

Package ‘ordgam’

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Type Package

Title Additive Model for Ordinal Data using Laplace P-Splines

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Maintainer Philippe Lambert <p.lambert@uliege.be>

BugReports <https://github.com/plambertULiege/ordgam/issues>

Description Additive proportional odds model for ordinal data using Laplace P-splines. The combination of Laplace approximations and P-splines enable fast and flexible inference in a Bayesian framework. Specific approximations are proposed to account for the asymmetry in the marginal posterior distributions of non-penalized parameters. For more details, see Lambert and Gressani (2023) <[doi:10.1177/1471082X231181173](https://doi.org/10.1177/1471082X231181173)> ; Preprint: <[arXiv:2210.01668](https://arxiv.org/abs/2210.01668)>).

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URL <<https://github.com/plambertULiege/ordgam>>

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LazyData true

Imports cubicBsplines, Matrix, mgcv, marqLevAlg, sn, MASS, numDeriv, ucminf

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Author Philippe Lambert [aut, cre] (<<https://orcid.org/0000-0002-3670-3328>>)

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centeredBasis.gen	<i>Generation of a recentered B-spline basis matrix in additive models</i>
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Description

Generation of a B-spline basis matrix with recentered columns to handle the identifiability constraint in additive models. See Wood (CRC Press 2017, pp. 175-176) for more details.

Usage

```
centeredBasis.gen(x, knots, cm = NULL, pen.order = 2, verbose = TRUE)
```

Arguments

x	vector of values where to compute the "recentered" B-spline basis
knots	vector of knots (that should cover the values in <x>)
cm	(Optional) values subtracted from each column of the original B-spline matrix
pen.order	penalty order for the B-spline parameters (Default: 2)
verbose	verbose indicator (Default: TRUE)

Value

List containing

- B : centered B-spline matrix (with columns recentered to have mean 0 over equi-spaced x values on the range of the knots).
- Dd : difference matrix (of order <pen.order>) for the associated centered B-spline matrix.
- Pd : penalty matrix (of order <pen.order>) for the associated centered B-spline matrix.
- K : number of centered B-splines in the basis.
- cm : values subtracted from each column of the original B-spline matrix. By default, this is a vector containing the mean of each column in the original B-spline matrix.

Author(s)

Philippe Lambert <p.lambert@uliege.be>

References

Lambert, P. and Gressani, O. (2023) Penalty parameter selection and asymmetry corrections to Laplace approximations in Bayesian P-splines models. *Statistical Modelling*. <doi:10.1177/1471082X231181173>. Preprint: <arXiv:2210.01668>.

Examples

```
x = seq(0,1,by=.01)
knots = seq(0,1,length=5)
obj = centeredBasis.gen(x,knots)
matplot(x,obj$B,type="l",ylab="Centered B-splines")
colMeans(obj$B)
```

freehmsData

Perception of gay men and lesbians in Wallonia, Belgium.

Description

Data extracted from the European Social Survey (2018) conducted in a series of European countries including Belgium and one of its three regions, Wallonia. Each of the 552 participants (aged at least 15) was asked to react to the following statement, "Gay men and lesbians should be free to live their own life as they wish", with a positioning on a Likert scale going from 1 (=Agree strongly) to 5 (=Disagree strongly), with 3 labelled as Neither agree nor disagree.

Usage

```
data(freehmsData)
```

Format

A data frame with 552 rows and 4 columns.

freehms Ordinal response (1: Agree strongly to 5: Disagree strongly).

age Age of the respondent.

gndr Gender of the respondent.

eduysr Number of years of education completed.

References

Lambert, P. and Gressani, O. (2023) Penalty parameter selection and asymmetry corrections to Laplace approximations in Bayesian P-splines models. *Statistical Modelling*. <doi:10.1177/1471082X231181173>. Preprint: <arXiv:2210.01668>.

European Social Survey Round 9 Data (2018) Data file edition 3.1. NSD - Norwegian Centre for Research Data, Norway.

freehmsDataBE

Perception of gay men and lesbians in Belgium.

Description

Data extracted from the European Social Survey (2018) conducted in a series of European countries including Belgium. Each of the 1737 participants (aged at least 15) was asked to react to the following statement, "Gay men and lesbians should be free to live their own life as they wish", with a positioning on a Likert scale going from 1 (=Agree strongly) to 5 (=Disagree strongly), with 3 labelled as Neither agree nor disagree.

Usage

```
data(freehmsDataBE)
```

Format

A data frame with 1737 rows and 5 columns.

freehms Ordinal response (1: Agree strongly to 5: Disagree strongly).

gndr Gender of the respondent.

age Age of the respondent.

edyrs Number of years of education completed.

region Belgian region of residence: WAL (Wallonia), FL (Flanders) or BXL (Brussels).

References

Lambert, P. and Gressani, O. (2023) Penalty parameter selection and asymmetry corrections to Laplace approximations in Bayesian P-splines models. *Statistical Modelling*. <doi:10.1177/1471082X231181173>. Preprint: <arXiv:2210.01668>.

European Social Survey Round 9 Data (2018) Data file edition 3.1. NSD - Norwegian Centre for Research Data, Norway.

lmarg.gammaTilde	<i>Marginal posterior density function for a remapped non-penalized parameter in an ordgam model</i>
------------------	--

Description

Marginal posterior density function for a remapped non-penalized parameter in an ordgam model

Usage

```
lmarg.gammaTilde(gamtk, k, model)
```

Arguments

gamtk	Remapped parameter value at which the marginal log posterior density for <gamma.tilde[k]> must be evaluated.
k	Targetted component in the vector of remapped non-penalized parameters <gamma.tilde>.
model	An ordgam.object .

Value

Log of $p(\text{gamma.tilde}[k] \mid \text{lambda}, \text{data})$

Author(s)

Philippe Lambert <p.lambert@uliege.be>

References

Lambert, P. and Gressani, O. (2023) Penalty parameter selection and asymmetry corrections to Laplace approximations in Bayesian P-splines models. *Statistical Modelling*. <doi:10.1177/1471082X231181173>. Preprint: <arXiv:2210.01668>.

See Also

[ordgam](#).

Examples

```
library(ordgam)
data(freehmsData)
mod = ordgam(freehms ~ s(eduysr) + s(age), data=freehmsData, descending=TRUE,
             lambda0=c(192,18),select.lambda=FALSE)
ngamma = with(mod, nalpha+nfixed) ## Number of non-penalized parms
k = 1 ## Focus on gamma.tilde[1]
x.grid = seq(-4,4,length=7) ## Grid of values for gamma.tilde[k]
lfy.grid = ordgam::lmarg.gammaTilde(x.grid,k=k,mod) ## log p(gamma.tilde[k] | D) on the grid
gam.t.ST = ordgam::STapprox(x.grid,lfy.grid)$dp ## Approximate using a skew-t
```

```
## Plot the estimated marginal posterior for <gamma.tilde[k]>
xlab = bquote(tilde(gamma)[.(k)])
ylab = bquote(p(tilde(gamma)[.(k)]~ "|~lambda~", "~D))
xlim = sn::qst(c(.0001, .9999), dp=gamt.ST)
curve(sn::dst(x, dp=gamt.ST), xlim=xlim,
      xlab=xlab, ylab=ylab, col="blue", lwd=2, lty=1)
```

lpost.gamma	<i>Posterior density function for the non-penalized parameters in an ordgam model</i>
-------------	---

Description

Posterior density function for the non-penalized parameters in an ordgam model

Usage

```
lpost.gamma(model)
```

Arguments

model An [ordgam.object](#)

Value

Log joint posterior density function for the non-penalized regression parameters.

Author(s)

Philippe Lambert <p.lambert@uliege.be>

References

Lambert, P. and Gressani, O. (2023) Penalty parameter selection and asymmetry corrections to Laplace approximations in Bayesian P-splines models. *Statistical Modelling*. <doi:10.1177/1471082X231181173>. Preprint: <arXiv:2210.01668>.

See Also

[ordgam](#).

Examples

```
library(ordgam)
data(freehmsData)
mod = ordgam(freehms ~ s(edyrs) + s(age), data=freehmsData, descending=TRUE)
print(mod$theta) ## Model regression parameters
gam.hat = mod$theta[1:4] ## Non-penalized parameter estimates
ordgam::lpost.gamma(mod)(gam.hat)
```

ordgam	<i>Fit of an additive proportional odds model for ordinal data using Laplace approximations and P-splines</i>
--------	---

Description

Fit of an additive proportional odds model for ordinal data using Laplace approximations and P-splines

Usage

```
ordgam(
  formula,
  data,
  nc = NULL,
  K = 10,
  pen.order = 2,
  descending = TRUE,
  select.lambda = TRUE,
  lambda.family = "dgamma",
  lambda.optimizer = "nlminb",
  lprior.lambda = function(x) dgamma(x, 1, 1e-04, log = TRUE),
  theta0 = NULL,
  lambda0 = NULL,
  ci.level = 0.95,
  verbose = FALSE
)
```

Arguments

formula	A model formula
data	A data frame containing a column 'y' with the ordinal response (taking integer values) besides the covariates.
nc	(optional) Number of categories for the ordinal response.
K	Number of B-splines to model each additive term (Default: 10).
pen.order	Penalty order (Default: 2).
descending	Logical indicating if the odds of the response taking a value in the upper scale should be preferred over values in the lower scale (Default: TRUE).
select.lambda	Logical indicating if the penalty parameters should be tuned (Default: TRUE).
lambda.family	Prior for <lambda>. Possible choices are "none", "dgamma", "BetaPrime" or "myprior" for a user specified function for the prior of <lambda>.
lambda.optimizer	Algorithm used to maximize p(lambda data). Possible choices are "nlminb", "ucminf", "nlm", "LevMarq" (Default: "nlminb").

lprior.lambda	Log of the prior density for a <lambda> component if lambda.family set to "myprior".
theta0	(Optional) Vector containing starting values for the regression parameters.
lambda0	Vector of penalty parameters for the additive terms (Default: 10 for each additive term).
ci.level	Confidence levels of the computed credible intervals for the regression parameters.
verbose	Verbose mode (logical)

Value

an object of type `ordgam.object`.

Author(s)

Philippe Lambert <p.lambert@uliege.be>

References

Lambert, P. and Gressani, O. (2023) Penalty parameter selection and asymmetry corrections to Laplace approximations in Bayesian P-splines models. *Statistical Modelling*. <doi:10.1177/1471082X231181173>. Preprint: <arXiv:2210.01668>.

See Also

`ordregr`, `ordgam.object`.

Examples

```
library(ordgam)
data(freehmsData)
mod = ordgam(freehms ~ gndr + s(eduysrs) + s(age),
             data=freehmsData, descending=TRUE)
print(mod)
plot(mod)
```

<code>ordgam.object</code>	<i>Object resulting from the fit of an additive proportional odds model using 'ordgam'</i>
----------------------------	--

Description

An object returned by the `ordgam` function: this is a list with various components related to the fit of such a model.

Value

An ordgam object is a list with following elements:

- `val` : Value of the log-posterior at convergence.
- `val.start` : Value of the log-posterior at the start of the Newton-Raphson (N-R) algorithm.
- `theta` : (Penalized) MLE or MAP of the regression coefficients.
- `grad` : Gradient of the log-posterior at `theta`.
- `Hessian` : Hessian of the log-posterior at `theta`.
- `iter` : Number of iterations of the N-R algorithm.
- `llik` : Multinomial log likelihood.
- `Hessian0` : Hessian of the (non-penalized) log-likelihood at `theta`.
- `Sigma.theta` : Variance-covariance of 'theta'.
- `ED.full` : Effective degrees of freedom associated to each regression parameter, penalized parameters included.
- `se.theta` : Standard errors of the regression coefficients.
- `theta.mat` : Matrix containing the point estimate, standard error, credible interval, Z-score and P-value for `theta`.
- `nc` : Number of categories for the ordinal response.
- `nalpha` : Number of intercepts in the proportional odds model (=nc-1).
- `nbeta` : Number of regression parameters (intercepts excluded).
- `nfixed` : Number of non-penalized regression parameters.
- `ci.level` : Nominal coverage of the credible intervals (Default: .95).
- `n` : Sample size.
- `call` : Function call.
- `descending` : Logical indicating if the odds of the response taking a value in the upper scale should be preferred over values in the lower scale.
- `use.prior` : Logical indicating if a prior (such as a penalty) is assumed for the regression parameters.
- `lpost` : Value of the log-posterior at convergence.
- `levidence` : Log of the marginal likelihood (also named 'evidence').
- `AIC` : Aikake information criterion: $AIC = -2 \log Lik + 2 \times edf$ where `edf` stands for the effective degrees of freedom.
- `BIC` : Schwarz information criterion: $BIC = -2 \log Lik + n \times \log(edf)$ where `edf` stands for the effective degrees of freedom.
- `y` : Vector containing the values of the ordinal response.
- `regr` : List created by the internal function `DesignFormula` and containing diverse objects associated to the model specification, including the part of the design matrix 'X' associated to regressors and its extended version 'Xcal' with B-spline bases for additive term.
- `ED.Chi2` : Matrix containing the Effective Degrees of Freedom associated to the additive terms with their respective significance Chi2 test and P-value.

- `ED.Tr` : Matrix containing the Effective Degrees of Freedom associated to the additive terms with their respective significance $\langle \text{Tr} \rangle$ test (described by S. Wood, *Biometrika* 2013) and P-value.
- `lpost.fun` : Function with arguments (`theta`,`lambda`,`gradient=TRUE`,`Hessian=TRUE`) computing the log-posterior for given regression (and possibly spline) parameters `theta` and vector of penalty parameters `lambda` associated to the additive terms. Gradient and Hessian are also computed if requested.
- `lambda0` : Initial values for the vector of penalty parameters. Its length corresponds to the number of additive terms.
- `lambda` : (Selected) vector of penalty parameters. Its length corresponds to the number of additive terms.
- `select.lambda` : Logical indicating if `lambda` should be selected by maximizing the marginal likelihood or its marginal posterior.
- `lambda.family` : Chosen prior for `lambda`: possible choices are "none", "dgamma" (i.e. `dgamma(1,1e-4)`), "BetaPrime" (`BetaPrime(.5,.5)`) or "myprior" (with log of the prior density function in `myprior`). When "none" is selected, the marginal likelihood is directly maximized.
- `lprior.lambda` : Log of the prior density for the penalty parameters `lambda` when `select.lambda` is TRUE.
- `loglambda.loss` : The function of $\log(\lambda)$ that is minimized to select `lambda`. It is minus the log marginal likelihood (when `lambda.family` is "none") or minus the log of the marginal posterior for `lambda` otherwise.
- `nu.lpost` : Function giving the log of the marginal posterior density of $\nu = \log(\lambda)$.
- `nu.hat` : The mode of the marginal posterior density `nu.lpost` for $\nu = \log(\lambda)$.
- `V.nu` : Variance of the marginal posterior for $\nu = \log(\lambda)$.
- `se.nu` : Standard error of $\nu = \log(\lambda)$, i.e. the square-root of the diagonal elements of `V.nu`.
- `nu.dp` : List containing the parameters of the skew-t approximation to the marginal posterior of $\nu[j] = \log \lambda[j]$ associated to each of the `J` additive terms.
- `formula` : Formula used during the model specification.
- `elapsed.time` : Elapsed time.

Author(s)

Philippe Lambert <p.lambert@uliege.be>

References

Lambert, P. and Gressani, O. (2023) Penalty parameter selection and asymmetry corrections to Laplace approximations in Bayesian P-splines models. *Statistical Modelling*. <doi:10.1177/1471082X231181173>. Preprint: <arXiv:2210.01668>.

See Also

[ordgam](#), [print.ordregr](#), [plot.ordgam](#)

ordgam_additive *Compute the additive terms estimated using an 'ordgam' model*

Description

Compute the additive terms estimated using an 'ordgam' model

Usage

```
ordgam_additive(obj.ordgam, ngrid = 300, ci.level = 0.95)
```

Arguments

obj.ordgam	An object of class 'ordgam'.
ngrid	Number of grid points where the additive terms are computed.
ci.level	Credibility level for the pointwise credible region for the additive terms

Value

a list containing:

- `nalpha` : number of intercepts in the proportional odds model.
- `nfixed` : number of non-penalized regression parameters in 'beta'.
- `J` : number of additive terms.
- `additive.lab` : labels of the additive terms.
- `K` : number of spline parameters to specify an additive term.
- `knots` : list of length J containing the knots for the B-spline basis associated to a given additive term.
- `f.grid` : list of length J with, for each additive term, a list of length 2 with 'x': a vector of grid values for the covariate ; 'y.mat': a matrix with 3 columns (est,low,up) giving the additive term and its pointwise credible region
- `f` : a list of length J with, for each additive term <x>, a list with `f$x`: a function computing the additive term $f(x)$ for a given covariate value 'x' ; `attributes(f$x)`: support, label, range.
- `f.se` : a list of length J with, for each additive term <x>, a list with `f.se$x`: a function computing the s.e. of $f(x)$ for a given covariate value 'x' ; `attributes(f.se$x)`: support, label, range

Author(s)

Philippe Lambert <p.lambert@uliege.be>

References

Lambert, P. and Gressani, O. (2023) Penalty parameter selection and asymmetry corrections to Laplace approximations in Bayesian P-splines models. *Statistical Modelling*. <doi:10.1177/1471082X231181173>. Preprint: <arXiv:2210.01668>.

Examples

```
library(ordgam)
data(freehmsData)
mod = ordgam(freehms ~ gndr + s(eduyrs) + s(age),
             data=freehmsData, descending=TRUE)
obj = ordgam_additive(mod)
names(obj)
with(obj$f.grid$age,
     matplot(x, y.mat, lty=c(1,2,2),type="l",col=1,
             xlab="Age", ylab="f(Age)"))
```

ordreg
Fit a proportional odds model for ordinal data

Description

Fit a proportional odds model for ordinal data

Usage

```
ordregr(
  y,
  nc = NULL,
  Xcal = Xcal,
  descending = FALSE,
  prior = list(mean = NULL, Prec = NULL),
  theta0 = NULL,
  ci.level = 0.95
)
```

Arguments

<code>y</code>	Vector containing the ordinal response (coded using integers in 1:nc).
<code>nc</code>	(optional) Maximum value of <code>y</code> .
<code>Xcal</code>	Design matrix (excluding intercept columns).
<code>descending</code>	Logical indicating if the odds of the response taking a value in the upper scale should be preferred over values in the lower scale.
<code>prior</code>	(optional) List giving the 'mean' and 'Prec' (ision) of the regression parameters.
<code>theta0</code>	(Optional) Vector containing starting values for the regression parameters.
<code>ci.level</code>	Confidence levels of the computed credible intervals for the regression parameters.

Value

An object of class `ordregr.object`.

Author(s)

Philippe Lambert <p.lambert@uliege.be>

References

Lambert, P. and Gressani, O. (2023) Penalty parameter selection and asymmetry corrections to Laplace approximations in Bayesian P-splines models. *Statistical Modelling*. <doi:10.1177/1471082X231181173>. Preprint: <arXiv:2210.01668>.

See Also

[ordgam](#), [ordregr.object](#).

Examples

```
library(ordgam)
data(freehmsData)
Xcal = with(freehmsData, cbind(gndr, eduyrs, age))
mod = ordregr(y=freehmsData$freehms, Xcal=Xcal, descending=TRUE)
print(mod)
```

ordregr.object	<i>Object resulting from the fit of a proportional odds model using 'ordregr'</i>
----------------	---

Description

An object returned by the [ordregr](#) function: this is a list with various components related to the fit of such a model.

Value

A `ordregr` object is a list with following elements:

- `val` : Value of the log-posterior at convergence.
- `val.start` : Value of the log-posterior at the start of the Newton-Raphson (N-R) algorithm.
- `theta` : (Penalized) MLE or MAP of the regression coefficients.
- `grad` : Gradient of the log-posterior at `theta`.
- `Hessian` : Hessian of the log-posterior at `theta`.
- `iter` : Number of iterations of the N-R algorithm.
- `Hessian0` : Hessian of the (non-penalized) log-likelihood at `theta`.
- `Sigma.theta` : Variance-covariance of 'theta'.
- `ED.full` : Effective degrees of freedom associated to each regression parameter, penalized parameters included.

- `se.theta` : Standard errors of the regression coefficients.
- `theta.mat` : Matrix containing the point estimate, standard error, credible interval, Z-score and P-value for theta.
- `nc` : Number of categories for the ordinal response.
- `nalp` : Number of intercepts in the proportional odds model (=nc-1) .
- `nbeta` : Number of regression parameters (intercepts excluded).
- `nfixed` : Number of non-penalized regression parameters.
- `ci.level` : Nominal coverage of the credible intervals (Default: .95).
- `n` : Sample size.
- `call` : Function call.
- `descending` : Logical indicating if the odds of the response taking a value in the upper scale should be preferred over values in the lower scale.
- `use.prior` : Logical indicating if a prior (such as a penalty) is assumed for the regression parameters.
- `lpost` : Value of the log-posterior at convergence.
- `levidence` : Log of the marginal likelihood (also named 'evidence').

Author(s)

Philippe Lambert <p.lambert@uliege.be>

References

Lambert, P. and Gressani, O. (2023) Penalty parameter selection and asymmetry corrections to Laplace approximations in Bayesian P-splines models. *Statistical Modelling*. <doi:10.1177/1471082X231181173>. Preprint: <arXiv:2210.01668>.

See Also

[ordregr](#), [print.ordregr](#)

ordregr_lpost

Log-posterior function for a proportional odds model

Description

Log-posterior function for a proportional odds model

Usage

```
ord regr_lpost(
  y,
  nc,
  Xcal,
  theta,
  descending = FALSE,
  prior = list(mean = NULL, Prec = NULL),
  gradient = TRUE,
  Hessian = TRUE
)
```

Arguments

y	Vector containing the ordinal response (coded using integers in 1:nc).
nc	(optional) Maximum value of y.
Xcal	Design matrix.
theta	Vector c(alpha,beta) with intercepts <alpha> and regression parameters <beta>.
descending	Logical indicating if the odds of the response taking a value in the upper scale should be preferred over values in the lower scale.
prior	(optional) List given the mean and Prec(ision) of the regression parameters.
gradient	Logical indicating if the gradient of the log-posterior should be computed.
Hessian	Logical indicating if the Hessian of the log-posterior should be computed.

Value

The log-posterior with the following attributes:

- `Salpha` : gradient wrt intercepts 'alpha'.
- `Sbeta` : gradient wrt regression parameters 'beta'.
- `grad` : gradient wrt c(alpha,beta).
- `Halpha` : Hessian wrt intercepts 'alpha'.
- `Hbeta` : Hessian wrt regression parameters 'beta'.
- `Hba` : cross-derivatives (Hessian) submatrix wrt 'alpha' & 'beta'.
- `Hessian` : Hessian wrt c(alpha,beta).
- `dtheta` : step in a Newton-Raphson iteration: solve(-Hessian,grad).

References

Lambert, P. and Gressani, O. (2023) Penalty parameter selection and asymmetry corrections to Laplace approximations in Bayesian P-splines models. *Statistical Modelling*. <doi:10.1177/1471082X231181173>. Preprint: <arXiv:2210.01668>.

Pcal.fun	<i>Compute the penalty matrix associated to a vector containing fixed (non-penalized) parameters and equal-size sub-vectors of penalized spline parameters</i>
----------	--

Description

Compute the penalty matrix associated to a vector containing fixed (non-penalized) parameters and equal-size sub-vectors of penalized spline parameters

Usage

```
Pcal.fun(nfixed, lambda, Pd.x)
```

Arguments

nfixed	the number of fixed (i.e. non-penalized) parameters
lambda	a vector of J penalty parameters where each component is associated to a sub-vector of spline parameters of length K
Pd.x	a penalty matrix of size J associated to a given sub-vector of spline parameters

Value

A block diagonal penalty matrix of size (nfixed+JK) given by `Blockdiag(diag(0,nfixed), diag(lambda).kron.Pd.x)`

References

Lambert, P. and Gressani, O. (2023) Penalty parameter selection and asymmetry corrections to Laplace approximations in Bayesian P-splines models. *Statistical Modelling*. <doi:10.1177/1471082X231181173>. Preprint: <arXiv:2210.01668>.

Examples

```
Dd = diff(diag(1,5),diff=2) ## Difference penalty matrix for a vector of length 5
Pd = t(Dd) %*% Dd ## Penalty matrix of order 2
nfixed = 2 ## 2 unpenalized parameters
## Global penalty matrix when 2 unpenalized parameters and 2 additive terms with
## 2 vectors of 5 P-splines coefficients with lambda values 10 and 100 respectively.
Pcal.fun(nfixed=2,lambda=c(10,100),Pd)
```

plot.ordgam	<i>Plot the the additive terms in an <ordgam> object with its credible regions</i>
-------------	--

Description

Plot the the additive terms in an object generated by ordgam with its credible regions

Usage

```
## S3 method for class 'ordgam'  
plot(x, ngrid=300, ci.level=.95, mfrow=NULL, ...)
```

Arguments

x	An ordgam.object generated by ordgam .
ngrid	An integer indicating the number of gridpoints where the additive terms should be evaluated.
ci.level	Credibility level for the pointwise credible region of the additive terms.
mfrow	(Optional) A vector of the form c(nr, nc). Subsequent figures will be drawn in an nr-by-nc array on the device by rows.
...	Additional generic plotting arguments.

Value

In addition to the plots, an invisible object containing information on the estimated additive terms is returned, see the `ordgam_additive` function documentation for more details.

Author(s)

Philippe Lambert <p.lambert@uliege.be>

References

Lambert, P. and Gressani, O. (2023) Penalty parameter selection and asymmetry corrections to Laplace approximations in Bayesian P-splines models. *Statistical Modelling*. <doi:10.1177/1471082X231181173>. Preprint: <arXiv:2210.01668>.

See Also

[ordgam](#), [ordgam.object](#), [ordgam.additive](#), [print.ordregr](#).

Examples

```
library(ordgam)
data(freehmsData)
mod = ordgam(freehms ~ gndr + s(eduyrs) + s(age),
             data=freehmsData, descending=TRUE)
print(mod)
plot(mod)
```

print.ordregr *Print an 'ordregr' or an 'ordgam' object.*

Description

Print a summary of the information contained in an `ordregr.object` or `ordgam.object` generated by `ordregr` or `ordgam`.

Usage

```
## S3 method for class 'ordregr'
print(x, expEst, ...)
```

Arguments

x	An <code>ordregr.object</code> generated by <code>ordregr</code> or <code>ordgam</code> .
expEst	Logical indicating if the exponential of the regression coefficients should be printed (Default: TRUE)
...	Possible additional printing options.

Value

Print summary statistics.

Author(s)

Philippe Lambert <p.lambert@uliege.be>

References

Lambert, P. and Gressani, O. (2023) Penalty parameter selection and asymmetry corrections to Laplace approximations in Bayesian P-splines models. *Statistical Modelling*. <doi:10.1177/1471082X231181173>. Preprint: <arXiv:2210.01668>.

See Also

[ordregr](#), [ordgam](#)

Examples

```
library(ordgam)
data(freehmsData)
mod = ordgam(freehms ~ gndr + s(eduyrs) + s(age),
             data=freehmsData, descending=TRUE)
print(mod)
plot(mod)
```

SNapprox*Skew-Normal approximation to a density evaluated on a sparse grid*

Description

Skew-Normal approximation to a density evaluated on a sparse grid

Usage

```
SNapprox(x, lfx)
```

Arguments

x	Vector containing a grid of values on the density support and covering the posterior mode.
lfx	Log density values on the grid x (possibly up to an additive constant)

Value

A list containing

- `dp`: Parameters of the approximating skew-Normal density.
- `fitted.moments`: Mean, variance, skewness, kurtosis of the approximating skew-Normal.

Author(s)

Philippe Lambert <p.lambert@uliege.be>

References

Lambert, P. and Gressani, O. (2023) Penalty parameter selection and asymmetry corrections to Laplace approximations in Bayesian P-splines models. *Statistical Modelling*. <doi:10.1177/1471082X231181173>. Preprint: <arXiv:2210.01668>.

See Also

[STapprox](#).

Examples

```

library(ordgam)

## Density to be approximated by a Skew-Normal
dtarget = function(x) dgamma(x,10,2)
curve(dtarget(x),0,15,lwd=2,ylab="Density")

## Values of the target density on a sparse grid
ngrid = 6 ## Sparse grid size
xgrid = seq(2,8,length=ngrid) ## Grid
lfx = log(dtarget(xgrid)) ## Log values

## Skew-Normal approximation
dp = ordgam::SNapprox(xgrid,lfx)$dp
curve(sn::dsn(x,dp=dp),add=TRUE,lwd=2,lty=2,col=2)
points(xgrid,exp(lfx))
legend("topright",legend=c("Target density","Skew-Normal approx."),
      col=1:2,lty=1:2,lwd=2,bty="n")#' library(ordgam)

```

STapprox

Skew-t approximation to a density evaluated on a sparse grid

Description

Skew-t approximation to a density evaluated on a sparse grid

Usage

```
STapprox(x, lfx)
```

Arguments

x	Vector containing a grid of values on the density support and covering the posterior mode.
lfx	Log density values on the grid x (possibly up to an additive constant)

Value

A list containing

- `dp`: Parameters of the approximating skew-t density.
- `fitted.moments`: Mean, variance, skewness, kurtosis of the approximating skew-t.

Author(s)

Philippe Lambert <p.lambert@uliege.be>

References

Lambert, P. and Gressani, O. (2023) Penalty parameter selection and asymmetry corrections to Laplace approximations in Bayesian P-splines models. *Statistical Modelling*. <doi:10.1177/1471082X231181173>. Preprint: <arXiv:2210.01668>.

See Also

[SNapprox](#).

Examples

```
library(ordgam)

## Density to be approximated by a Skew-t
dtarget = function(x) dgamma(x,10,2)
curve(dtarget(x),0,15,lwd=2,ylab="Density")

## Values of the target density on a sparse grid
ngrid = 6 ## Sparse grid size
xgrid = seq(2,8,length=ngrid) ## Grid
lfx = log(dtarget(xgrid)) ## Log values

## Skew-t approximation
dp = ordgam::STapprox(xgrid,lfx)$dp
curve(sn::dst(x,dp=dp),add=TRUE,lwd=2,lty=2,col=2)
points(xgrid,exp(lfx))
legend("topright",legend=c("Target density","Skew-t approx."),
      col=1:2,lty=1:2,lwd=2,bty="n")
```

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