The spatclus Package

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Title Arbitrarily Shaped Multiple Spatial Cluster Detection for Case Event Data.

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Depends spatstat, mgcv

Description Multiple cluster location and detection for 2D and 3D spatial point patterns (case event data). The methodology of this package is based on an original method that allows the detection of multiple clusters of any shape. A selection order and the distance from its nearest neighbour once pre-selected points have been taken into account are attributed at each point. This distance is weighted by the expected distance under the uniform distribution hypothesis. Potential clusters are located by modelling the multiple structural change of the distances on the selection order. Their presence is tested using the double maximum test and a Monte Carlo procedure. The main function of this R package is “clus”.

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airegrille

Surface computation in 2D

Description

Computes the surface of the area with "1" on the grid and out of the circle with (x,y) as center coordinates and r as ray.

Usage

airegrille(pop, x, y, r)

Arguments

pop
The underlying population with "1" if point has not yet been included in the trajectory, "0" else.

x
X-coordinate of the center of the circle.

y
Y-coordinate of the center of the circle.

r
Radius of the circle.

Value

The computed surface.

Author(s)

Christophe Dematteï (demattei@iurec.montp.inserm.fr)

See Also

dist2p
\textbf{airegrille3d} \hspace{1cm} \textit{Volume computation in 3D}

\textbf{Description}

This function is the 3D version of the airegrille function which is described hereafter.

\textbf{Usage}

\begin{verbatim}
airegrille3d(pop, x, y, z, r)
\end{verbatim}

\textbf{Arguments}

\begin{itemize}
\item \texttt{pop} \hspace{1cm} The underlying population with "1" if point has not yet been included in the trajectory, "0" else.
\item \texttt{x} \hspace{1cm} X-coordinate of the center of the sphere.
\item \texttt{y} \hspace{1cm} Y-coordinate of the center of the sphere.
\item \texttt{z} \hspace{1cm} Z-coordinate of the center of the sphere.
\item \texttt{r} \hspace{1cm} Radius of the sphere.
\end{itemize}

\textbf{Value}

The computed volume.

\textbf{Author(s)}

Christophe Dematteï \hspace{1cm} \{demattei@iurc.montp.inserm.fr\}

\textbf{See Also}

dist2p3d \hspace{1cm} airegrille

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\textbf{cercle} \hspace{1cm} \textit{Circle plot}

\textbf{Description}

Plots a circle in 2D from its center coordinates and its radius.

\textbf{Usage}

\begin{verbatim}
cercle(cx, cy, r, pas)
\end{verbatim}

\textbf{Arguments}

\begin{itemize}
\item \texttt{cx} \hspace{1cm} X-coordinate of the center
\item \texttt{cy} \hspace{1cm} Y-coordinate of the center
\item \texttt{r} \hspace{1cm} Radius
\item \texttt{pas} \hspace{1cm} Makes possible to choose the precision of the circle plot. $\frac{2\pi}{\text{pas}}$ is the number of points from which the circle is drawn.
\end{itemize}
Details
This function allows to draw the Kulldorff circular zone.

Value
The circle plot.

Author(s)
Christophe Dematteï (demattei@iurc.montp.inserm.fr)

chemist
Coordinates of chemist shops in Montpellier, France.

Description
This data set gives the X and Y coordinates of the 99 chemist shops in Montpellier, France.

Usage
data(chemist)

Format
A data frame containing 99 coordinates

Source
GPS location by Christophe Dematteï

clus
Cluster location and detection

Description
Locates and detects multiple spatial clusters in 2D and 3D and determines the Kulldorff’s circular zone in 2D (without detection).

Usage
clus(data, pop, dataincyn = "n", rndm = NaN, m = 9, eps = 0.1, limx, limy, limz, method = 1, methk = 3, start = 1, export = "n", repexport)
Arguments

data  Data frame with 2 or 3 columns (x and y, and z in 3D) giving coordinates of case data points.

pop  Matrix with 2 or 3 columns (depending on whether 2D or 3D data) giving coordinates of underlying population data points.

dataincyn  "y" means that cases are included in the grid, "n" that they are not.
rndm  Vector giving the number of the rows containing cases coordinates in the grid (only if datainc="y").
m  Maximum number of breaks.
eps  Minimum size of cluster (ratio of the total number of cases).
limx  2 element vector containing the study area bounds of the X-axis.
limy  2 element vector containing the study area bounds of the Y-axis.
limz  In 3D, 2 element vector containing the study area bounds of the Z-axis.
method  1 for multiple break clusters, 2 for Kulldorff localization, 3 for the 2 methods.
methk  In the Kulldorff localization, 1 for Bernoulli model, 2 for Poisson model.
start  Indicates the rank of the first trajectory point in terms of distance from the area edges. 1 means that the first point of the trajectory is the nearest from the edge.
export  If method = 2 or method = 3, and if export = "y", the data will be exported in "repexport" directory in SatScan software format.
repexport  If export = "y", defines the directory in which data in SatScan software format will be exported.

Details

The "clus" function is the main function. It uses all other functions described below, except "plot" functions. Thus, generally, only the clus function is necessary since others are implicitly called. However, they can be useful for other purposes, such as when one wants to determine the breaks from a series, not only in the spatial field. Its main arguments are "data" (case locations) and "pop" (underlying population locations). The function determines the trajectory giving a selection order to each point, computes the weighting of the distance, determines the potential clusters through the computation of the breaks by a regression of this weighted distance on the selection order, and finally tests the significativity of those potential clusters.

Value

A list of objects :

res  A result matrix giving, for each point ordered by its rank in the trajectory, its distance to the nearest neighbour, the expectancy of this distance, and its weighted distance.

pop  The matrix with 2 or 3 columns giving coordinates of underlying population data points without cases.

bc  A list of vectors. The kth element of the list gives the estimated breaks for the model with k breaks.

stat  A list of non corrected statistic values (F), corrected statistic value (wdm), threshold value for the WDM statistic (wdms) and significativity (signif).
A vector giving the results of the Kulldorff method with the Poisson model. 
lambda is the value of the spatial scan test statistic, loglambda is its logarithm, 
cx and cy are the coordinates of the circle center and rayon is its ray.

A vector giving the results of the Kulldorff method with the Bernoulli model. 
lambda is the value of the spatial scan test statistic, loglambda is its logarithm, 
cx and cy are the coordinates of the circle center and rayon is its ray.

**Note**

Only arguments "data", "pop", "limx" and "limy" are essential (and "limz" in 3D) but the others have default values. So do not forget to adapt them at your special case.

**Author(s)**

Christophe Dematteï (demattei@iurc.montp.inserm.fr)

**References**


Dematteï C., Molinari N. and Daurès J.P. (2006), Arbitrarily shaped multiple spatial cluster detection for case event data. *Accepted in Computational Statistics and Data Analysis*. Corrected proof available online via the DOI link http://dx.doi.org/10.1016/j.csda.2006.03.011.


**See Also**

data, inc regdist fstat kulld delai

**Examples**

```r
library(spatstat)
data(chemist)
data(grille)
data(irislist)

# plot of the chemist shop locations
par(mfrow=c(2,2))
for (i in 1:30) {plot(irislist[[i]],xlim=c(-6,8),ylim=c(-7,7),main="Chemist shop locations")
```
critval

Threshold sup F-statistic computation

description
Computes the sup F-statistic threshold.

usage
```r
critval(q = 1, k = 2, e = eps)
```

arguments
- `q` An unused argument fixed to 1.
- `k` The number of breaks.
- `e` The \( \epsilon \) parameter value.

value
The threshold value.

author(s)
Christophe Demattei (demattei@iurc.montp.inserm.fr)

references
critvalwdm  

**Threshold of the WD sup F-statistic computation**

**Description**  
Computes the WD sup F-statistic threshold.

**Usage**  
```r  
critvalwdm(q = 1, e = eps)  
```

**Arguments**
- `q`  
  An unused argument fixed to 1.
- `e`  
  The \( \epsilon \) parameter value.

**Value**  
The threshold value.

**Author(s)**  
Christophe Dematteï (demattei@iurc.montp.inserm.fr)

**References**

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datainc  

**Inclusion of cases in the grid**

**Description**  
If this is not yet done, the cases are included in the point grid.

**Usage**  
```r  
datainc(data, pop)  
```

**Arguments**
- `data`  
  Data frame with 2 columns (x and y) or 3 columns (x, y and z) giving coordinates of case data points.
- `pop`  
  Matrix with 3 or 4 columns giving coordinates of underlying population data points in the first 2 or 3 columns. Last is a column of 1’s.

**Value**  
The underlying population coordinate matrix including cases.
**delai**  
*Time computation between two dates*

**Description**
Computes the time between two dates.

**Usage**
\[
delai(date1, date2)
\]

**Arguments**
- `date1`: The first date, obtained by the function `date()`.
- `date2`: The second date, also obtained by the function `date()`.

**Value**
An output giving the date in hh:mm:ss format.

**Author(s)**
Christophe Dematteï (demattei@iurc.montp.inserm.fr)

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**dist2p**  
*Euclidian distance computation in 2D*

**Description**
Computes the euclidian distance between two 2D point coordinates or between one point and a vector of points.

**Usage**
\[
dist2p(x, y, x0, y0)
\]

**Arguments**
- `x`: X-coordinate of the second point or the vector of point
- `y`: Y-coordinate of the second point or the vector of point
- `x0`: X-coordinate of the first point
- `y0`: Y-coordinate of the first point

**Value**
\[
dist\]
The distance computed

**Author(s)**
Christophe Dematteï (demattei@iurc.montp.inserm.fr)
Author(s)

Christophe Dematteï ⟨demattei@iurc.montp.inserm.fr⟩

dist2p3d Euclidian distance computation in 3D

Description

Computes the euclidian distance between two 3D point coordinates or between one point and a vector of points.

Usage

dist2p3d(x, y, z, x0, y0, z0)

Arguments

x X-coordinate of the second point or the vector of point
y Y-coordinate of the second point or the vector of point
z Z-coordinate of the second point or the vector of point
x0 X-coordinate of the first point
y0 Y-coordinate of the first point
z0 Z-coordinate of the first point

Value

dist The distance computed

Author(s)

Christophe Dematteï ⟨demattei@iurc.montp.inserm.fr⟩

espdist Distance weighting in 2D

Description

The distances to the nearest neighbour are weighted by the expectancy of this distance in the uniform case. This allows first to avoid distance to be higher for the latest selected points, due to the elimination process of pre-selected points, and second to adjust for inhomogeneity in the underlying population density.

Usage

espdist(data, pop)
**espdist3d**

**Arguments**

- **data**
  Data frame with 2 columns (x and y) giving coordinates of case data points. The first row must be the first trajectory point.

- **pop**
  Matrix with 3 columns giving coordinates of underlying population data points in the first 2 columns. Last is a column of 1’s. This grid must include the cases of the "data" object.

**Details**

The theory used in this function is based on works of Bickel P. and Breiman L.

**Value**

A list of objects:

- **res**
  A result matrix giving, for each point ordered by its rank in the trajectory, its distance to the nearest neighbour, the expentancy of this distance, and its weighted distance. The last point of the trajectory is not included in the res matrix.

- **derpoint**
  A vector containing the last trajectory point coordinates.

**Author(s)**

Christophe Dematteï (demattei@iurc.montp.inserm.fr)

**References**


**See Also**

dist2p integre delai

---

**espdist3d**  
*Distance weighting in 3D*

**Description**

This function is the 3D version of the espdist function which is described hereafter.

**Usage**

```r
espdist3d(data, pop)
```

**Arguments**

- **data**
  Data frame with 3 columns (x, y and z) giving coordinates of case data points. The first row must be the first trajectory point.

- **pop**
  Matrix with 4 columns giving coordinates of underlying population data points in the first 3 columns. Last is a column of 1’s. This grid must include the cases of the "data" object.
Details

Value
A list of objects:

- `res` A result matrix giving, for each point ordered by its rank in the trajectory, its distance to the nearest neighbour, the expentancy of this distance, and its weighted distance. The last point of the trajectory is not included in the `res` matrix.
- `derpoint` A vector containing the last trajectory point coordinates.

Author(s)
Christophe Demattei (demattei@iurc.montp.inserm.fr)

References

See Also

`dist2p3d`, `integre3d`, `delai`

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### fstat

Test statistic

Description
Computes the F-statistics for each model with $k$ breaks for $k \in \{1, \ldots, m\}$, and the WD max F-statistic that allows to select the number of breaks and determines if the cluster(s) is significant.

Usage

```r
fstat(reslst, bc, m, T, eps)
```

Arguments

- `reslst` A matrix giving, for each point ordered by its rank in the trajectory, its distance to the nearest neighbour, the expentancy of this distance, and its weighted distance.
- `bc` A list. The element $k$ of the list is a vector containing the estimated breaks for the $k$-breaks model.
- `m` The maximum number of breaks.
- `T` The size of the weighted serie.
- `eps` Minimum size of cluster (ratio of the total number of cases).

Details
The theory used in this function is based on works of J. Bai and P. Perron.
**Value**

A list of objects:

- **F**: A F-statistics matrix giving in the first row the F-statistic value for each of the \( m \) models, and the corresponding weighted F-statistics in the second row.
- **wdm**: The WD max F-statistic value.
- **wdms**: The WD max F-statistic threshold at 5%.
- **signif**: A boolean. If True, the cluster(s) located is significant.
- **kmax**: The number of breaks of the model maximizing the WD max F-statistic.

**Author(s)**

Christophe Dematteï (demattei@iurc.montp.inserm.fr)

**References**


**See Also**

supf critval critvalwdm

**Description**

This data set gives the X and Y coordinates of 2251 underlying population individuals. It takes the Montpellier density into account. Each point represents 100 inhabitants.

**Usage**

data(grille)

**Format**

A 2 column matrix containing 2251 coordinates

**Source**

French 1999 population census, INSEE data.

**References**

**integre**

*Distance expectation computation in 2D*

**Description**

Computes the expectation of the distance from a point to its nearest neighbour.

**Usage**

```r
integre(pop, x, y, rmax, n, k, pas)
```

**Arguments**

- `pop`: The grid with "1" if the point has not been yet included in the trajectory, "0" else.
- `x`: X-coordinate of the point from which we want to compute the expectancy of the distance.
- `y`: Y-coordinate of the point from which we want to compute the expectancy of the distance.
- `rmax`: The maximal distance from the (x,y) point to the study area border.
- `n`: The total number of points (cases).
- `k`: The number of points already selected in the trajectory.
- `pas`: Makes possible to choose the precision of the integral calculation.

**Value**

Value of the computed expectation.

**Author(s)**

Christophe Demattei \(<\text{demattei@iurc.montp.inserm.fr}>\)

**See Also**

`airegrille`

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**integre3d**

*Distance expectation computation in 3D*

**Description**

This function is the 3D version of the integre function which is described hereafter.

**Usage**

```r
integre3d(pop, x, y, z, rmax, n, k, pas)
```
Arguments

pop  The grid with "1" if the point has not been yet included in the trajectory, "0" else.

x  X-coordinate of the point from which we want to compute the expectancy of the distance.

y  Y-coordinate of the point from which we want to compute the expectancy of the distance.

z  Z-coordinate of the point from which we want to compute the expectancy of the distance.

rmax  The maximal distance from the (x,y) point to the study area border.

n  The total number of points (cases).

k  The number of points already selected in the trajectory.

pas  Makes possible to choose the precision of the integral calculation.

Value

Value of the computed expectation.

Author(s)

Christophe Dematteï (demattei@iurc.montp.inserm.fr)

See Also

airegrille3d integre

irislist  List of the 30 Montpellier IRIS bounds.

Description

Montpellier is divided in 30 quarters, called IRIS. This data sets is a list in which each objects is an object of class "owin" giving the IRIS bounds. The "owin" class is defined in the "spatstat" R package.

Usage

data(irislist)

Format

A list of 30 objects of class "owin".

Source

GPS location by Christophe Dematteï

References

**kulld**  
*Kulldorff circular zone determination*

**Description**

The spatial scan statistic of Kulldorff is computed using the Poisson or Bernoulli model for each point of the grid, and the circular zone maximizing this statistic is located.

**Usage**

```r
kulld(pop, rndm, methk, export, repexport)
```

**Arguments**

- `pop`: Matrix with 3 columns giving coordinates of underlying population data points in the first 2 columns. Last is a column of 1’s. This population must include the cases of the "data" object.
- `rndm`: A vector giving the row number of the cases.
- `methk`: If 1, the Bernoulli model is used. If 2, the Poisson model is used. If 3, the two models are successively used.
- `export`: If "y", the data will be exported in "repexport" directory in SatScan software format.
- `repexport`: If export = "y", defines the directory in which data in SatScan software format will be exported.

**Details**

The theory used in this function is based on works of M. Kulldorff.

**Value**

A list of objects:

- `$pois`: A vector giving the results of the Kulldorff method with the Poisson model. Lambda is the value of the spatial scan test statistic, loglambda is its logarithm, cx and cy are the coordinates of the circle center and rayon is its ray.
- `$bern`: A vector giving the results of the Kulldorff method with the Bernoulli model. Lambda is the value of the spatial scan test statistic, loglambda is its logarithm, cx and cy are the coordinates of the circle center and rayon is its ray.

**Author(s)**

Christophe Demattei (demattei@iurc.montp.inserm.fr)

**References**


multbreak

See Also
dist2p delai

Description
Determines the breaks by the resolution of the least square problem in the weighted distance regression on the selection order.

Usage
multbreak(res,m,h,T)

Arguments
res       a matrix giving, for each point ordered by its rank in the trajectory, its distance to the nearest neighbour, the expectancy of this distance, and its weighted distance. The last point of the trajectory is not included in the res matrix.
m        The number of breaks.
h        The minimal cluster size.
T        The size of the weighted distance serie.

Details
This function programming and the underlying method are based on works of J. Bai and P. Perron.

Value
The m breaks vector.

Author(s)
Christophe Demattei (demattei@iurc.montp.inserm.fr)

References
nincdepart

**First trajectory point determination in 2D**

**Description**

The choice of the first point of the trajectory is given by the rank of the point in term of distance from the edge of the study area. Generally, the point nearest from the edge is chosen (rank = 1).

**Usage**

```
nincdepart(data, ordre, limx, limy)
```

**Arguments**

- **data**
  Data frame with 2 columns (x and y) giving coordinates of case data points.
- **ordre**
  The rank of the first trajectory point in term of distance from the edge.
- **limx**
  2 element vector containing the study area bounds of the X-axis.
- **limy**
  2 element vector containing the study area bounds of the Y-axis.

**Value**

The data frame "data" with the first trajectory point on the first row.

**Author(s)**

Christophe Demattei (demattei@iurc.montp.inserm.fr)

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nincdepart3d

**First trajectory point determination in 3D**

**Description**

This function is the 3D version of the nincdepart function which is described hereafter.

**Usage**

```
nincdepart3d(data, ordre, limx, limy, limz)
```

**Arguments**

- **data**
  Data frame with 3 columns (x, y and z) giving coordinates of case data points.
- **ordre**
  The rank of the first trajectory point in term of distance from the edge.
- **limx**
  2 element vector containing the study area bounds of the X-axis.
- **limy**
  2 element vector containing the study area bounds of the Y-axis.
- **limz**
  2 element vector containing the study area bounds of the Z-axis.

**Value**

The data frame "data" with the first trajectory point on the first row.
plotclus

Author(s)

Christophe Dematteï (demattei@iurc.montp.inserm.fr)

See Also

nincdepart

Description

Plots the data points and a representation of the cluster located.

Usage

plotclus(nomlst, m, limx = c(0, 100), limy = c(0, 100), col1 = 225, rcex = 0.68, pop, k=floor((m+1)/2))

Arguments

nomlst A list corresponding to the "clus" function’s return value.
m The number of breaks of the model to be plotted.
limx 2 element vector containing the study area bounds of the X-axis.
limy 2 element vector containing the study area bounds of the Y-axis.
col1 The color to be used for the cluster representation.
rcex The size to be used for the disc surrounding the points localized in cluster.
pop A 2 column matrix containing the underlying population coordinates.
k The number of clusters to be displayed.

Details

A cluster groups together the points between two breaks with a low mean distance. The plotreg function allow to choose the number of clusters.

Value

A R-graphic window containing the plot.

Author(s)

Christophe Dematteï (demattei@iurc.montp.inserm.fr)
Examples

```r
library(spatstat)
data(chemist)
data(grille)
data(irislist)

# location and detection of spatial clusters
# adjusted for an inhomogeneous population density
RES <- clus(chemist, grille, limx=c(-6,8), limy=c(-7,7))

# plot of the cluster located
for (i in 1:30){
  plot(irislist[[i]], xlim=c(-6,8), ylim=c(-7,7), main=" ", lty=3)
  par(new=TRUE)
}
plotclus(RES, m=2, limx=c(-6,8), limy=c(-7,7), rce=11.5, pop=grille)
```

plotreg

*Regression plot*

Description

Plots the ordered distance serie and the regression function.

Usage

```r
plotreg(nomlst, m)
```

Arguments

- `nomlst`: A list corresponding to the "clus" function’s return value.
- `m`: The number of breaks of the model to be plotted.

Value

A R-graphic window containing the plot.

Note

To plot the regression function with the number of breaks that maximizes the WD max F-statistic, one can use "RES$stat$kmax" as value for the parameter "m" in which RES is the list returned by the "clus" function.

Author(s)

Christophe Demattei (demattei@iurc.montp.inserm.fr)
**Examples**

```r
library(spatstat)
data(chemist)
data(grille)
data(irislist)

# location and detection of spatial clusters
# adjusted for an inhomogeneous population density
RES <- clus(chemist, grille, limx = c(-6, 8), limy = c(-7, 7))

# plot of the regression
plotreg(RES, RES$stat$kmax)
```

---

**regdist**

*Distance weighting and breaks determination in 2D*

**Description**

Determination of the trajectory, weighting of the distance and determination of the breaks by a regression of the distance on the selection order.

**Usage**

```r
regdist(data, pop, start, m, h, T, limx, limy)
```

**Arguments**

- `data`: Data frame with 2 columns (x and y) giving coordinates of case data points.
- `pop`: Matrix with 3 columns giving coordinates of underlying populations individuals in the first 2 columns. Last is a column of 1's.
- `start`: Indicates the rank of the first trajectory point in term of distance from the area edges. 1 means that the first point of the trajectory is the nearest from the edge.
- `m`: The maximal number of breaks.
- `h`: The minimal cluster size.
- `T`: The size of the weighted distance serie.
- `limx`: 2 element vector containing the study area bounds of the X-axis.
- `limy`: 2 element vector containing the study area bounds of the Y-axis.

**Value**

A list of objects:

- `res`: A result matrix giving, for each point ordered by its rank in the trajectory, its distance to the nearest neighbour, the expectancy of this distance, and its weighted distance.
- `bc`: A list of vectors. The \( k \)th element of the list gives the estimated breaks for the model with \( k \) breaks.
regdist3d

Description

This function is the 3D version of the regdist function which is described hereafter.

Usage

regdist3d(data, pop, start, m, h, T, limx, limy, limz)

Arguments

data Data frame with 3 columns (x, y and z) giving coordinates of case data points.
pop Matrix with 4 columns giving coordinates of underlying populations individuals
start in the first 3 columns. Last is a column of 1’s.
start Indicates the rank of the first trajectory point in term of distance from the area
edges. 1 means that the first point of the trajectory is the nearest from the edge.
m The maximal number of breaks.
h The minimal cluster size.
T The size of the weighted distance serie.
limx 2 element vector containing the study area bounds of the X-axis.
limy 2 element vector containing the study area bounds of the Y-axis.
limz 2 element vector containing the study area bounds of the Z-axis.

Value

A list of objects :

res A result matrix giving, for each point ordered by its rank in the trajectory, its
distance to the nearest neighbour, the expectancy of this distance, and its weighted
distance.
bc A list of vectors. The $k^{th}$ element of the list gives the estimated breaks for the
model with $k$ breaks.

Author(s)

Christophe Dematteï (demattei@iurc.montp.inserm.fr)

See Also

nincdepart espdist multbreak regdist
supf

**F-statistic computation**

**Description**

Computes the F-statistic.

**Usage**

`supf(reslst, bc, k, T)`

**Arguments**

- `reslst`: A matrix giving, for each point ordered by its rank in the trajectory, its distance to the nearest neighbour, the expectancy of this distance, and its weighted distance.
- `bc`: A list. The element `k` of the list is a vector containing the estimated breaks for the `k`-break model.
- `k`: The number of breaks.
- `T`: The size of the weighted distance serie.

**Value**

- `Fdiff`: The F-statistic value

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