

Package ‘irregulAR1’

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Type Package

Title Functions for Irregularly Sampled AR(1) Processes

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ar1_cov_chol_irregular

Upper triangular Cholesky decomposition for a stationary Gaussian AR(1) process covariance matrix, observed at irregularly spaced time points.

Description

Creates the upper Cholesky triangle of the covariance matrix of an AR(1) process with parameters `rho` and `sigma`, observed at the time points in the vector `times`. The process is assumed to be in stationarity and to have Gaussian errors.

Usage

```
ar1_cov_chol_irregular(times, rho, sigma)
```

Arguments

<code>times</code>	An vector of positive integers, preferably ordered.
<code>rho</code>	A real number strictly less than 1 in absolute value.
<code>sigma</code>	A positive real number.

Value

A square matrix with `length(times)` rows.

Examples

```
times <- c(1, 4:5, 7)
rho <- 0.5
sigma <- 1
ar1_cov_chol_irregular(times, rho, sigma)
```

ar1_cov_consecutive *Covariance matrix for a stationary Gaussian AR(1) process, observed at consecutive timepoints.*

Description

Creates the covariance matrix of an AR(1) process with parameters rho and sigma, observed at n consecutive time points. The process is assumed to be in stationarity and to have Gaussian errors.

Usage

```
ar1_cov_consecutive(n, rho, sigma)
```

Arguments

n An integer greater than or equal to 1.
rho A real number strictly less than 1 in absolute value.
sigma A positive real number.

Value

A matrix with n rows and n columns.

Examples

```
n <- 5  
rho <- 0.5  
sigma <- 1  
ar1_cov_consecutive(n, rho, sigma)
```

ar1_cov_irregular *Covariance matrix for a stationary Gaussian AR(1) process, observed at irregularly spaced time points.*

Description

Creates the covariance matrix of an AR(1) process with parameters rho and sigma, observed at the time points in the vector times. The process is assumed to be in stationarity and to have Gaussian errors.

Usage

```
ar1_cov_irregular(times, rho, sigma)
```

Arguments

times An vector of positive integers, preferably ordered.
rho A real number strictly less than 1 in absolute value.
sigma A positive real number.

Value

A square matrix with `length(times)` rows.

Examples

```
times <- c(1, 4:5, 7)
rho <- 0.5
sigma <- 1
ar1_cov_irregular(times, rho, sigma)
```

ar1_cross_cov	<i>Cross-covariance matrix of a stationary Gaussian AR(1) process.</i>
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Description

Creates the cross-covariance matrix of an AR(1) process with parameters `rho` and `sigma`, observed at (positive) integer times `times1` and `times2`, which may be irregularly spaced. The process is assumed to be in stationarity and to have Gaussian errors.

Usage

```
ar1_cross_cov(times1, times2, rho, sigma)
```

Arguments

times1 An vector of positive integers, preferably ordered.
times2 An vector of positive integers, preferably ordered.
rho A real number strictly less than 1 in absolute value.
sigma A positive real number.

Value

A matrix with `length(times2)` rows and `length(times1)` columns.

Examples

```
times1 <- c(1, 3, 6)
times2 <- c(2, 4, 8:9)
rho <- 0.5
sigma <- 1
ar1_cross_cov(times1, times2, rho, sigma)
```

ar1_lpdf	<i>Evaluate the log-density of a stationary Gaussian AR(1) process.</i>
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Description

Evaluate the log-density of a stationary Gaussian AR(1) process, observed at times `times` taking values `x`.

Usage

```
ar1_lpdf(x, times, rho, sigma, mu = 0)
```

Arguments

<code>x</code>	A vector of observed values.
<code>times</code>	A vector of the time points of observation.
<code>rho</code>	A real number strictly less than 1 in absolute value.
<code>sigma</code>	A positive real number.
<code>mu</code>	A vector of expected values.

Value

A scalar, the log density.

Examples

```
x <- rnorm(5) + 1:5
t <- c(1, 3, 5:6, 10)
rho <- 0.5
sigma <- 1
# zero mean
ar1_lpdf(x, t, rho, sigma)
# means equal times
mu <- t
ar1_lpdf(x + mu, t, rho, sigma, mu)
```

ar1_prec_chol_irregular	<i>Upper Cholesky triangle of the precision matrix of a stationary Gaussian AR(1) process, observed at irregularly spaced time points.</i>
-------------------------	--

Description

Creates the upper triangular Cholesky decomposition of the precision matrix of an AR(1) process with parameters `rho` and `sigma`, observed at the time points in the vector `times`. The process is assumed to be in stationarity and to have Gaussian errors.

Usage

```
ar1_prec_chol_irregular(times, rho, sigma)
```

Arguments

times	An vector of positive integers, preferably ordered.
rho	A real number strictly less than 1 in absolute value.
sigma	A positive real number.

Value

A sparse square matrix with `length(times)` rows.

Examples

```
library(Matrix)
times <- c(1, 4:5, 7)
rho <- 0.5
sigma <- 1
ar1_prec_chol_irregular(times, rho, sigma)
```

ar1_prec_consecutive *Sparse precision matrix for a stationary Gaussian AR(1) process, observed at consecutive timepoints.*

Description

Creates the precision (inverse covariance) matrix of an AR(1) process with parameters `rho` and `sigma`, observed at `n` consecutive time points. The process is assumed to be in stationarity and to have Gaussian errors. The matrix is a tridiagonal band matrix and thus sparse.

Usage

```
ar1_prec_consecutive(n, rho, sigma)
```

Arguments

n	An integer greater than or equal to 1.
rho	A real number strictly less than 1 in absolute value.
sigma	A positive real number.

Value

A matrix with `n` rows and `n` columns.

Examples

```
library(Matrix)
n <- 5
rho <- 0.5
sigma <- 1
ar1_prec_consecutive(n, rho, sigma)
```

ar1_prec_irregular	<i>Precision matrix for a stationary Gaussian AR(1) process, observed at irregularly spaced time points.</i>
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Description

Creates the precision (inverse covariance) matrix of an AR(1) process with parameters ρ and σ , observed at the time points in the vector `times`. The process is assumed to be in stationarity and to have Gaussian errors.

Usage

```
ar1_prec_irregular(times, rho, sigma)
```

Arguments

<code>times</code>	An vector of positive integers, preferably ordered.
<code>rho</code>	A real number strictly less than 1 in absolute value.
<code>sigma</code>	A positive real number.

Value

A square matrix with `length(times)` rows.

Examples

```
library(Matrix)
times <- c(1, 4:5, 7)
rho <- 0.5
sigma <- 1
ar1_prec_irregular(times, rho, sigma)
```

ar1_sim_conditional *Simulate from a stationary Gaussian AR(1) process.*

Description

Simulate from a stationary Gaussian AR(1) process at n consecutive time points.

Usage

```
ar1_sim_conditional(pred_times, obs_times, x_obs, rho, sigma, mu_pred = 0,  
  mu_obs = 0)
```

Arguments

pred_times	A vector of time points to simulate at.
obs_times	A vector of time points at which observations have been made.
x_obs	The observed values of the process.
rho	A real number strictly less than 1 in absolute value.
sigma	A positive real number.
mu_pred	A vector or scalar with expected values.
mu_obs	A vector or scalar with expected values.

Value

A vector of length `length(pred_times)` with the process values.

Examples

```
t_pred <- c(1, 3, 6:8, 10)  
t_obs <- c(2, 5, 11:12)  
x_obs <- rnorm(4)  
rho <- 0.5  
sigma <- 1  
# Means equal 0  
ar1_sim_conditional(t_pred, t_obs, x_obs, rho, sigma)  
# Time-varying means  
mu_pred <- t_pred + rnorm(length(t_pred))  
mu_obs <- t_obs + rnorm(length(t_obs))  
ar1_sim_conditional(t_pred, t_obs, x_obs + mu_obs, rho, sigma,  
  mu_pred, mu_obs)
```

ar1_sim_consecutive *Simulate from a stationary Gaussian AR(1) process.*

Description

Simulate from a stationary Gaussian AR(1) process at n consecutive time points.

Usage

```
ar1_sim_consecutive(n, rho, sigma, mu = 0)
```

Arguments

n	The number of timepoints to simulate for.
rho	A real number strictly less than 1 in absolute value.
sigma	A positive real number.
mu	A vector of expected values with length n , or a scalar (default equal to 0).

Value

A vector of length n with the process values.

Examples

```
n <- 10
rho <- 0.5
sigma <- 1
mu <- 1:10
ar1_sim_consecutive(n, rho, sigma)
ar1_sim_consecutive(n, rho, sigma, mu)
```

ar1_sim_irregular *Simulate from a stationary Gaussian AR(1) process at irregular times.*

Description

Simulate from a stationary Gaussian AR(1) process at irregular times.

Usage

```
ar1_sim_irregular(times, rho, sigma, mu = 0)
```

Arguments

times	The time points to simulate for.
rho	A real number strictly less than 1 in absolute value.
sigma	A positive real number.
mu	A vector of expected values with length <code>length(times)</code> , or a scalar (default equal to 0).

Value

A vector of length `n` with the process values.

Examples

```
times <- c(3, 5:7, 10)
rho <- 0.5
sigma <- 1
mu <- seq_along(times)
ar1_sim_irregular(times, rho, sigma)
ar1_sim_irregular(times, rho, sigma, mu)
```

band1_backsolve *Backsolve with band 1 upper Cholesky.*

Description

Backsolve with band 1 upper Cholesky.

Usage

```
band1_backsolve(U, z)
```

Arguments

U	An upper triangular square matrix with non-zero entries only on the main diagonal and the first superdiagonal.
z	A vector with as many elements as the number of rows of U.

Value

A vector.

Examples

```
Q <- ar1_prec_irregular(c(1, 3:4, 6), 0.5, 1)
U <- chol_tridiag_upper(Q)
z <- rnorm(nrow(U))
band1_backsolve(U, z)
```

chol_tridiag_upper	<i>Upper Cholesky decomposition of a tridiagonal matrix.</i>
--------------------	--

Description

Creates the lower Cholesky decomposition of a tridiagonal matrix. The decomposition will be a sparse lower triangular matrix with non-zero elements only on the main diagonal and the diagonal below it.

Usage

```
chol_tridiag_upper(Q)
```

Arguments

Q A square tridiagonal matrix.

Value

A sparse square matrix with the same size as the input matrix.

Examples

```
library(Matrix)
times <- c(1, 4:5, 7)
rho <- 0.5
sigma <- 1
Q <- ar1_prec_irregular(times, rho, sigma)
chol_tridiag_upper(Q)
```

dprecchol_drho	<i>Derivative of the upper Cholesky triangle of the precision matrix of a stationary Gaussian AR(1) process.</i>
----------------	--

Description

Creates the derivative of the upper Cholesky triangle of the precision matrix of an AR(1) process with respect to the parameter rho.

Usage

```
dprecchol_drho(U, dQ)
```

Arguments

U The upper Cholesky triangle of the precision matrix Q of the AR(1) process.
dQ The derivative of the precision matrix Q with respect to the correlation parameter rho.

Value

A band 1 upper triangular matrix of the same dimensions as U.

Examples

```
library(Matrix)
t <- c(1, 3:4, 6, 8)
r <- 0.5
s <- 1
U <- ar1_prec_cho1_irregular(t, r, s)
dQ <- dprec_drho(t, r, s)
(dU <- dpreccho1_drho(U, dQ))
```

dprec_drho	<i>Derivative of the precision matrix for a stationary Gaussian AR(1) process.</i>
------------	--

Description

Creates the derivate of the precision matrix of an AR(1) process with respect to the parameter rho. The process has been observed at the time points in the vector times and is assumed to be in stationarity, and to have Gaussian errors.

Usage

```
dprec_drho(times, rho, sigma)
```

Arguments

times	An vector of positive integers, preferably ordered.
rho	A real number strictly less than 1 in absolute value.
sigma	A positive real number.

Value

A sparse square matrix with length(times) rows.

Examples

```
library(Matrix)
times <- c(1, 4:5, 7)
rho <- 0.5
sigma <- 1
dprec_drho(times, rho, sigma)
```

mult_U_band1U	<i>Multiply an upper triangular matrix with a band 1 upper triangular matrix.</i>
---------------	---

Description

Multiply an upper triangular matrix with a band 1 upper triangular matrix.

Usage

```
mult_U_band1U(A, U)
```

Arguments

A	A sparse upper triangular matrix.
U	A sparse band 1 upper triangular matrix of the same dimensions as A.

Value

A sparse band 1 upper triangular matrix.

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