Package 'bayesestdft'

Title Estimating the Degrees of Freedom of the Student's
t-Distribution under a Bayesian Framework

Version 1.0.0

Description A Bayesian framework to estimate the Student's t-distribution's degrees of freedom is developed. Markov Chain Monte Carlo sampling routines are developed as in <doi:10.3390/axioms11090462> to sample from the posterior distribution of the degrees of freedom. A random walk Metropolis algorithm is used for sampling when Jeffrey's and Gamma priors are endowed upon the degrees of freedom. In addition, the Metropolis-adjusted Langevin algorithm for sampling is used under the Jeffrey's prior specification. The Log-normal prior over the degrees of freedom is posed as a viable choice with comparable performance in simulations and real-data application, against other prior choices, where an Elliptical Slice Sampler is used to sample from the concerned posterior.

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Encoding UTF-8

RoxygenNote 7.2.3

URL https://github.com/Roy-SR-007/bayesestdft

BugReports https://github.com/Roy-SR-007/bayesestdft/issues

Imports numDeriv, dplyr

Depends R (>= 4.0.4)

LazyData true

NeedsCompilation no

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Repository CRAN

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Contents

BayesGA	*Estimating the Student's t degrees of freedom (dof) with a Gamma Prior over the dof*

Description

BayesGA samples from the posterior distribution of the degrees of freedom (dof) with Gamma prior endowed upon the dof, using a random walk Metropolis (RMW) algorithm.

Usage

```
BayesGA(y, ini.nu = 1, S = 1000, delta = 0.001, a = 1, b = 0.1)
```

Arguments

y	an N-dimensional vector of continuous observations supported on the real-line
ini.nu	the initial posterior sample value of the degrees of freedom (default is 1)
S	the number of posterior samples (default is 1000)
delta	the step size for the respective sampling engines (default is 0.001)
a	rate parameter of Gamma prior (default is 1, corresponds to an Exponential prior)
b	rate parameter of Gamma prior (default is 0.1)

Value

A vector of posterior sample estimates

res	an S-dimensional vector with the posterior samples

References

Lee, S. Y. (2022). "The Use of a Log-Normal Prior for the Student t-Distribution", *Axioms*, doi:10.3390/axioms11090462

Fernández, C., Steel, M. F. (1998). "On Bayesian modeling of fat tails and skewness", *Journal of the American Statistical Association*, doi:10.1080/01621459.1998.10474117

Juárez, M. A., Steel, M. F. (2010). "Model-Based Clustering of Non-Gaussian Panel Data Based on Skew-t Distributions", *Journal of Business and Economic Statistics*, doi:10.1198/jbes.2009.07145

Examples

```
# data from Student's t-distribution with dof = 0.1
y = rt(n = 100, df = 0.1)

# running the random walk Metropolis algorithm with default settings
nu = BayesGA(y)
# reporting the posterior mean estimate of the dof
mean(nu)

# application to log-return (daily index values) of United States (S&P500)
data(index_return)
# log-returns of United States
index_return_US <- dplyr::filter(index_return, Country == "United States")
y = index_return_US$log_return_rate

# running the random walk Metropolis algorithm with default settings
nu = BayesGA(y)
# reporting the posterior mean estimate of the dof from the log-return data of US
mean(nu)
```

BayesJeffreys	*Estimating the Student's t degrees of freedom (dof) with a Jeffreys Prior over the dof*

Description

`BayesJeffreys` samples from the posterior distribution of the degrees of freedom (dof) with Jeffreys prior endowed upon the dof, using a random walk Metropolis (RMW) algorithm and Metropolis-adjusted Langevin algorithm (MALA).

Usage

```
BayesJeffreys(
  y,
  ini.nu = 1,
  S = 1000,
  delta = 0.001,
  sampling.alg = c("MH", "MALA")
)
```

Arguments

y	an N-dimensional vector of continuous observations supported on the real-line
ini.nu	the initial posterior sample value of the degrees of freedom (default is 1)
S	the number of posterior samples (default is 1000)
delta	the step size for the respective sampling engines (default is 0.001)
sampling.alg	takes the choice of the sampling algorithm to be performed, either 'MH' or 'MALA'

Value

A vector of posterior sample estimates

res   an S-dimensional vector with the posterior samples

References

Lee, S. Y. (2022). "The Use of a Log-Normal Prior for the Student t-Distribution", *Axioms*, doi:10.3390/axioms11090462

Gustafson, P. (1998). "A guided walk Metropolis algorithm", *Statistics and Computing*, doi:10.1023/A:1008880707168

Examples

```
# data from Student's t-distribution with dof = 0.1
y = rt(n = 100, df = 0.1)

# running the random walk Metropolis algorithm with default settings
nu1 = BayesJeffreys(y, sampling.alg = "MH")
# reporting the posterior mean estimate of the dof
mean(nu1)

# running MALA with default settings
nu2 = BayesJeffreys(y, sampling.alg = "MALA")
# reporting the posterior mean estimate of the dof
mean(nu2)

# application to log-return (daily index values) of United States (S&P500)
data(index_return)
# log-returns of United States
index_return_US <- dplyr::filter(index_return, Country == "United States")
y = index_return_US$log_return_rate

# running the random walk Metropolis algorithm with default settings
nu1 = BayesJeffreys(y, sampling.alg = "MH")
# reporting the posterior mean estimate of the dof from the log-return data of US
mean(nu1)

# running MALA with default settings
nu2 = BayesJeffreys(y, sampling.alg = "MALA")
# reporting the posterior mean estimate of the dof from the log-return data of US
mean(nu2)
```

BayesLNP   *Estimating the Student's t degrees of freedom (dof) with a Log-normal*
                           Prior over the dof

Description

BayesLNP samples from the posterior distribution of the degrees of freedom (dof) with Log-normal prior endowed upon the dof, using an Elliptical Slice Sampler (ESS).

Usage

```
BayesLNP(y, ini.nu = 1, S = 1000, mu = 1, sigma.sq = 1)
```

Arguments

y	an N-dimensional vector of continuous observations supported on the real-line
ini.nu	the initial posterior sample value of the degrees of freedom (default is 1)
S	the number of posterior samples (default is 1000)
mu	mean of the Log-normal prior density (default is 1)
sigma.sq	variance of the Log-normal prior density (default is 1)

Value

A vector of posterior sample estimates

res	an S-dimensional vector with the posterior samples

References

Lee, S. Y. (2022). "The Use of a Log-Normal Prior for the Student t-Distribution", *Axioms*, doi:10.3390/axioms11090462

Murray, I., Prescott Adams, R., MacKay, D. J. (2010). "Elliptical slice sampling", *Proceedings of the Thirteenth International Conference on Artificial Intelligence and Statistics*

Examples

```
# data from Student's t-distribution with dof = 0.1
y = rt(n = 100, df = 0.1)

# running the Elliptical Slice Sampler (ESS) with default settings
nu = BayesLNP(y)
# reporting the posterior mean estimate of the dof
mean(nu)

# application to log-return (daily index values) of United States (S&P500)
data(index_return)
# log-returns of United States
index_return_US <- dplyr::filter(index_return, Country == "United States")
y = index_return_US$log_return_rate

# running the Elliptical Slice Sampler (ESS) with default settings
nu = BayesLNP(y)
# reporting the posterior mean estimate of the dof from the log-return data of US
mean(nu)
```

`index_return`	*Stock Market Index Return Data*

Description

The stock market returns are recorded for four countries viz., United States (S&P500), Japan (NIKKEI225), Germany (DAX Index), and South Korea (KOSPI). Specifically log return rates (as computed in Section 5 of doi:10.3390/axioms11090462) are recorded for 5 months in the year 2009 for all the four countries, where these rates are considered to be Student's t-distributed and used for the purpose of estimating the corresponding degrees of freedom using a Bayesian model-based framework, developed in doi:10.3390/axioms11090462.

Usage

```
index_return
```

Format

A data frame with 4 columns:

Country name of the country to which the log return rate corresponds to: 'United States', 'Japan', 'Germany', and 'South Korea'

log_return_rate value of the log return rate

time_index an index for the log return rate observations

date the date on which the log return rate was recorded

Source

(Lee, 2022), doi:10.3390/axioms11090462.

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