Package: EL2Surv (via r-universe)

August 31, 2024

Title Empirical Likelihood (EL) for Comparing Two Survival Functions

Version 1.1

Description Functions for computing critical values and implementing the one-sided/two-sided EL tests.

Depends R (>= 2.13.0)

Imports survival, stats

License GPL (>= 2)

LazyData true

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Archs i386, x64

RoxygenNote 6.1.0

NeedsCompilation no

Date/Publication 2018-08-13 09:00:13 UTC

Repository https://j6020770416j.r-universe.dev

RemoteUrl https://github.com/cran/EL2Surv

RemoteRef HEAD

RemoteSha d958ea17da1324d6ffabefdd4fe43eea77712281

Contents

hazardcross *Simulated Survival with Crossing Hazard Functions*

Description

The data frame `hazardcross` is simulated from two groups of piecewise exponential lifetime distributions with crossing hazard functions. The estimated survival functions remain ordered even when the estimated hazard functions are crossed. See `supELtest` for the application.

Usage

```
hazardcross
```

Format

The `hazardcross` is a data frame with 100 simulated observations of 3 variables, and has the following columns:

- `time` the survival time
- `censor` the censoring indicator
- `group` the grouping variable

See Also

`supELtest`

hepatitis *Survival from Severe Alcoholic Hepatitis*

Description

The data frame `hepatitis` is obtained by digitizing the published Kaplan-Meier curves in Nguyen-Khac et al (2011). The method of digitizing is described in Guyot et al. (2012). See `intELtest` and `ptwiseELtest` for the application.

Usage

```
hepatitis
```

Format

The `hepatitis` is a data frame with 174 observations of 3 variables, and has the following columns:

- `time` the survival time
- `censor` the censoring indicator
- `group` the grouping variable

Source

Nguyen-Khac et al., "Glucocorticoids plus N-Acetylcysteine in Severe Alcoholic Hepatitis," *The New England Journal of Medicine*, Vol. 365, No. 19, pp. 1781-1789 (2011). http://www.nejm.org/doi/full/10.1056/NEJMoa1101214#t=article

References

P. Guyot, A. E. Ades, M. J. N. M. Ouwens, and N. J. Welton, "Enhanced secondary analysis of survival data: reconstructing the data from published Kaplan-Meier survival curves," *BMC Medical Research Methodology*, 12(1):9. http://bmcmedresmethodol.biomedcentral.com/articles/10.1186/1471-2288-12-9

See Also

intELtest, ptwiseELtest

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intELtest *The integrated likelihood ratio test*

Description

intELtest gives a class of the weighted likelihood ratio statistics:

$$\sum_{t \in U} w(t)\{-2 \log R(t)\},$$

where $w(t)$ is an objective weight function, and $R(t)$ is an empirical likelihood (EL) ratio that compares two survival functions at each time point t in the set of observed uncensored lifetimes, U.

Usage

```
intELtest(data, g1 = 1, t1 = 0, t2 = Inf, sided = 2,
  nboot = 1000, wt = "p.event", alpha = 0.05, compo = FALSE,
  seed = 1011, nlimit = 200)
```

Arguments

data	a data frame/matrix with 3 columns. The first column is the survival time. The second is the censoring indicator. The last is the grouping variable. An example as the input to data provided is hepatitis.
g1	the group with longer survival in one-sided testing with the default value of 1.
t1	pre-specified t_1 based on domain knowledge with the default value of 0
t2	pre-specified t_2 based on domain knowledge with the default value of ∞
sided	2 if two-sided test, and 1 if one-sided test. It assumes the default value of 2.
nboot	number of bootstrap replications in calculating critical values with the defualt value of 1000.

wt	a string for the integral statistic with a specific weight function. There are four types of integral statistics provided: "p.event", "dF", "dt", and "db". It assumes the default value of "p.event". See 'Details' for more about the integral statistics.
alpha	pre-specified significance level of the test with the default value of 0.05
compo	FALSE if taking the standardized square of the difference as the local statisic for two-sided testing, and TRUE if constructing for one-sided testing, but only the positive part of the difference included. It assumes the default value of $FALSE$.
seed	the parameter with the default value of 1011 to set.seed for generating bootstrap-based critical values in R. The set.seed is used implicitly in intELtest.
nlimit	the splitting unit with the default value of 200. To deal with large data problems, the bootstrap algorithm is to split the number of bootstrap replicates into nsplit parts. The number nsplit is the smallest integer not less than $\|U\|$ /nlimit.

Details

intELtest calculates the weighted likelihood ratio statistics:

$$\sum_{i=1}^{h} w_i \cdot \{-2 \log R(t_i)\},$$

where $w_1, ..., w_h$ are the values of the weight function evaluated at the distinct ordered uncensored times $t_1, ..., t_h$ in U. There are four types of weight functions considered.

- (wt = "p.event")
  This default option is an objective weight,

  $$w_i = \frac{d_i}{n}$$

  In other words, this w_i assigns weight proportional to the number of events at each observed uncensored time t_i.

- (wt = "dF")
  Based on the integral statistic built by Barmi and McKeague (2013), another weigth function is

  $$w_i = \hat{F}(t_i) - \hat{F}(t_{i-1})$$

  for $i = 1, \ldots, m$,where $\hat{F}(t) = 1 - \hat{S}(t)$, $\hat{S}(t)$ is the pooled KM estimator, and $t_0 \equiv 0$. This reduces to the objective weight when there is no censoring.The resulting I_n can be seen as an empirical version of $E(-2 \log \mathcal{R}(T))$, where T denotes the lifetime random variable of interest distributed as the common distribution under H_0.

- (wt = "dt")
  By means of an extension of the integral statistic derived by Pepe and Fleming (1989), another weight function is

  $$w_i = t_{i+1} - t_i$$

  for $i = 1, \ldots, m$, where $t_{m+1} \equiv t_m$. This gives more weight to the time intervals where there are fewer observed uncensored times, but may be affected by extreme observations.

- (wt = "db")
  According to a weigthing method mentioned in Chang and McKeague (2016), the other weight function is
  $$w_i = \hat{b}(t_i) - \hat{b}(t_{i-1})$$
  where $\hat{b}(t) = \hat{\sigma}^2(t)/(1 + \hat{\sigma}^2(t))$, and $\hat{\sigma}^2(t)$ is given. The $\hat{b}(t)$ is chosen so that the limiting distribution is the same as the asymptotic null distribution in EL Barmi and McKeague (2013).

Value

intELtest returns a list with three elements:

- teststat the resulting integrated test statistic
- critval the critical value
- pvalue the p-value based on the integrated statistic

References

- H.-w. Chang and I. W. McKeague, "Empirical likelihood based tests for stochastic ordering under right censorship," *Electronic Journal of Statistics*, Vol. 10, No. 2, pp. 2511-2536 (2016).
- M. S. Pepe and T. R. Fleming, "Weighted Kaplan-Meier Statistics: A Class of Distance Tests for Censored Survival Data," *Biometrics*, Vol. 45, No. 2, pp. 497-507 (1989). https://www.jstor.org/stable/2531492?seq=1#page_scan_tab_contents
- H. Uno, L. Tian, B. Claggett, and L. J. Wei, "A versatile test for equality of two survival functions based on weighted differences of Kaplan-Meier curves," *Statistics in Medicine*, Vol. 34, No. 28, pp. 3680-3695 (2015). http://onlinelibrary.wiley.com/doi/10.1002/sim.6591/abstract
- H. E. Barmi and I. W. McKeague, "Empirical likelihood-based tests for stochastic ordering," *Bernoulli*, Vol. 19, No. 1, pp. 295-307 (2013). https://projecteuclid.org/euclid.bj/1358531751

See Also

hepatitis, supELtest, ptwiseELtest

Examples

```
library(EL2Surv)
intELtest(hepatitis)

## OUTPUT:
## $teststat
## [1] 1.406016
##
## $critval
## [1] 0.8993514
##
## $pvalue
## [1] 0.012
```

`ptwiseELtest` *The pointwise likelihood ratio test*

Description

`ptwiseELtest` gives pointwise EL statistic values at uncensored time span. The pointwise statistic considers only the decision on each single time point; thus, it is different from the `integral type` and `sup type` statistics.

Usage

```
ptwiseELtest(data, g1 = 1, t1 = 0, t2 = Inf, sided = 2,
  nboot = 1000, alpha = 0.05, compo = FALSE, seed = 1011,
  nlimit = 200)
```

Arguments

`data`	a data frame/matrix with 3 columns. The first column is the survival time. The second is the censoring indicator. The last is the grouping variable. An example as the input to `data` provided is `hepatitis`.
`g1`	the group with longer survival in one-sided testing with the default value of 1.
`t1`	pre-specified t_1 based on domain knowledge with the default value of 0
`t2`	pre-specified t_2 based on domain knowledge with the default value of ∞
`sided`	2 if two-sided test, and 1 if one-sided test. It assumes the default value of 2.
`nboot`	number of bootstrap replications in calculating critical values with the defualt value of 1000.
`alpha`	pre-specified significance level of the test with the default value of 0.05
`compo`	FALSE if taking the standardized square of the difference as the local statisic for two-sided testing, and TRUE if constructing for one-sided testing, but only the positive part of the difference included. It assumes the default value of $FALSE$.
`seed`	the parameter with the default value of 1011 to `set.seed` for generating bootstrap-based critical values in R. The `set.seed` is used implicitly in `intELtest`.
`nlimit`	the splitting unit with the default value of 200. To deal with large data problems, the bootstrap algorithm is to split the number of bootstrap replicates into `nsplit` parts. The number `nsplit` is the smallest integer not less than $\|U\|$ /`nlimit`.

Value

`ptwiseELtest` returns a list with four elements:

- `time_pts` the values of statistics at each uncensored time point
- `decision` logical values. See `stat_ptwise`.
- `stat_ptwise` the decision of the test in which the null hypothesis os rejected at a specific day if the decision exhibits 1 and not rejected if otherwise
- `critval_ptwise` the critical values of the statistic at each uncensored time point

References

H.-w. Chang and I. W. McKeague, "Empirical likelihood based tests for stochastic ordering under right censorship," *Electronic Journal of Statistics*, Vol. 10, No. 2, pp. 2511-2536 (2016).

See Also

hepatitis, intELtest, supELtest

Examples

```
library(EL2Surv)
ptwiseELtest(hepatitis)
## It produces the estimates on 44 distinct uncensored days
## out of 57 possibly repeated uncensored days.

ptwiseELtest(hepatitis, t1 = 30, t2 = 60)
## It produces the estimates on 12 distinct uncensored days
## on the restricted time interval [30, 60].
```

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supELtest *The maximally selected likelihood ratio test*

Description

supELtest provides a maximal deviation type statistics that is better adapted at detecting local differences:

$$\sup_{t \in U} \{-2 \log R(t)\},$$

where $R(t)$ is an empirical likelihood (EL) ratio that compares two survival functions at each time point t in the set of observed uncensored lifetimes, U.

Usage

```
supELtest(data, g1 = 1, t1 = 0, t2 = Inf, sided = 2,
  nboot = 1000, alpha = 0.05, compo = FALSE, seed = 1011,
  nlimit = 200)
```

Arguments

data	a data frame/matrix with 3 columns. The first column is the survival time. The second is the censoring indicator. The last is the grouping variable. An example as the input to data provided is hepatitis.
g1	the group with longer survival in one-sided testing with the default value of 1.
t1	pre-specified t_1 based on domain knowledge with the default value of 0
t2	pre-specified t_2 based on domain knowledge with the default value of ∞
sided	2 if two-sided test, and 1 if one-sided test. It assumes the default value of 2.

nboot	number of bootstrap replications in calculating critical values with the defualt value of 1000.
alpha	pre-specified significance level of the test with the default value of 0.05
compo	FALSE if taking the standardized square of the difference as the local statisic for two-sided testing, and TRUE if constructing for one-sided testing, but only the positive part of the difference included. It assumes the default value of $FALSE$.
seed	the parameter with the default value of 1011 to set.seed for generating bootstrap-based critical values in R. The set.seed is used implicitly in intELtest.
nlimit	the splitting unit with the default value of 200. To deal with large data problems, the bootstrap algorithm is to split the number of bootstrap replicates into nsplit parts. The number nsplit is the smallest integer not less than $\|U\|$ /nlimit.

Value

supELtest returns a list with three elements:

- teststat the resulting integrated test statistic
- critval the critical value
- pvalue the p-value based on the integrated statistic

References

H.-w. Chang and I. W. McKeague, "Empirical likelihood based tests for stochastic ordering under right censorship," *Electronic Journal of Statistics*, Vol. 10, No. 2, pp. 2511-2536 (2016).

See Also

hazardcross, intELtest, ptwiseELtest

Examples

```
library(EL2Surv)
supELtest(hazardcross)

## OUTPUT:
## $teststat
## [1] 8.945539
##
## $critval
## [1] 8.738189
##
## $pvalue
## [1] 0.045
```

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