

Package ‘dupiR’

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Title Bayesian Inference from Count Data using Discrete Uniform Priors

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Description

We consider a set of sample counts obtained by sampling arbitrary fractions of a finite volume containing an homogeneously dispersed population of identical objects. This package implements a Bayesian derivation of the posterior probability distribution of the population size using a binomial likelihood and non-conjugate, discrete uniform priors under sampling with or without replacement. This can be used for a variety of statistical problems involving absolute quantification under uncertainty. See Comoglio et al. (2013) <[doi:10.1371/journal.pone.0074388](https://doi.org/10.1371/journal.pone.0074388)>.

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 dupiR-package

Bayesian inference from count data using discrete uniform priors

Description

This package allows to infer population sizes using a binomial likelihood and least informative discrete uniform priors.

Author(s)

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References

Comoglio F, Fracchia L, Rinaldi M (2013) Bayesian Inference from Count Data Using Discrete Uniform Priors. PLoS ONE 8(10): e74388

compute_ecdf	<i>Compute ECDF (empirical cumulative distribution function)</i>
--------------	--

Description

Compute ECDF (empirical cumulative distribution function)

Usage

```
compute_ecdf(posterior)
```

Arguments

posterior numeric vector of posterior probabilities over the prior support

Value

numeric vector with empirical cumulative distribution function (cumulative sum of posterior)

compute_normalization_constant	<i>Compute normalization constant</i>
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Description

Compute normalization constant

Usage

```
compute_normalization_constant(counts, n_start, n_end, f_product)
```

Arguments

counts integer vector of counts
n_start start of prior support range
n_end end of prior support range
f_product product of (1-fractions)

Value

normalization constant to compute posterior density

compute_posterior	<i>Compute the posterior probability distribution of the population size for an object of class Counts</i>
-------------------	--

Description

Compute the posterior probability distribution of the population size using a discrete uniform prior and a binomial likelihood ("dup" algorithm, Comoglio et al.). An approximation using a Gamma prior and a Poisson likelihood is used when applicable ("gamma" algorithm) method (see Clough et al. for details)

Usage

```
compute_posterior(  
  object,  
  n_start,  
  n_end,  
  replacement = FALSE,  
  b = 1e-10,  
  alg = "dup"  
)
```

Arguments

object	object of class Counts
n_start	start of prior support range
n_end	end of prior support range
replacement	was sampling performed with replacement? Default to FALSE
b	prior rate parameter of the gamma distribution used to compute the posterior with Clough. Default to 1e-10
alg	algorithm to be used to compute posterior. One of Default to "dup"

Value

an object of class Counts

Author(s)

Federico Comoglio

References

Comoglio F, Fracchia L and Rinaldi M (2013) Bayesian inference from count data using discrete uniform priors. [PLoS ONE 8\(10\): e74388](#)

Clough HE et al. (2005) Quantifying Uncertainty Associated with Microbial Count Data: A Bayesian Approach. [Biometrics 61: 610-616](#)

Examples

```
counts <- new_counts(counts = c(20,30), fractions = c(0.075, 0.10))

# default parameters ("dup" algorithm, sampling without replacement, default prior support)
posterior <- compute_posterior(counts)

# custom prior support ("dup" algorithm)
posterior <- compute_posterior(counts, n_start = 0, n_end = 1e3)

# gamma prior ("gamma" algorithm)
posterior <- compute_posterior(counts, alg = "gamma")

# sampling with replacement
posterior <- compute_posterior(counts, replacement = TRUE)
```

`compute_posterior_with_replacement`*Compute posterior probability with replacement*

Description

Compute posterior probability with replacement

Usage

```
compute_posterior_with_replacement(n, counts, f_product, denominator)
```

Arguments

n	integer for which to compute the posterior
counts	integer vector of counts
f_product	product of (1-fractions)
denominator	normalization constant returned by <code>compute_normalization_constant</code>

Value

posterior probability of n

See Also

[compute_normalization_constant](#)

compute_sum	<i>Compute sum of terms (function F, Comoglio et al.)</i>
-------------	---

Description

Compute sum of terms (function F, Comoglio et al.)

Usage

```
compute_sum(counts, n, f_product)
```

Arguments

counts	integer vector of counts
n	number of objects
f_product	product of (1-fractions)

Value

sum of terms in function F

compute_term	<i>Compute single term (function F, Comoglio et al.)</i>
--------------	--

Description

Compute single term (function F, Comoglio et al.)

Usage

```
compute_term(counts, n, f_product, t)
```

Arguments

counts	integer vector of counts
n	number of objects
f_product	product of (1-fractions)
t	index vector

Value

single term of function F

Counts-class	<i>An S4 class to store measurements (count data, sampling fractions), prior support and posterior parameters</i>
--------------	---

Description

An S4 class to store measurements (count data, sampling fractions), prior support and posterior parameters

Usage

```
## S4 method for signature 'Counts'
get_counts(object)

## S4 method for signature 'Counts'
get_fractions(object)

## S4 replacement method for signature 'Counts'
set_counts(object) <- value

## S4 replacement method for signature 'Counts'
set_fractions(object) <- value

## S4 method for signature 'Counts'
compute_posterior(
  object,
  n_start,
  n_end,
  replacement = FALSE,
  b = 1e-10,
  alg = "dup"
)

## S4 method for signature 'Counts'
get_posterior_param(object, low = 0.025, up = 0.975, ...)

## S4 method for signature 'Counts'
plot_posterior(object, low = 0.025, up = 0.975, xlab, step, ...)
```

Arguments

object	object of class Counts
value	numeric vector of sampling fractions
n_start	start of prior support range
n_end	end of prior support range
replacement	was sampling performed with replacement? Default to FALSE

b	prior rate parameter of the gamma distribution used to compute the posterior with Clough. Default to 1e-10
alg	algorithm to be used to compute posterior. One of Default to "dup"
low	1 - right tail posterior probability
up	left tail posterior probability
...	additional parameters to be passed to curve
xlab	x-axis label. Default to 'n' (no label)
step	integer defining the increment for x-axis labels (distance between two consecutive tick marks)

Value

counts vector from a Counts object
 fractions vector from a Counts object
 an object of class Counts
 an object of class Counts
 an object of class Counts
 an object of class Counts
 no return value, called for side effects

Methods (by generic)

- `get_counts(Counts)`: Returns counts from a Counts object
- `get_fractions(Counts)`: Returns fractions from a Counts object
- `set_counts(Counts) <- value`: Replaces counts of a Counts object with the provided values
- `set_fractions(Counts) <- value`: Replaces fractions of a Counts object with the provided values
- `compute_posterior(Counts)`: Compute the posterior probability distribution of the population size
- `get_posterior_param(Counts)`: Extract statistical parameters (e.g. credible intervals) from a posterior probability distribution
- `plot_posterior(Counts)`: Plot posterior probability distribution and posterior parameters

Slots

counts integer vector of counts (required)
 fractions numeric vector of sampling fractions (required)
 n_start start of prior support range. If omitted and total counts greater than zero, computed as $0.5 * mle$, where `mle` is the maximum likelihood estimate of the population size
 n_end end of prior support range. If omitted and total counts greater than zero, computed as $2 * mle$, where `mle` is the maximum likelihood estimate of the population size
 f_product product of (1-fractions)

mle maximum likelihood estimate of the population size (ratio between total counts and total sampling fraction)
norm_constant normalization constant
posterior numeric vector of posterior probabilities over the prior support
map_p maximum of posterior probability
map_index index of prior support corresponding to the maximum a posteriori
map maximum a posteriori of population size
q_low lower bound of the credible interval
q_low_p probability of the lower bound of the credible interval
q_low_index index of the prior support corresponding to **q_low**
q_low_cum_p cumulative posterior probability from **n_start** to **q_low** (left tail)
q_up upper bound of the credible interval
q_up_p probability of the upper bound of the credible interval
q_up_index index of the prior support corresponding to **q_high**
q_up_cum_p cumulative posterior probability from **q_high** to **n_end** (right tail)
gamma logical, TRUE if posterior computed using a Gamma approximation

Note

The `posterior` slot contains either the PMF or a logical value used to compute posterior parameters with a Gamma approximation (see reference for details)

Lower and upper bounds of the credible interval are computed at a default confidence level of 95

For more details on the normalization constant, see Corollary 1 in reference

Author(s)

Federico Comoglio

References

Comoglio F, Fracchia L and Rinaldi M (2013) Bayesian inference from count data using discrete uniform priors. [PLoS ONE 8\(10\): e74388](#)

See Also

[compute_posterior](#), [get_posterior_param](#)

Examples

```

# constructor:
# create an object of class 'Counts'
new_counts(counts = c(30, 35), fractions = c(0.075, 0.1))

# same, using new
new("Counts", counts = c(30, 35), fractions = c(0.075, 0.1))

```

gamma_poisson_clough *Compute posterior probability using a Gamma-Poisson model (Clough et al.)*

Description

Compute posterior probability using a Gamma-Poisson model (Clough et al.)

Usage

```
gamma_poisson_clough(object, n_start, n_end, a = 1, b = 1e-10)
```

Arguments

object	object of class Counts
n_start	start of prior support range
n_end	end of prior support range
a	prior shape parameter of the gamma distribution used to compute the posterior with Clough. Default to 1
b	prior rate parameter of the gamma distribution used to compute the posterior with Clough. Default to 1e-10

Value

vector of posterior probabilities

Note

if support range spans more than 100k values, the posterior is not computed

get_counts *Get counts slot for an object of class Counts*

Description

Get counts slot for an object of class Counts

Usage

```
get_counts(object)
```

Arguments

object	object of class Counts
--------	------------------------

Value

counts vector from a Counts object

get_fractions	<i>Get fractions slot for an object of class Counts</i>
---------------	---

Description

Get fractions slot for an object of class Counts

Usage

```
get_fractions(object)
```

Arguments

object	object of class Counts
--------	------------------------

Value

fractions vector from a Counts object

get_posterior_param	<i>Compute posterior probability distribution parameters (e.g. credible intervals) for an object of class Counts</i>
---------------------	--

Description

This function computes posterior parameters and credible intervals at the given confidence level (default to 95%).

Usage

```
get_posterior_param(object, low = 0.025, up = 0.975, ...)
```

Arguments

object	object of class Counts
low	1 - right tail posterior probability
up	left tail posterior probability
...	additional parameters to be passed to plot_posterior

Value

an object of class Counts

Author(s)

Federico Comoglio

References

Comoglio F, Fracchia L and Rinaldi M (2013) Bayesian inference from count data using discrete uniform priors. [PLoS ONE 8\(10\): e74388](#)

Clough HE et al. (2005) Quantifying Uncertainty Associated with Microbial Count Data: A Bayesian Approach. [Biometrics 61: 610-616](#)

Examples

```
counts <- new_counts(counts = c(20,30), fractions = c(0.075, 0.10))

# default parameters ("dup" algorithm, sampling without replacement, default prior support)
posterior <- compute_posterior(counts)

get_posterior_param(posterior)
```

```
initialize,Counts-method
      Initialize Counts class
```

Description

Initialize Counts class

Usage

```
## S4 method for signature 'Counts'
initialize(.Object, counts, fractions)
```

Arguments

.Object	an object of class "Counts"
counts	integer vector of counts
fractions	numeric vector of sampling fractions

new_counts	<i>Constructor for Counts class</i>
------------	-------------------------------------

Description

Constructor for Counts class

Usage

```
new_counts(counts, fractions)
```

Arguments

counts	integer vector of counts
fractions	numeric vector of sampling fractions

Value

An object of the Counts class

plot, Counts-method	<i>Plot method for Counts class</i>
---------------------	-------------------------------------

Description

Plot method for Counts class

Usage

```
## S4 method for signature 'Counts'  
plot(x, y, ...)
```

Arguments

x	object of class Counts
y	none
...	additional parameters to be passed to plot_posterior

Value

no return value, called for side effects

plot_posterior	<i>Plot posterior probability distribution and display posterior parameters for an object of class Counts</i>
----------------	---

Description

Plot posterior probability distribution and display posterior parameters for an object of class Counts

Usage

```
plot_posterior(object, low = 0.025, up = 0.975, xlab, step, ...)
```

Arguments

object	object of class Counts
low	1 - right tail posterior probability
up	left tail posterior probability
xlab	x-axis label. Default to 'n' (no label)
step	integer defining the increment for x-axis labels (distance between two consecutive tick marks)
...	additional parameters to be passed to curve

Value

no return value, called for side effects

Author(s)

Federico Comoglio

References

Comoglio F, Fracchia L and Rinaldi M (2013) Bayesian inference from count data using discrete uniform priors. [PLoS ONE 8\(10\): e74388](#)

Examples

```
counts <- new_counts(counts = c(20,30), fractions = c(0.075, 0.10))

# default parameters ("dup" algorithm, sampling without replacement, default prior support)
posterior <- compute_posterior(counts)

# plot posterior
plot_posterior(posterior, type = 'l', lwd = 3, col = 'blue3')
```

set_counts<- *Set counts slot for an object of class Counts*

Description

Set counts slot for an object of class Counts

Usage

set_counts(object) <- value

Arguments

object	object of class Counts
value	numeric vector of counts

Value

an object of class Counts

set_fractions<- *Set fractions slot for an object of class Counts*

Description

Set fractions slot for an object of class Counts

Usage

set_fractions(object) <- value

Arguments

object	object of class Counts
value	numeric vector of sampling fractions

Value

an object of class Counts

show,Counts-method *Print method for Counts class*

Description

Print method for Counts class

Usage

```
## S4 method for signature 'Counts'  
show(object)
```

Arguments

object object of class Counts

Value

no return value, called for side effects

summary,Counts-method *Summary method for Counts class*

Description

Summary method for Counts class

Usage

```
## S4 method for signature 'Counts'  
summary(object, ...)
```

Arguments

object object of class Counts
... additional parameters affecting the summary produced

Value

no return value, called for side effects

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