# Package 'bsplinePsd'

February 23, 2018

**Type** Package

**Title** Bayesian Nonparametric Spectral Density Estimation Using B-Spline Priors

**Version** 0.2.0

**Date** 2018-02-23

**Author** Matthew C. Edwards [aut, cre], Renate Meyer [aut], Nelson Christensen [aut]

**Maintainer** Matthew C. Edwards <matt.edwards@auckland.ac.nz>

**Description** Implementation of a Metropolis-within-Gibbs MCMC algorithm to flexibly estimate the spectral density of a stationary time series. The algorithm updates a nonparametric B-spline prior using the Whittle likelihood to produce pseudo-posterior samples and is based on the work presented in Edwards, M.C., Meyer, R. and Christensen, N., Statistics and Computing (2018). <doi.org/10.1007/s11222-017-9796-9>.

**License** GPL (>= 3)

**Imports** Rcpp (>= 0.12.5), splines (>= 3.2.3)

**LinkingTo** Rcpp

**RoxygenNote** 6.0.1

**NeedsCompilation** yes

**Repository** CRAN

**Date/Publication** 2018-02-23 12:55:00 UTC

## R topics documented:

## bsplinePsd-package *Bayesian Nonparametric Spectral Density Estimation Using B-Spline Priors*

### Description

Implementation of a Metropolis-within-Gibbs MCMC algorithm to flexibly estimate the spectral density of a stationary time series. The algorithm updates a nonparametric B-spline prior using the Whittle likelihood to produce pseudo-posterior samples.

### Details

The function `gibbs_bspline` is an implementation of the (serial version of the) MCMC algorithm presented in Edwards et al. (2017). This algorithm uses a nonparametric B-spline prior to estimate the spectral density of a stationary time series and can be considered a generalisation of the algorithm of Choudhuri et al. (2004), which used the Bernstein polynomial prior. A Dirichlet process prior is used to find the weights for the B-spline densities used in the finite mixture and a seperate and independent Dirichlet process prior used to place knots. The algorithm therefore allows for a data-driven choice of the number of knots/mixtures and their locations.

### Author(s)

Matthew C. Edwards, Renate Meyer, Nelson Christensen

Maintainer: Matthew C. Edwards <matt.edwards@auckland.ac.nz>

### References

Edwards, M. C., Meyer, R., and Christensen, N. (2017), Bayesian nonparametric spectral density estimation using B-spline priors, <arXiv:1707.04878>.

Choudhuri, N., Ghosal, S., and Roy, A. (2004), Bayesian estimation of the spectral density of a time series, *Journal of the American Statistical Association*, 99(468):1050–1059.

## dbspline *Generate a cubic B-spline density basis*

### Description

This function generates a cubic B-spline density basis.

### Usage

```
dbspline(x, knots)
```

### Arguments

| | |
|---|---|
| x | numeric vector for which the B-spline densities are to be generated |
| knots | knots used to generate the cubic B-spline densities |

### Details

splineDesign is used to generate a cubic B-spline basis. Each B-spline is then normalised to become a B-spline density using analytical integration. Note that the two end knots are each coincident four times.

### Value

matrix of the cubic B-spline density basis

### See Also

splineDesign

### Examples

```
## Not run:

# Generate basis functions
x = seq(0, 1, length = 256)
knots = sort(c(0, runif(10), 1))
basis = dbspline(x, knots)

# Plot basis functions
plot(x, basis[1, ], type = "l", ylim = c(min(basis), max(basis)))
for (i in 2:nrow(basis)) lines(x, basis[i, ], col = i)

## End(Not run)
```

---

## gibbs_bspline *Metropolis-within-Gibbs sampler for spectral inference of a stationary time series using a B-spline prior*

---

### Description

This function updates the (cubic) B-spline prior using the Whittle likelihood and obtains samples from the pseudo-posterior to infer the spectral density of a stationary time series.

### Usage

```
gibbs_bspline(data, Ntotal, burnin, thin = 1, k.theta = 0.01, MG = 1,
  G0.alpha = 1, G0.beta = 1, LG = 20, MH = 1, H0.alpha = 1,
  H0.beta = 1, LH = 20, tau.alpha = 0.001, tau.beta = 0.001,
  kmax = 100, k1 = 20)
```

## Arguments

| | |
|---|---|
| data | numeric vector |
| Ntotal | total number of iterations to run the Markov chain |
| burnin | number of initial iterations to be discarded |
| thin | thinning number (post-processing) |
| k.theta | prior parameter for number of B-spline densities k (proportional to exp(-k.theta*k^2)) in mixture |
| MG | Dirichlet process base measure constant for weights of B-spline densities in mixture (> 0) |
| G0.alpha, G0.beta | parameters of Beta base measure of Dirichlet process for weights of B-spline densities in mixture (default is Uniform[0, 1]) |
| LG | truncation parameter of Dirichlet process in stick breaking representation for weights of B-spline densities |
| MH | Dirichlet process base measure constant for knot placements of B-spline densities (> 0) |
| H0.alpha, H0.beta | parameters of Beta base measure of Dirichlet process for knot placements of B-spline densities (default is Uniform[0, 1]) |
| LH | truncation parameter of Dirichlet process in stick breaking representation for knot placements of B-spline densities |
| tau.alpha, tau.beta | prior parameters for tau (Inverse Gamma) |
| kmax | upper bound for number of B-spline densities in mixture |
| k1 | starting value for k. If k1 = NA then a random starting value between 5 and kmax is selected. |

## Details

The function gibbs_bspline is an implementation of the (serial version of the) MCMC algorithm presented in Edwards et al. (2018). This algorithm uses a nonparametric B-spline prior to estimate the spectral density of a stationary time series and can be considered a generalisation of the algorithm of Choudhuri et al. (2004), which used the Bernstein polynomial prior. A Dirichlet process prior is used to find the weights for the B-spline densities used in the finite mixture and a seperate and independent Dirichlet process prior used to place knots. The algorithm therefore allows for a data-driven choice of the number of knots/mixtures and their locations.

## Value

A list containing the following components:

| | |
|---|---|
| psd.median,psd.mean | psd estimates: (pointwise) posterior median and mean |
| psd.p05,psd.p95 | pointwise credibility interval |

| | |
|---|---|
| psd.u05,psd.u95 | uniform credibility interval |
| k,tau,V,Z,U,X | posterior traces of model parameters |
| knots.trace | trace of knot placements |
| ll.trace | trace of log likelihood |

## References

Edwards, M. C., Meyer, R., and Christensen, N. (2018), Bayesian nonparametric spectral density estimation using B-spline priors, *Statistics and Computing*, https://doi.org/10.1007/s11222-017-9796-9.

Choudhuri, N., Ghosal, S., and Roy, A. (2004), Bayesian estimation of the spectral density of a time series, *Journal of the American Statistical Association*, 99(468):1050–1059.

## Examples

```
## Not run:

# Generate AR(1) data with rho = 0.9
n = 128
data = arima.sim(n, model = list(ar = 0.9))
data = data - mean(data)

# Run MCMC (may take some time)
mcmc = gibbs_bspline(data, Ntotal = 4000, burnin = 2000, thin = 1)

# Compare estimate with true PSD
require(beyondWhittle)  # For psd_arma() function
freq = 2 * pi / n * (1:(n / 2 + 1) - 1)[-c(1, n / 2 + 1)]
psd.true <- psd_arma(freq, ar = 0.9, ma = numeric(0), sigma2 = 1)
plot(x = freq, y = psd.true, col = 2, type = "l", xlab = "Frequency", ylab = "PSD")
lines(x = freq, y = mcmc$psd.median, type = "l")
lines(x = freq, y = mcmc$psd.p05, type = "l", lty = 2)
lines(x = freq, y = mcmc$psd.p95, type = "l", lty = 2)
legend(x = "topright", legend = c("true psd", "pointwise median", "pointwise CI"),
lty = c(1, 1, 2), col = c(2, 1, 1))

## End(Not run)
```

# Index