Package ‘weibullness’

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Title Goodness-of-Fit Test for Weibull Distribution (Weibullness)

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Description

Performs a goodness-of-fit test for Weibull distribution (weibullness test) and provides the parameter estimates of the two- and three-parameter Weibull distributions. Note that the threshold parameter is estimated based on the correlation from the Weibull plot. For more details, see <doi:10.23055/ijietap.2017.24.4.2848>, <doi:10.1155/2018/6056975>, and <doi:10.3390/math11143156>. This w
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R topics documented:

`print.weibull.estimate` *Print the estimated values*

Description

Printing objects of class "weibull.estimate".

See Also

`weibull.mle`, `weibull.wp`, `weibull.rm`, `print`

`print.wp.test.critical` *Print the critical value for wp.test*

Description

Printing objects of class "wp.test.critical".

See Also

wp.test.critical, `print`

Wdata *Data set*

Description

`bearings`: It is from Lieblein and Zelen (1956). These data are deep-groove ball bearings failure times (number of millions of revolutions) in eudurance tests.

`glassfiber1.5` and `glassfiber15`: They are from Smith and Naylor (1987). These data sets are from experimental data for the strength of glass fiber of length 1.5cm and 15cm, respectively.

`urinary`: It is from Santiago and Smith (2013). It is about the days in between discharge of males in nosocomial urinary tract infections in patients.

`radiotherapy` and `radio.chemotherapy`: They are from Finkelstein, D. M. (1986) and Lindsey, J. C. and L. M. Ryan (1998). These data are interval-censored observations from a study of patients with breast cancer. The measurement is the time to cosmetic deterioration of the breast for women who received radiotherapy and women who received radio-chemotherapy.

Usage

```
Wdata
```

References

Lieblein, J. and M. Zelen (1956). Statistical Investigation of the Fatigue Life of Deep-Groove Ball Bearings. Journal of Research of the National Bureau of Standards, 57 (5), 273-316.

Smith, R. L. and J. C. Naylor (1987). A comparison of maximum likelihood and Bayesian estimators for the three-parameter Weibull distribution. Journal of the Royal Statistical Society. Series C (Applied Statistics), 36 (3), 358-369.

Santiago, E. and J. Smith (2013). Control Charts Based on the Exponential Distribution: Adapting Runs Rules for the t Chart, Quality Engineering, 25 (2), 85-96.

Finkelstein, D. M. (1986), A proportional hazards model for interval-censored failure time data. Biometrics, 42, 845-865.

Lindsey, J. C. and L. M. Ryan (1998). Tutorial in biostatistics: Methods for interval-censored data. Stat. Med., 17, 219-238.

Examples

```
# Attach data sets
attach(Wdata)
bearings
glassfiber1.5
glassfiber15
urinary
radiotherapy
radio.chemotherapy
```

`weibull.ic` *Maximum likelihood estimates with Interval Censoring*

Description

Calculates the maximum likelihood estimates with Interval Censoring Using the EM Algorithm.

Usage

```
weibull.ic(X, start=c(1,1), maxits=10000, eps=1E-5)
```

Arguments

`X`	a numeric matrix (n x 2) of observations.
`start`	a starting value.
`maxits`	the maximum number of iterations.
`eps`	the desired accuracy (convergence tolerance).

Details

The expectation-maximization(EM) algorithm is used for estimating the parameters with interval-censored data.

Value

Calculates the maximum likelihood estimates with interval-censored data

Author(s)

Chanseok Park

References

Park, C. (2023). A Note on Weibull Parameter Estimation with Interval Censoring Using the EM Algorithm. *Mathematics*, **11**(14), 3156.
doi: 10.3390/math11143156

Lawless, J. F. (2003). Statistical Models and Methods for Lifetime Data, 2nd ed.; John Wiley & Sons: New York, NY.

See Also

`weibull.wp` for the parameter estimation using the Weibull plot with full observations. `weibull.mle` for the parameter estimation using the maximum likelihood method with full observations.

Examples

```
library(weibullness)

attach(Wdata)
weibull.ic(radio.chemotherapy)

# Two-parameter Weibull with full observations
weibull.ic( cbind(bearings,bearings) )

# Two-parameter Weibull with full observations (using weibull.mle)
weibull.mle(bearings, threshold=0)
```

`weibull.mle` *Maximum likelihood estimates of three-parameter Weibull distribution*

Description

Calculates the maximum likelihood estimates of three-parameter Weibull distribution.

Usage

```
weibull.mle(x, threshold, interval, interval.threshold, extendInt="downX",
            a, tol = .Machine$double.eps^0.25, maxiter = 1000, trace = 0)
```

Arguments

`x`	a numeric vector of observations.
`threshold`	the threshold parameter value.
`interval`	a vector containing the end-points of the interval to be estimated for the shape parameter.
`interval.threshold`	a vector containing the end-points of the interval to be estimated for the threshold parameter.
`extendInt`	character string specifying if the interval c(left,right) should be extended or directly produce an error when f() has no differing signs at the endpoints. The default, "downX", keep lowering the the left end of the interval so that f() has different signs. See `uniroot`.
`a`	the offset fraction to be used; typically in (0,1).
`tol`	the desired accuracy (convergence tolerance).
`maxiter`	the maximum number of iterations.
`trace`	integer number; if positive, tracing information is produced. Higher values giving more details.

Details

The three-parameter Weibull distribution has the cumulative distribution function

$$F(x) = 1 - \exp\Big[- \Big(\frac{x - \theta}{\beta} \Big)^{\alpha} \Big],$$

where $x > \theta$. The shape (α) and scale (β) parameters are estimated using the maximum likelihood. The maximum likelihood estimation is performed using the method by Farnum and Booth (1997). If the `threshold` (θ) is missing, it is estimated by `weibull.threshold`. If `threshold=0`, then `weibull.mle` calculates the maximum likelihood estimates of the two-parameter Weibull distribution.

If `interval` is missing, the interval is given by the method in Farnum and Booth (1997).

If `interval.threshold` is missing, the interval is initally given by `(min(x)-sd(x), min(x))`. If this interval does not include the estimate, its lower bound is extended (see also `uniroot`).

The choice of `a` follows `ppoints` function.

Convergence is declared either if `f(x) == 0` or the change in `x` for one step of the algorithm is less than `tol` (see also `uniroot`).

If the algorithm does not converge in `maxiter` steps, a warning is printed and the current approximation is returned (see also `uniroot`).

Value

An object of class `"weibull.estimate"`, a list with two parameter estimates (if `threshold` is given) or three-parameter estimates.

Author(s)

Chanseok Park

References

Park, C. (2018). A Note on the Existence of the Location Parameter Estimate of the Three-Parameter Weibull Model Using the Weibull Plot. *Mathematical Problems in Engineering*, **2018**, 6056975.
doi: 10.1155/2018/6056975

Park, C. (2017). Weibullness test and parameter estimation of the three-parameter Weibull model using the sample correlation coefficient. *International Journal of Industrial Engineering - Theory, Applications and Practice*, **24**(4), 376-391.
doi: 10.23055/ijietap.2017.24.4.2848

Farnum, N. R. and P. Booth (1997). Uniqueness of Maximum Likelihood Estimators of the 2-Parameter Weibull Distribution. *IEEE Transactions on Reliability*, **46**, 523-525.

See Also

`weibull.wp` for the parameter estimation using the Weibull plot.

`weibull.rm` for robust parameter estimation using the repeated median method.

`weibull.threshold` for the estimate of the threshold parameter.

`fitdistr` for maximum-likelihood fitting of univariate distributions in package **MASS**.

Examples

```
library(weibullness)

# Three-parameter Weibull
data = c(355,725,884,462,1092,190,166,172,188,224,267,298,355,471,
        154,101,76,811,80,249,752,305,301,386,667,212,186,127,
        121,214,242,237,355,210,253,400,401,514,211,285)
weibull.mle(data)

# Two-parameter Weibull
weibull.mle(data, threshold=0)
```

`Weibull.Plot.Quantiles` *Weibull quantile values*

Description

Quantiles for the Weibullness Test. They are obtained from the sample correlation from the Weibull plot. The number of Monte Carlo iterations is 1E08.

Data set representing the quantiles and the associated critical values for the Weibullness test. They were obtained by conducting Monte Carlo simulations where the sample correlation coefficients were calculated based on the Weibull plot. We used 1.0E08 Monte Carlo iterations in the simulation.

Usage

```
Weibull.Plot.Quantiles
```

Format

This data frame contains 998 rows and 1001 columns.

References

Park, C. (2017). Weibullness test and parameter estimation of the three-parameter Weibull model using the sample correlation coefficient. *International Journal of Industrial Engineering - Theory, Applications and Practice* 24(4), 376-391.
doi: 10.23055/ijietap.2017.24.4.2848

weibull.rm — *Robust estimate of shape and scale parameters of Weibull using the repeated median method*

Description

Calculates the estimates of the shape and scale parameters.

Usage

```
weibull.rm(x, a)
```

Arguments

x	a numeric vector of observations.
a	the offset fraction to be used; typically in (0,1). See `ppoints`.

Details

`weibull.rm` obtains the robust estimates of the shape and scale parameters using the intercept and slope estimates using the repeated median method from the Weibull plot.

Value

An object of class `"weibull.estimate"`, a list with two parameter estimates

Author(s)

Chanseok Park

References

Siegel, A. F. (1982). Robust Regression Using Repeated Medians. *Biometrika*, **69**, 242-244.

See Also

`weibull.mle` for the parameter estimation using the maximum likelihood method.

`weibull.wp` for the parameter estimation using the Weibull plot.

`fitdistr` for maximum-likelihood fitting of univariate distributions in package **MASS**.

Examples

```
library(weibullness)

data = c(355,725,884,462,1092,190,166,172,188,224,267,298,355,471,
        154,101,76,811,80,249,752,305,301,386,667,212,186,127,
        121,214,242,237,355,210,253,400,401,514,211,285)
weibull.rm(data)
```

`weibull.threshold` *Estimate of threshold parameter of three-parameter Weibull distribution*

Description

Calculates the estimate of the threshold parameter.

Usage

```
weibull.threshold(x, a, interval.threshold, extendInt="downX")
```

Arguments

`x`	a numeric vector of observations.
`a`	the offset fraction to be used; typically in (0,1).
`interval.threshold`	a vector containing the end-points of the interval to be estimated for the threshold parameter.
`extendInt`	character string specifying if the interval c(left,right) should be extended or directly produce an error when f() has no differing signs at the endpoints. The default, "downX", keep lowering the the left end of the interval so that f() has different signs. See `uniroot`.

Details

The three-parameter Weibull distribution has the cumulative distribution function

$$F(x) = 1 - \exp\left[-\left(\frac{x-\theta}{\beta}\right)^{\alpha}\right],$$

where $x > \theta$. The threshold parameter (θ) is estimated by maximizing the correlation function from the Weibull plot.

The choice of `a` follows `ppoints` function.

If `interval.threshold` is missing, the interval is initially given by `(min(x)-sd(x), min(x))`. If this interval does not include the estimate, its lower bound is extended (see also `uniroot`).

Value

`weibull.threshold` returns a numeric value.

Author(s)

Chanseok Park

References

Park, C. (2018). A Note on the Existence of the Location Parameter Estimate of the Three-Parameter Weibull Model Using the Weibull Plot. *Mathematical Problems in Engineering*, **2018**, 6056975.
doi: 10.1155/2018/6056975

Park, C. (2017). Weibullness test and parameter estimation of the three-parameter Weibull model using the sample correlation coefficient. *International Journal of Industrial Engineering - Theory, Applications and Practice*, **24**(4), 376-391.
doi: 10.23055/ijietap.2017.24.4.2848

See Also

`weibull.mle` for the maximum likelihood estimate.

`weibull.wp` for the parameter estimation using the Weibull plot.

Examples

```
library(weibullness)

# Data
data = c(355,725,884,462,1092,190,166,172,188,224,267,298,355,471,
        154,101,76,811,80,249,752,305,301,386,667,212,186,127,
        121,214,242,237,355,210,253,400,401,514,211,285)
weibull.threshold(data)
```

`weibull.wp` *Estimate of shape and scale parameters of Weibull using the Weibull plot*

Description

Calculates the estimates of the shape and scale parameters.

Usage

```
weibull.wp(x, n, a)
```

Arguments

`x`	a numeric vector of observations.
`n`	The number of observations is needed if there is right-censoring.
`a`	the offset fraction to be used; typically in (0,1). See `ppoints`.

Details

`weibull.wp` obtains the estimates of the shape and scale parameters using the intercept and slope estimates from the Weibull plot.

Value

An object of class "weibull.estimate", a list with two parameter estimates

Author(s)

Chanseok Park

References

Park, C. (2018). A Note on the Existence of the Location Parameter Estimate of the Three-Parameter Weibull Model Using the Weibull Plot. *Mathematical Problems in Engineering*, **2018**, 6056975.
doi: 10.1155/2018/6056975

Park, C. (2017). Weibullness test and parameter estimation of the three-parameter Weibull model using the sample correlation coefficient. *International Journal of Industrial Engineering - Theory, Applications and Practice*, **24**(4), 376-391.
doi: 10.23055/ijietap.2017.24.4.2848

See Also

weibull.mle for the parameter estimation using the maximum likelihood method.

weibull.rm for robust parameter estimation using the repeated median method.

fitdistr for maximum-likelihood fitting of univariate distributions in package **MASS**.

Examples

```
library(weibullness)

data = c(355,725,884,462,1092,190,166,172,188,224,267,298,355,471,
        154,101,76,811,80,249,752,305,301,386,667,212,186,127,
        121,214,242,237,355,210,253,400,401,514,211,285)
weibull.wp(data)
```

---

wp.plot *Weibull Probability Plot*

Description

wp.plot produces a Weibull probability plot.

Usage

```
wp.plot(x, plot.it=TRUE, a, col.line="black", lty.line=1,
     xlim=NULL, ylim=NULL, main=NULL, sub=NULL, xlab=NULL, ylab="Probability", ...)
```

Arguments

`x`	a numeric vector of data values. Missing values are allowed.
`plot.it`	logical. Should the result be plotted?
`a`	the offset fraction to be used; typically in (0,1). See `ppoints`.
`col.line`	the color of the straight line.
`lty.line`	the line type of the straight line.
`xlim`	the x limits of the plot.
`ylim`	the y limits of the plot.
`main`	a main title for the plot, see also `title`.
`sub`	a sub title for the plot.
`xlab`	a label for the x axis, defaults to a description of x.
`ylab`	a label for the y axis, defaults to "Probability".
`...`	graphical parameters.

Details

The Weibull probability plot is based on taking the logarithm of the Weibull cumulative distribution function twice

Value

A list with the following components:

`x`	The sorted data
`y`	log(-log(1-ppoints(n,a=a)))

Author(s)

Chanseok Park

See Also

`plot`, `qqnorm`, `qqplot`.

Examples

```
attach(Wdata)

wp.plot( bearings )

# With cosmetic lines
wp.plot(bearings, main="Weibull Probability Plot", col.line="red",
        xlab="Lifetimes of bearings", lty.line=1, pch=3)
hline = log(-log(1- c( (1:5)/100, (1:9)/10)  ))
abline( h=hline, col=gray(0.1), lty=3, lwd=0.5 )
abline( v=  seq(15, 200,by=5), col=gray(0.1), lty=3, lwd=0.5 )
```

wp.test *The Weibullness Test from the Weibull Plot*

Description

Performs the statistical test of Weibullness (Goodness-of-fit test for the Weibull distribution) using the sample correlation from the Weibull plot.

Usage

```
wp.test(x, a)
```

Arguments

`x`	a numeric vector of data values. Missing values are allowed, but the number of non-missing values must be between 3 and 1000.
`a`	the offset fraction to be used; typically in (0,1). See ppoints().

Details

The Weibullness test is constructed using the sample correlation which is calculated using the associated Weibull plot. The critical value is then looked up in Weibull.Plot.Quantiles. There is `print` method for class `"htest"`.

Value

A list with class "htest" containing the following components:

`statistic`	the value of the test statistic (sample correlation from the Weibull plot)
`p.value`	the p-value for the test.
`sample.size`	sample size (missing observations are deleted).
`method`	a character string indicating the Weibullness test.
`data.name`	a character string giving the name(s) of the data.

Author(s)

Chanseok Park

References

Park, C. (2017). Weibullness test and parameter estimation of the three-parameter Weibull model using the sample correlation coefficient. *International Journal of Industrial Engineering - Theory, Applications and Practice*, **24**(4), 376-391.
doi: 10.23055/ijietap.2017.24.4.2848

Vogel, R. M. and C. N. Kroll (1989). Low-Flow Frequency Analysis Using Probability-Plot Correlation Coefficients. *Journal of Water Resources Planning and Management*, **115**, 338-357.

See Also

`ks.test` for performing the Kolmogorov-Smirnov test for the goodness of fit test of two samples.

`shapiro.test` for performing the Shapiro-Wilk test for normality.

Examples

```
library(weibullness)

# For Weibullness hypothesis test.
x = rweibull(10, shape=1)
wp.test(x)
```

---

wp.test.critical — *Critical value for the Weibullness test*

Description

Calculates the critical value for the Weibullness test

Usage

```
wp.test.critical(alpha, n)
```

Arguments

`alpha`	the significance level.
`n`	the sample size.

Details

This function calculates the critical value for the Weibullness test which is constructed using the sample correlation from the associated Weibull plot. The critical value is then looked up in Weibull.Plot.Quantiles. There is `print` method for class `"wp.test.critical"`.

Value

A list with class `"wp.test.critical"` containing the following components:

`sample.size`	sample size (missing observations are deleted).
`alpha`	significance level.
`critical.value`	critical value.
`data.name`	a character string giving the name(s) of the data.

Author(s)

Chanseok Park

References

Park, C. (2017). Weibullness test and parameter estimation of the three-parameter Weibull model using the sample correlation coefficient. *International Journal of Industrial Engineering - Theory, Applications and Practice*, **24**(4), 376-391.
doi: 10.23055/ijietap.2017.24.4.2848

Vogel, R. M. and C. N. Kroll (1989). Low-Flow Frequency Analysis Using Probability-Plot Correlation Coefficients. *Journal of Water Resources Planning and Management*, **115**, 338-357.

See Also

`ks.test` for performing the Kolmogorov-Smirnov test for the goodness of fit test of two samples.

`shapiro.test` for performing the Shapiro-Wilk test for normality.

Examples

```
library(weibullness)

# Critical value with alpha (significance level) and n (sample size).
wp.test.critical(alpha=0.01, n=10)
```

---

wp.test.pvalue *The p-value for the Weibullness test*

Description

Calculates the p-value for the Weibullness test which is based on the sample correlation from the Weibull plot.

Usage

```
wp.test.pvalue(r, n)
```

Arguments

`r`	the sample correlation coefficient from the Weibull plot; r is in (0,1).
`n`	the sample size.

Details

The p-value for the Weibullness test which is based on the sample correlation from the Weibull plot. There is `print` method for class `"htest"`.

Value

A list with class "htest" containing the following components:

`statistic`	the value of the test statistic (sample correlation from the Weibull plot)
`p.value`	the p-value for the test.
`method`	a character string indicating the Weibullness test.

Author(s)

Chanseok Park

References

Park, C. (2017). Weibullness test and parameter estimation of the three-parameter Weibull model using the sample correlation coefficient. *International Journal of Industrial Engineering - Theory, Applications and Practice*, **24**(4), 376-391.
doi: 10.23055/ijietap.2017.24.4.2848

Vogel, R. M. and C. N. Kroll (1989). Low-Flow Frequency Analysis Using Probability-Plot Correlation Coefficients. *Journal of Water Resources Planning and Management*, **115**, 338-357.

See Also

`ks.test` for performing the Kolmogorov-Smirnov test for the goodness of fit test of two samples.

`shapiro.test` for performing the Shapiro-Wilk test for normality.

Examples

```
library(weibullness)

# p.value with r (sample correlation from the Weibull plot) and n (sample size).
wp.test.pvalue(r=0.6, n=10)
```

Index