# Package ‘weibull4’

January 25, 2021

**Type** Package  
**Title** Fits Data into 4-Parameters Weibull Distribution  
**Version** 1.0.0  
**Author** Vitor Hugo Moreau  
**Maintainer** Vitor Hugo Moreau &lt;vitorhmc@ufba.br&gt;  
**Description** Performs a curve fit to 4-parameters Weibull distribution using Metropolis algorithm - Markov chain-Monte Carlo method. Special usage for fitting COVID-19 epidemic data on daily new cases and deaths. Also, builds the 4-parameters Weibull distribution curve using given parameters (shape, scale, location and area).  
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Brazil_COVID

Brazil’s COVID-19 number of daily new cases and deaths

Description

Dataset for weibull4 package. This dataset contain the number of the Brazil’s new daily cases and deaths for COVID-19 to be fitted to the 4-parameters Weibull distribution in weibull4 package.

Usage

data("Brazil_COVID")

Format

A data frame with 349 observations on the following 3 variables.

date  Brazil_COVID$date
new_cases  Brazil_COVID$new_cases
new_deaths  Brazil_COVID$new_deaths

Details

x values are in Date format. So, xmax must be as.Date() too.

Source

"https://covid.ourworldindata.org/data/owid-covid-data.csv"

References


Examples

data(Brazil_COVID)
## maybe str(Brazil_COVID) ; plot(Brazil_COVID) ...
**Description**

Dataset for weibull4 package. This dataset contain the number of the Canada’s new daily cases and deaths for COVID-19 to be fitted to the 4-parameters Weibull distribution in weibull4 package.

**Usage**

```r
data("Canada_COVID")
```

**Format**

A data frame with 349 observations on the following 3 variables.

```r
date  Canada_COVID$date
ew_cases  Canada_COVID$new_cases
new_deaths  Canada_COVID$new_deaths
```

**Details**

x values are in Date format. So, xmax must be as.Date() too.

**Source**

"https://covid.ourworldindata.org/data/owid-covid-data.csv"

**References**


**Examples**

```r
data(Canada_COVID)
## maybe str(Canada_COVID) ; plot(Canada_COVID) ...
```
Calculates the Log Likelihood

Description

Likelihood is an Internal Function of the Weibull4 Package

Usage

likelihood(x, y, param, modes)

Arguments

x Vector with the x values
y Vector with the y values
param Vector with shape, scale, location, area and SD parameters for calculating the log of Likelihood for the weibull4 package
modes Sets unimodal (modes=1) or bimodal (modes=2) Weibull’s distribution

Value

Unitary vector with the sum of the likelihood

Author(s)

Florian Hartig - Theoretical Ecology

References


Examples

function (param)
{
  shape <- param[1]
  scale <- param[2]
  loc <- param[3]
  area <- param[4]
  sd <- param[5]
  pred <- weibull4(xi, shape, scale, loc, area)
  singlelikelihoods <- dnorm(yi, mean = pred, sd = sd, log = T)
  sumll <- sum(singlelikelihoods, na.rm = T)
  return(sumll)
}
**posterior**

Calculates the posterior distribution for Metropolis-MCMC

**Description**

This is an internal function of the weibull4 package.

**Usage**

`posterior(x, y, param, modes)`

**Arguments**

- **x**: Vector with the x values
- **y**: Vector with the y values
- **param**: Vector containing shape, scale, location, area and SD parameters
- **modes**: Sets unimodal (modes=1) or bimodal (modes=2) Weibull’s distribution

**Value**

Vector containing the posterior distribution for Metropolis-MCMC

**Author(s)**

Florian Hartig - Theoretical Ecology

**References**


**Examples**

```r
function (param)
{
  return(likelihood(param) + prior(param))
}
```
prior  

Calculates the Prior Distribution for Metropolis-MCMC

Description
This is an internal function of the Weibull4 package

Usage
prior(param)

Arguments
param  A vector with shape, scale, location, area and SD parameters

Value
A vector with prior distribution for Metropolis-MCMC

Author(s)
Florian Hartig - Theoretical Ecology

References

Examples
function (param)
{
  shape <- param[1]
  scale <- param[2]
  loc <- param[3]
  area <- param[4]
  sd <- param[5]
  shapeprior <- dunif(shape, min = 1, max = 5, log = T)
  scaleprior <- dnorm(scale, sd = scale/2, log = T)
  locprior <- dunif(loc, min = 1, max = loc * 2, log = T)
  areaprior <- dunif(area, min = area/2, max = area * 2, log = T)
  sdprior <- dunif(sd, min = 1, max = sd * 2, log = T)
  return(shapeprior + scaleprior + locprior + areaprior + sdprior)
}
**Proposal Distribution for Metropolis-MCMC**

**Description**

This is an internal function of the weibull4 package.

**Usage**

proposalfunction(param)

**Arguments**

param Vector containing shape, scale, location, area and SD parameters

**Value**

Vector containing proposal values for shape, scale, location, area and SD

**Author(s)**

Florian Hartig - Theoretical Ecology

**References**


**Examples**

function (param)  
{  
  return(rnorm(5, mean = param, sd = param * 0.015))  
}

**Run Metropolis-MCMC**

Runs the Metropolis-MCMC algorithm for weibull4 package

**Description**

This is an internal function of the weibull4 package.

**Usage**

run_metropolis_MCMC(x, y, startvalue, iterations, modes)
Arguments

x Vector with the x values
y Vector with the y values
startvalue Vector with starting shape, scale, location, area and SD values for Metropolis-MCMC calculations
iterations Number of iterations to be performed in MCMC simulation
modes Sets unimodal (modes=1) or bimodal (modes=2) Weibull’s distribution

Value

Matrix with 5 columns and iterations rows with Markov chains for shape, scale, location, area and SD parameters

Author(s)

Florian Hartig - Theoretical Ecology

References


Examples

function (startvalue, iterations)
{
  chain <- array(dim = c(iterations + 1, 5))
  chain[1, ] <- startvalue
  for (i in 1:iterations) {
    proposal <- proposalfunction(chain[i, ])
    probab <- exp(posterior(proposal) - posterior(chain[i, ]))
    if (runif(1) < probab) {
      chain[i + 1, ] <- proposal
    } else {
      chain[i + 1, ] <- chain[i, ]
    }
  }
  return(chain)
}
Description

Dataset for weibull4 package. This dataset contain the number of the US' new daily cases of COVID-19 to be fitted to the 4-parameters Weibull distribution in weibull4 package with modes=2, in order to fit to the second wave of COVID-19 infections.

Usage

data("US_COVID")

Format

A data frame with 336 observations on the following 2 variables.

- date  US_COVID$date
- new_cases  US_COVID$new_cases
- new_deaths  US_COVID$new_deaths

Details

x values are in Date format. So, xmax must be as.Date()

Source

"https://covid.ourworldindata.org/data/owid-covid-data.csv"

References


Examples

data(US_COVID)
## maybe str(US_COVID) ; plot(US_COVID) ...
weibull4  

**non-linear regression data fitter to the 4-parameters Weibull distribution**

**Description**

Input script for using the weibull4 module. Weibull4 fit data from daily new cases and deaths of an epidemic peak. It was firstly designed to model data from COVID-19

**Usage**

```
weibull4(x, y, shape=NA, scale=NA, loc=NA, area=NA, shape2=NA, scale2=NA, loc2=NA, area2=NA, iter=1000, xmax=0, modes=1, modes2=1, split=NA)
```

**Arguments**

<table>
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<tr>
<th>x</th>
<th>y</th>
<th>shape</th>
<th>scale</th>
<th>loc</th>
<th>area</th>
<th>shape2</th>
<th>scale2</th>
<th>loc2</th>
<th>area2</th>
<th>iter</th>
<th>xmax</th>
<th>modes</th>
<th>modes2</th>
<th>split</th>
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</table>
| Vector: time data (may be date/time or numeric)| Vector: observed/measure event| Starting value for Weibull’s shape parameters. If it is NA, weibull4.fit will try to calculate it from x and y data.| Starting value for Weibull’s scale parameters. If it is NA, weibull4.fit will try to calculate it from x and y data.| Starting value for Weibull’s location parameters. If it is NA, weibull4.fit will try to calculate it from x and y data.| Starting value for Weibull’s area parameters or the area under the PDF curve. If it is NA, weibull4.fit will try to calculate it from x and y data.| Starting value for the shape parameters of the second mode of the Weibull’s distribution. If it is NA, weibull4.fit will try to calculate it from x and y data. It works only if modes=2.| Starting value for the scale parameters of the second mode of the Weibull’s distribution. If it is NA, weibull4.fit will try to calculate it from x and y data. It works only if modes=2.| Starting value for the location parameters of the second mode of the Weibull’s distribution. If it is NA, weibull4.fit will try to calculate it from x and y data. It works only if modes=2.| Starting value for the area parameters of the second mode of the Weibull’s distribution. If it is NA, weibull4.fit will try to calculate it from x and y data. It works only if modes=2.| Number of iterations to perform Metropolis-MCMC.| The date (x axis) in which the data will be split to be calculated by two distinct distribution. This option was implemented to fit data from the second wave of infections and deaths for COVID-19. With split set, it is possible to analyze curve pattern with up to 4 waves of infection, since both modes and modes2 are set to 2. In this case, the data will be analyzed as two bimodal Weibull distribution.
weibull4

modes
Sets whether data before the split date (if the split is not NA) may be fit with unimodal or bimodal Weibull distribution. If split is not set, modes is the number of modes of the unique distribution to be used. This option was implemented to fit data from the second wave of infections and deaths for COVID-19. Use modes=1 for unimodal distribution (single peak) and modes=2 for bimodal distribution (two peaks, with no or small valley between them).

modes2
Sets whether data after the split date (if split is not NA) may be fit with unimodal or bimodal Weibull distribution. If split is not set, modes2 will not be used. This option was implemented to fit data from the second wave of infections and deaths for COVID-19. Use modes=1 for unimodal distribution (single peak) and modes=2 for bimodal distribution (two peaks).

xmax
Forecast date to be calculated after x data. It must be in the same format than x.

Details
This package was specially built to fit COVID-19 data on the number of daily new cases and deaths in countries. So x must be integer. Alternatively, Date format is allowed.

Value
LIST containing:

Fit data
Matrix with x and y fitted data

Estimates
Matrix containing shape, scale, location, area and SD of the MEtropolis-MCMC in the row 1; and standard deviation for each parameter in the row 2

Markov chains
Matrix containing the Markov chains for shape, scale, location, area and SD parameters

Warning
This package is a secondary product of the referred science paper. Please, note that there is no warrants or professional support on its use.

Note
Comments, suggestions and doubts must be sent to vitorhmc@ufba.br

Author(s)
Vitor Hugo Moreau, Ph.D.

References
Examples

## Perform non-linear curve fitting with US' data for daily new deaths of COVID-19, with split date
## on Aug, 15th, bimodal distribution before and unimodal distribution after the split date.
## Examples below are with low number of iterations (1000), because of CRAN rules limitations.
## They will possibly give poor results. For best results set iter=10000.
fit <- weibull4(US_COVID$date, US_COVID$new_deaths, split=as.Date("2020-09-15"),
   modes=2, modes2=1, iter=1000)
plot(US.COVID$date, US.COVID$new_deaths, ylab="US' daily new deaths", xlab="Date")
lines(fit[[1]][,1], fit[[1]][,2], col="red")

## Perform non-linear curve fitting with Canada's data for daily new cases of COVID-19 using two
## unimodal Weibull distribution, with split date on Aug, 1st
fit <- weibull4(Canada_COVID$date, Canada_COVID$new_cases, split=as.Date("2020-08-01"),
   modes=1, modes2=1, iter=1000)
plot(Canada_COVID$date, Canada_COVID$new_cases, ylab="Canada's daily new cases", xlab="Date")
lines(fit[[1]][,1], fit[[1]][,2], col="red")

## Perform non-linear curve fitting with Brazil's data for daily new deaths of COVID-19 using a
## single bimodal Weibull distribution
fit <- weibull4(Brazil_COVID$date, Brazil_COVID$new_deaths, modes=2, iter=1000)
plot(Brazil_COVID$date, Brazil_COVID$new_deaths, ylab="Brazil's daily new deaths", xlab="Date")
lines(fit[[1]][,1], fit[[1]][,2], col="red")

weibull4.build  

weibull 4-parameters distribution building function

Description

Builds data for a 4-parameters Weibull distribution of a given x data

Usage

weibull4.build(x=seq(0,1,length.out=10), shape=2.5, scale=1, loc=0, area=20,
   shape2=5, scale2=2, loc2=6, area2=1, modes=1)

Arguments

x  Vector: data range for calculation of the Weibull distribution. If it is NULL, it
   will be set to seq(0,1,0.01)
shape  Weibull's shape parameter
scale  Weibull’s scale parameter
loc  Weibull’s location parameter
area  Weibull’s area parameter: area under the PDF curve
shape2  second mode Weibull’s shape parameter. It works only if modes=2.
scale2  second mode Weibull’s scale parameter. It works only if modes=2.
loc2  second mode Weibull’s location parameter. It works only if modes=2.
area2  second mode Weibull’s area parameter. It works only if modes=2.
weibull4.build

modes

Sets whether data may be fit with unimodal or bimodal Weibull distribution. This option was implemented to fit data from the second wave of infections and deaths for COVID-19. Use modes=1 for unimodal distribution (single peak) and modes=2 for bimodal distribution (two peaks).

Details

This package was specially built to fit COVID-19 data on the number of daily new cases and deaths in countries. So x must be integer. Alternatively, Date format is allowed.

Value

Vector: f(x) Weibull distribution’s ordinate

Warning

This package is a secondary product of the referred science paper. Please, note that there is no warrants or professional support on its use.

Note

Comments, suggestions and doubts must be sent to vitorhmc@ufba.br

Author(s)

Vitor Hugo Moreau, Ph.D.

References


Examples

```r
## Build a 4-parameters Weibull distribution with given parameters
weibull4.build(seq(1,100,1), shape=2.5, scale=30, loc=10, area=1000, modes=1)
## Build and plot 4-parameters Weibull distribution with given parameters
plot(seq(1,100,1), weibull4.build(seq(1,100,1), 2, 30, 10, 1), type="l")
## Build and plot 4-parameters Weibull distribution with a time series in the abscissa
Date <- seq(Sys.Date(), as.Date("2022-12-31"),1)
plot(Date, weibull4.build(Date, 1.6, 100, 100, 100), type="l")
## Build and plot a bimodal, 4-parameters Weibull distribution with given parameters
weibull4.build(seq(1,100,1), shape=2.5, scale=30, loc=10, area=1000, shape2=2.5, scale2=60, loc2=40, area2=1000, modes=2)
```
weibull4.fit

Weibull 4-parameters Metropolis-MCMC non-linear curve fitting function

Description

Package to perform non-linear regression in data on the number of daily new cases and daily new deaths of COVID-19 and other epidemics to the 4-parameters Weibull distribution using Metropolis-Markov Chain-Monte Carlo Simulations (MCMC), as described in Moreau, 2021

Usage

weibull4.fit(x, y, shape=NA, scale=NA, loc=NA, area=NA, shape2=NA, scale2=NA, loc2=NA, area2=NA, iter=1000, xmax=0, modes=1)

Arguments

x Vector: time data (may be date/time or numeric)
y Vector: observed/measure event
shape Starting value for Weibull’s shape parameters. If it is NA, weibull4.fit will try to calculate it from x and y data.
scale Starting value for Weibull’s scale parameters. If it is NA, weibull4.fit will try to calculate it from x and y data.
loc Starting value for Weibull’s location parameters. If it is NA, weibull4.fit will try to calculate it from x and y data.
area Starting value for Weibull’s area parameters or the area under the PDF curve. If it is NA, weibull4.fit will try to calculate it from x and y data.
shape2 Starting value for the shape parameters of the second mode of the Weibull’s distribution. If it is NA, weibull4.fit will try to calculate it from x and y data. It works only if modes=2.
scale2 Starting value for the scale parameters of the second mode of the Weibull’s distribution. If it is NA, weibull4.fit will try to calculate it from x and y data. It works only if modes=2.
loc2 Starting value for the location parameters of the second mode of the Weibull’s distribution. If it is NA, weibull4.fit will try to calculate it from x and y data. It works only if modes=2.
area2 Starting value for the area parameters of the second mode of the Weibull’s distribution. If it is NA, weibull4.fit will try to calculate it from x and y data. It works only if modes=2.
iter Number of iterations to perform Metropolis-MCMC.
modes Sets whether data may be fit with unimodal or bimodal Weibull distribution. This option was implemented to fit data from the second wave of infections and deaths for COVID-19. Use modes=1 for unimodal distribution (single peak) and modes=2 for bimodal distribution (two peaks).
xmax Forecast date to be calculated after x data. It must be in the same format than x.
Details

This package was specially built to fit COVID-19 data on the number of daily new cases and deaths in countries. So x must be integer. Alternatively, Date format is allowed.

Value

LIST containing:

- **Fit data**: Matrix with x and y fitted data
- **Estimates**: Matrix containing shape, scale, location, area and SD of the MCMC in the row 1; and standard deviation for each parameter in the row 2
- **Markov chains**: Matrix containing the Markov chains for shape, scale, location, area and SD parameters

Warning

This package is a secondary product of the referred science paper. Please, note that there is no warrants or professional support on its use.

Note

Comments, suggestions and doubts must be sent to vitorhmc@ufba.br

Author(s)

Vitor Hugo Moreau, Ph.D.

References


Examples

```r
## Perform non-linear curve fitting with World's data for daily new deaths
## of COVID-19
## Examples below are with low number of iterations (1000), because of CRAN rules limitations.
## They will possibly give poor results. For best results set iter=10000.
fit <- weibull4(US_COVID$date, US_COVID$new_deaths, iter=1000)
plot(US_COVID$date, US_COVID$new_deaths, ylab="US' daily new deaths", xlab="Date")
lines(fit[,1], fit[,2], col="red")

## Perform non-linear curve fitting with Canada's data for daily new cases of
## COVID-19 using two unimodal Weibull distribution, with split date on Aug, ## 1st
fit <- weibull4(Canada_COVID$date, Canada_COVID$new_cases, modes=1, iter=1000)
plot(Canada_COVID$date, Canada_COVID$new_cases, ylab="Canada's daily new cases", xlab="Date")
lines(fit[,1], fit[,2], col="red")

## Perform non-linear curve fitting with Brazil's data for daily new deaths of
## COVID-19 using a single bimodal Weibull distribution
```
fit <- weibull4(Brazil_COVID$date, Brazil_COVID$new_deaths, modes=2, iter=1000)
plot(Brazil_COVID$date, Brazil_COVID$new_deaths, ylab="Brazil’s daily new deaths", xlab="Date")
lines(fit[[1]][,1], fit[[1]][,2], col="red")
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