Package 'stopp'

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Title Spatio-Temporal Point Pattern Methods, Model Fitting, Diagnostics, Simulation, Local Tests

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Type Package

Description Toolbox for different kinds of spatio-temporal analyses to be performed on observed point patterns, following the growing stream of literature on point process theory. This R package implements functions to perform different kinds of analyses on point processes, proposed in the papers (Siino, Adelfio, and Mateu 2018<doi:10.1007/s00477-018-1579-0>; Siino et al. 2018<doi:10.1002/env.2463>; Adelfio et al. 2020<doi:10.1007/s00477-019-01748-1>; D'Angelo, Adelfio, and Mateu 2021<doi:10.1016/j.spasta.2021.100534>; D'Angelo, Adelfio, and Mateu 2022<doi:10.1007/s00362-022-01338-4>; D'Angelo, Adelfio, and Mateu 2023<doi:10.1016/j.csda.2022.107679>). The main topics include modeling, statistical inference, and simulation issues on spatio-temporal point processes on Euclidean space and linear networks.

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`stopp-package` *Spatio-Temporal Point Pattern Methods, Model Fitting, Diagnostics, Simulation, Local Tests*

Description

Toolbox for different kinds of spatio-temporal analyses to be performed on observed point patterns, following the growing stream of literature on point process theory. This R package implements functions to perform different kinds of analyses on point processes, proposed in the papers: Siino, Adelfio, and Mateu (2018), Siino et al. (2018), Adelfio et al. (2020), D'Angelo, Adelfio, and Mateu (2021), D'Angelo, Adelfio, and Mateu (2022), and D'Angelo, Adelfio, and Mateu (2023). The main topics include modeling, statistical inference, and simulation issues on spatio-temporal point processes on Euclidean space and linear networks.

Author(s)

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References

Adelfio, G., Siino, M., Mateu, J., and Rodríguez-Cortés, F. J. (2020). Some properties of local weighted second-order statistics for spatio-temporal point processes. Stochastic Environmental Research and Risk Assessment, 34(1), 149-168.

D'Angelo, N., Adelfio, G., and Mateu, J. (2021). Assessing local differences between the spatio-temporal second-order structure of two point patterns occurring on the same linear network. Spatial Statistics, 45, 100534.

D'Angelo, N., Adelfio, G. and Mateu, J. (2022) Local inhomogeneous second-order characteristics for spatio-temporal point processes on linear networks. Stat Papers. https://doi.org/10.1007/s00362-022-01338-4

D'Angelo, N., Adelfio, G., and Mateu, J. (2023). Locally weighted minimum contrast estimation for spatio-temporal log-Gaussian Cox processes. Computational Statistics & Data Analysis, 180, 107679.

Siino, M., Adelfio, G., and Mateu, J. (2018). Joint second-order parameter estimation for spatio-temporal log-Gaussian Cox processes. Stochastic environmental research and risk assessment, 32(12), 3525-3539.

Siino, M., Rodríguez-Cortés, F. J., Mateu, J. ,and Adelfio, G. (2018). Testing for local structure in spatiotemporal point pattern data. Environmetrics, 29(5-6), e2463.

`chicagonet` *Rescaled roads of Chicago (Illinois, USA)*

Description

A linear network of class `linnet` of the roads of Chicago (Illinois, USA) close to the University of Chicago. The window has been rescaled to be enclosed in a unit square.

Usage

```
data(chicagonet)
```

Format

A linear network of class `linnet`

Author(s)

Nicoletta D'Angelo

References

Ang, Q.W., Baddeley, A. and Nair, G. (2012) Geometrically corrected second-order analysis of events on a linear network, with applications to ecology and criminology. Scandinavian Journal of Statistics 39, 591–617.

Examples

```
data(chicagonet)
```

`globaldiag` *Global diagnostics of a spatio-temporal point process first-order intensity*

Description

This function performs global diagnostics of a model fitted for the first-order intensity of a spatio-temporal point pattern, by returning the inhomogeneous K-function weighted by the provided intensity to diagnose, its theoretical value, and their difference.

Usage

```
globaldiag(x, intensity)
```

Arguments

`x`	A `stp` object
`intensity`	A vector of intensity values, of the same length as the number of point in `x`

Details

If applied to a `stp` object, it resorts to the spatio-temporal inhomogeneous K-function (Gabriel and Diggle, 2009) documented by the function STIKhat of the `stpp` package (Gabriel et al, 2013).

If applied to a `stlp` object, it uses the spatio-temporal inhomogeneous K-function on a linear network (Moradi and Mateu, 2020) documented by the function STLKinhom of the `stlnpp` package (Moradi et al., 2020).

Value

A list of class `globaldiag`, containing

`x` The observed point pattern

`dist` The spatial ranges of the K-function

`times` The temporal ranges of the K-function

`est` The estimated K-function weighted by the intensity function in input

`theo` The theoretical K-function

`diffK` The difference between the estimated and the theoretical K-functions

`squared.diff` The sum of the squared differences between the estimated and the theoretical K-functions

Author(s)

Nicoletta D'Angelo and Giada Adelfio

References

Adelfio, G., Siino, M., Mateu, J., and Rodríguez-Cortés, F. J. (2020). Some properties of local weighted second-order statistics for spatio-temporal point processes. Stochastic Environmental Research and Risk Assessment, 34(1), 149-168.

D'Angelo, N., Adelfio, G. and Mateu, J. (2022) Local inhomogeneous second-order characteristics for spatio-temporal point processes on linear networks. Stat Papers. https://doi.org/10.1007/s00362-022-01338-4

Gabriel, E., and Diggle, P. J. (2009). Second-order analysis of inhomogeneous spatio-temporal point process data. Statistica Neerlandica, 63(1), 43-51.

Gabriel, E., Rowlingson, B. S., & Diggle, P. J. (2013). stpp: An R Package for Plotting, Simulating and Analyzing Spatio-Temporal Point Patterns. Journal of Statistical Software, 53(2), 1–29. https://doi.org/10.18637/jss.v053.i02

Moradi M, Cronie O, and Mateu J (2020). stlnpp: Spatio-temporal analysis of point patterns on linear networks.

Moradi, M. M., and Mateu, J. (2020). First-and second-order characteristics of spatio-temporal point processes on linear networks. Journal of Computational and Graphical Statistics, 29(3), 432-443.

See Also

plot.globaldiag, print.globaldiag, summary.globaldiag

Examples

```
set.seed(2)
inh <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)}, par = c(.3, 6))

mod1 <- stppm(inh, formula = ~ 1)
mod2 <- stppm(inh, formula = ~ x)

g1 <- globaldiag(inh, mod1$l)
g2 <- globaldiag(inh, mod2$l)
```

---

greececatalog *Catalog of Greek earthquakes*

Description

A dataset in `stp` format containing the catalog of Greek earthquakes of magnitude at least 4.0 from year 2005 to year 2014. Data come from the Hellenic Unified Seismic Network (H.U.S.N.).

Usage

```
data(greececatalog)
```

Format

A `stp` object for a spatio-temporal point pattern with 1111 points

Details

The variables are as follows:

- x. longitude, ranging from 20.02 to 27.98
- y. latitude, ranging from 33.75 to 40.45
- t. time, ranging from 38354, 42000

Author(s)

Nicoletta D'Angelo

References

D'Angelo, N., Siino, M., D'Alessandro, A., and Adelfio, G. (2022). Local spatial log-Gaussian Cox processes for seismic data. AStA Advances in Statistical Analysis, 1-39.

D'Angelo, N., Adelfio, G., and Mateu, J. (2023). Locally weighted minimum contrast estimation for spatio-temporal log-Gaussian Cox processes. Computational Statistics & Data Analysis, 180, 107679.

Gabriel, E., Rodriguez-Cortes, F., Coville, J., Mateu, J., and Chadoeuf, J. (2022). Mapping the intensity function of a non-stationary point process in unobserved areas. Stochastic Environmental Research and Risk Assessment, 1-17.

Siino, M., Adelfio, G., Mateu, J., Chiodi, M., and D'alessandro, A. (2017). Spatial pattern analysis using hybrid models: an application to the Hellenic seismicity. Stochastic Environmental Research and Risk Assessment, 31(7), 1633-1648.

Examples

```
data(greececatalog)

plot(greececatalog)
```

infl *Display outlying LISTA functions*

Description

This function works on the objects of class `localdiag`, as returned by localdiag, plotting the identified 'outlying' LISTA functions. These correspond to the influential points in the fitting of the model provided by localdiag

Usage

```
infl(x, id = NULL)
```

Arguments

`x`	An object of class `localdiag`
`id`	The id of the LISTA to display. Default is set to the ids identified and stored in the `localdiag` object

Author(s)

Nicoletta D'Angelo and Giada Adelfio

References

Adelfio, G., Siino, M., Mateu, J., and Rodríguez-Cortés, F. J. (2020). Some properties of local weighted second-order statistics for spatio-temporal point processes. Stochastic Environmental Research and Risk Assessment, 34(1), 149-168.

D'Angelo, N., Adelfio, G. and Mateu, J. (2022) Local inhomogeneous second-order characteristics for spatio-temporal point processes on linear networks. Stat Papers. https://doi.org/10.1007/s00362-022-01338-4

See Also

localdiag, plot.localdiag, print.localdiag, summary.localdiag

Examples

```
set.seed(2)
inh <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)}, par = c(.3, 6))

mod1 <- stppm(inh, formula = ~ 1)

resmod1 <- localdiag(inh, mod1$l, p = .9)

infl(resmod1)
```

`localdiag` *Local diagnostics of spatio-temporal point process models*

Description

This function performs local diagnostics of a model fitted for the first-order intensity of a spatio-temporal point pattern, returning the points identified as outlying following the diagnostics procedure on individual points of an observed point pattern, as introduced in Adelfio et al. (2020), and applied in D'Angelo et al. (2022) for the linear network case.

The points resulting from the local diagnostic procedure provided by this function can be inspected via the plot, print, summary, and infl functions.

Usage

```
localdiag(x, intensity, p = 0.95)
```

Arguments

`x`	Either a `stp` or a `stlp` object
`intensity`	A vector of intensity values, of the same length as the number of point in `x`
`p`	The percentile to consider as threshold for the outlying points. Default to 0.95.

Details

This function performs local diagnostics of a model fitted for the first-order intensity of a spatio-temporal point pattern, by means of the local spatio-temporal inhomogeneous K-function (Adelfio et al, 2020) documented by the function KLISTAhat of the `stpp` package (Gabriel et al, 2013).

The function can also perform local diagnostics of a model fitted for the first-order intensity of an spatio-temporal point pattern on a linear network, by means of the local spatio-temporal inhomogeneous K-function on linear networks (D'Angelo et al, 2021) documented by the function localSTLKinhom.

In both cases, it returns the points identified as outlying following the diagnostics procedure on individual points of an observed point pattern, as introduced in Adelfio et al. (2020), and applied in D'Angelo et al. (2022) for the linear network case.

This function computes discrepancies by means of the χ_i^2 values, obtained following the expression

$$\chi_i^2 = \int_L \int_T \left(\frac{\left(\hat{K}_I^i(r,h) - \mathbb{E}[\hat{K}^i(r,h)]\right)^2}{\mathbb{E}[\hat{K}^i(r,h)]} \right) \mathrm{d}h\mathrm{d}r,$$

one for each point in the point pattern.

Note that the Euclidean procedure is implemented by the local K-functions of Adelfio et al. (2020), documented in KLISTAhat of the `stpp` package (Gabriel et al, 2013). The network case uses the local K-functions on networks (D'Angelo et al., 2021), documented in localSTLKinhom.

Value

A list object of class `localdiag`, containing

`x` The `stp` object provided as input

`listas` The LISTA functions, in a list object

`ids` The ids of the points identified as outlying

`x2` A vector with the individual contributions to the Chi-squared statistics, normalized

`p` The percentile considered

Author(s)

Nicoletta D'Angelo and Giada Adelfio

References

Adelfio, G., Siino, M., Mateu, J., and Rodríguez-Cortés, F. J. (2020). Some properties of local weighted second-order statistics for spatio-temporal point processes. Stochastic Environmental Research and Risk Assessment, 34(1), 149-168.

D'Angelo, N., Adelfio, G. and Mateu, J. (2022) Local inhomogeneous second-order characteristics for spatio-temporal point processes on linear networks. Stat Papers. https://doi.org/10.1007/s00362-022-01338-4

Gabriel, E., Rowlingson, B. S., and Diggle, P. J. (2013). stpp: An R Package for Plotting, Simulating and Analyzing Spatio-Temporal Point Patterns. Journal of Statistical Software, 53(2), 1–29. https://doi.org/10.18637/jss.v053.i02

See Also

infl, plot.localdiag, print.localdiag, summary.localdiag, globaldiag

Examples

```
set.seed(2)
inh <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)},
             par = c(.3, 6))

mod1 <- stppm(inh, formula = ~ 1)

resmod1 <- localdiag(inh, mod1$l, p = .9)
```

`localplot` *Plot the coefficients of a fitted local spatio-temporal Poisson process or local LGCP model*

Description

The function plots the local estimates of a fitted local spatio-temporal Poisson process or local LGCP model

Usage

```
localplot(x, par = TRUE)
```

Arguments

`x`	An object of class `locstppm` or `stlgcppm`
`par`	Default to `TRUE`.

Author(s)

Nicoletta D'Angelo

References

D'Angelo, N., Adelfio, G., and Mateu, J. (2023). Locally weighted minimum contrast estimation for spatio-temporal log-Gaussian Cox processes. Computational Statistics & Data Analysis, 180, 107679.

See Also

locstppm, stlgcppm

Examples

```
# Local spatio-temporal Poisson process model

set.seed(2)
inh <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)},
             par = c(0.005, 5))
inh_local <- locstppm(inh, formula = ~ x)

localplot(inh_local)

# Local LGCP
catsub <- stp(greececatalog$df[1:200, ])

lgcp_loc <- stlgcppm(catsub, formula = ~ x, first = "local")
```

```
localplot(lgcp_loc)
```

`localSTLginhom` *Local inhomogeneous Spatio-temporal pair correlation functions on a linear network*

Description

The functions `localSTLKinhom` and `localSTLginhom` implement the inhomogeneous LISTA functions proposed in D'Angelo et al. (2022).

Usage

```
localSTLginhom(x, lambda, normalize = FALSE, r = NULL, t = NULL, nxy = 10)
```

Arguments

`x`	A realisation of a spatio-temporal point processes on a linear network in `stlp` format
`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

The homogeneous K-function and pair correlation functions, in D'Angelo et al. (2021), can be obtained easily with `localSTLKinhom` and `localSTLginhom`, by imputing a lambda vector of constant intensity values, the same for each point.

Value

A list of class `lista`. The objects are of class `sumstlpp` (Moradi and Mateu, 2020).

Author(s)

Nicoletta D'Angelo

References

D'Angelo, N., Adelfio, G., and Mateu, J. (2021). Assessing local differences between the spatio-temporal second-order structure of two point patterns occurring on the same linear network. Spatial Statistics, 45, 100534.

D'Angelo, N., Adelfio, G. and Mateu, J. (2022). Local inhomogeneous second-order characteristics for spatio-temporal point processes on linear networks. Stat Papers. https://doi.org/10.1007/s00362-022-01338-4

See Also

localSTLginhom, STLKinhom, STLginhom

Examples

```
set.seed(2)
df_net <- data.frame(x = runif(25, 0, 0.85), y = runif(25, 0, 0.85), t = runif(25))
stlp1 <- stp(df_net, L = chicagonet)
lambda <- rep(diff(range(stlp1$df$x)) * diff(range(stlp1$df$y))
* diff(range(stlp1$df$t)) / spatstat.geom::volume(stlp1$L),
nrow(stlp1$df))

g <- localSTLginhom(stlp1, lambda = lambda, normalize = TRUE)
```

---

localSTLKinhom *Local inhomogeneous Spatio-temporal K-functions on a linear network*

Description

The functions `localSTLKinhom` and `localSTLginhom` implement the inhomogeneous LISTA functions proposed in D'Angelo et al. (2022).

Usage

```
localSTLKinhom(
  x,
  lambda = lambda,
  normalize = FALSE,
  r = NULL,
  t = NULL,
  nxy = 10
)
```

Arguments

x	A realisation of a spatio-temporal point processes on a linear network in stlp format
lambda	values of estimated intensity.
normalize	normalization factor to be considered.
r	values of argument r where K-function will be evaluated. optional.
t	values of argument t where K-function will be evaluated. optional.
nxy	pixel array dimensions. optional.

Details

The homogeneous K-function and pair correlation functions, in D'Angelo et al. (2021), can be obtained easily with localSTLKinhom and localSTLginhom, by imputing a lambda vector of constant intensity values, the same for each point.

Value

A list of class lista. The objects are of class sumstlpp (Moradi and Mateu, 2020).

Author(s)

Nicoletta D'Angelo

References

D'Angelo, N., Adelfio, G., and Mateu, J. (2021). Assessing local differences between the spatio-temporal second-order structure of two point patterns occurring on the same linear network. Spatial Statistics, 45, 100534.

D'Angelo, N., Adelfio, G., and Mateu, J. (2022). Local inhomogeneous second-order characteristics for spatio-temporal point processes on linear networks. Stat Papers. https://doi.org/10.1007/s00362-022-01338-4

See Also

localSTLginhom, STLKinhom, STLginhom

Examples

```
set.seed(2)
df_net <- data.frame(x = runif(25, 0, 0.85), y = runif(25, 0, 0.85), t = runif(25))
stlp1 <- stp(df_net, L = chicagonet)
lambda <- rep(diff(range(stlp1$df$x)) * diff(range(stlp1$df$y))
 * diff(range(stlp1$df$t)) / spatstat.geom::volume(stlp1$L),
nrow(stlp1$df))

k <- localSTLKinhom(stlp1, lambda = lambda, normalize = TRUE)
```

`localsummary` *Summary plots of the fitted coefficient of a local spatio-temporal Poisson process or a local LGCP model*

Description

The function breaks up the contribution of the local estimates to the fitted intensity, by plotting the overall intensity and the density kernel smoothing of some artificial intensities, obtained by imputing the quartiles of the local parameters' distributions.

Usage

```
localsummary(
  x,
  scaler = c("silverman", "IQR", "sd", "var"),
  do.points = TRUE,
  print.bw = FALSE,
  zap = 1e-05,
  par = TRUE
)
```

Arguments

`x`	An object of class `locstppm` or `stlgcppm`
`scaler`	Optional. Controls the value for a scalar representation of the spatial scale of the data. Either a character string, `"silverman"` (default), `"IQR"`, `"sd"`, or `"var"`; or positive numeric value(s). See OS.
`do.points`	Add points to plot
`print.bw`	It prints the estimated oversmoothing (OS) bandwidth selector
`zap`	Noise threshold factor (default to 0.00001). A numerical value greater than or equal to 1. If the range of pixel values is less than `zap * .Machine$double.eps`, the image will be treated as constant. This avoids displaying images which should be constant but contain small numerical errors.
`par`	Default to `TRUE`.

Author(s)

Nicoletta D'Angelo and Giada Adelfio

References

D'Angelo, N., Adelfio, G., and Mateu, J. (2023). Locally weighted minimum contrast estimation for spatio-temporal log-Gaussian Cox processes. Computational Statistics & Data Analysis, 180, 107679.

Davies, T.M. and Hazelton, M.L. (2010). Adaptive kernel estimation of spatial relative risk, Statistics in Medicine, 29(23) 2423-2437.

Terrell, G.R. (1990). The maximal smoothing principle in density estimation, Journal of the American Statistical Association, 85, 470-477.

See Also

locstppm, stlgcppm

Examples

```
# Local spatio-temporal Poisson process model

set.seed(2)
inh <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)},
             par = c(0.005, 5))
inh_local <- locstppm(inh, formula = ~ x)

localsummary(inh_local)

# Local LGCP

catsub <- stp(greececatalog$df[1:200, ])

lgcp_loc <- stlgcppm(catsub, formula = ~ x, first = "local")

localsummary(lgcp_loc)
```

`localtest` *Test of local structure for spatio-temporal point processes*

Description

This function performs the permutation test of the local structure for spatio-temporal point pattern data, proposed in Siino et al. (2018), as well as for spatio-temporal point pattern data occurring on the same linear network, following D'Angelo et al. (2021).

Usage

```
localtest(X, Z, method = c("K", "g"), k, alpha = 0.05, verbose = TRUE)
```

Arguments

`X`	Background spatio-temporal point pattern. Usually, the most clustered between `X` and `Z`. Must be either a `stp` or `stlp` object.
`Z`	Other spatio-temporal point pattern. Must also be of the same class as `X`.

method	Character string indicating which version of LISTA function to use: either "K" or "g". If "K", the local spatio-temporal K-function is used to run the test. If "g", the local spatio-temporal pair correlation function is used.
k	Number of permutations
alpha	Significance level
verbose	If TRUE (default) the progress of the test is printed

Details

The test detects local differences between **x** and **z** occurring on the same space-time region.

The test ends providing a vector p of p- values, one for each point in **x**.

If the test is performed for spatio-temporal point patterns as in Siino et al. (2018), that is, on an object of class stp, the LISTA functions $\hat{L}^{(i)}$ employed are the local functions of Adelfio et al. (2020), documented in KLISTAhat and LISTAhat of the stpp package (Gabriel et al, 2013).

If the function is applied to a stlp object, that is, on two spatio-temporal point patterns observed on the same linear network L, the LISTA function $\hat{L}^{(i)}$ used are the ones proposed in D'Angelo et al. (2021), documented in localSTLKinhom and localSTLginhom.

Details on the performance of the test are found in Siino et al. (2018) and D'Angelo et al. (2021), for Euclidean and network spaces, respectively.

Value

A list of class localtest, containing

p A vector of p-values, one for each of the points in X

X The background spatio-temporal point pattern given in input

Z The alternative spatio-temporal point pattern given in input

alpha The threshold given in input

Xsig A stp object storing the resulting significant points

Xnosig A stp object storing the resulting non-significant points

id The ids of the resulting significant points

Author(s)

Nicoletta D'Angelo and Marianna Siino

References

Adelfio, G., Siino, M., Mateu, J., and Rodríguez-Cortés, F. J. (2020). Some properties of local weighted second-order statistics for spatio-temporal point processes. Stochastic Environmental Research and Risk Assessment, 34(1), 149-168.

D'Angelo, N., Adelfio, G., and Mateu, J. (2021). Assessing local differences between the spatio-temporal second-order structure of two point patterns occurring on the same linear network. Spatial Statistics, 45, 100534.

Gabriel, E., Rowlingson, B. S., and Diggle, P. J. (2013). stpp: An R Package for Plotting, Simulating and Analyzing Spatio-Temporal Point Patterns. Journal of Statistical Software, 53(2), 1–29. https://doi.org/10.18637/jss.v053.i02

Siino, M., Rodríguez-Cortés, F. J., Mateu, J. ,and Adelfio, G. (2018). Testing for local structure in spatiotemporal point pattern data. Environmetrics, 29(5-6), e2463.

See Also

print.localtest, summary.localtest, plot.localtest

Examples

```
set.seed(2)
X <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)},
           par = c(.005, 5))
Z <- rstpp(lambda = 30)

test <- localtest(X, Z, method = "K", k = 3)
```

`locstppm` *Fit a local Poisson process model to a spatio-temporal point pattern*

Description

This function fits a Poisson process model to an observed spatio-temporal point pattern stored in a `stp` object, that is, a Poisson model with a set of parameters θ_i for each point i.

Usage

```
locstppm(
  X,
  formula,
  verbose = TRUE,
  mult = 4,
  seed = NULL,
  hs = c("global", "local"),
  npx0 = 10,
  npt0 = 10
)
```

Arguments

X	A stp object
formula	An object of class "formula": a symbolic description of the model to be fitted. The current version only supports formulas depending on the spatial and temporal coordinates: x, y, t.
verbose	Default to TRUE
mult	The multiplicand of the number of data points, for setting the number of dummy points to generate for the quadrature scheme
seed	The seed used for the simulation of the dummy points. Default to NULL.
hs	Character string indicating whether to select fixed or variable bandwidths for the kernel weights to be used in the log-likelihood. In any of those cases, the well-supported rule-of-thumb for choosing the bandwidth of a Gaussian kernel density estimator is employed. If hs = "global" (default), a fixed bandwidth is selected. If hs = "local", an individual bandwidth is selected for each point in the pattern X.
npx0	Number of lags for the space grid period for variable bandwidths kernel
npt0	Number of lags for the time period for variable bandwidths kernel

Details

We assume that the template model is a Poisson process, with a parametric intensity or rate function $\lambda(\mathbf{u}, t; \theta_i)$ with space and time locations $\mathbf{u} \in W, t \in T$ and parameters $\theta_i \in \Theta$.

Estimation is performed through the fitting of a glm using a localized version of the quadrature scheme by Berman and Turner (1992), firstly introduced in the purely spatial context by Baddeley (2017), and in the spatio-temporal framework by D'Angelo et al. (2023).

Value

An object of class locstppm. A list of

IntCoefs The fitted global coefficients

IntCoefs_local The fitted local coefficients

X The stp object provided as input

nX The number of points in X

I Vector indicating which points are dummy or data

y_resp The response variable of the model fitted to the quadrature scheme

formula The formula provided as input

l Fitted intensity through the global parameters

l_local Fitted intensity through the local parameters

mod_global The glm object of the model fitted to the quadrature scheme

newdata The data used to fit the model, without the dummy points

time Time elapsed to fit the model, in minutes

Author(s)

Nicoletta D'Angelo

References

Baddeley, A. (2017). Local composite likelihood for spatial point processes. Spatial Statistics, 22, 261-295.

D'Angelo, N., Adelfio, G., and Mateu, J. (2023). Locally weighted minimum contrast estimation for spatio-temporal log-Gaussian Cox processes. Computational Statistics & Data Analysis, 180, 107679.

See Also

stppm

Examples

```
set.seed(2)
inh <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)},
             par = c(0.005, 5))
inh_local <- locstppm(inh, formula = ~ x)
```

`plot.globaldiag` *Plot of the global diagnostics of a spatio-temporal point process first-order intensity*

Description

This function performs global diagnostics of a model fitted for the first-order intensity of a spatio-temporal point pattern, by returning the plots of the inhomogeneous K-function weighted by the provided intensity to diagnose, its theoretical value, and their difference.

Usage

```
## S3 method for class 'globaldiag'
plot(x, samescale = TRUE, ...)
```

Arguments

`x`	A `globaldiag` object
`samescale`	Logical value. It indicates whether to plot the observed and the theoretical K-function in the same or different scale. Default to `TRUE`.
`...`	additional unused argument

Value

It plots three panels: the observed K-function, as returned by STLKinhom; the theoretical one; their difference. The function also prints the sum of squared differences between the observed and theoretical K-function on the console.

Author(s)

Nicoletta D'Angelo

References

Adelfio, G., Siino, M., Mateu, J., and Rodríguez-Cortés, F. J. (2020). Some properties of local weighted second-order statistics for spatio-temporal point processes. Stochastic Environmental Research and Risk Assessment, 34(1), 149-168.

D'Angelo, N., Adelfio, G. and Mateu, J. (2022) Local inhomogeneous second-order characteristics for spatio-temporal point processes on linear networks. Stat Papers. https://doi.org/10.1007/s00362-022-01338-4

Gabriel, E., and Diggle, P. J. (2009). Second-order analysis of inhomogeneous spatio-temporal point process data. Statistica Neerlandica, 63(1), 43-51.

Gabriel, E., Rowlingson, B. S., & Diggle, P. J. (2013). stpp: An R Package for Plotting, Simulating and Analyzing Spatio-Temporal Point Patterns. Journal of Statistical Software, 53(2), 1–29. https://doi.org/10.18637/jss.v053.i02

Moradi M, Cronie O, and Mateu J (2020). stlnpp: Spatio-temporal analysis of point patterns on linear networks.

Moradi, M. M., and Mateu, J. (2020). First-and second-order characteristics of spatio-temporal point processes on linear networks. Journal of Computational and Graphical Statistics, 29(3), 432-443.

See Also

globaldiag, print.globaldiag, summary.globaldiag

Examples

```
set.seed(2)
inh <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)},
               par = c(.3, 6))

mod1 <- stppm(inh, formula = ~ 1)
mod2 <- stppm(inh, formula = ~ x)

g1 <- globaldiag(inh, mod1$l)
g2 <- globaldiag(inh, mod2$l)

plot(g1)
plot(g2)
```

`plot.lista` *Display LISTA functions*

Description

This function works on the objects of class `lista`, as returned by `localSTLKinhom` or `localSTLginhom`, plotting the specified LISTA functions.

Usage

```
## S3 method for class 'lista'
plot(x, id, ...)
```

Arguments

`x`	An object of class `lista`
`id`	The id of the LISTA to display
`...`	additional unused argument

Author(s)

Nicoletta D'Angelo

References

D'Angelo, N., Adelfio, G., and Mateu, J. (2021). Assessing local differences between the spatio-temporal second-order structure of two point patterns occurring on the same linear network. Spatial Statistics, 45, 100534.

D'Angelo, N., Adelfio, G., and Mateu, J. (2022). Local inhomogeneous second-order characteristics for spatio-temporal point processes on linear networks. Stat Papers. https://doi.org/10.1007/s00362-022-01338-4

See Also

localSTLKinhom, localSTLginhom

Examples

```
set.seed(2)
df_net <- data.frame(x = runif(25, 0, 0.85), y = runif(25, 0, 0.85), t = runif(25))
stlp1 <- stp(df_net, L = chicagonet)
lambda <- rep(diff(range(stlp1$df$x)) * diff(range(stlp1$df$y))
 * diff(range(stlp1$df$t)) / spatstat.geom::volume(stlp1$L),
nrow(stlp1$df))

k <- localSTLKinhom(stlp1, lambda = lambda, normalize = TRUE)
```

```
plot(k, id = 1:9)
```

`plot.localdiag` *Plot of the local diagnostics' result on a spatio-temporal point process model*

Description

This function plots the result of the local diagnostics performed with localdiag on either a `stp` or `stlp` object. It highlights the points of the analysed spatio-temporal point pattern `X` which are identified as outlying by the previously performed local diagnostics; the remaining points of `X` are also represented.

It also shows the underlying linear network, if the local diagnostics has been applied to point patterns occurring on the same linear network, that is, if localdiag has been applied to a `stlp` object.

Usage

```
## S3 method for class 'localdiag'
plot(x, marg = TRUE, col = "grey", col2 = "red", cols = "lightgrey", ...)
```

Arguments

`x`	A `localdiag` object
`marg`	Default to `TRUE`. If `marg = F`, only the spatio-temporal point pattern is plotted
`col`	Color of the outlying points
`col2`	Color of the network (if applicable)
`cols`	Color of the non-outlying points
`...`	additional unused argument

Author(s)

Nicoletta D'Angelo and Giada Adelfio

References

Adelfio, G., Siino, M., Mateu, J., and Rodríguez-Cortés, F. J. (2020). Some properties of local weighted second-order statistics for spatio-temporal point processes. Stochastic Environmental Research and Risk Assessment, 34(1), 149-168.

D'Angelo, N., Adelfio, G. and Mateu, J. (2022) Local inhomogeneous second-order characteristics for spatio-temporal point processes on linear networks. Stat Papers. https://doi.org/10.1007/s00362-022-01338-4

See Also

infl, print.localdiag, summary.localdiag

Examples

```
set.seed(2)
inh <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)},
             par = c(.3, 6))

mod1 <- stppm(inh, formula = ~ 1)

resmod1 <- localdiag(inh, mod1$l, p = .9)

plot(resmod1)
plot(resmod1, marg = FALSE)
```

`plot.localtest` *Plot of the result of the local permutation test*

Description

This function plots the result of the local permutation test performed with localtest on either a `stp` or `stlp` object. It highlights the points of the background pattern `X`, which exhibit local differences in the second-order structure with respect to `Z`, according to the previously performed test. The remaining points of `X` are also represented.

It also shows the underlying linear network, if the local test has been applied to point patterns occurring on the same linear network, that is, if localtest has been applied to a `stlp` object.

Usage

```
## S3 method for class 'localtest'
plot(x, col = "grey", cols = "lightgrey", col2 = "red", ...)
```

Arguments

`x`	An object of class `localtest`
`col`	Color of the significant points
`cols`	Color of the linear network. If applicable.
`col2`	Color of the non-significant points
`...`	additional unused argument

Author(s)

Nicoletta D'Angelo

References

D'Angelo, N., Adelfio, G., and Mateu, J. (2021). Assessing local differences between the spatio-temporal second-order structure of two point patterns occurring on the same linear network. Spatial Statistics, 45, 100534.

Siino, M., Rodríguez-Cortés, F. J., Mateu, J. ,and Adelfio, G. (2018). Testing for local structure in spatiotemporal point pattern data. Environmetrics, 29(5-6), e2463.

See Also

localtest, print.localtest, summary.localtest

Examples

```
set.seed(2)
X <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)},
           par = c(.005, 5))
Z <- rstpp(lambda = 30)

test <- localtest(X, Z, method = "K", k = 3)

plot(test)
```

`plot.locstppm` *Plot of the fitted intensity of a local spatio-temporal Poisson process model*

Description

The function plots the local fitted intensity, displayed both in space and in space and time.

Usage

```
## S3 method for class 'locstppm'
plot(
  x,
  scaler = c("silverman", "IQR", "sd", "var"),
  do.points = TRUE,
  print.bw = FALSE,
  zap = 1e-05,
  par = TRUE,
  ...
)
```

Arguments

x	An object of class locstppm
scaler	Optional. Controls the value for a scalar representation of the spatial scale of the data. Either a character string, "silverman" (default), "IQR", "sd", or "var"; or positive numeric value(s). See OS.
do.points	Add points to plot
print.bw	It prints the estimated oversmoothing (OS) bandwidth selector
zap	Noise threshold factor (default to 0.00001). A numerical value greater than or equal to 1. If the range of pixel values is less than zap * .Machine$double.eps, the image will be treated as constant. This avoids displaying images which should be constant but contain small numerical errors.
par	Default to TRUE.
...	additional unused argument

Author(s)

Nicoletta D'Angelo

References

D'Angelo, N., Adelfio, G., and Mateu, J. (2023). Locally weighted minimum contrast estimation for spatio-temporal log-Gaussian Cox processes. Computational Statistics & Data Analysis, 180, 107679.

Davies, T.M. and Hazelton, M.L. (2010), Adaptive kernel estimation of spatial relative risk, Statistics in Medicine, 29(23) 2423-2437.

Terrell, G.R. (1990). The maximal smoothing principle in density estimation, Journal of the American Statistical Association, 85, 470-477.

See Also

locstppm, print.locstppm, summary.locstppm

Examples

```
set.seed(2)
inh <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)},
             par = c(0.005, 5))
inh_local <- locstppm(inh, formula = ~ x)

plot(inh_local)
```

plot.sepstlppm *Plot of the fitted intensity of a separable spatio-temporal Poisson model*

Description

The function plots the fitted intensity, displayed both in space and in space and time.

Usage

```
## S3 method for class 'sepstlppm'
plot(x, do.points = TRUE, par = TRUE, ...)
```

Arguments

x	An object of class sepstlppm
do.points	Add points to plot
par	Default to TRUE. If par=FALSE, the user is asked for input, before a new figure is drawn.
...	additional unused argument

Author(s)

Nicoletta D'Angelo

Examples

```
crimesub <- stpm(valenciacrimes$df[101:200, ],
           names = colnames(valenciacrimes$df)[-c(1:3)],
L = valencianet)

mod1 <- sepstlppm(crimesub, spaceformula = ~x ,
                  timeformula = ~ day)

plot(mod1)
```

plot.sepstppm *Plot of the fitted intensity of a separable spatio-temporal Poisson model*

Description

The function plots the fitted intensity, displayed both in space and in space and time.

Usage

```
## S3 method for class 'sepstppm'
plot(
  x,
  scaler = c("silverman", "IQR", "sd", "var"),
  do.points = TRUE,
  print.bw = FALSE,
  zap = 1e-05,
  par = TRUE,
  sig = NULL,
  ...
)
```

Arguments

x	An object of class sepstppm
scaler	Optional. Controls the value for a scalar representation of the spatial scale of the data. Either a character string, "silverman" (default), "IQR", "sd", or "var"; or positive numeric value(s). See OS.
do.points	Add points to plot
print.bw	It prints the estimated oversmoothing (OS) bandwidth selector
zap	Noise threshold factor (default to 0.00001). A numerical value greater than or equal to 1. If the range of pixel values is less than zap * .Machine$double.eps, the image will be treated as constant. This avoids displaying images which should be constant but contain small numerical errors.
par	Default to TRUE. If par=FALSE, the user is asked for input, before a new figure is drawn.
sig	Smoothing bandwidth for spatial representation
...	additional unused argument

Author(s)

Nicoletta D'Angelo

Examples

```
crimesub <- stpm(valenciacrimes$df[1:100, ],
           names = colnames(valenciacrimes$df)[-c(1:3)])

mod1 <- sepstppm(crimesub, spaceformula = ~x ,
                 timeformula = ~ day)

plot(mod1)
```

plot.stcov *Plot a* stcov *object*

Description

This function plots the covariate stored in the stcov object given in input, in a three panel plot representing the 3Dplot of the coordinates, and the covariate values.

Usage

```
## S3 method for class 'stcov'
plot(x, ...)
```

Arguments

x	An object of class stcov
...	additional unused argument

Author(s)

Nicoletta D'Angelo

See Also

stcov

Examples

```
set.seed(2)
df <- data.frame(runif(100), runif(100), runif(100), rpois(100, 15))

cov <- stcov(df, interp = FALSE)

plot(cov)
```

plot.stlgcppm *Plot of the fitted intensity of a LGCP model*

Description

The function plots the fitted intensity, displayed both in space and in space and time. In the case of local covariance parameters, the function returns the mean of the random intensity, displayed both in space and in space and time.

Usage

```
## S3 method for class 'stlgcppm'
plot(
  x,
  scaler = c("silverman", "IQR", "sd", "var"),
  do.points = TRUE,
  print.bw = FALSE,
  zap = 1e-05,
  par = TRUE,
  ...
)
```

Arguments

x	An object of class stlgcppm
scaler	Optional. Controls the value for a scalar representation of the spatial scale of the data. Either a character string, "silverman" (default), "IQR", "sd", or "var"; or positive numeric value(s). See OS.
do.points	Add points to plot
print.bw	It prints the estimated oversmoothing (OS) bandwidth selector
zap	Noise threshold factor (default to 0.00001). A numerical value greater than or equal to 1. If the range of pixel values is less than zap * .Machine$double.eps, the image will be treated as constant. This avoids displaying images which should be constant but contain small numerical errors.
par	Default to TRUE.
...	additional unused argument

Author(s)

Nicoletta D'Angelo and Giada Adelfio

References

D'Angelo, N., Adelfio, G., and Mateu, J. (2023). Locally weighted minimum contrast estimation for spatio-temporal log-Gaussian Cox processes. Computational Statistics & Data Analysis, 180, 107679.

Davies, T.M. and Hazelton, M.L. (2010), Adaptive kernel estimation of spatial relative risk, Statistics in Medicine, 29(23) 2423-2437.

Siino, M., Adelfio, G., and Mateu, J. (2018). Joint second-order parameter estimation for spatio-temporal log-Gaussian Cox processes. Stochastic environmental research and risk assessment, 32(12), 3525-3539.

Terrell, G.R. (1990). The maximal smoothing principle in density estimation, Journal of the American Statistical Association, 85, 470-477.

See Also

stlgcppm, print.stlgcppm, summary.stlgcppm, localsummary, localplot

Examples

```
catsub <- stp(greececatalog$df[1:200, ])

lgcp_loc <- stlgcppm(catsub, formula = ~ x, first = "local")

plot(lgcp_loc)
```

`plot.stlp` *Plot a* `stlp` *object*

Description

This function plots the point pattern on a linear network stored in the `stlp` object given in input, in a three panel plot representing the plot3D of the coordinates, and the marginal spatial and temporal coordinates.

Usage

```
## S3 method for class 'stlp'
plot(x, tcum = TRUE, marg = TRUE, col = 1, cols = "grey", ...)
```

Arguments

`x`	An object of class `stp`
`tcum`	If `TRUE` (default option), the temporal point pattern is displayed cumulatively. A barplot is automatically plotted if there are repeated counts (typically with discrete times).
`marg`	Default to `TRUE`. If `FALSE`, only the spatio-temporal point pattern is plotted.
`col`	The color of the points. Default to `"black"`
`cols`	The color of the linear network. Default to `"grey"`
`...`	additional unused argument

Author(s)

Nicoletta D'Angelo

See Also

stp, summary.stlp, print.stlp

Examples

```
set.seed(2)
df_net <- data.frame(cbind(runif(100, 0, 0.85), runif(100, 0, 0.85), runif(100)))

stlp1 <- stp(df_net, L = chicagonet)

plot(stlp1)
```

`plot.stlpm` *Plot a* `stlpm` *object*

Description

This function plots the covariate stored in the stcov object given in input, in a three panel plot representing the 3Dplot of the coordinates, and the mark values.

Usage

```
## S3 method for class 'stlpm'
plot(x, ...)
```

Arguments

`x`	An object of class `stpm`
`...`	additional unused argument

Author(s)

Nicoletta D'Angelo

See Also

stppm

Examples

```
set.seed(2)
df <- data.frame(x = runif(100, 0, 0.8), y = runif(100, 0, 0.8), t = runif(100), m = rpois(100, 15))

stlpm1 <- stpm(df, L = chicagonet)

plot(stlpm1)
```

plot.stp *Plot a* stp *object*

Description

This function plots the point pattern stored in the stp object given in input, in a three panel plot representing the 3Dplot of the coordinates, and the marginal spatial and temporal coordinates.

Usage

```
## S3 method for class 'stp'
plot(x, tcum = TRUE, marg = TRUE, col = 1, ...)
```

Arguments

x	An object of class stp
tcum	If TRUE (default option), the temporal point pattern is displayed cumulatively. A barplot is automatically plotted if there are repeated counts (typically with discrete times).
marg	Default to TRUE. If FALSE, only the spatio-temporal point pattern is plotted.
col	The color of the points. Default to "black"
...	additional unused argument

Author(s)

Nicoletta D'Angelo

See Also

stp, print.stp, summary.stp

Examples

```
set.seed(2)
df <- data.frame(cbind(runif(100), runif(100), runif(100)))

stp1 <- stp(df)
#plot
plot(stp1)

#cumulative time occurrances
plot(stp1, tcum = FALSE)

#change color of points
plot(stp1, col = "blue")

#display only in space-time
```

```
plot(stp1, marg = FALSE)

#discrete times
set.seed(2)
stp2 <- stp(data.frame(cbind(runif(100), runif(100), round(runif(100) * 100))))
plot(stp2)
```

`plot.stpm` *Plot a* `stpm` *object*

Description

This function plots the marked point pattern stored in the `stpm` object given in input, in a three panel plot representing the 3Dplot of the coordinates, and the mark values.

Usage

```
## S3 method for class 'stpm'
plot(x, ...)
```

Arguments

`x`	An object of class `stpm`
`...`	additional unused argument

Author(s)

Nicoletta D'Angelo

See Also

stppm

Examples

```
df <- data.frame(cbind(runif(100), runif(100), runif(100), rpois(100, 15),
rpois(100, 30)))

stpm1 <- stpm(df)

plot(stpm1)

## Categorical marks

dfA <- data.frame(x = runif(100), y = runif(100), t = runif(100),
                  m1 = rnorm(100), m2 = rep(c("C"), times = 100))
```

```
dfB <- data.frame(x = runif(50), y = runif(50), t = runif(50),
                  m1 = rnorm(25), m2 = rep(c("D"), times = 50))

stpm2 <- stpm(rbind(dfA, dfB), names = c("continuous", "dichotomous"))

plot(stpm2)
```

`plot.stppm` *Plot of the fitted intensity of a spatio-temporal Poisson process model*

Description

The function plots the fitted intensity, displayed both in space and in space and time.

Usage

```
## S3 method for class 'stppm'
plot(
  x,
  scaler = c("silverman", "IQR", "sd", "var"),
  do.points = TRUE,
  print.bw = FALSE,
  zap = 1e-05,
  par = TRUE,
  ...
)
```

Arguments

`x`	An object of class `stppm`
`scaler`	Optional. Controls the value for a scalar representation of the spatial scale of the data. Either a character string, `"silverman"` (default), `"IQR"`, `"sd"`, or `"var"`; or positive numeric value(s). See OS.
`do.points`	Add points to plot
`print.bw`	It prints the estimated oversmoothing (OS) bandwidth selector
`zap`	Noise threshold factor (default to 0.00001). A numerical value greater than or equal to 1. If the range of pixel values is less than `zap * .Machine$double.eps`, the image will be treated as constant. This avoids displaying images which should be constant but contain small numerical errors.
`par`	Default to `TRUE`.
`...`	additional unused argument

Author(s)

Nicoletta D'Angelo and Giada Adelfio

References

D'Angelo, N., Adelfio, G., and Mateu, J. (2023). Locally weighted minimum contrast estimation for spatio-temporal log-Gaussian Cox processes. Computational Statistics & Data Analysis, 180, 107679.

Davies, T.M. and Hazelton, M.L. (2010), Adaptive kernel estimation of spatial relative risk, Statistics in Medicine, 29(23) 2423-2437.

Terrell, G.R. (1990). The maximal smoothing principle in density estimation, Journal of the American Statistical Association, 85, 470-477.

See Also

stppm, print.stppm, summary.stppm

Examples

```
set.seed(2)
pin <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)}, par = c(2, 6),
nsim = 1, verbose = TRUE)
inh1 <- stppm(pin, formula = ~ x)

plot(inh1)
```

---

print.globaldiag *Print global diagnostics of a spatio-temporal point process first-order intensity*

Description

This function performs global diagnostics of a model fitted for the first-order intensity of a spatio-temporal point pattern, by returning the sum of the squared differences between the estimated and the theoretical K-functions obtained through `globaldiag`.

Usage

```
## S3 method for class 'globaldiag'
print(x, ...)
```

Arguments

`x`	A `globaldiag` object
`...`	additional unused argument

Value

It returns the sum of the squared differences between the estimated and the theoretical K-functions obtained through `globaldiag`

Author(s)

Nicoletta D'Angelo

References

Adelfio, G., Siino, M., Mateu, J., and Rodríguez-Cortés, F. J. (2020). Some properties of local weighted second-order statistics for spatio-temporal point processes. Stochastic Environmental Research and Risk Assessment, 34(1), 149-168.

D'Angelo, N., Adelfio, G. and Mateu, J. (2022) Local inhomogeneous second-order characteristics for spatio-temporal point processes on linear networks. Stat Papers. https://doi.org/10.1007/s00362-022-01338-4

Gabriel, E., and Diggle, P. J. (2009). Second-order analysis of inhomogeneous spatio-temporal point process data. Statistica Neerlandica, 63(1), 43-51.

Gabriel, E., Rowlingson, B. S., & Diggle, P. J. (2013). stpp: An R Package for Plotting, Simulating and Analyzing Spatio-Temporal Point Patterns. Journal of Statistical Software, 53(2), 1–29. https://doi.org/10.18637/jss.v053.i02

Moradi M, Cronie O, and Mateu J (2020). stlnpp: Spatio-temporal analysis of point patterns on linear networks.

Moradi, M. M., and Mateu, J. (2020). First-and second-order characteristics of spatio-temporal point processes on linear networks. Journal of Computational and Graphical Statistics, 29(3), 432-443.

See Also

globaldiag, plot.globaldiag, summary.globaldiag

Examples

```
set.seed(2)
inh <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)},
               par = c(.3, 6))

mod1 <- stppm(inh, formula = ~ 1)
mod2 <- stppm(inh, formula = ~ x)

g1 <- globaldiag(inh, mod1$l)
g2 <- globaldiag(inh, mod2$l)

g1
g2
```

print.lista *Print a* lista *object*

Description

It prints the main information on the local network summary statistics stored in a `lista` object.

Usage

```
## S3 method for class 'lista'
print(x, ...)
```

Arguments

`x`	An object of class `lista`
`...`	additional unused argument

Author(s)

Nicoletta D'Angelo

Examples

```
set.seed(2)
df_net <- data.frame(x = runif(25, 0, 0.85), y = runif(25, 0, 0.85), t = runif(25))
stlp1 <- stp(df_net, L = chicagonet)
lambda <- rep(diff(range(stlp1$df$x)) * diff(range(stlp1$df$y))
 * diff(range(stlp1$df$t)) / spatstat.geom::volume(stlp1$L),
nrow(stlp1$df))

k <- localSTLKinhom(stlp1, lambda = lambda, normalize = TRUE)

k
```

print.localdiag *Print of the diagnostics' result on a spatio-temporal point process model*

Description

It prints the main information on the result of the local diagnostics performed with localdiag on either a `stp` or `stlp` object: whether the local test was run on point patterns lying on a linear network or not; the number of points in the analysed spatio-temporal point pattern `X`; the number of points of `X` which are identified as outlying by the previously performed local diagnostics.

Usage

```
## S3 method for class 'localdiag'
print(x, ...)
```

Arguments

x	A localdiag object
...	additional unused argument

Author(s)

Nicoletta D'Angelo and Giada Adelfio

References

Adelfio, G., Siino, M., Mateu, J., and Rodríguez-Cortés, F. J. (2020). Some properties of local weighted second-order statistics for spatio-temporal point processes. Stochastic Environmental Research and Risk Assessment, 34(1), 149-168.

D'Angelo, N., Adelfio, G. and Mateu, J. (2022) Local inhomogeneous second-order characteristics for spatio-temporal point processes on linear networks. Stat Papers. https://doi.org/10.1007/s00362-022-01338-4

See Also

infl, plot.localdiag, summary.localdiag

Examples

```
set.seed(2)
inh <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)},
             par = c(.3, 6))

mod1 <- stppm(inh, formula = ~ 1)

resmod1 <- localdiag(inh, mod1$l, p = .9)

resmod1
```

`print.localtest` *Print of the result of the permutation local test*

Description

It prints the main information on the result of the local permutation test performed with localtest on either a `stp` or `stlp` object: whether the local test was run on point patterns lying on a linear network or not; the number of points in the background `X` and alternative `Z` patterns; the number of points in `X` which exhibit local differences in the second-order structure with respect to `Z`, according to the performed test.

Usage

```
## S3 method for class 'localtest'
print(x, ...)
```

Arguments

`x`	An object of class `localtest`
`...`	additional unused argument

Author(s)

Nicoletta D'Angelo

References

D'Angelo, N., Adelfio, G., and Mateu, J. (2021). Assessing local differences between the spatio-temporal second-order structure of two point patterns occurring on the same linear network. Spatial Statistics, 45, 100534.

Siino, M., Rodríguez-Cortés, F. J., Mateu, J. ,and Adelfio, G. (2018). Testing for local structure in spatiotemporal point pattern data. Environmetrics, 29(5-6), e2463.

See Also

localtest, summary.localtest, plot.localtest

Examples

```
set.seed(2)
X <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)},
           par = c(.005, 5))
Z <- rstpp(lambda = 30)

test <- localtest(X, Z, method = "K", k = 3)
```

```
test
```

`print.locstppm` *Print of a fitted local spatio-temporal Poisson process model*

Description

The function prints the main information of the distribution of the parameters of a fitted local spatio-temporal Poisson process model.

Usage

```
## S3 method for class 'locstppm'
print(x, ...)
```

Arguments

`x`	An object of class `locstppm`
`...`	additional unused argument

Author(s)

Nicoletta D'Angelo

References

D'Angelo, N., Adelfio, G., and Mateu, J. (2023). Locally weighted minimum contrast estimation for spatio-temporal log-Gaussian Cox processes. Computational Statistics & Data Analysis, 180, 107679.

See Also

locstppm, summary.locstppm, plot.locstppm

Examples

```
set.seed(2)
inh <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)},
             par = c(0.005, 5))
inh_local <- locstppm(inh, formula = ~ x)

inh_local
```

`print.sepstlppm` *Print of a fitted separable spatio-temporal Poisson process model on a linear network*

Description

The function prints the main information of the fitted model.

Usage

```
## S3 method for class 'sepstlppm'
print(x, ...)
```

Arguments

`x`	An object of class `sepstlppm`
`...`	additional unused argument

Author(s)

Nicoletta D'Angelo

See Also

sepstlppm

Examples

```
crimesub <- stpm(valenciacrimes$df[101:200, ],
          names = colnames(valenciacrimes$df)[-c(1:3)],
L = valencianet)

mod1 <- sepstlppm(crimesub, spaceformula = ~x ,
                  timeformula = ~ day)

mod1
```

`print.sepstppm` *Print of a fitted separable spatio-temporal Poisson process model*

Description

The function prints the main information of the fitted model.

Usage

```
## S3 method for class 'sepstppm'
print(x, ...)
```

Arguments

`x`	An object of class `sepstppm`
`...`	additional unused argument

Author(s)

Nicoletta D'Angelo

See Also

sepstppm

Examples

```
crimesub <- stpm(valenciacrimes$df[101:200, ],
           names = colnames(valenciacrimes$df)[-c(1:3)])

mod1 <- sepstppm(crimesub, spaceformula = ~x ,
                 timeformula = ~ day)
mod1
```

print.stcov *Print a* stcov *object*

Description

It prints the main information on the spatio-temporal covariate stored in the stcov object: the number of points; the enclosing spatial window; the temporal time period; information on the covariate values.

Usage

```
## S3 method for class 'stcov'
print(x, ...)
```

Arguments

x	An object of class stcov
...	additional unused argument

Author(s)

Nicoletta D'Angelo

Examples

```
set.seed(2)
df <- data.frame(runif(100), runif(100), runif(100), rpois(100, 15))

cov <- stcov(df, interp = FALSE)
cov
```

print.stlgcppm *Print of a fitted LGCP model*

Description

The function prints the main information on the fitted model. In this case of local parameters (both first- and second-order), the summary function contains information on their distributions.

Usage

```
## S3 method for class 'stlgcppm'
print(x, ...)
```

Arguments

x	An object of class stlgcppm
...	additional unused argument

Author(s)

Nicoletta D'Angelo and Giada Adelfio

References

D'Angelo, N., Adelfio, G., and Mateu, J. (2023). Locally weighted minimum contrast estimation for spatio-temporal log-Gaussian Cox processes. Computational Statistics & Data Analysis, 180, 107679.

Siino, M., Adelfio, G., and Mateu, J. (2018). Joint second-order parameter estimation for spatio-temporal log-Gaussian Cox processes. Stochastic environmental research and risk assessment, 32(12), 3525-3539.

See Also

stlgcppm, print.stlgcppm, localsummary, plot.stlgcppm, localplot

Examples

```
catsub <- stp(greececatalog$df[1:200, ])

lgcp1 <- stlgcppm(catsub)

lgcp1
```

---

print.stlp *Print a* stlp *object*

Description

It prints the main information on the spatio-temporal point pattern on a linear network stored in the stlp object: the number of points; vertices and lines of the linear network; the enclosing spatial window; the temporal time period.

Usage

```
## S3 method for class 'stlp'
print(x, ...)
```

Arguments

x	An object of class stlp
...	additional unused argument

Author(s)

Nicoletta D'Angelo

See Also

stp, plot.stlp, summary.stlp

Examples

```
set.seed(2)
df_net <- data.frame(cbind(runif(100, 0, 0.85), runif(100, 0, 0.85), runif(100)))

stlp1 <- stp(df_net, L = chicagonet)
stlp1
```

---

print.stlpm *Print a* stlpm *object*

Description

It prints the main information on the spatio-temporal point pattern stored in the stlpm object: the number of points; the enclosing spatial window; the temporal time period; information on marks.

Usage

```
## S3 method for class 'stlpm'
print(x, ...)
```

Arguments

x	An object of class stlpm
...	additional unused argument

Author(s)

Nicoletta D'Angelo

Examples

```
set.seed(2)
df <- data.frame(x = runif(100, 0, 0.8), y = runif(100, 0, 0.8), t = runif(100), m = rpois(100, 15))

stlpm1 <- stpm(df, L = chicagonet)

stlpm1
```

`print.stp` *Print a* `stp` *object*

Description

It prints the main information on the spatio-temporal point pattern stored in the `stp` object: the number of points; the enclosing spatial window; the temporal time period.

Usage

```
## S3 method for class 'stp'
print(x, ...)
```

Arguments

`x`	An object of class `stp`
`...`	additional unused argument

Author(s)

Nicoletta D'Angelo

See Also

stp, summary.stp, plot.stp

Examples

```
set.seed(2)
df <- data.frame(cbind(runif(100), runif(100), runif(100)))

stp1 <- stp(df)
stp1
```

print.stpm *Print a* stpm *object*

Description

It prints the main information on the spatio-temporal point pattern stored in the stpm object: the number of points; the enclosing spatial window; the temporal time period; information on marks.

Usage

```
## S3 method for class 'stpm'
print(x, ...)
```

Arguments

x	An object of class stpm
...	additional unused argument

Author(s)

Nicoletta D'Angelo

Examples

```
set.seed(2)
df <- data.frame(cbind(runif(100), runif(100), runif(100), rpois(100, 15),
rpois(100, 30)))

stpm1 <- stpm(df)

summary(stpm1)
```

print.stppm *Print of a fitted spatio-temporal Poisson process model*

Description

The function prints the main information of the fitted model.

Usage

```
## S3 method for class 'stppm'
print(x, ...)
```

Arguments

x	An object of class stppm
...	additional unused argument

Author(s)

Nicoletta D'Angelo

References

D'Angelo, N., Adelfio, G., and Mateu, J. (2023). Locally weighted minimum contrast estimation for spatio-temporal log-Gaussian Cox processes. Computational Statistics & Data Analysis, 180, 107679.

See Also

stppm, print.stppm, plot.stppm

Examples

```
set.seed(2)
pin <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)}, par = c(2, 6))
inh1 <- stppm(pin, formula = ~ x)

inh1
```

---

rETASlp *Simulation of a spatio-temporal ETAS (Epidemic Type Aftershock Sequence) model on a linear network*

Description

This function simulates a spatio-temporal ETAS (Epidemic Type Aftershock Sequence) process on a linear network as a stpm object.

It is firstly introduced and employed for simulation studies in D'Angelo et al. (2021).

It follows the generating scheme for simulating a pattern from an Epidemic Type Aftershocks-Sequences (ETAS) process (Ogata and Katsura 1988) with conditional intensity function (CIF) as in Adelfio and Chiodi (2020), adapted for the space location of events to be constrained on a linear network.

The simulation on the network is guaranteed by the homogeneous spatial Poisson processes being generated on the network.

Usage

```
rETASlp(
  pars = NULL,
  betacov = 0.39,
  m0 = 2.5,
  b = 1.0789,
  tmin = 0,
  t.lag = 200,
  covsim = FALSE,
  L,
  all.marks = FALSE
)
```

Arguments

pars	A vector of parameters of the ETAS model to be simulated. See the 'Details' section.
betacov	Numerical array. Parameters of the covariates ETAS model
m0	Parameter for the background general intensity of the ETAS model. In the common seismic analyses it represents the threshold magnitude.
b	1.0789
tmin	Minimum value of time.
t.lag	200
covsim	Default FALSE
L	linear network
all.marks	Logical value indicating whether to store all the simulation information as marks in the stlpm object. If FALSE (default option) only the magnitude is returned.

Details

The CIF of an ETAS process as in Adelfio and Chiodi (2020) can be written as

$$\lambda_\theta(t, \mathbf{u}|\mathcal{H}_t) = \mu f(\mathbf{u}) + \sum_{t_j<t} \frac{\kappa_0 \exp(\eta_j)}{(t - t_j + c)^p} \{(\mathbf{u} - \mathbf{u}_j)^2 + d\}^{-q},$$

where

$\mathcal{H}_t$ is the past history of the process up to time t

μ is the large-scale general intensity

$f(\mathbf{u})$ is the spatial density

$\eta_j = \boldsymbol{\beta}'\mathbf{Z}_j$ is a linear predictor

$\mathbf{Z}_j$ the external known covariate vector, including the magnitude

$\boldsymbol{\theta} = (\mu, \kappa_0, c, p, d, q, \boldsymbol{\beta})$ are the parameters to be estimated

κ_0 is a normalising constant

c and p are characteristic parameters of the seismic activity of the given region,

and d and q are two parameters related to the spatial influence of the mainshock

In the usual ETAS model for seismic analyses, the only external covariate represents the magnitude, $\boldsymbol{\beta} = \alpha$, as $\eta_j = \boldsymbol{\beta}'\mathbf{Z}_j = \alpha(m_j - m_0)$, where m_j is the magnitude of the j^{th} event and m_0 the threshold magnitude, that is, the lower bound for which earthquakes with higher values of magnitude are surely recorded in the catalogue.

Value

A `stlpm` object

Author(s)

Nicoletta D'Angelo and Marcello Chiodi

References

Adelfio, G., and Chiodi, M. (2021). Including covariates in a space-time point process with application to seismicity. Statistical Methods & Applications, 30(3), 947-971.

D'Angelo, N., Adelfio, G., and Mateu, J. (2021). Assessing local differences between the spatio-temporal second-order structure of two point patterns occurring on the same linear network. Spatial Statistics, 45, 100534.

Ogata, Y., and Katsura, K. (1988). Likelihood analysis of spatial inhomogeneity for marked point patterns. Annals of the Institute of Statistical Mathematics, 40(1), 29-39.

Examples

```
set.seed(95)
X <- rETASlp(pars = c(0.1293688525, 0.003696, 0.013362, 1.2,0.424466,  1.164793),
     L = chicagonet)
```

---

rETASp *Simulation of a spatio-temporal ETAS (Epidemic Type Aftershock Sequence) model*

Description

This function simulates a spatio-temporal ETAS (Epidemic Type Aftershock Sequence) process as a `stpm` object.

It follows the generating scheme for simulating a pattern from an Epidemic Type Aftershocks-Sequences (ETAS) process (Ogata and Katsura 1988) with conditional intensity function (CIF) as in Adelfio and Chiodi (2020), adapted for the space location of events to be constrained.

See the 'Details' section.

Usage

```
rETASp(
  pars = NULL,
  betacov = 0.39,
  m0 = 2.5,
  b = 1.0789,
  tmin = 0,
  t.lag = 200,
  xmin = 0,
  xmax = 1,
  ymin = 0,
  ymax = 1,
  covsim = FALSE,
  all.marks = FALSE
)
```

Arguments

pars	A vector of parameters of the ETAS model to be simulated. See the 'Details' section.
betacov	Numerical array. Parameters of the ETAS model covariates.
m0	Parameter for the background general intensity of the ETAS model. In the common seismic analyses it represents the threshold magnitude.
b	1.0789
tmin	Minimum value of time.
t.lag	200
xmin	Minimum of x coordinate range
xmax	Maximum of x coordinate range
ymin	Minimum of y coordinate range
ymax	Maximum of y coordinate range
covsim	Default FALSE
all.marks	Logical value indicating whether to store all the simulation information as marks in the stpm object. If FALSE (default option) only the magnitude is returned.

Details

The CIF of an ETAS process as in Adelfio and Chiodi (2020) can be written as

$$\lambda_\theta(t, \mathbf{u}|\mathcal{H}_t) = \mu f(\mathbf{u}) + \sum_{t_j<t} \frac{\kappa_0 \exp(\eta_j)}{(t - t_j + c)^p} \{(\mathbf{u} - \mathbf{u}_j)^2 + d\}^{-q},$$

where

$\mathcal{H}_t$ is the past history of the process up to time t

μ is the large-scale general intensity

$f(\mathbf{u})$ is the spatial density

$\eta_j = \boldsymbol{\beta}'\mathbf{Z}_j$ is a linear predictor

$\mathbf{Z}_j$ the external known covariate vector, including the magnitude

$\boldsymbol{\theta} = (\mu, \kappa_0, c, p, d, q, \boldsymbol{\beta})$ are the parameters to be estimated

κ_0 is a normalising constant

c and p are characteristic parameters of the seismic activity of the given region,

and d and q are two parameters related to the spatial influence of the mainshock

In the usual ETAS model for seismic analyses, the only external covariate represents the magnitude, $\boldsymbol{\beta} = \alpha$, as $\eta_j = \boldsymbol{\beta}'\mathbf{Z}_j = \alpha(m_j - m_0)$, where m_j is the magnitude of the j^{th} event and m_0 the threshold magnitude, that is, the lower bound for which earthquakes with higher values of magnitude are surely recorded in the catalogue.

Value

A `stpm` object

Author(s)

Nicoletta D'Angelo and Marcello Chiodi

References

Adelfio, G., and Chiodi, M. (2021). Including covariates in a space-time point process with application to seismicity. Statistical Methods & Applications, 30(3), 947-971.

Ogata, Y., and Katsura, K. (1988). Likelihood analysis of spatial inhomogeneity for marked point patterns. Annals of the Institute of Statistical Mathematics, 40(1), 29-39.

Examples

```
set.seed(95)
X <- rETASp(pars = c(0.1293688525, 0.003696, 0.013362, 1.2,0.424466,  1.164793),
         betacov = 0.5,
         xmin = 600, xmax = 2200, ymin = 4000, ymax = 5300)

plot(X)
```

`rstlpp` *Simulate homogeneous and inhomogeneous spatio-temporal Poisson point patterns on linear networks*

Description

This function creates a `stlp` object, simulating a spatio-temporal point pattern on a linear network following either an homogeneous or inhomogeneous intensity

Usage

```
rstlpp(
  lambda = 500,
  nsim = 1,
  verbose = FALSE,
  par = NULL,
  minX = 0,
  maxX = 1,
  minY = 0,
  maxY = 1,
  minT = 0,
  maxT = 1,
  L
)
```

Arguments

lambda	Expected number of points to simulate
nsim	Number of patterns to simulate. Default to 1.
verbose	Default to FALSE
par	Parameters of the reference intensity
minX	Minimum of x coordinate range
maxX	Maximum of x coordinate range
minY	Minimum of y coordinate range
maxY	Maximum of y coordinate range
minT	Minimum of t coordinate range
maxT	Maximum of t coordinate range
L	linear network

Value

A stp object

Author(s)

Nicoletta D'Angelo

Examples

```
set.seed(2)
h1 <- rstlpp(lambda = 500, L = chicagonet)

set.seed(2)
inh <- rstlpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)}, par = c(4, 1.5),
        L = chicagonet)
```

`rstpp` *Simulate homogeneous and inhomogeneous spatio-temporal Poisson point patterns*

Description

This function creates a `stp` object, simulating a spatio-temporal point pattern following either an homogeneous or inhomogeneous intensity

Usage

```
rstpp(
  lambda = 500,
  nsim = 1,
  verbose = FALSE,
  par = NULL,
  minX = 0,
  maxX = 1,
  minY = 0,
  maxY = 1,
  minT = 0,
  maxT = 1
)
```

Arguments

`lambda`	Expected number of points to simulate
`nsim`	Number of patterns to simulate. Default to 1.
`verbose`	Default to `FALSE`
`par`	Parameters of the reference intensity
`minX`	Minimum of x coordinate range
`maxX`	Maximum of x coordinate range
`minY`	Minimum of y coordinate range
`maxY`	Maximum of y coordinate range
`minT`	Minimum of t coordinate range
`maxT`	Maximum of t coordinate range

Value

A `stp` object

Author(s)

Nicoletta D'Angelo

See Also

stppm

Examples

```
# homogeneous Poisson processes
set.seed(2)
h1 <- rstpp(lambda = 500)

set.seed(2)
h2 <- rstpp(lambda = 500, minX = 0,
             maxX = 2, minY = 3, maxY = 5, minT = 1, maxT = 9)

set.seed(2)
h3 <- rstpp(lambda = 900, nsim = 3, verbose = TRUE)

# inhomogeneous Poisson process
set.seed(2)
inh <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)}, par = c(2, 6))
```

---

sepstlppm — *Fit a separable spatio-temporal Poisson process model on a linear network*

Description

Fit a separable spatio-temporal Poisson process model on a linear network

Usage

```
sepstlppm(x, spaceformula, timeformula)
```

Arguments

x	A stlpm object
spaceformula	A formula for the spatial component. See lppm for details
timeformula	A formula for the temporal component. It fits a log-linear model with the glm function

Value

An object of class sepstlppm

Examples

```
crimesub <- stpm(valenciacrimes$df[101:200, ],
          names = colnames(valenciacrimes$df)[-c(1:3)],
L = valencianet)

mod1 <- sepstlppm(crimesub, spaceformula = ~x ,
                  timeformula = ~ day)
```

`sepstppm` *Fit a separable spatio-temporal Poisson process model*

Description

Fit a separable spatio-temporal Poisson process model

Usage

```
sepstppm(x, spaceformula, timeformula)
```

Arguments

`x`	A `stpm` object
`spaceformula`	A formula for the spatial component. See ppm for details
`timeformula`	A formula for the temporal component. It fits a log-linear model with the glm function

Value

An object of class `sepstppm`

Examples

```
crimesub <- stpm(valenciacrimes$df[101:200, ],
          names = colnames(valenciacrimes$df)[-c(1:3)])

mod1 <- sepstppm(crimesub, spaceformula = ~x ,
                  timeformula = ~ day)
```

`stcov` *Create* `stcov` *objects and interpolate spatio-temporal covariates on a regular grid*

Description

This function interpolates the covariate values observed at some observed sites to a regular grid. The imput object should be either a matrix or a dataframe with four columns: `x`, `y`, `t`, and the covariate values, named as the covariate later called in the model formula (see `stppm`). The interpolation is performed through Inverse Distance Weighting (IDW). See the Details.

Usage

```
stcov(
  x,
  interp = TRUE,
  nx = NULL,
  mult = 1,
  p = 81,
  names = NULL,
  verbose = FALSE
)
```

Arguments

`x`	A data.frame with four columns, containing the spatio-temporal coordinates and the covariate values.
`interp`	Logical value indicating whether to interpolate the covariate on a regular grid. Default to `TRUE`.
`nx`	Number of coordinates to generate for each dimention. The default is `floor((mult * nrow(cov)) ^ (1/3))`.
`mult`	The multiplicand of the number of points in the default for `nx`.
`p`	Power of IDW distances.
`names`	Factor string to name the covariate.
`verbose`	Default to FALSE. If TRUE, the elapsed minutes are printed.

Details

The function builds a regular grid with equispaced values along the three coordinates and interpolates the covariate values at the new locations. The interpolation at a point location x_k is performed through the inverse-distance weighting smoothing procedure of the covariate values $Z(x_j)$ at their sampling locations $j = 1, \ldots, J$. In such a case, the smoothed value at location x_k is

$$Z(x_k) = \frac{\sum_j w_j Z(x_j)}{\sum_j w_j},$$

where the weight w_j is the j-th element of the inverse pth powers of distance,

$$\mathbf{w} = \{w_j\}_{j=1}^{J} = \{\frac{1}{d(x_k - x_j)^p}\}_{j=1}^{J},$$

with

$$d(x_k - x_j) = ||x_k - x_j||$$

the Euclidean distance from x_k to x_j.

Value

A `stpm` object, to be imputed as list object in `stppm`.

Author(s)

Nicoletta D'Angelo

See Also

stppm

Examples

```
set.seed(2)
df <- data.frame(runif(100), runif(100), runif(100), rpois(100, 15))

cov <- stcov(df, interp = FALSE)
```

`stlgcppm` *Fit a log-Gaussian Cox process model to a spatio-temporal point pattern*

Description

This function estimates a log-Gaussian Cox process (LGCP), following the **joint minimum contrast** procedure introduced in Siino et al. (2018) .

Three covariances are available: separable exponential, Gneiting, and De Iaco-Cesare.

If the `first` and `second` arguments are set to `local`, a local log-Gaussian Cox process is fitted by means of the ** locally weighted minimum contrast** procedure proposed in D'Angelo et al. (2023).

Usage

```
stlgcppm(
  X,
  formula = ~1,
  verbose = TRUE,
  seed = NULL,
  cov = c("separable", "gneiting", "iaco-cesare"),
  first = c("global", "local"),
  second = c("global", "local"),
  mult = 4,
  hs = c("global", "local"),
  npx0 = 10,
  npt0 = 10,
  itnmax = 100,
  min_vals = NULL,
  max_vals = NULL
)
```

Arguments

X	A stp object
formula	An object of class formula: a symbolic description of the first-order intensity to be fitted. The current version only supports formulas depending on the spatial and temporal coordinates: x, y, t. Default to formula = ~ 1 which provides an homogeneous first-order intensity.
verbose	Default to TRUE
seed	The seed used for the simulation of the dummy points. Default to NULL.
cov	Covariance function to be fitted for the second-order intensity function. Default to separable. Other options are gneiting and iaco-cesare".
first	Character string indicating whether to fit a first-order intensity function with global or local parameters: either global (default) or local.
second	Character string indicating whether to fit a second-order intensity function with global or local parameters: either global (default) or local.
mult	The multiplicand of the number of data points, for setting the number of dummy points to generate for the quadrature scheme
hs	Character string indicating whether to select fixed or variable bandwidths for the kernel weights to be used in the log-likelihood. In any of those cases, the well-supported rule-of-thumb for choosing the bandwidth of a Gaussian kernel density estimator is employed. If hs = "global" (default), a fixed bandwidth is selected. If hs = "local", an individual bandwidth is selected for each point in the pattern X.
npx0	A positive integer representing the spatial distance to np-th closest event. Used in the computation of the local bandwidth. Suitable values are in the range from 10 (default) to 100.

npt0	A positive integer representing the temporal distance to np-th closest event. Used in the computation of the local bandwidth. Suitable values are in the range from 10 (default) to 100.
itnmax	Maximum number of iterations to run in the optimization procedure for the estimation of the second-order intensity parameters.
min_vals	Minimum values of the optimization procedure for the minimum contrast.
max_vals	Maximum values of the optimization procedure for the minimum contrast.

Details

Following the inhomogeneous specification in Diggle et al. (2013), we consider LGCPs with intensity

$$\Lambda(\mathbf{u}, t) = \lambda(\mathbf{u}, t) \exp(S(\mathbf{u}, t)).$$

Value

A list of the class stlgcppm, containing

IntCoefs The fitted coefficients of the first-order intensity function

CovCoefs The fitted coefficients of the second-order intensity function

X The stp object provided as input

formula The formula provided as input

cov A string with the chosen covariance type

l Fitted first-order intensity

mu Mean function of the random intensity

mod_global The glm object of the model fitted to the quadrature scheme for the first-order intensity parameters estimation

newdata The data used to fit the model, without the dummy points

time Time elapsed to fit the model, in minutes

Author(s)

Nicoletta D'Angelo, Giada Adelfio, and Marianna Siino

References

Baddeley, A. (2017). Local composite likelihood for spatial point processes. Spatial Statistics, 22, 261-295.

D'Angelo, N., Adelfio, G., and Mateu, J. (2023). Locally weighted minimum contrast estimation for spatio-temporal log-Gaussian Cox processes. Computational Statistics & Data Analysis, 180, 107679.

Diggle, P. J., Moraga, P., Rowlingson, B., and Taylor, B. M. (2013). Spatial and spatio-temporal log-gaussian cox processes: extending the geostatistical paradigm. Statistical Science, 28(4):542–563.

Gabriel, E., Rowlingson, B. S., and Diggle, P. J. (2013). stpp: An R Package for Plotting, Simulating and Analyzing Spatio-Temporal Point Patterns. Journal of Statistical Software, 53(2), 1–29. https://doi.org/10.18637/jss.v053.i02

Siino, M., Adelfio, G., and Mateu, J. (2018). Joint second-order parameter estimation for spatio-temporal log-Gaussian Cox processes. Stochastic environmental research and risk assessment, 32(12), 3525-3539.

See Also

print.stlgcppm, summary.stlgcppm, localsummary, plot.stlgcppm, localplot

Examples

```
catsub <- stp(greececatalog$df[1:200, ])

lgcp1 <- stlgcppm(catsub)
```

`stp` *Create* `stp` *and* `stlp` *objects for point patterns storage*

Description

This function creates a `stp` object as a dataframe with three columns: `x`, `y`, and `t`. If also the linear network `L`, of class linnet, is provided, a `stlp` object is created instead.

Usage

```
stp(df, L)
```

Arguments

`df`	A matrix with three columns, containing to two space and the temporal coordinates
`L`	Optional. The linear network of class `linnet`. If provided, the function returns a `stlp` object.

Value

An `stp` or `stlpp` object, depending on whether or not an object of class linnet is provided for the `L` argument.

Author(s)

Nicoletta D'Angelo

See Also

summary.stp, print.stp, plot.stp

stppm, print.stp, summary.stp, plot.stp, print.stlp, summary.stlp, plot.stlp

Examples

```
set.seed(2)
df <- data.frame(runif(100), runif(100), runif(100))

stp1 <- stp(df)

set.seed(2)
df_net <- data.frame(runif(100, 0, 0.85), runif(100, 0, 0.85), runif(100))

stlp1 <- stp(df_net, L = chicagonet)
```

---

stpm *Create* stpm *and* stlpm *objects for marked point patterns storage*

Description

This function creates a stpm object as a dataframe with 3 + m columns: x, y, t, and m columns to store different marks. If also the linear network L, of class linnet, is provided, a stlp object is created instead.

Usage

```
stpm(df, names = NULL, L)
```

Arguments

df	A matrix with three columns + m marks
names	Factor string to name the marks columns.
L	Optional. The linear network of class linnet. If provided, the function returns a stlpm object.

Value

An stpm or stlppm object, depending on whether or not an object of class linnet is provided for the L argument.

Author(s)

Nicoletta D'Angelo

Examples

```
set.seed(2)
df <- data.frame(cbind(runif(100), runif(100), runif(100), rpois(100, 15),
rpois(100, 30)))

stpm1 <- stpm(df)

## Categorical marks

set.seed(2)
dfA <- data.frame(x = runif(100), y = runif(100), t = runif(100),
                  m1 = rnorm(100), m2 = rep(c("C"), times = 100))
dfB <- data.frame(x = runif(50), y = runif(50), t = runif(50),
                  m1 = rnorm(25), m2 = rep(c("D"), times = 50))

stpm2 <- stpm(rbind(dfA, dfB), names = c("continuous", "dichotomous"))

## Linear network

set.seed(2)
dfL <- data.frame(cbind(runif(100, 0, 0.85), runif(100, 0, 0.85), runif(100),
                        rpois(100, 15)))

stlpm1 <- stpm(dfL, L = chicagonet)
```

---

stppm *Fit a Poisson process model to a spatio-temporal point pattern*

Description

This function fits a Poisson process model to an observed spatio-temporal point pattern stored in a stp object.

Usage

```
stppm(
  X,
  formula,
  formula_mark = NULL,
  covs = NULL,
  marked = FALSE,
  spatial.cov = FALSE,
  verbose = FALSE,
  mult = 4,
  interp = TRUE,
```

```
  parallel = FALSE,
  sites = 1,
  seed = NULL,
  ncube = NULL,
  grid = FALSE,
  ncores = 2,
  lsr = FALSE
)
```

Arguments

X	A stp object
formula	An object of class "formula": a symbolic description of the model to be fitted. The current version only supports formulas depending on the spatial and temporal coordinates: x, y, t.
formula_mark	An object of class "formula"
covs	A list containing stcov objects of possible spatio-temporal covariates. It is advisable to construct the stcov objects with stcov. Each stcov object should contain the spatio-temporal coordinates and the covariate values as the fourth column, named as the covariate called in the formula.
marked	Logical value indicating whether the point process model to be fit is multitype. Default to FALSE.
spatial.cov	Logical value indicating whether the point process model to be fit depends on spatio-temporal covariates. Default to FALSE.
verbose	Default to FALSE.
mult	The multiplicand of the number of data points, for setting the number of dummy points to generate for the quadrature scheme.
interp	Logical value indicating whether to interpolate covariate values to dummy points or to use the covariates locations as dummies. Default to TRUE.
parallel	Logical values indicating whether to use parallelization to interpolate covariates. Default to FALSE.
sites	.....
seed	The seed used for the simulation of the dummy points. Default to NULL.
ncube	Number of cubes used for the cubature scheme.
grid	Logical value indicating whether to generate dummy points on a regular grid or randomly. Default to FALSE.
ncores	Number of cores to use, if parallelizing. Default to 2.
lsr	Logical value indicating whether to use Logistic Spatio-Temporal Regression or Poisson regression. Default to FALSE.

Details

We assume that the template model is a Poisson process, with a parametric intensity or rate function $\lambda(\mathbf{u}, t; \theta)$ with space and time locations $\mathbf{u} \in W, t \in T$ and parameters $\theta \in \Theta$.

Estimation is performed through the fitting of a glm using a spatio-temporal version of the quadrature scheme by Berman and Turner (1992).

Value

An object of class `stppm`. A list of

`IntCoefs` The fitted coefficients

`X` The `stp` object provided as input

`nX` The number of points in `X`

`I` Vector indicating which points are dummy or data

`y_resp` The response variable of the model fitted to the quadrature scheme

`formula` The formula provided as input

`l` Fitted intensity

`mod_global` The `glm` object of the model fitted to the quadrature scheme

`newdata` The data used to fit the model, without the dummy points

`time` Time elapsed to fit the model, in minutes

Author(s)

Nicoletta D'Angelo and Marco Tarantino

References

Baddeley, A. J., Møller, J., and Waagepetersen, R. (2000). Non-and semi-parametric estimation of interaction in inhomogeneous point patterns. Statistica Neerlandica, 54(3):329–350

Berman, M. and Turner, T. R. (1992). Approximating point process likelihoods with glim. Journal of the Royal Statistical Society: Series C (Applied Statistics), 41(1):31–38

D'Angelo, N., Adelfio, G., and Mateu, J. (2023). Locally weighted minimum contrast estimation for spatio-temporal log-Gaussian Cox processes. Computational Statistics & Data Analysis, 180, 107679.

See Also

plot.stppm, print.stppm, summary.stppm

locstppm

Examples

```
set.seed(2)
ph <- rstpp(lambda = 200)
hom1 <- stppm(ph, formula = ~ 1)

## Inhomogeneous
set.seed(2)
pin <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)}, par = c(2, 6))
inh1 <- stppm(pin, formula = ~ x)

## Inhomogeneous depending on external covariates
```

```
set.seed(2)
df1 <- data.frame(runif(100), runif(100), runif(100), rpois(100, 15))
df2 <- data.frame(runif(100), runif(100), runif(100), rpois(100, 15))

obj1 <- stcov(df1, names = "cov1")
obj2 <- stcov(df2, names = "cov2")

covariates <- list(cov1 = obj1, cov2 = obj2)

inh2 <- stppm(pin, formula = ~ x + cov2, covs = covariates, spatial.cov = TRUE)

## Inhomogeneous semiparametric

inh3 <- stppm(pin, formula = ~ s(x, k = 30))

## Multitype

set.seed(2)
dfA <- data.frame(x = runif(100), y = runif(100), t = runif(100),
                  m1 = rep(c("A"), times = 100))
dfB <- data.frame(x = runif(50), y = runif(50), t = runif(50),
                  m1 = rep(c("B"), each = 50))

stpm1 <- stpm(rbind(dfA, dfB))

inh4 <- stppm(stpm1, formula = ~ x + s(m1, bs = "re"), marked = TRUE)
```

`summary.globaldiag` *Summarizes global diagnostics of a spatio-temporal point process first-order intensity*

Description

This function performs global diagnostics of a model fitted for the first-order intensity of a spatio-temporal point pattern, by returning the sum of the squared differences between the estimated and the theoretical K-functions obtained through `globaldiag`.

Usage

```
## S3 method for class 'globaldiag'
summary(object, ...)
```

Arguments

`object`	A `globaldiag` object
`...`	additional unused argument

Value

It returns the sum of the squared differences between the estimated and the theoretical K-functions obtained through `globaldiag`

Author(s)

Nicoletta D'Angelo

References

Adelfio, G., Siino, M., Mateu, J., and Rodríguez-Cortés, F. J. (2020). Some properties of local weighted second-order statistics for spatio-temporal point processes. Stochastic Environmental Research and Risk Assessment, 34(1), 149-168.

D'Angelo, N., Adelfio, G. and Mateu, J. (2022) Local inhomogeneous second-order characteristics for spatio-temporal point processes on linear networks. Stat Papers. https://doi.org/10.1007/s00362-022-01338-4

Gabriel, E., and Diggle, P. J. (2009). Second-order analysis of inhomogeneous spatio-temporal point process data. Statistica Neerlandica, 63(1), 43-51.

Gabriel, E., Rowlingson, B. S., & Diggle, P. J. (2013). stpp: An R Package for Plotting, Simulating and Analyzing Spatio-Temporal Point Patterns. Journal of Statistical Software, 53(2), 1–29. https://doi.org/10.18637/jss.v053.i02

Moradi M, Cronie O, and Mateu J (2020). stlnpp: Spatio-temporal analysis of point patterns on linear networks.

Moradi, M. M., and Mateu, J. (2020). First-and second-order characteristics of spatio-temporal point processes on linear networks. Journal of Computational and Graphical Statistics, 29(3), 432-443.

See Also

globaldiag, plot.globaldiag, summary.globaldiag

Examples

```
set.seed(2)
inh <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)},
               par = c(.3, 6))

mod1 <- stppm(inh, formula = ~ 1)
mod2 <- stppm(inh, formula = ~ x)

g1 <- globaldiag(inh, mod1$l)
g2 <- globaldiag(inh, mod2$l)

summary(g1)
summary(g2)
```

summary.lista *Summary a* lista *object*

Description

It prints the main information on the local network summary statistics stored in a `lista` object.

Usage

```
## S3 method for class 'lista'
summary(object, ...)
```

Arguments

`object`	An object of class `lista`
`...`	additional unused argument

Author(s)

Nicoletta D'Angelo

Examples

```
set.seed(2)
df_net <- data.frame(x = runif(25, 0, 0.85), y = runif(25, 0, 0.85), t = runif(25))
stlp1 <- stp(df_net, L = chicagonet)
lambda <- rep(diff(range(stlp1$df$x)) * diff(range(stlp1$df$y))
 * diff(range(stlp1$df$t)) / spatstat.geom::volume(stlp1$L),
nrow(stlp1$df))

k <- localSTLKinhom(stlp1, lambda = lambda, normalize = TRUE)

summary(k)
```

summary.localdiag *Summary of the diagnostics performed on a spatio-temporal point process model*

Description

It summarises the main information on the result of the local diagnostics performed with localdiag on either a `stp` or `stlp` object: whether the local test was run on point patterns lying on a linear network or not; the number of points in the analysed spatio-temporal point pattern `X`; the number of points of `X` which are identified as outlying by the previously performed local diagnostics.

Usage

```
## S3 method for class 'localdiag'
summary(object, ...)
```

Arguments

object	A localdiag object
...	additional unused argument

Author(s)

Nicoletta D'Angelo and Giada Adelfio

References

Adelfio, G., Siino, M., Mateu, J., and Rodríguez-Cortés, F. J. (2020). Some properties of local weighted second-order statistics for spatio-temporal point processes. Stochastic Environmental Research and Risk Assessment, 34(1), 149-168.

D'Angelo, N., Adelfio, G. and Mateu, J. (2022) Local inhomogeneous second-order characteristics for spatio-temporal point processes on linear networks. Stat Papers. https://doi.org/10.1007/s00362-022-01338-4

See Also

infl, plot.localdiag, print.localdiag

Examples

```
set.seed(2)
inh <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)},
             par = c(.3, 6))

mod1 <- stppm(inh, formula = ~ 1)

resmod1 <- localdiag(inh, mod1$l, p = .9)

summary(resmod1)
```

`summary.localtest` *Summary of the result of the permutation local test*

Description

It summarises the main information on the result of the local permutation test performed with localtest on either a `stp` or `stlp` object: whether the local test was run on point patterns lying on a linear network or not; the number of points in the background `X` and alternative `Z` patterns; the number of points in `X` which exhibit local differences in the second-order structure with respect to `Z`, according to the performed test.

Usage

```
## S3 method for class 'localtest'
summary(object, ...)
```

Arguments

`object`	An object of class `localtest`
`...`	additional unused argument

Author(s)

Nicoletta D'Angelo

References

D'Angelo, N., Adelfio, G., and Mateu, J. (2021). Assessing local differences between the spatio-temporal second-order structure of two point patterns occurring on the same linear network. Spatial Statistics, 45, 100534.

Siino, M., Rodríguez-Cortés, F. J., Mateu, J. ,and Adelfio, G. (2018). Testing for local structure in spatiotemporal point pattern data. Environmetrics, 29(5-6), e2463.

See Also

localtest, print.localtest, plot.localtest

Examples

```
set.seed(2)
X <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)},
           par = c(.005, 5))
Z <- rstpp(lambda = 30)

test <- localtest(X, Z, method = "K", k = 3)
```

```
summary(test)
```

`summary.locstppm` *Summary of a fitted local spatio-temporal Poisson process model*

Description

The function summarises the main information on the distribution of the parameters of a fitted local spatio-temporal Poisson process model.

Usage

```
## S3 method for class 'locstppm'
summary(object, ...)
```

Arguments

`object`	An object of class `locstppm`
`...`	additional unused argument

Author(s)

Nicoletta D'Angelo

References

D'Angelo, N., Adelfio, G., and Mateu, J. (2023). Locally weighted minimum contrast estimation for spatio-temporal log-Gaussian Cox processes. Computational Statistics & Data Analysis, 180, 107679.

See Also

locstppm, print.locstppm, plot.locstppm

Examples

```
set.seed(2)
inh <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)},
             par = c(0.005, 5))
inh_local <- locstppm(inh, formula = ~ x)

summary(inh_local)
```

`summary.sepstlppm` *Summary of a fitted fitted separable spatio-temporal Poisson process model on a linear network*

Description

The function summarises the main information of the fitted model.

Usage

```
## S3 method for class 'sepstlppm'
summary(object, ...)
```

Arguments

`object`	An object of class `sepstlppm`
`...`	additional unused argument

Author(s)

Nicoletta D'Angelo

See Also

sepstlppm

Examples

```
crimesub <- stpm(valenciacrimes$df[101:200, ],
           names = colnames(valenciacrimes$df)[-c(1:3)],
L = valencianet)

mod1 <- sepstlppm(crimesub, spaceformula = ~x ,
                  timeformula = ~ day)

summary(mod1)
```

summary.sepstppm *Summary of a fitted separable spatio-temporal Poisson process model*

Description

The function summarises the main information of the fitted model.

Usage

```
## S3 method for class 'sepstppm'
summary(object, ...)
```

Arguments

object	An object of class sepstppm
...	additional unused argument

Author(s)

Nicoletta D'Angelo

See Also

sepstlppm

Examples

```
crimesub <- stpm(valenciacrimes$df[101:200, ],
           names = colnames(valenciacrimes$df)[-c(1:3)])

mod1 <- sepstppm(crimesub, spaceformula = ~x ,
                 timeformula = ~ day)

summary(mod1)
```

summary.stcov *Summary of a* stcov *object*

Description

It prints the summary statistics of the spatio-temporal coordinates and the covariates values of the spatio-temporal covariate stored in the stcov object.

Usage

```
## S3 method for class 'stcov'
summary(object, ...)
```

Arguments

object	An object of class stcov
...	additional unused argument

Author(s)

Nicoletta D'Angelo

Examples

```
set.seed(2)
df <- data.frame(runif(100), runif(100), runif(100), rpois(100, 15))

cov <- stcov(df, interp = FALSE)
summary(cov)
```

summary.stlgcppm *Summary of a fitted LGCP model*

Description

The function Summarises the main information on the fitted model. provided. In this case of local parameters (both first- and second-order), the summary function contains information on their distributions.

Usage

```
## S3 method for class 'stlgcppm'
summary(object, ...)
```

Arguments

`object`	An object of class `stlgcppm`
`...`	additional unused argument

Author(s)

Nicoletta D'Angelo and Giada Adelfio

References

D'Angelo, N., Adelfio, G., and Mateu, J. (2023). Locally weighted minimum contrast estimation for spatio-temporal log-Gaussian Cox processes. Computational Statistics & Data Analysis, 180, 107679.

Siino, M., Adelfio, G., and Mateu, J. (2018). Joint second-order parameter estimation for spatio-temporal log-Gaussian Cox processes. Stochastic environmental research and risk assessment, 32(12), 3525-3539.

See Also

stlgcppm, print.stlgcppm, localsummary, plot.stlgcppm, localplot

Examples

```
catsub <- stp(greececatalog$df[1:200, ])

lgcp1 <- stlgcppm(catsub)

summary(lgcp1)
```

`summary.stlp` *Summary of a* `stlp` *object*

Description

It prints the main information on the spatio-temporal point pattern on a linear network stored in the `stlp` object: the number of points; vertices and lines of the linear network; the enclosing spatial window; the temporal time period.

Usage

```
## S3 method for class 'stlp'
summary(object, ...)
```

Arguments

object	An object of class stlp
...	additional unused argument

Author(s)

Nicoletta D'Angelo

See Also

stp, plot.stlp, print.stlp

Examples

```
set.seed(2)
df_net <- data.frame(cbind(runif(100, 0, 0.85), runif(100, 0, 0.85), runif(100)))

stlp1 <- stp(df_net, L = chicagonet)
summary(stlp1)
```

---

summary.stlpm *Summary of a* stlpm *object*

Description

It prints the summary statistics of the spatio-temporal coordinates and the marks of the spatio-temporal point pattern stored in the stlpm object.

Usage

```
## S3 method for class 'stlpm'
summary(object, ...)
```

Arguments

object	An object of class stlpm
...	additional unused argument

Author(s)

Nicoletta D'Angelo

Examples

```
set.seed(2)
df <- data.frame(x = runif(100, 0, 0.8), y = runif(100, 0, 0.8),
 t = runif(100), m = rpois(100, 15))

stlpm1 <- stpm(df, L = chicagonet)

summary(stlpm1)
```

`summary.stp` *Summary of a* `stp` *object*

Description

It prints the summary statistics of the spatial and temporal coordinates of the spatio-temporal point pattern stored in the `stp` object.

Usage

```
## S3 method for class 'stp'
summary(object, ...)
```

Arguments

`object`	An object of class `stp`
`...`	additional unused argument

Author(s)

Nicoletta D'Angelo

See Also

stp, print.stp, plot.stp

Examples

```
set.seed(2)
df <- data.frame(cbind(runif(100), runif(100), runif(100)))

stp1 <- stp(df)
summary(stp1)
```

summary.stpm *Summary of a* stpm *object*

Description

It prints the summary statistics of the spatio-temporal coordinates and the marks of the spatio-temporal point pattern stored in the stpm object.

Usage

```
## S3 method for class 'stpm'
summary(object, ...)
```

Arguments

object	An object of class stpm
...	additional unused argument

Author(s)

Nicoletta D'Angelo

Examples

```
set.seed(2)
df <- data.frame(cbind(runif(100), runif(100), runif(100), rpois(100, 15),
rpois(100, 30)))

stpm1 <- stpm(df)

summary(stpm1)

## Categorical marks

set.seed(2)
dfA <- data.frame(x = runif(100), y = runif(100), t = runif(100),
                  m1 = rnorm(100), m2 = rep(c("C"), times = 100))
dfB <- data.frame(x = runif(50), y = runif(50), t = runif(50),
                  m1 = rnorm(25), m2 = rep(c("D"), times = 50))

stpm2 <- stpm(rbind(dfA, dfB), names = c("continuous", "dichotomous"))

summary(stpm2)
```

summary.stppm *Summary of a fitted spatio-temporal Poisson process model*

Description

The function summarises the main information of the fitted model.

Usage

```
## S3 method for class 'stppm'
summary(object, ...)
```

Arguments

object	An object of class stppm
...	additional unused argument

Author(s)

Nicoletta D'Angelo

References

D'Angelo, N., Adelfio, G., and Mateu, J. (2023). Locally weighted minimum contrast estimation for spatio-temporal log-Gaussian Cox processes. Computational Statistics & Data Analysis, 180, 107679.

See Also

stppm, print.stppm, plot.stppm

Examples

```
set.seed(2)
pin <- rstpp(lambda = function(x, y, t, a) {exp(a[1] + a[2]*x)}, par = c(2, 6))
inh1 <- stppm(pin, formula = ~ x)

summary(inh1)
```

`valenciacrimes` *Crimes in Valencia in 2019*

Description

A dataset in `stpm` format containing the 10929 crimes occurred in Valencia, Spain, in 2019.

Usage

```
data(valenciacrimes)
```

Format

A `stpm` object

Details

The 15 available marks are the following:

- month.
- week.
- day.
- week_day.
- atm_dist.
- bank_dist.
- bar_dist.
- cafe_dist.
- industrial_dist.
- market_dist.
- nightclub_dist.
- police_dist.
- pub_dist.
- restaurant_dist.
- taxi_dist.

Author(s)

Nicoletta D'Angelo

Examples

```
data(valenciacrimes)
```

valencianet *Roads of Valencia, Spain*

Description

A linear network of class `linnet` of the roads of Valencia, Spain

Usage

```
data(valencianet)
```

Format

A linear network of class `linnet`

Author(s)

Nicoletta D'Angelo

Examples

```
data(valencianet)
```

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