Package 'LBI'

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Version 0.2.1

Title Likelihood Based Inference

Description Maximum likelihood estimation and likelihood ratio test are essential for modern statistics. This package supports in calculating likelihood based inference.
Reference: Pawitan Y. (2001, ISBN:0-19-850765-8).

Depends R (>= 3.0.0)

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Contents

LBI-package | *Likelihood Based Inference*

Description

It conducts likelihood based inference.

Details

Modern likelihood concept and maximum likelihood estimation are established by Fisher RA, while Likelihood Ratio Test (LRT) is established by Neyman J. Post-Fisher methods - generalized linear model, survival analysis, and mixed effects model - are all likelihood based. Inferences from the perspective of Fisherian and pure likelihoodist are suggested here.

Author(s)

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References

1. Wilks SS. The Large-sample Distribution of the Likelihood Ratio for Testing Composite Hypotheses. Ann Math Stat. 1938;9(1):60-62.

2. Edwards AWF. Likelihood. 1972.

3. Fisher RA. Statistical Methods and Scientific Inference. 3e. 1973.

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8. Pawitan Y. In All Likelihood: Statistical Modelling and Inference Using Likelihood. 2001.

9. Lehmann EL. Fisher, Nayman, and the Creation of Classical Statistics. 2011.

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LBCIvar | *Likelihood Based Confidence Interval of sd and variance assuming Norml Distribution*

Description

Likelihood based confidence interval of sd and variance assuming normal distribution. It usually shows narrower interval than convenrtional chi-square interval. This uses estimated likelihood, not profile likelihood.

Usage

```
LBCIvar(x, conf.level=0.95)
```

Arguments

x	a vector of observation
conf.level	confidence level

Details

It calculates (same height) likelihood based confidence interval of sd and variance assuming normal distribution in one group. The likelihood interval is asymmetric and there is no standard error in the output.

Value

PE	maximum likelihood estimate
LL	lower limit of likelihood interval
UL	upper limit of likelihood interval

Author(s)

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Examples

```
LBCIvar(lh)
(length(lh) - 1)*var(lh)/qchisq(c(0.975, 0.025), length(lh) - 1)
```

LIbin   *Likelihood Interval for a Proportion or a Binomial Distribution*

Description

Likelihood interval of a proportion in one group

Usage

```
LIbin(y, n, k, conf.level=0.95, eps=1e-8)
```

Arguments

y	positive event count of a group
n	total count of a group
k	1/k likelihood interval will be calculated
conf.level	approximately corresponding confidence level. If k is specified, this is ignored.
eps	Values less than eps are considered as 0.

Details

It calculates likelihood interval of a proportion in one group. The likelihood interval is asymmetric and there is no standard error in the output. If you need percent scale, multiply the output by 100.

Value

y	positive (concerning) event count
n	total trial count
PE	maximum likelihood estimate on the proportion
LL	lower limit of likelihood interval
UL	upper limit of likelihood interval

Author(s)

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References

Fisher RA. Statistical methods and scientific inference. 3e. 1973. pp68-76.

See Also

`binom.test`, `prop.test`

Examples

```
  LIbin(3, 14, k=2)
  LIbin(3, 14, k=5)
  LIbin(3, 14, k=15)
  LIbin(3, 14)
# binom.test(3, 14)
# prop.test(3, 14)
```

LInorm	*Likelihood Interval of mean, sd and variance assuming Norml Distribution*

Description

Likelihood interval of mean and sd assuming normal distribution. This is estimated likelihood interval, not profile likelihood interval.

Usage

```
  LInorm(x, k, conf.level=0.95, PLOT="", LOCATE=FALSE, Resol=201)
```

Arguments

x	a vector of observation
k	1/k likelihood interval will be calculated
conf.level	approximately corresponding confidence level. If k is specified, this is ignored.
PLOT	"1d" for profile plot or "2d" for contour plot.
LOCATE	use locater. This works only with PLOT="2D" option.
Resol	resolution for plot. This works only with PLOT=TRUE option.

Details

It calculates likelihood interval of mean and sd assuming normal distribution in one group. There is no standard error in the output.

Value

PE	maximum likelihood estimate
LL	lower limit of likelihood interval
UL	upper limit of likelihood interval

Author(s)

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Examples

```
x = c(-5.3, -4.5, -1.0, -0.7, 3.7, 3.9, 4.2, 5.5, 6.8, 7.4, 9.3)
LInorm(x, k=1/0.15) # Pawitan Ex10-9 p289
LInorm(x)
LInorm(x, PLOT="1d")
LInorm(x, PLOT="2d", LOCATE=TRUE)
```

LInormVar | *Likelihood Interval of sd and variance assuming Norml Distribution*

Description

Likelihood interval of sd and variance assuming normal distribution. This is estimated likelihood interval, not profile likelihood interval.

Usage

```
LInormVar(x, k, conf.level=0.95)
```

Arguments

x	a vector of observation
k	1/k likelihood interval will be calculated
conf.level	approximately corresponding confidence level. If k is specified, this is ignored.

Details

It calculates likelihood interval of sd and variance assuming normal distribution in one group. The likelihood interval is asymmetric and there is no standard error in the output.

Value

PE	maximum likelihood estimate
LL	lower limit of likelihood interval
UL	upper limit of likelihood interval

Author(s)

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Examples

```
x = c(-5.3, -4.5, -1.0, -0.7, 3.7, 3.9, 4.2, 5.5, 6.8, 7.4, 9.3)
LInormVar(x, k=1/0.15) # Pawitan Ex10-9 p289
LInormVar(x)
```

LIpois   *Likelihood Interval of the Mean assuming Poisson Distribution*

Description

Likelihood interval of lambda assuming Poisson distribution.

Usage

```
LIpois(x, k, conf.level=0.95, eps=1e-8)
```

Arguments

x	mean or lambda, the count in a time unit.
k	1/k likelihood interval will be calculated
conf.level	approximately corresponding confidence level. If k is specified, this is ignored.
eps	Values less than eps are considered as 0.

Details

It calculates likelihood interval of mean(lambda) assuming Poisson distribution. The likelihood interval is asymmetric and there is no standard error in the output.

Value

PE	maximum likelihood estimate on the lambda
LL	lower limit of likelihood interval
UL	upper limit of likelihood interval

Author(s)

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Examples

```
  LIpois(4, k=1/0.15) # Pawitan
  LIpois(4, k=exp(2)) # Edwards
  LIpois(4, k=8)      # Rhode
  LIpois(4)           # Bae
  LIpois(4, k=15)     # Fisher
# poisson.test(4)
  LIpois(4, k=32)     # 0.7454614 11.7893612
```

LIvar	*Likelihood Interval of variance and sd assuming Norml Distribution with sample mean and sample size*

Description

Likelihood interval of sd and variance assuming normal distribution. This is estimated likelihood interval, not profile likelihood interval.

Usage

```
LIvar(s1, n1, k, conf.level=0.95)
```

Arguments

s1	standard deviation of the sample
n1	sample size
k	1/k likelihood interval will be calculated
conf.level	approximately corresponding confidence level. If k is specified, this is ignored.

Details

It calculates likelihood interval of sd and variance assuming normal distribution in one group. The likelihood interval is asymmetric and there is no standard error in the output.

Value

PE	maximum likelihood estimate on the population variance
LL	lower limit of likelihood interval
UL	upper limit of likelihood interval

Author(s)

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Examples

```
x = c(-5.3, -4.5, -1.0, -0.7, 3.7, 3.9, 4.2, 5.5, 6.8, 7.4, 9.3)
LInormVar(x)
LIvar(sd(x), length(x))
```

LIvRatio   *Likelihood Interval of the ratio of two variances from two groups*

Description

Likelihood interval of the ratio of two variances from two groups assuming normal distribution. Likelihood interval usually gives a narrower interval when the likelihood function is asymmetric.

Usage

```
LIvRatio(x, y, k, conf.level=0.95)
```

Arguments

x   observations from the first group, the test group, used for the numerator

y   observations from the second group, the control group, used for the denominator

k   1/k likelihood interval will be provided

conf.level   approximate confidence level

Details

It calculates likelihood interval of the ratio of two variances from two groups. Likelihood interval usually gives a narrower interval when the likelihood function is asymmetric.

Value

PE   maximum likelihood estimate on the ratio

LL   lower limit of likelihood interval

UL   upper limit of likelihood interval

logk   log(k) value used for LI

maxLL   maximum log likelihood

conf.level   approximate confidence level

Author(s)

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Examples

```
LIvRatio(mtcars$drat, mtcars$wt)
var.test(mtcars$drat, mtcars$wt)
LIvRatio(mtcars$qsec, mtcars$wt)
var.test(mtcars$qsec, mtcars$wt)
LIvtest(sd(mtcars$qsec), nrow(mtcars), sd(mtcars$wt), nrow(mtcars))
```

LIvtest | *Likelihood Interval of variance and sd assuming Norml Distribution using means and SDs*

Description

Likelihood interval of variance and sd assuming normal distribution. This is estimated likelihood interval, not profile likelihood interval.

Usage

```
LIvtest(s1, n1, s2, n2, k, conf.level=0.95)
```

Arguments

s1	sample standard deviation of the first group
n1	sample size of the first group
s2	sample standard deviation of the second group
n2	sample size of the second group
k	1/k likelihood interval will be calculated
conf.level	approximate confidence level. If k is specified, this is ignored.

Details

It calculates likelihood interval of variance and sd using sufficient statistics. There is no standard error in the output.

Value

PE	maximum likelihood estimate on the ratio
LL	lower limit of likelihood interval
UL	upper limit of likelihood interval
logk	log(k) value used for LI
maxLL	maximum log likelihood
conf.level	approximate confidence level

Author(s)

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Examples

```
LIvtest(10.5, 3529, 8.9, 5190)
LIvtest(3, 10, 2, 10)
LIvtest(3, 10, 2, 10, k=15)
```

LRT   *Likelihood Ratio Test*

Description

Likelihood ratio test with given fitting results, sample size, number of parameters, log-likelihoods, and alpha

Usage

```
LRT(n, pFull, pReduced, logLikFull, logLikReduced, alpha=0.05, Wilks=FALSE)
```

Arguments

n	number of observations
pFull	number of parameters of full model
pReduced	number of parameters of reduced model
logLikFull	log likelihood of full model
logLikReduced	log likelihood of reduced model
alpha	alpha value for type I error, significance level
Wilks	if TRUE, Wilks theorem (chi-square distribution) will be used, otherwise F distribution will be used.

Details

It performs likelihood ratio test with given fitting results. The default test is using F distribution. For small n (i.e. less than 100), you need to use F distribution. If the residuals are normally distributed, the delta -2 log likelihood (the difference between -2LL, the objective function value of each model) follows exactly an F-distribution, independent of sample size. When the distribution of the residuals is not normal (no matter what the distribution of the residuals is), it approaches a chi-square distribution as sample size increases (Wilks' theorem). The extreme distribution of the F-distribution (when the degrees of freedom in the denominator go to infinity) is chi-square distribution. The p-value from the F-distribution is slightly larger than the p-value from the chi-square distribution, meaning the F-distribution is more conservative. The difference decreases as sample size increases.

Value

n	number of observations
paraFull	number of parameters of full model
paraReduced	number of parameters of reduced model
deltaPara	difference of parameter counts
cutoff	cutoff, threshold, critical value of log-likelihood for the test
deltaLogLik	difference of log likelihood, if negative 0 is used.
Chisq or Fval	statistics according to the used distribution Chi-square of F
pval	p-value of null hypothesis. i.e. the reduced model is better.
Verdict	the model preferred.

Author(s)

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References

1. Ruppert D, Cressie N, Carroll RJ. A Transformation/Weighting Model For Estimating Michaelis-Menten Parameters. School of Operations Research and Industrial Engineering, College of Engineering, Cornell University. Technical Report No. 796. May 1988.

2. Scheffé H. The Analysis of Variance. Wiley. 1959.

3. Wilks SS. The Large-Sample Distribution of the Likelihood Ratio for Testing Composite Hypotheses. *Annals Math. Statist.* 1938;9:60-62

Examples

```
LRT(20, 4, 2, -58.085, -60.087)
LRT(20, 4, 2, -58.085, -60.087, Wilks=TRUE)
LRT(20, 4, 2, -57.315, -66.159)
LRT(20, 4, 2, -57.315, -66.159, Wilks=TRUE)

r1 = lm(mpg ~ disp + drat + wt, mtcars)
r2 = lm(mpg ~ disp + drat, mtcars)
anova(r2, r1)
LRT(nrow(mtcars), r1$rank, r2$rank, logLik(r1), logLik(r2))
```

OneTwo	*Likelihood Ratio Test for One group vs Two group gaussian mixture model*

Description

With a given vector, it performs likelihood ratio test which model - one or two group - is better.

Usage

```
OneTwo(x, alpha=0.05)
```

Arguments

x	a vector of numbers
alpha	alpha value for type I error, significance level

Details

It performs likelihood ratio test using both F distribution and Chi-square distribution (by Wilks' theorem).

Value

Estimate	n, Mean, SD for each group assumption and prior probability of each group in two group model
Delta	delta number of parameters and log-likelihoods
Statistic	Statistics from both the F distribution and Chi-square distribtuion. Cutoff is in terms of log-likelihood not the statistic.

Author(s)

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Examples

```
OneTwo(c(7, 5, 17, 13, 16, 5, 7, 3, 8, 10, 8, 14, 14, 11, 14, 17, 2, 12, 15, 19))
OneTwo(c(5, 3, 0, 6, 5, 2, 6, 6, 4, 4, 15, 13, 18, 18, 19, 14, 19, 13, 19, 18))
```

ORLI	*Odds Ratio and its Likelihood Interval between two groups without strata*

Description

Odds ratio and its likelihood interval between two groups without stratification

Usage

```
ORLI(y1, n1, y2, n2, conf.level=0.95, k, eps=1e-8)
```

Arguments

y1	positive event count of test (the first) group
n1	total count of the test (the first) group. Maximum allowable value is 1e8.
y2	positive event count of control (the second) group
n2	total count of control (the second) group. Maximum allowable value is 1e8.
conf.level	approximate confidence level to calculate k when k is missing.
k	1/k likelihood interval will be provided
eps	absolute value less than eps is regarded as negligible

Details

It calculates risk (proportion) difference and its likelihood interval between the two groups. The likelihood interval is asymmetric, and there is no standard error in the output. This does not support stratification.

Value

There is no standard error.

odd1	odd from the first group, y1/(n1 - y1)
odd2	odd from the second group, y2/(n2 - y2)
OR	odds ratio, odd1/odd2
lower	lower likelihood limit of OR
upper	upper likelihood limit of OR

Author(s)

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Examples

```
ORLI(7, 10, 3, 10)
ORLI(3, 10, 7, 10)
```

RDLI   *Risk (Proportion) Difference and its Likelihood Interval between two groups without strata*

Description

Risk difference and its likelihood interval between two groups without stratification

Usage

```
RDLI(y1, n1, y2, n2, conf.level=0.95, k, eps=1e-8)
```

Arguments

y1	positive event count of test (the first) group
n1	total count of the test (the first) group. Maximum allowable value is 1e8.
y2	positive event count of control (the second) group
n2	total count of control (the second) group. Maximum allowable value is 1e8.
conf.level	approximate confidence level to calculate k when k is missing.
k	1/k likelihood interval will be provided
eps	absolute value less than eps is regarded as negligible

Details

It calculates risk (proportion) difference and its likelihood interval between the two groups. The likelihood interval is asymmetric, and there is no standard error in the output. This does not support stratification.

Value

There is no standard error.

p1	proportion from the first group, y1/n1
p2	proportion from the second group, y2/n2
RD	risk difference, p1 - p2
lower	lower likelihood limit of RD
upper	upper likelihood limit of RD

Author(s)

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Examples

```
RDLI(7, 10, 3, 10)
RDLI(3, 10, 7, 10)
```

RRLI   *Relative Risk and its Likelihood Interval between two groups without*
                                       strata

Description

Relative risk and its likelihood interval between two groups without stratification

Usage

```
RRLI(y1, n1, y2, n2, conf.level=0.95, k, eps=1e-8)
```

Arguments

y1	positive event count of test (the first) group
n1	total count of the test (the first) group. Maximum allowable value is 1e8.
y2	positive event count of control (the second) group
n2	total count of control (the second) group. Maximum allowable value is 1e8.
conf.level	approximate confidence level to calculate k when k is missing.
k	1/k likelihood interval will be provided
eps	absolute value less than eps is regarded as negligible

Details

It calculates relative risk and its likelihood interval between the two groups. The likelihood interval is asymmetric, and there is no standard error in the output. This does not support stratification.

Value

There is no standard error.

p1	proportion from the first group, y1/n1
p2	proportion from the second group, y2/n2
RR	relative risk, p1/p2
lower	lower likelihood limit of RR
upper	upper likelihood limit of RR

Author(s)

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Examples

```
RRLI(7, 10, 3, 10)
RRLI(3, 10, 7, 10)
```

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