Package 'sdPrior'

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Title Scale-Dependent Hyperpriors in Structured Additive Distributional Regression

Version 1.0-0

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Description Utility functions for scale-dependent and alternative hyperpriors. The distribution parameters may capture location, scale, shape, etc. and every parameter may depend on complex additive terms (fixed, random, smooth, spatial, etc.) similar to a generalized additive model. Hyperpriors for all effects can be elicitated within the package. Including complex tensor product interaction terms and variable selection priors. The basic model is explained in in Klein and Kneib (2016) <doi:10.1214/15-BA983>.

Depends R (>= 3.1.0)

Imports splines, GB2, MASS, stats, pscl, mvtnorm, mgcv, graphics, doParallel, parallel

LazyData true

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NeedsCompilation no

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R topics documented:

`dapprox_unif` *Compute Density Function of Approximated (Differentiably) Uniform Distribution.*

Description

Compute Density Function of Approximated (Differentiably) Uniform Distribution.

Usage

```
dapprox_unif(x, scale, tildec = 13.86294)
```

Arguments

`x`	denotes the argument of the density function.
`scale`	the scale parameter originally defining the upper bound of the uniform distribution.
`tildec`	denotes the ratio between scale parameter θ and s. The latter is responsible for the closeness of the approximation to the uniform distribution. See also below for further details and the default value.

Details

The density of the uniform distribution for τ is approximated by

$$p(\tau) = (1/(1 + exp(\tau\tilde{c}/\theta - \tilde{c})))/(\theta(1 + log(1 + exp(-\tilde{c}))))$$

. This results in

$$p(\tau^2) = 0.5 * (\tau^2)^(- 1/2)(1/(1 + exp((\tau^2)^(1/2)\tilde{c}/\theta - \tilde{c})))/(\theta(1 + log(1 + exp(-\tilde{c}))))$$

for tau^2. $\tilde{c}$ is chosen such that $P(\tau <= \theta) >= 0.95$.

Value

the density.

Author(s)

Nadja Klein

References

Nadja Klein and Thomas Kneib (2015). Scale-Dependent Priors for Variance Parameters in Structured Additive Distributional Regression. *Working Paper*.

See Also

rapprox_unif,papprox_unif

DesignM *Computing Designmatrix for Splines*

Description

This function computes the design matrix for Bayesian P-splines as it would be done in BayesX. The implementation currently on works properly for default values (knots=20, degree=3).

Usage

```
DesignM(x, degree = 3, m = 20, min_x = min(x), max_x = max(x))
```

Arguments

x	the covariate vector.
degree	of the B-splines, default is 3.
m	number of knots, default is 20.
min_x	the left interval boundary, default is min(x).
max_x	the right interval boundary, defalut is max(x).

Value

a list with design matrix at distinct covariates, design matrix at all observations, index of sorted observations, the difference matrix, precision matrix and the knots used.

Author(s)

Nadja Klein

References

Stefan Lang and Andy Brezger (2004). Bayesian P-Splines. *Journal of Computational and Graphical Statistics*, **13**, 183–212.

Belitz, C., Brezger, A., Klein, N., Kneib, T., Lang, S., Umlauf, N. (2015): BayesX - Software for Bayesian inference in structured additive regression models. Version 3.0.1. Available from http://www.bayesx.org.

`get_theta` *Find Scale Parameter for (Scale Dependent) Hyperprior*

Description

This function implements a optimisation routine that computes the scale parameter θ of the scale dependent hyperprior for a given design matrix and prior precision matrix such that approximately $P(|f(x_k| \leq c, k = 1, \ldots, p) \geq 1 - \alpha$

Usage

```
get_theta(alpha = 0.01, method = "integrate", Z, c = 3,
  eps = .Machine$double.eps, Kinv)
```

Arguments

`alpha`	denotes the 1-α level.
`method`	either `integrate` or `trapezoid` with `integrate` as default. `trapezoid` is a self-implemented version of the trapezoid rule.
`Z`	the design matrix.
`c`	denotes the expected range of the function.
`eps`	denotes the error tolerance of the result, default is `.Machine$double.eps`.
`Kinv`	the generalised inverse of K.

Value

an object of class `list` with values from `uniroot`.

Author(s)

Nadja Klein

References

Nadja Klein and Thomas Kneib (2015). Scale-Dependent Priors for Variance Parameters in Structured Additive Distributional Regression. *Working Paper*.

Examples

```
## Not run:

set.seed(91179)
library(BayesX)
library(MASS)
# prior precision matrix to zambia data set
K <- read.gra(system.file("examples/zambia.gra", package="sdPrior"))
# generalised inverse of K
Kinv <- ginv(K)

# read data
dat <- read.table(system.file("examples/zambia_height92.raw", package="sdPrior"), header = TRUE)

# design matrix for spatial component
Z <- t(sapply(dat$district, FUN=function(x){1*(x==rownames(K))}))

# get scale parameter
theta <- get_theta(alpha = 0.01, method = "integrate", Z = Z,
                           c = 3, eps = .Machine$double.eps, Kinv = Kinv)$root

## End(Not run)
```

`get_theta_aunif` *Find Scale Parameter for Hyperprior for Variances Where the Standard Deviations have an Approximated (Differentiably) Uniform Distribution.*

Description

This function implements a optimisation routine that computes the scale parameter θ of the prior τ^2 (corresponding to a differentiably approximated version of the uniform prior for τ) for a given design matrix and prior precision matrix such that approximately $P(|f(x_k| \leq c, k = 1, \ldots, p) \geq 1 - \alpha$

Usage

```
get_theta_aunif(alpha = 0.01, method = "integrate", Z, c = 3,
  eps = .Machine$double.eps, Kinv)
```

Arguments

`alpha`	denotes the 1-α level.
`method`	with `integrate` as default. Currently no further method implemented.
`Z`	the design matrix.
`c`	denotes the expected range of the function.
`eps`	denotes the error tolerance of the result, default is `.Machine$double.eps`.
`Kinv`	the generalised inverse of K.

Value

an object of class `list` with values from `uniroot`.

Author(s)

Nadja Klein

References

Nadja Klein and Thomas Kneib (2015). Scale-Dependent Priors for Variance Parameters in Structured Additive Distributional Regression. *Working Paper*.

Andrew Gelman (2006). Prior Distributions for Variance Parameters in Hierarchical Models. *Bayesian Analysis*, **1**(3), 515–533.

Examples

```
set.seed(123)
library(MASS)
# prior precision matrix (second order differences)
# of a spline of degree l=3 and with m=20 inner knots
# yielding dim(K)=m+l-1=22
K <- t(diff(diag(22), differences=2))%*%diff(diag(22), differences=2)
# generalised inverse of K
Kinv <- ginv(K)
# covariate x
x <- runif(1)
Z <- matrix(DesignM(x)$Z_B,nrow=1)
theta <- get_theta_aunif(alpha = 0.01, method = "integrate", Z = Z,
                           c = 3, eps = .Machine$double.eps, Kinv = Kinv)$root
```

`get_theta_ga` *Find Scale Parameter for Gamma (Half-Normal) Hyperprior*

Description

This function implements a optimisation routine that computes the scale parameter θ of the gamma prior for τ^2 (corresponding to a half-normal prior for τ) for a given design matrix and prior precision matrix such that approximately $P(|f(x_k| \leq c, k = 1, \ldots, p) \geq 1 - \alpha$

Usage

```
get_theta_ga(alpha = 0.01, method = "integrate", Z, c = 3,
  eps = .Machine$double.eps, Kinv)
```

Arguments

alpha	denotes the 1-α level.
method	with integrate as default. Currently no further method implemented.
Z	the design matrix.
c	denotes the expected range of the function.
eps	denotes the error tolerance of the result, default is .Machine$double.eps.
Kinv	the generalised inverse of K.

Value

an object of class list with values from uniroot.

Author(s)

Nadja Klein

References

Nadja Klein and Thomas Kneib (2015). Scale-Dependent Priors for Variance Parameters in Structured Additive Distributional Regression. *Working Paper*.

Andrew Gelman (2006). Prior Distributions for Variance Parameters in Hierarchical Models. *Bayesian Analysis*, **1**(3), 515–533.

Examples

```
set.seed(123)
require(MASS)
# prior precision matrix (second order differences)
# of a spline of degree l=3 and with m=20 inner knots
# yielding dim(K)=m+l-1=22
K <- t(diff(diag(22), differences=2))%*%diff(diag(22), differences=2)
# generalised inverse of K
Kinv <- ginv(K)
# covariate x
x <- runif(1)
Z <- matrix(DesignM(x)$Z_B,nrow=1)
theta <- get_theta_ga(alpha = 0.01, method = "integrate", Z = Z,
                            c = 3, eps = .Machine$double.eps, Kinv = Kinv)$root

## Not run:

set.seed(91179)
library(BayesX)
library(MASS)
# prior precision matrix to zambia data set
K <- read.gra(system.file("examples/zambia.gra", package="sdPrior"))
# generalised inverse of K
Kinv <- ginv(K)
```

```
# read data
dat <- read.table(system.file("examples/zambia_height92.raw", package="sdPrior"), header = TRUE)

# design matrix for spatial component
Z <- t(sapply(dat$district, FUN=function(x){1*(x==rownames(K))}))

# get scale parameter
theta <- get_theta_ga(alpha = 0.01, method = "integrate", Z = Z,
                            c = 3, eps = .Machine$double.eps, Kinv = Kinv)$root

## End(Not run)
```

`get_theta_gbp` *Find Scale Parameter for Generalised Beta Prime (Half-Cauchy) Hyperprior*

Description

This function implements a optimisation routine that computes the scale parameter θ of the gamma prior for τ^2 (corresponding to a half cauchy for τ) for a given design matrix and prior precision matrix such that approximately $P(|f(x_k| \leq c, k = 1, \ldots, p) \geq 1 - \alpha$

Usage

```
get_theta_gbp(alpha = 0.01, method = "integrate", Z, c = 3,
  eps = .Machine$double.eps, Kinv)
```

Arguments

`alpha`	denotes the 1-α level.
`method`	with `integrate` as default. Currently no further method implemented.
`Z`	the design matrix.
`c`	denotes the expected range of the function.
`eps`	denotes the error tolerance of the result, default is `.Machine$double.eps`.
`Kinv`	the generalised inverse of K.

Value

an object of class `list` with values from `uniroot`.

Author(s)

Nadja Klein

References

Nadja Klein and Thomas Kneib (2015). Scale-Dependent Priors for Variance Parameters in Structured Additive Distributional Regression. *Working Paper*.

Andrew Gelman (2006). Prior Distributions for Variance Parameters in Hierarchical Models. *Bayesian Analysis*, **1**(3), 515–533.

Examples

```
set.seed(123)
require(MASS)
# prior precision matrix (second order differences)
# of a spline of degree l=3 and with m=20 inner knots
# yielding dim(K)=m+l-1=22
K <- t(diff(diag(22), differences=2))%*%diff(diag(22), differences=2)
# generalised inverse of K
Kinv <- ginv(K)
# covariate x
x <- runif(1)
Z <- matrix(DesignM(x)$Z_B,nrow=1)
theta <- get_theta_gbp(alpha = 0.01, method = "integrate", Z = Z,
                           c = 3, eps = .Machine$double.eps, Kinv = Kinv)$root

## Not run:

set.seed(91179)
library(BayesX)
library(MASS)
# prior precision matrix to zambia data set
K <- read.gra(system.file("examples/zambia.gra", package="sdPrior"))
# generalised inverse of K
Kinv <- ginv(K)

# read data
dat <- read.table(system.file("examples/zambia_height92.raw", package="sdPrior"), header = TRUE)

# design matrix for spatial component
Z <- t(sapply(dat$district, FUN=function(x){1*(x==rownames(K))}))

# get scale parameter
theta <- get_theta_gbp(alpha = 0.01, method = "integrate", Z = Z,
                           c = 3, eps = .Machine$double.eps, Kinv = Kinv)$root

## End(Not run)
```

`get_theta_ig` *Find Scale Parameter for Inverse Gamma Hyperprior*

Description

This function implements a optimisation routine that computes the scale parameter b of the inverse gamma prior for τ^2 when $a = b = \epsilon$ with ϵ small for a given design matrix and prior precision matrix such that approximately $P(|f(x_k| \leq c, k = 1, \ldots, p) \geq 1 - \alpha$ When a unequal to a the shape parameter a has to be specified.

Usage

```
get_theta_ig(alpha = 0.01, method = "integrate", Z, c = 3,
  eps = .Machine$double.eps, Kinv, equals = FALSE, a = 1,
  type = "marginalt")
```

Arguments

alpha	denotes the 1-α level.
method	with integrate as default. Currently no further method implemented.
Z	the design matrix.
c	denotes the expected range of the function.
eps	denotes the error tolerance of the result, default is .Machine$double.eps.
Kinv	the generalised inverse of K.
equals	saying whether a=b. The default is FALSE due to the fact that a is a shape parameter.
a	is the shape parameter of the inverse gamma distribution, default is 1.
type	is either numerical integration (integrate) of to obtain the marginal distribution of $z_p'\beta$ or the theoretical marginal t-distribution (marginalt). marginalt is the default value.

Details

Currently, the implementation only works properly for the cases a unequal b.

Value

an object of class list with values from uniroot.

Author(s)

Nadja Klein

References

Nadja Klein and Thomas Kneib (2015). Scale-Dependent Priors for Variance Parameters in Structured Additive Distributional Regression. *Working Paper*.

Stefan Lang and Andreas Brezger (2004). Bayesian P-Splines. *Journal of Computational and Graphical Statistics*, **13**, 183-212.

Examples

```
set.seed(123)
library(MASS)
# prior precision matrix (second order differences)
# of a spline of degree l=3 and with m=20 inner knots
# yielding dim(K)=m+l-1=22
K <- t(diff(diag(22), differences=2))%*%diff(diag(22), differences=2)
# generalised inverse of K
Kinv <- ginv(K)
# covariate x
x <- runif(1)
Z <- matrix(DesignM(x)$Z_B,nrow=1)
theta <- get_theta_ig(alpha = 0.01, method = "integrate", Z = Z,
                      c = 3, eps = .Machine$double.eps, Kinv = Kinv,
 equals = FALSE, a = 1, type="marginalt")$root
```

`get_theta_linear` *Find Scale Parameter for Inverse Gamma Hyperprior of Linear Effects with Spike and Slab Prior*

Description

This function implements a optimisation routine that computes the scale parameter v_2 and selection parameter r of the inverse gamma prior IG(v_1,v_2) for τ^2 when $\tau^2 \sim N(0, r(\delta)\tau^2)$ and given shape paramter such that approximately $P(\beta \leq c_2|spike) \geq 1 - \alpha_2$ and $P(\beta \geq c_1|slab) \geq 1 - \alpha 1$. α_1 and α_2 should not be smaller than 0.1 due to numerical sensitivity and possible instability. Better change c_1, c_2.

Usage

```
get_theta_linear(alpha1 = 0.1, alpha2 = 0.1, c1 = 0.1, c2 = 0.1,
  eps = .Machine$double.eps, v1 = 5)
```

Arguments

`alpha1`	denotes the 1-α_1 level for v_2.
`alpha2`	denotes the 1-α_2 level for r.
`c1`	denotes the expected range of the linear effect in the slab part.
`c2`	denotes the expected range of the linear effect in the spike part.
`eps`	denotes the error tolerance of the result, default is `.Machine$double.eps`.
`v1`	is the shape parameter of the inverse gamma distribution, default is 5.

Value

an object of class `list` with values from `uniroot`.

Warning

α_1 and α_2 should not be smaller than 0.1 due to numerical sensitivity and possible instability. Better change c_1, c_2.

Author(s)

Nadja Klein

References

Nadja Klein, Thomas Kneib, Stefan Lang and Helga Wagner (2016). Automatic Effect Selection in Distributional Regression via Spike and Slab Priors. *Working Paper*.

Examples

```
set.seed(123)
result <- get_theta_linear()
r <- result$r
v2 <- result$v2

get_theta_linear(alpha1=0.1,alpha2=0.1,c1=0.5,c2=0.1,v1=5)
```

`hyperpar` *Find Scale Parameters for Inverse Gamma Hyperprior of Nonlinear Effects with Spike and Slab Prior (Simulation-based)*

Description

This function implements a optimisation routine that computes the scale parameter b and selection parameter r. . Here, we assume an inverse gamma prior IG(a,b) for ψ^2 and $\tau^2 \sim N(0, r(\delta)\psi^2)$ and given shape paramter a, such that approximately $P(f(x) \leq c|spike, \forall x \in D) \geq 1 - \alpha 1$ and $P(\exists x \in Ds.t.f(x) \geq c|slab) \geq 1 - \alpha 2$.

Usage

```
hyperpar(Z, Kinv, a = 5, c = 0.1, alpha1 = 0.1, alpha2 = 0.1,
  R = 10000, myseed = 123)
```

Arguments

`Z`	the row of the design matrix (or the complete matrix of several observations) evaluated at.
`Kinv`	the generalised inverse of K.
`a`	is the shape parameter of the inverse gamma distribution, default is 5.
`c`	denotes the expected range of eqnf .
`alpha1`	denotes the 1-$\alpha 1$ level for b.

alpha2	denotes the 1-$\alpha 2$ level for r.
R	denotes the number of replicates drawn during simulation.
myseed	denotes the required seed for the simulation based method.

Value

an object of class `list` with root values r, b from `uniroot`.

Author(s)

Nadja Klein

References

Nadja Klein, Thomas Kneib, Stefan Lang and Helga Wagner (2016). Spike and Slab Priors for Effect Selection in Distributional Regression. *Working Paper*.

Examples

```
set.seed(123)
library(MASS)
# prior precision matrix (second order differences)
# of a spline of degree l=3 and with m=22 inner knots
# yielding dim(K)=m+l-1=22
K <- t(diff(diag(22), differences=2))%*%diff(diag(22), differences=2)
# generalised inverse of K (same as if we used mixed model representation!)
Kinv <- ginv(K)
# covariate x
x <- runif(1)
Z <- matrix(DesignM(x)$Z_B,nrow=1)
fgrid <- seq(-3,3,length=1000)
mdf <- hyperpar(Z,Kinv,a=5,c=0.1,alpha1=0.05,alpha2=0.05,R=10000,myseed=123)
```

`hyperparlin` *Find Scale Parameter for Inverse Gamma Hyperprior of Linear Effects with Spike and Slab Prior*

Description

This function implements a optimisation routine that computes the scale parameter b and selection parameter r. Here, we assume an inverse gamma prior IG(a,b) for τ^2 and $\beta|\delta, \tau^2 \sim N(0, r(\delta)\tau^2)$. For given shape paramter a the user gets b, r such that approximately $P(\beta \leq c2|spike) \geq 1 - \alpha 2$ and $P(\beta \geq c1|slab) \geq 1 - \alpha 1$ hold.
Note that if you observe numerical instabilities try not to specify $\alpha 1$ and $\alpha 2$ smaller than 0.1.

Usage

```
hyperparlin(alpha1 = 0.1, alpha2 = 0.1, c1 = 0.1, c2 = 0.1,
  eps = .Machine$double.eps, a = 5)
```

Arguments

alpha1	denotes the 1-$\alpha 1$ level for b.
alpha2	denotes the 1-$\alpha 2$ level for r.
c1	denotes the expected range of the linear effect in the slab part.
c2	denotes the expected range of the linear effect in the spike part.
eps	denotes the error tolerance of the result, default is .Machine$double.eps.
a	is the shape parameter of the inverse gamma distribution, default is 5.

Value

an object of class list with root values r, b from uniroot.

Warning

$\alpha 1$ and $\alpha 2$ should not be smaller than 0.1 due to numerical sensitivity and possible instability. Better change $c1$, $c2$.

Author(s)

Nadja Klein

References

Nadja Klein, Thomas Kneib, Stefan Lang and Helga Wagner (2016). Automatic Effect Selection in Distributional Regression via Spike and Slab Priors. *Working Paper*.

Examples

```
set.seed(123)
result <- hyperparlin()
r <- result$r
b <- result$b

hyperparlin(alpha1=0.1,alpha2=0.1,c1=0.5,c2=0.1,a=5)
```

hyperpar_mod *Find Scale Parameter for modular regression*

Description

Find Scale Parameter for modular regression

Usage

```
hyperpar_mod(Z, K1, K2, A, c = 0.1, alpha = 0.1, omegaseq, omegaprob,
  R = 10000, myseed = 123, thetaseq = NULL, type = "IG",
  lowrank = FALSE, k = 5, mc = FALSE, ncores = 1, truncate = 1)
```

Arguments

Z	rows from the tensor product design matrix
K1	precision matrix1
K2	precision matrix2
A	constraint matrix
c	threshold from eq. (8) in Klein & Kneib (2016)
alpha	probability parameter from eq. (8) in Klein & Kneib (2016)
omegaseq	sequence of weights for the anisotropy
omegaprob	prior probabilities for the weights
R	number of simulations
myseed	seed in case of simulation. default is 123.
thetaseq	possible sequence of thetas. default is NULL.
type	type of hyperprior for tau/tau^2; options: IG => IG(1,theta) for tau^2, SD => WE(0.5,theta) for tau^2, HN => HN(0,theta) for tau, U => U(0,theta) for tau, HC => HC(0,theta) for tau
lowrank	default is FALSE. If TRUE a low rank approximation is used for Z with k columns.
k	only used if lowrank=TRUE. specifies target rank of low rank approximation. Default is 5.
mc	default is FALSE. only works im thetaseq is supplied. can parallel across thetaseq.
ncores	default is 1. number of cores is mc=TRUE
truncate	default is 1. If < 1 the lowrank approximation is based on on cumsum(values)/sum(values).

Value

the optimal value for theta

Author(s)

Nadja Klein

References

Kneib, T., Klein, N., Lang, S. and Umlauf, N. (2017) Modular Regression - A Lego System for Building Structured Additive Distributional Regression Models with Tensor Product Interactions *Working Paper*.

---

mdbeta *Marginal Density of β*

Description

This function computes the marginal density of β and for β on an equidistant grid specified by the user. Currently only implemented for $dim(\beta) = 1, 2$.

Usage

```
mdbeta(D = 1, rangebeta, ngridbeta, a = 5, b = 25, r = 0.00025,
  a0 = 0.5, b0 = 0.5, plot = FALSE, log = FALSE)
```

Arguments

D	dimension of β.
rangebeta	a vector containing the start and ending point of β to be computed for.
ngridbeta	the number of grid values.
a	shape parameter of inverse gamma prior of ψ^2.
b	scale parameter of inverse gamma prior of ψ^2.
r	the scaling parameter $r(\delta = 1)$ in the variance $r(\delta)\psi^2$ of prior of τ^2.
a0	shape parameter of beta prior of ω.
b0	scale parameter of beta prior of ω.
plot	logical value (default is FALSE). If TRUE, a plot is also returned as the function pl().
log	logical value (default is FALSE). If TRUE, $log(p(\beta))$ is also returned in logval. as well as, if necessary, a plot function logpl().

Value

the marginal density, the sequence of β and depending on specified plot, log arguments also the log-density and plot functions.

Author(s)

Nadja Klein

References

Nadja Klein, Thomas Kneib, Stefan Lang and Helga Wagner (2016). Spike and Slab Priors for Effect Selection in Distributional Regression. *Working Paper*.

Examples

```
set.seed(123)
#1-dimensional example
D = 1
ngridbeta = 1000
rangebeta = c(0.000001,1)
a0 = b0 = 0.5
a = 5
b = 50
r = 0.005
mdf <- mdbeta(D=1,rangebeta,ngridbeta,a=a,b=b,r=r,a0=a0,b0=b0)

#2-dimensional example
D = 2
ngridbeta = 100
rangebeta = c(0.000001,8)
a0 = b0 = 0.5
a = 5
b = 50
r = 0.005
mdf <- mdbeta(D=2,rangebeta,ngridbeta,a=a,b=b,r=r,a0=a0,b0=b0,plot=TRUE,log=TRUE)
mdf$logpl()
```

---

mdf_aunif *Marginal Density for Given Scale Parameter and Approximated Uniform Prior for τ*

Description

This function computes the marginal density of $z_p'\beta$ for approximated uniform hyperprior for τ

Usage

```
mdf_aunif(f, theta, Z, Kinv)
```

Arguments

f	point the marginal density to be evaluated at.
theta	denotes the scale parameter of the approximated uniform hyperprior for τ.
Z	the row of the design matrix evaluated.
Kinv	the generalised inverse of K.

Value

the marginal density evaluated at point x.

Author(s)

Nadja Klein

References

Nadja Klein and Thomas Kneib (2015). Scale-Dependent Priors for Variance Parameters in Structured Additive Distributional Regression. *Working Paper*.

Examples

```
set.seed(123)
library(MASS)
# prior precision matrix (second order differences)
# of a spline of degree l=3 and with m=20 inner knots
# yielding dim(K)=m+l-1=22
K <- t(diff(diag(22), differences=2))%*%diff(diag(22), differences=2)
# generalised inverse of K
Kinv <- ginv(K)
# covariate x
x <- runif(1)
Z <- matrix(DesignM(x)$Z_B,nrow=1)
fgrid <- seq(-3,3,length=1000)
mdf <- mdf_aunif(fgrid,theta=0.0028,Z=Z,Kinv=Kinv)
```

---

mdf_ga *Marginal Density for Given Scale Parameter and Half-Normal Prior for τ*

Description

This function computes the marginal density of $z_p'\beta$ for gamma priors for τ^2 (referring to a half-normal prior for τ).

Usage

```
mdf_ga(f, theta, Z, Kinv)
```

Arguments

f	point the marginal density to be evaluated at.
theta	denotes the scale parameter of the gamma hyperprior for τ^2 (half-normal for τ).
Z	the row of the design matrix evaluated.
Kinv	the generalised inverse of K.

Value

the marginal density evaluated at point x.

Author(s)

Nadja Klein

References

Nadja Klein and Thomas Kneib (2015). Scale-Dependent Priors for Variance Parameters in Structured Additive Distributional Regression. *Working Paper*.

Examples

```
set.seed(123)
library(MASS)
# prior precision matrix (second order differences)
# of a spline of degree l=3 and with m=20 inner knots
# yielding dim(K)=m+l-1=22
K <- t(diff(diag(22), differences=2))%*%diff(diag(22), differences=2)
# generalised inverse of K
Kinv <- ginv(K)
# covariate x
x <- runif(1)
Z <- matrix(DesignM(x)$Z_B,nrow=1)
fgrid <- seq(-3,3,length=1000)
mdf <- mdf_ga(fgrid,theta=0.0028,Z=Z,Kinv=Kinv)
```

---

mdf_gbp *Marginal Density for Given Scale Parameter and Half-Cauchy Prior for τ*

Description

This function computes the marginal density of $z_p'\beta$ for generalised beta prior hyperprior for τ^2 (half-Chauchy for τ)

Usage

```
mdf_gbp(f, theta, Z, Kinv)
```

Arguments

f	point the marginal density to be evaluated at.
theta	denotes the scale parameter of the generalised beta prior hyperprior for τ^2 (half-Chauchy for τ).
Z	the row of the design matrix evaluated.
Kinv	the generalised inverse of K.

Value

the marginal density evaluated at point x.

Author(s)

Nadja Klein

References

Nadja Klein and Thomas Kneib (2015). Scale-Dependent Priors for Variance Parameters in Structured Additive Distributional Regression. *Working Paper*.

Examples

```
set.seed(123)
library(MASS)
# prior precision matrix (second order differences)
# of a spline of degree l=3 and with m=20 inner knots
# yielding dim(K)=m+l-1=22
K <- t(diff(diag(22), differences=2))%*%diff(diag(22), differences=2)
# generalised inverse of K
Kinv <- ginv(K)
# covariate x
x <- runif(1)
Z <- matrix(DesignM(x)$Z_B,nrow=1)
fgrid <- seq(-3,3,length=1000)
mdf <- mdf_gbp(fgrid,theta=0.0028,Z=Z,Kinv=Kinv)
```

---

mdf_ig *Marginal Density for Given Scale Parameter and Inverse Gamma Prior for $\tau\hat{}2$*

Description

This function computes the marginal density of $z_p'\beta$ for inverse gamma hyperpriors with shape parameter a=1.

Usage

```
mdf_ig(f, theta, Z, Kinv)
```

Arguments

f	point the marginal density to be evaluated at.
theta	denotes the scale parameter of the inverse gamma hyperprior.
Z	the row of the design matrix evaluated.
Kinv	the generalised inverse of K.

Value

the marginal density evaluated at point x.

Author(s)

Nadja Klein

References

Nadja Klein and Thomas Kneib (2015). Scale-Dependent Priors for Variance Parameters in Structured Additive Distributional Regression. *Working Paper*.

Examples

```
set.seed(123)
library(MASS)
# prior precision matrix (second order differences)
# of a spline of degree l=3 and with m=20 inner knots
# yielding dim(K)=m+l-1=22
K <- t(diff(diag(22), differences=2))%*%diff(diag(22), differences=2)
# generalised inverse of K
Kinv <- ginv(K)
# covariate x
x <- runif(1)
Z <- matrix(DesignM(x)$Z_B,nrow=1)
fgrid <- seq(-3,3,length=1000)
mdf <- mdf_ig(fgrid,theta=0.0028,Z=Z,Kinv=Kinv)
```

`mdf_sd` *Marginal Density for Given Scale Parameter and Scale-Dependent Prior for τ^2*

Description

This function computes the marginal density of $z_p'\beta$ for scale-dependent priors for τ^2

Usage

```
mdf_sd(f, theta, Z, Kinv)
```

Arguments

`f`	point the marginal density to be evaluated at.
`theta`	denotes the scale parameter of the scale-dependent hyperprior for τ^2.
`Z`	the row of the design matrix evaluated.
`Kinv`	the generalised inverse of K.

Value

the marginal density evaluated at point x.

Author(s)

Nadja Klein

References

Nadja Klein and Thomas Kneib (2015). Scale-Dependent Priors for Variance Parameters in Structured Additive Distributional Regression. *Working Paper*.

Examples

```
set.seed(123)
library(MASS)
# prior precision matrix (second order differences)
# of a spline of degree l=3 and with m=20 inner knots
# yielding dim(K)=m+l-1=22
K <- t(diff(diag(22), differences=2))%*%diff(diag(22), differences=2)
# generalised inverse of K
Kinv <- ginv(K)
# covariate x
x <- runif(1)
Z <- matrix(DesignM(x)$Z_B,nrow=1)
fgrid <- seq(-3,3,length=1000)
mdf <- mdf_sd(fgrid,theta=0.0028,Z=Z,Kinv=Kinv)
```

---

papprox_unif *Compute Cumulative Distribution Function of Approximated (Differentiably) Uniform Distribution.*

Description

Compute Cumulative Distribution Function of Approximated (Differentiably) Uniform Distribution.

Usage

```
papprox_unif(x, scale, tildec = 13.86294)
```

Arguments

x	denotes the argument of cumulative distribution function
scale	the scale parameter originally defining the upper bound of the uniform distribution.
tildec	denotes the ratio between scale parameter θ and s. The latter is responsible for the closeness of the approximation to the uniform distribution. See also below for further details and the default value.

Details

The cumulative distribution function of dapprox_unif is given by

$$(1/(log(1+exp(-\tilde{c}))+\tilde{c}))*(\tilde{c}*(\tau^2)^(1/2)/\theta - log(exp((\tau^2)^(1/2)*\tilde{c}/\theta)+exp(\tilde{c})))$$

$\tilde{c}$ is chosen such that $P(\tau^2 <= \theta) >= 0.95$.

Value

the cumulative distribution function.

Author(s)

Nadja Klein

References

Nadja Klein and Thomas Kneib (2015). Scale-Dependent Priors for Variance Parameters in Structured Additive Distributional Regression. *Working Paper*.

See Also

rapprox_unif,dapprox_unif

`rapprox_unif` *Draw Random Numbers from Approximated (Differentiably) Uniform Distribution.*

Description

Draw Random Numbers from Approximated (Differentiably) Uniform Distribution.

Usage

```
rapprox_unif(n = 100, scale, tildec = 13.86294, seed = 123)
```

Arguments

n	number of draws.
scale	the scale parameter originally defining the upper bound of the uniform distribution.
tildec	denotes the ratio between scale parameter θ and s. The latter is responsible for the closeness of the approximation to the uniform distribution. See also below for further details and the default value.
seed	denotes the seed

Details

The method is based on the inversion method and the quantile function is computed numerically using uniroot.

Value

n draws with density papprox_unif.

Author(s)

Nadja Klein

References

Nadja Klein and Thomas Kneib (2015). Scale-Dependent Priors for Variance Parameters in Structured Additive Distributional Regression. *Working Paper*.

See Also

rapprox_unif,papprox_unif

---

zambia_graph *Prior precision matrix for spatial variable in Zambia data set*

Description

This is a 57x57 matrix containing row- and columwise the regions of Zambia, and the entries define the neighbourhoodstructure. The corresponding map sambia.bnd can be downloaded from http://www.stat.uni-muenchen.de/~kneib/regressionsbuch/daten_e.html. from the bnd file the prior precision matrix is obtained by library(BayesX) map <- read.bnd("zambia.bnd") K <- bnd2gra(map)

---

zambia_height92 *Malnutrition in Zambia*

Description

The primary goal of a statistical analysis is to determine the effect of certain socioeconomic variables of the child, the mother, and the household on the child‘s nutritional condition

- zscore child‘s Z-score
- c _breastf duration of breastfeeding in months
- c_age child‘s age in months
- m_agebirth mother‘s age at birth in years

- m_height mother‘s height in centimeter
- m_bmi mother‘s body mass index
- m_education mother‘s level of education
- m_work mother‘s work status
- region region of residence in Zambia
- district district of residence in Zambia

Format

A data frame with 4421 rows and 21 variables

Source

http://www.stat.uni-muenchen.de/~kneib/regressionsbuch/daten_e.html

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