

Package ‘auRoc’

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Title Various Methods to Estimate the AUC

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Description Estimate the AUC using a variety of methods as follows:

- (1) frequentist nonparametric methods based on the Mann-Whitney statistic or kernel methods.
- (2) frequentist parametric methods using the likelihood ratio test based on higher-order asymptotic results, the signed log-likelihood ratio test, the Wald test, or the approximate "t" solution to the Behrens-Fisher problem.
- (3) Bayesian parametric MCMC methods.

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auc.nonpara.kernel *AUC by Kernel Methods*

Description

Obtain the point estimate and the confidence interval of the AUC using kernel methods.

Usage

```
auc.nonpara.kernel(x, y, conf.level=0.95,
                  integration=c("FALSE", "TRUE"),
                  bw=c("nrd0", "sj"), nint=512,
                  method=c("mw", "jackknife", "bootstrapP", "bootstrapBCa"),
                  nboot)
```

Arguments

x	a vector of observations from class P.
y	a vector of observations from class N.
conf.level	confidence level of the interval. The default is 0.95.
integration	a logical value. If its value is FALSE then the results are based on the kernel estimates of the CDF; otherwise the PDF. The default values is FALSE.
bw	method used for bandwidth selection. nrd0 uses a rule-of-thumb for choosing the bandwidth of a Gaussian kernel density estimation; sj uses the method of Sheather & Jones (1991). The default if nrd0.
nint	the number of equally spaced points at which the density is to be estimated. The default if 512.
method	a method used to construct the CI. mw uses the sd based on the Mann-Whitney statistic; jackknife uses the jackknife method; bootstrapP uses the bootstrap with percentile CI; bootstrapBCa uses bootstrap with bias-corrected and accelerated CI. The default is mw. It can be abbreviated.
nboot	number of bootstrap iterations.

Details

The AUC essentially depends on the CDFs of two classes N and P. We could use kernel smoothing methods to obtain the CDFs. The methods implemented in this function construct the CI based on two different strategies: the first uses kernel smoothing to estimate the PDFs and then the CDFs; and the second starts from the estimate of the CDFs directly. Gaussian kernel is used.

Value

Point estimate and lower and upper bounds of the CI of the AUC.

Note

The observations from class P tend to have larger values than that from class N.

Author(s)

Dai Feng

References

Dai Feng, Giuliana Cortese, and Richard Baumgartner (2015) A comparison of confidence/credible interval methods for the area under the ROC curve for continuous diagnostic tests with small sample size. *Statistical Methods in Medical Research* DOI: 10.1177/0962280215602040

Simon Sheather and Michael Jones (1991) A reliable data-based bandwidth selection method for kernel density estimation. *Journal of the Royal Statistical Society. Series B (Methodological)* **53** 683-690

Examples

```
#Example 1
data(petBrainGlioma)
y <- subset(petBrainGlioma, grade==1, select="FDG", drop=TRUE)
x <- subset(petBrainGlioma, grade==2, select="FDG", drop=TRUE)
auc.nonpara.kernel(x, y)

## Not run:
#Example 2
data(petBrainGlioma)
y <- subset(petBrainGlioma, grade==1, select="ACE", drop=TRUE)
x <- subset(petBrainGlioma, grade==2, select="ACE", drop=TRUE)
auc.nonpara.kernel(x, y, integration="TRUE",
                   bw="sj", method="bootstrapBCa", nboot=999)

## End(Not run)
```

Description

Obtain the point estimate and the confidence interval of the AUC by various methods based on the Mann-Whitney statistic.

Usage

```
auc.nonpara.mw(x, y, conf.level=0.95,
               method=c("newcombe", "pepe", "delong", "DL.corr",
                        "jackknife", "bootstrapP", "bootstrapBCa"),
               nboot)
```

Arguments

x	a vector of observations from class P.
y	a vector of observations from class N.
conf.level	confidence level of the interval. The default is 0.95.
method	a method used to construct the CI. newcombe is the method recommended in Newcombe (2006); pepe is the method proposed in Pepe (2003); delong is the method proposed in Delong et al. (1988); DL.corr is a method proposed in Perme and Manevski (2018); jackknife uses the jackknife method; bootstrapP uses the bootstrap with percentile CI; bootstrapBCa uses bootstrap with bias-corrected and accelerated CI. The default is newcombe. It can be abbreviated.
nboot	number of bootstrap iterations.

Details

The function implements various methods based on the Mann-Whitney statistic.

Value

Point estimate and lower and upper bounds of the CI of the AUC.

Note

The observations from class P tend to have larger values than that from class N.

Author(s)

Dai Feng, Damjan Manevski, Maja Pohar Perme

References

- Elizabeth R Delong, David M Delong, and Daniel L Clarke-Pearson (1988) Comparing the areas under two or more correlated receiver operating characteristic curves: a nonparametric approach. *Biometrics* **44** 837-845
- Dai Feng, Giuliana Cortese, and Richard Baumgartner (2017) A comparison of confidence/credible interval methods for the area under the ROC curve for continuous diagnostic tests with small sample size. *Statistical Methods in Medical Research* **26(6)** 2603-2621 DOI: 10.1177/0962280215602040
- Robert G Newcombe (2006) Confidence intervals for an effect size measure based on the Mann-Whitney statistic. Part 2: asymptotic methods and evaluation. *Statistics in Medicine* **25(4)** 559-573
- Margaret Sullivan Pepe (2003) The statistical evaluation of medical tests for classification and prediction. *Oxford University Press*

Maja Pohar Perme and Damjan Manevski (2018) Confidence intervals for the Mann-Whitney test. *Statistical Methods in Medical Research* DOI: 10.1177/0962280218814556

Examples

```
data(petBrainGlioma)
y <- subset(petBrainGlioma, grade==1, select="FDG", drop=TRUE)
x <- subset(petBrainGlioma, grade==2, select="FDG", drop=TRUE)
auc.nonpara.mw(x, y)
auc.nonpara.mw(x, y, method="delong")
```

auc.para.bayes	<i>AUC by the Bayesian MCMC</i>
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Description

Obtain the point estimate and the credible interval of the AUC using the Bayesian MCMC.

Usage

```
auc.para.bayes(x, y, conf.level=0.95,
               dist=c("normalDV", "normalEV", "exponential"),
               nburn=1000, niter=10000, nthin=1, seed=100)
```

Arguments

x	a vector of observations from class P.
y	a vector of observations from class N.
conf.level	confidence level of the interval. The default is 0.95.
dist	the name of a parametric distribution. <code>normalEV</code> stands for normal distributions with equal variance; <code>normalDV</code> stands for normal distributions with unequal variances; <code>exponential</code> stands for exponential distributions. The default is <code>normalDV</code> . It can be abbreviated.
nburn	number of burn-in. The default is 1000.
niter	number of iterations. The default is 10000.
nthin	number of thinning interval. The default is 1.
seed	the seed. The default is 100.

Details

Use the Bayesian MCMC to estimate the parameters of the distributions and hence the AUC values.

Value

Point estimate and lower and upper bounds of the CI of the AUC.

Note

The observations from class P tend to have larger values than that from class N.

Author(s)

Dai Feng

References

Dai Feng, Giuliana Cortese, and Richard Baumgartner (2015) A comparison of confidence/credible interval methods for the area under the ROC curve for continuous diagnostic tests with small sample size. *Statistical Methods in Medical Research* DOI: 10.1177/0962280215602040

Examples

```
#Example 1
data(petBrainGlioma)
y <- subset(petBrainGlioma, grade==1, select="FDG", drop=TRUE)
x <- subset(petBrainGlioma, grade==2, select="FDG", drop=TRUE)
auc.para.bayes(x, y, dist="exp")
```

```
#Example 2
data(petBrainGlioma)
y <- subset(petBrainGlioma, grade==1, select="ACE", drop=TRUE)
x <- subset(petBrainGlioma, grade==2, select="ACE", drop=TRUE)
auc.para.bayes(x, y, dist="normalDV")
```

auc.para.frequentist *AUC by Frequentist Parametric Methods*

Description

Obtain the point estimate and the confidence interval of the AUC using some frequentist parametric methods.

Usage

```
auc.para.frequentist(x, y, conf.level=0.95,
                    dist=c("normalDV", "normalEV", "exponential"),
                    method=c("lrstar", "lr", "wald", "RG1", "RG2"))
```

Arguments

x	a vector of observations from class P.
y	a vector of observations from class N.
conf.level	confidence level of the interval. The default is 0.95.
dist	the name of a parametric distribution. <code>normalEV</code> stands for normal distributions with equal variance; <code>normalDV</code> stands for normal distributions with unequal variances; <code>exponential</code> stands for exponential distributions. The default is <code>normalDV</code> . It can be abbreviated.
method	a method used to construct the CI. <code>lrstar</code> uses the likelihood ratio test based on higher-order asymptotic results; <code>lr</code> uses the signed log-likelihood ratio test; <code>wald</code> uses the Wald test; <code>RG1</code> is the approximate "t" solution to the Behrens-Fisher problem; <code>RG2</code> is the normal approximation to <code>RG1</code> . <code>RG1</code> and <code>RG2</code> are for normal distributions. The default is <code>lrstar</code> . It can be abbreviated.

Details

Use a variety of frequentist methods for different parametric models to estimate the AUC.

Value

Point estimate and lower and upper bounds of the CI of the AUC.

Note

The observations from class P tend to have larger values than that from class N.

Author(s)

Dai Feng

References

Giuliana Cortese and Laura Ventura (2013) Accurate higher-order likelihood inference on $P(Y < X)$. *Computational Statistics* **28(3)** 1035-1059

Dai Feng, Giuliana Cortese, and Richard Baumgartner (2015) A comparison of confidence/credible interval methods for the area under the ROC curve for continuous diagnostic tests with small sample size. *Statistical Methods in Medical Research* DOI: 10.1177/0962280215602040

Benjamin Reiser and Irwin Guttman (1986) Statistical inference for $\Pr(Y < X)$: The normal case. *Technometrics* **28(3)** 253-257

Examples

```
#Example 1
data(petBrainGlioma)
y <- subset(petBrainGlioma, grade==1, select="FDG", drop=TRUE)
x <- subset(petBrainGlioma, grade==2, select="FDG", drop=TRUE)
auc.para.frequentist(x, y, dist="exp")
```

```
#Example 2
data(petBrainGlioma)
y <- subset(petBrainGlioma, grade==1, select="ACE", drop=TRUE)
x <- subset(petBrainGlioma, grade==2, select="ACE", drop=TRUE)
auc.para.frequentist(x, y, method="RG1")
```

petBrainGlioma

Standard Uptake Value (SUV) for Brain Glioma Grading

Description

SUVs from FDG PET and ACE PET used in differentiating brain tumors.

Usage

```
petBrainGlioma
```

Format

A data-frame presenting the SUVs.

Source

Tatsuro Tsuchida, Hiroaki Takeuchi, Hidehiko Okazawa, Tetsuya Tsujikawa, and Yasuhisa Fujibayashi (2008) Grading of brain glioma with 1-¹¹C-acetate PET: comparison with ¹⁸F-FDG PET. *Nuclear medicine and biology* **35**(2) 171-176

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