+geom_point() +
geom_point(aes(x=f1,y=as.numeric(test$phi)),color="red") +
xlab("Frequencies") + ylab("iAR Coefficient") +
ylim(c(0,max(c(as.numeric(test$phi),test$bad$bad))))+theme_bw() +
ggtitle("")+
```

```
theme(plot.title = element_text(face = "bold", size = 20,hjust = 0.5),
panel.grid.major = element_blank(), panel.grid.minor = element_blank(),
panel.background = element_blank())
outbad
```

`IARTest2` *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

```
IARTest2(y, st, merr = 0, iter = 100, phi, plot = T, xlim = c(-1, 0))
```

Arguments

`y`	Array with the time series observations.
`st`	Array with the irregular observational times.
`merr`	Array with the variance of the measurement errors.
`iter`	Number of disordered samples of the original data (N).
`phi`	autocorrelation estimated by `IARloglik`.
`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 `IARTest` 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.
- bad MLEs of the phi parameters of the IAR model that has been fitted to the disordered samples.
- 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`,`IARloglik`, `IARTest`

Examples

```
data(Planets)
t<-Planets[,1]
res<-Planets[,2]
y=res/sqrt(var(res))
res3=IARloglik(y,t,standarized='TRUE')[1]
res3$phi
set.seed(6713)
require(ggplot2)
test<-IARTest2(y=y,st=t,phi=res3$phi,plot='TRUE',xlim=c(-9.6,-9.45))
```

IARtsample *Simulate from an IAR-T Model*

Description

Simulates an IAR-T Time Series Model.

Usage

```
IARtsample(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<-IARtsample(n,0.9,st,sigma2=1,nu=3)
plot(st,y$y,type='l')
hist(y$y,breaks=20)
```

`pairingits` *Pairing two irregularly observed time series*

Description

Pairing the observational times of two irregularly observed time series

Usage

```
pairingits(lc1, lc2, tol = 0.1)
```

Arguments

`lc1`	data frame with three columns corresponding to the first irregularly observed time series. The columns must be ordered as follow: First the observational times, second the measures of each time, and third the measurement errors.
`lc2`	data frame with three columns corresponding to the second irregularly observed time series. The columns must be ordered as follow: First the observational times, second the measures of each time, and third the measurement errors.
`tol`	tolerance parameter. Minimum time gap to consider that two observations have measured at different times.

Value

A list with the following components:

- n Number of observations paired by their observational times.
- parData Frame with the paired datasets.

References

Elorrieta F, Eyheramendy S, Palma W, Ojeda C (2021). "A novel bivariate autoregressive model for predicting and forecasting irregularly observed time series." *Monthly Notices of the Royal Astronomical Society*, **505**(1), 1105–1116. ISSN 0035-8711, doi: 10.1093/mnras/stab1216, `https://academic.oup.com/mnras/article-pdf/505/1/1105/38391762/stab1216.pdf`.

See Also

`cvnovag`, `cvnovar`, `BIARkalman`

Examples

```
data(cvnovag)
data(cvnovar)
pargr=pairingits(cvnovag,cvnovar,tol=0.1)
```

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)
```

Index