Package 'kmconfband'

February 20, 2015

Type Package

Title Kaplan-Meier Simultaneous Confidence Band for the Survivor Function

Version 0.1

Date 2013-10-23

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Description Computes and plots an exact nonparametric band for any user-specified level of confidence from a single-sample survfit object

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Depends R (>= 2.14.0), graphics, survival

NeedsCompilation no

Repository CRAN

Date/Publication 2013-10-25 17:49:25

R topics documented:

confband *Compute an Exact Nonparametric Confidence Band for the Population Survivor Function*

Description

This function computes an exact nonparametric confidence band for the population survivor function, based on its one-sample Kaplan-Meier estimate. The theory and methods used in the computations are described in the 2013 article by *Matthews*. The confidence level required can be specified by the user.

Usage

```
confband(sobj,conf.level=0.95)
```

Arguments

`sobj`	a one-sample Kaplan-Meier estimate, provided in the form of a `survfit.object`.
`conf.level`	confidence level, a proportion between 0 and 1; the default value is 0.95.

Details

The exact nonparametric confidence band is calculated as lower and upper estimates of the survivor function derived from the `survfit.object`.

Value

There are two outputs. The first is a scalar, the required quantile from the sample-specific, exact null distribution of the modified Berk-Jones (B-J) statistic. Inverting this B-J statistic generates a matrix of dimension $(k+1) \times 2$, where k represents the number of changes in the Kaplan-Meier estimate, i.e., the number of distinct, complete observations in the original dataset. This matrix is the primary output of the function. Its first column is the lower estimate; the second column is the corresponding upper estimate. If the smallest value of the Kaplan-Meier estimate is 0, then so is the smallest value of the lower bound; otherwise, it has a positive value. Each row in the matrix represents a pair of lower and upper limits for one of the $k+1$ distinct values of the Kaplan-Meier estimate. The ordering of these rows is the same as the ordering of the original `survfit.object`.

Author(s)

David E. Matthews <dematthews@uwaterloo.ca>

References

Matthews, D. (2013) "Exact nonparametric confidence bands for the survivor function." *Int J Biostat* **9**(1), doi: 10.1515/ijb-2012-0046

See Also

plotbands

Examples

```
## Calculate a nonparametric, exact, 95% confidence band for leukemia
## patient remission experience based on data from 20 patients
## receiving Treatment B
time<-c(1,1,2,2,3,4,5,8,8,9,11,12,14,16,18,21,27,31,38,44)
status<-c(rep(1,16),0,1,0,1)
fit<-survfit(Surv(time,status)~1)
bands<-confband(fit)

## Separately display the 95% (default) lower and upper confidence
## band values
bands[,1]
bands[,2]

## Repeat the same calculations, but for 80% confidence
bands<-confband(fit,0.80)

## Display the lower and upper confidence band values separately
bands[,1]
bands[,2]
```

---

cover *Calculate the Exact Coverage Probability of a Nonparametric Confidence Band for the Survivor Function*

Description

This function computes the exact coverage probability of a specified nonparametric confidence band for the population survivor function derived from a single-sample Kaplan-Meier estimate

Usage

```
cover(x,sobj)
```

Arguments

x	scalar, a quantile of the exact null distribution.
sobj	a one-sample Kaplan-Meier estimate, provided in the form of a survfit.object.

Details

The function uses the current value of the scalar x to calculate the lower and upper limits corresponding to each distinct value of the sample-specific Kaplan-Meier estimate, via the function exact. If there are k changes of value in the Kaplan-Meier estimate, there will be $k + 1$ pairs of limits. Then, using k ordered, uniform intervals derived from these $k + 1$ pairs, the coverage probability that corresponds to the current value of x is evaluated using Noe's recursions, via the function noe

Value

The function returns the calculated value of the coverage probability for the exact nonparametric confidence band, derived from the single-sample Kaplan-Meier estimate, that corresponds to quantile x

Author(s)

David E. Matthews <dematthews@uwaterloo.ca>

See Also

confband, exact, noe

Examples

```
## Calculate the coverage probability for an exact, nonparametric confidence
## band for leukemia patient remission experience based on data from 20
## patients receiving Treatment B when the value of x is 0.3
time<-c(1,1,2,2,3,4,5,8,8,9,11,12,14,16,18,21,27,31,38,44)
status<-c(rep(1,16),0,1,0,1)
fit<-survfit(Surv(time,status)~1)
cover(0.3,fit)
```

---

exact — *Calculate an Exact Nonparametric Confidence Band for the Survivor Function*

Description

This function computes exact nonparametric confidence limits for the population survivor function, based on its one-sample Kaplan-Meier estimate, when the quantile of the cumulative distribution function, a value of the modified B-J statistic, is x.

Usage

```
exact(sobj, x)
```

Arguments

sobj	a one-sample Kaplan-Meier estimate, provided in the form of a survfit.object.
x	scalar, a quantile of the exact null distribution.

Details

If the number of times the Kaplan-Meier estimate derived from the sample changes value is k, the function returns a matrix of $(k+1) \times 2$ values. These are the lower and upper limits that correspond to the $k+1$ different values for the sample-specific Kaplan-Meier estimate.

For the specified, fixed choice of x, each lower and upper limit is calculated using the Van Wijngaarden-Decker-Brent root-finding algorithm, zbrent. The tolerance required for convergence to each required root/limit is 1.0e-10.

Value

A matrix containing the lower and upper confidence band when the value of the modified B-J statistic is x. The first column of the matrix represents the lower estimate of the population survivor function, and the second column of the matrix provides the corresponding upper estimate.

Author(s)

David E. Matthews <dematthews@uwaterloo.ca>

See Also

confband, zbrent

Examples

```
## Calculate the exact, nonparametric lower and upper estimates of
## leukemia patient remission experience based on data from 20 patients
## receiving Treatment B when the value of x is 0.3
time<-c(1,1,2,2,3,4,5,8,8,9,11,12,14,16,18,21,27,31,38,44)
status<-c(rep(1,16),0,1,0,1)
fit<-survfit(Surv(time,status)~1)
exact(fit,0.3)
```

---

iv *Initial Value Calculation for Deriving an Exact Nonparametric Confidence Band for the Survivor Function*

Description

This function computes an initial value that very roughly approximates the 0.95-quantile from the exact null distribution of the modified B-J statistic from which a nonparametric confidence band for the population survivor function, based on its one-sample Kaplan-Meier estimate, can be derived.

Usage

```
iv(sobj)
```

Arguments

sobj	a one-sample Kaplan-Meier estimate, provided in the form of a survfit.object.

Details

The initial value approximation uses the 0.95-quantile formula from *Jager, L. and Wellner, J.A. (2005) "A new goodness of fit test: the reversed Berk-Jones statistic." Technical report 443. University of Washington, Department of Statistics.* The accuracy of the approximation depends on the presence and location of right-censored responses in the original dataset, since the Jager-Wellner formulae were developed for deriving a confidence band for the cumulative distribution function, based on the single-sample ecdf estimator.

Value

An approximate 0.95-quantile from the sample-specific exact null distribution of the modified B-J statistic derived from the single-sample Kaplan-Meier estimate.

Author(s)

David E. Matthews <dematthews@uwaterloo.ca>

See Also

confband

Examples

```
## Calculate an initial value from the exact null distribution of the
## modified Berk-Jones statistic leading to an exact confidence band for
## leukemia patient remission experience based on data from 20 patients
## receiving Treatment B
time<-c(1,1,2,2,3,4,5,8,8,9,11,12,14,16,18,21,27,31,38,44)
status<-c(rep(1,16),0,1,0,1)
fit<-survfit(Surv(time,status)~1)
iv(fit)
```

---

nhl *Response Times for 31 Advanced non-Hodgkin's Lymphoma Patients*

Description

This data set, which appears in chapter 7 of *Matthews and Farewell*, records the observed time from treatment to either death or end of follow-up for 31 patients suffering from advanced non-Hodgkin's lymphoma.

Variable name	description
time	Observed response measurement, in months
status	Status, 1 = died, 0 = alive

Usage

```
nhl
```

Format

A data frame consisting of 31 cases, with 2 variables for each case.

References

Matthews, D.E. and Farewell, V.T. (2007) *Using and Understanding Medical Statistics. 4th Completely Enlarged and Revised Edition*. Basel: S Karger AG.

---

noe *Noe Recursions for the Exact Coverage Probability of a Nonparametric Confidence Band for the Survivor Function*

Description

This function executes the Noe recursion algorithm for computing the exact coverage probability of a nonparametric confidence band for the survivor function, derived from its single-sample Kaplan-Meier estimate. The calculation relies on two related functions, `noe.compute.cgh` and `noe.compute.pv` to execute the necessary recursions.

Usage

```
noe(tn,ta,tb)
```

Arguments

`tn`	a scalar representing the number of individual events that comprise the joint event
`ta`	an ordered vector of lower endpoints; its length is `tn`
`tb`	an ordered vector of `tn` corresponding upper endpoints

Value

The calculated probability of the joint event, based on the recursions of Noe

Author(s)

David E. Matthews <dematthews@uwaterloo.ca>

References

Jager, L. and Wellner, J. (2005) "A new goodness of fit test: the reversed Berk-Jones statistic." Technical Report 443, Department of Statistics, University of Washington

Noe, M. (1972) "The calculation of distributions of two-sided Kolmogorov-Smirnov-Type statistics." *Ann Math Stat* **43**, 58–64

Shorak, G. R. and Wellner, J. A. (2008) *Empirical Processes with Applications to Statistics*. Philadelphia, PA: SIAM

See Also

confband, noe.compute.cgh, noe.compute.pv

Examples

```
## A check of the Noe recursion calculations.  This result is cited in
## Jager and Wellner's 2005 technical report, Table 1, p. 13.
## The correct value is 0.95

a<-c(0.001340,0.028958,0.114653,0.335379)
b<-c(0.664621,0.885347,0.971042,0.998660)
print(noe(4,a,b))
```

---

noe.compute.cgh — *Intermediate Steps in the Noe Recursions for the Exact Coverage Probability of a Nonparametric Confidence Band for the Survivor Function*

Description

This function computes the c, g, and h vectors at the heart of the Noe recursions for computing the exact coverage probability of a nonparametric confidence band for the population survivor function, based on its single-sample Kaplan-Meier estimate.

Usage

```
noe.compute.cgh(tn,ta,tb)
```

Arguments

tn	a scalar representing the number of individual events that comprise the joint event
ta	an ordered vector of lower endpoints; its length is tn
tb	an ordered vector of tn corresponding upper endpoints

Value

A $tn \times 3$ matrix. The three columns of the matrix are the vectors c, g, and h, respectively, used in the Noe recursion formulae.

Author(s)

David E. Matthews <dematthews@uwaterloo.ca>

See Also

confband, noe

Examples

```
## Check of Noe recursion calculations.

a<-c(0.001340,0.028958,0.114653,0.335379)
b<-c(0.664621,0.885347,0.971042,0.998660)
noe.compute.cgh(4,a,b)
```

---

noe.compute.pv — *Elements of the Noe Recursions for the Exact Coverage Probability of a Nonparametric Confidence Band for the Survivor Function*

Description

This function computes the probability vector at the heart of the Noe recursions for calculating the exact coverage probability of a nonparametric confidence band for the population survivor function, based on its single-sample Kaplan-Meier estimate.

Usage

```
noe.compute.pv(tn,tc)
```

Arguments

tn	a scalar quantity representing the total number of ordered uniform intervals for which a joint probability is required
tc	An ordered vector of endpoints between 0 and 1; its length is 2tn+1

Value

A probability vector of length 2tn+1 representing the partition of the rectangular distribution corresponding to the endpoints listed in the vector tc.

Author(s)

David E. Matthews <dematthews@uwaterloo.ca>

See Also

confband, noe, noe.compute.cgh

Examples

```
## Check of Noe recursion calculations.

a<-c(0.001340,0.028958,0.114653,0.335379)
b<-c(0.664621,0.885347,0.971042,0.998660)
cgh.mat<-noe.compute.cgh(4,a,b)
x<-cgh.mat[,1]
noe.compute.pv(4,x[-10])
```

`plotbands` *Plot an Exact Nonparametric Confidence Band for the Population Survivor Function*

Description

Computes, and then plots, an exact nonparametric confidence band for the population survivor function based on its one-sample Kaplan-Meier estimate and the modified B-J statistic. The confidence level, which can be specified by the user, must be a proportion between 0 and 1.

Usage

```
plotbands(sobj,conf.level=0.95,...)
```

Arguments

`sobj`	a one-sample Kaplan-Meier estimate, provided in the form of a `survfit.object`.
`conf.level`	confidence level, a proportion between 0 and 1. The default value is 0.95
`...`	Additional arguments, such as axis labels, scaling, etc., to pass to the generic `plot` function used for a `survfit.object`

Details

An exact nonparametric confidence band with the specified level of confidence is plotted as lower and upper estimates of the survivor function. These estimates are calculated by the function `confband`. Option '`lty=2`' in the display distinguishes the nonparametric confidence band from the Kaplan-Meier estimate which, by default, is plotted as a solid line (`lty=1`)

Value

The function returns two outputs, a scalar, which is printed, and a plot. The scalar value is the required quantile from the exact null distribution of the sample-specific modified B-J statistic derived from the single-sample nonparametric Kaplan-Meier estimate.

Author(s)

David E. Matthews <dematthews@uwaterloo.ca>

See Also

confband

Examples

```
## plot an exact, nonparametric, 95% confidence band for leukemia patient
## remission experience based on data from 20 patients receiving
## Treatment B
time<-c(1,1,2,2,3,4,5,8,8,9,11,12,14,16,18,21,27,31,38,44)
status<-c(rep(1,16),0,1,0,1)
fit<-survfit(Surv(time,status)~1)
plotbands(fit,xlab="Time (in months)",ylab="Probability")

## Repeat the same calculations, but require only 80% confidence
plotbands(fit,0.80,xlab="Time (in months)",ylab="Probability")
```

---

zbrent *Van Wijngaarden-Decker-Brent Root-finding Algorithm*

Description

The function `zbrent` searches the interval `int` for a root, i.e., a zero, with respect to the first argument of a one-dimensional user-supplied function `func`.

Usage

```
zbrent(func,int,tol)
```

Arguments

`func`	the function for which the root is sought
`int`	a vector representing the interval in which the required root is located
`tol`	the desired accuracy (convergence tolerance)

Details

The values of `func` at the two endpoints of `int` must have opposite signs.

Value

The algorithm returns the required root unless there is none, or the algorithm exceeds 100 iterations. In the latter case, an error message is displayed, and the current approximation is returned.

Author(s)

David E. Matthews <dematthews@uwaterloo.ca>

References

Press W.H., Flannery B.P., Teukolsky S.A., Vetterling W.T. (1988) *Numerical Recipes: The Art of Scientific Computing*. Cambridge: Cambridge University Press.

See Also

confband, exact

Examples

```
f<-function(x) x*(x^2-1)+0.5
x<-seq(-2,2,length=100)
plot(x,f(x),type="l")
zbrent(f,c(-2,2),1.0e-10)
```

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