Package ‘BASS’

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  bass ................................................................. 2
  bassBasis .......................................................... 6
  bassPCA ............................................................. 8
  plot.bass .......................................................... 10
  plot.bassBasis .................................................... 11
  plot.bassSob ....................................................... 11
  predict.bass ....................................................... 12
  predict.bassBasis ................................................ 13
Bayesian Adaptive Spline Surfaces (BASS)

Description

Fits a BASS model using RJMCMC. Optionally uses parallel tempering to improve mixing. Can be used with scalar or functional response. Also can use categorical inputs.

Usage

bass(
  xx,
  y,
  maxInt = 3,
  maxInt.func = 3,
  maxInt.cat = 3,
  xx.func = NULL,
  degree = 1,
  maxBasis = 1000,
  npart = NULL,
  npart.func = NULL,
  nmcmc = 10000,
  nburn = 9000,
  thin = 1,
  g1 = 0,
  g2 = 0,
  s2.lower = 0,
  h1 = 10,
  h2 = 10,
  a.tau = 0.5,
  b.tau = NULL,
  w1 = 5,
  w2 = 5,
  temp.ladder = NULL,
  start.temper = NULL,
  curr.list = NULL,
  save.yhat = TRUE,
  small = FALSE,
  verbose = TRUE,
ret.str = F
)

Arguments

xx  
a data frame or matrix of predictors. Categorical predictors should be included as factors.

y  
a response vector (scalar response) or matrix (functional response). Note: If sum(y^2) is large (i.e. 1e10), please center/rescale (and rescale g1 and g2 if necessary).

maxInt  
integer for maximum degree of interaction in spline basis functions. Defaults to the number of predictors, which could result in overfitting.

maxInt.func  
(functional response only) integer for maximum degree of interaction in spline basis functions describing the functional response.

maxInt.cat  
(categorical input only) integer for maximum degree of interaction of categorical inputs.

xx.func  
a vector, matrix or data frame of functional variables.

degree  
degree of splines. Stability should be examined for anything other than 1.

maxBasis  
maximum number of basis functions. This should probably only be altered if you run out of memory.

npart  
minimum number of non-zero points in a basis function. If the response is functional, this refers only to the portion of the basis function coming from the non-functional predictors. Defaults to 20 or 0.1 times the number of observations, whichever is smaller.

npart.func  
same as npart, but for functional portion of basis function.

nmcmc  
number of RJMCMC iterations.

nburn  
number of the nmcmc iterations to disregard.

thin  
keep every thin samples

g1  
shape for IG prior on σ^2.

g2  
scale for IG prior on σ^2.

s2.lower  
lower bound for s2. Turns IG prior for s2 into a truncated IG.

h1  
shape for gamma prior on λ.

h2  
rate for gamma prior on λ. This is the primary way to control overfitting. A large value of h2 favors fewer basis functions.

a.tau  
shape for gamma prior on τ.

b.tau  
rate for gamma prior on τ. Defaults to one over the number of observations, which centers the prior for the basis function weights on the unit information prior.

w1  
nominal weight for degree of interaction, used in generating candidate basis functions. Should be greater than 0.

w2  
nominal weight for variables, used in generating candidate basis functions. Should be greater than 0.
bass

temp.ladder: temperature ladder used for parallel tempering. The first value should be 1 and the values should increase.

start.temper: when to start tempering (after how many MCMC iterations). Defaults to 1000 or half of burn-in, whichever is smaller.

curr.list: list of starting models (one element for each temperature), could be output from a previous run under the same model setup.

save.yhat: logical; should predictions of training data be saved?

small: logical; if true, returns a smaller object by leaving out curr.list and other unnecessary objects. Use in combination with save.yhat to get smaller memory footprint for very large models.

verbose: logical; should progress be displayed?

ret.str: logical; return data and prior structures

Details

Explores BASS model space by RJMCMC. The BASS model has

\[ y = f(x) + \epsilon, \quad \epsilon \sim N(0, \sigma^2) \]

\[ f(x) = a_0 + \sum_{m=1}^{M} a_mB_m(x) \]

and \( B_m(x) \) is a BASS basis function (tensor product of spline basis functions). We use priors

\[ a \sim N(0, \sigma^2/\tau(B'B)^{-1}) \]

\[ M \sim \text{Poisson}(\lambda) \]

as well as the priors mentioned in the arguments above.

Value

An object of class ‘bass’. The other output will only be useful to the advanced user. Rather, users may be interested in prediction and sensitivity analysis, which are obtained by passing the entire object to the predict.bass or sobol functions.

See Also

predict.bass for prediction and sobol for sensitivity analysis.

Examples

```R
## Not run:
### univariate example
### simulate data (Friedman function)
f<-function(x){
10*sin(pi*x[,1]*x[,2])+20*(x[,3]-.5)^2+10*x[,4]+5*x[,5]
}
```
sigma<-1 # noise sd
n<-500 # number of observations
x<-matrix(runif(n*10),n,10) #10 variables, only first 5 matter
y<-rnorm(n,f(x),sigma)

## fit BASS, no tempering
mod<-bass(x,y)
plot(mod)

## fit BASS, tempering
mod<-bass(x,y,temp.ladder=1.3^(0:8),start.temper=1000)
plot(mod)

## prediction
npred<1000
xpred<-matrix(runif(npred*10),npred,10)
pred<-predict(mod,xpred,verbose=TRUE) # posterior predictive samples
true.y<-f(xpred)
plot(true.y,colMeans(pred),xlab='true values',ylab='posterior predictive means')
abline(a=0,b=1,col=2)

## sensitivity
sens<-sobol(mod)
plot(sens,cex.axis=.5)

###########################################################################
### functional example
###########################################################################
## simulate data (Friedman function with first variable as functional)
sigma<-1 # noise sd
n<-500 # number of observations
nfunc<-50 # size of functional variable grid
xfunc<-seq(0,1,length.out=nfunc) # functional grid
x<-matrix(runif(n*9),n,9) # 9 non-functional variables, only first 4 matter
X<-cbind(rep(xfunc,each=n),kronecker(rep(1,nfunc),x)) # to get y
y<-matrix(f(X),nrow=n)+rnorm(n*nfunc,0,sigma)

## fit BASS
mod<-bass(x,y,xx.func=xfunc)
plot(mod)

## prediction
npred<100
xpred<-matrix(runif(npred*9),npred,9)
Xpred<-cbind(rep(xfunc,each=npred),kronecker(rep(1,nfunc),xpred))
ypred<-matrix(f(Xpred),nrow=npred)
pred<-predict(mod,xpred) # posterior predictive samples (each is a curve)
matplot(ypred,apply(pred,2:3,mean),type='l',xlab='observed',ylab='mean prediction')
abline(a=0,b=1,col=2)
matplot(t(ypred),type='l') # actual
matplot(t(apply(pred,2:3,mean)),type='l') # mean prediction

## sensitivity
sens<-sobol(mod,mcmc.use=1:10) # for speed, only use a few samples
plot(sens) # functional variable labelled "a"

sens.func<-sobol(mod,mcmc.use=1:10,func.var=1)
plot(sens.func)

## End(Not run)

## minimal example for CRAN testing
mod<-bass(1:2,1:2,nmcmc=2,nburn=1)

---

**bassBasis**

*Bayesian Adaptive Spline Surfaces (BASS) with basis decomposition of response*

**Description**

Fits a BASS model to basis coefficients under the specified basis.

**Usage**

bassBasis(dat, n.cores = 1, parType = "fork", ...)

**Arguments**

- **dat**: list that includes elements `xx`, `n.pc` (number of basis functions), `basis` (dimension `m` x `n.pc`), `newy` (dimension `n.pc` x `n`), `trunc.error` (optional truncation error with dimension `n` x `m`), `y.m` (vector mean removed before basis decomposition with dimension `m`), `y.s` (vector sd scaled before basis decomposition with dimension `m`). See the documentation of `bassPCA` for more details.

- **n.cores**: integer number of cores (threads) to use

- **parType**: either "fork" or "socket". Forking is typically faster, but not compatible with Windows. If `n.cores==1`, `parType` is ignored.

... arguments to be passed to `bass` function calls.

**Details**

Under a user defined basis decomposition, fits a bass model to each PCA basis coefficient independently, `bass(dat$xx, dat$newy[i,],...)` for `i` in `1` to `n.pc`, possibly in parallel. The basis does not need to be orthogonal, but independent modeling of basis coefficients should be sensible.

**Value**

An object of class 'bassBasis' with two elements:

- **mod.list**: list (of length `n.pc`) of individual bass models

- **dat**: same as `dat` above
See Also

predict.bassBasis for prediction and sobolBasis for sensitivity analysis.

Examples

```r
## Not run:
## simulate data (Friedman function)
f<-function(x){
  10*sin(pi*x[,1]*x[,2])+20*(x[,3]-.5)^2+10*x[,4]+5*x[,5]
}
## simulate data (Friedman function with first variable as functional)
sigma<-.1 # noise sd
n<-500 # number of observations
nfunc<-50 # size of functional variable grid
xfunc<-seq(0,1,length.out=nfunc) # functional grid
x<-matrix(runif(n*9),n,9) # 9 non-functional variables, only first 4 matter
X<-cbind(rep(xfunc,each=n),kronecker(rep(1,nfunc),x)) # to get y
y<-matrix(f(X),nrow=n)+rnorm(n*nfunc,0,sigma)
## fit BASS
library(parallel)
mod<-bassPCA(x,y,n.pc=5,n.cores=min(5,parallel::detectCores()))
plot(mod$mod.list[[1]])
plot(mod$mod.list[[2]])
plot(mod$mod.list[[3]])
plot(mod$mod.list[[4]])
plot(mod$mod.list[[5]])
hist(mod$dat$trunc.error)
## prediction
npred<-100
xpred<-matrix(runif(npred*9),npred,9)
Xpred<-cbind(rep(xfunc,each=npred),kronecker(rep(1,nfunc),xpred))
ypred<-matrix(f(Xpred),nrow=npred)
pred<-predict(mod,xpred,mcmc.use=1:1000) # posterior predictive samples (each is a curve)
matplot(ypred,apply(pred,2:3,mean),type='l',xlab='observed',ylab='mean prediction')
abline(a=0,b=1,col=2)
matplot(t(ypred),type='l') # actual
matplot(t(apply(pred,2:3,mean)),type='l') # mean prediction
## sensitivity
sens<-sobolBasis(mod,int.order = 2,ncores = max(parallel::detectCores()-2,1),
                 mcmc.use=1000) # for speed, only use a few samples
plot(sens)
## End(Not run)
## minimal example for CRAN testing
mod<-bassPCA(1:10,matrix(1:20,10),n.pc=2,nmcmc=2,nburn=1)
```
bassPCA

Bayesian Adaptive Spline Surfaces (BASS) with PCA decomposition of response

Description

Decomposes a multivariate or functional response onto a principal component basis and fits a BASS model to each basis coefficient.

Usage

bassPCA(
  xx = NULL,
  y = NULL,
  dat = NULL,
  n.pc = NULL,
  perc.var = 99,
  n.cores = 1,
  parType = "fork",
  center = T,
  scale = F,
  ...

)

Arguments

xx a data frame or matrix of predictors with dimension n x p. Categorical predictors should be included as factors.

y a response matrix (functional response) with dimension n x m.

dat optional (for more control) list with elements xx (same as above), y (same as above), n.pc (number of principal components used), basis (principal components with dimension m x n.pc), newy (reduced dimension y with dimension n.pc x n), trunc.error (optional truncation error with dimension n x m), y.m (vector mean removed before PCA with dimension m), y.s (vector sd scaled before PCA with dimension m). If dat is specified, xx, y and n.pc do not need to be specified.

n.pc number of principal components to use

perc.var optionally specify percent of variance to explain instead of n.pc

n.cores integer number of cores (threads) to use

parType either "fork" or "socket". Forking is typically faster, but not compatible with Windows. If n.cores==1, parType is ignored.

center logical whether to subtract the mean before getting the principal components, or else a numeric vector of dimension m for the center to be used

scale logical whether to divide by the standard deviation before getting the principal components, or else a numeric vector of dimension m for the scale to be used

... arguments to be passed to bass function calls.
bassPCA

Details

Gets the PCA decomposition of the response $y$, and fits a bass model to each PCA basis coefficient, $\text{bass}(\text{dat}$xx, dat$newy[i,],\ldots)$ for $i$ in 1 to $n$.pc, possibly in parallel.

Value

An object of class ‘bassBasis’ with two elements:

- mod.list: list (of length $n$.pc) of individual bass models
- dat: same as dat above

See Also

predict.bassBasis for prediction and sobolBasis for sensitivity analysis.

Examples

```r
## Not run:
## simulate data (Friedman function)
f<-function(x)
  10*sin(pi*x[,1]*x[,2])+20*(x[,3]-.5)^2+10*x[,4]+5*x[,5]
}
## simulate data (Friedman function with first variable as functional)
sigma<-.1 # noise sd
n<-500 # number of observations
nfunc<-50 # size of functional variable grid
xfunc<-seq(0,1,length.out=nfunc) # functional grid
x<-matrix(runif(n*9),n,9) # 9 non-functional variables, only first 4 matter
X<-cbind(rep(xfunc,each=n),kronecker(rep(1,nfunc),x)) # to get y
y<-matrix(f(X),nrow=n)+rnorm(n*nfunc,0,sigma)
## fit BASS
library(parallel)
mod<-bassPCA(x,y,n.pc=5,n.cores=min(5,parallel::detectCores()))
plot(mod$mod.list[[1]])
plot(mod$mod.list[[2]])
plot(mod$mod.list[[3]])
plot(mod$mod.list[[4]])
plot(mod$mod.list[[5]])
hist(mod$dat$trunc.error)

## prediction
npred<-100
xpred<-matrix(runif(npred*9),npred,9)
Xpred<-cbind(rep(xfunc,each=npred),kronecker(rep(1,nfunc),xpred))
ypred<-matrix(f(Xpred),nrow=npred)
pred<-predict(mod,xpred,mcmc.use=1:1000) # posterior predictive samples (each is a curve)
matplot(ypred,apply(pred,2:3,mean),type='l',xlab='observed',ylab='mean prediction')
abline(a=0,b=1,col=2)
matplot(t(ypred),type='l') # actual
matplot(t(apply(pred,2:3,mean)),type='l') # mean prediction
```
## sensitivity
sens<-sobolBasis(mod,int.order = 2,ncores = max(parallel::detectCores()-2,1),
    mcmc.use=1000) # for speed, only use a few samples
plot(sens)

## End(Not run)

## minimal example for CRAN testing
mod<-bassPCA(1:10,matrix(1:20,10),n.pc=2,nmcmc=2,nburn=1)

---

**plot.bass**  
_BASS Plot Diagnostics_

### Description
Generate diagnostic plots for BASS model fit.

### Usage

```
## S3 method for class 'bass'
plot(x, quants = c(0.025, 0.975), ...)
```

### Arguments

- **x**  
a bass object.

- **quants**  
quantiles for intervals, if desired. NULL if not desired.

- **...**  
graphical parameters.

### Details
The first two plots are trace plots for diagnosing convergence. The third plot is posterior predicted vs observed, with intervals for predictions. The fourth plot is a histogram of the residuals (of the posterior mean model), with a red curve showing the assumed Normal density (using posterior mean variance). If bass was run with save.yhat = FALSE, the third and fourth plots are omitted.

### See Also

bass, predict.bass, sobol

### Examples

```
# See examples in bass documentation.
```
### plot.bassBasis

**BASS Plot Diagnostics**

**Description**

Generate diagnostic plots for BASS model fit.

**Usage**

```r
## S3 method for class 'bassBasis'
plot(x, quants = c(0.025, 0.975), pred = T, ...)
```

**Arguments**

- `x` a `bassBasis` object.
- `quants` quantiles for intervals, if desired. NULL if not desired.
- `pred` logical, should predictive performance be plotted?
- `...` graphical parameters.

**Details**

The first two plots are trace plots for diagnosing convergence. The third plot is posterior predicted vs observed, with intervals for predictions. The fourth plot is a histogram of the residuals (of the posterior mean model). If `pred = FALSE`, the third and fourth plots are omitted.

**See Also**

`bassBasis`, `bassPCA`, `predict.bassBasis`, `sobolBasis`

**Examples**

```r
# See examples in bassBasis documentation.
```

### plot.bassSob

**Plot BASS sensitivity indices**

**Description**

Generate plots for sensitivity analysis of BASS.

**Usage**

```r
## S3 method for class 'bassSob'
plot(x, ...)```

```
Arguments

x a bassSob object, returned from sobol.

... graphical parameters.

Details

If `func.var` in the call to `sobol` was NULL, this returns boxplots of sensitivity indices and total
sensitivity indices. If there were functional variables, they are labeled with letters alphabetically.
Thus, if I fit a model with 4 categorical/continuous inputs and 2 functional inputs, the functional
inputs are labeled a and b. If `func.var` was not NULL, then posterior mean functional sensitivity
indices are plotted, along with the functional partitioned variance. Variables and interactions that
are excluded did not explain any variance.

See Also

bass, predict.bass, sobol

Examples

# See examples in bass documentation.
**predict.bassBasis**

Arguments

- `object`: a fitted model, output from the `bass` function.
- `newdata`: a matrix of new input values at which to predict. The columns should correspond to the same variables used in the `bass` function.
- `newdata.func`: a matrix of new values of the functional variable. If none, the same values will be used as in the training data.
- `mcmc.use`: a vector indexing which MCMC iterations to use for prediction.
- `verbose`: logical; should progress be displayed?
- `...`: further arguments passed to or from other methods.

Details

Efficiently predicts when two MCMC iterations have the same basis functions (but different weights).

Value

If model output is a scalar, this returns a matrix with the same number of rows as `newdata` and columns corresponding to the the MCMC iterations `mcmc.use`. These are samples from the posterior predictive distribution. If model output is functional, this returns an array with first dimension corresponding to MCMC iteration, second dimension corresponding to the rows of `newdata`, and third dimension corresponding to the rows of `newdata.func`.

See Also

- `bass` for model fitting and `sobol` for sensitivity analysis.

Examples

```r
# See examples in bass documentation.
```

---

**predict.bassBasis**  
*BASS Prediction*

Description

Predict function for BASS. Outputs the posterior predictive samples based on the specified MCMC iterations.
Usage

```r
## S3 method for class 'bassBasis'
predict(
  object,
  newdata,
  mcmc.use = NULL,
  trunc.error = FALSE,
  nugget = T,
  n.cores = 1,
  parType = "fork",
  ...
)
```

Arguments

- `object`: a fitted model, output from the `bass` function.
- `newdata`: a matrix of new input values at which to predict. The columns should correspond to the same variables used in the `bassBasis` or `bassPCA` functions.
- `mcmc.use`: a vector indexing which MCMC iterations to use for prediction.
- `trunc.error`: logical, use basis truncation error when predicting?
- `nugget`: logical, use individual `bass` nugget variances when predicting?
- `n.cores`: number of cores, though 1 is often the fastest.
- `parType`: either "fork" or "socket". Forking is typically faster, but not compatible with Windows. If `n.cores==1`, `parType` is ignored.
- `...`: further arguments passed to or from other methods.

Details

Prediction combined across `bass` models.

Value

An array with first dimension corresponding to MCMC iteration, second dimension corresponding to the rows of `newdata`, and third dimension corresponding to the multivariate/functional response.

See Also

- `bassPCA` and `bassBasis` for model fitting and `sobolBasis` for sensitivity analysis.

Examples

```r
# See examples in bass documentation.
```
print.bass

Description

Print some of the details of a BASS model.

Usage

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

Arguments

  x  a bass object, returned from bass.

  ... further arguments passed to or from other methods.

print.bassBasis

Description

Print some of the details of a BASS model.

Usage

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

Arguments

  x  a bassBasis object, returned from bassPCA or bassBasis.

  ... further arguments passed to or from other methods.
**sobol**  

*BASS Sensitivity Analysis*

**Description**

Decomposes the variance of the BASS model into variance due to main effects, two way interactions, and so on, similar to the ANOVA decomposition for linear models. Uses the Sobol’ decomposition, which can be done analytically for MARS models.

**Usage**

```r
sobol(
  bassMod,
  prior = NULL,
  prior.func = NULL,
  mcmc.use = NULL,
  func.var = NULL,
  xx.func.var = NULL,
  verbose = TRUE,
  getEffects = FALSE
)
```

**Arguments**

- `bassMod`: a fitted model output from the `bass` function.
- `prior`: a list of priors; uniform, truncated mixture of Normals or Ts for continuous; vector of category weights for categorical. Default is uniform over range of data.
- `prior.func`: prior for functional variable. In almost all cases, keep this as the uniform default.
- `mcmc.use`: an integer vector indexing which MCMC iterations to use for sensitivity analysis.
- `func.var`: an integer indicating which functional variable to make sensitivity indices a function of. Disregard if `bassMod` is non-functional or if scalar sensitivity indices are desired.
- `xx.func.var`: grid for functional variable specified by `func.var`. Disregard if `func.var` is not specified. If `func.var` is specified and `xx.func.var` not specified, the grid used to fit `bass` will be used.
- `verbose`: logical; should progress be displayed?
- `getEffects`: logical; should Sobols ANOVA decomposition be computed?

**Details**

Performs analytical Sobol’ decomposition for each MCMC iteration in `mcmc.use` (each corresponds to a MARS model), yielding a posterior distribution of sensitivity indices. Can obtain Sobol’ indices as a function of one functional variable.
Value

If non-functional (func.var = NULL), a list with two elements:

S  a data frame of sensitivity indices with number of rows matching the length of mcmc.use. The columns are named with a particular main effect or interaction. The values are the proportion of variance in the model that is due to each main effect or interaction.

T  a data frame of total sensitivity indices with number of rows matching the length of mcmc.use. The columns are named with a particular variable.

Otherwise, a list with four elements:

S  an array with first dimension corresponding to MCMC samples (same length as mcmc.use), second dimension corresponding to different main effects and interactions (labeled in names.ind), and third dimension corresponding to the grid used for the functional variable. The elements of the array are sensitivity indices.

S.var  same as S, but scaled in terms of total variance rather than percent of variance.

names.ind  a vector of names of the main effects and interactions used.

xx  the grid used for the functional variable.

See Also

bass for model fitting and predict.bass for prediction.

Examples

# See examples in bass documentation.

sobolBasis( mod, int.order, prior = NULL, mcmc.use = NULL, nind = NULL, BASS Sensitivity Analysis

Description

Decomposes the variance of the BASS model into variance due to main effects, two way interactions, and so on, similar to the ANOVA decomposition for linear models. Uses the Sobol’ decomposition, which can be done analytically for MARS models.

Usage

sobolBasis(
sobolBasis

n.cores = 1,
parType = "fork",
plot = F,
verbose = T

Arguments

mod
output from the bassBasis or bassPCA function.

int.order
an integer indicating the highest order of interactions to include in the Sobol decomposition.

prior
a list with the same number of elements as there are inputs to mod. Each element specifies the prior for the particular input. Each prior is specified as a list with elements dist (one of c("normal","student","uniform")), trunc (a vector of dimension 2 indicating the lower and upper truncation bounds, taken to be the data bounds if omitted), and for "normal" or "student" priors, mean (scalar mean of the Normal/Student, or a vector of means for a mixture of Normals or Students), sd (scalar standard deviation of the Normal/Student, or a vector of standard deviations for a mixture of Normals or Students), df (scalar degrees of freedom of the Student, or a vector of degrees of freedom for a mixture of Students), and weights (a vector of weights that sum to one for the mixture components, or the scalar 1). If unspecified, a uniform is assumed with the same bounds as are represented in the input to mod.

mcmc.use
an integer indicating which MCMC iteration to use for sensitivity analysis. Defaults to the last iteration.

nind
number of Sobol indices to keep (will keep the largest nind).

n.cores
number of cores to use (nearly linear speedup for adding cores).

parType
either "fork" or "socket". Forking is typically faster, but not compatible with Windows. If n.cores==1, parType is ignored.

plot
logical; whether to plot results.

verbose
logical; print progress.

Details

Performs analytical Sobol’ decomposition for each MCMC iteration in mcmc.use (each corresponds to a MARS model), yeilding a posterior distribution of sensitivity indices. Can obtain Sobol’ indices as a function of one functional variable.

Value

If non-functional (func.var = NULL), a list with two elements:

S
a data frame of sensitivity indices with number of rows matching the length of mcmc.use. The columns are named with a particular main effect or interaction. The values are the proportion of variance in the model that is due to each main effect or interaction.
T  
a data frame of total sensitivity indices with number of rows matching the length of `mcmc.use`. The columns are named with a particular variable.

Otherwise, a list with four elements:

S  
an array with first dimension corresponding to MCMC samples (same length as `mcmc.use`), second dimension corresponding to different main effects and interactions (labeled in `names.ind`), and third dimension corresponding to the grid used for the functional variable. The elements of the array are sensitivity indices.

S.var  
same as S, but scaled in terms of total variance rather than percent of variance.

names.ind  
a vector of names of the main effects and interactions used.

See Also

`bassPCA` and `bassBasis` for model fitting and `predict.bassBasis` for prediction.

Examples

```r
# See examples in bass documentation.
```

---

**summary.bass**  
*Summarize BASS Details*

### Description

Summarize some of the details of a BASS model.

### Usage

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

### Arguments

- `object`  
a bass object, returned from bass.
- `...`  
further arguments passed to or from other methods.
Summary of BASS Details

**Description**

Summarize some of the details of a BASS model.

**Usage**

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

**Arguments**

- **object**
  - a `bassBasis` object, returned from `bassPCA` or `bassBasis`.
- **...**
  - further arguments passed to or from other methods.
Index

* Sobol
  sobol, 16
  sobolBasis, 17
* analysis
  bass, 2
  bassBasis, 6
  bassPCA, 8
* data
  bass, 2
  bassBasis, 6
  bassPCA, 8
* decomposition
  sobol, 16
  sobolBasis, 17
* functional
  bass, 2
  bassBasis, 6
  bassPCA, 8
* nonparametric
  bass, 2
  bassBasis, 6
  bassPCA, 8
* regression
  bass, 2
  bassBasis, 6
  bassPCA, 8
* splines
  bass, 2
  bassBasis, 6
  bassPCA, 8

bass, 2, 10, 12, 13, 17
bassBasis, 6, 11, 14, 19
bassPCA, 8, 11, 14, 19

plot.bass, 10
plot.bassBasis, 11
plot.bassSob, 11
predict.bass, 4, 10, 12, 17
predict.bassBasis, 7, 9, 11, 13, 19

print.bass, 15
print.bassBasis, 15

sobol, 4, 10, 12, 13, 16
sobolBasis, 7, 9, 11, 14, 17
summary.bass, 19
summary.bassBasis, 20