Package ‘bsplinePsd’

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Type Package

Title Bayesian Nonparametric Spectral Density Estimation Using B-Spline Priors

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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 by Edwards, Meyer, and Christensen (2017) <arXiv:1707.04878>.

License GPL (>= 3)

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

LinkingTo Rcpp

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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.

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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)
```

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

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.

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. (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.

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")
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)
```

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