

Package ‘retimes’

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density-estim

*Density Estimators***Description**

Functions to identify the peak of a probability density distribution using a Gaussian kernel estimator (`kernestim`), a fixed-width histogram estimator (`histestim`), and a distance density estimator (`distestim`).

Usage

```
kernestim(x, smoothing = NULL)
histestim(x, smoothing = NULL)
distestim(x, smoothing = NULL)
```

Arguments

<code>x</code>	Vector of data.
<code>smoothing</code>	Smoothing parameter, also named bandwidth. If the argument is defined as <code>NULL</code> , the smoothing parameter will be calculated from the data (see details).

Details

The functions `kernestim` and `histestim` implement two well-known methods to estimate the density of an empirical distribution (see Van Zandt, 2000, for their application in RT analysis). The functions can be used to find the value corresponding to the peak of an empirical distribution.

The function `kernestim` center a Gaussian density over each observation and identifies the value with the greater density.

The function `histestim` divides the data in bins, starting from the lower to the higher value of data. The function searches the bin with the higher data frequency. The peak of the distribution is identified calculating the mean of the data into the bin.

The function `distestim` is an experimental method which mixes the two previous techniques. Around each data point (pivot), an interval $[x_i - h/2, x_i + h/2]$ is built, where h is the smoothing parameter. The function searches the interval (bin) with the higher data frequency. The output value is the weighted average of the values into the selected bin, in which each observation is weighted on the basis of the distance from the pivot. If bins with equal densities are found, the bin presenting the smallest deviance from the pivot is chosen.

For the Gaussian kernel estimator, the smoothing parameter is calculated using the Silverman's method (Silverman, 1986). Differently, using histogram and distance estimators, the smoothing parameter is calculated as: $(Q_{0.975} - Q_{0.025})/\sqrt{n}$, where Q_p are the quantiles for $\alpha = 0.05$ and n is the sample dimension.

Value

The value at which the peak of density is located.

Author(s)

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References

Silverman, B. W. (1986). Density estimation for statistics and data analysis. London: Chapman & Hall.

Parzen, E. (1962). On estimation of a probability density function and mode. *Annals of Mathematical Statistics*, 33(3), 1065-1076.

Van Zandt, T. (2000). How to fit a response time distribution. *Psychonomic Bulletin & Review*, 7(3), 424-465.

Examples

```
x <- rexgauss(1000, mu=500, sigma=100, tau=250)
k <- kernestim(x); k
h <- histestim(x); h
d <- distestim(x); d
plot(density(x))
segments(k,0,k,1,col="red")
segments(h,0,h,1,col="blue")
segments(d,0,d,1,col="green")
```

exgauss

Ex-Gaussian Distribution

Description

Density function, parameter estimation by moments and random variable generation for the ex-Gaussian distribution.

Usage

```
dexgauss(q, mu = 0, sigma = 1, tau = 1)
mexgauss(x, n = length(x))
rexgauss(n, mu = 0, sigma = 1, tau = 1, positive = TRUE)
```

Arguments

x,q	Vector of reaction times.
n	Number of observations.
mu,sigma,tau	Parameters of the ex-Gaussian distribution.
positive	Logical: imposes the generation of a vector containing only positive values.

Details

The function `mexgauss` implements the method of moments to estimate the parameters of an ex-Gaussian distribution as described by Heathcote (1996).

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References

Heathcote, A. (1996). RTSYS: A DOS application for the analysis of reaction time data. *Behavior Research Methods, Instruments, & Computers*, 28(3), 427-445.

Luce, R. D. (1986). *Response times: their role in inferring elementary mental organization*. New York: Oxford University Press.

See Also

[timefit](#)

Examples

```
# Vector of reaction times from Heathcote (1996):
RT <- c(474.688, 506.445, 524.081, 530.672, 530.869,
        566.984, 582.311, 582.940, 603.574, 792.358)
mexgauss(RT)
```

skew

Skewness Index

Description

Calculate the skewness index of an empirical distribution.

Usage

```
skew(x)
```

Arguments

x Vector of data.

Details

The skewness measures the asymmetry of a probability distribution. If a positive skewness identifies a greater right tail, a negative skewness is symptom of a greater left tail of the distribution.

The skewness is calculated as: $k_3/k_2^{1.5}$, where k_2 and k_3 are respectively the second and the third moment of the distribution.

Value

The skewness index.

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Examples

```
# Vector of reaction times from Heathcote (1996):
RT <- c(474.688, 506.445, 524.081, 530.672, 530.869,
        566.984, 582.311, 582.940, 603.574, 792.358)
skew(RT)
```

timefit

Analyzing Reaction Times

Description

Parameter estimation for reaction time distributions using the maximum likelihood method. Currently, the function works only for the ex-Gaussian probability distribution.

Usage

```
timefit(x, iter = 0, size = length(x), replace = TRUE,
        plot = FALSE, start = NULL, ...)
```

Arguments

<code>x</code>	Vector of reaction times, in milliseconds or seconds.
<code>iter</code>	if <code>iter > 0</code> , the estimation is performed by bootstrap resampling. For each iteration, a sub-sample with a positive skewness will be extracted from the original sample, and distribution parameters will be estimated on resampled data.
<code>size</code>	Sample dimension to use in resampling, when the bootstrap is active.
<code>replace</code>	Logical: specifies if the resampling must be performed with replacement.
<code>plot</code>	Logical: if TRUE, it shows the data distribution (continuous line) and the estimated distribution (dashed line). Furthermore, when the bootstrap is used, the histogram of each parameter distribution is shown.
<code>start</code>	Vector containing starting values (in order: <i>mu</i> , <i>sigma</i> and <i>tau</i>) for the optimization routine. As default, the method of moments is used to estimate initial parameters. If the bootstrap is active, the argument will be ignored (starting values will be calculated on each bootstrapped sample using the method of moments).
<code>...</code>	Further arguments for the optimization routine. Arguments will be passed to the <code>optim</code> function: see the <code>optim</code> documentation for further details.

Details

The function `timefit` estimates ex-Gaussian parameters by maximum likelihood, using the `optim` function. As default, the Simplex method (Nelder-Mead) is applied to find the minimum of the objective function.

The function implements a bootstrap approach to identify distribution parameters. The bootstrap is useful especially working on small samples. The implemented method identifies μ and σ using a gaussian kernel estimator (see Van Zandt, 2000, for details). Since small samples often present problems of convergence for σ , for this parameter only the values included a theoretical plausible range are considered. This range is defined by:

$$\sqrt{\frac{\min(x - M)^2}{n - 1}} \leq \sigma \leq S$$

where M and S are respectively the mean and the standard deviation of data. When μ and σ are identified, τ is chosen within the bootstrapped values, according to the maximum likelihood criterion.

Value

An object of class `timefit`. The operator `@` should be used to extract the values from the slots of the output object.

- `@x`: vector of data.
- `@samples`: bootstrapped samples.
- `@par`: estimated parameters.
- `@bootPar`: bootstrapped parameters.
- `@bootValue`: log-likelihood of bootstrapped parameters.
- `@sigmaValid`: not rejected (TRUE) and rejected (FALSE) values for σ .
- `@start`: starting values.
- `@logLik`: log-likelihood of estimated parameters.
- `@AIC`: Akaike Information Criterion.
- `@BIC`: Bayesian Information Criterion.

Note

The methods `plot`, `logLik`, `AIC` and `BIC` are available.

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References

- Cousineau, D., Brown, S. & Heathcote, A. (2004). Fitting distributions using maximum likelihood: Methods and packages. *Behavior Research Methods, Instruments, & Computers*, 36(4), 742-756.
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- Lacouture, Y., & Cousineau, D. (2008). How to use MATLAB to fit the ex-Gaussian and other probability functions to a distribution of response times. *Tutorials in Quantitative Methods for Psychology*, 4(1), 35-45.
- Luce, R. D. (1986). *Response times: their role in inferring elementary mental organization*. New York: Oxford University Press.
- Ratcliff, R. (1978). A theory of memory retrieval. *Psychological Review*, 85(2), 59-108.
- Ratcliff, R. (1979). Group Reaction Time Distributions and an Analysis of Distribution Statistics. *Psychological Bulletin*, 86(3), 446-461.
- Ratcliff, R. & Murdock Jr., B. B. (1976). Retrieval Processes in Recognition Memory. *Psychological Review*, 83(3), 190-214.
- Van Zandt, T. (2000). How to fit a response time distribution. *Psychonomic Bulletin & Review*, 7(3), 424-465.
- Van Zandt, T.(2002). Analysis of response time distributions. In J. T. Wixted (Vol. Ed.) & H. Pashler (Series Ed.): *Stevens' Handbook of Experimental Psychology (3rd Edition)*, Volume 4: *Methodology in Experimental Psychology* (pp. 461-516). New York: Wiley Press.

See Also

[exgauss](#), [density-estim](#), [skew](#)

Examples

```
## Not run:

# Vector of reaction times from Heathcote (1996):
RT <- c(474.688, 506.445, 524.081, 530.672, 530.869,
        566.984, 582.311, 582.940, 603.574, 792.358)
RTfit <- timefit(RT); RTfit

# Bootstrap tesing with simulated data (m=500, s=100, t=250):

x1 <- c(451.536,958.612,563.538,505.735,1266.825,
        860.663,457.707,268.679,587.303,669.594)
fit1a <- timefit(x1); fit1a
fit1b <- timefit(x1, iter=1000); fit1b

x2 <- c(532.474,525.185,1499.471,480.732,631.752,
        672.419,322.341,571.356,428.832,680.848)
fit2a <- timefit(x2, plot=TRUE); fit2a
fit2b <- timefit(x2, iter=1000, plot=TRUE); fit2b

## End(Not run)
```

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