Package ‘DRHotNet’

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Title  Differential Risk Hotspots in a Linear Network
Version  1.1
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Description  Performs the identification of differential risk hotspots (Briz-
Redon et al. 2019) <doi:10.1016/j.aap.2019.105278> along a linear net-
work. Given a marked point pattern lying on the linear network, the method imple-
mented uses a network-constrained version of kernel density estimation (McSwig-
gan et al. 2017) <doi:10.1111/sjos.12255> to approximate the probability of occur-
rence across space for the type of event specified by the user through the marks of the pat-
tern (Kelsall and Diggle 1995) <doi:10.2307/3318678>. The goal is to detect micro-
zones of the linear network where the type of event indicated by the user is overrepresented.

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Identifies differential risk hotspots along a linear network given a vector of relative probabilities computed over the middle points of the segments of the network

Description

Given the relative probability surface corresponding to the occurrence of a type of event along a linear network, this function filters and groups in hotspots those segments satisfying two conditions: 1) exceeding the average of the relative probabilities for all the events in the network in \( k \) times the standard deviation of the set of probabilities, and 2) having provided \( n \) or more events of the network for the computation of their corresponding relative probability (a factor that depends on the choice of \( \sigma \) when using the function `RelativeProbabilityNetwork`). In summary, \( k \) and \( n \) control the formation of differential risk hotspots along the network, given a set of relative probabilities covering the network. The choice of a higher value for \( k \) or \( n \) (or both) is more demanding and leads to a lower number of differential risk hotspots being detected. Users should test several values of \( k \) and \( n \) (sensitivity analysis on \( k \) and \( n \)) in order to reach reasonable choices for the research or practical purposes of their data analyses.

Usage

```r
DRHotspots_k_n(X, rel_probs, k, n, event_distances = NULL)
```

Arguments

- **X**: A lpp object representing a marked point pattern lying on a road network (linnet object)
- **rel_probs**: An object containing the relative probabilities of a specific type of event along the linear network contained in \( X \), generated through the function `RelativeProbabilityNetwork`
- **k**: A numeric value that controls the procedure of detecting differential risk hotspots (departure from average relative probability), as described above
- **n**: A numeric value that controls the procedure of detecting differential risk hotspots (minimum size for the sample of events implicated in the computation of the relative probabilities), as described above
- **event_distances**: A matrix that contains the shortest-path distances between the middle points of the segments satisfying the condition on parameter \( k \) and the events of \( X \). By default it is set to NULL

Value

Returns a list that contains the differential risk hotspots found for \( X \) and the type of event specified by `rel_probs`
**References**


**Examples**

```r
criteria <- list(
  list(1, 2, 3),
  list(4, 5, 6),
  list(7, 8, 9)
)
```

**Description**

Given a linear network structure, this function creates the neighbourhood matrix ("queen" criterion) associated to it. Two segments of the network are neighbours if they share a vertex.

**Usage**

```r
NeighbourhoodMatrixNetwork(network)
```

**Arguments**

- `network` - A `linnet` object representing a linear network structure

**Value**

Returns a `listw` object in "W" style

**Examples**

```r
criteria <- list(
  list(1, 2, 3),
  list(4, 5, 6),
  list(7, 8, 9)
)
```

PlotHotspots

Plots an object obtained with DiffHotspots_n_k

Description

This function plots a set of differential risk hotspots located along a linear network. An extension of the hotspots (including the kth order neighbours of the segments of the hotspots) is also plotted.

Usage

PlotHotspots(X, hotspots, order_extension = NULL, which.plot = NULL, rotation_angle = 0, eps_image = F)

Arguments

X - A lpp object representing a marked point pattern lying on a road network (linnet object)

hotspots - A set of differential risk hotspots obtained with the function DiffHotspots_n_k

order_extension - A natural number indicating a neighbourhood order to be used for constructing an extension of the differential risk hotspots. The summary is also given for the segments forming this extension

which.plot - A numeric vector indicating which differential risk hotspots to plot (according to the way they are ordered in hotspots)

rotation_angle - A rotation angle (in degrees, from 0 to 180) to apply to the network (to improve visualization, if required). By default it is set to 0

eps_image - If set to TRUE, an .eps image is generated. By default it is set to FALSE

Examples

library(DRHotNet)
library(spatstat)
library(spdep)
library(raster)
library(maptools)

rel_probs_rear_end <- RelativeProbabilityNetwork(X = SampleMarkedPattern, lixel_length = 50, sigma = 100, mark = "Collision", category_mark = "Rear-end")

hotspots_rear_end <- DRHotspots_k_n(X = SampleMarkedPattern, rel_probs = rel_probs_rear_end, k = 1, n = 30)

PlotHotspots(X = SampleMarkedPattern, hotspots = hotspots_rear_end)
PlotRelativeProbabilities

Plots an object obtained with RelativeProbabilityNetwork

Description

This function plots the relative probability of occurrence of a type of event along a linear network.

Usage

PlotRelativeProbabilities(X, rel_probs, rotation_angle = 0, eps_image = F)

Arguments

X - A lpp object representing a marked point pattern lying on a road network (linnet object)
rel_probs - An object containing the relative probabilities of a specific type of event along the linear network contained in X, generated through the function RelativeProbabilityNetwork
rotation_angle - A rotation angle (in degrees, from 0 to 180) to apply to the network (to improve visualization, if required). By default it is set to 0
eps_image - If set to TRUE, an .eps image is generated. By default it is set to FALSE

Examples

library(DRHotNet)
library(spatstat)
library(spdep)
library(maptools)

rel_probs_rear_end <- RelativeProbabilityNetwork(X = SampleMarkedPattern, lixel_length = 50, sigma = 100, mark = "Collision", category_mark = "Rear-end")
PlotRelativeProbabilities(X = SampleMarkedPattern, rel_probs = rel_probs_rear_end)

RelativeProbabilityNetwork

Computes the relative probability of observing a type of event along a linear network.

Description

Given a marked point pattern lying on a linear network structure, this function uses kernel density estimation (KDE) to estimate a relative probability of occurrence for a type of event specified by the user through the marks of the pattern. The marks of a point pattern represent additional information of the events that are part of the pattern.
Usage

RelativeProbabilityNetwork(X, lixel_length, sigma, mark, category_mark)

Arguments

- **X** - A lpp object representing a marked point pattern lying on a linear network (linnet object)
- **lixel_length** - A numeric value representing a lixel length that will be used for creating a split version of the network contained in X. Then, the length of all the segments of the split network is below lixel_length
- **sigma** - A numeric value representing the bandwidth parameter (in meters)
- **mark** - Mark of X that is used to characterize the type of event. The algorithm searches microzones of the network where this mark is over- or underrepresented
- **category_mark** - A numeric/character value from the set allowed in the chosen mark to compute the relative probability in relation to it

Value

Returns a list that contains the relative probability values estimated along the network for the type of event specified by mark and category_mark

References


Examples

```
library(DRHotNet)
library(spatstat)
library(spdep)
library(raster)
library(maptools)

rel_probs_rear_end <- RelativeProbabilityNetwork(X = SampleMarkedPattern,
lixel_length = 50, sigma = 100, mark = "Collision", category_mark = "Rear-end")
```
Description

A simulated lpp object representing traffic accidents lying on a road structure. The pattern is marked, with the following marks: Collision, Bicycle, Car, Lorry, Motorcycle, Public.bus, Private.bus and Van. The mark Collision is a factor, with the following possible values: Crossing, Fixed-object, Rear-end, Run-off-road, Run-over, Side. The remaining marks are numeric and binary.

Usage

SampleMarkedPattern

Format

An object of class lpp (inherits from ppx) of length 3.

Sensitivity_k_n

Performs a sensitivity analysis on the parameters k and n that are provided to DRHotspots_k_n

Description

Given the relative probabilities of an event’s occurrence along a linear network, this function filters and groups in hotspots those segments satisfying two conditions: 1) exceeding the average of the relative probabilities for all the events in the network in k times the standard deviation of the set of probabilities, and 2) having provided n or more events of the network for the computation of their corresponding relative probability (a factor that depends on the choice of sigma when using the function RelativeProbabilityNetwork). In summary, k and n control the formation of differential risk hotspots along the network, given a set of relative probabilities covering the network. The choice of a higher value for k or n (or both) is more demanding and leads to a lower number of differential risk hotspots being detected. Users should test several values of k and n (sensitivity analysis on k and n) in order to reach reasonable choices for the research or practical purposes of their data analyses.

Usage

Sensitivity_k_n(X, rel_probs, ks, ns)
Arguments

- X: A `lpp` object representing a marked point pattern lying on a road network (linnet object)
- rel_probs: An object containing the relative probabilities of a specific type of event along the linear network contained in X, generated through the function `RelativeProbabilityNetwork`
- ks: A numeric vector of possible values for the k parameter that is provided to `DRHotspots_k_n`
- ns: A numeric vector of possible values for the n parameter that is provided to `DRHotspots_k_n`

Value

A matrix providing the type-specific prediction accuracy index that corresponds to the set differential risk hotspots obtained for each value of k or n provided in ks and ns, respectively. A NA value in this matrix indicates that no differential risk hotspots are found for the corresponding combination of k and n.

References


Examples

```r
library(DRHotNet)
library(spatstat)
library(spdep)
library(raster)
library(maptools)

rel_probs_rear_end <- RelativeProbabilityNetwork(X = SampleMarkedPattern, lixel_length = 50, sigma = 100, mark = "Collision", category_mark = "Rear-end")
sensitivity_analysis <- Sensitivity_k_n(X = SampleMarkedPattern, rel_probs = rel_probs_rear_end, ks = c(1,2), ns = c(30,40))
```

SummaryDRHotspots

Performs a summary of a set of differential risk hotspots located along a linear network.

Description

This function provides a basic summary of each differential risk hotspot provided in the object hotspots passed to the function. This includes the proportion of the type of event in each hotspot, the total length of the hotspot, a type-specific prediction accuracy index (PAI_type). Furthermore, this summary is also provided for an extension of each of the hotspots.
SummaryDRHotspots

Usage

SummaryDRHotspots(X, rel_probs, hotspots, order_extension = NULL, compute_p_value = F, n_it = 40)

Arguments

X - A lpp object representing a marked point pattern lying on a linear network (linnet object)

rel_probs - An object containing the relative probabilities of a specific type of event along the linear network contained in X, generated through the function RelativeProbabilityNetwork

hotspots - A set of differential risk hotspots obtained with the function DiffHotspots_n_k

order_extension - A natural number indicating a neighbourhood order to be used for constructing an extension of the differential risk hotspots. The summary is also given for the segments forming this extension

compute_p_value - A Boolean value allowing the user to compute a p-value representing the statistical significance of each differential risk hotspot

n_it - Number of simulations performed for the estimation of the p-value (if compute_p_value = T)

Value

Returns a data.frame providing a summary of a set of differential risk hotspots. Each row of the output corresponds to one hotspot

Examples

library(DRHotNet)
library(spatstat)
library(spdep)
library(raster)
library(maptools)

rel_probs_rear_end <- RelativeProbabilityNetwork(X = SampleMarkedPattern, lixel_length = 50, sigma = 100, mark = "Collision", category_mark = "Rear-end")

hotspots_rear_end <- DRHotspots_k_n(X = SampleMarkedPattern, rel_probs = rel_probs_rear_end, k = 1, n = 30)

hotspots_summary <- SummaryDRHotspots(X = SampleMarkedPattern, rel_probs = rel_probs_rear_end, hotspots = hotspots_rear_end)
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