Package ‘interp’

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Description Bivariate data interpolation on regular and irregular grids, either linear or using splines are the main part of this package. It is intended to provide FOSS replacement functions for the ACM licensed akima::interp and tripack::tri.mesh functions. Currently the piecewise linear interpolation part of akima::interp (and also akima::interpp) is implemented in interp::interp, this corresponds to the call akima::interp(..., linear=TRUE) which is the default setting and covers most of akima::interp use cases in depending packages. A re-implementation of Akimas spline interpolation (akima::interp(..., linear=FALSE)) is currently under development and will complete this package in a later version. Estimators for partial derivatives are already available, these are a prerequisite for the spline interpolation. The basic part is currently a GPLed triangulation algorithm (sweep hull algorithm by David Sinclair) providing the starting point for the piecewise linear interpolator. As side effect this algorithm is also used to provide replacements for the basic functions of the tripack package which also suffer from the ACM restrictions. All functions are designed to be backward compatible with their akima / tripack counterparts.

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Description

Interpolation of \( z \) values given regular or irregular gridded data sets containing coordinates \((x_i, y_i)\) and function values \( z_i \) is (will be) available through this package. As this interpolation is (for the irregular gridded data case) based on triangulation of the data locations also triangulation functions are implemented. Moreover the (not yet finished) spline interpolation needs estimators for partial derivates, these are also made available to the end user for direct use.

Details

The interpolation use can be divided by the used method into piecewise linear (finished in 1.0.27) and spline (not yet finished) interpolation and by input and output settings into gridded and point-wise setups.

Note

This package is a FOSS replacement for the ACM licensed packages akima and tripack. The function calls are backward compatible.

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See Also

interp, tri.mesh, voronoi.mosaic, locpoly

arcs

Extract a list of arcs from a triangulation object.

Description

This function extracts a list of arcs from a triangulation object created by tri.mesh.

Usage

arcs(tri.obj)

Arguments

tri.obj object of class triSht
area

Details

This function accesses the arcs component of a triangulation object returned by `tri.mesh` and extracts the arcs contained in this triangulation. This is e.g. used for plotting.

Value

A matrix with two columns "from" and "to" containing the indices of points connected by the arc with the corresponding row index.

Author(s)

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See Also

`triSht`, `triangles`, `area`

Examples

data(franke)
tr <- tri.mesh(franke$ds3)
arcs(tr)

area(tri.obj)

Arguments

tri.obj object of class `triSht`

Description

This function returns a list containing the areas of each triangle of a triangulation object created by `tri.mesh`.

Usage

area(tri.obj)

Details

This function accesses the cclist component of a triangulation object returned by `tri.mesh` and extracts the areas of the triangles contained in this triangulation.

Value

A vector containing the area values.
circles

Author(s)
Albrecht Gebhardt <albrecht.gebhardt@aau.at>, Roger Bivand <roger.bivand@nhh.no>

See Also
triSht, triangles, arcs

Examples

data(franke)
tr <- tri.mesh(franke$ds3)
area(tr)

circles(x, y, r, ...)

Arguments
x vector of x coordinates
y vector of y coordinates
r vector of radii
... additional graphic parameters will be passed through

Note
This function needs a previous plot where it adds the circles.
This function was earlier used in package tripack.

Author(s)
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See Also
lines, points
Examples

```r
x<-rnorm(10)
y<-rnorm(10)
r<-runif(10,0,0.5)
plot(x,y, xlim=c(-3,3), ylim=c(-3,3), pch="+")
circles(x,y,r)
```

convex.hull

Return the convex hull of a triangulation object

Description

Given a triangulation `tri.obj` of \( n \) points in the plane, this subroutine returns two vectors containing the coordinates of the nodes on the boundary of the convex hull.

Usage

```r
convex.hull(tri.obj, plot.it=FALSE, add=FALSE,...)
```

Arguments

- `tri.obj` object of class `triSht`
- `plot.it` logical, if `TRUE` the convex hull of `tri.obj` will be plotted.
- `add` logical. if `TRUE` (and `plot.it=TRUE`), add to a current plot.
- `...` additional plot arguments

Value

- `x` x coordinates of boundary nodes.
- `y` y coordinates of boundary nodes.

Author(s)

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See Also

`triSht`, `print.triSht`, `plot.triSht`, `summary.triSht`, `triangles`.
Examples

```r
## random points:
rand.tr <- tri.mesh(runif(10), runif(10))
plot(rand.tr)
rand.ch <- convex.hull(rand.tr, plot.it=TRUE, add=TRUE, col="red")
## use a part of the quakes data set:
data(quakes)
quakes.part <- quakes[quakes[,1]<=17 & quakes[,1]>=-19.0 &
quakes[,2]<=182.0 & quakes[,2]>=180.0,]
quakes.tri <- tri.mesh(quakes.part$lon, quakes.part$lat, duplicate="remove")
plot(quakes.tri)
convex.hull(quakes.tri, plot.it=TRUE, add=TRUE, col="red")
```

franke.data

Test datasets from Franke for interpolation of scattered data

Description

franke.data generates the test datasets from Franke, 1979, see references.

Usage

```r
franke.data(fn = 1, ds = 1, data)
franke.fn(x, y, fn = 1)
```

Arguments

- `fn` function number, from 1 to 5.
- `x` 'x' value
- `y` 'y' value
- `ds` data set number, from 1 to 3. Dataset 1 consists of 100 points, dataset 2 of 33 points and dataset 3 of 25 points scattered in the square $[0,1] \times [0,1]$. (and partially slightly outside).
- `data` A list of dataframes with 'x' and 'y' to choose from, dataset franke should be used here.

Details

These datasets are mentioned in Akima, (1996) as a testbed for the irregular scattered data interpolator.

Franke used the five functions:

$$
0.75e^{-\frac{(9x-2)^2+(9y-2)^2}{4}} + 0.75e^{-\frac{(9x+1)^2}{49}} - \frac{9y+1}{10} + 0.5e^{-\frac{(9x-7)^2+(9y-3)^2}{4}} - 0.2e^{-((9x-4)^2-(9y-7)^2)}
\frac{\tanh(9y-9x)+1}{9}
$$
\[
\frac{1.25 + \cos(5.4y)}{6(1 + (3x - 1)^2)}
\]

\[
e^{-\frac{81((x - 0.5)^2 + 1y - 0.5)^2}{3}}
\]

\[
e^{-\frac{81((x - 0.5)^2 + 1y - 0.5)^2}{3}}
\]

\[
\frac{\sqrt{64 - 81((x - 0.5)^2 + (y - 0.5)^2)}}{y} - 0.5
\]

and evaluated them on different more or less dense grids over \([0, 1] \times [0, 1]\).

**Value**

A data frame with components

- \(x\) ‘x’ coordinate
- \(y\) ‘y’ coordinate
- \(z\) ‘z’ value

**Note**

The datasets have to be generated via `franke.data` before use, the dataset `franke` only contains a list of 3 dataframes of ‘x’ and ‘y’ coordinates for the above mentioned irregular grids. Do not forget to load the `franke` dataset first.

The ‘x’ and ‘y’ values have been taken from Akima (1996).

**Author(s)**

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**References**


**See Also**

`interp`
**identify.triSht**

**Examples**

```r
## generate Frankes data set for function 2 and dataset 3:
data(franke)
F23 <- franke.data(2,3,franke)
str(F23)
```

---

**identify.triSht**  
*Identify points in a triangulation plot*

**Description**

Identify points in a plot of "x" with its coordinates. The plot of "x" must be generated with `plot.tri`.

**Usage**

```r
## S3 method for class 'triSht'
identify(x,...)
```

**Arguments**

- `x` object of class `triSht`
- `...` additional parameters for `identify`

**Value**

an integer vector containing the indexes of the identified points.

**Author(s)**

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**See Also**

`triSht`, `print.triSht`, `plot.triSht`, `summary.triSht`

**Examples**

```r
## Not run:
data(franke)
tr <- tri.mesh(franke$ds3$x, franke$ds3$y)
plot(tr)
identify(tr)

## End(Not run)
```
interp

Interpolation function

Description

This function currently implements piecewise linear interpolation (=barycentric interpolation).

Usage

interp(x, y = NULL, z, xo = seq(min(x), max(x), length = nx),
      yo = seq(min(y), max(y), length = ny),
      linear = (method == "linear"), extrap = FALSE,
      duplicate = "error", dupfun = NULL,
      nx = 40, ny = 40, input="points", output = "grid",
      method = "linear", deltri = "shull")

Arguments

x  vector of x-coordinates of data points or a SpatialPointsDataFrame object. Missing values are not accepted.

y  vector of y-coordinates of data points. Missing values are not accepted. If left as NULL indicates that x should be a SpatialPointsDataFrame and z names the variable of interest in this dataframe.

z  vector of z-values at data points or a character variable naming the variable of interest in the SpatialPointsDataFrame x. Missing values are not accepted.

x, y, and z must be the same length (except if x is a SpatialPointsDataFrame) and may contain no fewer than four points. The points of x and y should not be collinear, i.e, they should not fall on the same line (two vectors x and y such that y = ax + b for some a, b will not produce meaningful results).

interp is meant for cases in which you have x, y values scattered over a plane and a z value for each. If, instead, you are trying to evaluate a mathematical function, or get a graphical interpretation of relationships that can be described by a polynomial, try outer.

xo  If output="grid" (default): sequence of x locations for rectangular output grid, defaults to nx points between min(x) and max(x).
    If output="points": vector of x locations for output points.

yo  If output="grid" (default): sequence of y locations for rectangular output grid, defaults to ny points between min(y) and max(y).
    If output="points": vector of y locations for output points. In this case it has to be same length as xo.

input  text, possible values are "grid" (not yet implemented) and "points" (default). This is used to distinguish between regular and irregular gridded data.
output text, possible values are "grid" (=default) and "points".
If "grid" is chosen then xo and yo are interpreted as vectors spanning a rectangular grid of points \((xo[i], yo[j]), i = 1, ..., nx, j = 1, ..., ny\). This default behaviour matches how akima::interp works.
In the case of "points" xo and yo have to be of same length and are taken as possibly irregular spaced output points \((xo[i], yo[i]), i = 1, ..., no\) with \(no = length(xo)\). nx and ny are ignored in this case. This case is meant as replacement for the pointwise interpolation done by akima::interpp. If the input x is a SpatialPointsDataFrame and output="points" then xo has to be a SpatialPointsDataFrame, yo will be ignored.

linear logical, only for backward compatibility with akima::interp, indicates if piecewise linear interpolation or Akima splines should be used. Warning: in this release only linear=TRUE is implemented!
Please use the new method argument instead!

method text, possible methods are (currently only, more is under development) "linear" (piecewise linear interpolation within the triangles of the Delauney triangulation, also referred to as barycentric interpolation based on barycentric coordinates).
This replaces the old linear argument of akima::interp.

extrap logical, indicates if extrapolation outside the convex hull is intended, will not work for piecewise linear interpolation!

duplicate character string indicating how to handle duplicate data points. Possible values are
"error" produces an error message,
"strip" remove duplicate z values,
"mean","median","user" calculate mean, median or user defined function (dupfun) of duplicate z values.

dupfun a function, applied to duplicate points if duplicate= "user".

nx dimension of output grid in x direction

ny dimension of output grid in y direction

deltri triangulation method used, this argument will later be moved into a control set together with others related to the spline interpolation! Possible values are "shull" (default, sweep hull algorithm) and "deldir" (uses package deldir).

Value

a list with 3 components:

\(x, y\) If output="grid": vectors of \(x\)- and \(y\)-coordinates of output grid, the same as the input argument xo, or yo, if present. Otherwise, their default, a vector 40 points evenly spaced over the range of the input \(x\) and \(y\).
If output="points": vectors of \(x\)- and \(y\)-coordinates of output points as given by xo and yo.
z  If output="grid": matrix of fitted z-values. The value $z[i,j]$ is computed at
the point $(x_0[i], y_0[j])$. $z$ has dimensions $\text{length}(x_0) \times \text{length}(y_0)$.
If output="points": a vector with the calculated z values for the output points
as given by xo and yo.
If the input was a SpatialPointsDataFrame a SpatialPixelsDataFrame is
returned for output="grid" and a SpatialPointsDataFrame for output="points".

Author(s)
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References
Moebius, A. F. (1827) Der barymetrische Calcul. Verlag v. Johann Ambrosius Barth, Leipzig,
https://books.google.at/books?id=eFPluv_UqFEC&hl=de&pg=PR1#v=onepage&q&f=false

See Also
interpp

Examples
### Use all datasets from Franke, 1979:
data(franke)
for(i in 1:5)
  for(j in 1:3){
    FR <- franke.data(i,j,franke)
    IL <- with(FR, interp(x,y,z,method="linear"))
    image(IL)
    contour(IL,add=TRUE)
    with(FR,points(x,y))
  }
interpp

Pointwise interpolate irregular gridded data

Description
This function implements bivariate interpolation onto a set of points for irregularly spaced input
data.
This function is meant for backward compatibility to package akima, please use interp with its
output argument set to "points" now.
Usage

interpp(x, y = NULL, z, xo, yo = NULL, linear = TRUE, extrap = FALSE, duplicate = "error", dupfun = NULL, deltri = "shull")

Arguments

x vector of x-coordinates of data points or a SpatialPointsDataFrame object. Missing values are not accepted.
y vector of y-coordinates of data points. Missing values are not accepted. If left as NULL indicates that x should be a SpatialPointsDataFrame and z names the variable of interest in this dataframe.
z vector of z-coordinates of data points or a character variable naming the variable of interest in the SpatialPointsDataFrame x. Missing values are not accepted. x, y, and z must be the same length (except if x is a SpatialPointsDataFrame) and may contain no fewer than four points. The points of x and y cannot be collinear, i.e., they cannot fall on the same line (two vectors x and y such that y = ax + b for some a, b will not be accepted).
oxo vector of x-coordinates of points at which to evaluate the interpolating function. If x is a SpatialPointsDataFrame this has also to be a SpatialPointsDataFrame.
yo vector of y-coordinates of points at which to evaluate the interpolating function. If operating on SpatialPointsDataFrames this is left as NULL.
linear logical – indicating whether linear or spline interpolation should be used.
extrap logical flag: should extrapolation be used outside of the convex hull determined by the data points? Not possible for linear interpolation.
duplicate indicates how to handle duplicate data points. Possible values are "error" - produces an error message, "strip" - remove duplicate z values, "mean", "median", "user" - calculate mean, median or user defined function of duplicate z values.
dupfun this function is applied to duplicate points if duplicate="user"
deltri triangulation method used, this argument will later be moved into a control set together with others related to the spline interpolation!

Value

a list with 3 components:

x,y If output="grid": vectors of x- and y-coordinates of output grid, the same as the input argument xo, or yo, if present. Otherwise, their default, a vector 40 points evenly spaced over the range of the input x and y. If output="points": vectors of x- and y-coordinates of output points as given by xo and yo.

z If output="grid": matrix of fitted z-values. The value z[i,j] is computed at the point (xo[i], yo[j]). z has dimensions length(xo) times length(yo).
locpoly

Local polynomial fit.

Description

This function performs a local polynomial fit of up to order 3 to bivariate data. It returns estimated values of the regression function as well as estimated partial derivatives up to order 3.

Usage

locpoly(x, y, z, xo = seq(min(x), max(x), length = nx), yo = seq(min(y), max(y), length = ny), nx = 40, ny = 40, input = "points", output = "grid", h = 0, kernel = "uniform", solver = "QR", degree = 3, pd = "")
Arguments

x
vector of x-coordinates of data points.
Missing values are not accepted.

y
vector of y-coordinates of data points.
Missing values are not accepted.

z
vector of z-values at data points.
Missing values are not accepted.

x, y, and z must be the same length

xo
If output="grid" (default): sequence of x locations for rectangular output grid,
defaults to nx points between min(x) and max(x).
If output="points": vector of x locations for output points.

yo
If output="grid" (default): sequence of y locations for rectangular output grid,
defaults to ny points between min(y) and max(y).
If output="points": vector of y locations for output points. In this case it has
to be same length as xo.

input
text, possible values are "grid" (not yet implemented) and "points" (default).
This is used to distinguish between regular and irregular gridded data.

output
text, possible values are "grid" (=default) and "points".
If "grid" is chosen then xo and yo are interpreted as vectors spanning a rect-
grangular grid of points \((xo[i], yo[j]), i = 1, ..., nx, j = 1, ..., ny\). This default
behaviour matches how akima::interp works.
In the case of "points" xo and yo have to be of same length and are taken as
possibly irregular spaced output points \((xo[i], yo[i]), i = 1, ..., no\) with no=length(xo).

nx
dimension of output grid in x direction

ny
dimension of output grid in y direction

h
bandwidth parameter, between 0 and 1. If a scalar is given it is interpreted as
ratio applied to the dataset size to determine a local search neighbourhood, if set
to 0 a minimum useful search neighbourhood is chosen (e.g. 10 points for a
cubic trend function to determine all 10 parameters).
If a vector of length 2 is given both components are interpreted as ratio of the x-
and y-range and taken as global bandwidth.

kernel
Text value, implemented kernels are uniform (default), epanechnikov and gaussian.

solver
Text value, determines used solver in fastLM algorithm used by this code
Possible values are LLt, QR (default), SVD, Eigen and CPivQR (compare fastLm).

degree
Integer value, degree of polynomial trend, maximum allowed value is 3.

pd
Text value, determines which partial derivative should be returned, possible val-
ues are "" (default, the polynomial itself), "x", "y", "xx", "xy", "yy", "xxx", "xxy", "xyy", "yyy" or "all".
Value

If \( \text{pd} = \text{"all"} \):

- \( x \) \( x \) coordinates
- \( y \) \( y \) coordinates
- \( z \) estimates of \( z \)
- \( zx \) estimates of \( dz/dx \)
- \( zy \) estimates of \( dz/dy \)
- \( zxx \) estimates of \( d^2z/dx^2 \)
- \( zxy \) estimates of \( d^2z/dxdy \)
- \( zyy \) estimates of \( d^2z/dy^2 \)
- \( zxxx \) estimates of \( d^3z/dx^3 \)
- \( zxxy \) estimates of \( d^3z/dx^2dy \)
- \( zxyy \) estimates of \( d^3z/dxdy^2 \)
- \( zyyy \) estimates of \( d^3z/dy^3 \)

If \( \text{pd} = \text{"all"} \) only the elements \( x \), \( y \) and the desired derivative will be returned, e.g. \( zxy \) for \( \text{pd} = \text{"xy"} \).

Note

Function \text{locpoly} of package \text{KernSmooth} performs a similar task for univariate data.

Author(s)

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References


See Also

\text{locpoly}, \text{fastLm}

Examples

```r
## choose a kernel
knl <- "gaussian"

## choose global and local bandwidth
bwg <- 0.25 # *100% of x- y-range
bwl <- 0.1 # *100% of data set

## a bivariate polynomial of degree 5:
```
f <- function(x,y) 0.1+ 0.2*x-0.3*y+0.1*x*y+0.3*x^2*y-0.5*y^2*x+y^3*x^2+0.1*y^5
## degree of model
dg=3

## part 1:
## regular gridded data:
ng<- 21 # x/y size of a square data grid

## build and fill the grid with the theoretical values:
xg<seq(0,1,length=ng)
yg<-seq(0,1,length=ng)

# xg and yg as matrix matching fg
nx <- length(xg)
ny <- length(yg)
xx <- t(matrix(rep(xg,ny),nx,ny))
yy <- matrix(rep(yg,nx),ny,nx)

fg <- outer(xg,yg,f)

## local polynomial estimate
## global bw:
ttg <- system.time(pdg <- locpoly(xg,yg,fg,
                                 input="grid", pd="all", h=c(bwg,bwg), solver="QR", degree=dg, kernel=knl))
## time used:
ttg

## local bw:
ttl <- system.time(pdl <- locpoly(xg,yg,fg,
                                 input="grid", pd="all", h=bwl, solver="QR", degree=dg, kernel=knl))
## time used:
ttl

image(pdg$x,pdg$y,pdg$z)
contour(pdl$x,pdl$y,pdl$zx,add=TRUE,lty="dotted")
contour(pdl$x,pdl$y,pdl$zy,add=TRUE,lty="dashed")
points(xx,yy,pch=".")

## part 2:
## irregular data,
## results will not be as good as with the regular 21*21=231 points.

nd<- 41 # size of data set

## random regular data
oldseed <- set.seed(42)
x<-runif(ng)
y<-runif(ng)
set.seed(oldseed)
z <- f(x,y)

## global bw:
ttg <- system.time(pdg <- interp::locpoly(x,y,z, xg,yg, pd="all", h=c(bwg,bwg), solver="QR", degree=dg,kernel=knl))
ttg

## local bw:
ttl <- system.time(pdl <- interp::locpoly(x,y,z, xg,yg, pd="all", h=bwl, solver="QR", degree=dg,kernel=knl))
ttl

image(pdg$x,pdg$y,pdg$z)
contour(pdl$x,pdl$y,pdl$zx,add=TRUE,lty="dotted")
contour(pdl$x,pdl$y,pdl$zy,add=TRUE,lty="dashed")
points(x,y,pch=".")

---

nearest.neighbours  Nearest neighbour structure for a data set

Description

This function can be used to generate nearest neighbour information for a set of 2D data points.

Usage

nearest.neighbours(x, y)

Arguments

x  
vector containing x coordinates of points.

y  
vector containing x coordinates of points.

Details

The C++ implementation of this function is used inside the locpoly and interp functions.

Value

A list with two components

index  
A matrix with one row per data point. Each row contains the indices of the nearest neighbours to the point associated with this row, currently the point itself is also listed in the first row, so this matrix is of dimension n times n (will change to n times n − 1 later).

dist  
A matrix containing the distances according to the neighbours listed in component index.
Determines if a point is on or left of the vector described by two other points.

Description

A simple test function to determine the position of one (or more) points relative to a vector spanned by two points.

Usage

```r
on(x1, y1, x2, y2, x0, y0, eps = 1e-16)
left(x1, y1, x2, y2, x0, y0, eps = 1e-16)
```

Arguments

- `x1`: x coordinate of first point determining the vector.
- `y1`: y coordinate of first point determining the vector.
- `x2`: x coordinate of second point determining the vector.
- `y2`: y coordinate of second point determining the vector.
- `x0`: vector of x coordinates to locate relative to the vector \((x_2 - x_1, y_2 - y_1)\).
- `y0`: vector of x coordinates to locate relative to the vector \((x_2 - x_1, y_2 - y_1)\).
- `eps`: tolerance for checking if \(x_0, y_0\) is on or left of \((x_2 - x_1, y_2 - y_1)\), defaults to \(10^{-16}\).

Value

Logical vector with the results of the test.

Author(s)

Albrecht Gebhardt <albrecht.gebhardt@aau.at>, Roger Bivand <roger.bivand@nhh.no>
on.convex.hull

Determines if points are on or in the convex hull of a triangulation object

Description

Given a triangulation object `tri.obj` of `n` points in the plane, this subroutine returns a logical vector indicating if the points `(x_i, y_i)` lay on or in the convex hull of `tri.obj`.

Usage

```r
on.convex.hull(tri.obj, x, y, eps=1E-16)
in.convex.hull(tri.obj, x, y, eps=1E-16, strict=TRUE)
```

Arguments

- `tri.obj`: object of class `triShl`
- `x`: vector of `x`-coordinates of points to locate
- `y`: vector of `y`-coordinates of points to locate
- `eps`: accuracy for checking the condition
- `strict`: logical, default `TRUE`. It indicates if the convex hull is treated as an open (`strict=TRUE`) or closed (`strict=FALSE`) set. (applies only to `in.convex.hull`)

Value

Logical vector.

See Also

- `in.convex.hull`
- `on.convex.hull`

Examples

```r
y <- x <- c(0,1)
## should be TRUE
on(x[1], y[1], x[2], y[2], 0.5, 0.5)
## note the default setting of eps leading to
on(x[1], y[1], x[2], y[2], 0.5, 0.50000000000000001)
## also be TRUE

## should be TRUE
left(x[1], y[1], x[2], y[2], 0.5, 0.6)
## note the default setting of eps leading to
left(x[1], y[1], x[2], y[2], 0.5, 0.50000000000000001)
## already resulting to FALSE
```
Description

This version of outer evaluates FUN only on that part of the grid \( cx \) times \( cy \) that is enclosed within the convex hull of the points \( (px, py) \).

This can be useful for spatial estimation if no extrapolation is wanted.

Usage

outer.convhull(cx, cy, px, py, FUN, duplicate = "remove", ...)

Arguments

cx  
x coordinates of grid

cy  
y coordinates of grid

px  
vector of x coordinates of points

py  
vector of y coordinates of points

FUN  
function to be evaluated over the grid

duplicate  
indicates what to do with duplicate \((px, py)\) points, default "remove".

...  
additional arguments for FUN
Value

Matrix with values of FUN (NAs if outside the convex hull).

Author(s)

Albrecht Gebhardt <albrecht.gebhardt@aau.at>, Roger Bivand <roger.bivand@nhh.no>

See Also

in.convex.hull

Examples

```r
x<-runif(20)
y<-runif(20)
z<-runif(20)
z.lm<-lm(z~x+y)
f.pred<-function(x,y)
  {predict(z.lm,data.frame(x=as.vector(x),y=as.vector(y)))}
xg<-seq(0,1,0.05)
yg<-seq(0,1,0.05)
image(xg,yg,outer.convhull(xg,yg,x,y,f.pred))
points(x,y)
```

plot.triSht

Plot a triangulation object

Description

plots the triangulation object "x"

Usage

```r
## S3 method for class 'triSht'
plot(x, add = FALSE, xlim = range(x$x), ylim = range(x$y),
     do.points = TRUE, do.labels = FALSE, isometric = TRUE,
     do.circumcircles = FALSE, segment.lty = "dashed", circle.lty =
     "dotted", ...)
```

Arguments

- `x` object of class "triSht"
- `add` logical, if TRUE, add to a current plot.
- `do.points` logical, indicates if points should be plotted. (default TRUE)
- `do.labels` logical, indicates if points should be labelled. (default FALSE)
- `xlim, ylim` x/y ranges for plot
- `isometric` generate an isometric plot (default TRUE)
do.circumcircles  logical, indicates if circumcircles should be plotted (default FALSE)

segment.lty    line type for triangulation segments

circle.lty     line type for circumcircles

...             additional plot parameters

Value

None

Author(s)

Albrecht Gebhardt <albrecht.gebhardt@aau.at>, Roger Bivand <roger.bivand@nhh.no>

See Also

triSht, print.triSht, summary.triSht

Examples

## random points
plot(tri.mesh(rpois(100,lambda=20),rpois(100,lambda=20),duplicate="remove"))
## use a part of the quakes data set:
data(quakes)
quakes.part<-quakes[(quakes[,1]<=-10.78 & quakes[,1]>=-19.4 &
                      quakes[,2]<=182.29 & quakes[,2]>=165.77),]
quakes.tri<-tri.mesh(quakes.part$lon, quakes.part$lat, duplicate="remove")
plot(quakes.tri)
## use the whole quakes data set
## (will not work with standard memory settings, hence commented out)
## plot(tri.mesh(quakes$lon, quakes$lat, duplicate="remove"), do.points=F

---

**Description**

Plots the mosaic "x". Dashed lines are used for outer tiles of the mosaic.

**Usage**

```r
## S3 method for class 'voronoi'
plot(x, add=FALSE,
     xlim=c(min(x$tri$x)-0.1*diff(range(x$tri$x)),
            max(x$tri$x)+0.1*diff(range(x$tri$x))),
     ylim=c(min(x$tri$y)-0.1*diff(range(x$tri$y)),
            max(x$tri$y)+0.1*diff(range(x$tri$y))),
     ...)
```
plot.voronoi

0.1*diff(range(x$tri$y)),
max(x$tri$y)+
0.1*diff(range(x$tri$y)),
all=FALSE,
do.points=TRUE,
main="Voronoi mosaic",
sub=deparse(substitute(x)),
isometric=TRUE,
...)

Arguments

x object of class "voronoi"
add logical, if TRUE, add to a current plot.
xlim x plot ranges, by default modified to hide dummy points outside of the plot
ylim y plot ranges, by default modified to hide dummy points outside of the plot
all show all (including dummy points in the plot
do.points logical, indicates if points should be plotted.
main plot title
sub plot subtitle
isometric generate an isometric plot (default TRUE)
... additional plot parameters

Value

None

Author(s)

Albrecht Gebhardt <albrecht.gebhardt@aau.at>, Roger Bivand <roger.bivand@nhh.no>

See Also

tvoronoi, print.voronoi, summary.voronoi, plot.voronoi.polygons

Examples

data(franke)
tr <- tri.mesh(franke$ds3)
vr <- voronoi.mosaic(tr)
plot(tr)
plot(vr,add=TRUE)
plot.voronoi.polygons

plots an voronoi.polygons object

Description

plots an voronoi.polygons object

Usage

## S3 method for class 'voronoi.polygons'
plot(x, which, color=TRUE, isometric=TRUE, ...)

Arguments

x  
object of class voronoi.polygons

which  
index vector selecting which polygons to plot

color  
logical, determines if plot should be colored, default: TRUE

isometric  
generate an isometric plot (default TRUE)

...  
additional plot arguments

Author(s)

A. Gebhardt

See Also

voronoi.polygons

Examples

data(franke)
fd3 <- franke$ds3
fd3.vm <- voronoi.mosaic(fd3$x,fd3$y)
fd3.vp <- voronoi.polygons(fd3.vm)
plot(fd3.vp)
plot(fd3.vp,which=c(3,4,6,10))
print.summary.triSht  
Print a summary of a triangulation object

Description

Prints some information about tri.obj

Usage

## S3 method for class 'summary.triSht'
print(x, ...)

Arguments

x          object of class "summary.triSht", generated by summary.triSht.
...       additional parameters for print

Value

None

Note

This function is meant as replacement for the function of same name in package tripack.
The only difference is that no constraints are possible with triSht objects of package interp.

Author(s)

Albrecht Gebhardt <albrecht.gebhardt@aau.at>, Roger Bivand <roger.bivand@nhh.no>

See Also

triSht,tri.mesh,print.triSht,plot.triSht,summary.triSht.

print.summary.voronoi  
Print a summary of a voronoi object

Description

Prints some information about object x

Usage

## S3 method for class 'summary.voronoi'
print(x, ...)

---
print.triSht

Arguments

  x  object of class "summary.voronoi", generated by summary.voronoi.
  ... additional parameters for print

Value

  None

Note

  This function is meant as replacement for the function of same name in package tripack and should be fully backward compatible.

Author(s)

  Albrecht Gebhardt <albrecht.gebhardt@aau.at>, Roger Bivand <roger.bivand@nhh.no>

See Also

  voronoi, voronoi.mosaic, print.voronoi, plot.voronoi, summary.voronoi.

print.triSht  

\textit{Print a triangulation object}

Description

  prints a adjacency list of "x"

Usage

  \#
  \# S3 method for class 'triSht'
  print(x,...)

Arguments

  x  object of class "triSht"
  ... additional parameters for print

Value

  None

Author(s)

  Albrecht Gebhardt <albrecht.gebhardt@aau.at>, Roger Bivand <roger.bivand@nhh.no>

See Also

  triSht, plot.triSht, summary.triSht
print.voronoi  
*Print a voronoi object*

---

**Description**

prints a summary of "x"

**Usage**

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

**Arguments**

- `x`: object of class "voronoi"
- `...`: additional parameters for `print`

**Value**

None

**Author(s)**

Albrecht Gebhardt <albrecht.gebhardt@aau.at>, Roger Bivand <roger.bivand@nhh.no>

**See Also**

`voronoi`, `plot.voronoi`, `summary.voronoi`

---

summary.triSht  
*Return a summary of a triangulation object*

---

**Description**

Returns some information (number of nodes, triangles, arcs) about object.

**Usage**

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

**Arguments**

- `object`: object of class "triSht"
- `...`: additional parameters for `summary`


**Value**

An object of class "summary.triSht", to be printed by `print.summary.triSht`. It contains the number of nodes (n), of arcs (na), of boundary nodes (nb) and triangles (nt).

**Note**

This function is meant as replacement for the function of same name in package tripack. The only difference is that no constraints are possible with triSht objects of package interp.

**Author(s)**

Albrecht Gebhardt <albrecht.gebhardt@aau.at>, Roger Bivand <roger.bivand@nhh.no>

**See Also**

`triSht`, `print.triSht`, `plot.triSht`, `print.summary.triSht`.

---

**summary.voronoi**

*Return a summary of a voronoi object*

**Description**

Returns some information about object

**Usage**

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

**Arguments**

- `object` object of class "voronoi"
- `...` additional parameters for summary

**Value**

Object of class "summary.voronoi". It contains the number of nodes (nn) and dummy nodes (nd).

**Note**

This function is meant as replacement for the function of same name in package tripack and should be fully backward compatible.

**Author(s)**

Albrecht Gebhardt <albrecht.gebhardt@aau.at>, Roger Bivand <roger.bivand@nhh.no>
tri.find

Locate a point in a triangulation

Description

This subroutine locates a point \( P = (x, y) \) relative to a triangulation created by \texttt{tri.mesh}. If \( P \) is contained in a triangle, the three vertex indexes are returned. Otherwise, the indexes of the rightmost and leftmost visible boundary nodes are returned.

Usage

\texttt{tri.find(tri.obj,x,y)}

Arguments

\begin{itemize}
  \item \texttt{tri.obj} an triangulation object of class \texttt{triSht}
  \item \texttt{x} x-coordinate of the point
  \item \texttt{y} y-coordinate of the point
\end{itemize}

Value

A list with elements \texttt{i1, i2, i3} containing nodal indexes, in counterclockwise order, of the vertices of a triangle containing \( P = (x, y) \). \texttt{bc} contains the barycentric coordinates of \( P \) w.r.t. the found triangle.

If \( P \) is not contained in the convex hull of the nodes this indices are 0 (bc is meaningless then).

Author(s)

Albrecht Gebhardt \textless{}albrecht.gebhardt@aau.at\textgreater{}, Roger Bivand \textless{}roger.bivand@nhh.no\textgreater{}

See Also

\texttt{triSht, print.triSht, plot.triSht, summary.triSht, triangles, convex.hull}

Examples

\begin{verbatim}
data(franke)
tr<-tri.mesh(franke$ds3$x,franke$ds3$y)
plot(tr)
pnt<-list(x=0.3,y=0.4)
triangle.with.pnt<-tri.find(tr,pnt$x,pnt$y)
attach(triangle.with.pnt)
lines(franke$ds3$x[c(i1,i2,i3,i1)],franke$ds3$y[c(i1,i2,i3,i1)],col="red")
points(pnt$x,pnt$y)
\end{verbatim}
**tri.mesh**

**Delaunay triangulation**

**Description**

This function generates a Delaunay triangulation of arbitrarily distributed points in the plane. The resulting object can be printed or plotted, some additional functions can extract details from it like the list of triangles, arcs or the convex hull.

**Usage**

```r
tri.mesh(x, y = NULL, duplicate = "error")
```

**Arguments**

- **x**: vector containing \( x \) coordinates of the data. If \( y \) is missing \( x \) should be a list or dataframe with two components \( x \) and \( y \).
- **y**: vector containing \( y \) coordinates of the data. Can be omitted if \( x \) is a list with two components \( x \) and \( y \).
- **duplicate**: flag indicating how to handle duplicate elements. Possible values are:
  - "error" – default,
  - "strip" – remove all duplicate points,
  - "remove" – leave one point of the duplicate points.

**Details**

This function creates a Delaunay triangulation of a set of arbitrarily distributed points in the plane referred to as nodes.

The Delaunay triangulation is defined as a set of triangles with the following five properties:

1. The triangle vertices are nodes.
2. No triangle contains a node other than its vertices.
3. The interiors of the triangles are pairwise disjoint.
4. The union of triangles is the convex hull of the set of nodes (the smallest convex set which contains the nodes).
5. The interior of the circumcircle of each triangle contains no node.

The first four properties define a triangulation, and the last property results in a triangulation which is as close as possible to equiangular in a certain sense and which is uniquely defined unless four or more nodes lie on a common circle. This property makes the triangulation well-suited for solving closest point problems and for triangle-based interpolation.

This triangulation is based on the s-hull algorithm by David Sinclair. It consist of two steps:
1. Create an initial non-overlapping triangulation from the radially sorted nodes (w.r.t to an arbitrary first node). Starting from a first triangle built from the first node and its nearest neighbours this is done by adding triangles from the next node (in the sense of distance to the first node) to the hull of the actual triangulation visible from this node (sweep hull step).

2. Apply triangle flipping to each pair of triangles sharing a border until condition 5 holds (Cline-Renka test).

This algorithm has complexity $O(n \times \log(n))$.

Value

an object of class "triSht", see triSht.

Note

This function is meant as a replacement for tri.mesh from package tripack. Please note that the underlying algorithm changed from Renka’s method to Sinclair’s sweep hull method. Delaunay triangulations are unique if no four or more points exist which share the same circumcircle. Otherwise several solutions are available and different algorithms will give different results. This especially holds for regular grids, where in the case of rectangular gridded points each grid cell can be triangulated in two different ways.

The arguments are backward compatible, but the returned object is not compatible with package tripack (it provides a tri object type)! But you can apply methods with same names to the object returned in package interp which is of type triSht, so you can reuse your old code but you cannot reuse your old saved workspace.

Author(s)

Albrecht Gebhardt <albrecht.gebhardt@aau.at>, Roger Bivand <roger.bivand@nhh.no>

References


See Also

triSht, print.triSht, plot.triSht, summary.triSht, triangles, convex.hull, arcs.

Examples

```r
## use Frankes datasets:
data(franke)
tr1 <- tri.mesh(franke$ds3$x, franke$ds3$y)
tr1
tr2 <- tri.mesh(franke$ds2)
summary(tr2)
```
triangles

Extract a list of triangles from a triangulation object

Description
This function extracts a list of triangles from an triangulation object created by tri.mesh.

Usage
triangles(tri.obj)

Arguments
tri.obj object of class triSht

Details
The vertices in the returned matrix (let’s denote it with retval) are ordered counterclockwise. The columns \( \text{tr} \times \) and \( \text{arc} \times \), \( x = 1, 2, 3 \) index the triangle and arc, respectively, which are opposite (not shared by) node \( \text{node} \times \), with \( \text{tr} \times = 0 \) if \( \text{arc} \times \) indexes a boundary arc. Vertex indexes range from 1 to \( n \), the number of nodes, triangle indexes from 0 to \( nt \), and arc indexes from 1 to \( na = nt + n - 1 \).

Value
A matrix with columns \( \text{node}1 \), \( \text{node}2 \), \( \text{node}3 \), representing the vertex nodal indexes, \( \text{tr}1 \), \( \text{tr}2 \), \( \text{tr}3 \), representing neighboring triangle indexes and \( \text{arc}1 \), \( \text{arc}2 \), \( \text{arc}3 \) representing arc indexes.

Each row represents one triangle.

Author(s)
Albrecht Gebhardt <albrecht.gebhardt@aau.at>, Roger Bivand <roger.bivand@nhh.no>

See Also
triSht, print.triSht, plot.triSht, summary.triSht, triangles

Examples
# use the smallest Franke data set
data(franke)
fr3.tr <- tri.mesh(franke$ds3$x, franke$ds3$y)
triangles(fr3.tr)
triSht

A triangulation object

Description

R object that represents the triangulation of a set of 2D points, generated by `tri.mesh`.

Arguments

- **n**: Number of nodes
- **x**: x coordinates of the triangulation nodes
- **y**: y coordinates of the triangulation nodes
- **nt**: number of triangles
- **trlist**: Matrix of indices which defines the triangulation, each row corresponds to a triangle.
  - Columns i1, i2, i3 of the row i contain the node indices defining the i-th triangle.
  - Columns j1, j2, j3 of the row i contain the indices of neighbour triangles (or 0 if no neighbour available along the convex hull).
  - Columns k1, k2, k3 of the row i contain the indices of the arcs of the i-th triangle as returned by the `arcs` function.
- **cclist**: Matrix describing the circumcircles and triangles.
  - Columns x and y contain coordinates of the circumcircle centers, r is the circumcircle radius.
  - area is the triangle area and ratio is the ratio of the radius of the inscribed circle to the circumcircle radius. It takes it maximum value 0.5 for an equilateral triangle.
  - The radius of the inscribed circle can be get via \( r_i = \frac{r}{\text{ratio}} \).
- **nchull**: number of points on the convex hull
- **chull**: A vector containing the indices of nodes forming the convex hull (in counterclockwise ordering).
- **narcs**: number of arcs forming the triangulation
- **arcs**: A matrix with node indices describing the arcs, contains two columns from and to.
- **call**: call, which generated this object

Note

This object is not backward compatible with tri objects generated from package `tripack` but the functions and methods are! So you have to regenerate these objects and then you can continue to use the same calls as before.

The only difference is that no constraints to the triangulation are possible in package `interp`. 
Author(s)

Albrecht Gebhardt <albrecht.gebhardt@aau.at>, Roger Bivand <roger.bivand@nhh.no>

See Also

tri.mesh, print.triSht, plot.triSht, summary.triSht

<table>
<thead>
<tr>
<th>voronoi</th>
<th>Voronoi object</th>
</tr>
</thead>
</table>

Description

A voronoi object is created with voronoi.mosaic

Arguments

- **x, y**
  x and y coordinates of nodes of the voronoi mosaic. Each node is a circumcircle center of some triangle from the Delaunay triangulation.

- **node**
  logical vector, indicating real nodes of the voronoi mosaic. These nodes are the centers of circumcircles of triangles with positive area of the delaunay triangulation.
  If node[i]=FALSE, (c[i],x[i]) belongs to a triangle with area 0.

- **n1, n2, n3**
  indices of neighbour nodes. Negative indices indicate dummy points as neighbours.

- **tri**
  triangulation object, see triSht.

- **area**
  area of triangle i.

- **ratio**
  aspect ratio (inscribed radius/circumradius) of triangle i.

- **radius**
  circumradius of triangle i.

- **dummy.x, dummy.y**
  x and y coordinates of dummy points. They are used for plotting of unbounded tiles.

Note

This version of voronoi object is generated from the tri.mesh function from package interp. That's the only difference to voronoi objects generated with package tripack.

Author(s)

Albrecht Gebhardt <albrecht.gebhardt@aau.at>, Roger Bivand <roger.bivand@nhh.no>

See Also

voronoi.mosaic, plot.voronoi
Description

Computes the area of each Voronoi polygon. For some sites at the edge of the region, the Voronoi polygon is not bounded, and so the area of those sites cannot be calculated, and hence will be NA.

Usage

voronoi.area(voronoi.obj)

Arguments

voronoi.obj object of class "voronoi"

Value

A vector of polygon areas.

Author(s)

S. J. Eglen

See Also

voronoi.mosaic, voronoi.polygons.

Examples

data(franke)
fd3 <- franke$ds3
fd3.vm <- voronoi.mosaic(fd3$x,fd3$y)
f3.vm.areas <- voronoi.area(fd3.vm)
plot(fd3.vm)
text(fd3$x, fd3$y, round(fd3.vm.areas,5))
Find the Voronoi sites at the border of the region (to be rejected).

**Description**

Find the sites in the Voronoi tesselation that lie at the edge of the region. A site is at the edge if any of the vertices of its Voronoi polygon lie outside the rectangle with corners \((x_{\text{min}}, y_{\text{min}})\) and \((x_{\text{max}}, y_{\text{max}})\).

**Usage**

```r
voronoi.findrejectsites(voronoi.obj, xmin, xmax, ymin, ymax)
```

**Arguments**

- `voronoi.obj`: object of class "voronoi"
- `xmin`: minimum x-coordinate of sites in the region
- `xmax`: maximum x-coordinate of sites in the region
- `ymin`: minimum y-coordinate of sites in the region
- `ymax`: maximum y-coordinate of sites in the region

**Value**

A logical vector of the same length as the number of sites. If the site is a reject, the corresponding element of the vector is set to TRUE.

**Author(s)**

S. J. Eglen

**See Also**

- `voronoi.polygons`
Description

This function creates a Voronoi mosaic out of a given set of arbitrarily located points in the plane. Each cell of a voronoi mosaic is associated with a data point and contains all points \((x, y)\) closest to this data point.

Usage

```r
voronoi.mosaic(x, y = NULL, duplicate = "error")
```

Arguments

- **x**: vector containing \(x\) coordinates of the data. If \(y\) is missing \(x\) should be a list or dataframe with two components \(x\) and \(y\). \(x\) can also be an object of class `triSht` generated by `tri.mesh`. In this case the internal triangulation step can be skipped.
- **y**: vector containing \(y\) coordinates of the data. Can be omitted if \(x\) is a list with two components \(x\) and \(y\).
- **duplicate**: flag indicating how to handle duplicate elements. Possible values are:
  - "error" – default,
  - "strip" – remove all duplicate points,
  - "remove" – leave one point of the duplicate points.

Details

The function creates first a Delaunay triangulation (if not already given), extracts the circumcircle centers of these triangles, and then connects these points according to the neighbourhood relations between the triangles.

Value

An object of class `voronoi`.

Note

This function is meant as a replacement for `voronoi.mosaic` from package `tripack`. Please note that the underlying triangulation uses a different algorithm, see `tri.mesh`. Contrary to `tri.mesh` this should not affect the result for non unique triangulations e.g. on regular grids as the voronoi mosaic in this case will still be unique.

The arguments are backward compatible, even the returned object should be compatible with functions from package `tripack`.
**Author(s)**

Albrecht Gebhardt <albrecht.gebhardt@aau.at>, Roger Bivand <roger.bivand@nhh.no>

**References**


**See Also**

voronoi, voronoi.mosaic, print.voronoi, plot.voronoi

**Examples**

```r
data(franke)
f <- franke$ds3
vr <- voronoi.mosaic(f$x, f$y)
summary(vr)
```

---

**Description**

This function extracts polygons from a `voronoi.mosaic` object.

**Usage**

```r
voronoi.polygons(voronoi.obj)
```

**Arguments**

- `voronoi.obj`: object of class `voronoi.mosaic`

**Value**

Returns an object of class `voronoi.polygons` with unnamed list elements for each polygon. These list elements are matrices with columns `x` and `y`. Unbounded polygons along the border are represented by `NULL` instead of a matrix.

**Author(s)**

Denis White

**See Also**

plot.voronoi.polygons, voronoi.mosaic
Examples

data(franke)
fd3 <- franke$ds3
fd3.vm <- voronoi.mosaic(fd3$x,fd3$y)
fd3.vp <- voronoi.polygons(fd3.vm)
fd3.vp
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