Package 'ContRespPP'

January 20, 2025

Title Predictive Probability for a Continuous Response with an ANOVA
Structure

Version 0.4.2

Description A Bayesian approach to using
predictive probability in an ANOVA construct with a continuous normal response,
when threshold values must be obtained for the question of interest to be
evaluated as successful (Sieck and Christensen (2021) <doi:10.1002/qre.2802>).
The Bayesian Mission Mean (BMM) is used to evaluate a question
of interest (that is, a mean that randomly selects combination of factor levels
based on their probability of occurring instead of averaging over the factor
levels, as in the grand mean). Under this construct, in contrast to a Gibbs
sampler (or Metropolis-within-Gibbs sampler), a two-stage sampling method is
required. The nested sampler determines the conditional posterior distribution
of the model parameters, given Y, and the outside sampler determines the marginal
posterior distribution of Y (also commonly called the predictive distribution for Y).
This approach provides a sample from the joint posterior distribution of Y and
the model parameters, while also accounting for the threshold value that must be
obtained in order for the question of interest to be evaluated as successful.

URL https://github.com/jcliff89/ContRespPP

BugReports https://github.com/jcliff89/ContRespPP/issues

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Encoding UTF-8

LazyData true

RoxygenNote 7.1.1

Imports stats

Suggests rjags, coda, knitr, devtools, rmarkdown, testthat (>= 3.0.0)

VignetteBuilder knitr

Depends R (>= 2.10)

Config/testthat/edition 3

NeedsCompilation no

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Contents

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exData   *Example Continuous Response ANOVA Dataset.*

Description

A dataset containing an example test set result to run a predictive probability model with a continuous response variable. This data set is a result of a 2^4 full factorial with five replicates that included five main effects, with two-way interactions (excluding two-way interactions for the third factor). This design has a power of 80%, with an 80% confidence level, to detect a difference of 50 units with a standard deviation of 100 units.

Usage

```
exData
```

Format

A matrix with 80 rows and 14 columns:

Column 1 Continuous Response Variable

Columns 2-14 Design Matrix

Details

Please refer to the vignette for an example analysis of this data using ContRespPP.

Source

Sieck VRC, Christensen FGW. A framework for improving the efficiency of operational testing through Bayesian adaptive design. Quality and Reliability Engineering International. 2021; 3018-3033.

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gibbs.sampler	*Continuous Response Predictive Probability.*

Description

`gibbs.sampler` runs the estimation of the continuous response ANOVA predictive probability.

Usage

```
gibbs.sampler(
  X,
  Y,
  n.seen,
  beta.mean,
  beta.precision,
  shape,
  rate,
  n.sim,
  y.burnin,
  b.sim,
  b.burnin,
  phi.0,
  theta.t,
  prob,
  factor.no.2way = NA,
  colnames.pick = NA,
  seed = NA,
  verbose = TRUE
)
```

Arguments

X	Design matrix for the test (matrix of indicator functions defining which model parameters are active in each test event).
Y	A vector of the responses from the test.
n.seen	Number of test events already observed (i.e., the number of rows of the design matrix, X, that have been observed).
beta.mean	Mean vector of the multivariate normal distribution (or the mean of each of the priors on the model parameters), ordered the same as the columns of the design matrix, X. It also serves as the initialization for the model parameters.

`beta.precision`	Precisions of the multivariate normal distribution (precision of each of the priors on the model parameters), corresponding to the beta.mean values.
`shape`	Hyperparameter alpha for gamma prior on the precision of the ANOVA model, tau.
`rate`	Hyperparameter beta for gamma prior on the precision of the ANOVA model, tau.
`n.sim`	Number of non-conditional posterior draws (i.e., number of draws that will be returned to the user from the function after burn-in draws for the non-conditional draws are removed).
`y.burnin`	Number of burn-in samples for the non-conditional posterior.
`b.sim`	Number of conditional posterior draws used in analysis for each non-conditional draw.
`b.burnin`	Number of burn-in samples for the conditional posterior.
`phi.0`	Threshold value the parameter of interest (BMM) must obtain (i.e., BBM > phi.0).
`theta.t`	Certainty threshold for the conditional posterior probability of the parameter of interest (the Bayesian mission mean, "BMM") obtaining phi.0 (i.e., BMM > phi.0) that the conditional posterior probability must obtain (the certainty threshold for conditional P(BMM > phi.0)) must obtain for the question of interest to be evaluated as successfully passing the test.
`prob`	Matrix or dataframe of the "likelihood of encountering" (or probability of seeing a factor level); it is a two column matrix (or dataframe), where the first column identifies the factor numerically and the second column defines the probability of seeing each factor level.
`factor.no.2way`	Optional vector of model parameters (as defined by prob) that are not incorposhaped in the two way interactions for the model.
`colnames.pick`	Optional vector of model parameter names in the same order as in the design matrix to label the returned dataframe columns.
`seed`	Optional selection which will create a reproducible result from the function.
`verbose`	Allows suppression of sampler progress printing in console.

Details

The ANOVA model includes main effects and two-way interactions. Priors on model parameters are assumed to be independent of each other; beta is then defined as the set of model parameters, which is multivariate normal.

Value

Returns a list with three elements:

`pp` The predicted probability of the test ending in a successful evaluation of the question of interest

`posterior` The full dataframe of non-conditional posterior draws

`indicator` The vector of test success results for each posterior draw

Printing the result object will display the predicted probability result.

gibbs.sampler.posterior

Continuous Response Posterior Probability.

Description

gibbs.sampler.posterior obtains the ContRespPP method for obtaining the posterior (i.e., all observations have been seen, and this reverts to a traditional Bayesian analysis) using base R functions, drastically increasing the computational time required to obtain predictive draws.

Usage

```
gibbs.sampler.posterior(
  X,
  Y,
  beta.mean,
  beta.precision,
  shape,
  rate,
  b.sim,
  b.burnin,
  phi.0,
  prob,
  factor.no.2way = NA,
  colnames.pick = NA,
  seed = NA,
  verbose = TRUE
)
```

Arguments

X	Design matrix for the test (matrix of indicator functions defining which model parameters are active in each test event).
Y	A vector of the responses from the test.
beta.mean	Mean vector of the multivariate normal distribution (or the mean of each of the priors on the model parameters), ordered the same as the columns of the design matrix, X. It also serves as the initialization for the model parameters.
beta.precision	Precisions of the multivariate normal distribution (precision of each of the priors on the model parameters), corresponding to the beta.mean values.
shape	Hyperparameter alpha for gamma prior on the precision of the ANOVA model, tau.
rate	Hyperparameter beta for gamma prior on the precision of the ANOVA model, tau.
b.sim	Number of conditional posterior draws used in analysis for each non-conditional draw.

b.burnin	Number of burn-in samples for the conditional posterior.
phi.0	Threshold value the parameter of interest (BMM) must obtain (i.e., BBM > phi.0).
prob	Matrix or dataframe of the "likelihood of encountering" (or probability of seeing a factor level); it is a two column matrix (or dataframe), where the first column identifies the factor numerically and the second column defines the probability of seeing each factor level.
factor.no.2way	Optional vector of model parameters (as defined by prob) that are not incorporated in the two way interactions for the model.
colnames.pick	Optional vector of model parameter names in the same order as in the design matrix to label the returned dataframe columns.
seed	Optional selection which will create a reproducible result from the function.
verbose	Allows suppression of sampler progress printing in console.

Value

Returns a list with three elements:

pp This value will be NA since this function only calculates the posterior

posterior The full dataframe of non-conditional posterior draws

indicator This value will be NA since this function only calculates the posterior

Printing the result object will display the predicted probability result.

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gibbs.sampler.posterior.rjags

Continuous Response Posterior Probability.

Description

gibbs.sampler.posterior.rjags obtains the ContRespPP method for obtaining the posterior (i.e., all observations have been seen, and this reverts to a traditional Bayesian analysis) using rjags to generate samples instead of base R functions, drastically decreasing the computational time required to obtain predictive draws.

Usage

```
gibbs.sampler.posterior.rjags(
  X,
  Y,
  beta.mean,
  beta.precision,
  shape,
  rate,
  b.sim,
```

```
    b.burnin,
    phi.0,
    prob,
    factor.no.2way = NA,
    colnames.pick = NA,
    seed = NA,
    verbose = TRUE
)
```

Arguments

X	Design matrix for the test (matrix of indicator functions defining which model parameters are active in each test event).
Y	A vector of the responses from the test.
beta.mean	Mean vector of the multivariate normal distribution (or the mean of each of the priors on the model parameters), ordered the same as the columns of the design matrix, X. It also serves as the initialization for the model parameters.
beta.precision	Precisions of the multivariate normal distribution (precision of each of the priors on the model parameters), corresponding to the beta.mean values.
shape	Hyperparameter alpha for gamma prior on the precision of the ANOVA model, tau.
rate	Hyperparameter beta for gamma prior on the precision of the ANOVA model, tau.
b.sim	Number of conditional posterior draws used in analysis for each non-conditional draw.
b.burnin	Number of burn-in samples for the conditional posterior.
phi.0	Threshold value the parameter of interest (BMM) must obtain (i.e., BBM > phi.0).
prob	Matrix or dataframe of the "likelihood of encountering" (or probability of seeing a factor level); it is a two column matrix (or dataframe), where the first column identifies the factor numerically and the second column defines the probability of seeing each factor level.
factor.no.2way	Optional vector of model parameters (as defined by prob) that are not incorporated in the two way interactions for the model.
colnames.pick	Optional vector of model parameter names in the same order as in the design matrix to label the returned dataframe columns.
seed	Optional selection which will create a reproducible result from the function.
verbose	Allows suppression of sampler progress printing in console.

Value

Returns a list with three elements:

pp This value will be NA since this function only calculates the posterior

posterior The full dataframe of non-conditional posterior draws

indicator This value will be NA since this function only calculates the posterior

Printing the result object will display the predicted probability result.

---

gibbs.sampler.predictive

Continuous Response Predictive Probability.

Description

gibbs.sampler.predictive does the predictive ContRespPP method using base R functions, which drastically increases the computational time required to obtain predictive draws.

Usage

```
gibbs.sampler.predictive(
  X,
  Y,
  n.seen,
  beta.mean,
  beta.precision,
  shape,
  rate,
  n.sim,
  y.burnin,
  b.sim,
  b.burnin,
  phi.0,
  theta.t,
  prob,
  factor.no.2way = NA,
  colnames.pick = NA,
  seed = NA,
  verbose = TRUE
)
```

Arguments

X	Design matrix for the test (matrix of indicator functions defining which model parameters are active in each test event).
Y	A vector of the responses from the test.
n.seen	Number of test events already observed (i.e., the number of rows of the design matrix, X, that have been observed).
beta.mean	Mean vector of the multivariate normal distribution (or the mean of each of the priors on the model parameters), ordered the same as the columns of the design matrix, X. It also serves as the initialization for the model parameters.

beta.precision	Precisions of the multivariate normal distribution (precision of each of the priors on the model parameters), corresponding to the beta.mean values.
shape	Hyperparameter alpha for gamma prior on the precision of the ANOVA model, tau.
rate	Hyperparameter beta for gamma prior on the precision of the ANOVA model, tau.
n.sim	Number of non-conditional posterior draws (i.e., number of draws that will be returned to the user from the function after burn-in draws for the non-conditional draws are removed).
y.burnin	Number of burn-in samples for the non-conditional posterior.
b.sim	Number of conditional posterior draws used in analysis for each non-conditional draw.
b.burnin	Number of burn-in samples for the conditional posterior.
phi.0	Threshold value the parameter of interest (BMM) must obtain (i.e., BBM > phi.0).
theta.t	Certainty threshold for the conditional posterior probability of the parameter of interest (the Bayesian mission mean, "BMM") obtaining phi.0 (i.e., BMM > phi.0) that the conditional posterior probability must obtain (the certainty threshold for conditional P(BMM > phi.0)) must obtain for the question of interest to be evaluated as successfully passing the test.
prob	Matrix or dataframe of the "likelihood of encountering" (or probability of seeing a factor level); it is a two column matrix (or dataframe), where the first column identifies the factor numerically and the second column defines the probability of seeing each factor level.
factor.no.2way	Optional vector of model parameters (as defined by prob) that are not incorporated in the two way interactions for the model.
colnames.pick	Optional vector of model parameter names in the same order as in the design matrix to label the returned dataframe columns.
seed	Optional selection which will create a reproducible result from the function.
verbose	Allows suppression of sampler progress printing in console.

Value

Returns a list with three elements:

pp   The predicted probability of the test ending in a successful evaluation of the question of interest

posterior   The full dataframe of non-conditional posterior draws

indicator   The vector of test success results for each posterior draw

Printing the result object will display the predicted probability result.

gibbs.sampler.predictive.rjags

Continuous Response Predictive Probability.

Description

gibbs.sampler.predictive.jags does the predictive ContRespPP method using rjags to generate samples instead of base R functions, drastically decreasing the computational time required to obtain predictive draws.

Usage

```
gibbs.sampler.predictive.rjags(
  X,
  Y,
  n.seen,
  beta.mean,
  beta.precision,
  shape,
  rate,
  n.sim,
  y.burnin,
  b.sim,
  b.burnin,
  phi.0,
  theta.t,
  prob,
  factor.no.2way = NA,
  colnames.pick = NA,
  seed = NA,
  verbose = TRUE
)
```

Arguments

X	Design matrix for the test (matrix of indicator functions defining which model parameters are active in each test event).
Y	A vector of the responses from the test.
n.seen	Number of test events already observed (i.e., the number of rows of the design matrix, X, that have been observed).
beta.mean	Mean vector of the multivariate normal distribution (or the mean of each of the priors on the model parameters), ordered the same as the columns of the design matrix, X. It also serves as the initialization for the model parameters.
beta.precision	Precisions of the multivariate normal distribution (precision of each of the priors on the model parameters), corresponding to the beta.mean values.

shape	Hyperparameter alpha for gamma prior on the precision of the ANOVA model, tau.
rate	Hyperparameter beta for gamma prior on the precision of the ANOVA model, tau.
n.sim	Number of non-conditional posterior draws (i.e., number of draws that will be returned to the user from the function after burn-in draws for the non-conditional draws are removed).
y.burnin	Number of burn-in samples for the non-conditional posterior.
b.sim	Number of conditional posterior draws used in analysis for each non-conditional draw.
b.burnin	Number of burn-in samples for the conditional posterior.
phi.0	Threshold value the parameter of interest (BMM) must obtain (i.e., BBM > phi.0).
theta.t	Certainty threshold for the conditional posterior probability of the parameter of interest (the Bayesian mission mean, "BMM") obtaining phi.0 (i.e., BMM > phi.0) that the conditional posterior probability must obtain (the certainty threshold for conditional P(BMM > phi.0)) must obtain for the question of interest to be evaluated as successfully passing the test.
prob	Matrix or dataframe of the "likelihood of encountering" (or probability of seeing a factor level); it is a two column matrix (or dataframe), where the first column identifies the factor numerically and the second column defines the probability of seeing each factor level.
factor.no.2way	Optional vector of model parameters (as defined by prob) that are not incorporated in the two way interactions for the model.
colnames.pick	Optional vector of model parameter names in the same order as in the design matrix to label the returned dataframe columns.
seed	Optional selection which will create a reproducible result from the function.
verbose	Allows suppression of sampler progress printing in console.

Value

Returns a list with three elements:

pp The predicted probability of the test ending in a successful evaluation of the question of interest

posterior The full dataframe of non-conditional posterior draws

indicator The vector of test success results for each posterior draw

Printing the result object will display the predicted probability result.

`print.ContRespPP` *Print method for ContRespPP class*

Description

Print method for ContRespPP class

Usage

```
## S3 method for class 'ContRespPP'
print(x, ...)
```

Arguments

x	A list of class ContRespPP
...	Other arguments passed to `print`

Value

Prints the predictive or posterior probability result from ContRespPP class

---

`prob.creator` *Probability Matrix Creator.*

Description

`prob.creator` creates a matrix of probabilities of encountering factor levels to support construction of input for `gibbs.sampler`, which uses the Bayesian Mission Mean approach to analysis.

Usage

```
prob.creator(
  num.factors,
  num.factor.levels,
  likelihood.encountering,
  print.result = FALSE
)
```

Arguments

num.factors Number of factors in the model (e.g., factor α_i with levels i=1,2 is 1 factor). Input for `num.factors` should be a single number.

num.factor.levels

Number of levels for each factor (e.g., factor α_i with i=1,2 has 2 levels). Input for `num.factor.levels` may be a vector, a matrix, or a dataframe.

```
likelihood.encountering
```
> The probability of seeing each level of each factor (e.g., if the factor levels for α_i are equally likely, then the probabilities would be c(1/2, 1/2)). The probabilities for each factor should sum to one. Input for `likelihood.encountering` may be a vector, a matrix, or a dataframe.

`print.result`   Displays final probability matrix.

Details

The ANOVA model includes main effects and two-way interactions. Priors on model parameters are assumed to be independent of each other; beta is then defined as the set of model parameters, which is multivariate normal.

Value

Returns a matrix with two columns, one with the factor number and the other with the likelihoods of encountering.

---

summary.ContRespPP   *Summary method for ContRespPP class*

Description

Summary method for ContRespPP class

Usage

```
## S3 method for class 'ContRespPP'
summary(object, ...)
```

Arguments

`object`   A list of class ContRespPP

`...`   Other arguments passed to `summary`

Value

Prints a basic summary of posterior distribution from ContRespPP class

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