Package ‘mcmcse’

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Title Monte Carlo Standard Errors for MCMC
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Depends utils
Description mcmcse provides tools for computing Monte Carlo standard errors (MCSE) in Markov chain Monte Carlo (MCMC) settings. MCSE computation for expectation and quantile estimators is supported. The package also provides functions for computing effective sample size and for plotting Monte Carlo estimates versus sample size.
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R topics documented:

ess ................................................................. 2
estvssamp ......................................................... 3
mcse ............................................................... 3
mcse.mat .......................................................... 5
mcse.q ............................................................ 6
mcse.q.mat ....................................................... 8

Index 9
Description

Estimate effective sample size (ESS) as described in Kass et al. (1998) and Robert and Casella (2004; p. 500).

Usage

ess(x, imse = TRUE, verbose = FALSE)

Arguments

x
a vector of values from a Markov chain.

imse
logical. If TRUE, use an approach that is analogous to Geyer’s initial monotone positive sequence estimator (IMSE), where correlations beyond a certain lag are removed to reduce noise.

verbose
logical. If TRUE and imse = TRUE, inform about the lag at which truncation occurs, and warn if the lag is probably too small.

Details

ESS is the size of an iid sample with the same variance as the current sample. ESS is given by

\[ ESS = \frac{T}{\eta}, \]

where

\[ \eta = 1 + 2 \sum \text{all lag autocorrelations}. \]

Value

The function returns the estimated effective sample size.

References


estvssamp

Create a plot that shows how Monte Carlo estimates change with increasing sample size.

Description

Create a plot that shows how Monte Carlo estimates change with increasing sample size.

Usage

estvssamp(x, g = mean, main = "Estimates vs Sample Size",
add = FALSE, ...)

Arguments

- **x**: a sample vector.
- **g**: a function such that \( E(g(x)) \) is the quantity of interest. The default is \( g = \text{mean} \).
- **main**: an overall title for the plot. The default is “Estimates vs Sample Size”.
- **add**: logical. If TRUE, add to a current plot.
- **...**: additional arguments to the plotting function.

Value

NULL

Examples

```r
## Not run:
estvssamp(x, main = expression(E(beta)))
estvssamp(y, add = TRUE, lty = 2, col = "red")
## End(Not run)
```

mcse

Compute Monte Carlo standard errors for expectations.

Description

Compute Monte Carlo standard errors for expectations.

Usage

mcse(x, size = "sqroot", g = NULL,
method = c("bm", "obm", "tukey", "bartlett"),
warn = FALSE)
Arguments

- **x**: a vector of values from a Markov chain.
- **size**: the batch size. The default value is “sqrt”, which uses the square root of the sample size. “cubert” will cause the function to use the cube root of the sample size. A numeric value may be provided if neither “sqrt” nor “cubert” is satisfactory.
- **g**: a function such that $E(g(x))$ is the quantity of interest. The default is NULL, which causes the identity function to be used.
- **method**: the method used to compute the standard error. This is one of “bm” (batch means, the default), “obm” (overlapping batch means), “tukey” (spectral variance method with a Tukey-Hanning window), or “bartlett” (spectral variance method with a Bartlett window).
- **warn**: a logical value indicating whether the function should issue a warning if the sample size is too small (less than 1,000).

Value

`mcse` returns a list with two elements:

- **est**: an estimate of $E(g(x))$.
- **se**: the Monte Carlo standard error.

References


See Also

- `mcse.mat`, which applies `mcse` to each column of a matrix or data frame.
- `mcse.q` and `mcse.q.mat`, which compute standard errors for quantiles.
**Examples**

# Create 10,000 iterations of an AR(1) Markov chain with rho = 0.9.

```r
n = 10000
x = double(n)
x[1] = 2
for (i in 1:(n - 1))
  x[i + 1] = 0.9 * x[i] + rnorm(1)
```

# Estimate the mean, 0.1 quantile, and 0.9 quantile with MCSEs using batch means.

```r
mcse(x)
mcse.q(x, 0.1)
mcse.q(x, 0.9)
```

# Estimate the mean, 0.1 quantile, and 0.9 quantile with MCSEs using overlapping batch means.

```r
mcse(x, method = "obm")
mcse.q(x, 0.1, method = "obm")
mcse.q(x, 0.9, method = "obm")
```

# Estimate E(x^2) with MCSE using spectral methods.

```r
g = function(x) { x^2 }
mcse(x, g = g, method = "tukey")
```

**mcse.mat**

*Apply mcse to each column of a matrix or data frame of MCMC samples.*

**Description**

Apply mcse to each column of a matrix or data frame of MCMC samples.

**Usage**

```r
mcse.mat(x, size = "sqroot", g = NULL,
          method = c("bm", "obm", "tukey", "bartlett"))
```

**Arguments**

- `x` a matrix or data frame with each row being a draw from the multivariate distribution of interest.
- `size` the batch size. The default value is “sqroot”, which uses the square root of the sample size. “cubroot” will cause the function to use the cube root of the sample size. A numeric value may be provided if neither “sqroot” nor “cubroot” is satisfactory.
mcse.q

Compute Monte Carlo standard errors for quantiles.

Description

Compute Monte Carlo standard errors for quantiles.

Usage

mcse.q(x, q, size = "sqroot", g = NULL,
method = c("bm", "obm", "sub"), warn = FALSE)

Arguments

x a vector of values from a Markov chain.
q the quantile of interest.
size the batch size. The default value is “sqroot”, which uses the square root of the sample size. A numeric value may be provided if “sqroot” is not satisfactory.
g a function such that the qth quantile of the univariate distribution function of \( g(x) \) is the quantity of interest. The default is NULL, which causes the identity function to be used.
method the method used to compute the standard error. This is one of “bm” (batch means, the default), “obm” (overlapping batch means), “tukey” (spectral variance method with a Tukey-Hanning window), or “bartlett” (spectral variance method with a Bartlett window).
warn a logical value indicating whether the function should issue a warning if the sample size is too small (less than 1,000).
Value

mcse.q returns a list with two elements:

- **est**: an estimate of the qth quantile of the univariate distribution function of g(x).
- **se**: the Monte Carlo standard error.

References


See Also

- `mcse.q.mat`, which applies mcse.q to each column of a matrix or data frame.
- `mcse` and `mcse.mat`, which compute standard errors for expectations.

Examples

```R
# Create 10,000 iterations of an AR(1) Markov chain with rho = 0.9.

n = 10000
x = double(n)
x[1] = 2
for (i in 1:(n - 1))
x[i + 1] = 0.9 * x[i] + rnorm(1)

# Estimate the mean, 0.1 quantile, and 0.9 quantile with MCSEs using batch means.

mcse(x)
mcse.q(x, 0.1)
mcse.q(x, 0.9)

# Estimate the mean, 0.1 quantile, and 0.9 quantile with MCSEs using overlapping batch means.

mcse(x, method = "obm")
mcse.q(x, 0.1, method = "obm")
mcse.q(x, 0.9, method = "obm")

# Estimate E(x^2) with MCSE using spectral methods.
```
g = function(x) { x^2 }
mcse(x, g = g, method = "tukey")

mcse.q.mat

Apply mcse.q to each column of a matrix or data frame of MCMC samples.

Description

Apply mcse.q to each column of a matrix or data frame of MCMC samples.

Usage

mcse.q.mat(x, q, size = "sqroot", g = NULL,
method = c("bm", "obm", "sub"))

Arguments

x a matrix or data frame with each row being a draw from the multivariate distribution of interest.
q the quantile of interest.
size the batch size. The default value is “sqroot”, which uses the square root of the sample size. “cuberoot” will cause the function to use the cube root of the sample size. A numeric value may be provided if “sqroot” is not satisfactory.
g a function such that the qth quantile of the univariate distribution function of g(x) is the quantity of interest. The default is NULL, which causes the identity function to be used.
method the method used to compute the standard error. This is one of “bm” (batch means, the default), “obm” (overlapping batch means), or “sub” (subsampling bootstrap).

Value

mcse.q.mat returns a matrix with ncol(x) rows and two columns. The row names of the matrix are the same as the column names of x. The column names of the matrix are “est” and “se”. The jth row of the matrix contains the result of applying mcse.q to the jth column of x.

See Also

mcse.q, which acts on a vector.
mcse and mcse.mat, which compute standard errors for expectations.
Index

ess, 2
estvssamp, 3

mcse, 3, 6–8
mcse.mat, 4, 5, 7, 8
mcse.q, 4, 6, 6, 8
mcse.q.mat, 4, 6, 7, 8
mean, 3