Package ‘akima’

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Title Interpolation of Irregularly and Regularly Spaced Data
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Description Several cubic spline interpolation methods of H. Akima for irregular and regular gridded data are available through this package, both for the bivariate case (irregular data: ACM 761, regular data: ACM 760) and univariate case (ACM 433 and ACM 697). Linear interpolation of irregular gridded data is also covered by reusing D. J. Renkas triangulation code which is part of Akimas Fortran code. A bilinear interpolator for regular grids was also added for comparison with the bicubic interpolator on regular grids.
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Enhances tripack
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akima

Waveform Distortion Data for Bivariate Interpolation

Description

akima is a list with components x, y and z which represents a smooth surface of z values at selected points irregularly distributed in the x-y plane.

The data was taken from a study of waveform distortion in electronic circuits, described in: Hiroshi Akima, "A Method of Bivariate Interpolation and Smooth Surface Fitting Based on Local Procedures", CACM, Vol. 17, No. 1, January 1974, pp. 18-20.

References


Examples

```r
## Not run:
library(rgl)
data(akima)
# data
rgl.spheres(akima$x, akima$z, akima$y, 0.5, color="red")
rgl.bbox()
# bivariate linear interpolation
# interp:
akima.li <- interp(akima$x, akima$y, akima$z,
  xo=seq(min(akima$x), max(akima$x), length = 100),
  yo=seq(min(akima$y), max(akima$y), length = 100))
# interp surface:
rgl.surface(akima.li$x, akima.li$y, akima.li$z, color="green", alpha=c(0.5))
# interpp:
akima.p <- interpp(akima$x, akima$y, akima$z,
  runif(200, min(akima$x), max(akima$x)),
```
akima760

Sample data from Akima’s Bicubic Spline Interpolation code (TOMS 760)

Description

akima760 is a list with vector components x, y and a matrix z which represents a smooth surface of z values at the points of a regular grid spanned by the vectors x and y.

References

Hiroshi Akima, “


Examples

## Not run:
library(rgl)
data(akima)
# data
rgl.spheres(akima760$x, akima760$z, akima760$y, 0.5, color="red")
rgl.bbox()
# bivariate linear interpolation
# interp:
akima.li <- interp(akima$x, akima$y, akima$z,
                   xo=seq(min(akima$x), max(akima$x), length = 100),
                   yo=seq(min(akima$y), max(akima$y), length = 100))

# interp surface:
rgl.surface(akima.li$x,akima.li$y,akima.li$z,color="green",alpha=c(0.5))

# interpp:
akima.p <- interpp(akima$x, akima$y, akima$z,
                    runif(200,min(akima$x),max(akima$x)),
                    runif(200,min(akima$y),max(akima$y)))

# interpp points:
rgl.points(akima.p$x,akima.p$z , akima.p$y,size=4,color="yellow")

# bivariate spline interpolation
# data
rgl.spheres(akima$x,akima$z , akima$y,0.5,color="red")
rgl.bbox()

# bivariate cubic spline interpolation
# interp:
akima.si <- interp(akima$x, akima$y, akima$z,
                   xo=seq(min(akima$x), max(akima$x), length = 100),
                   yo=seq(min(akima$y), max(akima$y), length = 100),
                   linear = FALSE, extrap = TRUE)

# interp surface:
rgl.surface(akima.si$x,akima.si$y,akima.si$z,color="green",alpha=c(0.5))

# interpp:
akima.sp <- interpp(akima$x, akima$y, akima$z,
                     runif(200,min(akima$x),max(akima$x)),
                     runif(200,min(akima$y),max(akima$y)),
                     linear = FALSE, extrap = TRUE)

# interpp points:
rgl.points(akima.sp$x,akima.sp$z , akima.sp$y,size=4,color="yellow")

## End(Not run)

---

**aspline**

*Univariate Akima interpolation*

---

**Description**

The function returns a list of points which smoothly interpolate given data points, similar to a curve drawn by hand.

**Usage**

```R
aspline(x, y=NULL, xout, n = 50, ties = mean, method="original", degree=3)
```
Arguments

x, y  vectors giving the coordinates of the points to be interpolated. Alternatively a single plotting structure can be specified: see xy.coords.

xout  an optional set of values specifying where interpolation is to take place.
n  If xout is not specified, interpolation takes place at n equally spaced points spanning the interval [min(x), max(x)].
ties  Handling of tied x values. Either a function with a single vector argument returning a single number result or the string "ordered".
method  either "original" method after Akima (1970) or "improved" method after Akima (1991)
degree  if improved algorithm is selected: degree of the polynomials for the interpolating function

Details

The original algorithm is based on a piecewise function composed of a set of polynomials, each of degree three, at most, and applicable to successive interval of the given points. In this method, the slope of the curve is determined at each given point locally, and each polynomial representing a portion of the curve between a pair of given points is determined by the coordinates of and the slopes at the points.

Value

A list with components x and y, containing n coordinates which interpolate the given data points.

References


See Also

approx, spline

Examples

## regular spaced data
x <- 1:10
y <- c(rnorm(5), c(1,1,1,1,3))
xnew <- seq(-1, 11, 0.1)
plot(x, y, ylim=c(-3, 3), xlim=range(xnew))
lines(spline(x, y, xmin=min(xnew), xmax=max(xnew), n=200), col="blue")
lines(aspline(x, y, xnew), col="red")
lines(aspline(x, y, xnew, method="improved"), col="black", lty="dotted")
bicubic

Bivariate Interpolation for Data on a Rectangular grid

Description

The description in the Fortran code says:

This subroutine performs interpolation of a bivariate function, z(x,y), on a rectangular grid in the x-y plane. It is based on the revised Akima method.

In this subroutine, the interpolating function is a piecewise function composed of a set of bicubic (bivariate third-degree) polynomials, each applicable to a rectangle of the input grid in the x-y plane. Each polynomial is determined locally.

This subroutine has the accuracy of a bicubic polynomial, i.e., it interpolates accurately when all data points lie on a surface of a bicubic polynomial.

The grid lines can be unevenly spaced.

Usage

bicubic(x, y, z, x0, y0)
Arguments

- **x**: a vector containing the x coordinates of the rectangular data grid.
- **y**: a vector containing the y coordinates of the rectangular data grid.
- **z**: a matrix containing the \( z_{i,j} \) data values for the grid points \((x[i], y[j])\).
- **x0**: vector of x coordinates used to interpolate at.
- **y0**: vector of y coordinates used to interpolate at.

Details

This function is a R interface to Akima’s Rectangular-Grid-Data Fitting algorithm (TOMS 760). The algorithm has the accuracy of a bicubic (bivariate third-degree) polynomial.

Value

This function produces a list of interpolated points:

- **x**: vector of x coordinates.
- **y**: vector of y coordinates.
- **z**: vector of interpolated data \( z \).

If you need an output grid, see `bicubic.grid`.

Note

Use `interp` for the general case of irregular gridded data!

References


See Also

`interp, bicubic.grid`

Examples

data(akima760)

# interpolate at the diagonal of the grid [0,8]x[0,10]
akima.bic <- cubic(akima760$x, akima760$y, akima760$z,
  seq(0,8,length=50), seq(0,10,length=50))

plot(sqrt(akima.bic$x^2+akima.bic$y^2), akima.bic$z, type="l")
bicubic.grid

Bicubic Interpolation for Data on a Rectangular Grid

Description

The description in the Fortran code says:

This subroutine performs interpolation of a bivariate function, \( z(x,y) \), on a rectangular grid in the \( x\)-\( y \) plane. It is based on the revised Akima method.

In this subroutine, the interpolating function is a piecewise function composed of a set of bicubic (bivariate third-degree) polynomials, each applicable to a rectangle of the input grid in the \( x\)-\( y \) plane. Each polynomial is determined locally.

This subroutine has the accuracy of a bicubic polynomial, i.e., it interpolates accurately when all data points lie on a surface of a bicubic polynomial.

The grid lines can be unevenly spaced.

Usage

\[
\text{bicubic.grid}(x,y,z,\text{xlim}=c(\text{min}(x),\text{max}(x)),\text{ylim}=c(\text{min}(y),\text{max}(y)),
\text{nx}=40,\text{ny}=40,\text{dx}=\text{NULL},\text{dy}=\text{NULL})
\]

Arguments

- **x**
  - a vector containing the \( x \) coordinates of the rectangular data grid.
- **y**
  - a vector containing the \( y \) coordinates of the rectangular data grid.
- **z**
  - a matrix containing the \( z[i,j] \) data values for the grid points \((x[i],y[j])\).
- **xlim**
  - vector of length 2 giving lower and upper limit for range \( x \) coordinates used for output grid.
- **ylim**
  - vector of length 2 giving lower and upper limit for range of \( y \) coordinates used for output grid.
- **nx**
  - output grid dimension in \( x \) direction.
- **ny**
  - output grid dimension in \( y \) direction.
- **dx**
  - output grid spacing in \( x \) direction, not used by default, overrides \( nx \) if specified.
- **dy**
  - output grid spacing in \( y \) direction, not used by default, overrides \( ny \) if specified.

Details

This function is an R interface to Akima’s Rectangular-Grid-Data Fitting algorithm (TOMS 760). The algorithm has the accuracy of a bicubic (bivariate third-degree) polynomial.
This function produces a grid of interpolated points, feasible to be used directly with `image` and `contour`:

- **x**: vector of x coordinates of the output grid.
- **y**: vector of y coordinates of the output grid.
- **z**: matrix of interpolated data for the output grid.

**Note**

Use `interp` for the general case of irregular gridded data!

**References**


**See Also**

`interp, bicubic`

**Examples**

```r
data(akima760)
# interpolate at a grid [0,8]x[0,10]
akima.bic <- bicubic.grid(akima760$x, akima760$y,akima760$z)
zmin <- min(akima.bic$z, na.rm=TRUE)
zmax <- max(akima.bic$z, na.rm=TRUE)
breaks <- pretty(c(zmin, zmax), 10)
colors <- heat.colors(length(breaks)-1)
image(akima.bic, breaks=breaks, col=colors)
contour(akima.bic, levels=breaks, add=TRUE)
```

**Description**

This is an implementation of a bilinear interpolating function. For a point (x0,y0) contained in a rectangle (x1,y1),(x2,y1), (x2,y2),(x1,y2) and x1<x2, y1<y2, the first step is to get z() at locations (x0,y1) and (x0,y2) as convex linear combinations z(x0,y*)=a*z(x1,y*)+(1-a)*z(x2,y*) where a=(x2-x1)/(x0-x1) for y*=y1,y2. In a second step z(x0,y0) is calculated as convex linear combination between z(x0,y1) and z(x0,y2) as z(x0,y1)=b*z(x0,y1)+(1-b)*z(x0,y2) where b=(y2-y1)/(y0-y1).

Finally, z(x0,y0) is a convex linear combination of the z values at the corners of the containing rectangle with weights according to the distance from (x0,y0) to these corners.

The grid lines can be unevenly spaced.
Usage

\texttt{bilinear(x, y, z, x0, y0)}

Arguments

\texttt{x} \quad \text{a vector containing the } x \text{ coordinates of the rectangular data grid.}
\texttt{y} \quad \text{a vector containing the } y \text{ coordinates of the rectangular data grid.}
\texttt{z} \quad \text{a matrix containing the } z[i,j] \text{ data values for the grid points } (x[i],y[j]).
\texttt{x0} \quad \text{vector of } x \text{ coordinates used to interpolate at.}
\texttt{y0} \quad \text{vector of } y \text{ coordinates used to interpolate at.}

Value

This function produces a list of interpolated points:

\texttt{x} \quad \text{vector of } x \text{ coordinates.}
\texttt{y} \quad \text{vector of } y \text{ coordinates.}
\texttt{z} \quad \text{vector of interpolated data } z.

If you need an output grid, see \texttt{bilinear.grid}.

Note

Use \texttt{interpp} for the general case of irregular gridded data!

References


See Also

\texttt{interp, bilinear.grid, bicubic.grid}

Examples

data(akima760)
# interpolate at the diagonal of the grid [0,8]x[0,10]
akima.bil <- bilinear(akima760$x, akima760$y, akima760$z, 
seq(0,8,length=50), seq(0,10,length=50))
plot(sqrt(akima.bil$x^2+akima.bil$y^2), akima.bil$z, type="l")
bilinear.grid

Bilinear Interpolation for Data on a Rectangular Grid

Description

This is an implementation of a bilinear interpolating function.

For a point \((x_0,y_0)\) contained in a rectangle \((x_1,y_1),(x_2,y_1),(x_2,y_2),(x_1,y_2)\) and \(x_1<x_2, y_1<y_2\), the first step is to get \(z()\) at locations \((x_0,y_1)\) and \((x_0,y_2)\) as convex linear combinations \(z(x_0,y^*)=a*z(x_1,y^*)+(1-a)*z(x_2,y^*)\) where \(a=(x_2-x_1)/(x_0-x_1)\) for \(y^*=y_1,y_2\). In a second step \(z(x_0,y_0)\) is calculated as convex linear combination between \(z(x_0,y_1)\) and \(z(x_0,y_2)\) as \(z(x_0,y_1)=b*z(x_0,y_1)+(1-b)*z(x_0,y_2)\) where \(b=(y_2-y_1)/(y_0-y_1)\).

Finally, \(z(x_0,y_0)\) is a convex linear combination of the \(z\) values at the corners of the containing rectangle with weights according to the distance from \((x_0,y_0)\) to these corners.

The grid lines can be unevenly spaced.

Usage

\[
bilinear.grid(x,y,z,xlim=c(\text{min}(x),\text{max}(x)),ylim=c(\text{min}(y),\text{max}(y)),\ nx=40,ny=40,dx=NULL,dy=NULL)\]

Arguments

- \(x\) a vector containing the \(x\) coordinates of the rectangular data grid.
- \(y\) a vector containing the \(y\) coordinates of the rectangular data grid.
- \(z\) a matrix containing the \(z[i,j]\) data values for the grid points \((x[i],y[j])\).
- \(xlim\) vector of length 2 giving lower and upper limit for range \(x\) coordinates used for output grid.
- \(ylim\) vector of length 2 giving lower and upper limit for range of \(y\) coordinates used for output grid.
- \(nx\) output grid dimension in \(x\) direction.
- \(ny\) output grid dimension in \(y\) direction.
- \(dx\) output grid spacing in \(x\) direction, not used by default, overrides \(nx\) if specified.
- \(dy\) output grid spacing in \(y\) direction, not used by default, overrides \(ny\) if specified.

Value

This function produces a grid of interpolated points, feasible to be used directly with \texttt{image} and \texttt{contour}:

- \(x\) vector of \(x\) coordinates of the output grid.
- \(y\) vector of \(y\) coordinates of the output grid.
- \(z\) matrix of interpolated data for the output grid.
Francesca data

**Note**

Use *interp* for the general case of irregular gridded data!

**References**


**See Also**

*interp, bicubic*

**Examples**

```r
data(akima760)
# interpolate at a grid [0,8]x[0,10]
akima.bil <- bilinear.grid(akima760$x, akima760$y, akima760$z)
zmin <- min(akima.bil$z, na.rm=TRUE)
zmax <- max(akima.bil$z, na.rm=TRUE)
breaks <- pretty(c(zmin, zmax), 10)
colors <- heat.colors(length(breaks)-1)
image(akima.bil, breaks=breaks, col=colors)
contour(akima.bil, levels=breaks, add=TRUE)
```

---

**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 testbed for the irregular scattered data interpolator. Franke used the five functions:

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

\[
\frac{1.25 + \cos(5.4y)}{6(1 + (3x - 1)^2)}
\]

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

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

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

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 out of [Akima 1996].

Author(s)

A. Gebhardt,
References


See Also

interp

Examples

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

interp

Gridded Bivariate Interpolation for Irregular Data

Description

These functions implement bivariate interpolation onto a grid for irregularly spaced input data. Bilinear or bicubic spline interpolation is applied using different versions of algorithms from Akima.

Usage

```r
interp(x, y=NULL, z, xo=seq(min(x), max(x), length = nx),
yo=seq(min(y), max(y), length = ny),
linear = TRUE, extrap=FALSE, duplicate = "error", dupfun = NULL,
nx = 40, ny = 40,
jitter = 10^-12, jitter.iter = 6, jitter.random = FALSE,
remove = !linear)
```

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` 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). Some heuristics is built in to avoid this case by adding small jitter to \( x \) and \( y \) when the number of NA values in the result exceeds 10%.

\texttt{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 \texttt{outer()}.

- **\( xo \)**: vector of \( x \)-coordinates of output grid. The default is 40 points evenly spaced over the range of \( x \). If extrapolation is not being used (\texttt{extrap=FALSE}, the default), \( xo \) should have a range that is close to or inside of the range of \( x \) for the results to be meaningful.

- **\( yo \)**: vector of \( y \)-coordinates of output grid; analogous to \( xo \), see above.

- **\( linear \)**: 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?

- **\( duplicate \)**: 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 \( (\text{dupfun}) \) 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

- **\( jitter \)**: Jitter of amount of \( \text{diff} \text{range}(XX))*\text{jitter} \) \( (XX=x \text{ or } y) \) will be added to coordinates if collinear points are detected. Afterwards interpolation will be tried once again.

  Note that the jitter is not generated randomly unless \texttt{jitter.random} is set to TRUE. This ensures reproducible result. \texttt{tri.mesh} of package \texttt{tripack} uses the same jitter mechanism. That means you can plot the triangulation on top of the interpolation and see the same triangulation as used for interpolation, see examples below.

- **\( jitter.iter \)**: number of iterations to retry with jitter, amount will be multiplied in each iteration by \( \text{iter}^{1.5} \)

- **\( jitter.random \)**: logical, see \texttt{jitter}, defaults to FALSE

- **\( remove \)**: logical, indicates whether Akimas removal of thin triangles along the border of the convex hull should be performed, experimental setting! defaults to !\texttt{linear}, so it will be left out for linear interpolation by default. For some point configurations it is the only available option to skip this removal step.

**Details**

If \texttt{linear} is TRUE (default), linear interpolation is used in the triangles bounded by data points. Cubic interpolation is done if \texttt{linear} is set to FALSE. If \texttt{extrap} is FALSE, \( z \)-values for points outside the convex hull are returned as NA. No extrapolation can be performed for the linear case.
The `interp` function handles duplicate \((x, y)\) points in different ways. As default it will stop with an error message. But it can give duplicate points an unique \(z\) value according to the parameter `duplicate` (mean, median or any other user defined function).

The triangulation scheme used by `interp` works well if \(x\) and \(y\) have similar scales but will appear stretched if they have very different scales. The spreads of \(x\) and \(y\) must be within four orders of magnitude of each other for `interp` to work.

**Value**

list with 3 components:

- \(x, y\) vectors of \(x\)- and \(y\)- coordinates of output grid, the same as the input argument \(x_0\), or \(y_0\), if present. Otherwise, their default, a vector 40 points evenly spaced over the range of the input \(x\).

- \(z\) matrix of fitted \(z\)-values. The value \(z[i,j]\) is computed at the \(x, y\) point \(x_0[i]\), \(y_0[j]\). \(z\) has dimensions length(\(x_0\)) times length(\(y_0\)).

If input is a `SpatialPointsDataFrame` a `SpatialPixelsDataFrame` is returned.

**Note**

`interp` uses Akimas new Fortran code (ACM 761) from 1996 in the revised version by Renka from 1998 for spline interpolation, the triangulation (based on Renkas tripack) is reused for linear interpolation. In this newer version Akima switched from his own triangulation to Renkas tripack (ACM 751).

Note that earlier versions (up to version 0.5-12) as well as S-Plus used the old Fortran code from Akima 1978 (ACM 526).

The resulting structure is suitable for input to the functions `contour` and `image`. Check the requirements of these functions when choosing values for \(x_0\) and \(y_0\).

**References**


**See Also**

`contour, image, approx, spline, aspline, outer, expand.grid`, link{franke.data}. 
Examples

data(akima)
plot(y ~ x, data = akima, main = "akima example data")
with(akima, text(x, y, formatC(z, dig = 2), adj = -0.1))

## linear interpolation
akima.li <- interp(akima$x, akima$y, akima$z)
li.zmin <- min(akima.li$z, na.rm = TRUE)
li.zmax <- max(akima.li$z, na.rm = TRUE)
breaks <- pretty(c(li.zmin, li.zmax), 10)
colors <- heat.colors(length(breaks) - 1)
with(akima.li, image(x, y, z, breaks = breaks, col = colors))
with(akima.li, contour(x, y, z, levels = breaks, add = TRUE))
points(akima, pch = 3)

## increase smoothness (using finer grid):
akima.smooth <-
  with(akima, interp(x, y, z, nx = 100, ny = 100))
si.zmin <- min(akima.smooth$z, na.rm = TRUE)
si.zmax <- max(akima.smooth$z, na.rm = TRUE)
breaks <- pretty(c(si.zmin, si.zmax), 10)
colors <- heat.colors(length(breaks) - 1)
image(akima.smooth, main = "interp(<akima data>, *) on finer grid",
  breaks = breaks, col = colors)
contour(akima.smooth, add = TRUE, levels = breaks, col = "thistle")
points(akima, pch = 3, cex = 2, col = "blue")

## use triangulation package to show underlying triangulation:
## Not run:
if(library(tripack, logical.return = TRUE))
  plot(tri.mesh(akima), add = TRUE, lty = "dashed")
## End(Not run)

## use only 15 points (interpolation only within convex hull!)
akima.part <- with(akima, interp(x[1:15], y[1:15], z[1:15]))
p.zmin <- min(akima.part$z, na.rm = TRUE)
p.zmax <- max(akima.part$z, na.rm = TRUE)
breaks <- pretty(c(p.zmin, p.zmax), 10)
colors <- heat.colors(length(breaks) - 1)
image(akima.part, breaks = breaks, col = colors)
title("interp() on subset of only 15 points")
contour(akima.part, levels = breaks, add = TRUE)
points(akima$x[1:15], akima$y[1:15], col = "blue")

## spline interpolation
akima.spl <- with(akima, interp(x, y, z, nx = 100, ny = 100, linear = FALSE))
contour(akima.spl, main = "smooth interp(*, linear = FALSE")
points(akima)
full.pal <- function(n) hcl(h = seq(340, 20, length = n))
cool.pal <- function(n) hcl(h = seq(120, 0, length = n) + 150)
warm.pal <- function(n) hcl(h = seq(120, 0, length = n) - 30)

filled.contour(akima.spl, color.palette = full.pal,
plot.axes = { axis(1); axis(2);
    title("smooth interp(*, linear = FALSE)";
    points(akima, pch = 3, col = hcl(c = 100, l = 20)))})

## no extrapolation!
## Not run:
## interp can handle spatial point dataframes created by the sp package:
library(sp)
data(meuse)
coordinates(meuse) <- ~x+y
## argument z has to be named, y has to be omitted!
z <- interp(meuse, z = "zinc", nx = 100, ny = 150)
spplot(z, "zinc")
z <- interp(meuse, z = "zinc", nx = 100, ny = 150, linear = FALSE)
spplot(z, "zinc")

## End(Not run)

## Not run:
### An example demonstrating the problems that occur for rectangular
### gridded data.
###
### require(tripack)
### Create irregularly spaced sample data on even values of x and y
### (the "14" makes it irregular spacing).
x <- c(seq(2, 10, 2), 14)
nx <- length(x)
y <- c(seq(2, 10, 2), 14)
ny <- length(y)
nxy <- nx*ny
xy <- expand.grid(x, y)
colnames(xy) <- c("x", "y")
### prepare a dataframe for interp
df <- cbind(xy, z = rnorm(nxy))
### and a matrix for bicubic and bilinear
z <- matrix(df$z, nx, ny)

old.par <- par(mfrow = c(2, 2))
### First: bicubic spline interpolation:
### This is Akimas bicubic spline implementation for regular gridded
### data:
iRbic <- bicubic.grid(x, y, z, nx = 250, ny = 250)
### Note that this interpolation tends to extreme values in large cells.
### Therefore zmin and zmax are taken from here to generate the same
### color scheme for the next plots.
zmin <- min(iRbic$z, na.rm = TRUE)
zmax <- max(iRbic$z, na.rm = TRUE)
breaks <- pretty(c(zmin, zmax), 10)
colors <- heat.colors(length(breaks)-1)
image(iRbic,breaks=breaks,col = colors)
contour(iRbic,col="black",levels=breaks,add=TRUE)
points(xy$x,xy$y)
title(main="bicubic interpolation",
 xlab="bcubic.grid(...)",
 sub="Akimas regular grid version, ACM 760")

### Now Akima splines with accuracy of bicubic polynomial
### for irregular gridded data:
iRspl <- with(df,interp(x,y,z,linear=FALSE,nx=250,ny=250))
### Note that the triangulation is created by adding small amounts
### of jitter to the coordinates, resulting in an unique triangulation.
### This jitter is not randomly choosen to get reproducable results.
### tri.mesh() from package tripack uses the same code and so produces the
### same triangulation.
image(iRspl,breaks=breaks,col = colors)
contour(iRspl,col="black",levels=breaks,add=TRUE)
plot(tri.mesh(xy$x,xy$y),col="white",add=TRUE)
title(main="bicubic* interpolation",
 xlab="interp(...,linear=FALSE)",
 ylab="*: accuracy of bicubic polynomial"
 sub="Akimas irregular grid version, ACM 761")

### Just for comparison an implementation of bilinear interpolation,
### only applicable to regular gridded data:
iRbil <- bilinear.grid(x,y,z,nx=250,ny=250)
### Note the lack of differentiability at grid cell borders.
image(iRbil,breaks=breaks,col = colors)
contour(iRbil,col="black",levels=breaks,add=TRUE)
points(xy$x,xy$y)
title(main="bilinear interpolation",
 xlab="bilinear.grid(...)",
 sub="only works for regular grid")

### Linear interpolation using the same triangulation as
### Akima bicubic splines for irregular gridded data.
iRlin <- with(df,interp(x,y,z,linear=TRUE,nx=250,ny=250))
### Note how the triangulation influences the interpolation.
### For this rectangular gridded dataset the triangulation
### in each rectangle is arbitrarily choosen from two possible
### solutions, hence the interpolation would change drastically
### when the triangulation changes. For this reason interp()
### is not meant for regular (rectangular) gridded data!
image(iRlin,breaks=breaks,col = colors)
contour(iRlin,col="black",levels=breaks,add=TRUE)
plot(tri.mesh(xy$x,xy$y),col="white",add=TRUE)
title(main="linear interpolation",
 xlab="interp(...,linear=TRUE)",
 sub="same triangulation as Akima irregular grid")

### And now four times Akima 761 with random jitter for
### triangulation correction, note that now interp() and tri.mesh()
### need the same random seed to produce identical triangulations!

```r
for(i in 1:4){
  set.seed(42+i)
  iRspl <- with(df,interp(x,y,z,linear=FALSE,nx=250,ny=250,jitter.random=TRUE))
  image(iRspl,breaks=breaks,col = colors)
  contour(iRspl,col="black",levels=breaks,add=TRUE)
  set.seed(42+i)
  plot(tri.mesh(xy$x,xy$y,jitter.random=TRUE),col="white",add=TRUE)
  title(main="bicubic interpolation",
       xlab="interp(...,linear=FALSE)",
       ylab="random jitter added",
       sub="Akimas irregular grid version, ACM 761")
}
par(old.par)
```

## End(Not run)

### Use all datasets from Franke, 1979:

```r
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,linear=FALSE))
    image(IL)
    contour(IL,add=TRUE)
    with(FR,points(x,y))
  }
```

---

**interp.old**

**Gridded Bivariate Interpolation for Irregular Data**

**Description**

These functions implement bivariate interpolation onto a grid for irregularly spaced input data. These functions are only for backward compatibility, use `interp` instead.

**Usage**

```r
interp.old(x, y, z, xo = seq(min(x), max(x), length = 40),
          yo=seq(min(y), max(y), length = 40), ncp = 0,
          extrapol=FALSE, duplicate = "error", dupfun = NULL)
interp.new(x, y, z, xo = seq(min(x), max(x), length = 40),
          yo = seq(min(y), max(y), length = 40), linear = FALSE,
          ncp = NULL, extrapol=FALSE, duplicate = "error", dupfun = NULL)
```

**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). 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 vector of x-coordinates of output grid. The default is 40 points evenly spaced over the range of x. If extrapolation is not being used (extrap=FALSE, the default), xo should have a range that is close to or inside of the range of x for the results to be meaningful.

yo vector of y-coordinates of output grid; analogous to xo, see above.

linear logical – indicating whether linear or spline interpolation should be used. supercedes old ncp parameter

ncp deprecated, use parameter linear. Now only used by interp.old().
old meaning was: number of additional points to be used in computing partial derivatives at each data point. ncp must be either 0 (partial derivatives are not used), or at least 2 but smaller than the number of data points (and smaller than 25).

extrap logical flag: should extrapolation be used outside of the convex hull determined by the data points?

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".

Details see interp

Value list with 3 components:

x,y 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.
z matrix of fitted z-values. The value z[i,j] is computed at the x,y point xo[i], yo[j]. z has dimensions length(xo) times length(yo).

If input is a SpatialPointsDataFrame a SpatialPixelssDataFrame is returned.

Note

interp.new is deprecated and interp.old will soon be deprecated.

References


See Also

ccontour, image, approx, spline, aspline, outer, expand.grid.

interp2xyz

From interp() Result, Produce 3-column Matrix

Description

From an interp() result, produce a 3-column matrix or data.frame cbind(x, y, z).

Usage

interp2xyz(al, data.frame = FALSE)

Arguments

al a list as produced from interp().

data.frame logical indicating if result should be data.frame or matrix (default).

Value

a matrix (or data.frame) with three columns, called "x", "y", "z".

Author(s)

Martin Maechler, Jan.18, 2013

See Also

cexpand.grid() is the “essential ingredient” of interp2xyz().
c interp.
Examples

data(akima)
ak.spl <- with(akima, interp(x, y, z, linear = FALSE,
xo= seq(0,25, length=100),
    yo= seq(0,20, length= 96)))
str(ak.spl)# list (x[i], y[j], z = <matrix>[i,j])

## Now transform to simple (x,y,z) matrix / data.frame :
str(am <- interp2xyz(ak.spl))
str(ad <- interp2xyz(ak.spl, data.frame=TRUE))  
## and they are the same:
stopifnot( am == ad | (is.na(am) & is.na(ad)) )

interpp  
Pointwise Bivariate Interpolation for Irregular Data

Description

These functions implement bivariate interpolation onto a set of points for irregularly spaced input data. These functions are only for backward compatibility, use interpp instead.

If linear is code{TRUE}, linear interpolation is used in the triangles bounded by data points, otherwise cubic interpolation is done.

If extrap is FALSE, z-values for points outside the convex hull are returned as NA. No extrapolation can be performed for linear interpolation.

The interpp function handles duplicate (x,y) points in different ways. As default it will stop with an error message. But it can give duplicate points an unique z value according to the parameter duplicate (mean, median or any other user defined function).

The triangulation scheme used by interp works well if x and y have similar scales but will appear stretched if they have very different scales. The spreads of x and y must be within four orders of magnitude of each other for interpp to work.

Usage

interpp(x, y=NULL, z, xo, yo=NULL, linear=TRUE, extrap=FALSE,
duplicate = "error", dupfun = NULL,
jitter = 10^(-12), jitter.iter = 6, jitter.random = FALSE,
remove = !linear)

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.
interpp

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).

xo 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"

jitter Jitter of amount of diff(range(XX))*jitter (XX=x or y) will be added to coordinates if collinear points are detected. Afterwards interpolation will be tried once again.

Note that the jitter is not generated randomly unless jitter.random is set to TRUE. This ensures reproducible result. tri.mesh of package tripack uses the same jitter mechanism. That means you can plot the triangulation on top of the interpolation and see the same triangulation as used for interpolation, see examples below.

jitter.iter number of iterations to retry with jitter, amount will be increased in each iteration by iter^1.5

jitter.random logical, see jitter, defaults to FALSE

remove logical, indicates whether Akimas removal of thin triangles along the border of the convex hull should be performed, experimental setting! defaults to !linear, so it will be left out for linear interpolation by default. For some point configurations it is the only available option to skip this removal step.

Value

list with 3 components:

x vector of x-coordinates of output points, the same as the input argument xo.

y vector of y-coordinates of output points, the same as the input argument yo.

z fitted z-values. The value z[i] is computed at the x,y point x[i], y[i].

If input is SpatialPointsDataFrame than an according SpatialPointsDataFrame is returned.
NOTE

Use interp if interpolation on a regular grid is wanted.

See interp for more details.

References


See Also

contour, image, approxfun, splinefun, outer, expand.grid, interp, aspline.

Examples

data(akima)
# linear interpolation at points (1,2), (5,6) and (10,12)
akima.lip<-interpp(akima$x, akima$y, akima$z,c(1,5,10),c(2,6,12))
akima.lip$z
# spline interpolation at the same locations
akima.sip<-interpp(akima$x, akima$y, akima$z,c(1,5,10),c(2,6,12),
  linear=FALSE)
akima.sip$z
## Not run:
## interaction with sp objects:
library(sp)
## take 30 sample points out of meuse grid:
data(meuse.grid)
m0 <- meuse.grid[sample(1:3103,30),]
coordinates(m0) <- ~x+y
## interpolate on this 30 points:
## note: both "meuse" and "m0" are sp objects
## (SpatialPointsDataFrame) !!
## arguments z and xo have to given, y has to be omitted!
ipp <- interpp(meuse,z="zinc",xo=m0)
spplot(ipp)
## End(Not run)
**interpp.old**

**Pointwise Bivariate Interpolation for Irregular Data**

**Description**

If ncp is zero, linear interpolation is used in the triangles bounded by data points. Cubic interpolation is done if partial derivatives are used. If extrap is FALSE, z-values for points outside the convex hull are returned as NA. No extrapolation can be performed if ncp is zero.

The interpp function handles duplicate (x, y) points in different ways. As default it will stop with an error message. But it can give duplicate points an unique z value according to the parameter duplicate (mean, median or any other user defined function).

The triangulation scheme used by interp works well if x and y have similar scales but will appear stretched if they have very different scales. The spreads of x and y must be within four orders of magnitude of each other for interpp to work.

**Usage**

```r
interpp.old(x, y, z, xo, yo, ncp = 0, extrap = FALSE,
            duplicate = "error", dupfun = NULL)
interpp.new(x, y, z, xo, yo, extrap = FALSE,
            duplicate = "error", dupfun = NULL)
```

**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).
- **xo**: 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.
- **ncp**: deprecated, use parameter linear. Now only used by interpp.old(). meaning was: number of additional points to be used in computing partial derivatives at each data point. ncp must be either 0 (partial derivatives are not used, = linear interpolation), or at least 2 but smaller than the number of data points (and smaller than 25).
**extrap**

logical flag: should extrapolation be used outside of the convex hull determined by the data points?

**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"

### Value

list with 3 components:

- **x** vector of x-coordinates of output points, the same as the input argument xo.
- **y** vector of y-coordinates of output points, the same as the input argument yo.
- **z** fitted z-values. The value z[i] is computed at the x,y point x[i], y[i].

If input is SpatialPointsDataFrame than an according SpatialPointsDataFrame is returned.

### NOTE

Use interp if interpolation on a regular grid is wanted.

The two versions interpp.old and interpp.new are now deprecated, use interpp instead, see details there.

Earlier versions (pre 0.5-1) of interpp used the parameter ncp to choose between linear and cubic interpolation, this is now done by setting the logical parameter linear. Use of ncp is still possible, but is deprecated.

### References


### See Also

contour, image, approxfun, splinefun, outer, expand.grid, interp, aspline.
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