Package 'plpoisson'

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Type Package

Title Prediction Limits for Poisson Distribution

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Description Prediction limits for the Poisson distribution
are produced from both frequentist and Bayesian viewpoints. Limiting results
are provided in a Bayesian setting with uniform, Jeffreys and gamma as prior
distributions. More details on the methodology are discussed in Bejleri and
Nandram (2018) <doi:10.1080/03610926.2017.1373814> and Bejleri, Sartore and
Nandram (2021) <doi:10.1007/s42952-021-00157-x>.

License GPL-3

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`plpoisson-package` *Prediction Limits for Poisson Distribution*

Description

Prediction limits for Poisson distribution are useful when quantifying the uncertainty associated with predicting the occurrences of real life phenomena. The **plpoisson** package provides a set of functions to compute prediction limits of the inferred Poisson distribution under both, frequentist and Bayesian frameworks.

For frequentist prediction a common approach is to estimate the parameter based on the observed data firstly, then, to predict based on the estimated parameter. Different from the common approach of frequentist prediction, this approach does not require the estimation of the parameter. In a Bayesian setting, the uniform, Jeffreys and gamma distributions are used as priors when deriving the predictive posterior distribution.

Details

Package:	plpoisson
Type:	Package
Version:	0.3.1
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License:	GPL-3

For a complete list of exported functions, use `library(help = "plpoisson")`.

Author(s)

Valbona Bejleri, Luca Sartore and Balgobin Nandram

Maintainer: Luca Sartore <drwolf85@gmail.com>

References

Bejleri, V., & Nandram, B. (2018). Bayesian and frequentist prediction limits for the Poisson distribution. *Communications in Statistics-Theory and Methods*, **47**(17), 4254-4271.

Bejleri, V., Sartore, L. & Nandram, B. (2021). *Asymptotic equivalence between frequentist and Bayesian prediction limits for the Poisson distribution*. Journal of the Korean Statistical Society doi:10.1007/s4295202100157x

Bejleri, V. (2005). *Bayesian Prediction Intervals for the Poisson Model, Noninformative Priors*, Ph.D. Dissertation, American University, Washington, DC.

Examples

```
## Loading the package
library(plpoisson)

## Setting quantities of interest
xobs <- rpois(1, 50)    # Number of the observed occurrencies
n <- 1                  # Total number of the time windows of
                        #   of size 's' observed in the past
s <- rgamma(1, 4, .567) # Fixed size of observed time windows
t <- rgamma(1, 3, .33)  # Future time window
a <- 5                  # Shape hyperparameter of a gamma prior
b <- 1.558              # Rate hyperparameter of a gamma prior

## Frequentist prediction limits
poiss(xobs, n, s, t)

## Bayesian prediction limits (with uniform prior)
poisUNIF(xobs, n, s, t)

## Bayesian prediction limits (with Jeffreys prior)
poisJEFF(xobs, n, s, t)

## Bayesian prediction limits (with gamma prior)
poisBayes(xobs, n, s, t, a, b)
```

`hyperbootstrap` *Bootstrap Methods to Estimate Hyperparameters for a Gamma Prior*

Description

The function provides three bootstrap implementations to estimate the hyperparameters of a gamma prior distribution. The method of moments, maximum likelihood and chi-square approximation are implemented for studying the uncertainties associated with the choice of the hyperparameters a (shape) and b (rate).

Usage

```
hyperbootstrap(xvec, B = 1000L,
               method = c("moments", "likelihood", "chisq"))
```

Arguments

`xvec`	a numeric vector of data with the observed occurrencies (assumed to be Poisson distributed).
`B`	a numeric value representing the total number of bootstrap iterations.
`method`	a character string (or strings) with the name/s of the method/s chosen to obtain hyperparameter estiamtes.

Details

The function performs a choosen number of iterations using either the method of momemnts (`method = "moments"`), the maximum likelihood (`method = "likelihood"`), or the chi-square approximation (`method = "chisq"`).

Value

A list containing the following components:

a	A matrix of values for the shape hyperparameter of the gamma distribution. The results of each method are organized by column.
b	A matrix of values for the rate hyperparameter of the gamma distribution. The results of each method are organized by column.

Author(s)

Valbona Bejleri, Luca Sartore and Balgobin Nandram

References

Bejleri, V., Sartore, L. & Nandram, B. (2021). *Asymptotic equivalence between frequentist and Bayesian prediction limits for the Poisson distribution*. Journal of the Korean Statistical Society doi:10.1007/s4295202100157x

Bejleri, V. (2005). *Bayesian Prediction Intervals for the hyperbootstrapon Model, Noninformative Priors*, Ph.D. Dissertation, American University, Washington, DC.

See Also

`poisBayes`, `poisJEFF`, `poisUNIF`

Examples

```
# Loading the package
library(plpoisson)
set.seed(2021L)

# Number of observed time windows
n <- 555L

# Simulating a dataset
data <- cbind.data.frame(
    occ_obs = rpois(n, rgamma(n, 5.5, .5)),
    win_siz = rgamma(n, 1.44, .777)
)

## Compute bootstrap estimates using all methods
hyperbootstrap(data$occ_obs, 10L) # only 10 iterations
```

poisBayes *Bayesian Prediction Limits for Poisson Distribution (Gamma Prior)*

Description

The function provides the Bayesian prediction limits of a Poisson random variable derived based on a gamma prior. The resulting prediction bounds quantify the uncertainty associated with the predicted future number of occurences in a time window of size t.

Usage

```
poisBayes(xobs, n, s, t, a, b, alpha = 0.05)
```

Arguments

xobs	a numeric value denoting the number of the observed occurrencies.
n	a numeric value representing the total number of the time windows s in the past (observed time windows).
s	a numeric value corresponding to the fixed size (or average size) of the observed time windows.
t	a numeric value indicating the size of the future time window.
a	a poisitive real number denoting the shape hyperparameter of a gamma prior distribution.
b	a poisitive real number representing the rate hyperparameter of a gamma prior distribution.
alpha	a numeric value associated to the credible probability. By default alpha = 0.05, thus an prediction interval at 95% will be returned.

Details

When the argument b = Inf, one can obtain prediction limits with uniform prior by setting the argument a = 1. Similarly, one can get the limits with a Jeffreys prior by setting the argument a = 0.

Value

A list containing the following components:

lower	An integer value representing the lower bound of the prediction limit.
upper	An integer value representing the upper bound of the prediction limit.

Author(s)

Valbona Bejleri, Luca Sartore and Balgobin Nandram

References

Bejleri, V., & Nandram, B. (2018). Bayesian and frequentist prediction limits for the Poisson distribution. *Communications in Statistics-Theory and Methods*, **47**(17), 4254-4271.

Bejleri, V. (2005). *Bayesian Prediction Intervals for the Poisson Model, Noninformative Priors*, Ph.D. Dissertation, American University, Washington, DC.

See Also

poiss, poisJEFF, poisUNIF

Examples

```
# Loading the package
library(plpoisson)
set.seed(2020L)

# Number of observed time windows
n <- 555L

# Simulating a dataset
data <- cbind.data.frame(
    occ_obs = rpois(n, rgamma(n, 5.5, .5)),
    win_siz = rgamma(n, 1.44, .777)
)

## Bayesian prediction limits
##  (with gamma prior)
poisBayes(sum(data$occ_obs), # Past occurrencies
    nrow(data), # Total past time windows
    mean(data$win_siz), # Window size
    333, # Size of future window
    2, 2.22) # Hyper-parameters for gamma prior
```

---

poisJEFF *Bayesian Prediction Limits for Poisson Distribution (Jeffreys Prior)*

Description

The function provides the Bayesian prediction limits of a Poisson random variable derived based on a Jeffreys prior. The resulting prediction bounds quantify the uncertainty associated to the predicted future number of occurences in a time windows of size t.

Usage

```
poisJEFF(xobs, n, s, t, alpha = 0.05)
```

Arguments

xobs	a numeric value denoting the number of the observed occurrencies.
n	a numeric value representing the total number of the time windows s in the past (observed time windows).
s	a numeric value corresponding to the fixed size (or average size) of the observed time windows.
t	a numeric value indicating the size of the future time window.
alpha	a numeric value associated to the credible probability. By default alpha = 0.05, thus an prediction interval at 95% will be returned.

Details

The resulting limits are equivalent to those provided when running the function poisBayes() with arguments a = 0 and b = Inf.

Value

A list containing the following components:

lower	An integer value representing the lower bound of the prediction limit.
upper	An integer value representing the upper bound of the prediction limit.

Author(s)

Valbona Bejleri, Luca Sartore and Balgobin Nandram

References

Bejleri, V., & Nandram, B. (2018). Bayesian and frequentist prediction limits for the Poisson distribution. *Communications in Statistics-Theory and Methods*, **47**(17), 4254-4271.

Bejleri, V. (2005). *Bayesian Prediction Intervals for the Poisson Model, Noninformative Priors*, Ph.D. Dissertation, American University, Washington, DC.

See Also

poiss, poisBayes, poisUNIF

Examples

```
# Loading the package
library(plpoisson)
set.seed(2020L)

# Number of observed time windows
n <- 555L

# Simulating a dataset
data <- cbind.data.frame(
    occ_obs = rpois(n, rgamma(n, 5.5, .5)),
```

```
    win_siz = rgamma(n, 1.44, .777)
)

## Bayesian prediction limits
##  (with Jeffreys prior)
poisJEFF(sum(data$occ_obs), # Past occurrencies
    nrow(data), # Total past time windows
    mean(data$win_siz), # Window size
    444) # Size of future window
```

`poiss` *Frequentist Prediction Limits for Poisson Distribution*

Description

The function provides the frequentist prediction limits of a Poisson random variable. The resulting prediction bounds quantify the uncertainty associated to the predicted future number of occurences in a time windows of size t.

Usage

```
poiss(xobs, n, s, t, alpha = 0.05)
```

Arguments

`xobs`	a numeric value denoting the number of the observed occurrencies.
`n`	a numeric value representing the total number of the time windows `s` in the past (observed time windows).
`s`	a numeric value corresponding to the fixed size (or average size) of the observed time windows.
`t`	a numeric value indicating the size of the future time window.
`alpha`	a numeric value associated to the probability of prediction. By default `alpha = 0.05`, thus a prediction interval at 95% will be returned.

Details

Prediction bounds are obtained through the binary search algorithm.

Value

A list containing the following components:

`lower`	An integer value representing the lower bound of the prediction limit.
`upper`	An integer value representing the upper bound of the prediction limit.

Author(s)

Valbona Bejleri, Luca Sartore and Balgobin Nandram

References

Bejleri, V., & Nandram, B. (2018). Bayesian and frequentist prediction limits for the Poisson distribution. *Communications in Statistics-Theory and Methods*, **47**(17), 4254-4271.

Bejleri, V. (2005). *Bayesian Prediction Intervals for the Poisson Model, Noninformative Priors*, Ph.D. Dissertation, American University, Washington, DC.

Davis, C. H. (1969). The binary search algorithm. *American Documentation (pre-1986)*, **20**(2), 167.

See Also

poisBayes, poisJEFF, poisUNIF

Examples

```
# Loading the package
library(plpoisson)
set.seed(2020L)

# Number of observed time windows
n <- 555L

# Simulating a dataset
data <- cbind.data.frame(
    occ_obs = rpois(n, rgamma(n, 5.5, .5)),
    win_siz = rgamma(n, 1.44, .777)
)

## Frequentist prediction limits
poiss(sum(data$occ_obs), # Past occurrencies
    nrow(data), # Total past time windows
    mean(data$win_siz), # Window size
    3) # Size of future window
```

---

poisUNIF *Bayesian Prediction Limits for Poisson Distribution (Uniform Prior)*

Description

The function provides the Bayesian prediction limits of a Poisson random variable derived based on a uniform prior. The resulting prediction bounds quantify the uncertainty associated to the predicted future number of occurences in a time windows of size t.

Usage

```
poisUNIF(xobs, n, s, t, alpha = 0.05)
```

Arguments

xobs	a numeric value denoting the number of the observed occurrencies.
n	a numeric value representing the total number of the time windows s in the past (observed time windows).
s	a numeric value corresponding to the fixed size (or average size) of the observed time windows.
t	a numeric value indicating the size of the future time window.
alpha	a numeric value associated to the credible probability. By default alpha = 0.05, thus an prediction interval at 95% will be returned.

Details

The resulting limits are equivalent to those provided when running the function poisBayes() with arguments a = 1 and b = Inf.

Value

A list containing the following components:

lower	An integer value representing the lower bound of the prediction limit.
upper	An integer value representing the upper bound of the prediction limit.

Author(s)

Valbona Bejleri, Luca Sartore and Balgobin Nandram

References

Bejleri, V., & Nandram, B. (2018). Bayesian and frequentist prediction limits for the Poisson distribution. *Communications in Statistics-Theory and Methods*, **47**(17), 4254-4271.

Bejleri, V. (2005). *Bayesian Prediction Intervals for the Poisson Model, Noninformative Priors*, Ph.D. Dissertation, American University, Washington, DC.

See Also

poiss, poisJEFF, poisBayes

Examples

```
# Loading the package
library(plpoisson)
set.seed(2020L)

# Number of observed time windows
n <- 555L

# Simulating a dataset
data <- cbind.data.frame(
    occ_obs = rpois(n, rgamma(n, 5.5, .5)),
```

```
    win_siz = rgamma(n, 1.44, .777)
)

## Bayesian prediction limits
##  (with uniform prior)
poisUNIF(sum(data$occ_obs), # Past occurrencies
    nrow(data), # Total past time windows
    mean(data$win_siz), # Window size
    444) # Size of future window
```

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