Package 'BeviMed'

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Contents

`BeviMed-package` *Bayesian Evaluation of Variant Involvement in Mendelian Disease*

Description

A fast integrative genetic association test for rare diseases.

Details

BeviMed estimates a probability of association between a case/control label and allele counts at rare variant sites in a genomic locus and also, given that there is an association, the probabilities that each variant is involved in the disease. It does so by estimating the evidence for a model where the case/control label is independent of the allele configurations, and a model in which the probability of the case/control label depends on the corresponding allele configuration and a latent partition of variants into pathogenic and non-pathogenic groups.

Author(s)

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References

Greene et al., A Fast Association Test for Identifying Pathogenic Variants Involved in Rare Diseases, The American Journal of Human Genetics (2017), http://dx.doi.org/10.1016/j.ajhg.2017.05.015.

See Also

bevimed

---

bevimed *Bayesian Evaluation of Variant Involvement in Mendelian Disease*

Description

Infer probabilities of association between disease label and locus and posterior parameter values under BeviMed model.

Usage

```
bevimed(
  y,
  G,
  ploidy = rep(2L, length(y)),
  G2 = NULL,
  prior_prob_association = 0.01,
  prior_prob_dominant = 0.5,
  dominant_args = NULL,
  recessive_args = NULL,
  ...
)
```

Arguments

y	Logical vector of case (TRUE) control (FALSE) status.
G	Integer matrix of variant counts per individual, one row per individual and one column per variant.
ploidy	Integer vector giving ploidy of samples.
G2	For when phased genotype data is available, corresponding matrix of genotypes for the second haplotype (defaults to NULL, if provided BeviMed is run in phased mode where allele configurations are only pathogenic when all haplotypes harbour a pathogenic allele under recessive recessive inheritance).

prior_prob_association
: The prior probability of association.

prior_prob_dominant
: The prior probability of dominant inheritance given that there is an association.

dominant_args
: Arguments to pass to bevimed_m conditioning on dominant inheritance.

recessive_args
: Arguments to pass to bevimed_m conditioning on recessive inheritance.

...
: Arguments to be passed to bevimed_m for both modes of inheritance.

Value

BeviMed object containing results of inference.

References

Greene et al., A Fast Association Test for Identifying Pathogenic Variants Involved in Rare Diseases, The American Journal of Human Genetics (2017), http://dx.doi.org/10.1016/j.ajhg.2017.05.015.

See Also

prob_association, bevimed_m, summary.BeviMed, bevimed_polytomous

---

bevimed_m *Perform inference under model gamma = 1 conditional on mode of inheritance*

Description

Sample from posterior distribution of parameters under model gamma = 1 and conditional on mode of inheritance, set via the min_ac argument.

Usage

```
bevimed_m(
  y,
  G,
  min_ac = 1L,
  G2 = NULL,
  tau_shape = c(1, 1),
  pi_shape = c(6, 1),
  omega_shape = if (max(min_ac) == 1L) c(2, 8) else c(2, 2),
  samples_per_chain = 1000,
  stop_early = FALSE,
  blocks = 5,
  burn = as.integer(samples_per_chain/10),
  temperatures = (0:6/6)^2,
  tune_temps = 0,
  vec_sums = FALSE,
```

```
  return_z_trace = TRUE,
  return_x_trace = TRUE,
  raw_only = FALSE,
  swaps = as.integer(length(temperatures)/2),
  optimise_z0 = FALSE,
  tune_omega_and_phi_proposal_sd = FALSE,
  tune_block_size = 100,
  variant_weights = NULL,
  standardise_weights = TRUE,
  log_phi_mean = -0.15,
  log_phi_sd = sqrt(0.3),
  tandem_variant_updates = if (max(min_ac) == 1) 0 else min(sum(y), ncol(G)),
  ...
)
```

Arguments

y	Logical vector of case (TRUE) control (FALSE) status.
G	Integer matrix of variant counts per individual, one row per individual and one column per variant.
min_ac	Integer vector with a length equalling the number of individuals or length 1 (in which case the given value is used for all individuals) giving the minimum number of alleles at pathogenic variant sites each individual requires in order to classify as having a 'pathogenic allele configuration'. Thus, this parameter encodes the mode of inheritance. For instance, setting this parameter to 1 corresponds to dominant inheritance. If there are differences in ploidy between individuals in the locus, it is necessary to set it on an sample level basis - e.g. to ensure sex is accounted for if the locus lies on the X chromosome.
G2	For when phased genotype data is available, corresponding matrix of genotypes for the second haplotype (defaults to NULL, if provided BeviMed is run in phased mode where allele configurations are only pathogenic when all haplotypes harbour a pathogenic allele under recessive recessive inheritance).
tau_shape	Beta shape hyper-priors for prior on rate of affection (i.e. being a case) amongst individuals with non-pathogenic variant combinations (i.e. they have less than min_ac variants.
pi_shape	Beta shape hyper-priors for prior on rate of affection (i.e. being a case) amongst individuals with pathogenic variant combinations (i.e. they have at least min_ac variants.
omega_shape	Beta shape hyper-priors for prior on rate of pathogenicity amongst variants.
samples_per_chain	Number of samples to draw from each chain.
stop_early	Logical value determining whether to attempt to stop the sampling as soon as certain conditions are met (i.e. either the estimated marginal log likelihood lies within a certain confidence interval, or we are sufficiently confidence that the log Bayes factor against of model gamma = 1 over model gamma = 0 is sufficiently low).

blocks	Maximum number of blocks of samples_per_chain samples to draw before either the confidence interval for the marginal likelihood under the model gamma = 1 is sufficiently small or terminating the sampling. This parameter is ignored if unless stop_early==TRUE.
burn	Number of samples to drop from the start of the chain.
temperatures	Numeric vector of temperatures of power posteriors. One chain will be created for each element of the vector at the corresponding temperature.
tune_temps	Integer value - if greater than 0, the temperatures argument is ignored, and instead tune_temps tuned temperatures are used instead.
vec_sums	Logical value determining whether to calculate vector summary statistics.
return_z_trace	Logical value determining whether to store the z-vectors for each chain, which uses alot of memory, particularly if samples_per_chain, k and length(temperatures) are large.
return_x_trace	Logical value determining whether to store the x variable determined by success samples of z. Potentially uses alot of memory, particularly if samples_per_chain, k and length(temperatures) are large.
raw_only	Logical value determining whether to return raw output of MCMC routine only.
swaps	Number of swaps between adjacent tempered chains to perform per update cycle.
optimise_z0	Logical value determining whether to use a simulated annealing optimisation run to tune the initial values of z.
tune_omega_and_phi_proposal_sd	Logical value determining whether the proposal SDs of the Metropolis-Hastings estimated parameters should be tuned for a target acceptance range.
tune_block_size	Integer value giving number of samples to draw when estimatating the acceptance rate of the omega/phi proposals.
variant_weights	Vector of log-odds off-sets for rates of pathogenicity of individual variants relative to the global rate, omega.
standardise_weights	Boolean value determining whether weights should be standardised by subtracting their mean and dividing by their sample standard deviation. If FALSE, weights are untransformed.
log_phi_mean	Mean for normal prior on scaling factor phi.
log_phi_sd	SD for normal prior on scaling factor phi. Setting to 0 causes the weights to be fixed and not estimated.
tandem_variant_updates	Number of tandem variant updates to make per update cycle.
...	Other arguments to be passed to stop_chain and/or tune_proposal_sds.

Details

A BeviMed_m object is a list containing elements:

- 'parameters': a list containing arguments used in the function call, including the adjusted weights used in the inference in the 'c_weights' slot,
- 'traces': a list of traces of model parameters from all MCMC chains for each parameter. Parameters sampled are z, omega, phi and x (the indicator of having a pathogenic configuration of alleles). The list of traces is named by parameter name, and each is a matrix where the rows correspond to samples. $z has k columns for each temperature, with the samples from the true posterior (i.e. with temperature equal to 1) of z corresponding to the final k columns. Likewise, the true posterior is given by the final column for the traces of phi and omega. The trace of x is only given for temperature equal to 1 to reduce memory usage.
- 'final': a list named by model parameter giving the final sample of each,
- 'swaps': a list with an element named 'accept' which is a logical vector whose ith element indicates whether the ith swap between adjacent tempered chains was accepted or not, and an element named 'at_temperature', an integer vector whose ith element indicates which pair of consecutive temperatures was the ith to be proposed for swapping (giving the lowest one).

Value

An object of class `BeviMed_m`.

References

Greene et al., A Fast Association Test for Identifying Pathogenic Variants Involved in Rare Diseases, The American Journal of Human Genetics (2017), http://dx.doi.org/10.1016/j.ajhg.2017.05.015.

See Also

`bevimed_m`, `prob_association_m`

`bevimed_polytomous` *Model selection for multiple association models*

Description

Apply bevimed to the no association model (gamma = 0) and multiple association models for different sets of variants, for instance, corresponding to different functional consequences.

Usage

```
bevimed_polytomous(
  y,
  G,
  ploidy = rep(2L, length(y)),
  G2 = NULL,
  variant_sets,
  prior_prob_association = rep(0.01/length(variant_sets), length(variant_sets)),
  tau0_shape = c(1, 1),
  moi = rep("dominant", length(variant_sets)),
```

```
  model_specific_args = vector(mode = "list", length = length(variant_sets)),
  ...
)
```

Arguments

y	Logical vector of case (TRUE) control (FALSE) status.
G	Integer matrix of variant counts per individual, one row per individual and one column per variant.
ploidy	Integer vector giving ploidy of samples.
G2	For when phased genotype data is available, corresponding matrix of genotypes for the second haplotype (defaults to NULL, if provided BeviMed is run in phased mode where allele configurations are only pathogenic when all haplotypes harbour a pathogenic allele under recessive recessive inheritance).
variant_sets	List of integer vectors corresponding to sets of indices of G, each of which is to be considered in a model explaining the phenotype, y.
prior_prob_association	The prior probability of association.
tau0_shape	Beta shape hyper-priors for prior on rate of case labels.
moi	Character vector giving mode of inheritance for each model.
model_specific_args	List of named lists of parameters to use in bevimed_m applications for specific models.
...	Other arguments to pass to bevimed_m.

References

Greene et al., A Fast Association Test for Identifying Pathogenic Variants Involved in Rare Diseases, The American Journal of Human Genetics (2017), http://dx.doi.org/10.1016/j.ajhg.2017.05.015.

See Also

bevimed_m, bevimed

---

call_cpp *R interface to BeviMed c++ MCMC procedure*

Description

Allows other functions in the package to call the c++ function passing arguments more succinctly and by name.

Usage

```
call_cpp(
  samples_per_chain,
  y,
  block_starts,
  block_ends,
  cases,
  counts,
  counts2,
  phased,
  min_ac,
  tau_shape,
  pi_shape,
  omega_shape,
  temperatures,
  z0_matrix,
  estimate_omega,
  logit_omegas,
  logit_omega_proposal_sds,
  variant_weights,
  estimate_phi,
  log_phis,
  log_phi_mean,
  log_phi_sd,
  log_phi_proposal_sds,
  chain_swaps_per_cycle,
  annealing,
  tandem_variant_updates,
  comphet_variant_block_starts,
  comphet_variant_block_ends,
  comphet_variants,
  return_z_trace,
  return_x_trace,
  vec_sums = FALSE,
  burn = 0,
  check = TRUE
)
```

Arguments

samples_per_chain	Number of samples to draw from each chain.
y	Logical vector of subject affectedness status.
block_starts	Integer vector of k 0-indexed start positions (with respect to cases and counts) for contiguous blocks relating to the k variants.
block_ends	Integer vector of (exclusive) k 0-indexed end positions.
cases	0 based vector of case indices with respect to y.

counts	Vector of variant counts.
counts2	Vector of variant counts on second haplotype.
phased	Boolean value indicating whether phased mode should be used (i.e. where phased genotypes are supplied and allele configurations are only pathogenic when all haplotypes harbour a pathogenic allele under recessive recessive inheritance).
min_ac	Integer vector with a length equalling the number of individuals or length 1 (in which case the given value is used for all individuals) giving the minimum number of alleles at pathogenic variant sites each individual requires in order to classify as having a 'pathogenic allele configuration'. Thus, this parameter encodes the mode of inheritance. For instance, setting this parameter to 1 corresponds to dominant inheritance. If there are differences in ploidy between individuals in the locus, it is necessary to set it on an sample level basis - e.g. to ensure sex is accounted for if the locus lies on the X chromosome.
tau_shape	Beta distribution parameterisation of benign variant configuration rate of affection, q.
pi_shape	Beta distribution parameterisation of pathogenic variant configuration rate of affection, p.
omega_shape	Beta distribution of global rate of pathogenicty of variants in gene given pathogenicity of gene, omega.
temperatures	Numeric vector of temperatures of power posteriors. One chain will be created for each element of the vector at the corresponding temperature.
z0_matrix	Matrix of logicals, where the rows are used as an initial zs for the chains.
estimate_omega	Logical value determining whether to estimate the parameter omega.
logit_omegas	Numeric vector of logit omega values, one value per chain.
logit_omega_proposal_sds	Numeric vector of proposal standard deviations for Metropolis-Hastings sampling of logit omega parameter, one value per chain.
variant_weights	Vector of log-odds off-sets for rates of pathogenicity of individual variants relative to the global rate, omega.
estimate_phi	Logical value determining whether to estimate a scaling factor of variant_weights.
log_phis	Numeric vector of log phi values, one value per chain.
log_phi_mean	Mean for normal prior on scaling factor phi.
log_phi_sd	SD for normal prior on scaling factor phi.
log_phi_proposal_sds	Numeric vector of proposal standard deviations for Metropolis-Hastings sampling of log phi parameter, one value per chain.
chain_swaps_per_cycle	Number of chain swaps to propose per update cycle.
annealing	Logical value determining whether to anneal the chains, e.g. for optimisation.
tandem_variant_updates	Number of tandem variant updates to make per update cycle.

comphet_variant_block_starts
: 0-indexed start positions for contiguous blocks of variants in comphet_variants.

comphet_variant_block_ends
: As comphet_variant_block_starts for (exclusive) stop positions.

comphet_variants
: Integer vector giving variant numbers (0-based, i.e. between 0 and k-1). Used to pick pairs of variants for tandem updates from.

return_z_trace
: Logical value determining whether to store the z-vectors for each chain, which uses alot of memory, particularly if samples_per_chain, k and length(temperatures) are large.

return_x_trace
: Logical value determining whether to store the x variable determined by success samples of z. Potentially uses alot of memory, particularly if samples_per_chain, k and length(temperatures) are large.

vec_sums
: Logical value determining whether to calculate vector summary statistics.

burn
: Number of samples to drop from the start of the chain.

check
: Logical value indicating whether to perform validation on the arguments before calling the c++ function.

Value

Object of class BeviMed_raw, containing the output of the MCMC sampling.

CI_gamma1_evidence *Estimate confidence interval for estimated marginal likelihood*

Description

Central limit theorem not applicable so use simulation to estimate confidence interval for evidence.

Usage

```
CI_gamma1_evidence(
  temperatures,
  y_log_lik_t_equals_1_traces,
  confidence = 0.95,
  simulations = 1000
)
```

Arguments

temperatures
: Numeric vector of temperatures of power posteriors. One chain will be created for each element of the vector at the corresponding temperature.

y_log_lik_t_equals_1_traces
: Numeric matrix of log probabilities of y at different temperatures (columns) in different iterations (rows).

`confidence`	Numeric value of statistical confidence with which returning interval should contain the true value.
`simulations`	Integer value of number of simulations to use in estimation of the confidence interval.

Value

Confidence interval as numeric vector of length 2.

`conditional_prob_pathogenic`

Calculate probability of pathogencity for variants conditional on mode of inheritance.

Description

Calls `bevimed_m` and `extract_conditional_prob_pathogenic` to obtain probabilities of pathogenicity.

Usage

```
conditional_prob_pathogenic(...)
```

Arguments

`...`	Arguments to pass to `bevimed_m`.

Value

Probabilities of pathogenicity.

See Also

`extract_conditional_prob_pathogenic`, `bevimed_m`

expected_explained *Calculate expected number of explained cases*

Description

Use bevimed_m to perform inference under model gamma = 1 and return only the expected number of cases explained by pathogenic allele configurations.

Usage

```
expected_explained(...)
```

Arguments

...	Arguments to pass to bevimed_m.

Value

Numeric value.

See Also

bevimed_m, extract_expected_explained

explaining_variants *Calculate expected number of pathogenic variants in cases*

Description

Use bevimed_m to perform inference under model gamma = 1 and return only the expected number of pathogenic variants in cases.

Usage

```
explaining_variants(...)
```

Arguments

...	Arguments to pass to bevimed_m.

Value

Numeric value.

See Also

extract_explaining_variants, bevimed_m

`extract_conditional_prob_pathogenic` *Extract probability of pathogenicity for variant conditional on a given association model*

Description

Extract the probability of pathogenicity for individual variants from a `BeviMed_m` object.

Usage

```
extract_conditional_prob_pathogenic(x)
```

Arguments

`x`	Object of class `x_BeviMed_m`. See function `bevimed_m`.

Value

Vector of probabilities of pathogenicity for individual variants.

See Also

`conditional_prob_pathogenic`, `bevimed_m`

`extract_expected_explained` *Extract expected number of explained cases*

Description

Extract expected number of cases explained by pathogenic configurations of alleles from `BeviMed_m` object.

Usage

```
extract_expected_explained(x)
```

Arguments

`x`	Object of class `x_BeviMed_m`. See function `bevimed_m`.

Value

Numeric value.

See Also

expected_explained, bevimed_m

`extract_explaining_variants` *Extract expected number of pathogenic variants in cases*

Description

Extract expected number of variants involved in cases explained by pathogenic conigurations of alleles from `BeviMed_m` object.

Usage

```
extract_explaining_variants(x)
```

Arguments

`x`	Object of class `x_BeviMed_m`. See function `bevimed_m`.

Value

Numeric value.

See Also

explaining_variants, bevimed_m

`extract_gamma1_evidence` *Extract evidence for model gamma = 1*

Description

Extract evidence from `BeviMed_m` object.

Usage

```
extract_gamma1_evidence(x)
```

Arguments

`x`	Object of class `x_BeviMed_m`. See function `bevimed_m`.

Value

Log marginal likelihood.

See Also

gamma1_evidence, bevimed_m

`extract_prob_association` *Extract the posterior probability of association*

Description

Get posterior probability of association as numeric value, or optionally as numeric vector of length two with probabilities broken down by mode of inheritance (by passing `by_model=TRUE`), from a `BeviMed` object.

Usage

```
extract_prob_association(x, by_model = FALSE)
```

Arguments

`x`	Object of class `BeviMed`.
`by_model`	Logical value determining whether to return probabilities broken down by mode of inheritance.

Value

Probability values.

See Also

prob_association, bevimed

extract_prob_pathogenic *Extract variant marginal probabilities of pathogenicity*

Description

Extract the marginal probability of pathogenicity for individual variants from BeviMed object, optionally broken down by mode of inheritance/model.

Usage

```
extract_prob_pathogenic(x, by_model = TRUE)
```

Arguments

x	Object of class BeviMed.
by_model	Logical value determining whether to return probabilities broken down by mode of inheritance.

Value

A vector of probabilities of pathogenicity for individual variants, or if by_model is TRUE, then a matrix of probabilities, with rows corresponding to modes of inheritance and columns to variants.

See Also

prob_pathogenic, bevimed

gamma0_evidence *Calculate marginal probability of observed case-control status y under model gamma = 0*

Description

Marginal probability calculated exactly by integration.

Usage

```
gamma0_evidence(y, tau0_shape = c(1, 1))
```

Arguments

y	Logical vector of case (TRUE) control (FALSE) status.
tau0_shape	Beta shape hyper-priors for prior on rate of case labels

Value

Log marginal likelihood.

See Also

bevimed, gamma1_evidence

---

gamma1_evidence *Calculate evidence under model gamma = 1*

Description

Use bevimed_m to perform inference under model gamma = 1 and return only the log evidence/integrated likelihood.

Usage

```
gamma1_evidence(...)
```

Arguments

...	Arguments to pass to bevimed_m.

Value

Log marginal likelihood.

See Also

bevimed_m, extract_gamma1_evidence

---

log_BF *Calculate log Bayes factor between an association model with a given mode of inheritance and model gamma = 0*

Description

Compute log Bayes factor of an association model and model gamma = 0.

Usage

```
log_BF(y, tau0_shape = c(1, 1), ...)
```

Arguments

y	Logical vector of case (TRUE) control (FALSE) status.
tau0_shape	Beta shape hyper-priors for prior on rate of case labels.
...	Arguments to pass to bevimed_m.

Value

Log Bayes factor.

See Also

bevimed_m, prob_association_m

---

print.BeviMed *Print readable summary of* BeviMed *object*

Description

Print summary statistics of BeviMed inference, including probability of association, probability of dominant inheritance given association and probability of pathogenicity of each variant under dominant and recessive inheritance.

Usage

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

Arguments

x	BeviMed object.
...	Arguments passed to summary.BeviMed

Value

Prints a summary.

See Also

summary.BeviMed

print.BeviMed_m *Print* BeviMed_m *object*

Description

Print summary statistics for BeviMed_m object.

Usage

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

Arguments

x	Object of class x_BeviMed_m. See function bevimed_m.
...	Unused arguments.

Value

Prints a summary.

See Also

summary.BeviMed_m

print.BeviMed_summary *Print readable summary of* BeviMed_summary *object.*

Description

Print summary statistics of BeviMed inference, including probability of association, probability of dominant inheritance given association and probability of pathogenicity of each variant under dominant and recessive inheritance.

Usage

```
## S3 method for class 'BeviMed_summary'
print(x, print_prob_pathogenic = TRUE, ...)
```

Arguments

x	BeviMed_summary object.
print_prob_pathogenic	Logical value indicating whether to print list of marginal probabilities of z_j = 1 for all variants j under each mode of inheritance.
...	Unused arguments

Value

Prints a summary

`prob_association` *Calculate probability of association*

Description

Calculate probability of an association between case/control label and allele configuration, optionally broken down by mode of inheritance/model.

Usage

```
prob_association(by_model = FALSE, ...)
```

Arguments

`by_model`	Logical value determining whether to return probabilities broken down by mode of inheritance.
`...`	Arguments to pass to `bevimed`.

Value

Probability of association.

See Also

`bevimed`, `extract_prob_association`

`prob_association_m` *Calculate probability of association for one mode of inheritance*

Description

Equivalent to `prob_association` where the prior probability of one mode of inheritance is 1. This function is faster, as it only calls `bevimed_m` once.

Usage

```
prob_association_m(y, min_ac = 1L, prior_prob_association = 0.01, ...)
```

Arguments

y	Logical vector of case (TRUE) control (FALSE) status.
min_ac	Integer vector with a length equalling the number of individuals or length 1 (in which case the given value is used for all individuals) giving the minimum number of alleles at pathogenic variant sites each individual requires in order to classify as having a 'pathogenic allele configuration'. Thus, this parameter encodes the mode of inheritance. For instance, setting this parameter to 1 corresponds to dominant inheritance. If there are differences in ploidy between individuals in the locus, it is necessary to set it on an sample level basis - e.g. to ensure sex is accounted for if the locus lies on the X chromosome.
prior_prob_association	The prior probability of association.
...	Other arguments to pass to log_BF.

Value

Probability value.

See Also

log_BF, prob_association, bevimed_m

---

prob_pathogenic *Calculate variant marginal probabilities of pathogencity*

Description

Calls bevimed and extract_prob_pathogenic to obtain marginal probabilities of pathogenicity.

Usage

```
prob_pathogenic(by_model = FALSE, ...)
```

Arguments

by_model	Logical value determining whether to return probabilities broken down by mode of inheritance.
...	Arguments to pass to bevimed.

Value

If by_model is FALSE, a vector of probabilities of pathogenicity for each variant, otherwise a list of vectors of probabilities of pathogenicity conditional on each compared association model.

See Also

extract_prob_pathogenic, bevimed

stack_BeviMeds *Concatenate objects of class* BeviMed_raw

Description

This function could be used to stitch together consecutive chains to create one larger sampled set of states from the MCMC procedure.

Usage

```
stack_BeviMeds(objects)
```

Arguments

objects	list of BeviMed_raw objects.

Value

BeviMed object.

stop_chain *Apply the MCMC algorithm in blocks until conditions are met*

Description

Sample blocks of a given size until either the estimated log marginal likelihood falls within a given confidence interval, there is sufficient confidence that the evidence model gamma = 1 is at most a certain quantity, or a certain number of blocks have been sampled.

Usage

```
stop_chain(
  y,
  blocks_remaining,
  start_zs,
  start_logit_omegas,
  start_log_phis,
  temperatures,
  tolerance = 1,
  confidence = 0.95,
  simulations = 1000,
  log_evidence_threshold = -Inf,
  y_log_lik_t_equals_1_traces = matrix(ncol = length(temperatures), nrow = 0),
  full_block_traces = list(),
  verbose = FALSE,
  ...
)
```

Arguments

y	Logical vector of case (TRUE) control (FALSE) status.
blocks_remaining	Maximum number of blocks left before termination.
start_zs	Initial (logical) z-matrix.
start_logit_omegas	Initial values of logit_omega (numeric vector - one value per chain).
start_log_phis	Initial values of log_phi (numeric vector - one value per chain).
temperatures	Numeric vector of temperatures of power posteriors. One chain will be created for each element of the vector at the corresponding temperature.
tolerance	Maximum width for confidence_interval of log marginal likelihood to allow before stopping the chain.
confidence	Numeric value of statistical confidence with which returning interval should contain the true value.
simulations	Integer value of number of simulations to use in estimation of the confidence interval.
log_evidence_threshold	Numeric value used to determine whether to stop the sampling procedure after successive blocks. If we are confident (to the level of confidence) that the evidence for model gamma = 1 is under this value, sampling is halted.
y_log_lik_t_equals_1_traces	Numeric matrix of log probabilities of y at different temperatures (columns) in different iterations (rows).
full_block_traces	List of outputs of calls to MCMC routine.
verbose	To print execution progress or not.
...	Other arguments passed to call_cpp

Value

An object of class BeviMed.

---

subset_variants *Remove variants with no data for pathogenicity*

Description

Subset an allele count matrix given a minimum allele count threshold for pathogenicity per individual so that only variants for which data relevant to pathogencity are retained. This is useful to apply before running bevimed as it reduces the size of the parameter space used in the inference.

Usage

```
subset_variants(G, min_ac = 1L, return_variants = FALSE)
```

Arguments

G	Integer matrix of variant counts per individual, one row per individual and one column per variant.
min_ac	Integer vector with a length equalling the number of individuals or length 1 (in which case the given value is used for all individuals) giving the minimum number of alleles at pathogenic variant sites each individual requires in order to classify as having a 'pathogenic allele configuration'. Thus, this parameter encodes the mode of inheritance. For instance, setting this parameter to 1 corresponds to dominant inheritance. If there are differences in ploidy between individuals in the locus, it is necessary to set it on an sample level basis - e.g. to ensure sex is accounted for if the locus lies on the X chromosome.
return_variants	Logical value determining whether to return an integer vector of indices of retained variants or the subsetted allele count matrix

---

summary.BeviMed *Summarise a* BeviMed *object*

Description

Create a summary of inference over model gamma = 0 and association models.

Usage

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

Arguments

object	Object of class BeviMed.
...	Arguments passed to summary.BeviMed_m.

Details

Returns a BeviMed_summary object, which is a list containing elements:

- 'prob_association': the probability of association under each association model,
- 'prior_prob_association': the prior probability of association for each association model,
- 'gamma0_evidence': the log evidence under model gamma = 0,
- 'models': a list of summaries of model conditional inferences, i.e. objects of class BeviMed_m_summary. See summary.BeviMed_m for more details.

Value

Object of class BeviMed_summary.

See Also

summary.BeviMed_m

---

summary.BeviMed_m *Summarise a* BeviMed_m *object*

Description

Create a summary of inference conditional on mode of inheritance.

Usage

```
## S3 method for class 'BeviMed_m'
summary(object, confidence = 0.95, simulations = 1000, ...)
```

Arguments

object	Object of class BeviMed_m. See function bevimed_m.
confidence	Numeric value of statistical confidence with which returning interval should contain the true value.
simulations	Integer value of number of simulations to use in estimation of the confidence interval.
...	Unused arguments.

Details

Returns a BeviMed_m_summary object, which is a list containing elements:

- 'gamma1_evidence': the log evidence under model gamma = 1,
- 'gamma1_evidence_confidence_interval': a confidence interval for the log evidence under model gamma = 1,
- 'conditional_prob_pathogenic': vector of marginal probabilities of pathogenicity for individual variants,
- 'expected_explained': the expected number of cases with a pathogenic configuration of alleles,
- 'explaining_variants': the expected number of variants present for which cases harbour a rare allele,
- 'number_of_posterior_samples': the number of samples from the posterior distribution of the model parameters which upon which the summary is based,
- 'omega_estimated': logical value indicating whether the parameter omega was estimated,
- 'omega': the posterior mean of omega,
- 'omega_acceptance_rate': if omega was estimated, the rate of acceptance of proposed omega values in the Metropolis-Hastings sampling routine,

- 'phi_estimated': logical value indicating whether the parameter phi was estimated,
- 'tau': the posterior mean of tau,
- 'pi': the posterior mean of pi,
- 'phi': the posterior mean of phi,
- 'phi_acceptance_rate': if phi was estimated, the rate of acceptance of proposed phi values in the Metropolis-Hastings sampling routine,
- 'N': number of samples in the analysis,
- 'k': number of variants in the analysis,
- 'variant_counts': list of counts of each variant for cases and controls,
- 'temperatures': numeric vector of temperatures used as temperatures for tempered MCMC chains

Value

Object of class `BeviMed_m_summary`.

See Also

`summary.BeviMed`

`sum_ML_over_PP` *Calculate marginal likelihood from power posteriors output*

Description

Calculate the Marginal Likelihood by summation over power posterior likelihood exptectances

Usage

```
sum_ML_over_PP(y_log_lik_t_equals_1_traces, temperatures)
```

Arguments

`y_log_lik_t_equals_1_traces`	Numeric matrix of log probabilities of `y` at different temperatures (columns) in different iterations (rows).
`temperatures`	Numeric vector of temperatures used to produce `y_log_lik_t_equals_1_traces`.

Value

Numeric value of estimated log marginal likelihood.

`tune_proposal_sds` *Tune proposal standard deviation for MH sampled parameters*

Description

Tune the proposal standard deviations for the Metropolis-Hastings updates of either phi or omega

Usage

```
tune_proposal_sds(
  tune_for = c("logit_omega"),
  initial_proposal_sds,
  target_acceptance_range = c(0.3, 0.7),
  other_param_proposal_sd = 0.7,
  max_tuning_cycles = 10,
  initial_rate = 1,
  rate_decay = 1.2,
  verbose = FALSE,
  ...
)
```

Arguments

`tune_for`	Character vector of length one, naming which variable to tune the proposal SDs for: either `"logit_omega"` or `"log_phi"`.
`initial_proposal_sds`	Numeric vector with the initial values of the proposal SDs.
`target_acceptance_range`	Numeric vector of length 2 where the first element is the lower bound for the acceptance interval and the second is the upper bound.
`other_param_proposal_sd`	The proposal SD to use for `log_phi` when tuning `logit_omega` or vice versa.
`max_tuning_cycles`	Maximum number of tuning cycles to perform before returning the proposal SDs as they are.
`initial_rate`	Initial rate at which to mutate the proposal SDs.
`rate_decay`	Geometric rate of decay for size of proposal SD mutation with each successive tuning cycle.
`verbose`	To print execution progress or not.
`...`	Other arguments to be passed to `call_cpp`.

Value

Numeric vector of proposal SDs for the different temperature chains.

`tune_temperatures` *Tune temperatures*

Description

Tune temperatures using interval bisection to minimimise Kullback-Liebler divergence between adjacent power posteriors

Usage

```
tune_temperatures(number_of_temperatures, return_temperatures = FALSE, ...)
```

Arguments

`number_of_temperatures`	Integer value giving number of tuned temperatures (including 0 and 1) to obtain.
`return_temperatures`	Logical value determining whether to return just the numeric vector of tuned temperatures or to return the `BeviMed_m`-classed object containing the output of the MCMC sampling.
`...`	Other arguments to pass to `call_cpp`.

Value

If `return_temperatures == TRUE`, a numeric vector of tuned temperatures, otherwise an object of class `BeviMed_m`.

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