Package ‘InvStablePrior’

July 21, 2025

Type Package

Title Inverse Stable Prior for Widely-Used Exponential Models

Version 0.1.1

Description Contains functions that allow Bayesian inference on a parameter of some widely-used exponential models. The functions can generate independent samples from the closed-form posterior distribution using the inverse stable prior. Inverse stable is a non-conjugate prior for a parameter of an exponential subclass of discrete and continuous data distributions (e.g. Poisson, exponential, inverse gamma, double exponential (Laplace), half-normal/half-Gaussian, etc.). The prior class provides flexibility in capturing a wide array of prior beliefs (right-skewed and left-skewed) as modulated by a parameter that is bounded in (0,1). The generated samples can be used to simulate the prior and posterior predictive distributions. More details can be found in Cahoy and Sedransk (2019) <doi:10.1007/s42519-018-0027-2>. The package can also be used as a teaching demo for introductory Bayesian courses.

License GPL (>= 3)

Encoding UTF-8

Imports stats, fdrtool, nimble

RoxygenNote 7.2.3

NeedsCompilation no

Author Dexter Cahoy [aut, cre],
Joseph Sedransk [aut]

Maintainer Dexter Cahoy <dexter.cahoy@gmail.com>

Repository CRAN

Date/Publication 2023-08-21 22:10:02 UTC

Contents

InvStablePrior *InvStablePrior Package*

Description

Contains random number generation, plotting, and estimation algorithms for performing Bayesian inference on a parameter of some widely-used exponential data models. The package contains algorithms for the inverse stable-Poisson, inverse stable-exponential, inverse stable-double exponential, inverse stable-inverse gamma, and inverse stable-half-normal models.

Details

References:

Cahoy and Sedransk (2019)<doi:10.1007/s42519-018-0027-2>

Meerschaert and Straka (2013)<doi:10.1051/mmnp/20138201>

Mainardi, Mura, and Pagnini (2010) <doi:10.1155/2010/104505>

Author(s)

Dexter Cahoy <cahoyd@uhd.edu>

---

isdexp *Bayesian inference for the true rate of double exponential (Laplace) distribution.*

Description

Generates random numbers from the prior and posterior distributions of the inverse stable-double exponential model. The random variates can be used to simulate prior and posterior predictive distributions as well.

Usage

```
isdexp(x, B, alp, rho)
```

Arguments

x	vector of double exponential (Laplace) data.
B	test size for the adaptive rejection sampling algorithm.
alp	value between 0 and 1 that controls the shape of the inverse stable prior.
rho	positive value that scales the mean of the inverse stable prior.

Value

list consisting of the vectors of random numbers from the prior and posterior distributions, the accepted sample size, and the acceptance probability of the adaptive rejection sampling procedure (Algorithm 2 of the first reference below).

References

Cahoy and Sedransk (2019). *Inverse stable prior for exponential models.* Journal of Statistical Theory and Practice, 13, Article 29. <doi:10.1007/s42519-018-0027-2>

Meerschaert and Straka (2013). *Inverse stable subordinators.* Math. Model. Nat. Phenom., 8(2), 1-16. <doi:10.1051/mmnp/20138201>

Mainardi, Mura, and Pagnini (2010). *The M-Wright Function in Time-Fractional Diffusion Processes: A Tutorial Survey*. Int. J. Differ. Equ., Volume 2010. <doi:10.1155/2010/104505>

Examples

```
alp=0.95
require(nimble)
dat=rdexp(30, location = 0,  rate = 2)
rho=1/sd(dat)


#b=n
#a=sum(abs(dat) )
#rho=optimize(function(r){exp(-b)*(b/a)^b - (r^b)*exp(-a*r)}, c(0,20),  tol=10^(-50)  )$min

out= isdexp(dat, B=1000000, alp , rho)
#prior samples
thetprior=unlist(out[2])
summary(thetprior)

#posterior samples
thet=unlist(out[1])

#95% Credible intervals
quantile (thet, c(0.025,0.975) )
summary(thet)

#The accepted sample size:
unlist(out[3])

#The acceptance probability:
unlist(out[4])

#Plotting with normalization to have a maximum of 1
#for comparing prior and posterior
out2=density(thet)
ymaxpost=max(out2$y)
out3=density(thetprior)
ymaxprior=max(out3$y)
plot(out2$x,out2$y/ymaxpost, xlim=c(0,5), col="blue", type="l",
```

```
 xlab="theta", ylab="density", lwd=2, frame.plot=FALSE)
lines(out3$x,out3$y/ymaxprior,lwd=2,col="red")
#points(dat,rep(0,length(dat)), pch='*')


#Generating 1000 random numbers from the Inverse Stable (alpha=0.4,rho=5) prior
U1 = runif(1000)
U2 = runif(1000)
alp=0.4
rho=5
stab = ( ( sin(alp*pi*U1)*sin((1-alp)*pi*U1)^(1/alp-1) )
/ (  ( sin(pi*U1)^(1/alp) )*abs(log(U2))^(1/alp-1))  )
#Inverse stable random numbers are below:
#rho*stab^(-alp)
```

---

isexp *Bayesian inference for the true rate of exponential distribution.*

Description

Generates random numbers from the prior and posterior distributions of the inverse stable-exponential model. The random variates can be used to simulate prior and posterior predictive distributions as well.

Usage

```
isexp(x, B, alp, rho)
```

Arguments

x	vector of exponential data.
B	test size for the adaptive rejection sampling algorithm.
alp	value between 0 and 1 that controls the shape of the inverse stable prior.
rho	positive value that scales the mean of the inverse stable prior.

Value

list consisting of the vectors of random numbers from the prior and posterior distributions, the accepted sample size, and the acceptance probability of the adaptive rejection sampling procedure (Algorithm 2 of the first reference below).

References

Cahoy and Sedransk (2019). *Inverse stable prior for exponential models.* Journal of Statistical Theory and Practice, 13, Article 29. <doi:10.1007/s42519-018-0027-2>

Meerschaert and Straka (2013). *Inverse stable subordinators.* Math. Model. Nat. Phenom., 8(2), 1-16. <doi:10.1051/mmnp/20138201>

Mainardi, Mura, and Pagnini (2010). *The M-Wright Function in Time-Fractional Diffusion Processes: A Tutorial Survey*. Int. J. Differ. Equ., Volume 2010. <doi:10.1155/2010/104505>

Examples

```
alp=0.5
dat=rexp(10,rate=0.5)
rho=1/mean(dat)
#rho=1/mean(dat) + 3*sd(dat)
#rho=1/mean(dat) - 3*sd(dat)

#b=length(dat)
#a=sum(dat)
#rho=optimize(function(r){exp(-b)*(b/a)^b - (r^b)*exp(-a*r)}, c(0,20),  tol=10^(-50)  )$min

out= isexp(dat, B=1000000, alp , rho)
#prior samples
thetprior=unlist(out[2])
summary(thetprior)

#posterior samples
thet=unlist(out[1])

#95% Credible intervals
quantile (thet, c(0.025,0.975) )
summary(thet)

#The accepted sample size:
unlist(out[3])

#The acceptance probability:
unlist(out[4])

#Plotting with normalization to have a maximum of 1
#for comparing prior and posterior
out2=density(thet)
ymaxpost=max(out2$y)
out3=density(thetprior)
ymaxprior=max(out3$y)
plot(out2$x,out2$y/ymaxpost, xlim=c(0,1), col="blue", type="l",
 xlab="theta", ylab="density",lwd=2,  frame.plot=FALSE)
lines(out3$x,out3$y/ymaxprior,lwd=2, col="red")
#points(dat,rep(0,length(dat)), pch='*')


#Generating 1000 random numbers from the Inverse Stable (alpha=0.4,rho=5) prior
```

```
U1 = runif(1000)
U2 = runif(1000)
alp=0.4
rho=5
stab = ( ( sin(alp*pi*U1)*sin((1-alp)*pi*U1)^(1/alp-1) )
/ (  ( sin(pi*U1)^(1/alp) )*abs(log(U2))^(1/alp-1))  )
#Inverse stable random numbers are below:
#rho*stab^(-alp)
```

`ishalfn` *Bayesian inference for the true inverse mean/rate of half-normal/half-Gaussian distribution.*

Description

Generates random numbers from the prior and posterior distributions of the inverse stable-half-normal model. The random variates can be used to simulate prior and posterior predictive distributions as well.

Usage

```
ishalfn(x, B, alp, rho)
```

Arguments

`x`	vector of half-normal/half-Gaussian data.
`B`	test size for the adaptive rejection sampling algorithm.
`alp`	value between 0 and 1 that controls the shape of the inverse stable prior.
`rho`	positive value that scales the mean of the inverse stable prior.

Value

list consisting of the vectors of random numbers from the prior and posterior distributions, the accepted sample size, and the acceptance probability of the adaptive rejection sampling procedure (Algorithm 2 of the first reference below).

References

Cahoy and Sedransk (2019). *Inverse stable prior for exponential models.* Journal of Statistical Theory and Practice, 13, Article 29. <doi:10.1007/s42519-018-0027-2>

Meerschaert and Straka (2013). *Inverse stable subordinators.* Math. Model. Nat. Phenom., 8(2), 1-16. <doi:10.1051/mmnp/20138201>

Mainardi, Mura, and Pagnini (2010). *The M-Wright Function in Time-Fractional Diffusion Processes: A Tutorial Survey*. Int. J. Differ. Equ., Volume 2010. <doi:10.1155/2010/104505>

Examples

```
alp=0.95
require(fdrtool)
dat=rhalfnorm(100, theta=sqrt(pi/2) )
rho=1/mean(dat)


#b=length(dat)/2
#a=sum(dat^2)/pi
#rho=optimize(function(r){exp(-b)*(b/a)^b - (r^b)*exp(-a*r)}, c(0,20),  tol=10^(-50)  )$min

out= ishalfn(dat, B=1000000, alp , rho)
#prior samples
thetprior=unlist(out[2])
summary(thetprior)

#posterior samples
thet=unlist(out[1])

#95% Credible intervals
quantile (thet, c(0.025,0.975) )
summary(thet)

#The accepted sample size:
unlist(out[3])

#The acceptance probability:
unlist(out[4])

#Plotting with normalization to have a maximum of 1
#for comparing prior and posterior
out2=density(thet)
ymaxpost=max(out2$y)
out3=density(thetprior)
ymaxprior=max(out3$y)
plot(out2$x,out2$y/ymaxpost, xlim=c(0,2), col="blue", type="l",
 xlab="theta", ylab="density", lwd=2,  frame.plot=FALSE)
lines(out3$x,out3$y/ymaxprior, lwd=2,col="red")
#points(dat,rep(0,length(dat)), pch='*')


#Generating 1000 random numbers from the Inverse Stable (alpha=0.4,rho=5) prior
U1 = runif(1000)
U2 = runif(1000)
alp=0.4
rho=5
stab = ( ( sin(alp*pi*U1)*sin((1-alp)*pi*U1)^(1/alp-1) )
/ (  ( sin(pi*U1)^(1/alp) )*abs(log(U2))^(1/alp-1))  )
#Inverse stable random numbers are below:
#rho*stab^(-alp)
```

`isinvgam` *Bayesian inference for the true scale of inverse gamma distribution.*

Description

Generates random numbers from the prior and posterior distributions of the inverse stable-inverse gamma model. The random variates can be used to simulate prior and posterior predictive distributions as well.

Usage

```
isinvgam(x, B, alp, rho, sh)
```

Arguments

x	vector of data from inverse gamma population.
B	test size for the adaptive rejection sampling algorithm.
alp	value between 0 and 1 that controls the shape of the inverse stable prior.
rho	positive value that scales the mean of the inverse stable prior.
sh	a required known shape parameter value for the inverse gamma distribution.

Value

list consisting of the vectors of random numbers from the prior and posterior distributions, the accepted sample size, and the acceptance probability of the adaptive rejection sampling procedure (Algorithm 2 of the first reference below).

References

Cahoy and Sedransk (2019). *Inverse stable prior for exponential models.* Journal of Statistical Theory and Practice, 13, Article 29. <doi:10.1007/s42519-018-0027-2>

Meerschaert and Straka (2013). *Inverse stable subordinators.* Math. Model. Nat. Phenom., 8(2), 1-16. <doi:10.1051/mmnp/20138201>

Mainardi, Mura, and Pagnini (2010). *The M-Wright Function in Time-Fractional Diffusion Processes: A Tutorial Survey*. Int. J. Differ. Equ., Volume 2010. <doi:10.1155/2010/104505>

Examples

```
alp=0.95
require(nimble)
sh=2.1 # a>2 so variance exists, known
dat=rinvgamma(50, shape=sh,  scale = 4)
rho= (sh-1)*mean(dat)


#b=n
```

```
#a=sum(1/dat )
#rho=optimize(function(r){exp(-b)*(b/a)^b - (r^b)*exp(-a*r)}, c(0,20),  tol=10^(-50)  )$min

out= isinvgam(dat, B=1000000, alp , rho,sh)
#prior samples
thetprior=unlist(out[2])
summary(thetprior)

#posterior samples
thet=unlist(out[1])
summary(thet)

#95% Credible intervals
quantile (thet, c(0.025,0.975) )
summary(thet)

#The accepted sample size:
unlist(out[3])

#The acceptance probability:
unlist(out[4])

#Plotting with normalization to have a maximum of 1
#for comparing prior and posterior
out2=density(thet)
ymaxpost=max(out2$y)
out3=density(thetprior)
ymaxprior=max(out3$y)
plot(out2$x,out2$y/ymaxpost, xlim=c(0,5), col="blue", type="l",
 xlab="theta", ylab="density",lwd=2,  frame.plot=FALSE)
lines(out3$x,out3$y/ymaxprior,lwd=2,col="red")
#points(dat,rep(0,length(dat)), pch='*')


#Generating 1000 random numbers from the Inverse Stable (alpha=0.4,rho=5) prior
U1 = runif(1000)
U2 = runif(1000)
alp=0.4
rho=5
stab = ( ( sin(alp*pi*U1)*sin((1-alp)*pi*U1)^(1/alp-1) )
/ (  ( sin(pi*U1)^(1/alp) )*abs(log(U2))^(1/alp-1))  )
#Inverse stable random numbers are below:
#rho*stab^(-alp)
```

---

ispoi — *Bayesian inference for the true mean of Poisson distribution.*

Description

Generates random numbers from the prior and posterior distributions of the inverse stable-Poisson model. The random variates can be used to simulate prior and posterior predictive distributions as well.

Usage

```
ispoi(x, B, alp, rho)
```

Arguments

`x`	vector of Poisson count data.
`B`	test size for the adaptive rejection sampling algorithm.
`alp`	value between 0 and 1 that controls the shape of the inverse stable prior.
`rho`	positive value that scales the mean of the inverse stable prior.

Value

list consisting of the vectors of random numbers from the prior and posterior distributions, the accepted sample size, and the acceptance probability of the adaptive rejection sampling procedure (Algorithm 2 of the first reference below).

References

Cahoy and Sedransk (2019). *Inverse stable prior for exponential models.* Journal of Statistical Theory and Practice, 13, Article 29. <doi:10.1007/s42519-018-0027-2>

Meerschaert and Straka (2013). *Inverse stable subordinators.* Math. Model. Nat. Phenom., 8(2), 1-16. <doi:10.1051/mmnp/20138201>

Mainardi, Mura, and Pagnini (2010). *The M-Wright Function in Time-Fractional Diffusion Processes: A Tutorial Survey*. Int. J. Differ. Equ., Volume 2010. <doi:10.1155/2010/104505>

Examples

```
alp=0.9
dat=rpois(50,lambda=10)
rho=mean(dat)
#rho=mean(dat) + 3*sd(dat)
#rho=mean(dat) - 3*sd(dat)

#a=length(dat)
#b=sum(dat)
#rho=optimize(function(r){exp(-b)*(b/a)^b - (r^b)*exp(-a*r)}, c(0,20),  tol=10^(-50) )$min

out= ispoi(dat, B=1000000, alp , rho)
#prior samples
thetprior=unlist(out[2])
summary(thetprior)

#posterior samples
```

```
thet=unlist(out[1])

#95% Credible intervals
quantile (thet, c(0.025,0.975) )
summary(thet)

#The accepted sample size:
unlist(out[3])

#The acceptance probability:
unlist(out[4])

#Plotting with normalization to have a maximum of 1
#for comparing prior and posterior
out2=density(thet)
ymaxpost=max(out2$y)
out3=density(thetprior)
ymaxprior=max(out3$y)
plot(out2$x,out2$y/ymaxpost, xlim=c(0,15), col="blue", type="l",
 xlab="theta", ylab="density", lwd=2, frame.plot=FALSE)
lines(out3$x,out3$y/ymaxprior,lwd=2,col="red")
#points(dat,rep(0,length(dat)), pch='*')


#Generating 1000 random numbers from the Inverse Stable (alpha=0.4,rho=5) prior
U1 = runif(1000)
U2 = runif(1000)
alp=0.4
rho=5
stab = ( ( sin(alp*pi*U1)*sin((1-alp)*pi*U1)^(1/alp-1) )
/ (  ( sin(pi*U1)^(1/alp) )*abs(log(U2))^(1/alp-1))  )
#Inverse stable random numbers are below:
#rho*stab^(-alp)
```

Index