

# Package ‘stlnpp’

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**Type** Package

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

**Version** 0.3.3

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

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

**Depends** spatstat (>= 1.60-1.013), stats

**Suggests** plot3D, lattice, graphics

**License** GPL (>= 2)

**Encoding** UTF-8

**LazyData** true

**RoxygenNote** 6.1.1

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as.stlpp	<i>Convert data to a space-time point pattern on a linear network</i>
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## 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 occurrence. Alternatively, x can be of classes <a href="#">data.frame</a> , <a href="#">ppp</a> and <a href="#">lpp</a> .
L	Linear network (object of class <a href="#">linnet</a> ) 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 [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 corresponding 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 corresponding 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` into the linear network `L`.

**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	<i>Methods for space-time point patterns on a linear network.</i>
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---

**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](#)

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density.stlpp	<i>Kernel estimation of intensity of space-time point patterns on a linear network</i>
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**Description**

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

**Usage**

```
## S3 method for class stlpp
density(X,lbw,tbw,...)
```

**Arguments**

X                      an object of class [stlpp](#)  
 lbw                    network smoothing bandwidth  
 tbw                    time smoothing bandwidth  
 ...                    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**

a vector of intensity values at the data points of  $X$ . 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.

**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)
```

**Arguments**

`x` a temporal point pattern (of class [tpp](#))

**Value**

a vector of intensity values at the data points of  $X$ . 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.

## See Also

[density](#), [bw.nrd0](#)

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Eastbourne	<i>Eastbourne traffic accident data</i>
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## 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](http://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](http://www.data.gov.uk) and obtained through kaggle at [www.kaggle.com](http://www.kaggle.com).

The dataset [Eastbourne](#) is an object of class [stlpp](#).

## Usage

```
data(Eastbourne)
```

## Author(s)

Mehdi Moradi <[m2.moradi@yahoo.com](mailto: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.

## See Also

[stlpp](#)

## Examples

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

---

easynet	<i>simple linear network</i>
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---

**Description**

A simple and not real network.

**Usage**

```
data(easynet)
```

**Source**

Created by Mehdi Moradi

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Medellin	<i>Medellin traffic accident data</i>
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---

**Description**

This dataset represents the spatio-temporal locations of traffic accidents in an area near the pontifical bolivarian university in Medellin (Colombia) during 2016. The entire data were published in the OpenData portal of Medellin 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 entire 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.

**See Also**

[stlpp](#)

**Examples**

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

---

methods.tpp

*Methods for temporal point patterns.*

---

### Description

Methods for temporal point patterns.

### Usage

```
## S3 method for class tpp
plot(x)
## S3 method for class tpp
print(x)
## S3 method for class tppint
plot(x)
## S3 method for class tppint
print(x)
```

### Arguments

`x` an object of class tpp or tppint.

### Author(s)

Mehdi Moradi <m2.moradi@yahoo.com>

### Examples

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

---

plot.stlpp

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

---

### Description

plot objects of class [stlpp](#).

### Usage

```
plot(X, ...)
```

### Arguments

`X` an object of classes [stlpp](#).  
`...` arguments passed to [plot](#)



**Author(s)**

Mehdi Moradi <m2.moradi@yahoo.com>

**See Also**

[as.stlpp](#)

**Examples**

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

---

plot.stlppint

---

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


---

**Description**

plot an estimated intensity function of a space-time point patterns on a linear network.

**Usage**

```
plot.stlppint(X)
```

**Author(s)**

Mehdi Moradi <m2.moradi@yahoo.com>

**See Also**

[as.stlpp](#), [density.stlpp](#)

**Examples**

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

---

plot.sumstlpp

---

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


---

**Usage**

```
plot(X,style=c("level","contour","perspective"), theta = 35, phi = 10,
      facets = FALSE, ticktype = "detailed", resfac = 5,
      xlab="r = distance",ylab="t = time",...)
```

**Arguments**

X	an object of class sumstlpp.
style	type of plot to be exhibited.
...	arguments passed to <a href="#">levelplot</a> , <a href="#">contour</a> or <a href="#">persp3D</a> .

**Details**

This function plots K-function and pair correlation function for spatio-temporal point patterns on linear networks using different styles.

**Author(s)**

Mehdi Moradi <m2.moradi@yahoo.com>

**See Also**

[levelplot](#), [contour](#), [persp3D](#)

---

print.stlpp

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

---

**Description**

Methods to print an object of class [stlpp](#).

**Usage**

```
print.stlpp(x)
```

**Author(s)**

Mehdi Moradi <m2.moradi@yahoo.com>

**See Also**

[as.stlpp](#)

**Examples**

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

---

print.stlppint

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

---

**Description**

Methods to print an object of class [stlppint](#).

**Usage**

```
print.stlppint(x)
```

**Author(s)**

Mehdi Moradi <m2.moradi@yahoo.com>

**See Also**

[as.stlpp](#), [density.stlpp](#)

**Examples**

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

---

print.sumstlpp

---

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


---

**Description**

Methods to print an object of class [stlpp](#).

**Usage**

```
print.sumstlpp(x)
```

**Author(s)**

Mehdi Moradi <m2.moradi@yahoo.com>

**See Also**

[STLg](#), [STLK](#), [STLginhom](#), [STLKinhom](#)

**Examples**

```
X = rpoistlpp(.2,a=0,b=5,L=easynet)
STLK(X)
STLg(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 <a href="#">ppp</a> .
lmax	upper bound for the values of labmda. This is optinal.
nsim	number of simulated patterns to generate.

**Details**

This function generates a realisation of a spatio-temporal poisson point process on a linear network based on 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.

**See Also**

[density](#)

**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 <code>stlpp</code>
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

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

---

**Description**

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

**Usage**

```
STLg(X, seqr=NULL, seqt=NULL)
```

**Arguments**

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

**See Also**

[pcf](#), [STLK](#)

**Examples**

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

---

STLginhom

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

---

**Description**

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

**Usage**

```
STLginhom(X,lambda,normalize=FALSE,seqr=NULL,seqt=NULL)
```

**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.
seqr	values of argument r where pair correlation function will be evaluated. optional.
seqt	values of argument t where pair correlation function will be evaluated. 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.

**See Also**

[STLg](#), [STLK](#), [STLKinhom](#)

**Examples**

```
X = rpoistlpp(.2,a=0,b=5,L=easynet)
d = density(X)
STLginhom(X,lambda=d)
```

---

STLk	<i>spatio-temporal K-function for point processes on linear networks</i>
------	--

---

**Description**

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

**Usage**

```
STLk(X, seqr=NULL, seqt=NULL)
```

**Arguments**

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

**See Also**

[Kest](#), [STLg](#)

**Examples**

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

STLkinhom

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

**Description**

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

**Usage**

```
STLkinhom(X,lambda=lambda,normaliz=FALSE,seqr=NULL,seqt=NULL)
```

**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.
seqr	values of argument r where pair correlation function will be evaluated. optional.
seqt	values of argument t where pair correlation function will be evaluated. 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.

**See Also**

[STLg](#), [STLK](#), [STLginhom](#)

**Examples**

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



---

stlpp	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 <a href="#">as.ppp</a> or <a href="#">lpp</a>
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](#)

---

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 <a href="#">numeric</a> , <a href="#">integer</a> or <a href="#">vector</a>
---	--

**Details**

Create a temporal point pattern.

**Value**

an object of class tpp.

**Author(s)**

Mehdi Moradi <m2.moradi@yahoo.com>

**See Also**

[stlpp](#)

---

unique.stlpp	<i>extract unique points from a spatio-temporal point pattern on a linear network</i>
--------------	---

---

**Usage**

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

**Arguments**

X	a realisation of a spatio-temporal point processes on a linear networks.
...	arguments for <a href="#">unique</a> .

**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.

**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 = T), ]
Y = as.stlpp(df_dup,L=easynet)
npoints(Y)
npoints(unique(Y))
```

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