Package ‘BPST’

April 9, 2019

**Type** Package

**Title** Bivariate Spline over Triangulation

**Version** 0.1.0

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**Description** Spline smoothing via bivariate spline over triangulation.

**License** GPL (>= 2)

**Imports** Rcpp (>= 1.0.0)

**Depends** Matrix, pracma

**LinkingTo** Rcpp

**RoxygenNote** 6.1.1

R topics documented:

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1 BPST-package

2 A short title line describing what the package does

Description

A more detailed description of what the package does. A length of about one to five lines is recommended.

Details

This section should provide a more detailed overview of how to use the package, including the most important functions.
Author(s)
Your Name, email optional.
Maintainer: Your Name <your@email.com>

References
This optional section can contain literature or other references for background information.

See Also
Optional links to other man pages

Examples
```r
## not run
## optional simple examples of the most important functions
## These can be in \dontrun{} and \donttest{} blocks.
## End(Not run)
```

---

**basis**

**Bivariate Spline Basis Function**

Description
This function generates the basis for bivariate spline over triangulation.

Usage
```r
basis(V, Tr, d = 5, r = 1, Z, Hmtx = TRUE, Kmtx = TRUE,
      QR = TRUE, TA = TRUE)
```

Arguments
- **V**: The N by two matrix of vertices of a triangulation, where N is the number of vertices. Each row is the coordinates for a vertex.
- **Tr**: The triangulation matrix of dimension nT by three, where nT is the number of triangles in the triangulation. Each row is the indices of vertices in V.
- **d**: The degree of piecewise polynomials – default is 5, and usually d is greater than one. -1 represents piecewise constant.
- **r**: The smoothness parameter – default is 1, and $0 \leq r < d$.
- **Z**: The coordinates of dimension n by two. Each row is the coordinates of a point.
- **Hmtx**: The indicator of whether the smoothness matrix H need to be generated – default is TRUE.
fit.BPST

Kmtx
The indicator of whether the energy matrix K need to be generated – default is TRUE.

QR
The indicator of whether a QR decomposition need to be performed on the smoothness matrix – default is TRUE.

TA
The indicator of whether the area of the triangles need to be calculated – default is TRUE.

Details
This R program is modified based on the Matlab program written by Ming-Jun Lai from the University of Georgia and Li Wang from the Iowa State University.

Value
A list of vectors and matrices, including:

B
The spline basis function of dimension n by nT*{(d+1)(d+2)/2}, where n is the number of observationed points, nT is the number of triangles in the given triangulation, and d is the degree of the spline. If some points do not fall in the triangulation, the generation of the spline basis will not take those points into consideration.

Ind.inside
A vector contains the indexes of all the points which are inside the triangulation.

H
The smoothness matrix.

Q2
The Q2 matrix after QR decomposition of the smoothness matrix H.

K
The thin-plate energy function.

tria.all
The area of each triangle within the given triangulation.

Examples

# example 1
xx=c(-0.25,0.75,0.25,1.25)
yy=c(-0.25,0.25,0.75,1.25)
Z=cbind(xx,yy)
d=4; r=1;
V0=rbind(c(0,0),c(1,0),c(1,1),c(0,1))
Tr0=rbind(c(1,2,3),c(1,3,4))
basis(V0,Tr0,d,r,Z)

---

Model Fitting using Bivariate Penalized Spline over Triangulation

Description
This function conducts the model fitting via bivariate penalized spline over triangulation.

Usage

fit.BPST(Y, Z, V, Tr, d = 5, r = 1, lambda = 10*seq(-6, 6, by = 0.5), Hmtx = TRUE, Kmtx = TRUE, QR = TRUE, TA = TRUE)
Arguments

\( Y \)  
The response variable observed over the domain.

\( Z \)  
The coordinates of dimension \( n \) by two. Each row is the coordinates of a point.

\( V \)  
The \( n \) by two matrix of vertices of a triangulation, where \( N \) is the number of vertices. Each row is the coordinates for a vertex.

\( Tr \)  
The triangulation matrix of dimension \( nT \) by three, where \( nT \) is the number of triangles in the triangulation. Each row is the indices of vertices in \( V \).

\( d \)  
The degree of piecewise polynomials – default is 5, and usually \( d \) is greater than one. -1 represents piecewise constant.

\( r \)  
The smoothness parameter – default is 1, and \( 0 \leq r < d \).

\( \lambda \)  
The tuning parameter – default is \( 10^{-6}, -5.5, -5, \ldots, 5, 5.5, 6 \).

\( hmtx \)  
The indicator of whether the smoothness matrix \( h \) need to be generated – default is TRUE.

\( kmtx \)  
The indicator of whether the energy matrix \( K \) need to be generated – default is TRUE.

\( QR \)  
The indicator of whether a QR decomposition need to be performed on the smoothness matrix – default is TRUE.

\( TA \)  
The indicator of whether the area of the triangles need to be calculated – default is TRUE.

Details

This R program is modified based on the Matlab program written by Ming-Jun Lai from the University of Georgia and Li Wang from the Iowa State University.

Value

A list of vectors and matrice, including:

\( \text{gamma_hat} \)  
The estimated spline coefficients.

\( \text{lamc} \)  
The tuning parameter selected by Generalized Cross Validation (GCV).

\( B \)  
The spline basis function of dimension \( n \) by \( nT^*\{(d+1)(d+2)/2\} \), where \( n \) is the number of observationed points, \( nT \) is the number of triangles in the given triangulation, and \( d \) is the degree of the spline. The length of points means the length of ordering indices of observation points. If some points do not fall in the triangulation, the generation of the spline basis will not take those points into consideration.

\( \text{Ind.inside} \)  
A vector contains the indexes of all the points which are inside the triangulation.
inVT

Decide whether a point is inside of a given triangulation.

Description

This function is used to decided whether a point is inside of a given triangulation.

Usage

inVT(V0, Tr0, xx, yy)

Arguments

V0
The N by two matrix of vertices of a triangulation, where N is the number of vertices. Each row is the coordinates for a vertex.
The triangulation matrix of dimension $nT$ by three, where $nT$ is the number of triangles in the triangulation. Each row is the indices of vertices in $V$.

The x-coordinate of points of dimension $n$ by one.

The y-coordinate of points of dimension $n$ by one.

Details

This R program is modified based on the Matlab program written by Ming-Jun Lai from the University of Georgia and Li Wang from the Iowa State University.

Value

A list of vectors, including:

ind A vector of dimension $n$ by one matrix that lists whether the points are inside of a given triangulation. 0 – represents outside the triangulation, while 1 – represents inside the triangulation.

ind.inside A vector contains the indexes of all the points which are inside the triangulation.

Examples

```r
xx=c(-0.25,0.75,0.25,1.25)
yy=c(-0.25,0.25,0.75,1.25)
V0=rbind(c(0,0),c(1,0),c(1,1),c(0,1))
Tr0=rbind(c(1,2,3),c(1,3,4))
inVT(V0,Tr0,xx,yy)
```

plot.BPST

Produces the contour plot for the estimated surface of a fitted "BPST" object.

Description

This function produces the contour map for the estimated surface of a fitted "BPST" object.

Usage

```r
## S3 method for class 'BPST'
plot(mfit, Zgrid = NULL)
```

Arguments

- **mfit** Fitted “BPST” object.
- **Zgrid** The grid points used to construct the contour plot.
Details
This R program is modified based on the Matlab program written by Ming-Jun Lai from the University of Georgia and Li Wang from the Iowa State University.

Value
None

pred.BPST

Make predictions from a fitted BPST object.

Description
This function is used to make predictions of a fitted BPST object.

Usage
pred.BPST(mfit, Zpred = NULL)

Arguments

mfit Fitted “BPST” object.

Zpred The coordinates for prediction – default is the observed coordinates, Z.

Details
This R program is modified based on the Matlab program written by Ming-Jun Lai from the University of Georgia and Li Wang from the Iowa State University.

Value
A vector of predicted values is returned.
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