Package 'ppweibull'

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Title Piecewise Lifetime Models

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Description Provides functions for estimation and data generation for several piecewise lifetime distributions. The package implements the power piecewise Weibull model, which includes the piecewise Rayleigh and piecewise exponential models as special cases. See Feigl and Zelen (1965) <doi:10.2307/2528247> for methodological details.

Depends R (>= 4.0.0), stats

Imports survival, pracma, segmented, msm, nloptr

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NeedsCompilation no

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Contents

`choose.pweibull` *Choose a Partition for a Power Piecewise Weibull Model*

Description

Selects a time partition for the power piecewise Weibull model, given a maximum number of allowed partitions. For `choose.pweibull`, the user may specify whether the λ's are equal (default `FALSE`), whether the α's are equal (default `FALSE`), and whether α is fixed (default `FALSE`). For `choose2.pweibull`, the procedure selects the best combination among:

- λ's different and α's different,
- λ's equal and α's different,
- λ's different and α's equal,
- λ's different and $\alpha = 1$ (piecewise exponential distribution),
- λ's different and $\alpha = 2$ (piecewise Rayleigh distribution).

Usage

```
choose.pweibull(formula, data, criteria = "AIC", L.max = 5, t = NULL,
    prec = 1e-04, max.iter = 1000, lambda.identical = FALSE,
    alpha.identical = FALSE, alpha.fixed = FALSE)

choose2.pweibull(formula, data, criteria = "AIC", L.max = 5, t = NULL,
    prec = 1e-04, max.iter = 1000, alpha.fixed = c(1, 2))
```

Arguments

`formula`	A model formula of class `"formula"` describing the survival model to be fitted. Details about model specification are given in *Details*.
`data`	An optional data frame, list, or environment containing the variables in the model. If not found in `data`, variables are taken from `environment(formula)`.
`criteria`	Model selection criterion: `"AIC"` (default) or `"BIC"`.
`L.max`	Maximum number of partitions to consider (default `5`).
`t`	Optional fixed time partition. If provided, both `choose.pweibull` and `choose2.pweibull` evaluate only the model combinations with the specified partition.
`prec`	Numerical tolerance for the estimation algorithm (default `1e-4`).
`max.iter`	Maximum number of iterations for the estimation algorithm (default `1000`).
`lambda.identical`	Logical; should the λ's be constrained to be equal? (default `FALSE`).
`alpha.identical`	Logical; should the α's be constrained to be equal? (default `FALSE`).
`alpha.fixed`	If `FALSE` (default), α is estimated. If a positive numeric value is supplied, all α's are fixed at that value. For `choose2.pweibull`, this may be a vector of fixed values.

Details

The hazard function of the power piecewise Weibull model is

$$h(t \mid \boldsymbol{\lambda}, \boldsymbol{\alpha}) = \lambda_\ell \alpha_\ell t^{\alpha_\ell - 1}, \qquad t \in (a_{\ell-1}, a_\ell),\ \ell = 1, \ldots, L,$$

where $0 = a_0 < a_1 < \cdots < a_L < \infty$ is the time partition, $\boldsymbol{\lambda} = (\lambda_1, \ldots, \lambda_L)$ and $\boldsymbol{\alpha} = (\alpha_1, \ldots, \alpha_L)$.

The special cases include:

- $\alpha_1 = \cdots = \alpha_L = 1$: the piecewise exponential model (Feigl and Zelen, 1965; Friedman, 1982),
- $\alpha_1 = \cdots = \alpha_L = 2$: a piecewise Rayleigh model.

Value

A list with components:

`estimate`	A matrix of parameter estimates and standard errors for the selected partition.
`logLik`	Log-likelihood evaluated at the parameter estimates.
`t`	Selected time partition.
`AIC`	Akaike Information Criterion.
`BIC`	Bayesian Information Criterion.
`L.sel`	Number of selected partitions.
`AIC.L`	AIC values for $L = 1, \ldots, L.max$.
`BIC.L`	BIC values for $L = 1, \ldots, L.max$.

Author(s)

Diego I. Gallardo, Yolanda M. Gomez, Hector W. Gomez, and Barry C. Arnold.

References

Feigl P., Zelen M. (1965). Estimation of exponential survival probabilities with concomitant information. *Biometrics*, **21**, 826-838.

Friedman M. (1982). Piecewise exponential models for survival data with covariates. *Annals of Statistics*, **10**, 101-113.

Gomez Y. M., Gallardo D. I., Arnold B. C. (2018). The power piecewise exponential model. *Journal of Statistical Computation and Simulation*, **88**, 825-840.

Examples

```
library(survival)
set.seed(3100)

n  <- 200
x1 <- rnorm(n)
x2 <- rnorm(n)

## drawing covariates
lambda <- c(0.05, 0.03)
rate   <- exp(cbind(x1, x2) %*% c(0.5, -0.5))

time2 = c()
for (i in 1:n)
  time2[i] <- rpweibull(1, rate = lambda * rate[i], alpha = c(1, 1), t = c(0, 10))

delta <- rbinom(n, size = 1, prob = 0.75)
cc    <- runif(n, 0, max(time2))
time  <- ifelse(delta == 1, time2, cc)

data  <- data.frame(time = time, x1 = x1, x2 = x2, delta = delta)

choose.pweibull(survival::Surv(time, delta) ~ x1 + x2, data = data, L.max = 3)
```

`fit.pweibull` *Parameter Estimation for the Power Piecewise Weibull Model*

Description

Fits the power piecewise Weibull model and returns parameter estimates, standard errors, likelihood measures, and the selected time partition.

Usage

```
fit.pweibull(formula, data, L = 1, t = NULL, prec = 1e-04, max.iter = 1000,
    lambda.identical = FALSE, alpha.identical = FALSE, alpha.fixed = FALSE)
```

Arguments

`formula`	A model formula of class `"formula"` describing the survival model to be fitted. Details on model specification are given in *Details*.
`data`	An optional data frame, list, or environment containing the variables in the model. If not found in `data`, variables are taken from `environment(formula)`.
`L`	Number of partitions to be used. Ignored if `t` is specified.
`t`	A fixed time partition. Ignored if `L` is supplied.

`prec`	Numerical tolerance used in the estimation procedure (default `1e-4`).
`max.iter`	Maximum number of iterations allowed in the estimation algorithm (default `1000`).
`lambda.identical`	Logical; should the λ's be constrained to be equal? (default `FALSE`).
`alpha.identical`	Logical; should the α's be constrained to be equal? (default `FALSE`).
`alpha.fixed`	Should α be fixed at a known value? If `FALSE` (default), α is estimated. If a positive number is provided, all α_ℓ are fixed at that value.

Details

The hazard function of the power piecewise Weibull model is given by

$$h(t \mid \boldsymbol{\lambda}, \boldsymbol{\alpha}) = \lambda_\ell \alpha_\ell t^{\alpha_\ell - 1}, \qquad t \in (a_{\ell-1}, a_\ell),\ \ell = 1, \ldots, L,$$

where $0 = a_0 < a_1 < \cdots < a_L < \infty$ defines the time partition, $\boldsymbol{\lambda} = (\lambda_1, \ldots, \lambda_L)$ and $\boldsymbol{\alpha} = (\alpha_1, \ldots, \alpha_L)$.

Special cases include:

- $\alpha_1 = \cdots = \alpha_L = 1$: the piecewise exponential model (Feigl and Zelen, 1965; Friedman, 1982),
- $\alpha_1 = \cdots = \alpha_L = 2$: a piecewise Rayleigh model.

Value

A list with components:

`estimate`	A matrix containing parameter estimates and corresponding standard errors.
`logLik`	Log-likelihood evaluated at the estimated parameters.
`t`	The time partition used.
`AIC`	Akaike Information Criterion.
`BIC`	Bayesian Information Criterion.

Author(s)

Diego I. Gallardo, Yolanda M. Gomez, Hector W. Gomez, and Barry C. Arnold.

References

Feigl P., Zelen M. (1965). Estimation of exponential survival probabilities with concomitant information. *Biometrics*, **21**, 826-838.

Friedman M. (1982). Piecewise exponential models for survival data with covariates. *Annals of Statistics*, **10**, 101-113.

Gomez Y. M., Gallardo D. I., Arnold B. C. (2018). The power piecewise exponential model. *Journal of Statistical Computation and Simulation*, **88**, 825-840.

Examples

```
library(survival)
set.seed(3100)

n  <- 200
x1 <- rnorm(n)
x2 <- rnorm(n)

## design matrix
x  <- model.matrix(~ x1 + x2)[, -1]

lambda <- c(0.05, 0.03)
rate   <- exp(cbind(x1, x2) %*% c(0.5, -0.5))

time <- numeric(n)
for (i in 1:n)
  time[i] <- rpweibull(1, rate = lambda * rate[i], alpha = c(1, 1), t = c(0, 10))

delta <- rep(1, n)

data <- data.frame(time = time, delta = delta, x1 = x1, x2 = x2)

fit.pweibull(survival::Surv(time, delta) ~ x1 + x2, data = data, L = 2)
```

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pweibull *The Power Piecewise Weibull Distribution*

Description

Density, distribution function, quantile function, and random generation for the power piecewise Weibull distribution.

Usage

```
dpweibull(x, rate = 1, alpha = 1, t = 0, log = FALSE)

ppweibull(q, rate = 1, alpha = 1, t = 0, lower.tail = TRUE, log.p = FALSE)

qpweibull(p, rate = 1, alpha = 1, t = 0, lower.tail = TRUE, log.p = FALSE)

rpweibull(n = 1, rate = 1, alpha = 1, t = 0)
```

Arguments

x	Vector of quantiles for the density function.
q	Vector of quantiles for the distribution function.
p	Vector of probabilities for the quantile function.

n	Number of observations to generate. If length(n) > 1, the length is taken as the number of observations.
rate	A numeric vector of length L containing the rate parameters $\lambda_1, \ldots, \lambda_L$.
alpha	A numeric vector of length L containing the shape parameters $\alpha_1, \ldots, \alpha_L$.
t	A non-decreasing vector defining the time partition $(0 = a_0, a_1, \ldots, a_L)$.
log	Logical; if TRUE, probabilities are returned on the log scale.
lower.tail	Logical; if TRUE (default), probabilities are $P(T \leq q)$; otherwise $P(T > q)$.
log.p	Logical; if TRUE, probabilities p are given on the log scale.

Details

The hazard function of the power piecewise Weibull model is

$$h(t \mid \boldsymbol{\lambda}, \boldsymbol{\alpha}) = \lambda_\ell \alpha_\ell t^{\alpha_\ell - 1}, \qquad t \in (a_{\ell-1}, a_\ell),\ \ell = 1, \ldots, L,$$

where $0 = a_0 < a_1 < \cdots < a_{L-1} < a_L < \infty$ defines the partition of time, $\boldsymbol{\lambda} = (\lambda_1, \ldots, \lambda_L)$, and $\boldsymbol{\alpha} = (\alpha_1, \ldots, \alpha_L)$.

Special cases include:

- $\alpha_1 = \cdots = \alpha_L = 1$: the piecewise exponential model (Feigl and Zelen, 1965; Friedman, 1982),
- $\alpha_1 = \cdots = \alpha_L = 2$: a piecewise Rayleigh model.

Value

dpweibull returns the density, ppweibull returns the distribution function, qpweibull returns the quantile function, and rpweibull generates random deviates.

For rpweibull, the result has length n. For the other functions, the result has length equal to the maximum of the lengths of the numerical arguments. Arguments are recycled as needed.

Only the first elements of the logical arguments log, lower.tail, and log.p are used.

References

Feigl P., Zelen M. (1965). Estimation of exponential survival probabilities with concomitant information. *Biometrics*, **21**, 826-838.

Friedman M. (1982). Piecewise exponential models for survival data with covariates. *Annals of Statistics*, **10**, 101-113.

Gomez Y. M., Gallardo D. I., Arnold B. C. (2018). The power piecewise exponential model. *Journal of Statistical Computation and Simulation*, **88**, 825-840.

Examples

```
set.seed(3100)
## Random sample
rpweibull(n = 10, rate = c(0.05, 0.03), alpha = c(1, 1.5), t = c(0, 10))
## Distribution function
ppweibull(c(5, 10, 20), rate = c(0.05, 0.03), alpha = c(1, 1.5), t = c(0, 10))
```

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