Package ‘Reliability’

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**duane**

*Maximum Likelihood estimation of mean value function for Duane model*

---

**Description**

`duane` computes the Maximum Likelihood estimates for the parameters `rho` and `theta` of the mean value function for the Duane model.

**Usage**

```r
duane(t, init = c(1, 1), method = "Nelder-Mead", maxit = 10000, ...)
```

**Arguments**

- **t** time between failure data
- **init** initial values for Maximum Likelihood fit of the mean value function for the Duane model.
- **method** the method to be used for optimization, see `optim` for details.
- **maxit** the maximum number of iterations, see `optim` for details.
- **...** control parameters and plot parameters optionally passed to the optimization and/or plot function. Parameters for the optimization function are passed to components of the control argument of `optim`.

**Details**

This function estimates the parameters `rho` and `theta` of the mean value function for the Duane model. With Maximum Likelihood estimation one gets the following equations, which have to be minimized. This is

\[
\text{equation}_1 := \rho - \frac{n}{t^n} = 0
\]

and

\[
\text{equation}_2 := \theta - \frac{n}{\sum_{i=1}^{n-1} \log(t_n/t_i)} = 0.
\]

Where `t` is the time between failure data and `n` is the length or in other words the size of the time between failure data. So the simultaneous minimization of these equations happens by minimization of the equation

\[
equation_1^2 + equation_2^2 = 0.
\]

**Value**

A list containing following components:

- **rho** Maximum Likelihood estimate for `rho`
- **theta** Maximum Likelihood estimate for `theta`
Author(s)

Andreas Wittmann <andreas\_wittmann@gmx.de>

References


See Also

duane.plot, mvf.duane

Examples

```r
# time between failure data from DACS Software Reliability Dataset
# homepage, see system code 1. Number of failures is 136.
t <- c(3, 30, 113, 81, 115, 9, 2, 20, 20, 15, 138, 50, 77, 24,
     108, 88, 670, 120, 26, 114, 325, 55, 242, 68, 422, 180,
     10, 1146, 600, 15, 36, 4, 0, 8, 227, 65, 176, 58, 457,
     300, 97, 263, 452, 255, 197, 193, 6, 79, 816, 1351, 148,
     21, 233, 134, 357, 193, 236, 31, 369, 748, 0, 232, 330,
     365, 1222, 543, 10, 16, 529, 379, 44, 129, 810, 290, 300,
     529, 281, 160, 828, 1011, 445, 296, 1755, 1064, 1783,
     860, 983, 707, 33, 868, 724, 2323, 2930, 1461, 843, 12,
     261, 1800, 865, 1435, 30, 143, 108, 0, 3110, 1247, 943,
     700, 875, 245, 729, 1897, 447, 386, 446, 122, 990, 948,
     1082, 22, 75, 482, 5509, 100, 10, 1071, 371, 790, 6150,
     3321, 1045, 648, 5485, 1160, 1864, 4116)

duane(t)
```

**duane.plot**

*Plotting the mean value function for the Duane model*

Description

`duane.plot` plots the mean value function for the Duane model and the raw data into one window.

Usage

```r
duane.plot(rho, theta, t, xlab = "time",
ylab = "Cumulated failures and estimated mean value function",
main = NULL)
```
Arguments

- **rho**: parameter value for rho
- **theta**: parameter value for theta
- **t**: time between failure data
- **xlab**: a title for the x axis
- **ylab**: a title for the y axis
- **main**: an overall title for the plot

Details

This function gives a plot of the mean value function for the Duane model. Here the estimated parameter values for rho and theta, which are obtained by using `duane`, can be put in. Internally the function `mvf.duane` is used to get the mean value function for the Duane model.

Value

A graph of the mean value function for the Duane model and of the raw data.

Author(s)

Andreas Wittmann <andreas\_wittmann@gmx.de>

References


See Also

`duane`, `mvf.duane`

Examples

```r
# time between-failure-data from DACS Software Reliability Dataset
# homepage, see system code 1. Number of failures is 136.
t <- c(3, 30, 113, 81, 115, 9, 2, 20, 20, 15, 138, 50, 77, 24,
      108, 88, 670, 120, 26, 114, 325, 55, 242, 68, 422, 180,
      10, 1146, 600, 15, 36, 4, 0, 8, 227, 65, 176, 58, 457,
      300, 97, 263, 452, 255, 197, 193, 6, 79, 816, 1351, 148,
      21, 233, 134, 357, 193, 236, 31, 369, 748, 0, 232, 330,
      365, 1222, 543, 10, 16, 529, 379, 44, 129, 810, 290, 300,
      529, 281, 160, 828, 1011, 445, 296, 1755, 1064, 1783,
      868, 983, 707, 33, 868, 724, 2323, 2930, 1461, 843, 12,
      261, 1800, 865, 1435, 30, 143, 108, 0, 3110, 1247, 943,
      700, 875, 245, 729, 1897, 447, 386, 446, 122, 990, 948,
      1082, 22, 75, 482, 5509, 100, 10, 1071, 371, 790, 6150,
```
littlewood.verall

Maximum Likelihood estimation of mean value function for Littlewood-Verall model

Description

littlewood.verall computes the Maximum Likelihood estimates for the parameters $\theta_0$, $\theta_1$ and $\rho$ of the mean value function for the Littlewood-Verall model.

Usage

littlewood.verall(t, linear = TRUE, init = c(1, 1, 1), method = "Nelder-Mead", maxit = 10000, ...)

Arguments

t time between failure data

linear logical. Should the linear or the quadratic form of the mean value function for the Littlewood-Verrall model be used of computation? If TRUE, which is the default, the linear form of the mean value function is used.

init initial values for Maximum Likelihood fit of the mean value function for the Littlewood-Verall model.

method the method to be used for optimization, see optim for details.

maxit the maximum number of iterations, see optim for details.

... control parameters and plot parameters optionally passed to the optimization and/or plot function. Parameters for the optimization function are passed to components of the control argument of optim.

Details

This function estimates the parameters $\theta_0$, $\theta_1$ and $\rho$ of the mean value function in the linear or the quadratic form for the Littlewood-Verall model.

First, the computation with the mean value function in the linear form is explained. With Maximum Likelihood estimation one gets the following equations, which have to be minimized. This is

$$
equation_1 := \frac{n}{\rho} + \sum_{i=1}^{n} \log(\theta_0 + \theta_1 i) - \sum_{i=1}^{n} \log(\theta_0 + \theta_1 i + t_i) = 0,$$
Second, the computation with the mean value function in the quadratic form is explained. With Maximum Likelihood estimation one gets the following equations, which have to be minimized. This is

\[equation_1 := \frac{n}{\rho} + \sum_{i=1}^{n} \log(\theta_0 + \theta_1 i^2) - \sum_{i=1}^{n} \log(\theta_0 + \theta_1 i^2 + t_i) = 0,\]

\[equation_2 := \rho \sum_{i=1}^{n} \frac{1}{\theta_0 + \theta_1 i^2} - \rho + 1 \sum_{i=1}^{n} \frac{1}{\theta_0 + \theta_1 i^2 + t_i} = 0\]

and

\[equation_3 := \rho \sum_{i=1}^{n} \frac{i^2}{\theta_0 + \theta_1 i^2} - \rho + 1 \sum_{i=1}^{n} \frac{i^2}{\theta_0 + \theta_1 i^2 + t_i} = 0.\]

Where \( t \) is the time between failure data and \( n \) is the length or in other words the size of the time between failure data. So the simultaneous minimization of these equations happens by minimization of the equation

\[equation_1^2 + equation_2^2 + equation_3^2 = 0.\]

**Value**

A list containing following components:

- theta0: Maximum Likelihood estimate for \( \theta_0 \)
- theta1: Maximum Likelihood estimate for \( \theta_1 \)
- rho: Maximum Likelihood estimate for \( \rho \)

**Author(s)**

Andreas Wittmann <andreas\_wittmann@gmx.de>

**References**


**See Also**

littlewood.verall.plot.mvf.ver.lin,mvf.ver.quad
Examples

```r

littlewood.verall(t, linear = TRUE)
littlewood.verall(t, linear = FALSE)
```

littlewood.verall.plot

*Plotting the mean value function for the Littlewood-Verall model*

Description

`littlewood.verall.plot` plots the mean value function for the Littlewood-Verall model and the raw data into one window.

Usage

```r
littlewood.verall.plot(theta0, theta1, rho, t, linear = T, xlab = "time", ylab = "Cumulated failures and estimated mean value function", main = NULL)
```

Arguments

- `theta0`: parameter value for theta0
- `theta1`: parameter value for theta1
- `rho`: parameter value for rho
- `t`: time between failure data
- `linear`: logical. Should the linear or the quadratic form of the mean value function for the Littlewood-Verrall model be used of computation? If TRUE, which is the default, the linear form of the mean value function is used.
- `xlab`: a title for the x axis
- `ylab`: a title for the y axis
- `main`: an overall title for the plot
Details

This function gives a plot of the mean value function for the Littlewood-Verall model. Here the estimated parameter values for $\theta_0$, $\theta_1$ and $\theta$, which are obtained by using `littlewood.verall`, can be put in. Internally the functions `mvf.ver.lin` or `mvf.ver.quad` are used to get the mean value function for the Littlewood-Verall model. This depends on the calibration, if the linear or the quadratic form of the mean value function for the Littlewood-Verall model should be used.

Value

A graph of the mean value function for the Littlewood-Verall model and of the raw data.

Author(s)

Andreas Wittmann <andreas\_wittmann@gmx.de>

References


See Also

`littlewood.verall`, `mvf.ver.lin`, `mvf.ver.quad`

Examples

```r
# time between-failure-data from DACS Software Reliability Dataset
# homepage, see system code 1. Number of failures is 136.
# not run:
t <- c(3, 30, 113, 81, 115, 9, 2, 20, 20, 15, 138, 50, 77, 54,
     108, 88, 670, 120, 26, 114, 325, 55, 242, 68, 422, 180,
     10, 1146, 600, 15, 36, 4, 0, 8, 227, 65, 176, 58, 457,
     300, 97, 263, 452, 255, 197, 193, 6, 79, 816, 1351, 148,
     21, 233, 134, 357, 193, 236, 31, 369, 748, 0, 232, 330,
     365, 1222, 543, 10, 16, 529, 379, 44, 129, 810, 290, 300,
     529, 281, 100, 828, 1011, 445, 296, 1755, 1064, 1783,
     860, 983, 707, 33, 868, 724, 2323, 2930, 1461, 843, 12,
     261, 1800, 865, 1435, 30, 143, 108, 0, 3110, 1247, 943,
     700, 875, 245, 729, 1897, 447, 386, 446, 122, 990, 948,
     1082, 22, 75, 482, 5509, 108, 10, 1071, 371, 790, 6150,
     3321, 1045, 648, 5485, 1160, 1864, 4116)

theta0 <- littlewood.verall(t, linear = TRUE)$theta0
theta1 <- littlewood.verall(t, linear = TRUE)$theta1
rho <- littlewood.verall(t, linear = TRUE)$rho
littlewood.verall.plot(theta0, theta1, rho, t, linear = TRUE,
               xlab = "time (in seconds)", main = "Littlewood-Verall model (linear)"

## Not run:
## theta0 <- littlewood.verall(t, linear = FALSE)$theta0
```
moranda.geometric

## Code
```
## theta1 <- littlewood.verall(t, linear = FALSE)$theta1
## rho <- littlewood.verall(t, linear = FALSE)$rho
## littlewood.verall.plot(theta0, theta1, rho, t, linear = FALSE,
## ## xlab = "time (in seconds)", main = "Littlewood-Verall modell (quadratic)"
## ## End(Not run)
```

### Description

`moranda.geometric` computes the Maximum Likelihood estimates for the parameters $D$ and $\theta$ of the mean value function for the Moranda-Geometric model.

### Usage

```
moranda.geometric(t, init = c(0, 1), tol = .Machine$double.eps^0.25)
```

### Arguments

- `t`: time between failure data
- `init`: initial values for Maximum Likelihood fit of the mean value function for the Moranda-Geometric model.
- `tol`: the desired accuracy

### Details

This function estimates the parameters $D$ and $\theta$ of the mean value function for the Moranda-Geometric model. With Maximum Likelihood estimation one gets the following equation, which have to be minimized, to get $\phi$. This is

$$
\sum_{i=1}^{n} i \phi t_i - \frac{n + 1}{2} = 0.
$$

The solution of these is then put in in the following equation in order to get $D$

$$
D = \frac{\phi n}{\sum_{i=1}^{n} \phi i t_i}.
$$

Where $t$ is the time between failure data and $n$ is the length or in other words the size of the time between failure data.

### Value

A list containing following components:

- `rho`: Maximum Likelihood estimate for rho
- `theta`: Maximum Likelihood estimate for theta
Author(s)
Andreas Wittmann <andreas\_wittmann@gmx.de>

References


See Also
moranda.geometric.plot, mvf.mor

Examples
```r
# time between failure data from DACS Software Reliability Dataset
# homepage, see system code 1. Number of failures is 136.
t <- c(3, 30, 113, 81, 115, 9, 2, 20, 28, 15, 138, 50, 77, 24,
      108, 88, 670, 120, 26, 114, 325, 55, 242, 68, 422, 180,
      10, 1146, 600, 15, 36, 4, 0, 8, 227, 65, 176, 58, 457,
      300, 97, 263, 452, 255, 197, 193, 6, 79, 816, 1351, 148,
      31, 233, 134, 357, 193, 236, 31, 369, 748, 0, 232, 330,
      365, 1222, 543, 10, 16, 529, 379, 44, 129, 810, 290, 300,
      529, 281, 168, 828, 1011, 445, 296, 1755, 1064, 1783,
      860, 983, 707, 33, 868, 724, 2323, 2930, 1461, 843, 12,
      261, 1800, 865, 1435, 30, 143, 108, 0, 3110, 1247, 943,
      700, 875, 245, 729, 1897, 447, 386, 446, 122, 990, 948,
      1082, 22, 75, 482, 5509, 100, 10, 1071, 371, 790, 6150,
      3321, 1045, 648, 5485, 1160, 1864, 4116)
moranda.geometric(t)
```

```
moranda.geometric.plot

Plotting the mean value function for the Moranda-Geometric model
```

Description
moranda.geometric.plot plots the mean value function for the Moranda-Geometric model and the raw data into one window.

Usage
```
moranda.geometric.plot(D, theta, t, xlab = "time",
ylab = "Cumulated failures and estimated mean value function",
main = NULL)
```
Arguments

D parameter value for D
theta parameter value for theta
t time between failure data
xlab a title for the x axis
ylab a title for the y axis
main an overall title for the plot

Details

This function gives a plot of the mean value function for the Moranda-Geometric model. Here the estimated values for D and theta, which are obtained by using moranda.geometric, can be put in. Internally the function mvf.mor is used to get the mean value function for the Moranda-Geometric model.

Value

A graph of the mean value function for the Moranda-Geometric model and of the raw data.

Author(s)

Andreas Wittmann <andreas\_wittmann@gmx.de>

References


See Also

moranda.geometric, mvf.mor

Examples

```r
# time between-failure-data from DACS Software Reliability Dataset
# homepage, see system code 1. Number of failures is 136.
```
musa.okumoto

Maximum Likelihood estimation of mean value function for Musa-Okumoto model

Description

musa.okumoto computes the Maximum Likelihood estimates for the parameters theta0 and theta1 of the mean value function for the Musa-Okumoto model.

Usage

musa.okumoto(t, init = c(0, 1), tol = .Machine$double.eps^0.25)

Arguments

t time between failure data
init initial values for Maximum Likelihood fit of the mean value function for the Musa-Okumoto model.
tol the desired accuracy

Details

This function estimates the parameters theta0 and theta1 of the mean value function for the Musa-Okumoto model. With Maximum Likelihood estimation one gets the following equation, which have to be minimized, to get theta1. This is

\[
\frac{1}{\theta_1} \sum_{i=1}^{n} \frac{1}{1 + \theta_1 t_i} - \frac{n t_n}{(1 + \theta_1 t_n) \log(1 + \theta_1 t_n)} = 0.
\]

The solution of these is then put in in the following equation in order to get theta0

\[
\theta_0 = \frac{n}{\log(1 + \theta_1 t_n)}.
\]

Where t is the time between failure data and n is the length or in other words the size of the time between failure data.
Value

A list containing following components:

- \( \theta_0 \) Maximum Likelihood estimate for \( \theta_0 \)
- \( \theta_1 \) Maximum Likelihood estimate for \( \theta_1 \)

Author(s)

Andreas Wittmann <andreas\_wittmann@gmx.de>

References


See Also

musa.okumoto.plot, mvf.musa

Examples

```r
# time between failure data from DACS Software Reliability Dataset
# homepage, see system code 1. Number of failures is 136.

musa.okumoto(t)
```

---

**musa.okumoto.plot**  
Plotting the mean value function for the Musa-Okumoto model

Description

*musa.okumoto.plot* plots the estimated mean value function for the Musa-Okumoto model and the raw data into one window.
Usage

musa.okumoto.plot(theta0, theta1, t, xlab = "time",
                 ylab = "Cumulated failures and estimated mean value function",
                 main = NULL)

Arguments

theta0  parameter value for theta0
theta1  parameter value for theta1
t      time between failure data
xlab    a title for the x axis
ylab    a title for the y axis
main    an overall title for the plot

Details

This function gives a plot of the mean value function for the Musa-Okumoto model. Here the
estimated parameter values for theta0 and theta1, which are obtained by using musa.okumoto,
can be put in. Internally the function mvf.musa is used to get the mean value function for the
Musa-Okumoto model.

Value

A graph of the mean value function for the Musa-Okumoto model and of the raw data.

Author(s)

Andreas Wittmann <andreas\_wittmann@gmx.de>

References


See Also

musa.okumoto, mvf.musa

Examples

# time between failure data from DACS Software Reliability Dataset
# homepage, see system code 1. Number of failures is 136.
t <- c(3, 30, 113, 81, 115, 9, 2, 20, 20, 15, 138, 50, 77, 24,
       108, 88, 670, 120, 26, 114, 325, 55, 242, 68, 422, 180,
       10, 1146, 600, 15, 36, 4, 0, 8, 227, 65, 176, 58, 457,
       300, 97, 263, 452, 255, 197, 193, 6, 79, 816, 1351, 148,
mvf.duane

Mean value function for the Duane model

Description

mvf.duane returns the mean value function for the Duane model.

Usage

mvf.duane(rho, theta, t)

Arguments

rho  parameter value for rho
theta parameter value for theta
t  time between failure data

Details

This function gives the values of the mean value function for the Duane model, this is written as

\[ \mu(t) = \rho t^\theta. \]

Further there is a verifying if the parameters rho and theta satisfy the assumptions for the Duane model. So the parameters rho and theta have to be larger than zero, in equations \( \rho > 0 \) and \( \theta > 0 \).

Value

The mean value function for the Duane model.

Author(s)

Andreas Wittmann <andreas\_wittmann@gmx.de>
References


See Also
duane, duane.plot

Examples

```r
# time between-failure-data from DACS Software Reliability Dataset
# homepage, see system code 1. Number of failures is 136.

duane.par1 <- duane(t)$rho
duane.par2 <- duane(t)$theta

mvf.duanex(duane.par1, duane.par2, t)
```

### Description

`mvf.mor` returns the mean value function for the Moranda-Geometric model.

### Usage

```r
mvf.mor(D, theta, t)
```

### Arguments

- **D**: parameter value for D
- **theta**: parameter value for theta
- **t**: time between failure data
Details
This function gives the values of the mean value function for the Moranda-Geometric model, this is written as
\[
\mu(t) = \frac{1}{\theta} \log\{[D\theta \exp(\theta)]t + 1\}.
\]
Further there is a verifying if the parameter \(\theta\) satisfy the assumptions of the Moranda-Geometric model. So the parameter \(\theta\) have to be larger than zero, in equation \(\theta > 0\).

Value
The mean value function for the Moranda-Geometric model.

Author(s)
Andreas Wittmann <andreas\_wittmann@gmx.de>

References


See Also
moranda.geometric, moranda.geometric.plot

Examples
```r
# time between-failure-data from DACS Software Reliability Dataset
# homepage, see system code 1. Number of failures is 136.
mor.par1 <- moranda.geometric(t)$D
mor.par2 <- moranda.geometric(t)$theta
mvf.mor(mor.par1, mor.par2, t)
```
Description

`mvf.musa` returns the mean value function for the Musa-Okumoto model.

Usage

`mvf.musa(theta0, theta1, t)`

Arguments

- `theta0`: parameter value for `theta0`
- `theta1`: parameter value for `theta1`
- `t`: time between failure data

Details

This function gives the values of the mean value function for the Musa-Okumoto model, this is written as

$$\mu(t) = \theta_0 \log(\theta_1 t + 1).$$

Value

The mean value function for the Musa-Okumoto model.

Author(s)

Andreas Wittmann <andreas\_wittmann@gmx.de>

References


See Also

`musa.okumoto`, `musa.okumoto.plot`
Examples

```r
# time between failure data from DACS Software Reliability Dataset
# homepage, see system code 1. Number of failures is 136.
t <- c(3, 30, 113, 81, 115, 9, 2, 20, 20, 15, 138, 50, 77, 24,
      108, 88, 670, 120, 26, 114, 325, 55, 242, 68, 422, 180,
      10, 1146, 600, 15, 36, 4, 0, 8, 227, 65, 176, 58, 457,
      300, 97, 263, 452, 255, 197, 193, 6, 79, 816, 1351, 148,
      21, 233, 134, 357, 193, 236, 31, 369, 748, 0, 232, 330,
      365, 1222, 543, 10, 16, 529, 379, 44, 129, 810, 290, 300,
      529, 281, 160, 828, 1011, 445, 296, 1755, 1064, 1783,
      860, 983, 707, 33, 868, 724, 2323, 2930, 1461, 843, 12,
      261, 1800, 865, 1435, 30, 143, 108, 0, 3110, 1247, 943,
      700, 875, 245, 729, 1897, 447, 386, 446, 122, 990, 948,
      1082, 22, 75, 482, 5509, 100, 10, 1071, 371, 790, 6150,
      3321, 1045, 648, 5485, 1160, 1864, 4116)
musa.par1 <- musa.okumoto(t)$theta0
musa.par2 <- musa.okumoto(t)$theta1

mvf.musa(musa.par1, musa.par2, t)
```

Description

`mvf.ver.lin` returns the mean value function in the linear form for the Littlewood-Verall model.

Usage

```r
mvf.ver.lin(theta0, theta1, rho, t)
```

Arguments

- `theta0`: parameter value for `theta0`
- `theta1`: parameter value for `theta1`
- `rho`: parameter value for `rho`
- `t`: time between failure data

Details

This function gives the values of the mean value function in the linear form for the Littlewood-Verall model, this is written as

\[
\mu(t) = \frac{1}{\theta_1} \sqrt{\theta_0^2 + 2\theta_1 t \rho}.
\]

Further there is a verifying if the parameter `theta1` satisfy the assumptions for the Littlewood-Verall model. So the parameter `theta1` should not be equal zero, in equation \( \theta_1 \neq 0 \).
Value

The mean value function in the linear form for the Littlewood-Verall model.

Author(s)

Andreas Wittmann <andreas\_wittmann@gmx.de>

References


See Also

littlewood.verall, littlewood.verall.plot, mvf.ver.quad

Examples

```r
# time between-failure data from DACS Software Reliability Dataset
# homepage, see system code 1. Number of failures is 136.
t <- c(3, 30, 113, 81, 115, 9, 2, 20, 20, 15, 138, 50, 77, 24,
      108, 88, 670, 120, 26, 114, 325, 55, 242, 68, 422, 180,
      10, 1146, 600, 15, 36, 4, 0, 8, 227, 65, 176, 58, 457,
      300, 97, 263, 452, 255, 197, 193, 6, 79, 816, 1351, 148,
      21, 233, 134, 357, 193, 236, 31, 369, 748, 0, 232, 330,
      365, 1222, 543, 10, 16, 529, 379, 44, 129, 810, 290, 300,
      529, 281, 160, 828, 1011, 445, 296, 1755, 1064, 1783,
      860, 983, 707, 33, 868, 724, 2323, 2930, 1461, 843, 12,
      261, 1800, 865, 1435, 30, 143, 108, 0, 3110, 1247, 943,
      700, 875, 245, 729, 1897, 447, 386, 446, 122, 990, 948,
      1082, 22, 75, 482, 5509, 100, 10, 1071, 371, 790, 6150,
      3321, 1045, 648, 5485, 1160, 1864, 4116)

lit.par1 <- littlewood.verall(t, linear = TRUE)$theta0
lit.par2 <- littlewood.verall(t, linear = TRUE)$theta1
lit.par3 <- littlewood.verall(t, linear = TRUE)$rho

mvf.ver.lin(lit.par1, lit.par2, lit.par3, t)
```

`mvf.ver.quad` Mean value function in the quadratic form for the Littlewood-Verall model.

Description

`mvf.ver.quad` returns mean value function in the quadratic form for the Littlewood-Verall model.
Usage

\texttt{mvf.ver.quad(theta0, theta1, rho, t)}

Arguments

\texttt{theta0} \quad \text{parameter value for theta0}

\texttt{theta1} \quad \text{parameter value for theta1}

\texttt{rho} \quad \text{parameter value for rho}

\texttt{t} \quad \text{time between failure data}

Details

This function gives the values of the mean value function in the quadratic form for the Littlewood-Verall model, this is written as

\[ \mu(t) = 3v_1(Q_1 + Q_2), \]

where

\[ v_1 = \frac{(\rho - 1)^{1/3}}{(18\theta_1)^{1/3}}, \]

\[ v_2 = \frac{4\theta_0^3}{9(\rho - 1)^2\theta_1}, \]

\[ Q_1 = [t + (t^2 + v_2)^{1/2}]^{1/3} \]

and

\[ Q_2 = [t - (t^2 + v_2)^{1/2}]^{1/3}. \]

Further there is a verifying if the parameter theta1 satisfy the assumptions for the Littlewood-Verall model. So the parameter theta1 should not be equal zero, in equation \( \theta_1 \neq 0 \).

Value

The mean value function in the quadratic form for the Littlewood-Verall model.

Author(s)

Andreas Wittmann <andreas\_wittmann@gmx.de>

References


See Also

\texttt{littlewood.verall, littlewood.verall.plot, mvf.ver.lin}
Examples

# time between-failure-data from DACS Software Reliability Dataset
# homepage, see system code 1. Number of failures is 136.
t <- c(3, 30, 113, 81, 115, 9, 2, 20, 20, 15, 138, 50, 77, 24,
108, 88, 670, 120, 26, 114, 325, 55, 242, 68, 422, 180,
10, 1146, 600, 15, 36, 4, 0, 8, 227, 65, 176, 58, 457,
300, 97, 263, 452, 255, 197, 193, 6, 79, 816, 1351, 148,
21, 233, 134, 357, 193, 236, 31, 369, 748, 0, 232, 330,
365, 1222, 543, 10, 16, 529, 379, 44, 129, 810, 290, 300,
529, 281, 160, 828, 1011, 445, 296, 1755, 1064, 1783,
860, 983, 707, 33, 868, 724, 2323, 2930, 1461, 843, 12,
261, 1800, 865, 1435, 30, 143, 108, 0, 3110, 1247, 943,
700, 875, 245, 729, 1897, 447, 386, 446, 122, 990, 948,
1082, 22, 75, 482, 5509, 100, 10, 1071, 371, 790, 6150,
3321, 1045, 648, 5485, 1160, 1864, 4116)

lit.par1 <- littlewood.verall(t, linear = TRUE)$theta0
lit.par2 <- littlewood.verall(t, linear = TRUE)$theta1
lit.par3 <- littlewood.verall(t, linear = TRUE)$rho

mvf.ver.quad(lit.par1, lit.par2, lit.par3, t)

rel.plot(duane.par1, duane.par2, lit.par1, lit.par2, lit.par3, mor.par1,
mor.par2, musa.par1, musa.par2, t, linear = T, ym
xlab = "time", ylab = "relative error", main = NULL)

Arguments

duane.par1 parameter value for rho for Duane model
duane.par2 parameter value for theta for Duane model
lit.par1 parameter value for theta0 for Littlewood-Verall model
lit.par2 parameter value for theta1 for Littlewood-Verall model
lit.par3 parameter value for rho for Littlewood-Verall model
mor.par1 parameter value for d for Moranda-Geometric model
mor.par2 parameter value for theta for Moranda-Geometric model
musa.par1 parameter value for theta0 for Musa-Okumoto model
musa.par2 parameter value for theta1 for Musa-Okumoto model

Description

total.plot plots the relative error for the the mean value function for all models into one window.

Usage

rel.plot(duane.par1, duane.par2, lit.par1, lit.par2, lit.par3, mor.par1,
mor.par2, musa.par1, musa.par2, t, linear = T, ym
xlab = "time", ylab = "relative error", main = NULL)
rel.plot

- **t**: time between failure data
- **linear**: logical. Should the linear or the quadratic form of the mean value function for the Littlewood-Verrall model be used of computation? If TRUE, which is the default, the linear form of the mean value function is used.
- **ymin**: the minimal y limit of the plot
- **ymax**: the maximal y limit of the plot
- **xlab**: a title for the x axis
- **ylab**: a title for the y axis
- **main**: an overall title for the plot

**Details**

This function gives a plot of the relative error for the mean value functions for all models, this is

$$\text{relative error} = \frac{\mu(t_i) - i}{i}, i = 1, 2, ..., $$

where $\mu(t)$ is a mean value function and $i$ is the number of failures. Here the estimated parameter values, which are obtained by using duane, littlewood.verall, moranda.geometric und musa.okumoto can be put in. Internally the functions mvf.duane, mvf.ver.lin, mvf.ver.quad, mvf.mor and mvf.musa are used to get the mean value functions for all models.

**Value**

A graph of the relative error for the mean value functions for all models.

**Author(s)**

Andreas Wittmann <andreas\_wittmann@gmx.de>

**References**


**See Also**

duane.plot, littlewood.verall.plot, moranda.geometric.plot, musa.okumoto.plot, total.plot

**Examples**

# time between-failure-data from DACS Software Reliability Dataset
# homepage, see system code 1. Number of failures is 136.
t <- c(3, 30, 113, 81, 115, 9, 2, 20, 20, 15, 138, 50, 77, 24,
  108, 88, 670, 120, 26, 114, 325, 55, 242, 68, 422, 180,
  10, 1146, 600, 15, 36, 4, 0, 8, 227, 65, 176, 58, 457,
  300, 97, 263, 452, 255, 197, 193, 6, 79, 816, 1351, 148,
total.plot

Plotting the mean value functions for all models

duane.par1 <- duane(t)$rho
duane.par2 <- duane(t)$theta

lit.par1 <- littlewood.verall(t, linear = TRUE)$theta0
lit.par2 <- littlewood.verall(t, linear = TRUE)$theta1
lit.par3 <- littlewood.verall(t, linear = TRUE)$rho

mor.par1 <- moranda.geometric(t)$D
mor.par2 <- moranda.geometric(t)$theta

musa.par1 <- musa.okumoto(t)$theta0
musa.par2 <- musa.okumoto(t)$theta1

rel.plot(duane.par1, duane.par2, lit.par1, lit.par2, lit.par3, mor.par1,
mor.par2, musa.par1, musa.par2, t, linear = TRUE, ymin = -1,
ymax = 2.5, xlab = "time (in seconds)", main = "relative error")

## Not run:
## rel.plot(duane.par1, duane.par2, lit.par1, lit.par2, lit.par3, mor.par1,
##     mor.par2, musa.par1, musa.par2, t, linear = TRUE,
##     xlab = "time (in seconds)", main = "relative error")
## End(Not run)

description

total.plot plots the mean value function for all models and the raw data into one window.

Usage

total.plot(duane.par1, duane.par2, lit.par1, lit.par2, lit.par3, mor.par1,
mor.par2, musa.par1, musa.par2, t, linear = TRUE, xlab = "time",
ylab = "Cumulated failures and estimated mean value functions",
main = NULL)

Arguments

duane.par1 parameter value for rho for Duane model
duane.par2  parameter value for theta for Duane model
lit.par1   parameter value for theta0 for Littlewood-Verall model
lit.par2   parameter value for theta1 for Littlewood-Verall model
lit.par3   parameter value for rho for Littlewood-Verall model
mor.par1   parameter value for D for Moranda-Geometric model
mor.par2   parameter value for theta for Moranda-Geometric model
musa.par1  parameter value for theta0 for Musa-Okumoto model
musa.par2  parameter value for theta1 for Musa-Okumoto model
t         time between failure data
linear   logical. Should the linear or the quadratic form of the mean value function for the Littlewood-Verrall model be used of computation? If TRUE, which is the default, the linear form of the mean value function is used.
xlab     a title for the x axis
ylab     a title for the y axis
main     an overall title for the plot

Details

This function gives a plot of the mean value functions for all models. Here the estimated parameter values, which are obtained by using duane, littlewood.verall, moranda.geometric und musa.okumoto can be put in. Internally the functions mvf.duane, mvf.ver.lin, mvf.ver.quad, mvf.mor and mvf.musa are used to get the mean value functions for all models.

Value

A graph of the mean value functions for all models and of the raw data.

Author(s)

Andreas Wittmann <andreas\_wittmann@gmx.de>

References


See Also

duane.plot, littlewood.verall.plot, moranda.geometric.plot, musa.okumoto.plot
Examples

```r
# time between-failure-data from DACS Software Reliability Dataset
# homepage, see system code 1. Number of failures is 136.
t <- c(3, 30, 113, 81, 115, 9, 2, 20, 20, 15, 138, 50, 77, 24,
      108, 88, 670, 120, 26, 114, 325, 55, 242, 68, 422, 180,
      10, 1146, 600, 15, 36, 4, 0, 8, 227, 65, 176, 58, 457,
      300, 97, 263, 452, 255, 197, 193, 6, 79, 816, 1351, 148,
      21, 233, 134, 357, 193, 236, 31, 369, 748, 0, 232, 330,
      365, 1222, 543, 10, 16, 529, 379, 44, 129, 810, 290, 300,
      529, 281, 160, 828, 1011, 445, 296, 1755, 1064, 1783,
      860, 983, 707, 33, 868, 724, 2323, 2930, 1461, 843, 12,
      261, 1800, 865, 1435, 30, 143, 108, 0, 3110, 1247, 943,
      700, 875, 245, 729, 1897, 447, 386, 446, 122, 990, 948,
      1082, 22, 75, 482, 5509, 100, 10, 1071, 371, 790, 6150,
      3321, 1045, 648, 5485, 1160, 1864, 4116)
duane.par1 <- duane(t)$rho
duane.par2 <- duane(t)$theta

lit.par1 <- littlewood.verall(t, linear = TRUE)$theta0
lit.par2 <- littlewood.verall(t, linear = TRUE)$theta1
lit.par3 <- littlewood.verall(t, linear = TRUE)$theta0

mor.par1 <- moranda.geometric(t)$D
mor.par2 <- moranda.geometric(t)$theta

musa.par1 <- musa.okumoto(t)$theta0
musa.par2 <- musa.okumoto(t)$theta1

total.plot(duane.par1, duane.par2, lit.par1, lit.par2, lit.par3, mor.par1,
mor.par2, musa.par1, musa.par2, t, linear = TRUE,
xlab = "time (in seconds)", main = "all models")
```
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