Package 'matrixdist'

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Type Package

Title Statistics for Matrix Distributions

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Description Tools for phase-type distributions including the following variants:
continuous, discrete, multivariate, in-homogeneous, right-censored, and regression.
Methods for functional evaluation, simulation and estimation using the
expectation-maximization (EM) algorithm are provided for all models.
The methods of this package are based on the following references.
Asmussen, S., Nerman, O., & Olsson, M. (1996) <https://www.jstor.org/stable/4616418>,
Olsson, M. (1996) <https://www.jstor.org/stable/4616419>,
Albrecher, H., & Bladt, M. (2019) <doi:10.1017/jpr.2019.60>,
Albrecher, H., Bladt, M., & Yslas, J. (2020) <doi:10.1111/sjos.12505>,
Albrecher, H., Bladt, M., Bladt, M., & Yslas, J. (2022) <doi:10.1016/j.insmatheco.2022.08.001>,
Bladt, M., & Yslas, J. (2022) <doi:10.1080/03461238.2022.2097019>,
Bladt, M. (2022) <doi:10.1017/asb.2021.40>,
Bladt, M. (2022). <arXiv:2110.05179>,
Albrecher, H., Bladt, M., & Mueller, A. (2022) <arXiv:2207.01279>.

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License GPL-3

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R topics documented:

`matrixdist-package` *Statistics for Matrix Distributions*

Description

This package is concerned with homogeneous and inhomogeneous phase–type distributions. Methods for functional evaluation, simulation and estimation using the EM algorithm are provided.

Author(s)

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References

Asmussen, S., Nerman, O., & Olsson, M. (1996). Fitting phase-type distributions via the EM algorithm. Scandinavian Journal of Statistics, 419-441.

Olsson, M. (1996). Estimation of phase-type distributions from censored data. Scandinavian journal of statistics, 443-460.

Albrecher, H., & Bladt, M. (2019). Inhomogeneous phase-type distributions and heavy tails. Journal of Applied Probability, 56(4), 1044-1064.

Albrecher, H., Bladt, M., & Yslas, J. (2020). Fitting inhomogeneous Phase-Type distributions to data: The univariate and the multivariate case. Scandinavian Journal of Statistics.

Bladt, M., & Yslas, J. (2020). Inhomogeneous Markov Survival Regression Models. arXiv:2011.03219.

+,dph,dph-method *Sum Method for discrete phase-type distributions*

Description

Sum Method for discrete phase-type distributions

Usage

```
## S4 method for signature 'dph,dph'
e1 + e2
```

Arguments

e1	An object of class dph.
e2	An object of class dph.

Value

An object of class dph.

Examples

```
dph1 <- dph(structure = "general", dimension = 3)
dph2 <- dph(structure = "general", dimension = 5)
dph_sum <- dph1 + dph2
dph_sum
```

+,ph,ph-method *Sum Method for phase-type distributions*

Description

Sum Method for phase-type distributions

Usage

```
## S4 method for signature 'ph,ph'
e1 + e2
```

Arguments

e1	An object of class ph.
e2	An object of class ph.

Value

An object of class ph.

Examples

```
ph1 <- ph(structure = "general", dimension = 3)
ph2 <- ph(structure = "gcoxian", dimension = 5)
ph_sum <- ph1 + ph2
ph_sum
```

`a_rungekutta` *Runge-Kutta for the calculation of the a vector in a EM step*

Description

Runge-Kutta for the calculation of the a vector in a EM step

Usage

```
a_rungekutta(avector, dt, h, S)
```

Arguments

`avector`	The a vector.
`dt`	Increment.
`h`	Step-length.
`S`	Sub-intensity matrix.

`bivdph` *Constructor function for bivariate discrete phase-type distributions*

Description

Constructor function for bivariate discrete phase-type distributions

Usage

```
bivdph(alpha = NULL, S11 = NULL, S12 = NULL, S22 = NULL, dimensions = c(3, 3))
```

Arguments

`alpha`	A probability vector.
`S11`	A sub-transition matrix.
`S12`	A matrix.
`S22`	A sub-transition matrix.
`dimensions`	The dimensions of the bivariate discrete phase-type (if no parameters are provided).

Value

An object of class bivdph.

Examples

```
bivdph(dimensions = c(3, 3))
S11 <- matrix(c(0.1, .5, .5, 0.1), 2, 2)
S12 <- matrix(c(.2, .3, .2, .1), 2, 2)
S22 <- matrix(c(0.2, 0, 0.1, 0.1), 2, 2)
bivdph(alpha = c(.5, .5), S11, S12, S22)
```

---

bivdph-class *Bivariate discrete phase-type distributions*

Description

Class of objects for bivariate discrete phase-type distributions.

Value

Class object.

Slots

`name` Name of the discrete phase-type distribution.

`pars` A list comprising of the parameters.

`fit` A list containing estimation information.

---

bivdph_density *Bivariate discrete phase-type joint density of the feed forward type*

Description

Bivariate discrete phase-type joint density of the feed forward type

Usage

```
bivdph_density(x, alpha, S11, S12, S22)
```

Arguments

`x`	Matrix of values.
`alpha`	Vector of initial probabilities.
`S11`	Sub-transition matrix.
`S12`	Matrix.
`S22`	Sub-transition matrix.

Value

Joint density at x.

`bivdph_tail` *Bivariate discrete phase-type joint tail of the feed forward type*

Description

Bivariate discrete phase-type joint tail of the feed forward type

Usage

```
bivdph_tail(x, alpha, S11, S12, S22)
```

Arguments

x	Matrix of values.
alpha	Vector of initial probabilities.
S11	Sub-transition matrix.
S12	Matrix.
S22	Sub-transition matrix.

Value

Joint tail at x.

`biviph` *Constructor Function for bivariate inhomogeneous phase-type distributions*

Description

Constructor Function for bivariate inhomogeneous phase-type distributions

Usage

```
biviph(
  bivph = NULL,
  gfun = NULL,
  gfun_pars = NULL,
  alpha = NULL,
  S11 = NULL,
  S12 = NULL,
  S22 = NULL,
  dimensions = c(3, 3)
)
```

Arguments

bivph	An object of class bivph.
gfun	Vector of inhomogeneity transforms.
gfun_pars	List of parameters for the inhomogeneity functions.
alpha	A probability vector.
S11	A sub-intensity matrix.
S12	A matrix.
S22	A sub-intensity matrix.
dimensions	The dimensions of the bivariate phase-type (if no parameters are provided).

Value

An object of class biviph.

Examples

```
under_bivph <- bivph(dimensions = c(3, 3))
biviph(under_bivph, gfun = c("weibull", "pareto"), gfun_pars = list(c(2), c(3)))
```

---

biviph-class *Bivariate Inhomogeneous Phase Type distributions*

Description

Class of objects for bivariate inhomogeneous phase-type distributions.

Value

Class object.

Slots

name Name of the phase type distribution.

gfun A list comprising of the parameters.

bivph *Constructor function for bivariate phase-type distributions*

Description

Constructor function for bivariate phase-type distributions

Usage

```
bivph(alpha = NULL, S11 = NULL, S12 = NULL, S22 = NULL, dimensions = c(3, 3))
```

Arguments

alpha	A probability vector.
S11	A sub-intensity matrix.
S12	A matrix.
S22	A sub-intensity matrix.
dimensions	The dimensions of the bivariate phase-type (if no parameters are provided).

Value

An object of class bivph.

Examples

```
bivph(dimensions = c(3, 3))
S11 <- matrix(c(-1, .5, .5, -1), 2, 2)
S12 <- matrix(c(.2, .4, .3, .1), 2, 2)
S22 <- matrix(c(-2, 0, 1, -1), 2, 2)
bivph(alpha = c(.5, .5), S11, S12, S22)
```

bivph-class *Bivariate phase-type distributions*

Description

Class of objects for bivariate phase-type distributions.

Value

Class object.

Slots

name Name of the phase-type distribution.

pars A list comprising of the parameters.

fit A list containing estimation information.

bivph_density *Bivariate phase-type joint density of the feed forward type*

Description

Bivariate phase-type joint density of the feed forward type

Usage

```
bivph_density(x, alpha, S11, S12, S22)
```

Arguments

x	Matrix of values.
alpha	Vector of initial probabilities.
S11	Sub-intensity matrix.
S12	Matrix.
S22	Sub-intensity matrix.

Value

Joint density at x.

bivph_laplace *Bivariate phase-type joint Laplace*

Description

Bivariate phase-type joint Laplace

Usage

```
bivph_laplace(r, alpha, S11, S12, S22)
```

Arguments

r	Matrix of values.
alpha	Vector of initial probabilities.
S11	Sub-intensity matrix.
S12	Matrix.
S22	Sub-intensity matrix.

Value

Joint laplace at r.

bivph_tail *Bivariate phase-type joint tail of the feed forward type*

Description

Bivariate phase-type joint tail of the feed forward type

Usage

```
bivph_tail(x, alpha, S11, S12, S22)
```

Arguments

x	Matrix of values.
alpha	Vector of initial probabilities.
S11	Sub-intensity matrix.
S12	Matrix.
S22	Sub-intensity matrix.

Value

Joint tail at x.

cdf *New Generic for the Distribution of Matrix Distributions*

Description

Methods are available for objects of class ph.

Usage

```
cdf(x, ...)
```

Arguments

x	An object of the model class.
...	Further parameters to be passed on.

Value

CDF from the matrix distribution.

cdf,dph-method *Distribution Method for discrete phase-type distributions*

Description

Distribution Method for discrete phase-type distributions

Usage

```
## S4 method for signature 'dph'
cdf(x, q, lower.tail = TRUE)
```

Arguments

x	An object of class dph.
q	A vector of locations.
lower.tail	Logical parameter specifying whether lower tail (cdf) or upper tail is computed.

Value

A vector containing the CDF evaluations at the given locations.

Examples

```
obj <- dph(structure = "general")
cdf(obj, c(1, 2, 3))
```

cdf,iph-method *Distribution Method for inhomogeneous phase-type distributions*

Description

Distribution Method for inhomogeneous phase-type distributions

Usage

```
## S4 method for signature 'iph'
cdf(x, q, lower.tail = TRUE)
```

Arguments

x	An object of class iph.
q	A vector of locations.
lower.tail	Logical parameter specifying whether lower tail (cdf) or upper tail is computed.

Value

A vector containing the CDF evaluations at the given locations.

Examples

```
obj <- iph(ph(structure = "general"), gfun = "weibull", gfun_pars = 2)
cdf(obj, c(1, 2, 3))
```

`cdf,miph-method` *Distribution Method for multivariate inhomogeneous phase-type distributions*

Description

Distribution Method for multivariate inhomogeneous phase-type distributions

Usage

```
## S4 method for signature 'miph'
cdf(x, y, lower.tail = TRUE)
```

Arguments

`x`	An object of class miph.
`y`	A matrix of observations.
`lower.tail`	Logical parameter specifying whether lower tail (cdf) or upper tail is computed.

Value

A list containing the locations and corresponding CDF evaluations.

Examples

```
under_mph <- mph(structure = c("general", "general"))
obj <- miph(under_mph, gfun = c("weibull", "pareto"), gfun_pars = list(c(2), c(3)))
cdf(obj, c(1, 2))
```

cdf,mph-method *Distribution Method for multivariate phase-type distributions*

Description

Distribution Method for multivariate phase-type distributions

Usage

```
## S4 method for signature 'mph'
cdf(x, y, lower.tail = TRUE)
```

Arguments

x	An object of class mph.
y	A matrix of observations.
lower.tail	Logical parameter specifying whether lower tail (cdf) or upper tail is computed.

Value

A list containing the locations and corresponding CDF evaluations.

Examples

```
obj <- mph(structure = c("general", "general"))
cdf(obj, matrix(c(0.5, 1), ncol = 2))
```

cdf,ph-method *Distribution Method for phase-type distributions*

Description

Distribution Method for phase-type distributions

Usage

```
## S4 method for signature 'ph'
cdf(x, q, lower.tail = TRUE)
```

Arguments

x	An object of class ph.
q	A vector of locations.
lower.tail	Logical parameter specifying whether lower tail (cdf) or upper tail is computed.

Value

A vector containing the CDF evaluations at the given locations.

Examples

```
obj <- ph(structure = "general")
cdf(obj, c(1, 2, 3))
```

`clone_matrix` *Clone a matrix*

Description

Clone a matrix

Usage

```
clone_matrix(m)
```

Arguments

`m`	A matrix.

Value

A clone of the matrix.

`clone_vector` *Clone a vector*

Description

Clone a vector

Usage

```
clone_vector(v)
```

Arguments

`v`	A vector.

Value

A clone of the vector.

coef,bivdph-method *Coef method for bivdph class*

Description

Coef method for bivdph class

Usage

```
## S4 method for signature 'bivdph'
coef(object)
```

Arguments

object	An object of class bivdph.

Value

Parameters of bivariate discrete phase-type model.

Examples

```
obj <- bivdph(dimensions = c(3, 3))
coef(obj)
```

coef,biviph-method *Coef method for biviph class*

Description

Coef method for biviph class

Usage

```
## S4 method for signature 'biviph'
coef(object)
```

Arguments

object	An object of class biviph.

Value

Parameters of bivariate inhomogeneous phase-type model.

Examples

```
under_bivph <- bivph(dimensions = c(3, 3))
obj <- biviph(under_bivph, gfun = c("weibull", "pareto"), gfun_pars = list(c(2), c(3)))
coef(obj)
```

`coef,bivph-method` *Coef method for bivph class*

Description

Coef method for bivph class

Usage

```
## S4 method for signature 'bivph'
coef(object)
```

Arguments

`object`	An object of class bivph.

Value

Parameters of bivariate phase-type model.

Examples

```
obj <- bivph(dimensions = c(3, 3))
coef(obj)
```

`coef,dph-method` *Coef Method for dph Class*

Description

Coef Method for dph Class

Usage

```
## S4 method for signature 'dph'
coef(object)
```

Arguments

`object`	An object of class dph.

Value

Parameters of dph model.

Examples

```
obj <- dph(structure = "general", dim = 3)
coef(obj)
```

---

coef,iph-method *Coef Method for iph Class*

Description

Coef Method for iph Class

Usage

```
## S4 method for signature 'iph'
coef(object)
```

Arguments

object	An object of class iph.

Value

Parameters of iph model.

Examples

```
obj <- iph(ph(structure = "general", dimension = 2), gfun = "lognormal", gfun_pars = 2)
coef(obj)
```

---

coef,mdph-method *Coef method for mdph class*

Description

Coef method for mdph class

Usage

```
## S4 method for signature 'mdph'
coef(object)
```

Arguments

object	An object of class mdph.

Value

Parameters of multivariate discrete phase-type model.

Examples

```
obj <- mdph(structure = c("general", "general"))
coef(obj)
```

---

coef,ph-method *Coef Method for ph Class*

Description

Coef Method for ph Class

Usage

```
## S4 method for signature 'ph'
coef(object)
```

Arguments

object	An object of class ph.

Value

Parameters of ph model.

Examples

```
obj <- ph(structure = "general")
coef(obj)
```

coef,sph-method *Coef Method for sph Class*

Description

Coef Method for sph Class

Usage

```
## S4 method for signature 'sph'
coef(object)
```

Arguments

object	An object of class sph.

Value

Parameters of sph model.

cor,bivdph-method *Cor Method for bivdph class*

Description

Cor Method for bivdph class

Usage

```
## S4 method for signature 'bivdph'
cor(x)
```

Arguments

x	An object of class bivdph.

Value

The correlation matrix of the bivariate discrete phase-type distribution.

Examples

```
obj <- bivdph(dimensions = c(3, 3))
cor(obj)
```

cor,bivph-method *Cor Method for bivph class*

Description

Cor Method for bivph class

Usage

```
## S4 method for signature 'bivph'
cor(x)
```

Arguments

x	An object of class bivph.

Value

The correlation matrix of the bivariate phase-type distribution.

Examples

```
obj <- bivph(dimensions = c(3, 3))
cor(obj)
```

cor,mdph-method *Cor Method for multivariate discrete phase-type distributions*

Description

Cor Method for multivariate discrete phase-type distributions

Usage

```
## S4 method for signature 'mdph'
cor(x)
```

Arguments

x	An object of class mdph.

Value

The correlation matrix of the multivariate discrete phase-type distribution.

Examples

```
obj <- mdph(structure = c("general", "general"))
cor(obj)
```

cor,mph-method *Cor Method for multivariate phase-type distributions*

Description

Cor Method for multivariate phase-type distributions

Usage

```
## S4 method for signature 'mph'
cor(x)
```

Arguments

x	An object of class mph.

Value

The correlation matrix of the multivariate phase-type distribution.

Examples

```
obj <- mph(structure = c("general", "general"))
cor(obj)
```

cor,MPHstar-method *Cor Method for MPHstar class*

Description

Cor Method for MPHstar class

Usage

```
## S4 method for signature 'MPHstar'
cor(x)
```

Arguments

x	An object of class MPHstar.

Value

The correlation matrix of the MPHstar distribution.

Examples

```
obj <- MPHstar(structure = "general")
cor(obj)
```

cumulate_matrix *Cumulate matrix*

Description

Creates a new matrix with entries the cumulated rows of A.

Usage

```
cumulate_matrix(A)
```

Arguments

A	A matrix.

Value

The cumulated matrix.

cumulate_vector *Cumulate vector*

Description

Creates a new vector with entries the cumulated entries of A.

Usage

```
cumulate_vector(A)
```

Arguments

A	A vector.

Value

The cumulated vector.

default_step_length *Default size of the steps in the RK*

Description

Computes the default step length for a matrix `S` to be employed in the RK method.

Usage

```
default_step_length(S)
```

Arguments

`S`	Sub-intensity matrix.

Value

The step length for `S`.

dens *New Generic for the Density of Matrix Distributions*

Description

Methods are available for objects of class ph.

Usage

```
dens(x, ...)
```

Arguments

`x`	An object of the model class.
`...`	Further parameters to be passed on.

Value

Density from the matrix distribution.

dens,bivdph-method *Density method for bivariate discrete phase-type distributions*

Description

Density method for bivariate discrete phase-type distributions

Usage

```
## S4 method for signature 'bivdph'
dens(x, y)
```

Arguments

x	An object of class bivdph.
y	A matrix of locations.

Value

A vector containing the joint density evaluations at the given locations.

Examples

```
obj <- bivdph(dimensions = c(3, 3))
dens(obj, matrix(c(1, 2), ncol = 2))
```

dens,biviph-method *Density method for bivariate inhomogeneous phase-type distributions*

Description

Density method for bivariate inhomogeneous phase-type distributions

Usage

```
## S4 method for signature 'biviph'
dens(x, y)
```

Arguments

x	An object of class biviph.
y	A matrix of locations.

Value

A vector containing the joint density evaluations at the given locations.

Examples

```
under_bivph <- bivph(dimensions = c(3, 3))
obj <- biviph(under_bivph, gfun = c("weibull", "pareto"), gfun_pars = list(c(2), c(3)))
dens(obj, matrix(c(0.5, 1), ncol = 2))
```

---

dens,bivph-method *Density method for bivariate phase-type distributions*

Description

Density method for bivariate phase-type distributions

Usage

```
## S4 method for signature 'bivph'
dens(x, y)
```

Arguments

x	An object of class bivph.
y	A matrix of locations.

Value

A vector containing the joint density evaluations at the given locations.

Examples

```
obj <- bivph(dimensions = c(3, 3))
dens(obj, matrix(c(0.5, 1), ncol = 2))
```

---

dens,dph-method *Density Method for discrete phase-type distributions*

Description

Density Method for discrete phase-type distributions

Usage

```
## S4 method for signature 'dph'
dens(x, y)
```

Arguments

x	An object of class dph.
y	A vector of locations.

Value

A vector containing the density evaluations at the given locations.

Examples

```
obj <- dph(structure = "general")
dens(obj, c(1, 2, 3))
```

`dens,iph-method` *Density Method for inhomogeneous phase-type distributions*

Description

Density Method for inhomogeneous phase-type distributions

Usage

```
## S4 method for signature 'iph'
dens(x, y)
```

Arguments

x	An object of class iph.
y	A vector of locations.

Value

A vector containing the density evaluations at the given locations.

Examples

```
obj <- iph(ph(structure = "general"), gfun = "weibull", gfun_pars = 2)
dens(obj, c(1, 2, 3))
```

`dens,mdph-method` *Density method for multivariate discrete phase-type distributions*

Description

Density method for multivariate discrete phase-type distributions

Usage

```
## S4 method for signature 'mdph'
dens(x, y)
```

Arguments

x	An object of class mdph.
y	A matrix of locations.

Value

A vector containing the joint density evaluations at the given locations.

Examples

```
obj <- mdph(structure = c("general", "general"))
dens(obj, matrix(c(1, 1), ncol = 2))
```

---

dens,miph-method *Density Method for multivariate inhomogeneous phase-type distributions*

Description

Density Method for multivariate inhomogeneous phase-type distributions

Usage

```
## S4 method for signature 'miph'
dens(x, y, delta = NULL)
```

Arguments

x	An object of class miph.
y	A matrix of observations.
delta	Matrix with right-censoring indicators (1 uncensored, 0 right censored).

Value

A list containing the locations and corresponding density evaluations.

Examples

```
under_mph <- mph(structure = c("general", "general"))
obj <- miph(under_mph, gfun = c("weibull", "pareto"), gfun_pars = list(c(2), c(3)))
dens(obj, c(1, 2))
```

dens,mph-method *Density Method for multivariate phase-type distributions*

Description

Density Method for multivariate phase-type distributions

Usage

```
## S4 method for signature 'mph'
dens(x, y, delta = NULL)
```

Arguments

x	An object of class mph.
y	A matrix of observations.
delta	Matrix with right-censoring indicators (1 uncensored, 0 right censored).

Value

A list containing the locations and corresponding density evaluations.

Examples

```
obj <- mph(structure = c("general", "general"))
dens(obj, matrix(c(0.5, 1), ncol = 2))
```

dens,ph-method *Density Method for phase-type distributions*

Description

Density Method for phase-type distributions

Usage

```
## S4 method for signature 'ph'
dens(x, y)
```

Arguments

x	An object of class ph.
y	A vector of locations.

Value

A vector containing the density evaluations at the given locations.

Examples

```
obj <- ph(structure = "general")
dens(obj, c(1, 2, 3))
```

---

dph *Constructor Function for discrete phase-type distributions*

Description

Constructor Function for discrete phase-type distributions

Usage

```
dph(alpha = NULL, S = NULL, structure = NULL, dimension = 3)
```

Arguments

alpha	A probability vector.
S	A sub-transition matrix.
structure	A valid dph structure ("general", "coxian", "hyperexponential", "gcoxian", "gerlang").
dimension	The dimension of the dph structure (if structure is provided).

Value

An object of class dph.

Examples

```
dph(structure = "general", dim = 5)
dph(alpha = c(0.5, 0.5), S = matrix(c(0.1, 0.5, 0.5, 0.2), 2, 2))
```

dph-class *Discrete Phase Type distributions*

Description

Class of objects for discrete phase-type distributions.

Value

Class object.

Slots

`name` Name of the discrete phase-type distribution.

`pars` A list comprising of the parameters.

`fit` A list containing estimation information.

dphcdf *Discrete phase-type cdf*

Description

Computes the cdf (tail) of a discrete phase-type distribution with parameters `alpha` and `S` at `x`.

Usage

```
dphcdf(x, alpha, S, lower_tail = TRUE)
```

Arguments

`x`	Non-negative value.
`alpha`	Initial probabilities.
`S`	Sub-intensity matrix.
`lower_tail`	Cdf or tail.

Value

The cdf (tail) at `x`.

dphdensity *Discrete phase-type density*

Description

Computes the density of discrete phase-type distribution with parameters `alpha` and `S` at `x`.

Usage

```
dphdensity(x, alpha, S)
```

Arguments

`x`	Non-negative value.
`alpha`	Initial probabilities.
`S`	Sub-transition matrix.

Value

The density at `x`.

dph_pgf *Pgf of a discrete phase-type distribution*

Description

Computes the pgf at `z` of a discrete phase-type distribution with parameters `alpha` and `S`.

Usage

```
dph_pgf(z, alpha, S)
```

Arguments

`z`	Vector of real values.
`alpha`	Vector of initial probabilities.
`S`	Sub-transition matrix.

Value

Laplace transform at `r`.

embedded_mc *Embedded Markov chain of a sub-intensity matrix*

Description

Returns the transition probabilities of the embedded Markov chain determined the sub-intensity matrix.

Usage

```
embedded_mc(S)
```

Arguments

S	A sub-intensity matrix.

Value

The embedded Markov chain.

EMstep_bivdph *EM for discrete bivariate phase-type*

Description

EM for discrete bivariate phase-type

Usage

```
EMstep_bivdph(alpha, S11, S12, S22, obs, weight)
```

Arguments

alpha	Initial probabilities.
S11	Sub-transition matrix.
S12	Matrix.
S22	Sub-transition matrix.
obs	The observations.
weight	The weights for the observations.

EMstep_bivdph_MoE *EM for discrete bivariate phase-type MoE*

Description

EM for discrete bivariate phase-type MoE

Usage

```
EMstep_bivdph_MoE(alpha, S11, S12, S22, obs, weight)
```

Arguments

alpha	Initial probabilities.
S11	Sub-transition matrix.
S12	Matrix.
S22	Sub-transition matrix.
obs	The observations.
weight	The weights for the observations.

EMstep_bivph *EM for bivariate phase-type distributions using Pade for matrix exponential*

Description

EM for bivariate phase-type distributions using Pade for matrix exponential

Usage

```
EMstep_bivph(alpha, S11, S12, S22, obs, weight)
```

Arguments

alpha	Initial probabilities.
S11	Sub-intensity.
S12	A matrix.
S22	Sub-intensity.
obs	The observations.
weight	The weights for the observations.

Value

Fitted alpha, S11, S12 and S22 after one iteration.

EMstep_dph *EM for discrete phase-type*

Description

EM for discrete phase-type

Usage

```
EMstep_dph(alpha, S, obs, weight)
```

Arguments

alpha	Initial probabilities.
S	Sub-transition matrix.
obs	The observations.
weight	The weights for the observations.

EMstep_dph_MoE *EM for discrete phase-type MoE*

Description

EM for discrete phase-type MoE

Usage

```
EMstep_dph_MoE(alpha, S, obs, weight)
```

Arguments

alpha	Initial probabilities.
S	Sub-transition matrix.
obs	The observations.
weight	The weights for the observations.

EMstep_mdph *EM for multivariate discrete phase-type*

Description

EM for multivariate discrete phase-type

Usage

```
EMstep_mdph(alpha, S_list, obs, weight)
```

Arguments

alpha	Initial probabilities.
S_list	List of marginal sub-transition matrices.
obs	The observations.
weight	The weights for the observations.

EMstep_mdph_MoE *EM for multivariate discrete phase-type MoE*

Description

EM for multivariate discrete phase-type MoE

Usage

```
EMstep_mdph_MoE(alpha, S_list, obs, weight)
```

Arguments

alpha	Initial probabilities.
S_list	List of marginal sub-transition matrices.
obs	The observations.
weight	The weights for the observations.

EMstep_MoE_PADE *EM for PH-MoE*

Description

No recycling of information

Usage

```
EMstep_MoE_PADE(alpha, S, obs, weight, rcens, rcweight)
```

Arguments

alpha	Initial probabilities.
S	Sub-intensity matrix.
obs	The observations.
weight	The weights for the observations.
rcens	Censored observations.
rcweight	The weights for the censored observations.

EMstep_PADE *EM for phase-type distributions using Pade approximation for matrix exponential*

Description

EM for phase-type distributions using Pade approximation for matrix exponential

Usage

```
EMstep_PADE(h, alpha, S, obs, weight, rcens, rcweight)
```

Arguments

h	Nuisance parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
obs	The observations.
weight	The weights for the observations.
rcens	Censored observations.
rcweight	The weights for the censored observations.

EMstep_RK *EM step for phase-type using Runge-Kutta*

Description

Computes one step of the EM algorithm by using a Runge-Kutta method of fourth order.

Usage

```
EMstep_RK(h, alpha, S, obs, weight, rcens, rcweight)
```

Arguments

h	Step-length.
alpha	Initial probabilities.
S	Sub-intensity matrix.
obs	The observations.
weight	The weights for the observations.
rcens	Censored observations.
rcweight	The weights for the censored observations.

EMstep_UNI *EM for phase-type using uniformization for matrix exponential*

Description

EM for phase-type using uniformization for matrix exponential

Usage

```
EMstep_UNI(h, alpha, S, obs, weight, rcens, rcweight)
```

Arguments

h	Positive parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
obs	The observations.
weight	The weights for the observations.
rcens	Censored observations.
rcweight	The weights for the censored observations.

EM_step_mPH_rc — *EM step for the mPH class with right-censoring, for different marginal sub-intensity matrices*

Description

EM step for the mPH class with right-censoring, for different marginal sub-intensity matrices

Usage

```
EM_step_mPH_rc(alpha, S_list, y, delta, h)
```

Arguments

alpha	Common initial distribution vector.
S_list	List of marginal sub-intensity matrices.
y	Matrix of marginal observations.
delta	Matrix with right-censoring indications (1 uncensored, 0 right-censored).
h	Tolerance of uniformization.

evaluate — *New Generic for Evaluating Survival Matrix Distributions*

Description

Methods are available for objects of class sph.

Usage

```
evaluate(x, subject, ...)
```

Arguments

x	An object of the model class.
subject	A vector of data.
...	Further parameters to be passed on.

evaluate,sph-method *Evaluation Method for sph Class*

Description

Evaluation Method for sph Class

Usage

```
## S4 method for signature 'sph'
evaluate(x, subject)
```

Arguments

x	An object of class sph.
subject	Covariates of a single subject.

Value

A ph model.

expmat *Matrix exponential*

Description

Armadillo matrix exponential implementation.

Usage

```
expmat(A)
```

Arguments

A	A matrix.

Value

exp(A).

expm_terms *expm terms of phase-type likelihood using uniformization*

Description

expm terms of phase-type likelihood using uniformization

Usage

```
expm_terms(h, S, obs)
```

Arguments

h	Positive parameter.
S	Sub-intensity matrix.
obs	The observations.

find_n *Find n such that P(N > n) = h with N Poisson distributed*

Description

Find n such that P(N > n) = h with N Poisson distributed

Usage

```
find_n(h, lambda)
```

Arguments

h	Probability.
lambda	Mean of Poisson random variable.

Value

Integer satisfying condition.

`find_weight` *Find weight of observations*

Description

Find weight of observations

Usage

```
find_weight(x)
```

Arguments

`x`	A vector of observations from which we want to know their weights.

Value

A matrix with unique observations as fisrt column and associated weights for second column.

`Fisher` *New Generic for obtaining the Fisher Information of Survival Matrix Distributions*

Description

Methods are available for objects of class sph.

Usage

```
Fisher(x, ...)
```

Arguments

`x`	An object of the model class.
`...`	Further parameters to be passed on.

Fisher,sph-method *Fisher Information Method for sph Class*

Description

Fisher Information Method for sph Class

Usage

```
## S4 method for signature 'sph'
Fisher(x, y, X, w = numeric(0))
```

Arguments

x	An object of class sph.
y	Independent variate.
X	Matrix of covariates.
w	Weights.

Value

A matrix.

fit *New Generic for Estimating Matrix Distributions*

Description

Methods are available for objects of class ph.

Usage

```
fit(x, y, ...)
```

Arguments

x	An object of the model class.
y	A vector of data.
...	Further parameters to be passed on.

Value

An object of the fitted model class.

fit,bivdph-method *Fit Method for bivdph Class*

Description

Fit Method for bivdph Class

Usage

```
## S4 method for signature 'bivdph'
fit(x, y, weight = numeric(0), stepsEM = 1000, every = 10)
```

Arguments

x	An object of class bivdph.
y	A matrix with the data.
weight	Vector of weights.
stepsEM	Number of EM steps to be performed.
every	Number of iterations between likelihood display updates.

Value

An object of class bivdph.

Examples

```
obj <- bivdph(dimensions = c(3, 3))
data <- sim(obj, n = 100)
fit(obj, data, stepsEM = 100, every = 50)
```

fit,bivph-method *Fit Method for bivph Class*

Description

Fit Method for bivph Class

Usage

```
## S4 method for signature 'bivph'
fit(
  x,
  y,
  weight = numeric(0),
  stepsEM = 1000,
  maxit = 100,
  reltol = 1e-08,
  every = 10
)
```

Arguments

x	An object of class bivph.
y	A matrix with the data.
weight	Vector of weights.
stepsEM	Number of EM steps to be performed.
maxit	Maximum number of iterations when optimizing g functions.
reltol	Relative tolerance when optimizing g functions.
every	Number of iterations between likelihood display updates.

Value

An object of class bivph.

Examples

```
obj <- bivph(dimensions = c(3, 3))
data <- sim(obj, n = 100)
fit(obj, data, stepsEM = 100, every = 50)
```

---

fit,dph-method *Fit Method for dph Class*

Description

Fit Method for dph Class

Usage

```
## S4 method for signature 'dph'
fit(x, y, weight = numeric(0), stepsEM = 1000, every = 100)
```

Arguments

x	An object of class dph.
y	Vector or data.
weight	Vector of weights.
stepsEM	Number of EM steps to be performed.
every	Number of iterations between likelihood display updates.

Value

An object of class dph.

Examples

```
obj <- dph(structure = "general", dimension = 2)
data <- sim(obj, n = 100)
fit(obj, data, stepsEM = 100, every = 20)
```

---

fit,mdph-method *Fit Method for mdph Class*

Description

Fit Method for mdph Class

Usage

```
## S4 method for signature 'mdph'
fit(x, y, weight = numeric(0), stepsEM = 1000, every = 10)
```

Arguments

x	An object of class mdph.
y	A matrix with the data.
weight	Vector of weights.
stepsEM	Number of EM steps to be performed.
every	Number of iterations between likelihood display updates.

Value

An object of class mdph.

Examples

```
obj <- mdph(structure = c("general", "general"))
data <- sim(obj, n = 100)
fit(obj, data, stepsEM = 100, every = 50)
```

`fit,mph-method` *Fit Method for mph Class*

Description

Fit Method for mph Class

Usage

```
## S4 method for signature 'mph'
fit(
  x,
  y,
  delta = numeric(0),
  stepsEM = 1000,
  equal_marginals = FALSE,
  r = 1,
  maxit = 100,
  reltol = 1e-08
)
```

Arguments

`x`	An object of class mph.
`y`	Matrix of data.
`delta`	Matrix with right-censoring indicators. (1 uncensored, 0 right censored)
`stepsEM`	Number of EM steps to be performed.
`equal_marginals`	Logical. If TRUE, all marginals are fitted to be equal.
`r`	Sub-sampling parameter, defaults to 1.
`maxit`	Maximum number of iterations when optimizing g function.
`reltol`	Relative tolerance when optimizing g function.

Examples

```
obj <- mph(structure = c("general", "coxian"))
data <- sim(obj, 100)
fit(x = obj, y = data, stepsEM = 20)
```

`fit,MPHstar-method` *Fit Method for mph Class*

Description

Fit Method for mph Class

Usage

```
## S4 method for signature 'MPHstar'
fit(
  x,
  y,
  weight = numeric(0),
  stepsEM = 1000,
  uni_epsilon = 1e-04,
  zero_tol = 1e-04,
  every = 100,
  plot = F,
  r = 1,
  replace = F
)
```

Arguments

`x`	An object of class MPHstar.
`y`	A matrix of marginal data.
`weight`	A matrix of marginal weights.
`stepsEM`	The number of EM steps to be performed, defaults to 1000.
`uni_epsilon`	The epsilon parameter for the uniformization method, defaults to 1e-4.
`zero_tol`	The smallest value that a reward can take (to avoid numerical instability), defaults to 1e-4.
`every`	The number of iterations between likelihood display updates. The originating distribution is used, given that there is no explicit density.
`plot`	Boolean that determines if the plot of the loglikelihood evolution is plotted, defaults to False.
`r`	The sub-sampling proportion for stochastic EM, defaults to 1.
`replace`	Boolean that determines if sub-sampling is done with replacement or not, defaults to False.

Value

An object of class MPHstar.

Examples

```
set.seed(123)
obj <- MPHstar(structure = "general")
data <- sim(obj, 100)
fit(obj, data, stepsEM = 20)
```

`fit,ph-method` *Fit Method for ph Class*

Description

Fit Method for ph Class

Usage

```
## S4 method for signature 'ph'
fit(
  x,
  y,
  weight = numeric(0),
  rcen = numeric(0),
  rcenweight = numeric(0),
  stepsEM = 1000,
  methods = c("RK", "RK"),
  rkstep = NA,
  uni_epsilon = NA,
  maxit = 100,
  reltol = 1e-08,
  every = 100,
  r = 1
)
```

Arguments

`x`	An object of class ph.
`y`	Vector or data.
`weight`	Vector of weights.
`rcen`	Vector of right-censored observations
`rcenweight`	Vector of weights for right-censored observations.
`stepsEM`	Number of EM steps to be performed.
`methods`	Methods to use for matrix exponential calculation: RM, UNI or PADE.
`rkstep`	Runge-Kutta step size (optional).
`uni_epsilon`	Epsilon parameter for uniformization method.
`maxit`	Maximum number of iterations when optimizing g function.

reltol	Relative tolerance when optimizing g function.
every	Number of iterations between likelihood display updates.
r	Sub-sampling proportion for stochastic EM, defaults to 1.

Value

An object of class ph.

Examples

```
obj <- iph(ph(structure = "general", dimension = 2), gfun = "weibull", gfun_pars = 2)
data <- sim(obj, n = 100)
fit(obj, data, stepsEM = 100, every = 20)
```

---

haz *New Generic for the Hazard rate of Matrix Distributions*

Description

Methods are available for objects of class ph.

Usage

```
haz(x, ...)
```

Arguments

x	An object of the model class.
...	Further parameters to be passed on.

Value

Hazard rate from the matrix distribution.

haz,ph-method *Hazard rate Method for phase-type distributions*

Description

Hazard rate Method for phase-type distributions

Usage

```
## S4 method for signature 'ph'
haz(x, y)
```

Arguments

x	An object of class ph.
y	A vector of locations.

Value

A vector containing the hazard rate evaluations at the given locations.

Examples

```
obj <- ph(structure = "general")
haz(obj, c(1, 2, 3))
```

inf_norm *L inf norm of a matrix*

Description

Computes the L inf norm of a matrix A, which is defined as: L_inf(A) = max(1 <= i <= M) sum(1 <= j <= N) abs(A(i,j)).

Usage

```
inf_norm(A)
```

Arguments

A	A matrix.

Value

The L inf norm.

initial_state *Initial state of Markov jump process*

Description

Given the accumulated values of the initial probabilities `alpha` and a uniform value `u`, it returns the initial state of a Markov jump process. This corresponds to the states satisfying cum_alpha_(k-1) < u < cum_alpha_(k).

Usage

```
initial_state(cum_alpha, u)
```

Arguments

`cum_alpha`	A cummulated vector of initial probabilities.
`u`	Random value in (0,1).

Value

Initial state of the Markov jump process.

iph *Constructor Function for inhomogeneous phase-type distributions*

Description

Constructor Function for inhomogeneous phase-type distributions

Usage

```
iph(
  ph = NULL,
  gfun = NULL,
  gfun_pars = NULL,
  alpha = NULL,
  S = NULL,
  structure = NULL,
  dimension = 3,
  scale = 1
)
```

Arguments

ph	An object of class ph.
gfun	Inhomogeneity transform.
gfun_pars	The parameters of the inhomogeneity function.
alpha	A probability vector.
S	A sub-intensity matrix.
structure	A valid ph structure.
dimension	The dimension of the ph structure (if provided).
scale	Scale.

Value

An object of class iph.

Examples

```
iph(ph(structure = "coxian", dimension = 4), gfun = "pareto", gfun_pars = 3)
```

---

iph-class *Inhomogeneous Phase Type distributions*

Description

Class of objects for inhomogeneous phase-type distributions.

Value

Class object.

Slots

`name` Name of the phase-type distribution.

`gfun` A list comprising of the parameters.

`scale` Scale.

laplace *New Generic for Laplace transform of Matrix Distributions*

Description

Methods are available for objects of class ph.

Usage

```
laplace(x, ...)
```

Arguments

x	An object of the model class.
...	Further parameters to be passed on.

Value

Laplace transform of the matrix distribution.

laplace,bivph-method *Laplace Method for bivph class*

Description

Laplace Method for bivph class

Usage

```
## S4 method for signature 'bivph'
laplace(x, r)
```

Arguments

x	An object of class mph.
r	A matrix of real values.

Value

A vector containing the corresponding Laplace transform evaluations.

Examples

```
obj <- bivph(dimensions = c(3, 3))
laplace(obj, matrix(c(0.5, 1), ncol = 2))
```

laplace,mph-method *Laplace Method for multivariate phase-type distributions*

Description

Laplace Method for multivariate phase-type distributions

Usage

```
## S4 method for signature 'mph'
laplace(x, r)
```

Arguments

x	An object of class mph.
r	A matrix of real values.

Value

A vector containing the corresponding Laplace transform evaluations.

Examples

```
set.seed(123)
obj <- mph(structure = c("general", "general"))
laplace(obj, matrix(c(0.5, 1), ncol = 2))
```

laplace,ph-method *Laplace Method for phase-type distributions*

Description

Laplace Method for phase-type distributions

Usage

```
## S4 method for signature 'ph'
laplace(x, r)
```

Arguments

x	An object of class ph.
r	A vector of real values.

Value

The Laplace transform of the ph (or undelying ph) object at the given locations.

Examples

```
set.seed(123)
obj <- ph(structure = "general", dimension = 3)
laplace(obj, 3)
```

`linCom` *New generic for linear combinations of multivariate matrix distributions*

Description

Methods are available for objects of multivariate classes.

Usage

```
linCom(x, ...)
```

Arguments

`x`	An object of the model class.
`...`	Further parameters to be passed on.

Value

Marginal of the matrix distribution.

`linCom,bivph-method` *Linear Combination method for bivariate phase-type distributions*

Description

Linear Combination method for bivariate phase-type distributions

Usage

```
## S4 method for signature 'bivph'
linCom(x, w = c(1, 1))
```

Arguments

`x`	An object of class bivph.
`w`	A vector with non-negative entries.

Value

An object of class ph.

Examples

```
obj <- bivph(dimensions = c(3, 3))
linCom(obj, c(1, 0))
```

`linCom,MPHstar-method` *Linear Combination method for MPHstar class*

Description

Linear Combination method for MPHstar class

Usage

```
## S4 method for signature 'MPHstar'
linCom(x, w)
```

Arguments

`x`	An object of class MPHstar.
`w`	A vector with non-negative entries.

Value

An object of class ph.

Examples

```
obj <- MPHstar(structure = "general")
linCom(obj, c(1, 0))
```

`linear_combination` *Computes PH parameters of a linear combination of vector from MPHstar*

Description

Computes PH parameters of a linear combination of vector from MPHstar

Usage

```
linear_combination(w, alpha, S, R)
```

Arguments

w	Vector with weights.
alpha	Initial distribution vector.
S	Sub-intensity matrix.
R	Reward matrix.

Value

A list of PH parameters.

---

logLik,ph-method *logLik Method for ph Class*

Description

logLik Method for ph Class

Usage

```
## S4 method for signature 'ph'
logLik(object)
```

Arguments

object	An object of class ph.

Value

An object of class logLik.

Examples

```
obj <- iph(ph(structure = "general", dimension = 2), gfun = "weibull", gfun_pars = 2)
data <- sim(obj, n = 100)
fitted_ph <- fit(obj, data, stepsEM = 10)
logLik(fitted_ph)
```

logLikelihoodbivDPH *Loglikelihood for bivariate discrete phase-type*

Description

Loglikelihood for bivariate discrete phase-type

Usage

```
logLikelihoodbivDPH(alpha, S11, S12, S22, obs, weight)
```

Arguments

alpha	Initial probabilities.
S11	Sub-transition matrix.
S12	Matrix.
S22	Sub-transition matrix.
obs	The observations.
weight	The weights of the observations.

logLikelihoodbivDPH_MoE *Loglikelihood for bivariate discrete phase-type MoE*

Description

Loglikelihood for bivariate discrete phase-type MoE

Usage

```
logLikelihoodbivDPH_MoE(alpha, S11, S12, S22, obs, weight)
```

Arguments

alpha	Initial probabilities.
S11	Sub-transition matrix.
S12	Matrix.
S22	Sub-transition matrix.
obs	The observations.
weight	The weights of the observations.

logLikelihoodbivPH *Loglikelihood for Bivariate PH*

Description

Loglikelihood for Bivariate PH

Usage

```
logLikelihoodbivPH(alpha, S11, S12, S22, obs, weight)
```

Arguments

alpha	Vector of initial probabilities.
S11	Sub-intensity matrix.
S12	Matrix.
S22	Sub-intensity matrix.
obs	The observations.
weight	The weights of the observations.

logLikelihoodDPH *Loglikelihood for discrete phase-type*

Description

Loglikelihood for discrete phase-type

Usage

```
logLikelihoodDPH(alpha, S, obs, weight)
```

Arguments

alpha	Initial probabilities.
S	Sub-transition matrix.
obs	The observations.
weight	The weights of the observations.

logLikelihoodDPH_MoE *Loglikelihood for discrete phase-type MoE*

Description

Loglikelihood for discrete phase-type MoE

Usage

```
logLikelihoodDPH_MoE(alpha, S, obs, weight)
```

Arguments

alpha	Initial probabilities.
S	Sub-transition matrix.
obs	The observations.
weight	The weights of the observations.

logLikelihoodmDPH *Loglikelihood for multivariate discrete phase-type*

Description

Loglikelihood for multivariate discrete phase-type

Usage

```
logLikelihoodmDPH(alpha, S_list, obs, weight)
```

Arguments

alpha	Initial probabilities.
S_list	List of marginal sub-transition matrices.
obs	The observations.
weight	The weights of the observations.

logLikelihoodmDPH_MoE *Loglikelihood for multivariate discrete phase-type MoE*

Description

Loglikelihood for multivariate discrete phase-type MoE

Usage

```
logLikelihoodmDPH_MoE(alpha, S_list, obs, weight)
```

Arguments

alpha	Initial probabilities.
S_list	List of marginal sub-transition matrices.
obs	The observations.
weight	The weights of the observations.

logLikelihoodMgev_PADE *Loglikelihood of matrix-GEV using Pade*

Description

Loglikelihood for a sample

Usage

```
logLikelihoodMgev_PADE(h, alpha, S, beta, obs, weight, rcens, rcweight)
```

Arguments

h	Nuisance parameter.
alpha	Initial probabilities.
S	sub-intensity matrix.
beta	Inhomogeneity parameter.
obs	The observations.
weight	The weights of the observations.
rcens	Censored observations.
rcweight	The weights of the censored observations.

logLikelihoodMgev_RK *Loglikelihood of matrix-GEV using Runge-Kutta*

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMgev_RK(h, alpha, S, beta, obs, weight, rcens, rcweight)
```

Arguments

h	Step-length.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Parameter of transformation
obs	The observations.
weight	Weights of the observations.
rcens	Censored observations.
rcweight	Weights of the censored observations.

logLikelihoodMgev_UNI *Loglikelihood of matrix-GEV using uniformization*

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMgev_UNI(h, alpha, S, beta, obs, weight, rcens, rcweight)
```

Arguments

h	Positive parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Parameter of transformation.
obs	The observations.
weight	Weights of the observations.
rcens	censored observations.
rcweight	Weights of the censored observations.

logLikelihoodMgompertz_PADE

Loglikelihood of matrix-Gompertz using Pade

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMgompertz_PADE(h, alpha, S, beta, obs, weight, rcens, rcweight)
```

Arguments

h	Nuisance parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Inhomogeneity parameter.
obs	The observations.
weight	The weights of the observations.
rcens	Censored observations.
rcweight	The weights of the censored observations.

logLikelihoodMgompertz_PADEs

Loglikelihood of PI with matrix-Gompertz using Pade

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMgompertz_PADEs(
  h,
  alpha,
  S,
  beta,
  obs,
  weight,
  rcens,
  rcweight,
  scale1,
  scale2
)
```

Arguments

h	Nuisance parameter.
alpha	Initial probabilities.
S	Sub-intensity.
beta	Inhomogeneity parameter.
obs	The observations.
weight	Weights of the observations.
rcens	Censored observations.
rcweight	Weights of the censored observations.
scale1	Scale for observations.
scale2	Scale for censored observations.

---

logLikelihoodMgompertz_RK

Loglikelihood of matrix-Gompertz using Runge-Kutta

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMgompertz_RK(h, alpha, S, beta, obs, weight, rcens, rcweight)
```

Arguments

h	Step-length.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Parameter of transformation.
obs	The observations.
weight	Weights of the observations.
rcens	Censored observations.
rcweight	Weights of the censored observations.

`logLikelihoodMgompertz_RKs` *Loglikelihood of PI with matrix-Gompertz using Runge-Kutta*

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMgompertz_RKs(
  h,
  alpha,
  S,
  beta,
  obs,
  weight,
  rcens,
  rcweight,
  scale1,
  scale2
)
```

Arguments

`h`	Step-length.
`alpha`	Initial probabilities.
`S`	Sub-intensity matrix.
`beta`	Parameter of transformation.
`obs`	The observations.
`weight`	Weights of the observations.
`rcens`	Censored observations.
`rcweight`	Weights of the censored observations.
`scale1`	Scale for observations.
`scale2`	Scale for censored observations.

logLikelihoodMgompertz_UNI *Loglikelihood of matrix-Gompertz using uniformization*

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMgompertz_UNI(h, alpha, S, beta, obs, weight, rcens, rcweight)
```

Arguments

h	Positive parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Parameter of transformation.
obs	The observations.
weight	Weights of the observations.
rcens	censored observations.
rcweight	Weights of the censored observations.

logLikelihoodMgompertz_UNIs *Loglikelihood of PI with matrix-Gompertz using Uniformization*

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMgompertz_UNIs(
  h,
  alpha,
  S,
  beta,
  obs,
  weight,
  rcens,
  rcweight,
  scale1,
  scale2
)
```

Arguments

h	Positive parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Parameter of transformation.
obs	The observations.
weight	Weights of the observations.
rcens	Censored observations.
rcweight	Weights of the censored observations.
scale1	Scale for observations.
scale2	Scale for censored observations.

---

logLikelihoodMloglogistic_PADE

Loglikelihood of matrix-loglogistic using Pade

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMloglogistic_PADE(h, alpha, S, beta, obs, weight, rcens, rcweight)
```

Arguments

h	Nuisance parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Inhomogeneity parameter.
obs	The observations.
weight	The weights of the observations.
rcens	Censored observations.
rcweight	The weights of the censored observations.

`logLikelihoodMloglogistic_PADEs` *Loglikelihood of PI with matrix-loglogistic using Pade*

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMloglogistic_PADEs(
  h,
  alpha,
  S,
  beta,
  obs,
  weight,
  rcens,
  rcweight,
  scale1,
  scale2
)
```

Arguments

`h`	Nuisance parameter.
`alpha`	Initial probabilities.
`S`	Sub-intensity matrix.
`beta`	Inhomogeneity parameter.
`obs`	The observations.
`weight`	Weights of the observations.
`rcens`	Censored observations.
`rcweight`	Weights of the censored observations.
`scale1`	Scale for observations.
`scale2`	Scale for censored observations.

logLikelihoodMloglogistic_RK

Loglikelihood of matrix-loglogistic using Runge-Kutta

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMloglogistic_RK(h, alpha, S, beta, obs, weight, rcens, rcweight)
```

Arguments

h	Step-length.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Parameters of transformation.
obs	The observations.
weight	Weights of the observations.
rcens	Censored observations.
rcweight	Weights of the censored observations.

logLikelihoodMloglogistic_RKs

Loglikelihood of PI with matrix-loglogistic using Runge-Kutta

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMloglogistic_RKs(
  h,
  alpha,
  S,
  beta,
  obs,
  weight,
  rcens,
  rcweight,
  scale1,
  scale2
)
```

Arguments

h	Step-length.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Parameters of transformation.
obs	The observations.
weight	Weights of the observations.
rcens	Censored observations.
rcweight	Weights of the censored observations.
scale1	Scale for observations.
scale2	Scale for censored observations.

---

logLikelihoodMloglogistic_UNI

Loglikelihood of matrix-loglogistic using uniformization

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMloglogistic_UNI(h, alpha, S, beta, obs, weight, rcens, rcweight)
```

Arguments

h	Positive parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Parameter of transformation.
obs	The observations.
weight	Weights of the observations.
rcens	censored observations.
rcweight	Weights of the censored observations.

`logLikelihoodMloglogistic_UNIs` *Loglikelihood of PI with matrix-loglogistic using uniformization*

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMloglogistic_UNIs(
  h,
  alpha,
  S,
  beta,
  obs,
  weight,
  rcens,
  rcweight,
  scale1,
  scale2
)
```

Arguments

`h`	Positive parameter.
`alpha`	Initial probabilities.
`S`	Sub-intensity matrix.
`beta`	Parameter of transformation.
`obs`	The observations.
`weight`	Weights of the observations.
`rcens`	Censored observations.
`rcweight`	Weights of the censored observations.
`scale1`	Scale for observations.
`scale2`	Scale for censored observations.

logLikelihoodMlognormal_PADE

Loglikelihood of matrix-lognormal using Pade

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMlognormal_PADE(h, alpha, S, beta, obs, weight, rcens, rcweight)
```

Arguments

h	Nuisance parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Inhomogeneity parameter.
obs	The observations.
weight	The weights of the observations.
rcens	Censored observations.
rcweight	The weights of the censored observations.

logLikelihoodMlognormal_PADEs

Loglikelihood of PI with matrix-lognormal using Pade

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMlognormal_PADEs(
  h,
  alpha,
  S,
  beta,
  obs,
  weight,
  rcens,
  rcweight,
  scale1,
  scale2
)
```

Arguments

h	Nuisance parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Inhomogeneity parameter.
obs	The observations.
weight	Weights of the observations.
rcens	Censored observations.
rcweight	Weights of the censored observations.
scale1	Scale for observations.
scale2	Scale for censored observations.

---

logLikelihoodMlognormal_RK

Loglikelihood of matrix-lognormal using Runge-Kutta

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMlognormal_RK(h, alpha, S, beta, obs, weight, rcens, rcweight)
```

Arguments

h	Step-length.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Parameter of transformation.
obs	The observations.
weight	Weights of the observations.
rcens	Censored observations.
rcweight	Weights of the censored observations.

`logLikelihoodMlognormal_RKs` *Loglikelihood of PI matrix-lognormal using Runge-Kutta*

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMlognormal_RKs(
  h,
  alpha,
  S,
  beta,
  obs,
  weight,
  rcens,
  rcweight,
  scale1,
  scale2
)
```

Arguments

`h`	Step-length.
`alpha`	Initial probabilities.
`S`	Sub-intensity matrix.
`beta`	Parameter of transformation.
`obs`	The observations.
`weight`	Weights of the observations.
`rcens`	Censored observations.
`rcweight`	Weights of the censored observations.
`scale1`	Scale for observations.
`scale2`	Scale for censored observations.

logLikelihoodMlognormal_UNI

Loglikelihood of matrix-lognormal using uniformization

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMlognormal_UNI(h, alpha, S, beta, obs, weight, rcens, rcweight)
```

Arguments

h	Positive parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Parameter of transformation.
obs	The observations.
weight	Weights of the observations.
rcens	censored observations.
rcweight	Weights of the censored observations.

logLikelihoodMlognormal_UNIs

Loglikelihood of PI with matrix-lognormal using uniformization

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMlognormal_UNIs(
  h,
  alpha,
  S,
  beta,
  obs,
  weight,
  rcens,
  rcweight,
  scale1,
  scale2
)
```

Arguments

h	Positive parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Parameter of transformation.
obs	The observations.
weight	Weights of the observations.
rcens	Censored observations.
rcweight	Weights of the censored observations.
scale1	Scale for observations.
scale2	Scale for censored observations.

---

logLikelihoodMpareto_PADE

Loglikelihood of matrix-Pareto using Pade

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMpareto_PADE(h, alpha, S, beta, obs, weight, rcens, rcweight)
```

Arguments

h	Nuisance parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Inhomogeneity parameter.
obs	The observations.
weight	The weights of the observations.
rcens	Censored observations.
rcweight	The weights of the censored observations.

logLikelihoodMpareto_PADEs *Loglikelihood of PI with matrix-Pareto using Pade*

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMpareto_PADEs(
  h,
  alpha,
  S,
  beta,
  obs,
  weight,
  rcens,
  rcweight,
  scale1,
  scale2
)
```

Arguments

h	Nuisance parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Inhomogeneity parameter.
obs	The observations.
weight	Weights of the observations.
rcens	Censored observations.
rcweight	Weights of the censored observations.
scale1	Scale for observations.
scale2	Scale for censored observations.

logLikelihoodMpareto_RK

Loglikelihood of matrix-Pareto using Runge-Kutta

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMpareto_RK(h, alpha, S, beta, obs, weight, rcens, rcweight)
```

Arguments

h	Step-length.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Parameter of transformation.
obs	The observations.
weight	Weights of the observations.
rcens	Censored observations.
rcweight	Weights of the censored observations.

logLikelihoodMpareto_RKs

Loglikelihood of PI with matrix-Pareto using Runge-Kutta

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMpareto_RKs(
  h,
  alpha,
  S,
  beta,
  obs,
  weight,
  rcens,
  rcweight,
  scale1,
  scale2
)
```

Arguments

h	Step-length.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Parameter of transformation.
obs	The observations.
weight	Weights of the observations.
rcens	Censored observations.
rcweight	Weights of the censored observations.
scale1	Scale for observations.
scale2	Scale for censored observations.

---

logLikelihoodMpareto_UNI

Loglikelihood of matrix-Pareto using uniformization

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMpareto_UNI(h, alpha, S, beta, obs, weight, rcens, rcweight)
```

Arguments

h	Positive parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Parameter of transformation.
obs	The observations.
weight	Weights of the observations.
rcens	censored observations.
rcweight	Weights of the censored observations.

`logLikelihoodMpareto_UNIs` *Loglikelihood of PI with matrix-Pareto using uniformization*

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMpareto_UNIs(
  h,
  alpha,
  S,
  beta,
  obs,
  weight,
  rcens,
  rcweight,
  scale1,
  scale2
)
```

Arguments

`h`	Positive parameter.
`alpha`	Initial probabilities.
`S`	Sub-intensity matrix.
`beta`	Parameter of transformation.
`obs`	The observations.
`weight`	Weights of the observations.
`rcens`	Censored observations.
`rcweight`	Weights of the censored observations.
`scale1`	Scale for observations.
`scale2`	Scale for censored observations.

logLikelihoodMweibull_PADE

Loglikelihood of matrix-Weibull using Pade

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMweibull_PADE(h, alpha, S, beta, obs, weight, rcens, rcweight)
```

Arguments

h	Nuisance parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Inhomogeneity parameter.
obs	The observations.
weight	The weights of the observations.
rcens	Censored observations.
rcweight	The weights of the censored observations.

logLikelihoodMweibull_PADEs

Loglikelihood of PI with matrix-Weibull using Pade

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMweibull_PADEs(
  h,
  alpha,
  S,
  beta,
  obs,
  weight,
  rcens,
  rcweight,
  scale1,
  scale2
)
```

Arguments

h	Nuisance parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Inhomogeneity parameter.
obs	The observations.
weight	The weights of the observations.
rcens	Censored observations.
rcweight	The weights of the censored observations.
scale1	Scale for observations.
scale2	Scale for censored observations.

---

logLikelihoodMweibull_RK

Loglikelihood of matrix-Weibull using Runge-Kutta

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMweibull_RK(h, alpha, S, beta, obs, weight, rcens, rcweight)
```

Arguments

h	Step-length.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Parameter of transformation.
obs	The observations.
weight	Weights of the observations.
rcens	Censored observations.
rcweight	Weights of the censored observations.

`logLikelihoodMweibull_RKs` *Loglikelihood of PI with matrix-Weibull using Runge-Kutta*

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMweibull_RKs(
  h,
  alpha,
  S,
  beta,
  obs,
  weight,
  rcens,
  rcweight,
  scale1,
  scale2
)
```

Arguments

`h`	Step-length.
`alpha`	Initial probabilities.
`S`	Sub-intensity matrix.
`beta`	Parameter of transformation.
`obs`	The observations.
`weight`	Weights of the observations.
`rcens`	Censored observations.
`rcweight`	Weights of the censored observations.
`scale1`	Scale for observations.
`scale2`	Scale for censored observations.

logLikelihoodMweibull_UNI

Loglikelihood of matrix-Weibull using uniformization

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMweibull_UNI(h, alpha, S, beta, obs, weight, rcens, rcweight)
```

Arguments

h	Positive parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Parameter of transformation.
obs	The observations.
weight	Weights of the observations.
rcens	censored observations.
rcweight	Weights of the censored observations.

logLikelihoodMweibull_UNIs

Loglikelihood of PI with matrix-Weibull using uniformization

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodMweibull_UNIs(
  h,
  alpha,
  S,
  beta,
  obs,
  weight,
  rcens,
  rcweight,
  scale1,
  scale2
)
```

Arguments

h	Positive parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Parameter of transformation.
obs	The observations.
weight	Weights of the observations.
rcens	Censored observations.
rcweight	Weights of the censored observations.
scale1	Scale for observations.
scale2	Scale for censored observations.

---

logLikelihoodPH_MoE *Loglikelihood for PH-MoE*

Description

Loglikelihood for PH-MoE

Usage

```
logLikelihoodPH_MoE(alpha1, alpha2, S, obs, weight, rcens, rcweight)
```

Arguments

alpha1	Initial probabilities for non-censored data.
alpha2	Initial probabilities for censored data.
S	Sub-intensity matrix.
obs	The observations.
weight	The weights of the observations.
rcens	Censored observations.
rcweight	The weights of the censored observations.

logLikelihoodPH_PADE *Loglikelihood of phase-type using Pade approximation*

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodPH_PADE(h, alpha, S, obs, weight, rcens, rcweight)
```

Arguments

h	Nuisance parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
obs	The observations.
weight	The weights of the observations.
rcens	Censored observations.
rcweight	The weights of the censored observations.

logLikelihoodPH_PADEs *Loglikelihood of PI with phase-type using Pade*

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodPH_PADEs(
  h,
  alpha,
  S,
  obs,
  weight,
  rcens,
  rcweight,
  scale1,
  scale2
)
```

Arguments

h	Nuisance parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
obs	The observations.
weight	The weights of the observations.
rcens	Censored observations.
rcweight	The weights of the censored observations.
scale1	Scale for observations.
scale2	Scale for censored observations.

---

logLikelihoodPH_RK *Loglikelihood of phase-type using Runge-Kutta*

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodPH_RK(h, alpha, S, obs, weight, rcens, rcweight)
```

Arguments

h	Step-length.
alpha	Initial probabilities.
S	Sub-intensity matrix.
obs	The observations.
weight	Weights of the observations.
rcens	Censored observations.
rcweight	Weights of the censored observations.

logLikelihoodPH_RKs *Loglikelihood of PI with phase-type using Runge-Kutta*

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodPH_RKs(h, alpha, S, obs, weight, rcens, rcweight, scale1, scale2)
```

Arguments

h	Step-length.
alpha	Initial probabilities.
S	Sub-intensity matrix.
obs	The observations.
weight	Weights of the observations.
rcens	Censored observations.
rcweight	Weights of the censored observations.
scale1	Scale for observations.
scale2	Scale for censored observations.

logLikelihoodPH_UNI *Loglikelihood of phase-type using uniformization*

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodPH_UNI(h, alpha, S, obs, weight, rcens, rcweight)
```

Arguments

h	Positive parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
obs	The observations.
weight	Weights of the observations.
rcens	Censored observations.
rcweight	Weights of the censored observations.

logLikelihoodPH_UNIs *Loglikelihood of PI with phase-type using uniformization*

Description

Loglikelihood for a sample.

Usage

```
logLikelihoodPH_UNIs(h, alpha, S, obs, weight, rcens, rcweight, scale1, scale2)
```

Arguments

h	Positive parameter.
alpha	Initial probabilities.
S	Sub-intensity matrix.
obs	The observations.
weight	Weights of the observations.
rcens	Censored observations.
rcweight	Weights of the censored observations.
scale1	Scale for observations.
scale2	Scale for censored observations.

LRT *New Generic for doing a likelihood ratio test between two Matrix Distribution models*

Description

Methods are available for objects of class ph.

Usage

```
LRT(x, y, ...)
```

Arguments

x, y	Objects of the model class.
...	Further parameters to be passed on.

Value

A likelihood ratio test result.

LRT,ph,ph-method *LRT Method for ph Class*

Description

LRT Method for ph Class

Usage

```
## S4 method for signature 'ph,ph'
LRT(x, y)
```

Arguments

x, y	Objects of class ph.

Value

LRT between the models.

marginal *New generic for the marginals of multivariate matrix distributions*

Description

Methods are available for objects of multivariate classes.

Usage

```
marginal(x, ...)
```

Arguments

x	An object of the model class.
...	Further parameters to be passed on.

Value

Marginal of the matrix distribution.

marginal,bivdph-method

Marginal method for bivdph class

Description

Marginal method for bivdph class

Usage

```
## S4 method for signature 'bivdph'
marginal(x, mar = 1)
```

Arguments

x	An object of class bivdph.
mar	Indicator of which marginal.

Value

An object of the of class dph.

Examples

```
obj <- bivdph(dimensions = c(3, 3))
marginal(obj, 1)
```

marginal,biviph-method

Marginal method for biviph class

Description

Marginal method for biviph class

Usage

```
## S4 method for signature 'biviph'
marginal(x, mar = 1)
```

Arguments

x	An object of class biviph.
mar	Indicator of which marginal.

Value

An object of the of class iph.

Examples

```
under_bivph <- bivph(dimensions = c(3, 3))
obj <- biviph(under_bivph, gfun = c("weibull", "pareto"), gfun_pars = list(c(2), c(3)))
marginal(obj, 1)
```

`marginal,bivph-method` *Marginal method for bivph class*

Description

Marginal method for bivph class

Usage

```
## S4 method for signature 'bivph'
marginal(x, mar = 1)
```

Arguments

`x`	An object of class bivph.
`mar`	Indicator of which marginal.

Value

An object of the of class ph.

Examples

```
obj <- bivph(dimensions = c(3, 3))
marginal(obj, 1)
```

marginal,mdph-method *Marginal method for mdph class*

Description

Marginal method for mdph class

Usage

```
## S4 method for signature 'mdph'
marginal(x, mar = 1)
```

Arguments

x	An object of class mdph.
mar	Indicator of which marginal.

Value

An object of the of class dph.

Examples

```
obj <- mdph(structure = c("general", "general"))
marginal(obj, 1)
```

marginal,miph-method *Marginal method for multivariate inhomogeneous phase-type distributions*

Description

Marginal method for multivariate inhomogeneous phase-type distributions

Usage

```
## S4 method for signature 'miph'
marginal(x, mar = 1)
```

Arguments

x	An object of class miph.
mar	Indicator of which marginal.

Value

An object of the of class iph.

Examples

```
under_mph <- mph(structure = c("general", "general"))
obj <- miph(under_mph, gfun = c("weibull", "pareto"), gfun_pars = list(c(2), c(3)))
marginal(obj, 1)
```

`marginal,mph-method` *Marginal method for multivariate phase-type distributions*

Description

Marginal method for multivariate phase-type distributions

Usage

```
## S4 method for signature 'mph'
marginal(x, mar = 1)
```

Arguments

`x`	An object of class mph.
`mar`	Indicator of which marginal.

Value

An object of the of class ph.

Examples

```
obj <- mph(structure = c("general", "general"))
marginal(obj, 1)
```

`marginal,MPHstar-method`
Marginal method for MPHstar class

Description

Marginal method for MPHstar class

Usage

```
## S4 method for signature 'MPHstar'
marginal(x, mar = 1)
```

Arguments

x	An object of class MPHstar.
mar	Indicator of which marginal.

Value

An object of the of class ph.

Examples

```
obj <- MPHstar(structure = "general")
marginal(obj, 1)
```

---

marginal_expectation *Marginal conditional expectations*

Description

Marginal conditional expectations

Usage

```
marginal_expectation(rew, pos, N, alpha, S, obs, weight)
```

Arguments

rew	Column of the reward matrix corresponding to its marginal.
pos	Vector that indicates which state is associated to a positive reward.
N	Uniformization parameter.
alpha	Marginal initial distribution vector.
S	Marginal sub-intensity matrix.
obs	Marginal observations.
weight	Marginal weights.

Value

A vector with the expected time spent in each state by the marginal, conditional on the observations.

matrix_exponential *Matrix exponential*

Description

MATLAB's built-in algorithm for matrix exponential - Pade approximation.

Usage

```
matrix_exponential(A)
```

Arguments

A	A matrix.

Value

exp(A).

matrix_inverse *Inverse of a matrix*

Description

Inverse of a matrix

Usage

```
matrix_inverse(A)
```

Arguments

A	A matrix.

Value

Inverse of A.

matrix_power *Computes A^n*

Description

Computes A^n

Usage

```
matrix_power(n, A)
```

Arguments

n	An integer.
A	A matrix.

Value

A^n.

matrix_product *Product of two matrices*

Description

Product of two matrices

Usage

```
matrix_product(A1, A2)
```

Arguments

A1	A matrix.
A2	A matrix.

Value

Computes A1 * A2.

matrix_vanloan *Creates the matrix (A1, B1 ; 0, A2)*

Description

Creates the matrix (A1, B1 ; 0, A2)

Usage

```
matrix_vanloan(A1, A2, B1)
```

Arguments

A1	Matrix.
A2	Matrix.
B1	Matrix.

Value

Computes (A1, B1 ; 0, A2).

maximum *New Generic for Maximum of two Matrix Distributions*

Description

Methods are available for objects of class ph.

Usage

```
maximum(x1, x2, ...)
```

Arguments

x1	An object of the model class.
x2	An object of the model class.
...	Further parameters to be passed on.

Value

An object of the model class.

maximum,dph,dph-method

Maximum Method for discrete phase-type distributions

Description

Maximum Method for discrete phase-type distributions

Usage

```
## S4 method for signature 'dph,dph'
maximum(x1, x2)
```

Arguments

x1	An object of class dph.
x2	An object of class dph.

Value

An object of class dph.

Examples

```
dph1 <- dph(structure = "general", dimension = 3)
dph2 <- dph(structure = "general", dimension = 5)
dph_max <- maximum(dph1, dph2)
dph_max
```

maximum,iph,iph-method

Maximum Method for inhomogeneous phase-type distributions

Description

Maximum Method for inhomogeneous phase-type distributions

Usage

```
## S4 method for signature 'iph,iph'
maximum(x1, x2)
```

Arguments

x1	An object of class iph.
x2	An object of class iph.

Value

An object of class iph.

Examples

```
iph1 <- iph(ph(structure = "general", dimension = 3), gfun = "weibull", gfun_pars = 2)
iph2 <- iph(ph(structure = "gcoxian", dimension = 5), gfun = "weibull", gfun_pars = 2)
iph_min <- maximum(iph1, iph2)
iph_min
```

---

maximum,ph,ph-method *Maximum Method for phase-type distributions*

Description

Maximum Method for phase-type distributions

Usage

```
## S4 method for signature 'ph,ph'
maximum(x1, x2)
```

Arguments

x1	An object of class ph.
x2	An object of class ph.

Value

An object of class ph.

Examples

```
ph1 <- ph(structure = "general", dimension = 3)
ph2 <- ph(structure = "gcoxian", dimension = 5)
ph_max <- maximum(ph1, ph2)
ph_max
```

max_diagonal *Maximum diagonal element of a matrix*

Description

Maximum diagonal element of a matrix

Usage

```
max_diagonal(A)
```

Arguments

A	Matrix.

Value

The maximum value in the diagonal.

mdph *Constructor Function for multivariate discrete phase-type distributions*

Description

Constructor Function for multivariate discrete phase-type distributions

Usage

```
mdph(alpha = NULL, S = NULL, structure = NULL, dimension = 3, variables = NULL)
```

Arguments

alpha	A probability vector.
S	A list of sub-transition matrices.
structure	A vector of valid ph structures.
dimension	The dimension of the dph structure (if provided).
variables	The dimension of the multivariate discrete phase-type.

Value

An object of class mdph.

mdph-class *Multivariate Discrete Phase Type distributions*

Description

Class of objects for multivariate discrete phase-type distributions.

Value

Class object.

Slots

`name` Name of the discrete phase type distribution.

`pars` A list comprising of the parameters.

`fit` A list containing estimation information.

mdphdensity *Multivariate discrete phase-type density*

Description

Computes the density of multivariate discrete phase-type distribution with parameters `alpha` and `S` at `x`.

Usage

```
mdphdensity(x, alpha, S_list)
```

Arguments

`x`	Matrix of positive integer values.
`alpha`	Initial probabilities.
`S_list`	List of marginal sub-transition matrices.

Value

The density at `x`.

mean,bivdph-method *Mean Method for bivdph class*

Description

Mean Method for bivdph class

Usage

```
## S4 method for signature 'bivdph'
mean(x)
```

Arguments

x	An object of class bivdph.

Value

The mean of the bivariate discrete phase-type distribution.

Examples

```
obj <- bivdph(dimensions = c(3, 3))
mean(obj)
```

mean,bivph-method *Mean Method for bivph class*

Description

Mean Method for bivph class

Usage

```
## S4 method for signature 'bivph'
mean(x)
```

Arguments

x	An object of class bivph.

Value

The mean of the bivariate phase-type distribution.

Examples

```
obj <- bivph(dimensions = c(3, 3))
mean(obj)
```

mean,dph-method *Mean Method for discrete phase-type distributions*

Description

Mean Method for discrete phase-type distributions

Usage

```
## S4 method for signature 'dph'
mean(x)
```

Arguments

x	An object of class dph.

Value

The raw first moment of the dph object.

Examples

```
set.seed(123)
obj <- dph(structure = "general", dimension = 3)
mean(obj)
```

mean,mdph-method *Mean Method for multivariate discrete phase-type distributions*

Description

Mean Method for multivariate discrete phase-type distributions

Usage

```
## S4 method for signature 'mdph'
mean(x)
```

Arguments

x	An object of class mdph.

Value

The mean of the multivariate discrete phase-type distribution.

Examples

```
obj <- mdph(structure = c("general", "general"))
mean(obj)
```

---

mean,mph-method *Mean Method for multivariate phase-type distributions*

Description

Mean Method for multivariate phase-type distributions

Usage

```
## S4 method for signature 'mph'
mean(x)
```

Arguments

x	An object of class mph.

Value

The mean of the multivariate phase-type distribution.

Examples

```
obj <- mph(structure = c("general", "general"))
mean(obj)
```

---

mean,MPHstar-method *Mean Method for MPHstar class*

Description

Mean Method for MPHstar class

Usage

```
## S4 method for signature 'MPHstar'
mean(x)
```

Arguments

x	An object of class MPHstar.

Value

The mean of MPHstar distribution.

Examples

```
obj <- MPHstar(structure = "general")
mean(obj)
```

`mean,ph-method` *Mean Method for phase-type distributions*

Description

Mean Method for phase-type distributions

Usage

```
## S4 method for signature 'ph'
mean(x)
```

Arguments

`x`	An object of class ph.

Value

The raw first moment of the ph (or undelying ph) object.

Examples

```
set.seed(123)
obj <- ph(structure = "general", dimension = 3)
mean(obj)
```

`merge_matrices` *Merges the matrices S11, S12 and S22 into a sub-intensity matrix*

Description

Merges the matrices S11, S12 and S22 into a sub-intensity matrix

Usage

```
merge_matrices(S11, S12, S22)
```

Arguments

S11	A sub-intensity matrix.
S12	A matrix.
S22	A sub-intensity matrix.

Value

A sub-intensity matrix.

---

mgevcdf *Matrix-GEV cdf*

Description

Computes the cdf (tail) of a matrix-GEV distribution with parameters alpha, S and beta at x.

Usage

```
mgevcdf(x, alpha, S, beta, lower_tail = TRUE)
```

Arguments

x	Non-negative value.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Transformation parameters.
lower_tail	Cdf or tail.

Value

The cdf (tail) at x.

mgevden *Matrix-GEV density*

Description

Computes the density of a matrix-GEV distribution with parameters `alpha`, `S` and `beta` at `x`. Does not allow for atoms in zero.

Usage

```
mgevden(x, alpha, S, beta)
```

Arguments

`x`	Non-negative value.
`alpha`	Initial probabilities.
`S`	Sub-intensity matrix.
`beta`	Transformation parameters.

Value

The density at `x`.

mgf *New Generic for mgf of Matrix Distributions*

Description

Methods are available for objects of class ph.

Usage

```
mgf(x, ...)
```

Arguments

`x`	An object of the model class.
`...`	Further parameters to be passed on.

Value

Mgf transform of the matrix distribution.

mgf,bivph-method *Mgf Method for bivph class*

Description

Mgf Method for bivph class

Usage

```
## S4 method for signature 'bivph'
mgf(x, r)
```

Arguments

x	An object of class mph.
r	A matrix of real values.

Value

A vector containing the corresponding mgf evaluations.

Examples

```
set.seed(123)
obj <- bivph(dimensions = c(3, 3))
mgf(obj, matrix(c(0.5, 0.1), ncol = 2))
```

mgf,mph-method *Mgf Method for multivariate phase-type distributions*

Description

Mgf Method for multivariate phase-type distributions

Usage

```
## S4 method for signature 'mph'
mgf(x, r)
```

Arguments

x	An object of class mph.
r	A matrix of real values.

Value

A vector containing the corresponding mgf evaluations.

Examples

```
set.seed(124)
obj <- mph(structure = c("general", "general"))
mgf(obj, matrix(c(0.5, 0.3), ncol = 2))
```

`mgf,ph-method` *Mgf Method for phase-type distributions*

Description

Mgf Method for phase-type distributions

Usage

```
## S4 method for signature 'ph'
mgf(x, r)
```

Arguments

`x`	An object of class ph.
`r`	A vector of real values.

Value

The mgf of the ph (or undelying ph) object at the given locations.

Examples

```
set.seed(123)
obj <- ph(structure = "general", dimension = 3)
mgf(obj, 0.4)
```

mgompertzcdf *Matrix-Gompertz cdf*

Description

Computes the cdf (tail) of a matrix-Gompertz distribution with parameters `alpha`, `S` and `beta` at `x`.

Usage

```
mgompertzcdf(x, alpha, S, beta, lower_tail = TRUE)
```

Arguments

`x`	Non-negative value.
`alpha`	Initial probabilities.
`S`	Sub-intensity matrix.
`beta`	Shape parameter.
`lower_tail`	Cdf or tail.

Value

The cdf (tail) at `x`.

mgompertzden *Matrix-Gompertz density*

Description

Computes the density of a matrix-Gompertz distribution with parameters `alpha`, `S` and `beta` at `x`.

Usage

```
mgompertzden(x, alpha, S, beta)
```

Arguments

`x`	Non-negative value.
`alpha`	Initial probabilities.
`S`	Sub-intensity matrix.
`beta`	Shape parameter.

Value

The density at `x`.

`minimum` *New Generic for Minimum of two Matrix Distributions*

Description

Methods are available for objects of class ph.

Usage

```
minimum(x1, x2, ...)
```

Arguments

`x1`	An object of the model class.
`x2`	An object of the model class.
`...`	Further parameters to be passed on.

Value

An object of the model class.

`minimum,dph,dph-method`
Minimum Method for discrete phase-type distributions

Description

Minimum Method for discrete phase-type distributions

Usage

```
## S4 method for signature 'dph,dph'
minimum(x1, x2)
```

Arguments

`x1`	An object of class dph.
`x2`	An object of class dph.

Value

An object of class dph.

Examples

```
dph1 <- dph(structure = "general", dimension = 3)
dph2 <- dph(structure = "general", dimension = 5)
dph_min <- minimum(dph1, dph2)
dph_min
```

---

minimum,iph,iph-method *Minimum Method for inhomogeneous phase-type distributions*

Description

Minimum Method for inhomogeneous phase-type distributions

Usage

```
## S4 method for signature 'iph,iph'
minimum(x1, x2)
```

Arguments

x1	An object of class iph.
x2	An object of class iph.

Value

An object of class iph.

Examples

```
iph1 <- iph(ph(structure = "general", dimension = 3), gfun = "weibull", gfun_pars = 2)
iph2 <- iph(ph(structure = "gcoxian", dimension = 5), gfun = "weibull", gfun_pars = 2)
iph_min <- minimum(iph1, iph2)
iph_min
```

---

minimum,ph,ph-method *Minimum Method for phase-type distributions*

Description

Minimum Method for phase-type distributions

Usage

```
## S4 method for signature 'ph,ph'
minimum(x1, x2)
```

Arguments

x1	An object of class ph.
x2	An object of class ph.

Value

An object of class ph.

Examples

```
ph1 <- ph(structure = "general", dimension = 3)
ph2 <- ph(structure = "gcoxian", dimension = 5)
ph_min <- minimum(ph1, ph2)
ph_min
```

---

miph *Constructor Function for multivariate inhomogeneous phase-type distributions*

Description

Constructor Function for multivariate inhomogeneous phase-type distributions

Usage

```
miph(
  mph = NULL,
  gfun = NULL,
  gfun_pars = NULL,
  alpha = NULL,
  S = NULL,
  structure = NULL,
  dimension = 3,
  variables = NULL,
  scale = 1
)
```

Arguments

mph	An object of class mph.
gfun	Vector of inhomogeneity transforms.
gfun_pars	List of parameters for the inhomogeneity functions.
alpha	A probability vector.
S	A list of sub-intensity matrices.
structure	A vector of valid ph structures.

dimension	The dimension of the ph structure (if provided).
variables	Number of marginals.
scale	Scale.

Value

An object of class iph.

Examples

```
under_mph <- mph(structure = c("gcoxian", "general"), dimension = 4)
miph(under_mph, gfun = c("weibull", "pareto"), gfun_pars = list(c(2), c(3)))
```

---

miph-class *Multivariate Inhomogeneous Phase Type distributions*

Description

Class of objects for multivariate inhomogeneous phase-type distributions.

Value

Class object.

Slots

name Name of the phase type distribution.

gfun A list comprising of the parameters.

scale Scale.

---

mixture *New Generic for Mixture of two Matrix Distributions*

Description

Methods are available for objects of classes ph and dph.

Usage

```
mixture(x1, x2, ...)
```

Arguments

x1	An object of the model class.
x2	An object of the model class.
...	Further parameters to be passed on.

Value

An object of the model class.

`mixture,dph,dph-method`
Mixture Method for phase-type distributions

Description

Mixture Method for phase-type distributions

Usage

```
## S4 method for signature 'dph,dph'
mixture(x1, x2, prob)
```

Arguments

`x1`	An object of class dph.
`x2`	An object of class dph.
`prob`	Probability for first object.

Value

An object of class dph.

Examples

```
dph1 <- dph(structure = "general", dimension = 3)
dph2 <- dph(structure = "general", dimension = 5)
dph_mix <- mixture(dph1, dph2, 0.5)
dph_mix
```

`mixture,ph,ph-method` *Mixture Method for phase-type distributions*

Description

Mixture Method for phase-type distributions

Usage

```
## S4 method for signature 'ph,ph'
mixture(x1, x2, prob)
```

Arguments

x1	An object of class ph.
x2	An object of class ph.
prob	Probability for first object.

Value

An object of class ph.

Examples

```
ph1 <- ph(structure = "general", dimension = 3)
ph2 <- ph(structure = "gcoxian", dimension = 5)
ph_mix <- mixture(ph1, ph2, 0.5)
ph_mix
```

---

mloglogisticcdf *Matrix-loglogistic cdf*

Description

Computes the cdf (tail) of a matrix-loglogistic distribution with parameters alpha, S and beta at x.

Usage

```
mloglogisticcdf(x, alpha, S, beta, lower_tail = TRUE)
```

Arguments

x	Non-negative value.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Transformation parameters.
lower_tail	Cdf or tail.

Value

The cdf (tail) at x.

mloglogisticden *Matrix-loglogistic density*

Description

Computes the density of a matrix-loglogistic distribution with parameters `alpha`, `S` and `beta` at `x`.

Usage

```
mloglogisticden(x, alpha, S, beta)
```

Arguments

`x`	Non-negative value.
`alpha`	Initial probabilities.
`S`	Sub-intensity matrix.
`beta`	Transformation parameters.

Value

The density at `x`.

mlognormalcdf *Matrix-lognormal cdf*

Description

Computes the cdf (tail) of a matrix-lognormal distribution with parameters `alpha`, `S` and `beta` at `x`.

Usage

```
mlognormalcdf(x, alpha, S, beta, lower_tail = TRUE)
```

Arguments

`x`	Non-negative value.
`alpha`	Initial probabilities.
`S`	Sub-intensity matrix.
`beta`	Shape parameter.
`lower_tail`	Cdf or tail.

Value

The cdf (tail) at `x`.

mlognormalden *Matrix-lognormal density*

Description

Computes the density of a matrix-lognormal distribution with parameters `alpha`, `S` and `beta` at `x`.

Usage

```
mlognormalden(x, alpha, S, beta)
```

Arguments

`x`	Non-negative value.
`alpha`	Initial probabilities.
`S`	Sub-intensity matrix.
`beta`	Shape parameter.

Value

The density at `x`.

MoE *New Generic for Regression with Matrix Distributions*

Description

Methods are available for objects of class ph

Usage

```
MoE(x, y, ...)
```

Arguments

`x`	An object of the model class.
`y`	A vector of data.
`...`	Further parameters to be passed on.

Value

An object of the fitted model class.

`MoE,bivdph-method` *MoE Method for bivdph Class*

Description

MoE Method for bivdph Class

Usage

```
## S4 method for signature 'bivdph'
MoE(
  x,
  formula,
  y,
  data,
  alpha_vecs = NULL,
  weight = numeric(0),
  stepsEM = 1000,
  every = 10,
  rand_init = TRUE
)
```

Arguments

`x`	An object of class bivdph.
`formula`	A regression formula.
`y`	A matrix of observations.
`data`	A data frame of covariates.
`alpha_vecs`	Matrix of initial probabilities.
`weight`	Vector of weights.
`stepsEM`	Number of EM steps to be performed.
`every`	Number of iterations between likelihood display updates.
`rand_init`	Random initiation in the R-step.

Value

An object of class sph.

MoE,dph-method *MoE Method for dph Class*

Description

MoE Method for dph Class

Usage

```
## S4 method for signature 'dph'
MoE(
  x,
  formula,
  data,
  alpha_vecs = NULL,
  weight = numeric(0),
  stepsEM = 1000,
  every = 10,
  rand_init = TRUE
)
```

Arguments

x	An object of class dph.
formula	A regression formula.
data	A data frame.
alpha_vecs	Matrix of initial probabilities.s
weight	Vector of weights.
stepsEM	Number of EM steps to be performed.
every	Number of iterations between likelihood display updates.
rand_init	Random initiation in the R-step.

Value

An object of class sph.

`MoE,mdph-method` *MoE Method for mdph Class*

Description

MoE Method for mdph Class

Usage

```
## S4 method for signature 'mdph'
MoE(
  x,
  formula,
  y,
  data,
  alpha_vecs = NULL,
  weight = numeric(0),
  stepsEM = 1000,
  every = 10,
  rand_init = TRUE
)
```

Arguments

`x`	An object of class mdph.
`formula`	A regression formula.
`y`	A matrix of observations.
`data`	A data frame of covariates.
`alpha_vecs`	Matrix of initial probabilities.
`weight`	Vector of weights.
`stepsEM`	Number of EM steps to be performed.
`every`	Number of iterations between likelihood display updates.
`rand_init`	Random initiation in the R-step.

Value

An object of class sph.

MoE,mph-method *Fit Method for mph/miph Class, using mixture-of-experts regression*

Description

Fit Method for mph/miph Class, using mixture-of-experts regression

Usage

```
## S4 method for signature 'mph'
MoE(
  x,
  formula,
  y,
  data,
  alpha_mat = NULL,
  delta = numeric(0),
  stepsEM = 1000,
  r = 1,
  maxit = 100,
  reltol = 1e-08,
  rand_init = T
)
```

Arguments

x	An object of class mph.
formula	a regression formula.
y	A matrix of observations.
data	A data frame of covariates (they need to be scaled for the regression).
alpha_mat	Matrix with initial distribution vectors for each row of observations.
delta	Matrix with right-censoring indicators (1 uncensored, 0 right censored).
stepsEM	Number of EM steps to be performed.
r	Sub-sampling parameter, defaults to 1 (Not supported for this method).
maxit	Maximum number of iterations when optimizing the g function (inhomogeneous likelihood).
reltol	Relative tolerance when optimizing g function.
rand_init	Random initiation in the R-step of the EM algorithm.

Examples

```
x <- mph(structure = c("general", "general"), dimension = 3, variables = 2)
n <- 100
responses <- cbind(rexp(n), rgamma(n, 2, 3))
covariate <- data.frame(age = sample(18:65, n, replace = TRUE) / 100, income = runif(n, 0, 0.99))
f <- responses~age + income # regression formula
MoE(x = x, formula = f, y = responses, data = covariate, stepsEM = 20)
```

`MoE,ph-method` *MoE Method for ph Class*

Description

MoE Method for ph Class

Usage

```
## S4 method for signature 'ph'
MoE(
  x,
  formula,
  data,
  inhom = NULL,
  alpha_vecs = NULL,
  weight = numeric(0),
  delta = numeric(0),
  stepsEM = 1000,
  optim_method = "BFGS",
  maxit = 50,
  reltol = 1e-08,
  every = 10,
  rand_init = TRUE
)
```

Arguments

`x`	An object of class ph.
`formula`	A regression formula.
`data`	A data frame.
`inhom`	A list with the inhomogeneity functions.
`alpha_vecs`	Matrix of initial probabilities.s
`weight`	Vector of weights.
`delta`	Right-censoring indicator.
`stepsEM`	Number of EM steps to be performed.

optim_method	Method to use in gradient optimization
maxit	Maximum number of iterations when optimizing g function.
reltol	Relative tolerance when optimizing g function.
every	Number of iterations between likelihood display updates.
rand_init	Random initiation in the R-step.

Value

An object of class sph.

---

moment *New Generic for Moment of Matrix Distributions*

Description

Methods are available for objects of class ph.

Usage

```
moment(x, ...)
```

Arguments

x	An object of the model class.
...	Further parameters to be passed on.

Value

Moment of the matrix distribution.

---

moment,bivdph-method *Moment method for bivdph class*

Description

Moment method for bivdph class

Usage

```
## S4 method for signature 'bivdph'
moment(x, k = c(1, 1))
```

Arguments

x	An object of class bivdph.
k	A vector with the location.

Value

An real value.

Examples

```
obj <- bivdph(dimensions = c(3, 3))
moment(obj, c(1, 1))
```

---

moment,bivph-method *Moment method for bivph class*

Description

Moment method for bivph class

Usage

```
## S4 method for signature 'bivph'
moment(x, k = c(1, 1))
```

Arguments

x	An object of class bivph.
k	A vector with the location.

Value

An real value.

Examples

```
obj <- bivph(dimensions = c(3, 3))
moment(obj, c(1, 1))
```

---

moment,dph-method *Moment Method for discrete phase-type distributions*

Description

Moment Method for discrete phase-type distributions

Usage

```
## S4 method for signature 'dph'
moment(x, k = 1)
```

Arguments

x	An object of class dph.
k	A positive integer (moment order).

Value

The factional moment of the dph object.

Examples

```
set.seed(123)
obj <- dph(structure = "general", dimension = 3)
moment(obj, 2)
```

---

moment,mdph-method *Moment Method for multivariate discrete phase-type distributions*

Description

Moment Method for multivariate discrete phase-type distributions

Usage

```
## S4 method for signature 'mdph'
moment(x, k)
```

Arguments

x	An object of class mdph.
k	A vector of positive integer values.

Value

The corresponding joint factorial moment evaluation.

Examples

```
obj <- mdph(structure = c("general", "general"))
moment(obj, c(2, 1))
```

moment,mph-method *Moment Method for multivariate phase-type distributions*

Description

Moment Method for multivariate phase-type distributions

Usage

```
## S4 method for signature 'mph'
moment(x, k)
```

Arguments

x	An object of class mph.
k	A vector of non-negative integer values.

Value

The corresponding joint moment evaluation.

Examples

```
obj <- mph(structure = c("general", "general"))
moment(obj, c(2, 1))
```

moment,ph-method *Moment Method for phase-type distributions*

Description

Moment Method for phase-type distributions

Usage

```
## S4 method for signature 'ph'
moment(x, k = 1)
```

Arguments

x	An object of class ph.
k	A positive integer (moment order).

Value

The raw moment of the ph (or undelying ph) object.

Examples

```
set.seed(123)
obj <- ph(structure = "general", dimension = 3)
moment(obj, 2)
```

`mparetocdf` *Matrix-Pareto cdf*

Description

Computes the cdf (tail) of a matrix-Pareto distribution with parameters `alpha`, `S` and `beta` at `x`.

Usage

```
mparetocdf(x, alpha, S, beta, lower_tail = TRUE)
```

Arguments

`x`	Non-negative value.
`alpha`	Initial probabilities.
`S`	Sub-intensity matrix.
`beta`	Scale parameter.
`lower_tail`	Cdf or tail.

Value

The cdf (tail) at `x`.

`mparetoden` *Matrix-Pareto density*

Description

Computes the density of a matrix-Pareto distribution with parameters `alpha`, `S` and `beta` at `x`.

Usage

```
mparetoden(x, alpha, S, beta)
```

Arguments

`x`	Non-negative value.
`alpha`	Initial probabilities.
`S`	Sub-intensity matrix.
`beta`	Scale parameter.

Value

The density at x.

---

mph *Constructor Function for multivariate phase-type distributions*

Description

Constructor Function for multivariate phase-type distributions

Usage

```
mph(alpha = NULL, S = NULL, structure = NULL, dimension = 3, variables = NULL)
```

Arguments

alpha	A probability vector.
S	A list of sub-intensity matrices.
structure	A vector of valid ph structures.
dimension	The dimension of the ph structure (if provided).
variables	The dimension of the multivariate phase-type.

Value

An object of class mph.

Examples

```
mph(structure = c("gcoxian", "general"), dimension = 5)
```

---

mph-class *Multivariate Phase Type distributions*

Description

Class of objects for multivariate phase-type distributions.

Value

Class object.

Slots

name Name of the phase type distribution.

pars A list comprising of the parameters.

fit A list containing estimation information.

`MPHstar` *Constructor Function for multivariate phase type distributions (MPH* class)*

Description

Constructor Function for multivariate phase type distributions (MPH* class)

Usage

```
MPHstar(
  alpha = NULL,
  S = NULL,
  structure = NULL,
  dimension = 3,
  R = NULL,
  variables = 2
)
```

Arguments

`alpha`	A probability vector.
`S`	A sub-intensity matrix.
`structure`	A valid ph structure.
`dimension`	The dimension of the ph structure (if provided).
`R`	A compatible (non-negative) reward matrix.
`variables`	The number of desired marginals.

Value

An object of class MPHstar.

Examples

```
MPHstar(structure = "general", dimension = 4, variables = 3)
```

MPHstar-class *Multivariate Phase Type distributions obtained by transformation via rewards*

Description

Class of objects for multivariate phase type distributions.

Slots

`name` Name of the phase type distribution.

`pars` A list comprising of the parameters.

MPHstar_data_aggregation *Prepare data for the MPHstar_EMstep_UNI*

Description

Prepare data for the MPHstar_EMstep_UNI

Usage

```
MPHstar_data_aggregation(y, w = numeric(0))
```

Arguments

`y`	A matrix with marginal observations, each column corresponds to a marginal.
`w`	A matrix of weights, each column corresponds to a marginal.

Value

For summed and marginal observations we have a list with matrices of unique observations and their associated weights, separated by uncensored and right-censored data.

MPHstar_EMstep_UNI *EM step using Uniformization for MPHstar class*

Description

EM step using Uniformization for MPHstar class

Usage

```
MPHstar_EMstep_UNI(h, Rtol, alpha, S, R, mph_obs)
```

Arguments

h	positive parameter for precision of uniformization method.
Rtol	The smallest value that a reward can take.
alpha	Vector of initial probabilities of the originating distribution.
S	The sub-intensity matrix of the originating distribution.
R	The reward matrix.
mph_obs	The list of summed, marginal observations with associated weights.

mweibullcdf *Matrix-Weibull cdf*

Description

Computes the cdf (tail) of a matrix-Weibull distribution with parameters alpha, S and beta at x.

Usage

```
mweibullcdf(x, alpha, S, beta, lower_tail = TRUE)
```

Arguments

x	Non-negative value.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Shape parameter.
lower_tail	Cdf or tail.

Value

The cdf (tail) at x.

mweibullden *Matrix-Weibull density*

Description

Computes the density of a matrix-Weibull distribution with parameters `alpha`, `S` and `beta` at `x`.

Usage

```
mweibullden(x, alpha, S, beta)
```

Arguments

`x`	Non-negative value.
`alpha`	Initial probabilities.
`S`	Sub-intensity matrix.
`beta`	Shape parameter.

Value

The density at `x`.

m_exp_sum *Computes exp(Sx) via series representation*

Description

Computes exp(Sx) via series representation

Usage

```
m_exp_sum(x, n, pow_vector, a)
```

Arguments

`x`	A number.
`n`	An integer.
`pow_vector`	A vector.
`a`	A number.

new_state *New state in a Markov jump process*

Description

Given a transition matrix Q, a uniform value u, and a previous state k, it returns the new state of a Markov jump process.

Usage

```
new_state(prev_state, cum_embedded_mc, u)
```

Arguments

prev_state	Previous state of the Markov jump process.
cum_embedded_mc	Transition matrix.
u	Random value in (0,1).

Value

Next state of the Markov jump process.

Nfold *New Generic for N-fold convolution of two Matrix Distributions*

Description

Methods are available for objects of classes ph and dph.

Usage

```
Nfold(x1, x2, ...)
```

Arguments

x1	An object of the class dph.
x2	An object of the model class.
...	Further parameters to be passed on.

Value

An object of the model class.

Nfold,dph-method *Nfold Method for phase-type distributions*

Description

Nfold Method for phase-type distributions

Usage

```
## S4 method for signature 'dph'
Nfold(x1, x2)
```

Arguments

x1	An object of class ph.
x2	An object of class dph.

Value

An object of class ph.

Examples

```
dph1 <- dph(structure = "general", dimension = 3)
dph2 <- dph(structure = "general", dimension = 2)
ph0 <- ph(structure = "general", dimension = 2)
Nfold(dph1, ph0)
Nfold(dph1, dph2)
```

n_pos *Find how many states have positive reward*

Description

Find how many states have positive reward

Usage

```
n_pos(R)
```

Arguments

R	reward vector

Value

The number of states with positive rewards

pgf *New Generic for pgf of Matrix Distributions*

Description

Methods are available for objects of class dph.

Usage

```
pgf(x, ...)
```

Arguments

x	An object of the model class.
...	Further parameters to be passed on.

Value

Pgf transform of the matrix distribution.

pgf,bivdph-method *Pgf Method for bivariate discrete phase-type distributions*

Description

Pgf Method for bivariate discrete phase-type distributions

Usage

```
## S4 method for signature 'bivdph'
pgf(x, z)
```

Arguments

x	An object of class bivdph.
z	A vector of real values.

Value

The joint pdf of the dph object at the given location.

Examples

```
obj <- bivdph(dimensions = c(3, 3))
pgf(obj, c(0.5, 0.2))
```

pgf,dph-method *Pgf Method for discrete phase-type distributions*

Description

Pgf Method for discrete phase-type distributions

Usage

```
## S4 method for signature 'dph'
pgf(x, z)
```

Arguments

x	An object of class dph.
z	A vector of real values.

Value

The probability generating of the dph object at the given locations.

Examples

```
set.seed(123)
obj <- dph(structure = "general", dimension = 3)
pgf(obj, 0.5)
```

pgf,mdph-method *Pgf Method for multivariate discrete phase-type distributions*

Description

Pgf Method for multivariate discrete phase-type distributions

Usage

```
## S4 method for signature 'mdph'
pgf(x, z)
```

Arguments

x	An object of class mdph.
z	A matrix of real values.

Value

A vector containing the corresponding pgf evaluations.

Examples

```
obj <- mdph(structure = c("general", "general"))
pgf(obj, matrix(c(0.5, 1), ncol = 2))
```

---

ph *Constructor Function for phase-type distributions*

Description

Constructor Function for phase-type distributions

Usage

```
ph(alpha = NULL, S = NULL, structure = NULL, dimension = 3)
```

Arguments

alpha	A probability vector.
S	A sub-intensity matrix.
structure	A valid ph structure ("general", "coxian", "hyperexponential", "gcoxian", "gerlang").
dimension	The dimension of the ph structure (if structure is provided).

Value

An object of class ph.

Examples

```
ph(structure = "gcoxian", dimension = 5)
ph(alpha = c(.5, .5), S = matrix(c(-1, .5, .5, -1), 2, 2))
```

ph-class *Phase Type distributions*

Description

Class of objects for phase-type distributions.

Value

Class object.

Slots

`name` Name of the phase-type distribution.

`pars` A list comprising of the parameters.

`fit` A list containing estimation information.

phcdf *Phase-type cdf*

Description

Computes the cdf (tail) of a phase-type distribution with parameters `alpha` and `S` at `x`.

Usage

```
phcdf(x, alpha, S, lower_tail = TRUE)
```

Arguments

`x`	Non-negative value.
`alpha`	Initial probabilities.
`S`	Sub-intensity matrix.
`lower_tail`	Cdf or tail.

Value

The cdf (tail) at `x`.

phdensity *Phase-type density*

Description

Computes the density of a phase-type distribution with parameters `alpha` and `S` at `x`.

Usage

```
phdensity(x, alpha, S)
```

Arguments

`x`	Non-negative value.
`alpha`	Initial probabilities.
`S`	Sub-intensity matrix.

Value

The density at `x`.

ph_laplace *Laplace transform of a phase-type distribution*

Description

Computes the Laplace transform at `r` of a phase-type distribution with parameters `alpha` and `S`.

Usage

```
ph_laplace(r, alpha, S)
```

Arguments

`r`	Vector of real values.
`alpha`	Vector of initial probabilities.
`S`	Sub-intensity matrix.

Value

Laplace transform at `r`.

plus_states *Find which states have positive reward*

Description

Find which states have positive reward

Usage

```
plus_states(R)
```

Arguments

R	reward vector

Value

A vector with the states (number) that are associated with positive rewards

pow2_matrix *Computes A^(2^n)*

Description

Computes A^(2^n)

Usage

```
pow2_matrix(n, A)
```

Arguments

n	An integer.
A	A matrix.

Value

A^(2^n).

quan *New Generic for the Quantile of Matrix Distributions*

Description

Methods are available for objects of class ph.

Usage

```
quan(x, ...)
```

Arguments

x	An object of the model class.
...	Further parameters to be passed on.

Value

Quantile from the matrix distribution.

quan,ph-method *Quantile Method for phase-type distributions*

Description

Quantile Method for phase-type distributions

Usage

```
## S4 method for signature 'ph'
quan(x, p)
```

Arguments

x	An object of class ph.
p	A vector of probabilities.

Value

A vector containing the quantile evaluations at the given locations.

Examples

```
obj <- ph(structure = "general")
quan(obj, c(0.5, 0.9, 0.99))
```

random_reward *Random reward matrix*

Description

Generates a random reward matrix for a multivariate phase-type distribution with p states and d marginals.

Usage

```
random_reward(p, d)
```

Arguments

p	Number of transient states in the sub-intensity matrix.
d	Number of marginals.

Value

A random reward matrix.

random_structure *Random structure of a phase-type*

Description

Generates random parameters alpha and S of a phase-type distribution of dimension p with chosen structure.

Usage

```
random_structure(p, structure = "general", scale_factor = 1)
```

Arguments

p	Dimension of the phase-type.
structure	Type of structure: "general", "hyperexponential", "gerlang", "coxian" or "gcoxian".
scale_factor	A factor that multiplies the sub-intensity matrix.

Value

Random parameters alpha and S of a phase-type.

random_structure_bivph *Random structure of a bivariate phase-type*

Description

Generates random parameters `alpha`, `S11`, `S12`, and `S22` of a bivariate phase-type distribution of dimension `p = p1 + p2`.

Usage

```
random_structure_bivph(p1, p2, scale_factor = 1)
```

Arguments

`p1`	Dimension of the first block.
`p2`	Dimension of the second block.
`scale_factor`	A factor that multiplies the sub-intensity matrix.

Value

Random parameters `alpha`, `S11`, `S12`, and `S22` of a bivariate phase-type.

rdphasetype *Simulate discrete phase-type*

Description

Generates a sample of size `n` from a discrete phase-type distribution with parameters `alpha` and `S`.

Usage

```
rdphasetype(n, alpha, S)
```

Arguments

`n`	Sample size.
`alpha`	Vector of initial probabilities.
`S`	Sub-transition matrix.

Value

Simulated sample.

reg *New Generic for Regression with Matrix Distributions*

Description

Methods are available for objects of class ph.

Usage

```
reg(x, y, ...)
```

Arguments

x	An object of the model class.
y	A vector of data.
...	Further parameters to be passed on.

Value

An object of the fitted model class.

reg,ph-method *Regression Method for ph Class*

Description

Regression Method for ph Class

Usage

```
## S4 method for signature 'ph'
reg(
  x,
  y,
  weight = numeric(0),
  rcen = numeric(0),
  rcenweight = numeric(0),
  X = numeric(0),
  B0 = numeric(0),
  stepsEM = 1000,
  methods = c("RK", "UNI"),
  rkstep = NA,
  uni_epsilon = NA,
  optim_method = "BFGS",
  maxit = 50,
```

```
  reltol = 1e-08,
  every = 10
)
```

Arguments

x	An object of class ph.
y	Vector or data.
weight	Vector of weights.
rcen	Vector of right-censored observations.
rcenweight	Vector of weights for right-censored observations.
X	Model matrix (no intercept needed).
B0	Initial regression coefficients (optional).
stepsEM	Number of EM steps to be performed.
methods	Methods to use for matrix exponential calculation: RM, UNI or PADE.
rkstep	Runge-Kutta step size (optional)
uni_epsilon	Epsilon parameter for uniformization method.
optim_method	Method to use in gradient optimization.
maxit	Maximum number of iterations when optimizing g function.
reltol	Relative tolerance when optimizing g function.
every	Number of iterations between likelihood display updates.

Value

An object of class sph.

---

revers_data_trans *Applies the inverse of the GEV transformation but giving back the resulting vector in reverse order*

Description

Used for EM step in RK.

Usage

```
revers_data_trans(obs, weights, beta)
```

Arguments

obs	The observations.
weights	Weights of the observations.
beta	Parameters of the GEV.

rew_sanity_check *Transform a reward matrix with very small rewards to avoid numerical problems*

Description

Transform a reward matrix with very small rewards to avoid numerical problems

Usage

```
rew_sanity_check(R, tol)
```

Arguments

R	Reward matrix
tol	Lower bound considered for a reward

Value

A reward matrix that does not cause issues with uniformization

riph *Random inhomogeneous phase-type*

Description

Generates a sample of size n from an inhomogeneous phase-type distribution with parameters alpha, S and beta.

Usage

```
riph(n, dist_type, alpha, S, beta)
```

Arguments

n	Sample size.
dist_type	Type of IPH.
alpha	Initial probabilities.
S	Sub-intensity matrix.
beta	Parameter of the transformation.

Value

The simulated sample.

rmatrixgev *Random matrix GEV*

Description

Generates a sample of size n from an inhomogeneous phase-type distribution with parameters alpha, S and beta.

Usage

```
rmatrixgev(n, alpha, S, mu, sigma, xi = 0)
```

Arguments

n	Sample size.
alpha	Initial probabilities.
S	Sub-intensity matrix.
mu	Location parameter.
sigma	Scale parameter.
xi	Shape parameter: Default 0 which corresponds to the Gumbel case.

Value

The simulated sample.

rMDPHstar *Simulate MDPH***

Description

Generates a sample of size n from a MDPH* distribution with parameters alpha, S, and R.

Usage

```
rMDPHstar(n, alpha, S, R)
```

Arguments

n	Sample size.
alpha	Vector of initial probabilities.
S	Sub-transition matrix.
R	Reward matrix.

Value

Simulated sample.

rMIPHstar *Simulate a MIPH* random vector*

Description

Generates a sample of size n from a MIPH* distribution with parameters alpha, S and R.

Usage

```
rMIPHstar(n, alpha, S, R, gfun, gfun_par)
```

Arguments

n	Sample size.
alpha	Initial probabilities.
S	Sub-intensity matrix.
R	Reward matrix.
gfun	Vector with transformations names.
gfun_par	List with transformations parameters.

Value

The simulated sample.

rMPHstar *Simulate a MPH* random vector*

Description

Generates a sample of size n from a MPH* distribution with parameters alpha, S and R.

Usage

```
rMPHstar(n, alpha, S, R)
```

Arguments

n	Sample size.
alpha	Initial probabilities.
S	Sub-intensity matrix.
R	Reward matrix.

Value

The simulated sample.

rphasetype *Simulate phase-type*

Description

Generates a sample of size n from a phase-type distribution with parameters alpha and S.

Usage

```
rphasetype(n, alpha, S)
```

Arguments

n	Sample size.
alpha	Vector of initial probabilities.
S	Sub-intensity matrix.

Value

Simulated sample.

runge_kutta *Runge-Kutta for the calculation of the a and b vectors and the c matrix in a EM step*

Description

Performs the Runge-Kutta method of fourth order.

Usage

```
runge_kutta(avector, bvector, cmatrix, dt, h, S, s)
```

Arguments

avector	The a vector.
bvector	The b vector.
cmatrix	The c matrix.
dt	The increment.
h	Step-length.
S	Sub-intensity matrix.
s	Exit rates.

show,bivdph-method *Show method for bivariate discrete phase-type distributions*

Description

Show method for bivariate discrete phase-type distributions

Usage

```
## S4 method for signature 'bivdph'
show(object)
```

Arguments

object	An object of class bivdph.

show,biviph-method *Show Method for bivariate inhomogeneous phase-type distributions*

Description

Show Method for bivariate inhomogeneous phase-type distributions

Usage

```
## S4 method for signature 'biviph'
show(object)
```

Arguments

object	An object of class biviph.

show,bivph-method *Show method for bivariate phase-type distributions*

Description

Show method for bivariate phase-type distributions

Usage

```
## S4 method for signature 'bivph'
show(object)
```

Arguments

object	An object of class bivph.

show,dph-method *Show Method for discrete phase-type distributions*

Description

Show Method for discrete phase-type distributions

Usage

```
## S4 method for signature 'dph'
show(object)
```

Arguments

object	An object of class dph.

show,iph-method *Show Method for inhomogeneous phase-type distributions*

Description

Show Method for inhomogeneous phase-type distributions

Usage

```
## S4 method for signature 'iph'
show(object)
```

Arguments

object	An object of class iph.

show,mdph-method *Show Method for multivariate discrete phase-type distributions*

Description

Show Method for multivariate discrete phase-type distributions

Usage

```
## S4 method for signature 'mdph'
show(object)
```

Arguments

object	An object of class mdph.

show,miph-method *Show Method for multivariate inhomogeneous phase-type distributions*

Description

Show Method for multivariate inhomogeneous phase-type distributions

Usage

```
## S4 method for signature 'miph'
show(object)
```

Arguments

object	An object of class miph.

show,mph-method *Show Method for multivariate phase-type distributions*

Description

Show Method for multivariate phase-type distributions

Usage

```
## S4 method for signature 'mph'
show(object)
```

Arguments

object	An object of class mph.

show,MPHstar-method *Show Method for multivariate phase type distributions*

Description

Show Method for multivariate phase type distributions

Usage

```
## S4 method for signature 'MPHstar'
show(object)
```

Arguments

object	An object of class MPHstar.

show,ph-method *Show Method for phase-type distributions*

Description

Show Method for phase-type distributions

Usage

```
## S4 method for signature 'ph'
show(object)
```

Arguments

object	An object of class ph.

show,sph-method *Show Method for survival phase-type objects*

Description

Show Method for survival phase-type objects

Usage

```
## S4 method for signature 'sph'
show(object)
```

Arguments

object	An object of class sph.

sim *New Generic for Simulating Matrix Distributions*

Description

Methods are available for objects of class ph.

Usage

```
sim(x, ...)
```

Arguments

x	An object of the model class.
...	Further parameters to be passed on.

Value

A realization from the matrix distribution.

sim,bivdph-method *Simulation method for bivariate discrete phase-type distributions*

Description

Simulation method for bivariate discrete phase-type distributions

Usage

```
## S4 method for signature 'bivdph'
sim(x, n = 1000)
```

Arguments

x	An object of class bivdph.
n	An integer of length of realization.

Value

A realization of independent and identically distributed bivariate discrete phase-type vector.

Examples

```
obj <- bivdph(dimensions = c(3, 3))
sim(obj, n = 100)
```

sim,biviph-method *Simulation method for bivariate inhomogeneous phase-type distributions*

Description

Simulation method for bivariate inhomogeneous phase-type distributions

Usage

```
## S4 method for signature 'biviph'
sim(x, n = 1000)
```

Arguments

x	An object of class biviph.
n	An integer of length of realization.

Value

A realization of independent and identically distributed bivariate inhomogeneous phase-type vector.

Examples

```
under_bivph <- bivph(dimensions = c(3, 3))
obj <- biviph(under_bivph, gfun = c("weibull", "pareto"), gfun_pars = list(c(2), c(3)))
sim(obj, n = 100)
```

sim,bivph-method *Simulation method for bivariate phase-type distributions*

Description

Simulation method for bivariate phase-type distributions

Usage

```
## S4 method for signature 'bivph'
sim(x, n = 1000)
```

Arguments

x	An object of class bivph.
n	An integer of length of realization.

Value

A realization of independent and identically distributed bivariate phase-type vector.

Examples

```
obj <- bivph(dimensions = c(3, 3))
sim(obj, n = 100)
```

`sim,dph-method` *Simulation Method for phase-type distributions*

Description

Simulation Method for phase-type distributions

Usage

```
## S4 method for signature 'dph'
sim(x, n = 1000)
```

Arguments

`x`	An object of class dph.
`n`	An integer of length of realization.

Value

A realization of independent and identically distributed discrete phase-type variables.

Examples

```
obj <- dph(structure = "general")
sim(obj, n = 100)
```

`sim,iph-method` *Simulation Method for inhomogeneous phase-type distributions*

Description

Simulation Method for inhomogeneous phase-type distributions

Usage

```
## S4 method for signature 'iph'
sim(x, n = 1000)
```

Arguments

x	An object of class iph.
n	An integer of length of realization.

Value

A realization of independent and identically distributed inhomogeneous phase-type variables.

Examples

```
obj <- iph(ph(structure = "general"), gfun = "lognormal", gfun_pars = 2)
sim(obj, n = 100)
```

---

sim,mdph-method *Simulation Method for multivariate discrete phase-type distributions*

Description

Simulation Method for multivariate discrete phase-type distributions

Usage

```
## S4 method for signature 'mdph'
sim(x, n = 1000, equal_marginals = 0)
```

Arguments

x	An object of class mdph.
n	Length of realization.
equal_marginals	Non-negative integer. If positive, it specifies the number of marginals to simulate from, all from the first matrix.

Value

A realization of a multivariate discrete phase-type distribution.

Examples

```
obj <- mdph(structure = c("general", "general"))
sim(obj, 100)
```

sim,miph-method *Simulation Method for inhomogeneous multivariate phase-type distributions*

Description

Simulation Method for inhomogeneous multivariate phase-type distributions

Usage

```
## S4 method for signature 'miph'
sim(x, n = 1000)
```

Arguments

x	An object of class miph.
n	An integer of length of realization.

Value

A realization of independent and identically distributed inhomogeneous multivariate phase-type variables. If x is a MoE miph an array of dimension c(n,d,m) is returned, with d the number of marginals and m the number of initial distribution vectors.

Examples

```
under_mph <- mph(structure = c("general", "general"))
obj <- miph(under_mph, gfun = c("weibull", "pareto"), gfun_pars = list(c(2), c(3)))
sim(obj, 100)
```

sim,mph-method *Simulation Method for multivariate phase-type distributions*

Description

Simulation Method for multivariate phase-type distributions

Usage

```
## S4 method for signature 'mph'
sim(x, n = 1000, equal_marginals = 0)
```

Arguments

x	An object of class mph.
n	Length of realization.
equal_marginals	Non-negative integer. If positive, it specifies the number of marginals to simulate from, all from the first matrix.

Value

A realization of a multivariate phase-type distribution.

Examples

```
obj <- mph(structure = c("general", "general"))
sim(obj, 100)
```

---

sim,MPHstar-method *Simulation Method for multivariate phase type distributions*

Description

Simulation Method for multivariate phase type distributions

Usage

```
## S4 method for signature 'MPHstar'
sim(x, n = 1000)
```

Arguments

x	An object of class MPHstar.
n	Desired sample size for each marginal.

Value

A matrix of sample data for each marginal.

Examples

```
obj <- MPHstar(structure = "general")
sim(obj, 100)
```

sim,ph-method *Simulation Method for phase-type distributions*

Description

Simulation Method for phase-type distributions

Usage

```
## S4 method for signature 'ph'
sim(x, n = 1000)
```

Arguments

x	An object of class ph.
n	An integer of length of realization.

Value

A realization of independent and identically distributed phase-type variables.

Examples

```
obj <- ph(structure = "general")
sim(obj, n = 100)
```

sph *Constructor Function for Survival phase-type objects*

Description

Constructor Function for Survival phase-type objects

Usage

```
sph(x = NULL, coefs = list(B = numeric(0), C = numeric(0)), type = "reg")
```

Arguments

x	An object of class ph
coefs	Coefficients of the survival regression object.
type	Type of survival object.

Value

An object of class sph.

sph-class *Survival Analysis for Phase Type distributions*

Description

Class of objects for inhomogeneous phase-type distributions

Value

Class object

Slots

`coefs` Coefficients of the survival regression object.

`type` Type of survival object.

sum_dph *Computes the initial distribution and sub-intensity of the sum of two discrete phase-type distributed random variables*

Description

Computes the initial distribution and sub-intensity of the sum of two discrete phase-type distributed random variables

Usage

```
sum_dph(alpha1, S1, alpha2, S2)
```

Arguments

`alpha1`	Initial distribution.
`S1`	Sub-transition matrix.
`alpha2`	Initial distribution.
`S2`	Sub-transition matrix.

sum_ph

Computes the initial distribution and sub-intensity of the sum of two phase-type distributed random variables.

Description

Computes the initial distribution and sub-intensity of the sum of two phase-type distributed random variables.

Usage

```
sum_ph(alpha1, S1, alpha2, S2)
```

Arguments

alpha1	Initial distribution.
S1	Sub-intensity matrix.
alpha2	Initial distribution.
S2	Sub-intensity matrix.

TVR

New Generic for the transformation via rewards of a phase-type distribution

Description

Methods are available for objects of class ph

Usage

```
TVR(x, ...)
```

Arguments

x	An object of the model class.
...	Further parameters to be passed on.

Value

An object of the model class.

TVR,dph-method *TVR Method for dph Class*

Description

TVR Method for dph Class

Usage

```
## S4 method for signature 'dph'
TVR(x, rew)
```

Arguments

x	An object of class dph.
rew	A vector of rewards.

Value

An object of the of class dph.

Examples

```
obj <- dph(structure = "general")
TVR(obj, c(1, 0, 1))
```

TVR,ph-method *TVR Method for ph Class*

Description

TVR Method for ph Class

Usage

```
## S4 method for signature 'ph'
TVR(x, rew)
```

Arguments

x	An object of class ph.
rew	A vector of rewards.

Value

An object of the of class ph.

Examples

```
obj <- ph(structure = "general")
TVR(obj, c(1, 2, 3))
```

`tvr_dph` *Performs TVR for discrete phase-type distributions*

Description

Performs TVR for discrete phase-type distributions

Usage

```
tvr_dph(alpha, S, R)
```

Arguments

`alpha`	Initial distribution vector.
`S`	Sub-intensity matrix.
`R`	Reward vector.

Value

A list of PH parameters.

`tvr_ph` *Performs TVR for phase-type distributions*

Description

Performs TVR for phase-type distributions

Usage

```
tvr_ph(alpha, S, R)
```

Arguments

`alpha`	Initial distribution vector.
`S`	Sub-intensity matrix.
`R`	Reward vector.

Value

A list of phase-type parameters.

var,bivdph-method *Var Method for bivdph class*

Description

Var Method for bivdph class

Usage

```
## S4 method for signature 'bivdph'
var(x)
```

Arguments

x	An object of class bivdph.

Value

The covariance matrix of the bivariate discrete phase-type distribution.

Examples

```
obj <- bivdph(dimensions = c(3, 3))
var(obj)
```

var,bivph-method *Var Method for bivph class*

Description

Var Method for bivph class

Usage

```
## S4 method for signature 'bivph'
var(x)
```

Arguments

x	An object of class bivph.

Value

The covariance matrix of the bivariate phase-type distribution.

Examples

```
obj <- bivph(dimensions = c(3, 3))
var(obj)
```

var,dph-method *Var Method for discrete phase-type distributions*

Description

Var Method for discrete phase-type distributions

Usage

```
## S4 method for signature 'dph'
var(x)
```

Arguments

x	An object of class dph.

Value

The variance of the dph object.

Examples

```
set.seed(123)
obj <- dph(structure = "general", dimension = 3)
var(obj)
```

var,mdph-method *Var Method for multivariate discrete phase-type distributions*

Description

Var Method for multivariate discrete phase-type distributions

Usage

```
## S4 method for signature 'mdph'
var(x)
```

Arguments

x	An object of class mdph.

Value

The covariance matrix of the multivariate discrete phase-type distribution.

Examples

```
obj <- mdph(structure = c("general", "general"))
var(obj)
```

---

var,mph-method *Var Method for multivariate phase-type distributions*

Description

Var Method for multivariate phase-type distributions

Usage

```
## S4 method for signature 'mph'
var(x)
```

Arguments

x	An object of class mph.

Value

The covariance matrix of the multivariate phase-type distribution.

Examples

```
obj <- mph(structure = c("general", "general"))
var(obj)
```

---

var,MPHstar-method *Var Method for MPHstar class*

Description

Var Method for MPHstar class

Usage

```
## S4 method for signature 'MPHstar'
var(x)
```

Arguments

x	An object of class MPHstar.

Value

The covariance matrix of the MPHstar distribution.

Examples

```
obj <- MPHstar(structure = "general")
var(obj)
```

`var,ph-method` *Var Method for phase-type distributions*

Description

Var Method for phase-type distributions

Usage

```
## S4 method for signature 'ph'
var(x)
```

Arguments

x	An object of class ph.

Value

The variance of the ph (or undelying ph) object.

Examples

```
set.seed(123)
obj <- ph(structure = "general", dimension = 3)
var(obj)
```

`vector_of_matrices` *Computes the elements S^n / n! until the a given size*

Description

Computes the elements S^n / n! until the a given size

Usage

```
vector_of_matrices(vect, S, a, vect_size)
```

Arguments

vect	A vector.
S	Sub-intensity matrix.
a	A number.
vect_size	Size of vector.

---

vector_of_matrices_2 *Computes the elements S^n / n! until given value of n*

Description

Computes the elements S^n / n! until given value of n

Usage

```
vector_of_matrices_2(vect, S, vect_size)
```

Arguments

vect	A vector.
S	Sub-intensity matrix.
vect_size	Size of vector.

---

vector_of_powers *Computes elements A^n until the given size*

Description

Computes elements A^n until the given size

Usage

```
vector_of_powers(A, vect_size)
```

Arguments

A	A matrix.
vect_size	Size of vector.

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