Package 'multChernoff'

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Title Finite-Sample Tail Bound of Likelihood Ratio Test under Multinomial Sampling

Version 1.0.0

Description Computes a finite-sample tail bound for the log-likelihood ratio test (LRT) statistic under multinomial sampling. The resulting bound is used to compute finite-sample conservative p-values and critical values when the standard chi-squared asymptotics can be unreliable. The package also supports multiple independent multinomial trials.

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Encoding UTF-8

RoxygenNote 7.3.3

URL https://github.com/richardkwo/multChernoff

BugReports https://github.com/richardkwo/multChernoff/issues

Imports plyr

Suggests knitr, rmarkdown, testthat (>= 3.0.0)

VignetteBuilder knitr

Config/testthat/edition 3

NeedsCompilation no

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Repository CRAN

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`criticalValue` *Critical value x such that* $P(2LRT > x) \leq p$

Description

The LRT is the log-likelihood ratio test statistic, which can be written as

$$LRT = n\, KL(\hat{p} \| p).$$

By the Wilks' theorem, for a fixed k-dimensional probability vector, it holds that

$$2 \times LRT \rightarrow_d \chi^2_{k-1}.$$

This function returns a finite-sample counterpart to `qchisq(p, k-1, lower.tail=FALSE)`. The LRT is also extended to multiple independent multinomial trials. For example, for a (k_1, n_1)-trial and a (k_2, n_2)-trial, we have

$$LRT = n_1\, KL(\hat{p}_1 \| p_1) + n_2\, KL(\hat{p}_2 \| p_2).$$

Usage

```
criticalValue(k, n, p = 0.05, verbose = FALSE)
```

Arguments

k	number of categories (a vector for independent multinomial draws)
n	sample size (a vector for independent multinomial draws)
p	significance level (e.g., 0.05)
verbose	draw the minimizer if TRUE

Value

A finite-sample critical value x such that the bound on $P(2 \times LRT > x)$ is at most p.

Note

For independent multinomial samples, k and n must be of the same length.

See Also

`tailProbBound`, `mgfBound`

Examples

```
n <- 1:40
crit <- sapply(n, function(.n) criticalValue(20, .n, p=0.01))
plot(n, crit)
# chi-squared asymptotic by Wilks' theorem
abline(h=qchisq(0.01, df=20-1, lower.tail = FALSE))
criticalValue(10, 40, p=0.05)
# two independent multinomial trials (k=3, n=4) and (k=12, n=20)
criticalValue(c(3, 4), c(12, 20), p=0.05)
```

`mgfBound` *An upper bound on the moment generating function of LRT*

Description

The LRT is the log-likelihood ratio test statistic, which can be written as

$$LRT = n\, KL(\hat{p} \| p),$$

namely the Kullback-Leibler divergence from the empirical probabilities to the true probabilities multiplied by the sample size. $G(\lambda; k, n)$ is a polynomial in λ such that

$$MGF(\lambda; LRT) := E_p[\exp(\lambda \times LRT)] \leq G(\lambda; k, n)$$

holds for every $\lambda \in [0, 1]$ and every p.

Usage

```
mgfBound(k, n, lambda)
```

Arguments

`k`	number of categories
`n`	sample size
`lambda`	number between 0 and 1

Value

A numeric upper bound on the MGF of LRT evaluated at `lambda`.

See Also

`tailProbBound`, `criticalValue`

Examples

```
mgfBound(k = 5, n = 20, lambda = 0.5)
mgfBound(k = 5, n = 20, lambda = 0)  # always 1 at lambda = 0
```

`tailProbBound` *Tail bound on P(2 LRT > x).*

Description

The LRT is the log-likelihood ratio test statistic, which can be written as

$$LRT = n\, KL(\hat{p}\|p).$$

By the Wilks' theorem, for a fixed k-dimensional probability vector, it holds that

$$2 \times LRT \to_d \chi^2_{k-1}.$$

This function returns a finite-sample counterpart to `pchisq(x, k-1, lower.tail=FALSE)`. The LRT is also extended to multiple independent multinomial trials. For example, for a (k_1, n_1)-trial and a (k_2, n_2)-trial, we have

$$LRT = n_1\, KL(\hat{p}_1\|p_1) + n_2\, KL(\hat{p}_2\|p_2).$$

Usage

```
tailProbBound(x, k, n, verbose = FALSE)
```

Arguments

`x`	the value of $2 \times LRT$
`k`	number of categories (a vector for independent multinomial draws)
`n`	sample size (a vector for independent multinomial draws)
`verbose`	draw the minimizer if `TRUE`

Value

An upper bound on P(2 LRT > x), which can be used as a conservative p-value.

Note

For independent multinomial samples, k and n must be of the same length.

See Also

`criticalValue`, `mgfBound`

Examples

```
tailProbBound(20, 7, 50)
pchisq(20, 6, lower.tail=FALSE) # compare with the standard chi-square asymptotic
# two independent multinomial trials (k=3, n=4) and (k=12, n=20)
tailProbBound(12, c(3, 4), c(12, 20))
pchisq(12, 5, lower.tail=FALSE) # compare with the standard chi-square asymptotic
```

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