# Package 'stlnpp'

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**Type** Package

**Title** Spatio-temporal analysis of point patterns on linear networks

**Version** 0.3.5

**Maintainer** Mehdi Moradi <m2.moradi@yahoo.com>

**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** spatstat (>= 1.61-0), stats

**Suggests** plot3D, lattice, graphics

**License** GPL (>= 2)

**Encoding** UTF-8

**LazyData** true

**RoxygenNote** 7.0.2

## R topics documented:

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

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

## Description

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

## Usage

```
as.stlpp.lpp(X)
```

## Arguments

| | |
|---|---|
| `X` | an object of class `stlpp` |

## 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.stlpp.lpp(Y)
```

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

### Description

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

### Usage

```
as.stlpp.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.stlpp.tpp(X)
```

## density.stlpp *Kernel estimation of intensity of space-time 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). 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))
```

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 stlpp
print(X)
## S3 method for class stlpp
print(X)
```

## Arguments

| | |
|---|---|
| `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. |
| `...` | gracphical arguments passed to `plot`. |

## Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

## 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,...)
## S3 method for class tpp
print(X)
## S3 method for class tppint
print(X)
```

### 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. |
| ... | graphics parameters passed to plot 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 or a function of location and time. |
| 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
```

`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)
STLg(X)
```

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")
STLginhom(X,lambda=d,normalize=TRUE)
```

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)
STLK(X)
```

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")
STLKinhom(X,lambda=lambda,normalize=TRUE)
```

`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") |
| `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)
```

### Arguments

| | |
|---|---|
| X | an object of class numeric, integer or vector |

### 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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