Package ‘stlnpp’

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Type Package

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Title Spatio-Temporal Analysis of Point Patterns on Linear Networks

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Description Statistical analysis of spatio-temporal point processes on linear networks. This packages provides tools to visualise and analyse spatio-temporal point patterns on linear networks using first- and second-order summary statistics.

Depends R (>= 3.3.0), spatstat(>= 1.61-0)

Imports stats, graphics

Suggests plot3D, lattice

License GPL (>= 2)

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R topics documented:

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as.lpp.stlpp *Methods for space-time point patterns on a linear network.*

Description

This function projects an object of class stlpp to a linear network.

Usage

```
## S3 method for class 'stlpp'
as.lpp(x,...)
```

Arguments

x	an object of class stlpp
...	arguments passed to as.lpp

Details

This function projects the space-time point pattern x on linear network L into L, giving its corresponding spatial point pattern.

Value

An object of class lpp.

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

See Also

as.stlpp, lpp, as.lpp

Examples

```
data(easynet)
x <- runifpointOnLines(40, easynet)
t1 <- sample(1:10,40,replace=TRUE)
Y <- as.stlpp(x,t=t1,L=easynet)
as.lpp.stlpp(Y)
```

---

as.stlpp *Convert data to a space-time point pattern on a linear network*

Description

Convert data to a space-time point pattern on a linear network

Usage

```
as.stlpp(x,y,t,L)
```

Arguments

x,y,t	vectors of cartesian coordinates and time occurance. Alternatively, x can be of classes data.frame, ppp and lpp.
L	linear network (object of class linnet) on which the points lie.

Details

This function converts data to an object of class stlpp.

Data can be of formats:

- x is of class class data.frame with three columns. Then columns are considered as cartesian coordinates (i.e. x,y,t) and they will be converted to a spatio-temporal point pattern on the linear network L.
- x is a planar point pattern (class ppp). Then x will be converted to a spatio-temporal point pattern on the linear network L and with coresponding time vector t.
- x is a linear point pattern (class lpp). Then x will be converted to a spatio-temporal point pattern on the linear network L and with coresponding time vector t.
- x,y,t are vectors of same length where x,y are living on the corresponding network L.

Value

A spatio-temporal point pattern on a linear network. An object of class stlpp.

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

See Also

as.lpp.stlpp, runifpointOnLines, as.lpp

Examples

```
data(easynet)
x <- runifpointOnLines(40, easynet)
t1 <- sample(1:10,40,replace=TRUE)
Y <- as.stlpp(x,t=t1,L=easynet)

Z <- as.lpp.stlpp(Y)
t2 <- sample(1:10,40,replace=TRUE)
W <- as.stlpp(Z,t=t2)
```

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as.tpp.stlpp *Methods for space-time point patterns on a linear network.*

Description

This function converts an object of class stlpp to class tpp.

Usage

```
## S3 method for class 'stlpp'
as.tpp(X)
```

Arguments

X	an object of class stlpp

Details

This function projects the space-time point pattern X on L times T into the time interval T.

Value

An object of class tpp.

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

See Also

as.stlpp, lpp, as.lpp

Examples

```
X <- rpoistlpp(10,1,2,easynet)
as.tpp.stlpp(X)
```

density.stlpp *Kernel estimation of intensity of spatio-temporal point patterns on a linear network*

Description

Kernel density estimation of a spatio-temporal point pattern on a linear network.

Usage

```
## S3 method for class 'stlpp'
density(x,lbw,tbw,at=c(”points”,”pixels”),dimt=512,...)
```

Arguments

`x` an object of class `stlpp`

`lbw` netwrok smoothing bandwidth

`tbw` time smoothing bandwidth

`at` string specifying whether to compute the intensity values at a grid of pixel locations and time (at="pixels") or only at the points of x (at="points"). default is to estimate the intensity at pixels

`dimt` the number of equally spaced points at which the temporal density is to be estimated. see density

`...` arguments passed to `density.lpp`

Details

Kernel smoothing is applied to the spatio-temporal point pattern x using methods in Moradi et al (2019). The function computes estimated intensities based on first-order separability assumption. Estimated intensity values of the marginal spatial point pattern on the linear network will be obtained using the fast kernel smoothing technique of Rakshit et al. (2019) and function `densityQuick.lpp`, and the estimated intensity values of the marginal temporal point pattern will be estimated suing the function `density`.

If lbw and tbw are not given, then they will be selected using `bw.nrd0` and `bw.scott.iso` respectively.

Value

If `at="points"`: a vector of intensity values at the data points of x.

If `at="pixels"`: a list of images on linear network. Each image represents an estimated saptio-temporal intensity at a fixed time. check the attributes for more accommodated outputs.

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

References

Moradi, M.M. and Mateu, J. (2019). First and second-order characteristics of spatio-temporal point processes on linear networks. Journal of Computational and Graphical Statistics. In press.

See Also

`density`, `density.lpp`, `bw.nrd0`, `bw.scott.iso`

Examples

```
X <- rpoistlpp(.2,a=0,b=5,L=easynet)
density(X)
```

`density.tpp` *Kernel estimation of intensity of temporal point patterns*

Description

Kernel estimation of intensity of temporal point patterns.

Usage

```
## S3 method for class 'tpp'
density(x,tbw,at=c(”points”,”pixels”),...)
```

Arguments

`x`	a temporal point pattern (of class `tpp`)
`tbw`	time smoothing bandwidth
`at`	string specifying whether to compute the intensity values at a grid of pixel locations (at="pixels") or only at the points of x (at="points"). default is to estimate the intensity at pixels
`...`	arguments passed to density

Value

A vector of intensity values.

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

References

Moradi, M.M. and Mateu, J. (2019). First and second-order characteristics of spatio-temporal point processes on linear networks. Journal of Computational and Graphical Statistics. In press.

See Also

`density`, `bw.nrd0`

Examples

```
X <- tpp(sample(c(1:24),200,replace = TRUE))
plot(density(X))
```

densityVoronoi.stlpp *Intensity estimate of spatio-temporal point pattern using Voronoi-Dirichlet tessellation*

Description

adaptive intensity estimation for spatio-temporal point patterns on linear networks using Voronoi-Dirichlet tessellation.

Usage

```
## S3 method for class 'stlpp'
densityVoronoi(X, f = 1, nrep = 1,
                      separable=FALSE,at=c("points","pixels"),
                      dimt=128,...)
```

Arguments

`X` an object of class `stlpp`

`f` fraction (between 0 and 1 inclusive) of the data points that will be used to build a tessellation for the intensity estimate

`nrep` number of independent repetitions of the randomised procedure

`separable` logical. If FALSE, it then calculates a pseudo-separable estimate

`at` string specifying whether to return the intensity values at a grid of pixel locations and time (at="pixels") or only at the points of X (at="points"). default is to estimate the intensity at pixels

`dimt` the number of equally spaced points at which the temporal density is to be estimated. see density

`...` arguments passed to `densityVoronoi.lpp`

Details

This function computes intensity estimates for spatio-temporal point patterns on linear networks using Voronoi-Dirichlet tessellation. Both first-order separability and pseudo-separability assumptions are accommodated in the function.

If separable=TRUE, the estimated intensities will be a product of the estimated intensities on the network and those on time. Each will be obtained using `densityVoronoi.lpp`. If f=1, the function calculates the estimations based on the original Voronoi intensity estimator.

If separable=FALSE, the estimated intensities will be calculated based on a subsampling technique explained in Mateu et al. (2019). nrep subsamples will be obtained from X based on a given retention probability f, the function `densityVoronoi.stlpp`, considering separable=TRUE and f=1, will be applied to each obtained subsample, and finally, the estimated intensities will be the sum of all obtained estimated intensities from all subsamples divided by the (f * nrep).

Value

If `at="points"`: a vector of intensity values at the data points of X.

If `at="pixels"`: a list of images on a linear network. Each image represents an estimated saptio-temporal intensity at a fixed time.

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>, and Ottmar Cronie.

References

Mateu, J., Moradi, M., & Cronie, O. (2019). Spatio-temporal point patterns on linear networks: Pseudo-separable intensity estimation. Spatial Statistics, 100400.

See Also

`densityVoronoi.lpp`, `density.stlpp`

Examples

```
X <- rpoistlpp(0.2,a=0,b=5,L=easynet)
densityVoronoi(X)
```

`densityVoronoi.tpp` *Intensity estimate of temporal point patterns using Voronoi-Dirichlet tessellation*

Description

adaptive intensity estimation for temporal point patterns using Voronoi-Dirichlet tessellation.

Usage

```
## S3 method for class 'tpp'
densityVoronoi(X, f = 1, nrep = 1,at=c("points","pixels"),
                                dimt=128,...)
```

Arguments

`X` an object of class `tpp`

`f` fraction (between 0 and 1 inclusive) of the data points that will be used to build a tessellation for the intensity estimate

`nrep` number of independent repetitions of the randomised procedure

`at` string specifying whether to return the intensity values at a grid of pixel locations and time (at="pixels") or only at the points of X (at="points"). default is to estimate the intensity at pixels

`dimt` the number of equally spaced points at which the temporal density is to be estimated. see density

`...` arguments passed to `densityVoronoi.lpp`

Details

This function computes intensity estimates for temporal point patterns using Voronoi-Dirichlet tessellation.

Value

If `at="points"`: a vector of intensity values at the data points of X.

If `at="pixels"`: a vector of intensity values over a grid.

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>, and Ottmar Cronie.

References

Mateu, J., Moradi, M., & Cronie, O. (2019). Spatio-temporal point patterns on linear networks: Pseudo-separable intensity estimation. Spatial Statistics, 100400.

See Also

`densityVoronoi.lpp`, `densityVoronoi.stlpp`

Examples

```
X <- rpoistlpp(0.2,a=0,b=5,L=easynet)
Y <- as.tpp.stlpp(X)
densityVoronoi(Y)
```

Eastbourne *Eastbourne traffic accident data*

Description

This dataset represents the spatio-temporal locations of traffic accidents in the down-town of Eastbourne (UK) in the period of 2005-2010. The network was provided by “OS OpenData" at www.ordnancesurvey.co.uk and is usable under the terms of the OS OpenData license. The traffic locations were collected by the UK Department for Transport at www.data.gov.uk and obtained through kaggle at www.kaggle.com.

The dataset `Eastbourne` is an object of class `stlpp`.

Usage

```
data(Eastbourne)
```

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

Source

Usability: The network of Eastbourne was provided by OS OpenData and contains OS data © Crown copyright and database right (2018). The traffic accident locations in Eastbourne were collected by the UK Department for Transport and were provided by kaggle.

This data is a part of enitre data which is selected and converted to this format by Mehdi Moradi.

References

Moradi, M.M. and Mateu, J. (2019). First and second-order characteristics of spatio-temporal point processes on linear networks. Journal of Computational and Graphical Statistics. In press.

See Also

`stlpp`

Examples

```
data(Eastbourne)
plot(Eastbourne)
```

easynet *A simple linear network*

Description

A simple and not real network.

Usage

```
data(easynet)
```

Source

Created by Mehdi Moradi

Medellin *Medellin traffic accident data*

Description

This dataset represents the spatio-temporal locations of traffic accidents in an area near the pontifical bolivarian university in Medell\'in (Colombia) during 2016. The entire data were published in the OpenData portal of Medell\'in Town Hall at https://www.medellin.gov.co/geomedellin/index.hyg.

The dataset `Medellin` is an object of class `stlpp`.

Usage

```
data(Medellin)
```

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

Source

This data is a part of enitre data which is selected and converted to this format by Mehdi Moradi.

References

Moradi, M.M. and Mateu, J. (2019). First and second-order characteristics of spatio-temporal point processes on linear networks. Journal of Computational and Graphical Statistics. In press.

See Also

`stlpp`

Examples

```
data(Medellin)
plot(Medellin)
```

methods.stlpp *Methods for space-time point patterns on a linear network*

Description

Methods for space-time point patterns on a linear network.

Usage

```
## S3 method for class 'stlpp'
plot(x,xlab = xlab,...)
## S3 method for class 'stlppint'
plot(x,style=style,xlab=xlab,xlim=xlim,...)
## S3 method for class 'sumstlpp'
plot(x,style=c(”level”,”contour”,”perspective”), theta = 35, phi = 10,
facets = FALSE, ticktype = ”detailed”, resfac = 5,xlab=”r = distance”,ylab=”t = time”,...)
## S3 method for class 'stlpp'
print(x,...)
## S3 method for class 'stlppint'
print(x,...)
## S3 method for class 'sumstlpp'
print(x,...)
## S3 method for class 'stlpp'
x[i]
## S3 method for class 'stlppint'
x[i]
## S3 method for class 'stlppint'
as.linim(X,...)
## S3 method for class 'stlppint'
as.tppint(x)
```

Arguments

`x,X`	an object of classes `stlpp`, stlppint or sumstlpp
`style`	style of plot
`theta,phi`	see persp3D
`facets,ticktype`	see persp3D
`resfac`	see persp3D
`xlab,ylab`	the x,y label of the plot
`xlim`	giving the x limits for the plot
`i`	numeric, logical, or an object of class `stlpp`
`...`	either ignore for `as.linim`, or gracphical arguments passed to `plot`/`print`

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

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methods.tpp *Methods for temporal point patterns*

Description

Methods for temporal point patterns.

Usage

```
## S3 method for class 'tpp'
plot(x,xlab="time",ylab="",main = "cumulative number",...)
## S3 method for class 'tppint'
plot(x,xlab=xlab,xlim=xlim,line=2.5,main="NULL",...)
## S3 method for class 'tpp'
print(x,...)
## S3 method for class 'tppint'
print(x,...)
## S3 method for class 'tpp'
x[i]
## S3 method for class 'tppint'
x[i]
```

Arguments

x	an object of class tpp or tppint.
xlab,ylab	the x,y label of the plot.
main	overall title for the plot.
xlim	giving the x limits for the plot.
line	specifying a value for line overrides the default placement of y label, and places it this many lines outwards from the plot edge.
i	numeric, logical, or an object of class tpp
...	graphics parameters passed to plot/print function.

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

Examples

```
X <- tpp(sample(c(1:24),200,replace = TRUE))
plot(X)
plot(density(X))
```

rpoistlpp *Simulating spatio-temporal poisson point processes on a linear network*

Description

simulating a realisation of a spatio-temporal poisson point process on a linear network.

Usage

```
rpoistlpp(lambda,a,b,L,check=FALSE,lmax=NULL,nsim=1)
```

Arguments

`lambda`	intensity of the point process. It can be either a number, function of location and time, or an abject of class `stlppint`.
`a`	lower bound of time period.
`b`	upper bound of time period.
`L`	a linear network.
`check`	Logical value indicating whether to check that all the (x,y) points lie inside the specified window. see `ppp`.
`lmax`	upper bound for the values of labmda. This is optinal.
`nsim`	number of simulated patterns to generate.

Details

This function generates realisations of a spatio-temporal poisson point process on a linear network based on an intensity function lambda and lower/upper bounds a and b.

Value

an object of class `stlpp` if nsim=1, otherwise a list of objects of class `stlpp`.

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

References

Moradi, M.M. and Mateu, J. (2019). First and second-order characteristics of spatio-temporal point processes on linear networks. Journal of Computational and Graphical Statistics. In press.

See Also

`density.stlpp`

Examples

```
X <- rpoistlpp(.2,a=0,b=5,L=easynet)
X
```

`rpoistpp` *Simulating temporal poisson point patterns*

Description

simulating realisations of a temporal poisson point process.

Usage

```
rpoistpp(lambda,a,b,check=FALSE,lmax=NULL,nsim=1)
```

Arguments

`lambda`	intensity of the point process. It can be either a number, a function of location and time, or an object of class `tppint`.
`a`	lower bound of time period.
`b`	upper bound of time period.
`check`	Logical value indicating whether to check that all the points lie inside the specified time period.
`lmax`	upper bound for the values of labmda. This is optinal.
`nsim`	number of simulated patterns to generate.

Details

This function generates realisations of a temporal poisson point process based on a given intensity function lambda and lower/upper bounds a and b.

Value

an object of class `tpp` if nsim=1, otherwise a list of objects of class `tpp`.

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

References

Moradi, M.M. and Mateu, J. (2019). First and second-order characteristics of spatio-temporal point processes on linear networks. Journal of Computational and Graphical Statistics. In press.

See Also

`rpoistlpp`

Examples

```
f <- function(t){0.1*exp(t)}
X <- rpoistpp(f,a=1,b=10)
```

rthin.stlpp *Random thinning*

Description

Applies independent random thinning to a spatio-temporal point pattern on a linear network.

Usage

```
## S3 method for class 'stlpp'
rthin(X, P = P, nsim = 1)
```

Arguments

`X`	a spatio-temporal point pattern of class `stlpp`
`P`	retention probability
`nsim`	number of simulated realisations to be generated

Details

See `rthin`.

Value

An object of the same kind as X if nsim=1, or a list of such objects if nsim > 1.

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

See Also

`stlpp`, `rthin`

Examples

```
data(Medellin)
rthin(Medellin,P=.5)
```

STLg *Pair correlation function for spatio-temporal point processes on linear networks*

Description

Pair correlation function for spatio-temporal point processes on linear networks.

Usage

```
STLg(X,r=NULL,t=NULL,nxy=10)
```

Arguments

X	a realisation of a spatio-temporal point processes on a linear networks.
r	values of argument r where pair correlation function will be evaluated. optional.
t	values of argument t where pair correlation function will be evaluated. optional.
nxy	pixel array dimensions. optional.

Details

This function calculates the pair correlation function for a homogeneous spatio-temporal point processes on a linear network.

Value

An object of class sumstlpp.

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

References

Moradi, M.M. and Mateu, J. (2019). First and second-order characteristics of spatio-temporal point processes on linear networks. Journal of Computational and Graphical Statistics. In press.

See Also

pcf, STLK

Examples

```
X <- rpoistlpp(.2,a=0,b=5,L=easynet)
g <- STLg(X)
plot(g)
```

STLginhom *Inhomogeneous pair correlation function for spatio-temporal point processes on linear networks*

Description

Inhomogeneous pair correlation function for spatio-temporal point processes on linear networks.

Usage

```
STLginhom(X,lambda,normalize=FALSE,r=NULL,t=NULL,nxy=10)
```

Arguments

`X`	a realisation of a spatio-temporal point processes on a linear networks.
`lambda`	values of estimated intensity at data points.
`normalize`	normalization factor to be considered.
`r`	values of argument r where pair correlation function will be evaluated. optional.
`t`	values of argument t where pair correlation function will be evaluated. optional.
`nxy`	pixel array dimensions. optional.

Details

This function calculates the inhomogeneous pair correlation function for a spatio-temporal point processes on a linear network.

Value

An object of class `sumstlpp`.

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

References

Moradi, M.M. and Mateu, J. (2019). First and second-order characteristics of spatio-temporal point processes on linear networks. Journal of Computational and Graphical Statistics. In press.

See Also

`STLg`, `STLK`, `STLKinhom`

Examples

```
X <- rpoistlpp(.2,a=0,b=5,L=easynet)
d <- density(X,at="points")
g <- STLginhom(X,lambda=d,normalize=TRUE)
plot(g)
```

STLK *K-function for spatio-temporal point processes on linear networks*

Description

K-function for spatio-temporal point processes on linear networks.

Usage

```
STLK(X,r=NULL,t=NULL,nxy=10)
```

Arguments

`X`	a realisation of a spatio-temporal point processes on a linear networks.
`r`	values of argument r where pair correlation function will be evaluated. optional.
`t`	values of argument t where pair correlation function will be evaluated. optional.
`nxy`	pixel array dimensions. optional.

Details

This function calculates the K-function for a homogeneous spatio-temporal point processes on a linear network.

Value

An object of class `sumstlpp`.

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

References

Moradi, M.M. and Mateu, J. (2019). First and second-order characteristics of spatio-temporal point processes on linear networks. Journal of Computational and Graphical Statistics. In press.

See Also

`Kest`, `STLg`

Examples

```
X <- rpoistlpp(.2,a=0,b=5,L=easynet)
k <- STLK(X)
plot(k)
```

STLKinhom *Inhomogeneous K-function for spatio-temporal point processes on linear networks*

Description

Inhomogeneous K-function for spatio-temporal point processes on linear networks

Usage

```
STLKinhom(X,lambda=lambda,normalize=FALSE,r=NULL,t=NULL,nxy=10)
```

Arguments

`X` a realisation of a spatio-temporal point processes on a linear networks.

`lambda` values of estimated intensity.

`normalize` normalization factor to be considered.

`r` values of argument r where pair correlation function will be evaluated. optional.

`t` values of argument t where pair correlation function will be evaluated. optional.

`nxy` pixel array dimensions. optional.

Details

This function calculates the inhomogeneous K-function for a spatio-temporal point processes on a linear network.

Value

An object of class `sumstlpp`.

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

References

Moradi, M.M. and Mateu, J. (2019). First and second-order characteristics of spatio-temporal point processes on linear networks. Journal of Computational and Graphical Statistics. In press.

See Also

`STLg`, `STLK`, `STLginhom`

Examples

```
X <- rpoistlpp(.2,a=0,b=5,L=easynet)
lambda <- density(X,at="points")
k <- STLKinhom(X,lambda=lambda,normalize=TRUE)
plot(k)
```

---

stlpp *Create spatio-temporal point pattern on linear network*

Description

Create spatio-temporal point pattern on linear network.

Usage

```
stlpp(X, L, T, ...)
```

Arguments

X	Locations of the points. A matrix or data frame of coordinates, or a point pattern object (of class "ppp") or other data acceptable to as.ppp or lpp
L	linear network (object of class "linnet"). No need to be given if X is an object of lpp
T	time vector
...	ignored

Details

This function creates an object of class stlpp. For details about X see lpp. T represents the time occurrence of data points.

Value

an object of class stlpp.

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

See Also

as.stlpp, lpp

Examples

```
X <- rpoislpp(1,easynet)
t <- runif(npoints(X))
stlpp(X,T=t,L=easynet)
```

tpp — *Create a temporal point pattern*

Description

Create an object of class tpp that represents a temporal point pattern.

Usage

```
tpp(X,a,b)
```

Arguments

X	an object of class numeric, integer or vector
a	lower band
b	upper bound

Details

Create a temporal point pattern.

Value

An object of class tpp.

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

See Also

stlpp

Examples

```
tpp(runif(10))
```

`unique.stlpp` *Extract unique points from a spatio-temporal point pattern on a linear network*

Description

Extract unique points from a spatio-temporal point pattern on a linear network.

Usage

```
## S3 method for class 'stlpp'
unique(x,...)
```

Arguments

`x`	a realisation of a spatio-temporal point processes on a linear networks.
`...`	arguments for `unique`.

Details

This function calculates the inhomogeneous pair correlation function for a spatio-temporal point processes on a linear network.

Value

A spatio-temporal point pattern on a linear network with no duplicated point.

Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

References

Moradi, M.M. and Mateu, J. (2019). First and second-order characteristics of spatio-temporal point processes on linear networks. Journal of Computational and Graphical Statistics. In press.

See Also

`unique`

Examples

```
X <-  rpoistlpp(0.1,0,5,L=easynet)
df <- as.data.frame(X)
df_dup <- df[sample(nrow(df), 20,replace = TRUE), ]
Y <- as.stlpp(df_dup,L=easynet)
npoints(Y)
npoints(unique(Y))
```

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