

# Package ‘orthogonalsplinebasis’

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**Type** Package

**Title** Orthogonal B-Spline Basis Functions

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**Description** Represents the basis functions for B-splines in a simple matrix formulation that facilitates, taking integrals, derivatives, and making orthogonal the basis functions.

**License** GPL (>= 2)

**URL** <https://github.com/halpo/obsplines>

**NeedsCompilation** no

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 orthogonal-spline-basis-package

*A Matrix Representation for Spline Basis Functions*


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### Description

This package provides functions for manipulation of spline basis functions. A matrix representation for the basis functions is at the center of the functions. The matrix representation simplifies the process of orthogonalization as well as differentiation and integration.

### Author(s)

Andrew Redd Maintainer: Andrew Redd <aredd at stat.tamu.edu>

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evaluate-methods

*Generic evaluate method*


---

### Description

Methods for function evaluate.

### Methods

**object = "SplineBasis", x = "numeric"** Evaluates a SplineBasis object for the spline basis curves at points x. See [SplineBasis](#)

---

expand.knots

*Expands knots for appropriate number of knots in bsplines*


---

### Description

This function is for convenience of specifying knots for B-splines. Since the user usually only want to specify the interval that they are interested in the end knots are usually duplicated. This function interprets the first and last knots as the end points and duplicates them.

### Usage

```
expand.knots(interior, order = 4)
```

### Arguments

interior	The knots including all interior and endpoint knots
order	the order of the splines that the knots are to be used with. Defaults to 4, being cubic splines

**Value**

A vector of knots with the order specified as an attribute

**Author(s)**

Andrew Redd

**See Also**

[SplineBasis](#), ~~~

**Examples**

```
(knots<-expand.knots(1:10))
plot(OBasis(knots))
```

---

fitLS

*Fitting splines with penalized least squares.*


---

**Description**

Estimates the control vector for a spline fit by penalized least squares. The penalty being the penalty parameter times the functional inner product of the second derivative of the spline curve.

**Usage**

```
fitLS(object, x, y, penalty = 0)
```

**Arguments**

object	The SplineBasis object to be used to make the fit
x	predictor variable.
y	response variable.
penalty	The penalty multiplier.

**Details**

For numeric vector  $y$ , and  $x$ , and a set of basis functions, represented in `object`, defined on the knots  $(k_0, \dots, k_m)$ . The likelihood is defined by

$$\sum_{i=1}^n (y_i - b(x_i)\mu) + \int_{k_0}^{k_m} \mu^T b''(t)^T b''(t) \mu dt$$

The function estimates  $\mu$ .

**Value**

a vector of the control points.

**Author(s)**

Andrew Redd <aredd at stat.tamu.edu>

**See Also**

[SplineBasis](#)

**Examples**

```
knots<-c(0,0,0,0:5,5,5,5)
base<-SplineBasis(knots)
x<-seq(0,5,by=.5)
y<-exp(x)+rnorm(length(x),sd=5)
fitLS(base,x,y)
```

---

GramMatrix

*Computing the Gram Matrix for a set of Spline Basis*

---

**Description**

Function for computing the Gram matrix of a spline basis.

**Usage**

```
GramMatrix(object)
```

**Arguments**

object            a [SplineBasis](#) object

**Details**

Compute the Gram Matrix. If object denotes the basis functions  $b(t) = \{b_1(t), \dots, b_J(t)\}$  then the Gram Matrix is,

$$G = \int b^T(t)b(t)dt$$

**Value**

a matrix as defined above.

---

Hankel

*Generating a Hankel Matrix*


---

**Description**

Functions to generate a Hankel matrix.

**Usage**

Hankel(x, nrow = length(x)%/2, ncol = length(x)%/2)

**Arguments**

x	numeric vector to specify the entries of the matrix. Should have an even number of entries.
nrow	integer, must be at most length(x)
ncol	integer, must be at most length(x)

**Details**

Computes a Hankel matrix. If we denote the vector  $x = (x_1, \dots, x_n)$  the Hankel matrix is defined and formed as

$$H = \begin{pmatrix} x_1 & x_2 & x_3 & \cdots & x_{1/2} \\ x_2 & x_3 & & \vdots & \vdots \\ x_3 & & \vdots & & \vdots \\ \vdots & \vdots & & & \vdots \\ x_{1/2} & \cdots & \cdots & \cdots & x_n \end{pmatrix}.$$

**Value**

a matrix as defined above.

**Author(s)**

Andrew Redd <aredd at stat.tamu.edu>

**Examples**

Hankel(1:6)

---

integrate-methods      *Methods for Function integrate*

---

### Description

Methods for function integrate. integrate integrates generic objects for which an integral is defined.

### Methods

**object = "SplineBasis"** Returns a new SplineBasis object for the integral of the basis functions.  
See [SplineBasis](#)

---

MatrixPower      *Matrix Power*

---

### Description

Performs the matrix power operation.

### Usage

```
MatrixPower(A, n)
```

### Arguments

A	A square matrix.
n	An integer telling the exponent.

### Details

Only well defined for integers the matrix power operation is a convenience function to multiply a matrix, A, with itself n times.

### Value

A matrix of the same dimension as A.

### Author(s)

Andrew Redd <aredd at stat.tamu.edu>

### Examples

```
A<-rbind(0,cbind(diag(1:5),0)) #a nilpotent matrix
A
MatrixPower(A,3)
MatrixPower(A,5)
MatrixPower(A,6) #Gets to a zero matrix
```

---

orthogonalize-methods *Methods for Function orthogonalize*

---

### Description

A generic function for orthogonalizing an object and returning the orthogonal object

### Methods

**object = "SplineBasis"** orthogonalizes the spline basis functions. See [SplineBasis](#)

---

OrthogonalizeBasis *Orthogonalize a Spline Basis*

---

### Description

Specific function for orthogonalizing the functions in a SplineBasis object.

### Usage

```
OrthogonalizeBasis(object, ...)
```

### Arguments

object	A SplineBasis object
...	ignored

### Value

An [OrthogonalSplineBasis](#) object.

### Author(s)

Andrew Redd <aredd at stat.tamu.edu>

### See Also

[OrthogonalSplineBasis](#), [SplineBasis](#), [orthogonalize](#)

OuterProdSecondDerivative

*Outer Product of Second Derivatives of Spline Bases*

---

### Description

Provides the functional outer product of second derivatives of a set of basis functions in a SplineBasis object. It a convenient form for forming a penalty on curve smoothness when fitting a spline curve.

### Usage

```
OuterProdSecondDerivative(basis)
```

### Arguments

basis            A SplineBasis object

### Value

A square matrix of order nrow(basis).

### Author(s)

Andrew Redd <aredd at stat.tamu.edu>

### See Also

[SplineBasis](#), [fitLS](#)

---

SplineBasis

*Creating and SplineBasis Objects.*

---

### Description

The function to create SplineBasis and OrthogonalSplineBasis Objects

### Usage

```
SplineBasis(knots, order=4, keep.duplicates=FALSE)
OrthogonalSplineBasis(knots, ...)
OBasis(...)
```



**Arguments**

knots	The full set of knots used to define the basis functions.
order	Order of the spline fit.(degree= order-1)
keep.duplicates	Should duplicate interior knots that could cause computation problem be kept or removed. Defaults to false, which removes duplicate knots with a warning if duplicate interior knots are found.
...	Other arguments either ignored or passed onto other functions.

**Details**

SplineBasis produces an object representing the basis functions used in spline fitting. Provides a compact easily evaluated representation of the functions. Produces a class of object SplineBasis. OrthogonalSplineBasis is a shortcut to obtain a set of orthogonalized basis functions from the knots. OBasis is an alias for OrthogonalSplineBasis. Both provide an object of class OrthogonalSplineBasis. The class OrthogonalSplineBasis inherits directly from SplineBasis meaning all functions that apply to SplineBasis functions also apply to the orthogonalized version.

**Value**

Object of class SplineBasis or OrthogonalSplineBasis

**References**

*General matrix representations for Bsplines* KaihuaiQin, The Visual Computer 2000 16:177–186

**See Also**

[SplineBasis](#), [spline](#), [orthogonalsplinebasis-package](#)

**Examples**

```
knots<-c(0,0,0,0:10,10,10,10)
plot(SplineBasis(knots))
obase<-OBasis(knots)
plot(obase)
dim(obase)[2] #number of functions
evaluate(obase, 1:10-.5)
```

---

SplineBasis-class      *Classes "SplineBasis" and "OrthogonalSplineBasis"*

---

**Description**

Contains the matrix representation for spline basis functions. The OrthongonalSplineBasis class has the basis functions orthogonalized.

### Objects from the Class

Objects can be created by calls of the form `SplineBasis(knots, order)` or to generate orthogonal spline basis functions directly `OrthogonalSplineBasis(knots, order)` or the short version `OBasis(knots,order)`.

### Slots

**transformation:** Object of class "matrix" Only applicable on OrthogonalSplineBasis Class, shows the transformation matrix use to get from regular basis functions to orthogonal basis functions.

**knots:** Object of class "numeric"

**order:** Object of class "integer"

**Matrices:** Object of class "array"

### Methods

**deriv** signature(expr = "SplineBasis"): Computes the derivative of the basis functions. Returns an object of class SplineBasis.

**dim** signature(x = "SplineBasis"): gives the dim as the order and number of basis functions. Returns numeric of length 2.

**evaluate** signature(object = "SplineBasis", x = "numeric"): Evaluates the basis functions and the points provided in x. Returns a matrix with length(x) rows and dim(object)[2] columns.

**integrate** signature(object = "SplineBasis"): computes the integral of the basis functions defined by  $\int_{k_0}^x b(t)dt$  where  $k_0$  is the first knot. Returns an object of class SplineBasis.

**orthogonalize** signature(object = "SplineBasis"): Takes in a SplinesBasis object, computes the orthogonalization transformation and returns an object of class OrthogonalSplineBasis.

**plot** signature(x = "SplineBasis", y = "missing"): Takes an object of class SplineBasis and plots the basis functions for the domain defined by the knots in object.

**plot** signature(x = "SplineBasis", y = "vector"): Interprets y as a vector of coefficients and plots the resulting curve.

**plot** signature(x = "SplineBasis", y = "matrix"): Interprets y as a matrix of coefficients and plots the resulting curves.

### Author(s)

Andrew Redd <aredd at stat.tamu.edu>

### References

*General matrix representations for Bsplines* Kaihuai Qin, The Visual Computer 2000 16:177–186

### See Also

[SplineBasis](#)

**Examples**

```
showClass("SplineBasis")  
  
knots<-c(0,0,0,0:5,5,5,5)  
(base <-SplineBasis(knots))  
(obase<-OBasis(knots))  
plot(base)  
plot(obase)
```

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