Package: BSPBSS (via r-universe)

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Title Bayesian Spatial Blind Source Separation

Version 1.0.6

Description Gibbs sampling for Bayesian spatial blind source separation (BSP-BSS). BSP-BSS is designed for spatially dependent signals in high dimensional and large-scale data, such as neuroimaging. The method assumes the expectation of the observed images as a linear mixture of multiple sparse and piece-wise smooth latent source signals, and constructs a Bayesian nonparametric prior by thresholding Gaussian processes. Details can be found in our paper: Wu, B., Guo, Y., & Kang, J. (2024). Bayesian spatial blind source separation via the thresholded gaussian process. Journal of the American Statistical Association, 119(545), 422-433.

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Suggests knitr, rmarkdown

VignetteBuilder knitr

NeedsCompilation yes

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Contents

init_bspbss 2
levelplot2D 3
mcmc_bspbss 4
output_nii 5
pre_nii 6
sim_2Dimage 6
sum_mcmc_bspbss 7

Index **9**

`init_bspbss` *Initial values*

Description

Generate initial values, set up priors and perform kernel decomposition for the MCMC algorithm.

Usage

```
init_bspbss(
  X,
  coords,
  rescale = TRUE,
  center = FALSE,
  q = 2,
  dens = 0.5,
  ker_par = c(0.05, 20),
  num_eigen = 500,
  noise = 0
)
```

Arguments

`X`	Data matrix with n rows (sample) and p columns (voxel).
`coords`	Cordinate matrix with p rows (voxel) and d columns (dimension).
`rescale`	If TRUE, rows of X are rescaled to have unit variance.
`center`	If TRUE, rows of X are mean-centered.
`q`	Number of latent sources.
`dens`	The initial density level (between 0 and 1) of the latent sources.
`ker_par`	2-dimensional vector (a,b) with a>0, b>0, specifing the parameters in the modified exponetial squared kernel.
`num_eigen`	Number of eigen functions.
`noise`	Gaussian noise added to the initial latent sources, with mean 0 and standard deviation being noise * sd(S0), where sd(S0) is the standard deviation of the initial latent sources.

Value

List containing initial values, priors and eigen functions/eigen values of the kernel of the Gaussian process.

Examples

```
sim = sim_2Dimage(length = 30, sigma = 5e-4, n = 30, smooth = 6)
ini = init_bspbss(sim$X, sim$coords, q = 3, ker_par = c(0.1,50), num_eigen = 50)
```

---

levelplot2D *levelplot for 2D images.*

Description

The function plots 2D images for a data matrix.

Usage

```
levelplot2D(
  S,
  coords,
  lim = c(min(S), max(S)),
  xlim = c(0, max(coords[, 1])),
  ylim = c(0, max(coords[, 2])),
  color = bluered(100),
  layout = c(1, nrow(S)),
  file = NULL
)
```

Arguments

S	Data matrix with q rows (sample) and p colums (pixel).
coords	Coordinates matrix with p rows (pixel) and 2 columns (dimension), specifying the coordinates of the data points.
lim	2-dimensional numeric vector, specifying the limits for the data.
xlim	2-dimensional numeric vector, specifying the lower and upper limits of x.
ylim	2-dimensional numeric vector, specifying the lower and upper limits of y.
color	Colorbar.
layout	2-dimensional numeric vector, specifying the number of rows and number of columns for the layout of components.
file	Name of the file to be saved.

Value

No return value.

Examples

```
sim = sim_2Dimage(length = 30, sigma = 5e-4, n = 30, smooth = 6)
levelplot2D(sim$S,lim = c(-0.04,0.04), sim$coords)
```

`mcmc_bspbss` *MCMC algorithm for Bayesian spatial blind source separation with the thresholded Gaussian Process prior.*

Description

Performan MCMC algorithm to draw samples from a Bayesian spatial blind source separation model.

Usage

```
mcmc_bspbss(
  X,
  init,
  prior,
  kernel,
  n.iter,
  n.burn_in,
  thin = 1,
  show_step,
  ep = 0.01,
  lr = 0.01,
  decay = 0.01,
  num_leapfrog = 5,
  subsample_n = 0.5,
  subsample_p = 0.5
)
```

Arguments

`X`	Data matrix with n rows (sample) and p columns (voxel).
`init`	List of initial values, see `init_bspbss`.
`prior`	List of priors, see `init_bspbss`.
`kernel`	List including eigenvalues and eigenfunctions of the kernel, see `init_bspbss`.
`n.iter`	Total iterations in MCMC.
`n.burn_in`	Number of burn-in.
`thin`	Thining interval.
`show_step`	Frequency for printing the current number of iterations.
`ep`	Approximation parameter.

lr	Per-batch learning rate in SGHMC.
decay	Decay parameter in SGHMC.
num_leapfrog	Number of leapfrog steps in SGHMC.
subsample_n	Mini-batch size of samples.
subsample_p	Mini-batch size of voxels.

Value

List containing MCMC samples of: A, b, sigma, and zeta.

Examples

```
sim = sim_2Dimage(length = 30,
                  sigma = 5e-4,
                  n = 30,
                  smooth = 6)
ini = init_bspbss(sim$X, sim$coords,
                  q = 3,
                  ker_par = c(0.1,50),
                  num_eigen = 50)
res = mcmc_bspbss(ini$X,ini$init,
                  ini$prior,ini$kernel,
                  n.iter=200,n.burn_in=100,
                  thin=10,show_step=50)
```

---

output_nii *Write a NIfTI file.*

Description

This function saves a data matrix into a NIfTI file.

Usage

```
output_nii(X, nii, xgrid, file = NULL, std = TRUE, thres = 0)
```

Arguments

X	Data matrix with n rows (sample) and p colums (pixel).
nii	a reference NIfTI-class object, representing a image with p voxels.
xgrid	Cordinate matrix with p rows (voxel) and d columns (dimension).
file	The name of the file to be saved.
std	If TRUE, standarize each row of X.
thres	Quantile to threshold each row of X.

Value

NIfTI-class object.

`pre_nii` *Transforms NIfTI to matrix*

Description

This function transforms a NIfTI-class object into a matrix.

Usage

```
pre_nii(nii, mask)
```

Arguments

`nii`	4D NIfTI-class object with dimensions x,y,z and t. Can be read from NIfTI file with `readNIfTI` function from the package `oro.nifti`.
`mask`	Mask variable, also in NIfTI format.

Value

List containing the data matrix with t rows and x*y*z colums (voxels), and the coordinates of the voxels.

`sim_2Dimage` *Simulate image data using ICA*

Description

The function simulates image data using a probabilistic ICA model whose latent components have specific spatial patterns.

Usage

```
sim_2Dimage(length = 20, n = 50, sigma = 0.002, smooth = 6)
```

Arguments

`length`	The length of the image.
`n`	sample size.
`sigma`	variance of the noise.
`smooth`	smoothness of the latent components.

Details

The observations are generated using probabilistic ICA:

$$X_i(v) = \sum_{j=1}^{q} A_{i,j} S_j(v) + \epsilon_i(v),$$

where $S_j, j = 1, ..., q$ are the latent components, $A_{i,j}$ is the mixing coeffecient and ϵ_i is the noise term. Specifically, the number of components in this function is $q = 3$, with each of them being a specific geometric shape. The mixing coefficient matrix is generated with a von Mises-Fisher distribution with the concentration parameter being zero, which means it is uniformly distributed on the sphere. ϵ_i is a i.i.d. Gaussian noise term with 0 mean and user-specified variance.

Value

List that contains the following terms:

X Data matrix with n rows (sample) and p columns (pixel).

coords Cordinate matrix with p rows (pixel) and d columns (dimension)

S Latent components.

A Mixing coefficent matrix.

snr Signal-to-noise ratio.

Examples

```
sim = sim_2Dimage(length = 30, sigma = 5e-4, n = 30, smooth = 6)
```

`sum_mcmc_bspbss` *Summarization of the MCMC result.*

Description

The function summarizes the MCMC results obtained from `mcmc_bspbss`.

Usage

```
sum_mcmc_bspbss(res, X, kernel, start = 1, end = 100, select_prob = 0.8)
```

Arguments

`res`	List including MCMC samples, which can be obtained from function `mcmc_bspbss`
`X`	Original data matrix.
`kernel`	List including eigenvalues and eigenfunctions of the kernel, see `init_bspbss`.
`start`	Start point of the iterations being summarized.
`end`	End point of the iterations being summarized.
`select_prob`	Lower bound of the posterior inclusion probability required when summarizing the samples of latent sources.

Value

List that contains the following terms:

S Estimated latent sources.

pip Voxel-wise posterior inclusion probability for the latent sources.

A Estimated mixing coefficent matrix.

zeta Estimated zeta.

sigma Estimated sigma.

logLik Trace of log-likelihood.

Slist MCMC samples of S.

Examples

```
sim = sim_2Dimage(length = 30, sigma = 5e-4, n = 30, smooth = 6)
ini = init_bspbss(sim$X, sim$coords, q = 3, ker_par = c(0.1,50), num_eigen = 50)
res = mcmc_bspbss(ini$X,ini$init,ini$prior,ini$kernel,n.iter=200,n.burn_in=100,thin=10,show_step=50)
res_sum = sum_mcmc_bspbss(res, ini$X, ini$kernel, start = 11, end = 20, select_p = 0.5)
```

Index

init_bspbss, 2

levelplot2D, 3

mcmc_bspbss, 4

output_nii, 5

pre_nii, 6

sim_2Dimage, 6
sum_mcmc_bspbss, 7