

# Package ‘GLDEX’

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**Title** Fitting Single and Mixture of Generalised Lambda Distributions  
(RS and FMKL) using Various Methods

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**Depends** cluster, grDevices, graphics, stats

**Description** The fitting algorithms considered in this package have two major objectives. One is to provide a smoothing device to fit distributions to data using the weight and unweighted discretised approach based on the bin width of the histogram. The other is to provide a definitive fit to the data set using the maximum likelihood and quantile matching estimation. Other methods such as moment matching, starship method, L moment matching are also provided. Diagnostics on goodness of fit can be done via qqplots, KS-resample tests and comparing mean, variance, skewness and kurtosis of the data with the fitted distribution.

**License** GPL (>= 3)

**NeedsCompilation** yes

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GLDEX-package	<i>This package fits RS and FMKL generalised lambda distributions using various methods. It also provides functions for fitting bimodal distributions using mixtures of generalised lambda distributions.</i>
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## Description

The fitting algorithms considered in this package have two major objectives. One is to provide a smoothing device to fit distributions to data using the weight and unweighted discretised approach based on the bin width of the histogram. The other is to provide a definitive fit to the data set using the maximum likelihood estimation.

Copyright Information: To ensure the stability of this package, this package ports other functions from other open sourced packages directly so that any changes in other packages will not cause this package to malfunction.

All functions obtained from other sources have been acknowledged by the author in the authorship or the description sections of the help files and they are freely available online for all to use. Please contact the author for any copyright issues.

Specifically the following functions have been modified from R:

hist.su, ks.gof, pretty.su

The following functions are taken from other open source packages in R:

runif.pseudo, rnorm.pseudo, runif.halton, rnorm.halton, runif.sobol, rnorm.sobol by Diethelm Wuertz distributed under GPL.

digitsBase, QUnif and sHalton written by Martin Maechler distributed under GPL.

dgl, pgl, rgl, qgl, starship.adaptivegrid, starship.obj and starship written by Robert King and some functions modified by Steve Su distributed under GPL.

Lmoments and t1lmoments written by Juha Karvanen distributed under GPL.

## Details

Package: GLDEX  
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This package allows a direct fitting method onto the data set using `fun.RMFMKL.ml`, `fun.RMFMKL.ml.m`, `fun.RMFMKL.hs`, `fun.RMFMKL.hs.nw`, `fun.RPRS.ml`, `fun.RPRS.ml.m`, `fun.RPRS.hs`, `fun.RPRS.hs.nw`, `fun.RMFMKL.qs`, `fun.RPRS.qs`, `fun.RMFMKL.mm`, `fun.RPRS.mm`, `fun.RMFMKL.lm`, `fun.RPRS.lm` and in the case of bimodal data set: `fun.auto.bimodal.qs`, `fun.auto.bimodal.ml`, `fun.auto.bimodal.pml` functions. The resulting fits can be graphically gauged by `fun.plot.fit` or `fun.plot.fit.bm` (for bimodal data), or examined by numbers using the Kolmogorov-Smirnoff resample tests (`fun.diag.ks.g`) and `fun.diag.ks.g.bimodal`). For unimodal data fits, it is also possible to compare the mean, variance, skewness and kurtosis of the fitted distribution with the data set using `fun.comp.moments.ml` and `fun.comp.moments.ml.2` functions. Similarly, for bimodal data fits, this is done via `fun.theo.bi.mv.gld` and `fun.moments.r`. Additionally, L moments for single generalised lambda distribution can be obtained using `fun.lm.theo.gld`. For graphical display of goodness of fit, quantile plots can be used, these can be done using `qqplot.gld` and `qqplot.gld.bi` for univariate and bimodal generalised lambda distribution fits respectively.

## Author(s)

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Su, S. (2014) "Flexible Parametric Quantile Regression Model" *Statistics & Computing*

### See Also

**GLDreg** package in R for GLD regression models.

### Examples

```
#### Univariate distributions example:

set.seed(1000)

junk<-rweibull(300,3,2)

### A faster ML estimation

# junk.fit1<-fun.RFMKL.ml.m(junk)
# junk.fit2<-fun.RPRS.ml.m(junk)

# qqplot.gld(junk.fit1,data=junk,param="fml")
# qqplot.gld(junk.fit2,data=junk,param="rs")

### Using discretised approach, with 50 classes

## Using discretised method with weights
# obj.fit1.hs<-fun.data.fit.hs(junk)

## Plot the resulting fit. The fun.plot.fit function also works for singular fits
## such as those by fun.plot.fit(obj.fit1.ml,junk,nclass=50,
## param=c("rs","fml","fml"),xlab="x")

# fun.plot.fit(obj.fit1.hs,junk,nclass=50,param=c("rs","fml"),xlab="x")

## Compare the mean, variance, skewness and kurtosis of the fitted distribution
## with actual data
```

```

# fun.theo.mv.gld(obj.fit1.hs[1,1],obj.fit1.hs[2,1],obj.fit1.hs[3,1],
# obj.fit1.hs[4,1],param="rs")
# fun.theo.mv.gld(obj.fit1.hs[1,2],obj.fit1.hs[2,2],obj.fit1.hs[3,2],
# obj.fit1.hs[4,2],param="fmk1")
# fun.moments.r(junk)

## Conduct resample KS tests
# fun.diag.ks.g(obj.fit1.hs[,1],junk,param="rs")
# fun.diag.ks.g(obj.fit1.hs[,2],junk,param="fmk1")

### Try another fit, say 15 classes

# obj.fit2.hs<-fun.data.fit.hs(junk,rs.default="N",fmk1.default="N",no.c.rs = 15,
# no.c.fmk1 = 15)

# fun.plot.fit(obj.fit2.hs,junk,nclass=50,param=c("rs","fmk1"),xlab="x")

# fun.theo.mv.gld(obj.fit2.hs[1,1],obj.fit2.hs[2,1],obj.fit2.hs[3,1],
# obj.fit2.hs[4,1],param="rs")
# fun.theo.mv.gld(obj.fit2.hs[1,2],obj.fit2.hs[2,2],obj.fit2.hs[3,2],
# obj.fit2.hs[4,2],param="fmk1")
# fun.moments.r(junk)

# fun.diag.ks.g(obj.fit2.hs[,1],junk,param="rs")
# fun.diag.ks.g(obj.fit2.hs[,2],junk,param="fmk1")

### Uses the maximum likelihood estimation method

## Fit the function using fun.data.fit.ml
# obj.fit1.ml<-fun.data.fit.ml(junk)

## Plot the resulting fit
# fun.plot.fit(obj.fit1.ml,junk,nclass=50,param=c("rs","fmk1","fmk1"),xlab="x",
# name=".ML")

## Compare the mean, variance, skewness and kurtosis of the fitted distribution
## with actual data
# fun.comp.moments.ml(obj.fit1.ml,junk)

## Do a quantile plot

# qqplot.gld(junk,obj.fit1.ml[,1],param="rs",name="RS ML fit")

## Run a KS resample test on the resulting fit

# fun.diag2(obj.fit1.ml,junk,1000)

## It is possible to use say fun.data.fit.ml(junk,rs.leap=409,fmk1.leap=409,
## FUN="QUnif") to find solution under a different set of low discrepancy number
## generators.

#### Bimodal distributions example:

```

```

## Fitting mixture of generalised lambda distributions on the data set using both
## the maximum likelihood and partition maximum likelihood and plot the resulting
## fits

# par(mfrow=c(2,1))

# junk<-fun.auto.bimodal.ml(faithful[,1],per.of.mix=0.01,clustering.m=clara,
# init1.sel="rprs",init2.sel="rmfml",init1=c(-1.5,1.5),init2=c(-0.25,1.5),
# leap1=3,leap2=3)
# fun.plot.fit.bm(nclass=50,fit.obj=junk,data=faithful[,1],
# name="Maximum likelihood using",xlab="faithful1",param.vec=c("rs","fml"))

## Do a quantile plot

# qqplot.gld.bi(faithful[,1],junk$par,param1="rs",param2="fml",
# name="RS FMKL ML fit",range=c(0.001,0.999))

# junk<-fun.auto.bimodal.pml(faithful[,1],clustering.m=clara,init1.sel="rprs",
# init2.sel="rmfml",init1=c(-1.5,1.5),init2=c(-0.25,1.5),leap1=3,leap2=3)
# fun.plot.fit.bm(nclass=50,fit.obj=junk,data=faithful[,1],
# name="Partition maximum likelihood using",xlab="faithful1",
# param.vec=c("rs","fml"))

## Fit the faithful[,1] data from the dataset library using sobol sequence
## generator for the first distribution fit and halton sequence for the second
## distribution fit.

# fit1<-fun.auto.bimodal.ml(faithful[,1],init1.sel="rmfml",init2.sel="rmfml",
# init1=c(-0.25,1.5),init2=c(-0.25,1.5),leap1=3,leap2=3,fun1="runif.sobol",
# fun2="runif.halton")

## Run diagnostic KS tests

# fun.diag.ks.g.bimodal(fit1$par[1:4],fit1$par[5:8],prop1=fit1$par[9],
# data=faithful[,1],param1="fml",param2="fml")

## Find the theoretical moments of the fit

# fun.theo.bi.mv.gld(fit1$par[1],fit1$par[2],fit1$par[3],fit1$par[4],"fml",
# fit1$par[5],fit1$par[6],fit1$par[7],fit1$par[8],"fml",fit1$par[9])

## Compare this with the empirical moments from the data set.

# fun.moments.r(faithful[,1])

## Do a quantile plot

# qqplot.gld.bi(faithful[,1],fit1$par,param1="fml",param2="fml",
# name="FMKL FMKL ML fit")

## Quantile matching method

```

```

## Fitting faithful data from the dataset library, with the clara clustering
## regime. The first distribution is RS and the second distribution is fmk1.
## The percentage of data mix is 1%.

## Fitting normal(3,2) distribution using the default setting
# junk<-rnorm(50,3,2)
# fun.data.fit.qs(junk)

# fun.auto.bimodal.qs(faithful[,1],per.of.mix=0.01,clustering.m=clara,
# init1.sel="rprs",init2.sel="rmfmkl",init1=c(-1.5,1,5),init2=c(-0.25,1.5),
# leap1=3,leap2=3)

# L Moment matching

## Fitting normal(3,2) distribution using the default setting
# junk<-rnorm(50,3,2)
# fun.data.fit.lm(junk)

# Moment matching method

## Fitting normal(3,2) distribution using the default setting
# junk<-rnorm(50,3,2)
# fun.data.fit.mm(junk)

# Example on fitting mixture of normal distributions

#data1<-c(rnorm(1500,-1,2/3),rnorm(1500,1,2/3))

#junk<-fun.auto.bimodal.ml(data1,per.of.mix=0.01,clustering.m=data1>0,
#init1.sel="rprs",init2.sel="rmfmkl",init1=c(-1.5,1.5),init2=c(-0.25,1.5),
#leap1=3,leap2=3)

#fun.plot.fit.bm(nclass=50,fit.obj=junk,data=data1,
#name="Maximum likelihood using",xlab="faithful1",param.vec=c("rs","fmkl"))

#qqplot.gld.bi(data1,junk$par,param1="rs",param2="fmkl",
#name="RS FMKL ML fit",range=c(0.001,0.999))

# Generate random observations from FMKL generalised lambda distributions with
# parameters (1,2,3,4) and (4,3,2,1) with 50% of data from each distribution.
fun.simu.bimodal(c(1,2,3,4),c(4,3,2,1),prop1=0.5,param1="fmkl",param2="fmkl")

```

## Description

Integer number representations in other Bases.

Formally, for every element  $N = x[i]$ , compute the (vector of) “digits”  $A$  of the base  $b$  representation of the number  $N$ ,  $N = \sum_{k=0}^M A_{M-k} b^k$ .

Revert such a representation to integers.



**Usage**

```
digitsBase(x, base = 2, ndigits = 1 + floor(log(max(x), base)))
```

**Arguments**

x	For <code>digitsBase()</code> : non-negative integer (vector) whose base base digits are wanted. For <code>as.intBase()</code> : a list of numeric vectors, a character vector, or an integer matrix as returned by <code>digitsBase()</code> , representing digits in base base.
base	integer, at least 2 specifying the base for representation.
ndigits	number of bits/digits to use.
...	potential further arguments passed to methods, notably <code>print</code> .

**Value**

For `digitsBase()`, an object, say `m`, of class "basedInt" which is basically a (ndigits x n) `matrix` where `m[,i]` corresponds to `x[i]`, `n <- length(x)` and `attr(m, "base")` is the input base. `as.intBase()` and the `as.integer` method for `basedInt` objects return an `integer` vector.

**Note**

`digits` and `digits.v` are now deprecated and will be removed from the `sfsmisc` package.

**Author(s)**

Martin Maechler, Dec 4, 1991 (for S-plus; then called `digits.v`).

**Examples**

```
digitsBase(0:12, 8) #-- octal representation

## This may be handy for just one number (and default decimal):
digits <- function(n, base = 10) as.vector(digitsBase(n, base = base))
digits(128, base = 8) # 2 0 0

## one way of pretty printing (base <= 10!)
b2ch <- function(db)
  noquote(gsub("^0+({1,})$", " \\1", apply(db, 2, paste, collapse = "")))
b2ch(digitsBase(0:33, 2)) #-> 0 1 10 11 100 101 ... 100001
b2ch(digitsBase(0:33, 4)) #-> 0 1 2 3 10 11 12 13 20 ... 200 201

## Hexadecimal:
i <- c(1:20, 100:106)
M <- digitsBase(i, 16)
hexdig <- c(0:9, LETTERS[1:6])
cM <- hexdig[1 + M]; dim(cM) <- dim(M)
b2ch(cM) #-> 1 2 3 4 5 6 7 8 9 A B C D E F 10 11 ... 6A
```

---

fun.auto.bimodal.ml     *Fitting mixture of generalised lambda distributions to data using maximum likelihood estimation via the EM algorithm*

---

## Description

This function will fit mixture of generalised lambda distributions to dataset. It is restricted to two generalised lambda distributions. The method of fitting is maximum likelihood via EM algorithm. It is a two step optimization procedure, each unimodal part of the bimodal distribution is modelled using the maximum likelihood method or the starship method (FMKL GLD only), these initial values are the used to maximise the likelihood for the entire bimodal distribution using the EM algorithm. It fits mixture of the form  $p*(f1)+(1-p)*(f2)$  where f1 and f2 are pdfs of the generalised lambda distributions.

## Usage

```
fun.auto.bimodal.ml(data, per.of.mix = 0.01, clustering.m = clara,
  init1.sel = "rprs", init2.sel = "rprs", init1=c(-1.5, 1.5), init2=c(-1.5, 1.5),
  leap1=3, leap2=3, fun1="runif.sobol", fun2="runif.sobol", no=10000, max.it=5000,
  optim.further="Y")
```

## Arguments

data	A numerical vector representing the dataset.
per.of.mix	Level of mix between two parts of the distribution, usually 1-2% of cross mix is sufficient.
clustering.m	Clustering method used in classifying the dataset into two parts. Valid arguments include clara, fanny and pam from the cluster library. Default is clara. Or a logical vector specifying how data should be split.
init1.sel	This can be "rprs", "rmfml" or "star", the initial method used to fit the first distribution.
init2.sel	This can be "rprs", "rmfml" or "star", the initial method used to fit the second distribution.
init1	Initial values lambda3 and lambda4 for the first generalised lambda distribution.
init2	Initial values lambda3 and lambda4 for the second generalised lambda distribution.
leap1	Scrambling (0,1,2,3) for the sobol sequence for the first distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
leap2	Scrambling (0,1,2,3) for the sobol sequence for the second distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
fun1	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif" for the first distribution fit.

fun2	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif" for the second distribution fit.
no	Number of initial random values to find the best initial values for optimisation.
max.it	Maximum number of iterations for numerical optimisation.
optim.further	Whether to optimise the function further using full maximum likelihood method, recommended setting is "Y"

### Details

The initial values that work well for RPRS are  $c(-1.5, 1.5)$  and for RMFMKL are  $c(-0.25, 1.5)$ . For scrambling, if 1, 2 or 3 the sequence is scrambled otherwise not. If 1, Owen type type of scrambling is applied, if 2, Faure-Tezuka type of scrambling, is applied, and if 3, both Owen+Faure-Tezuka type of scrambling is applied. The star method uses the same initial values as rmfmkl since it uses the FMKL generalised lambda distribution. Nelder-Simplex algorithm is used in the numerical optimization. rprs stands for revised percentile method for RS generalised lambda distribution and "rmfmkl" stands for revised method of moment for FMKL generalised lambda distribution. These acronyms represents the initial optimization algorithm used to get a reasonable set of initial values for the subsequent optimization procedues. This function is an improvement from Su (2007) in Journal of Statistical Software.

### Value

par	The best set of parameters found, the first four corresponds to the first distribution fit, the second four corresponds to the second distribution fit, the last value correspond to p for the first distribution fit.
value	The value of -ML for the paramters obtained.
counts	A two-element integer vector giving the number of calls to fn and gr respectively. This excludes those calls needed to compute the Hessian, if requested, and any calls to fn to compute a finite-difference approximation to the gradient.
convergence	0 indicates successful convergence, 1 indicates the iteration limit maxit had been reached, 10 indicates degeneracy of the Nelder-Mead simplex.
message	A character string giving any additional information returned by the optimizer, or NULL.

### Note

If the number of observations is small, rprs can sometimes fail as the percentiles may not exist for this data. Also, if the initial values do not span a valid generalised lambda distribution, try another set of initial values.

### Author(s)

Steve Su

## References

Bratley P. and Fox B.L. (1988) Algorithm 659: Implementing Sobol's quasi random sequence generator, ACM Transactions on Mathematical Software 14, 88-100.

Joe S. and Kuo F.Y. (1998) Remark on Algorithm 659: Implementing Sobol's quasi random Sequence Generator.

Nelder, J. A. and Mead, R. (1965) A simplex algorithm for function minimization. Computer Journal \*7\*, 308-313.

Su (2007). Fitting Single and Mixture of Generalized Lambda Distributions to Data via Discretized and Maximum Likelihood Methods: GLDEX in R. Journal of Statistical Software: \*21\* 9.

## See Also

[fun.auto.bimodal.pml](#), [fun.plot.fit.bm](#), [fun.diag.ks.g.bimodal](#)

## Examples

```
## Fitting faithful data from the dataset library, with the clara clustering
## regime. The first distribution is RS and the second distribution is fmk1.
## The percentage of data mix is 1%.

# fun.auto.bimodal.ml(faithful[,1],per.of.mix=0.01,clustering.m=clara,
# init1.sel="rprs",init2.sel="rmfmkl",init1=c(-1.5,1,5),init2=c(-0.25,1,5),
# leap1=3,leap2=3)
```

---

fun.auto.bimodal.pml     *Fitting mixture of generalised lambda distributions to data using partition maximum likelihood estimation*

---

## Description

This function will fit mixture of generalised lambda distributions to dataset. It is restricted to two generalised lambda distributions. The method of fitting is partition maximum likelihood. It is a two step optimization procedure, each unimodal part of the bimodal distribution is modelled using the maximum likelihood method or the starship method (FMKL GLD only). These initial values are used to "maximise" the complete log likelihood for the entire bimodal distribution. It fits mixture of the form  $p*(f1)+(1-p)*(f2)$  where  $f1$  and  $f2$  are pdfs of the generalised lambda distributions.

## Usage

```
fun.auto.bimodal.pml(data, clustering.m = clara, init1.sel = "rprs",
init2.sel = "rprs", init1=c(-1.5, 1.5), init2=c(-1.5, 1.5), leap1=3, leap2=3,
fun1="runif.sobol", fun2="runif.sobol",no=10000,max.it=5000, optim.further="Y")
```

**Arguments**

data	A numerical vector representing the dataset.
clustering.m	Clustering method used in classifying the dataset into two parts. Valid arguments include clara, fanny and pam from the cluster library. Default is clara. Or a logical vector specifying how data should be split.
init1.sel	This can be "rprs", "rmfmkl" or "star", the initial method used to fit the first distribution.
init2.sel	This can be "rprs", "rmfmkl" or "star", the initial method used to fit the second distribution.
init1	Initial values lambda3 and lambda4 for the first generalised lambda distribution.
init2	Initial values lambda3 and lambda4 for the second generalised lambda distribution.
leap1	Scrambling (0,1,2,3) for the sobol sequence for the first distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
leap2	Scrambling (0,1,2,3) for the sobol sequence for the second distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
fun1	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif" for the first distribution fit.
fun2	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif" for the second distribution fit.
no	Number of initial random values to find the best initial values for optimisation.
max.it	Maximum number of iterations for numerical optimisation.
optim.further	Whether to optimise the function further using full maximum likelihood method, recommended setting is "Y"

**Details**

The initial values that work well for RPRS are  $c(-1.5, 1.5)$  and for RMFMKL are  $c(-0.25, 1.5)$ . For scrambling, if 1, 2 or 3 the sequence is scrambled otherwise not. If 1, Owen type type of scrambling is applied, if 2, Faure-Tezuka type of scrambling, is applied, and if 3, both Owen+Faure-Tezuka type of scrambling is applied. The star method uses the same initial values as rmfmkl since it uses the FMKL generalised lambda distribution. Nelder-Simplex algorithm is used in the numerical optimization. rprs stands for revised percentile method for RS generalised lambda distribution and "rmfmkl" stands for revised method of moment for FMKL generalised lambda distribution. These acronyms represents the initial optimization algorithm used to get a reasonable set of initial values for the subsequent optimization procedues. This function is an improvement from Su (2007) in Journal of Statistical Software.

**Value**

par	The best set of parameters found, the first four corresponds to the first distribution fit, the second four corresponds to the second distribution fit, the last value correspond to p for the first distribution fit.
-----	--

value	The value of -PML for the paramters obtained.
counts	A two-element integer vector giving the number of calls to "fn" and "gr" respectively. This excludes those calls needed to compute the Hessian, if requested, and any calls to 'fn' to compute a finite-difference approximation to the gradient.
convergence	0 indicates successful convergence, 1 indicates the iteration limit <code>maxit</code> had been reached, 10 indicates degeneracy of the Nelder-Mead simplex.
message	A character string giving any additional information returned by the optimizer, or NULL.

**Note**

If the number of observations is small, `rprs` can sometimes fail as the percentiles may not exist for this data. Also, if the initial values do not result in a valid generalised lambda distribution, try another set of initial values.

**References**

- Bratley P. and Fox B.L. (1988) Algorithm 659: Implementing Sobol's quasi random sequence generator, ACM Transactions on Mathematical Software 14, 88-100.
- Joe S. and Kuo F.Y. (1998) Remark on Algorithm 659: Implementing Sobol's quasi random Sequence Generator.
- Nelder, J. A. and Mead, R. (1965) A simplex algorithm for function minimization. Computer Journal \*7\*, 308-313.
- Su (2007). Fitting Single and Mixture of Generalized Lambda Distributions to Data via Discretized and Maximum Likelihood Methods: GLDEX in R. Journal of Statistical Software: \*21\* 9.

**See Also**

[fun.auto.bimodal.ml](#), [fun.plot.fit.bm](#), [fun.diag.ks.g.bimodal](#)

**Examples**

```
## Fitting faithful data from the dataset library, with the clara clustering
## regime. The first distribution is RS and the second distribution is fmk1.

# fun.auto.bimodal.pml(faithful[,1],clustering.m=clara,init1.sel="rprs",
# init2.sel="rmfmkl",init1=c(-1.5,1,5),init2=c(-0.25,1,5),leap1=3,leap2=3)
```

---

fun.auto.bimodal.qs     *Fitting mixtures of generalied lambda distribtions to data using quantile matching method*

---

## Description

This function will fit mixture of generalised lambda distributions to dataset. It is restricted to two generalised lambda distributions. The method of fitting is quantile matching method. It is a two step optimization procedure, each unimodal part of the bimodal distribution is modelled using quantile matching method. The initial values obtained are then used to maximise the theoretical and empirical quantile match for the entire bimodal distribution. It fits mixture of the form  $p*(f1)+(1-p)*(f2)$  where  $f1$  and  $f2$  are pdfs of the generalised lambda distributions.

## Usage

```
fun.auto.bimodal.qs(data, per.of.mix = 0.01, clustering.m = clara,
  init1.sel = "rprs", init2.sel = "rprs", init1=c(-1.5, 1.5), init2=c(-1.5, 1.5),
  leap1=3, leap2=3, fun1 = "runif.sobol", fun2 = "runif.sobol", trial.n = 100,
  len = 1000, type = 7, no = 10000, maxit = 5000)
```

## Arguments

data	A numerical vector representing the dataset.
per.of.mix	Level of mix between two parts of the distribution, usually 1-2% of cross mix is sufficient.
clustering.m	Clustering method used in classifying the dataset into two parts. Valid arguments include clara, fanny and pam from the cluster library. Default is clara. Or a logical vector specifying how data should be split.
init1.sel	This can be "rprs" or "rmfmkl", representing the choice (RS or FMKL) of the first distribution
init2.sel	This can be "rprs" or "rmfmkl", representing the choice (RS or FMKL) of the second distribution
init1	Initial values lambda3 and lambda4 for the first generalised lambda distribution.
init2	Initial values lambda3 and lambda4 for the second generalised lambda distribution.
leap1	Scrambling (0,1,2,3) for the sobol sequence for the first distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
leap2	Scrambling (0,1,2,3) for the sobol sequence for the second distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
fun1	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif" for the first distribution fit.
fun2	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif" for the second distribution fit.
trial.n	Number of evenly spaced quantile ranging from 0 to 1 to be used in the checking phase, to find the best set of initial values for optimisation, this is intended to be lower than len to speed up the fitting algorithm. Default is 100.
len	Number of evenly spaced quantile ranging from 0 to 1 to be used, default is 1000
type	Type of quantile to be used, default is 7, see <a href="#">quantile</a>
no	Number of initial random values to find the best initial values for optimisation.
maxit	Maximum number of iterations for numerical optimisation. Default is 5000.

**Details**

The initial values that work well for RPRS are  $c(-1.5, 1.5)$  and for RMFMKL are  $c(-0.25, 1.5)$ . For scrambling, if 1, 2 or 3 the sequence is scrambled otherwise not. If 1, Owen type type of scrambling is applied, if 2, Faure-Tezuka type of scrambling, is applied, and if 3, both Owen+Faure-Tezuka type of scrambling is applied. The star method uses the same initial values as `rmfmkl` since it uses the FMKL generalised lambda distribution. Nelder-Simplex algorithm is used in the numerical optimization. `rprs` stands for revised percentile method for RS generalised lambda distribution and "`rmfmkl`" stands for revised method of moment for FMKL generalised lambda distribution. These acronyms represents the initial optimization algorithm used to get a reasonable set of initial values for the subsequent optimization procedues.

**Value**

<code>par</code>	The best set of parameters found, the first four corresponds to the first distribution fit, the second four corresponds to the second distribution fit, the last value correspond to $p$ for the first distribution fit.
<code>value</code>	The value of -ML for the paramters obtained.
<code>counts</code>	A two-element integer vector giving the number of calls to <code>fn</code> and <code>gr</code> respectively. This excludes those calls needed to compute the Hessian, if requested, and any calls to <code>fn</code> to compute a finite-difference approximation to the gradient.
<code>convergence</code>	0 indicates successful convergence, 1 indicates the iteration limit <code>maxit</code> had been reached, 10 indicates degeneracy of the Nelder-Mead simplex.
<code>message</code>	A character string giving any additional information returned by the optimizer, or NULL.

**Note**

If the number of observations is small, `rprs` can sometimes fail as the percentiles may not exist for this data. Also, if the initial values do not span a valid generalised lambda distribution, try another set of initial values.

**Author(s)**

Steve Su

**References**

- Bratley P. and Fox B.L. (1988) Algorithm 659: Implementing Sobol's quasi random sequence generator, ACM Transactions on Mathematical Software 14, 88-100.
- Joe S. and Kuo F.Y. (1998) Remark on Algorithm 659: Implementing Sobol's quasi random Sequence Generator.
- Nelder, J. A. and Mead, R. (1965) A simplex algorithm for function minimization. Computer Journal \*7\*, 308-313.
- Su (2008). Fitting GLD to data via quantile matching method. (Book chapter to appear)



**See Also**

[fun.auto.bimodal.pml](#), [fun.auto.bimodal.ml](#), [fun.plot.fit.bm](#), [fun.diag.ks.g.bimodal](#)

**Examples**

```
## Fitting faithful data from the dataset library, with the clara clustering
## regime. The first distribution is RS and the second distribution is fmk1.
## The percentage of data mix is 1%.

# fun.auto.bimodal.qs(faithful[,1],per.of.mix=0.01,clustering.m=clara,
# init1.sel="rprs",init2.sel="rmfmkl",init1=c(-1.5,1,5),init2=c(-0.25,1.5),
# leap1=3,leap2=3)
```

---

fun.bimodal.fit.ml	<i>Finds the final fits using the maximum likelihood estimation for the bimodal dataset.</i>
--------------------	--

---

**Description**

This is the secondary optimization procedure to evaluate the final bimodal distribution fits using the maximum likelihood. It usually relies on initial values found by `fun.bimodal.init` function.

**Usage**

```
fun.bimodal.fit.ml(data, first.fit, second.fit, prop, param1, param2, selc1,
selc2)
```

**Arguments**

data	Dataset to be fitted.
first.fit	The distribution parameters or the initial values of the first distribution fit.
second.fit	The distribution parameters or the initial values of the second distribution fit.
prop	The proportion of the data set, usually obtained from <a href="#">fun.bimodal.init</a> .
param1	Can be either "rs" or "fmkl", depending on the type of first distribution used.
param2	Can be either "rs" or "fmkl", depending on the type of second distribution used.
selc1	Selection of initial values for the first distribution, can be either "rs", "fmkl" or "star". Choose initial values from RPRS (ML), RMFMKL (ML) or STAR method.
selc2	Selection of initial values for the second distribution, can be either "rs", "fmkl" or "star". Choose initial values from RPRS (ML), RMFMKL (ML) or STAR method.

**Details**

This function should be used in tandem with [fun.bimodal.init](#).

**Value**

par	The first four numbers are the parameters of the first generalised lambda distribution, the second four numbers are the parameters of the second generalised lambda distribution and the last value is the proportion of the first generalised lambda distribution.
value	The objective value of negative likelihood obtained using the par above.
counts	A two-element integer vector giving the number of calls to functions. Gradient is not used in this case.
convergence	An integer code. 0 indicates successful convergence. Error codes are: 1 indicates that the iteration limit 'maxit' had been reached. 10 indicates degeneracy of the Nelder-Mead simplex.
message	A character string giving any additional information returned by the optimizer, or NULL.

**Note**

There is currently no guarantee of a global convergence.

**Author(s)**

Steve Su

**References**

Su (2007). Fitting Single and Mixture of Generalized Lambda Distributions to Data via Discretized and Maximum Likelihood Methods: GLDEX in R. *Journal of Statistical Software*: \*21\* 9.

**See Also**

[link{fun.bimodal.fit.pml}](#), [fun.bimodal.init](#)

**Examples**

```
## Extract faithful[,2] into faithful2
# faithful2<-faithful[,2]

## Uses clara clustering method
# clara.fairful2<-fun.class.regime.bi(faithful2, 0.01, clara)

## Save into two different objects
# qq1.fairful2.cc<-clara.fairful2$data.a
# qq2.fairful2.cc<-clara.fairful2$data.b

## Find the initial values
# result.fairful2.init<-fun.bimodal.init(data1=qq1.fairful2.cc,
# data2=qq2.fairful2.cc, rs.leap1=3, fmk1.leap1=3, rs.init1 = c(-1.5, 1.5),
# fmk1.init1 = c(-0.25, 1.5), rs.leap2=3, fmk1.leap2=3, rs.init2 = c(-1.5, 1.5),
# fmk1.init2 = c(-0.25, 1.5))
```

```
## Find the final fits
# result.faithful2.rsrs<-fun.bimodal.fit.ml(data=faithful2,
# result.faithful2.init[[2]],result.faithful2.init[[3]],
# result.faithful2.init[[1]], param1="rs",param2="rs",selc1="rs",selc2="rs")

## Output
# result.faithful2.rsrs
```

---

fun.bimodal.fit.pml     *Finds the final fits using partition maximum likelihood estimation for the bimodal dataset.*

---

### Description

This is the secondary optimization procedure to evaluate the final bimodal distribution fits using the partition maximum likelihood. It usually relies on initial values found by `fun.bimodal.init` function.

### Usage

```
fun.bimodal.fit.pml(data1, data2, first.fit, second.fit, prop, param1, param2,
selc1, selc2)
```

### Arguments

<code>data1</code>	First data set, usually obtained by <code>fun.class.regime.bi</code> .
<code>data2</code>	Second data set, usually obtained by <code>fun.class.regime.bi</code> .
<code>first.fit</code>	The distribution parameters or the initial values of the first distribution fit.
<code>second.fit</code>	The distribution parameters or the initial values of the second distribution fit.
<code>prop</code>	The proportion of the data set, usually obtained from <code>fun.bimodal.init</code> .
<code>param1</code>	Can be either <code>rs</code> or <code>fmk1</code> , depending on the type of first distribution used.
<code>param2</code>	Can be either <code>rs</code> or <code>fmk1</code> , depending on the type of second distribution used.
<code>selc1</code>	Selection of initial values for the first distribution, can be either <code>"rs"</code> , <code>"fmk1"</code> or <code>"star"</code> . Choose initial values from RPRS (ML), RMFMKL (ML) or STAR method.
<code>selc2</code>	Selection of initial values for the second distribution, can be either <code>"rs"</code> , <code>"fmk1"</code> or <code>"star"</code> . Choose initial values from RPRS (ML), RMFMKL (ML) or STAR method.

### Details

This function should be used in tandem with `fun.bimodal.init` function.

**Value**

par	The first four numbers are the parameters of the first generalised lambda distribution, the second four numbers are the parameters of the second generalised lambda distribution and the last value is the proportion of the first generalised lambda distribution.
value	The objective value of negative likelihood obtained.
counts	A two-element integer vector giving the number of calls to functions. Gradient is not used in this case.
convergence	An integer code. 0 indicates successful convergence. Error codes are: 1 indicates that the iteration limit 'maxit' had been reached. 10 indicates degeneracy of the Nelder-Mead simplex.
message	A character string giving any additional information returned by the optimizer, or NULL.

**Note**

There is currently no guarantee of a global convergence.

**Author(s)**

Steve Su

**References**

Su (2007). Fitting Single and Mixture of Generalized Lambda Distributions to Data via Discretized and Maximum Likelihood Methods: GLDEX in R. *Journal of Statistical Software*: \*21\* 9.

**See Also**

[fun.bimodal.fit.ml](#), [fun.bimodal.init](#)

**Examples**

```
## Extract faithful[,2] into faithful2
# faithful2<-faithful[,2]

## Uses clara clustering method
# clara.fairful2<-clara(faithful2,2)$clustering

## Save into two different objects
# qq1.fairful2.cc<-faithful2[clara.fairful2==1]
# qq2.fairful2.cc<-faithful2[clara.fairful2==2]

## Find the initial values
# result.fairful2.init<-fun.bimodal.init(data1=qq1.fairful2.cc,
# data2=qq2.fairful2.cc, rs.leap1=3, fmk1.leap1=3, rs.init1 = c(-1.5, 1.5),
# fmk1.init1 = c(-0.25, 1.5), rs.leap2=3, fmk1.leap2=3, rs.init2 = c(-1.5, 1.5),
# fmk1.init2 = c(-0.25, 1.5))
```

```
## Find the final fits
# result.faithful2.rsrs<-fun.bimodal.fit.pml(data1=qqqq1.faithful2.cc,
# data2=qqqq2.faithful2.cc, result.faithful2.init[[2]],
# result.faithful2.init[[3]], result.faithful2.init[[1]],param1="rs",
# param2="rs",selc1="rs",selc2="rs")

## Output
# result.faithful2.rsrs
```

---

fun.bimodal.init	<i>Finds the initial values for optimisation in fitting the bimodal generalised lambda distribution.</i>
------------------	--

---

## Description

After classifying the data using [fun.class.regime.bi](#), this function evaluates the temporary or initial solutions by estimating each part of the bimodal distribution using the maximum likelihood estimation and starship method. These initial solutions are then passed onto [fun.bimodal.fit.ml](#) or [fun.bimodal.fit.pml](#) to obtain the final fits.

## Usage

```
fun.bimodal.init(data1, data2, rs.leap1, fmk1.leap1, rs.init1, fmk1.init1,
rs.leap2, fmk1.leap2, rs.init2, fmk1.init2,fun1="runif.sobol",
fun2="runif.sobol",no=10000)
```

## Arguments

data1	The first data obtained by the clustering algorithm.
data2	The second data obtained by the clustering algorithm.
rs.leap1	Scrambling (0,1,2,3) for the sobol sequence for the first RS distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
fmk1.leap1	Scrambling (0,1,2,3) for the sobol sequence for the first FMKL distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
rs.init1	Initial values (lambda3 and lambda4) for the first RS generalised lambda distribution. <code>c(-1.5, 1.5)</code> tends to work well.
fmk1.init1	Initial values (lambda3 and lambda4) for the first FMKL generalised lambda distribution. <code>c(-0.25, 1.5)</code> tends to work well
rs.leap2	Scrambling (0,1,2,3) for the sobol sequence for the second RS distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
fmk1.leap2	Scrambling (0,1,2,3) for the sobol sequence for the second FMKL distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
rs.init2	Initial values (lambda3 and lambda4) for the second RS generalised lambda distribution. <code>c(-1.5, 1.5)</code> tends to work well.

fmkl.init2	Initial values (lambda3 and lambda4) for the second FMKL generalised lambda distribution. <code>c(-0.25, 1.5)</code> tends to work well
fun1	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif" for the first distribution fit.
fun2	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif" for the second distribution fit.
no	Number of initial random values to find the best initial values for optimisation.

### Details

All three methods of fitting (RPRS, RMFMKL and STAR) will be given for each part of the bimodal distribution.

### Value

prop	Proportion of the number of observations in the first data in relation to the entire data.
first.fit	A matrix comprising the parameters of GLD obtained from RPRS, RMFMKL and STAR for the first dataset.
second.fit	A matrix comprising the parameters of GLD obtained from RPRS, RMFMKL and STAR for the second dataset.

### Note

This is not designed to be called by the end user explicitly, the difficulties with RPRS parameterisation should be noted by the users.

### Author(s)

Steve Su

### References

Su (2007). Fitting Single and Mixture of Generalized Lambda Distributions to Data via Discretized and Maximum Likelihood Methods: GLDEX in R. *Journal of Statistical Software*: \*21\* 9.

### See Also

[fun.class.regime.bi](#), [fun.bimodal.fit.pml](#), [fun.bimodal.fit.ml](#)

### Examples

```
## Split the first column of the faithful data into two using
## fun.class.regime.bi
# faithful1.mod<-fun.class.regime.bi(faithful[,1], 0.1, clara)

## Save the datasets
# qq1.faithful1.cc1<-faithful1.mod$data.a
# qq2.faithful1.cc1<-faithful1.mod$data.b
```

```
## Find the initial values for secondary optimisation.
# result.fairful1.init1<-fun.bimodal.init(data1=qqq1.fairful1.cc1,
# data2=qqq2.fairful1.cc1, rs.leap1=3,fmkl.leap1=3,rs.init1 = c(-1.5, 1.5),
# fmkl.init1 = c(-0.25, 1.5), rs.leap2=3,fmkl.leap2=3,rs.init2 = c(-1.5, 1.5),
# fmkl.init2 = c(-0.25, 1.5))

## These initial values are then passed onto fun,bimodal.fit.ml to obtain the
## final fits.
```

---

fun.check.gld	<i>Check whether the RS or FMKL/FKML GLD is a valid GLD for single values of L1, L2, L3 and L4</i>
---------------	--

---

### Description

This function will return a single logical value showing whether a combination of L1, L2, L3 and L4 is a valid GLD.

### Usage

```
fun.check.gld(lambda1, lambda2, lambda3, lambda4, param)
```

### Arguments

lambda1	A numerical vector for L1 of GLD
lambda2	A numerical vector for L2 of GLD
lambda3	A numerical vector for L3 of GLD
lambda4	A numerical vector for L4 of GLD
param	Can be "rs", "fmkl", or "fkml"

### Value

A single logical value indicating whether the specified GLD is a valid probability density function

### Author(s)

Steve Su

### See Also

[fun.check.gld.multi](#)

## Examples

```
fun.check.gld(1,4,3,2,"rs")  
fun.check.gld(1,4,3,2,"fkml")  
fun.check.gld(1,4,3,-2,"rs")
```

---

fun.check.gld.multi	<i>Check whether the RS or FMKL/FKML GLD is a valid GLD for vectors of L1, L2, L3 and L4</i>
---------------------	--

---

## Description

This function will return a logical vector showing whether vector combinations of L1, L2, L3 and L4 are valid GLDs.

## Usage

```
fun.check.gld.multi(l1, l2, l3, l4, param)
```

## Arguments

l1	A numerical vector for L1 of GLD
l2	A numerical vector for L2 of GLD
l3	A numerical vector for L3 of GLD
l4	A numerical vector for L4 of GLD
param	Can be "rs", "fmkl", or "fkml"

## Details

This is an extension to [fun.check.gld](#)

## Value

A logical vector indicating whether the specified parameters are valid GLDs

## Author(s)

Steve Su

## See Also

[fun.check.gld](#)



## Examples

```
fun.check.gld.multi(c(1,2,3),c(4,5,6),c(7,8,9),c(10,11,12),param="rs")
```

```
fun.check.gld.multi(c(1,2,3),c(4,5,6),c(7,8,9),c(10,11,-12),param="rs")
```

---

fun.class.regime.bi      *Classifies data into two groups using a clustering regime.*

---

## Description

This function is primarily designed to split a bimodal data vector into two groups to allow the fitting of mixture generalised lambda distributions.

## Usage

```
fun.class.regime.bi(data, perc.cross, fun.cross)
```

## Arguments

data	Data to be classified into two groups.
perc.cross	Percentage of cross over from one data to the other, usually set at 1%
fun.cross	Any clustering function such as <code>link{clara}</code> , <code>pam</code> , <code>fanny</code> can be used here. Or a logical vector indicating how data should be split.

## Details

This function is part of the routine mixture fitting procedure provided in this package. The `perc.cross` argument or percentage of cross over is designed to allow the use of maximum likelihood estimation via EM algorithm for fitting bimodal data. When this is invoked, it will ensure both part of the data will contain both the minimum and maximum of the data set as well as a proportion ( specified in `perc.cross` argument) of observations from each other. If 1% is required, then `data.a` will contains 1% of the `data.b` and vice versa after the full data set has been classified into `data.a` and `data.b` by the `fun.cross` classification regime.

## Value

data.a	First group of data obtained by the classification algorithm.
data.b	Second group of data obtained by the classification algorithm.

## Author(s)

Steve Su

## References

Kaufman, L. and Rousseeuw, P. J. (1990). Finding Groups in Data: An Introduction to Cluster Analysis. Wiley, New York.

Su (2006) Maximum Log Likelihood Estimation using EM Algorithm and Partition Maximum Log Likelihood Estimation for Mixtures of Generalized Lambda Distributions. Working Paper.

## See Also

link{clara}, pam, fanny

## Examples

```
## Classify the faithful[,1] data into two categories with 10% cross over mix.
# fun.class.regime.bi(faithful[,1],0.1,clara)
```

```
## Classify the faithful[,1] data into two categories with no mixing:
# fun.class.regime.bi(faithful[,1],0,clara)
```

---

fun.comp.moments.ml     *Compare the moments of the data and the fitted univariate generalised lambda distribution.*

---

## Description

After fitting the distribution, it is often desirable to see whether the moments of the data matches with the fitted distribution. This function computes the theoretical and actual moments especially for fun.data.fit.ml function output.

## Usage

```
fun.comp.moments.ml(theo.obj, data, name = "ML")
```

## Arguments

theo.obj	Fitted distribution parameters, usually output from <a href="#">fun.data.fit.ml</a>
data	Data set used
name	Naming the method used in fitting the distribution, by default this is "ML".

## Value

r.mat	A matrix showing the mean, variance, skewness and kurtosis of the fitted distribution in comparison to the data set.
eval.mat	Absolute difference in each of the four moments from the data under each of the distributional fits.

**Note**

Sometimes it is difficult to find RPRS type of fits to data set, so instead [fun.comp.moments.ml.2](#) is used to compare the theoretical moments of RMFMKL.ML and STAR methods with respect to the dataset fitted.

**Author(s)**

Steve Su

**See Also**

[fun.comp.moments.ml.2](#)

**Examples**

```
## Generate random normally distributed observations.
# junk<-rnorm(1000,3,2)

## Fit the dataset using fun.data.ml
# fit<-fun.data.fit.ml(junk)

## Compare the resulting fits. It is usually the case the maximum likelihood
## provides better estimation of the moments than the starship method.
# fun.comp.moments.ml(fit,junk)
```

---

`fun.comp.moments.ml.2` *Compare the moments of the data and the fitted univariate generalised lambda distribution. Specialised function designed for RMFMKL.ML and STAR methods.*

---

**Description**

After fitting the distribution, it is often desirable to see whether the moments of the data matches with the fitted distribution. This function computes the theoretical and actual moments for the FMKL GLD maximum likelihood estimation and starship method.

**Usage**

```
fun.comp.moments.ml.2(theo.obj, data, name = "ML")
```

**Arguments**

<code>theo.obj</code>	Fitted distribution parameters, there should be two sets, both FMKL GLD.
<code>data</code>	Data set used
<code>name</code>	Naming the method used in fitting the distribution, by default this is "ML".

**Value**

r.mat	A matrix showing the mean, variance, skewness and kurtosis of the fitted distribution in comparison to the data set.
eval.mat	Absolute difference in each of the four moments from the data under each of the distributional fits.

**Note**

To compare all three fits under [fun.data.fit.ml](#) see [fun.comp.moments.ml](#) function.

**Author(s)**

Steve Su

**See Also**

[fun.comp.moments.ml](#)

**Examples**

```
## Generate random normally distributed observations.
# junk<-rnorm(1000,3,2)

## Fit the dataset using fun.data.ml
# fit<-cbind(fun.RMFMKL.ml(junk),starship(junk)$lambda)

## Compare the resulting fits. It is usually the case the maximum likelihood
## provides better estimation of the moments than the starship method.
# fun.comp.moments.ml.2(fit,junk)
```

---

fun.data.fit.hs	<i>Fit RS and FMKL generalised distributions to data using discretised approach with weights.</i>
-----------------	---

---

**Description**

This function fits RS and FMKL generalised distribution to data using discretised approach with weights. It is designed to act as a smoother device rather than a definitive fit.

**Usage**

```
fun.data.fit.hs(data, rs.default = "Y", fmk1.default = "Y", rs.leap = 3,
  fmk1.leap = 3, rs.init = c(-1.5, 1.5), fmk1.init = c(-0.25, 1.5), no.c.rs = 50,
  no.c.fmk1 = 50,FUN="runif.sobol", no=10000)
```

**Arguments**

data	Dataset to be fitted
rs.default	If yes, this function uses the default method <code>fun.nclass.e</code> to calculate number of classes required for the RS distribution fits.
fmkl.default	If yes, this function uses the default method <code>fun.nclass.e</code> to calculate number of classes required for the FMKL distribution fits.
rs.leap	Scrambling (0,1,2,3) for the Sobol sequence for the RS distribution fit. See scrambling/leap argument for <code>runif.sobol</code> , <code>runif.halton</code> or <code>QUnif</code> .
fmkl.leap	Scrambling (0,1,2,3) for the Sobol sequence for the FMKL distribution fit. See scrambling/leap argument for See scrambling/leap argument for <code>runif.sobol</code> , <code>runif.halton</code> or <code>QUnif</code> .
rs.init	Initial values for RS distribution optimization, <code>c(-1.5, 1.5)</code> tends to work well.
fmkl.init	Initial values for FMKL distribution optimization, <code>c(-0.25, 1.5)</code> tends to work well.
no.c.rs	Number of classes or bins of histogram to be optimized over for the RS GLD. This argument is ineffective if <code>default="Y"</code> .
no.c.fmkl	Number of classes or bins of histogram to be optimized over for the FMKL GLD. This argument is ineffective if <code>default="Y"</code> .
FUN	A character string of either <code>"runif.sobol"</code> (default), <code>"runif.halton"</code> or <code>"QUnif"</code> .
no	Number of initial random values to find the best initial values for optimisation.

**Details**

This function optimises the deviations of frequency of the bins to that of the theoretical so it has the effect of "fitting clothes" onto the data set. The user can decide the frequency of the bins they want the distribution to smooth over. The resulting fit may or may not be an adequate fit from a formal statistical point of view such as satisfying the goodness of fit for example, but it can be useful to suggest the range of different distributions exhibited by the data set. The default number of classes calculates the mean and variance after categorising the data into different bins and uses the number of classes that best matches the mean and variance of the original, ungrouped data. The weighting is designed to accentuate the peak or the dense part of the distribution and suppress the tails.

**Value**

A matrix showing the four parameters of the RS and FMKL distribution fit.

**Note**

In some cases, the resulting fit may not converge, there are currently no checking mechanism in place to ensure global convergence. The RPRS method can sometimes fail if there are no valid percentiles in the data set or if initial values do not give a valid distribution.

**Author(s)**

Steve Su

## References

Su, S. (2005). A Discretized Approach to Flexibly Fit Generalized Lambda Distributions to Data. Journal of Modern Applied Statistical Methods (November): 408-424.

Su (2007). Fitting Single and Mixture of Generalized Lambda Distributions to Data via Discretized and Maximum Likelihood Methods: GLDEX in R. Journal of Statistical Software: \*21\* 9.

## See Also

[fun.RPRS.hs.nw](#), [fun.RFMKL.hs.nw](#), [fun.RFMKL.hs](#), [fun.RPRS.hs](#), [fun.data.fit.hs.nw](#), [fun.data.fit.ml](#)

## Examples

```
## Fitting normal(3,2) distribution using the default setting
# junk<-rnorm(1000,3,2)
# fun.data.fit.hs(junk)
```

---

fun.data.fit.hs.nw	<i>Fit RS and FMKL generalised distributions to data using discretised approach without weights.</i>
--------------------	--

---

## Description

This function fits RS and FMKL generalised distribution to data using discretised approach without weights. It is designed to act as a smoother device rather than a definitive fit.

## Usage

```
fun.data.fit.hs.nw(data, rs.default = "Y", fmk1.default = "Y", rs.leap = 3,
  fmk1.leap = 3, rs.init = c(-1.5, 1.5), fmk1.init = c(-0.25, 1.5), no.c.rs = 50,
  no.c.fmk1 = 50, FUN="runif.sobol", no=10000)
```

## Arguments

data	Dataset to be fitted
rs.default	If yes, this function uses the default method <a href="#">fun.nclass.e</a> to calculate number of classes required for the RS distribution fits.
fmk1.default	If yes, this function uses the default method <a href="#">fun.nclass.e</a> to calculate number of classes required for the FMKL distribution fits.
rs.leap	Scrambling (0,1,2,3) for the Sobol sequence for the RS distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
fmk1.leap	Scrambling (0,1,2,3) for the Sobol sequence for the FMKL distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
rs.init	Initial values for RS distribution optimization, c(-1.5, 1.5) tends to work well.
fmk1.init	Initial values for FMKL distribution optimization, c(-0.25, 1.5) tends to work well.

no.c.rs	Number of classes or bins of histogram to be optimized over for the RS GLD. This argument is ineffective if default="Y".
no.c.fmk1	Number of classes or bins of histogram to be optimized over for the FMKL GLD. This argument is ineffective if default="Y".
FUN	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif".
no	Number of initial random values to find the best initial values for optimisation.

### Details

This function optimises the deviations of frequency of the bins to that of the theoretical so it has the effect of "fitting clothes" onto the data set. The user can decide the frequency of the bins they want the distribution to smooth over. The resulting fit may or may not be an adequate fit from a formal statistical point of view such as satisfying the goodness of fit for example, but it can be useful to suggest the range of different distributions exhibited by the data set. The default number of classes calculates the mean and variance after categorising the data into different bins and uses the number of classes that best matches the mean and variance of the original, ungrouped data.

### Value

A matrix showing the four parameters of the RS and FMKL distribution fit.

### Note

In some cases, the resulting fit may not converge, there are currently no checking mechanism in place to ensure global convergence. The RPRS method can sometimes fail if there are no valid percentiles in the data set or if initial values do not give a valid distribution.

### Author(s)

Steve Su

### References

Su, S. (2005). A Discretized Approach to Flexibly Fit Generalized Lambda Distributions to Data. *Journal of Modern Applied Statistical Methods* (November): 408-424.

Su (2007). Fitting Single and Mixture of Generalized Lambda Distributions to Data via Discretized and Maximum Likelihood Methods: GLDEX in R. *Journal of Statistical Software*: \*21\* 9.

### See Also

[fun.RPRS.hs](#), [fun.RFMKL.hs](#), [fun.RFMKL.hs.nw](#), [fun.RPRS.hs.nw](#), [fun.data.fit.hs](#), [fun.data.fit.ml](#)

### Examples

```
## Fitting normal(3,2) distribution using the default setting
# junk<-rnorm(1000,3,2)
# fun.data.fit.hs.nw(junk)
```

---

fun.data.fit.lm      *Fit data using L moment matching estimation for RS and FMKL GLD*

---

## Description

This function fits generalised lambda distributions to data using L moment matching method

## Usage

```
fun.data.fit.lm(data, rs.leap = 3, fmk1.leap = 3, rs.init = c(-1.5, 1.5),
fmk1.init = c(-0.25, 1.5), FUN = "runif.sobol", no = 10000)
```

## Arguments

data	Dataset to be fitted.
rs.leap	Scrambling (0,1,2,3) for the sobol sequence for the RPRS distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
fmk1.leap	Scrambling (0,1,2,3) for the sobol sequence for the RMFMKL distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
rs.init	Initial values (lambda3 and lambda4) for the RS generalised lambda distribution.
fmk1.init	Initial values (lambda3 and lambda4) for the FMKL generalised lambda distribution.
FUN	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif".
no	Number of initial random values to find the best initial values for optimisation.

## Details

This function consolidates [fun.RPRS.lm](#) and [fun.RMFMKL.lm](#) and gives all the fits in one output.

## Value

A matrix showing the parameters of RS and FMKL generalised lambda distributions.

## Author(s)

Steve Su

## References

Asquith, W. (2007). "L-moments and TL-moments of the generalized lambda distribution." *Computational Statistics and Data Analysis* 51(9): 4484-4496.

Karvanen, J. and A. Nuutinen (2008). "Characterizing the generalized lambda distribution by L-moments." *Computational Statistics and Data Analysis* 52(4): 1971-1983.



**See Also**

[fun.RPRS.qs](#), [fun.RMFMKL.qs](#), [fun.data.fit.ml](#), [fun.data.fit.hs](#), [fun.data.fit.hs.nw](#),  
[fun.data.fit.qs](#), [fun.data.fit.mm](#)

**Examples**

```
## Fitting normal(3,2) distribution using the default setting
# junk<-rnorm(50,3,2)
# fun.data.fit.lm(junk)
```

---

fun.data.fit.ml	<i>Fit data using RS, FMKL maximum likelihood estimation and the FMKL starship method.</i>
-----------------	--

---

**Description**

This function fits generalised lambda distributions to data using RPRS, RMFMKL and starship methods.

**Usage**

```
fun.data.fit.ml(data, rs.leap = 3, fmk1.leap = 3, rs.init = c(-1.5, 1.5),
fmk1.init = c(-0.25, 1.5),FUN="runif.sobol",no=10000)
```

**Arguments**

data	Dataset to be fitted.
rs.leap	Scrambling (0,1,2,3) for the sobol sequence for the RPRS distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
fmk1.leap	Scrambling (0,1,2,3) for the sobol sequence for the RMFMKL distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
rs.init	Initial values (lambda3 and lambda4) for the RS generalised lambda distribution.
fmk1.init	Initial values (lambda3 and lambda4) for the FMKL generalised lambda distribution.
FUN	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif".
no	Number of initial random values to find the best initial values for optimisation.

**Details**

This function consolidates [fun.RPRS.ml](#), [fun.RMFMKL.ml](#) and [starship](#) and gives all the fits in one output.

**Value**

A matrix showing the parameters of generalised lambda distribution for RPRS, FMFKL and STAR methods.

**Note**

RPRS can sometimes fail if it is not possible to calculate the percentiles of the data set. This usually happens when the number of data point is small.

**Author(s)**

Steve Su

**References**

King, R.A.R. & MacGillivray, H. L. (1999), A starship method for fitting the generalised lambda distributions, Australian and New Zealand Journal of Statistics, 41, 353-374

Su, S. (2007). Numerical Maximum Log Likelihood Estimation for Generalized Lambda Distributions. Computational statistics and data analysis 51(8) 3983-3998.

Su (2007). Fitting Single and Mixture of Generalized Lambda Distributions to Data via Discretized and Maximum Likelihood Methods: GLDEX in R. Journal of Statistical Software: \*21\* 9.

**See Also**

[fun.RPRS.ml](#), [fun.RMFMKL.ml](#), [starship](#), [fun.data.fit.hs](#), [fun.data.fit.hs.nw](#), [fun.data.fit.qs](#), [fun.data.fit.mm](#), [fun.data.fit.lm](#)

**Examples**

```
## Fitting normal(3,2) distribution using the default setting
# junk<-rnorm(50,3,2)
# fun.data.fit.ml(junk)
```

---

fun.data.fit.mm

*Fit data using moment matching estimation for RS and FMKL GLD*

---

**Description**

This function fits generalised lambda distributions to data using moment matching method

**Usage**

```
fun.data.fit.mm(data, rs.leap = 3, fmk1.leap = 3, rs.init = c(-1.5, 1.5),
fmk1.init = c(-0.25, 1.5), FUN = "runif.sobol", no = 10000)
```

**Arguments**

data	Dataset to be fitted.
rs.leap	Scrambling (0,1,2,3) for the sobol sequence for the RPRS distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
fmkl.leap	Scrambling (0,1,2,3) for the sobol sequence for the RMFMKL distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
rs.init	Initial values (lambda3 and lambda4) for the RS generalised lambda distribution.
fmkl.init	Initial values (lambda3 and lambda4) for the FMKL generalised lambda distribution.
FUN	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif".
no	Number of initial random values to find the best initial values for optimisation.

**Details**

This function consolidates [fun.RPRS.mm](#) and [fun.RMFMKL.mm](#) and gives all the fits in one output.

**Value**

A matrix showing the parameters of RS and FMKL generalised lambda distributions.

**Note**

RPRS can sometimes fail if it is not possible to calculate the percentiles of the data set. This usually happens when the number of data point is small.

**References**

Karian, Z. and E. Dudewicz (2000). Fitting Statistical Distributions: The Generalized Lambda Distribution and Generalised Bootstrap Methods. New York, Chapman and Hall.

**See Also**

[fun.RPRS.qs](#), [fun.RMFMKL.qs](#), [fun.data.fit.ml](#), [fun.data.fit.hs](#), [fun.data.fit.hs.nw](#), [fun.data.fit.qs](#), [fun.data.fit.lm](#)

**Examples**

```
## Fitting normal(3,2) distribution using the default setting
# junk<-rnorm(50,3,2)
# fun.data.fit.mm(junk)
```

fun.data.fit.qs

*Fit data using quantile matching estimation for RS and FMKL GLD***Description**

This function fits generalised lambda distributions to data using quantile matching method

**Usage**

```
fun.data.fit.qs(data, rs.leap = 3, fmk1.leap = 3, rs.init = c(-1.5, 1.5),
  fmk1.init = c(-0.25, 1.5), FUN = "runif.sobol", trial.n = 100, len = 1000,
  type = 7, no = 10000)
```

**Arguments**

data	Dataset to be fitted.
rs.leap	Scrambling (0,1,2,3) for the sobol sequence for the RPRS distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
fmk1.leap	Scrambling (0,1,2,3) for the sobol sequence for the RMFMKL distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
rs.init	Initial values (lambda3 and lambda4) for the RS generalised lambda distribution.
fmk1.init	Initial values (lambda3 and lambda4) for the FMKL generalised lambda distribution.
FUN	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif".
trial.n	Number of evenly spaced quantile ranging from 0 to 1 to be used in the checking phase, to find the best set of initial values for optimisation, this is intended to be lower than len to speed up the fitting algorithm. Default is 100.
len	Number of evenly spaced quantile ranging from 0 to 1 to be used, default is 1000
type	Type of quantile to be used, default is 7, see <a href="#">quantile</a>
no	Number of initial random values to find the best initial values for optimisation.

**Details**

This function consolidates [fun.RPRS.qs](#) and [fun.RMFMKL.qs](#) and gives all the fits in one output.

**Value**

A matrix showing the parameters of RS and FMKL generalised lambda distributions.

**Note**

RPRS can sometimes fail if it is not possible to calculate the percentiles of the data set. This usually happens when the number of data point is small.

**Author(s)**

Steve Su

**References**

Su (2008). Fitting GLD to data via quantile matching method. (Book chapter to appear)

**See Also**[fun.RPRS.qs](#), [fun.RFMKL.qs](#), [fun.data.fit.ml](#), [fun.data.fit.hs](#), [fun.data.fit.hs.nw](#),  
[fun.data.fit.mm](#), [fun.data.fit.lm](#)**Examples**

```
## Fitting normal(3,2) distribution using the default setting
# junk<-rnorm(50,3,2)
# fun.data.fit.qs(junk)
```

---

fun.diag.ks.g	<i>Compute the simulated Kolmogorov-Smirnov tests for the unimodal dataset</i>
---------------	--

---

**Description**

This function counts the number of times the p-value exceed 0.05 for the null hypothesis that the observations simulated tom fitted distribution is the same as the observations simulated from the bimodal data set.

**Usage**

```
fun.diag.ks.g(result, data, no.test = 1000, len = floor(0.9 * length(data)),  
param, alpha = 0.05)
```

**Arguments**

result	A vector representing the four parameters of the generalised lambda distribution.
data	The unimodal dataset.
no.test	Total number of tests required.
len	Number of data to sample.
param	Type of the generalised lambda distribution, "rs" or "fmkl".
alpha	Significance level of KS test.

**Value**

A numerical value representing number of times the p-value exceeds alpha.

**Note**

If there are ties, jittering is used in [ks.gof](#).

**Author(s)**

Steve Su

**References**

Stephens, M. A. (1986). Tests based on EDF statistics. In Goodness-of-Fit Techniques. D'Agostino, R. B. and Stevens, M. A., eds. New York: Marcel Dekker.

Su, S. (2005). A Discretized Approach to Flexibly Fit Generalized Lambda Distributions to Data. Journal of Modern Applied Statistical Methods (November): 408-424.

Su (2007). Numerical Maximum Log Likelihood Estimation for Generalized Lambda Distributions. Computational Statistics and Data Analysis: \*51\*, 8, 3983-3998.

Su (2007). Fitting Single and Mixture of Generalized Lambda Distributions to Data via Discretized and Maximum Likelihood Methods: GLDEX in R. Journal of Statistical Software: \*21\* 9.

**See Also**

[fun.diag.ks.g.bimodal](#)

**Examples**

```
## Generate 1000 random observations from Normal distribution with mean=100,
## standard deviation=10. Save this as junk
# junk<-rnorm(1000,100,10)

## Fit junk using RPRS method via the maximum likelihood.
# fit1<-fun.RPRS.ml(junk, c(-1.5, 1.5), leap = 3)

## Calculate the simulated KS test result:
# fun.diag.ks.g(fit1,junk,param="rs")
```

---

fun.diag.ks.g.bimodal *Compute the simulated Kolmogorov-Smirnov tests for the bimodal dataset*

---

**Description**

This function counts the number of times the p-value exceed 0.05 for the null hypothesis that the observations simulated from fitted distribution is the same as the observations simulated from the bimodal data set.

**Usage**

```
fun.diag.ks.g.bimodal(result1, result2, prop1, prop2, data, no.test = 1000,
len = floor(0.9 * length(data)), param1, param2, alpha = 0.05)
```

**Arguments**

result1	A vector representing the four parameters of the first generalised lambda distribution.
result2	A vector representing the four parameters of the second generalised lambda distribution.
prop1	Proportion of the first distribution fitted to the bimodal dataset.
prop2	Proportion of the second distribution fitted to the bimodal dataset.
data	The bimodal dataset.
no.test	Total number of tests required.
len	Number of data to sample.
param1	Type of first generalised lambda distribution, can be "rs" or "fmkl".
param2	Type of second generalised lambda distribution, can be "rs" or "fmkl".
alpha	Significance level of KS test.

**Value**

A numerical value representing number of times the p-value exceeds alpha.

**Note**

If there are ties, jittering is used in [ks.gof](#).

**Author(s)**

Steve Su

**References**

- Stephens, M. A. (1986). Tests based on EDF statistics. In Goodness-of-Fit Techniques. D'Agostino, R. B. and Stevens, M. A., eds. New York: Marcel Dekker.
- Su, S. (2005). A Discretized Approach to Flexibly Fit Generalized Lambda Distributions to Data. *Journal of Modern Applied Statistical Methods* (November): 408-424.
- Su (2007). Nmerical Maximum Log Likelihood Estimation for Generalized Lambda Distributions. *Computational Statistics and Data Analysis*: \*51\*, 8, 3983-3998.
- Su (2007). Fitting Single and Mixture of Generalized Lambda Distributions to Data via Discretized and Maximum Likelihood Methods: GLDEX in R. *Journal of Statistical Software*: \*21\* 9.

**See Also**

[fun.diag.ks.g](#)

**Examples**

```
## Fit the faithful[,1] data from the MASS library
# fit1<-fun.auto.bimodal.ml(faithful[,1],init1.sel="rprs",init2.sel="rmfml",
# init1=c(-1.5,1,5),init2=c(-0.25,1.5),leap1=3,leap2=3)
## Run diagnostic KS tests
# fun.diag.ks.g.bimodal(fit1$par[1:4],fit1$par[5:8],prop1=fit1$par[9],
# data=faithful[,1],param1="rs",param2="fml")
```

---

fun.diag1	<i>Diagnostic function for theoretical distribution fits through the resampled Kolmogorov-Smirnoff tests</i>
-----------	--

---

**Description**

This function is primarily designed to be used for testing the fitted distribution with reference to a theoretical distribution. It is also tailored for output obtained from the [fun.data.fit.ml](#) function.

**Usage**

```
fun.diag1(result, test, no.test = 1000, alpha = 0.05)
```

**Arguments**

result	Output from <a href="#">fun.data.fit.ml</a> function.
test	Simulated observations from theoretical distribution, the length should be no.test~2.
no.test	Number of times to do the KS tests.
alpha	Significance level of KS test.

**Value**

A vector showing the number of times the KS p-value is greater than alpha for each of the distribution fit strategy.

**Note**

If there are ties, jittering is used in [ks.gof](#).

**Author(s)**

Steve Su

**References**

Su, S. (2005). A Discretized Approach to Flexibly Fit Generalized Lambda Distributions to Data. *Journal of Modern Applied Statistical Methods* (November): 408-424.

Su, S. (2007). Numerical Maximum Log Likelihood Estimation for Generalized Lambda Distributions. *Journal of Computational statistics and data analysis* 51(8) 3983-3998.

Su (2007). Fitting Single and Mixture of Generalized Lambda Distributions to Data via Discretized and Maximum Likelihood Methods: GLDEX in R. *Journal of Statistical Software*: \*21\* 9.



**See Also**

[fun.diag2](#), [fun.diag.ks.g](#), [fun.diag.ks.g.bimodal](#)

**Examples**

```
## Fits a Weibull 5,2 distribution:
# weibull.approx.ml<-fun.data.fit.ml(rweibull(1000,5,2))

## Compute the resample K-S test results.
# fun.diag1(weibull.approx.ml, rweibull(100000, 5, 2))
```

---

fun.diag2

*Diagnostic function for empirical data distribution fits through the resample Kolmogorov-Smirnoff tests*

---

**Description**

This function is primarily designed to be used for testing the fitted distribution with reference to an empirical data. It is also tailored for output obtained from the [fun.data.fit.ml](#) function.

**Usage**

```
fun.diag2(result, data, no.test = 1000, len=100, alpha = 0.05)
```

**Arguments**

result	Output from <a href="#">fun.data.fit.ml</a> function.
data	Observations in which the distribution was fitted upon.
no.test	Number of times to do the KS tests.
len	Number of observations to sample from the data. This is also the number of observations sampled from the fitted distribution in each KS test.
alpha	Significance level of KS test.

**Value**

A vector showing the number of times the KS p-value is greater than alpha for each of the distribution fit strategy.

**Note**

If there are ties, jittering is used in [ks.gof](#).

**Author(s)**

Steve Su

## References

- Su, S. (2005). A Discretized Approach to Flexibly Fit Generalized Lambda Distributions to Data. *Journal of Modern Applied Statistical Methods* (November): 408-424.
- Su, S. (2007). Numerical Maximum Log Likelihood Estimation for Generalized Lambda Distributions. *Journal of Computational statistics and data analysis* 51(8) 3983-3998.
- Su (2007). Fitting Single and Mixture of Generalized Lambda Distributions to Data via Discretized and Maximum Likelihood Methods: GLDEX in R. *Journal of Statistical Software*: \*21\* 9.

## See Also

[fun.diag1](#), [fun.diag.ks.g](#), [fun.diag.ks.g.bimodal](#)

## Examples

```
## Fits a Normal 3,2 distribution:
# junk<-rnorm(1000,3,2)
# fit<-fun.data.fit.ml(junk)

## Compute the resample K-S test results.
# fun.diag2(fit,junk)
```

---

fun.disc.estimation	<i>Estimates the mean and variance after cutting up a vector of variable into evenly spaced categories.</i>
---------------------	---

---

## Description

This function supplements [fun.nclass.e](#) and it is not intended to be used by the users directly.

## Usage

```
fun.disc.estimation(x, nint)
```

## Arguments

x	A vector of observations.
nint	Number of intervals to cut the vectors into.

## Details

The function cuts the vector into evenly spaced categories and estimate the mean and variance of the actual data based on the categorisation.

## Value

Two numerical values, the first being the mean and the second being the variance.

**Author(s)**

Steve Su

**See Also**[fun.nclass.e](#)**Examples**

```
## Cut up a randomly normally distributed observations into 5 evenly spaced
## categories and estimate the mean and variance based on this categorisation.
junk<-rnorm(1000,3,2)
fun.disc.estimation(junk,5)
```

---

`fun.gen.qrn`*Finds the low discrepancy quasi random numbers*

---

**Description**

This function calls the `link{runif.sobol}` and `runif.halton` from the **fOptions** package and `QUnif` from **sfsmisc** package.

**Usage**

```
fun.gen.qrn(n, dimension, scrambling, FUN = "runif.sobol")
```

**Arguments**

<code>n</code>	Number to generate.
<code>dimension</code>	Number of dimensions.
<code>scrambling</code>	Scrambling method used, or leap as in the case of <code>QUnif</code> .
<code>FUN</code>	This can be "runif.sobol" (default), "runif.halton" or "QUnif".

**Value**

A vector of values if `dimension=1`, otherwise a matrix of values between 0 and 1.

**Author(s)**

Steve Su

**References**

Bratley P., Fox B.L. (1988); Algorithm 659: Implementing Sobol's Quasirandom Sequence Generator, ACM Transactions on Mathematical Software 14, 88-100.

Joe S., Kuo F.Y. (1998); Remark on Algorithm 659: Implementing Sobol's Quasirandom Sequence Generator.

**See Also**

[link{runif.sobol}](#), [runif.halton](#), [QUnif](#)

**Examples**

```
fun.gen.qrn(1000,5,3,"runif.sobol")
```

```
fun.gen.qrn(1000,5,409,"QUnif")
```

---

fun.lm.theo.gld	<i>Find the theoretical first four L moments of the generalised lambda distribution.</i>
-----------------	--

---

**Description**

This function computes the first four L moments for both RS and FMKL generalised lambda distributions.

**Usage**

```
fun.lm.theo.gld(L1, L2, L3, L4, param)
```

**Arguments**

L1	Lambda 1. Or c(Lambda 1,Lambda 2,Lambda 3,Lambda 4).
L2	Lambda 2.
L3	Lambda 3.
L4	Lambda 4.
param	"rs" or "fmkl" or "fkml"

**Value**

A vector listing the first four L moments

**Note**

Sometimes the theoretical moments may not exist, in those cases, NA is returned.

**Author(s)**

Steve Su

**References**

Asquith, W. (2007). "L-moments and TL-moments of the generalized lambda distribution." *Computational Statistics and Data Analysis* 51(9): 4484-4496.

Karvanen, J. and A. Nuutinen (2008). "Characterizing the generalized lambda distribution by L-moments." *Computational Statistics and Data Analysis* 52(4): 1971-1983.

**See Also**[fun.theo.mv.gld](#)**Examples**

```
fun.lm.theo.gld(1, 2, 3, 4, "rs")
fun.lm.theo.gld(1, 2, 3, 4, "fmk1")
```

---

`fun.mApply`*Applying functions based on an index for a matrix.*

---

**Description**

This is a generic function that can be used to find mean, variance, sum or other operations according to some index imposed on the matrix or vector.

**Usage**

```
fun.mApply(X, INDEX, FUN = NULL, ..., simplify = TRUE)
```

**Arguments**

X	Matrix with n rows.
INDEX	Vector or list of vectors of length n.
FUN	Function to operate on submatrices of X by INDEX
...	Arguments to function.
simplify	Set as TRUE by default, see <a href="#">sapply</a> fo details.

**Value**

If FUN returns more than one number, fun.mApply returns a matrix with rows corresponding to unique values of INDEX.

**Author(s)**

Tony Plate

**Examples**

```
# Finding the row medians of a matrix (matrix(1:20,nrow=5))
fun.mApply(matrix(1:20,nrow=5),list(1:5),median)
```

---

fun.minmax.check.gld *Check whether the specified GLDs cover the minimum and the maximum values in a dataset*

---

### Description

This function checks the lowest and highest quantiles of the specified GLDs against the specified dataset

### Usage

```
fun.minmax.check.gld(data, lambdas, param, lessequalmin = 1,
  greaterequalmax = 1)
```

### Arguments

data	A vector of numerical dataset
lambdas	A matrix of four columns representing lambda 1 to lambda 4 of the GLD
param	Can be "rs", "fkml" or "fmkl"
lessequalmin	Can be 0 or 1
greaterequalmax	Can be 0 or 1

### Details

lessequalmin==1 means the lowest value of GLD  $\leq$  minimum value of data  
 lessequalmin==0 means the lowest value of GLD  $<$  minimum value of data  
 greaterequalmin==1 means the highest value of GLD  $\geq$  maximum value of data  
 greaterequalmin==0 means the highest value of GLD  $>$  maximum value of data

### Value

A vector of logical values indicating whether the specified data the specified GLDs cover the minimum and the maximum values in a dataset

### Author(s)

Steve Su

### Examples

```
fun.minmax.check.gld(runif(100, .9, 1), matrix(1:12, ncol=4), param="rs", 0, 0)
fun.minmax.check.gld(runif(100, .98, 1), matrix(1:12, ncol=4), param="fkml", 1, 1)
```

---

fun.moments.bimodal *Finds the moments of fitted mixture of generalised lambda distribution by simulation.*

---

### Description

This functions compute the mean, variance, skewness and kurtosis of the fitted generalised lambda distribution mixtures using Monte Carlo simulation.

### Usage

```
fun.moments.bimodal(result1, result2, prop1, prop2, len = 1000,  
no.test = 1000, param1, param2)
```

### Arguments

result1	A vector comprising four values for the first generalised lambda distribution.
result2	A vector comprising four values for the second generalised lambda distribution.
prop1	Proportion of the first generalised lambda distribution
prop2	1-prop1, this can be left unspecified.
len	Length of object for each simulation run.
no.test	Number of simulation run.
param1	This can be "rs" or "fmk1", specifying the type of the first generalised lambda distribution.
param2	This can be "rs" or "fmk1", specifying the type of the second generalised lambda distribution.

### Details

There is also a theoretical computation of the moments in [fun.theo.bi.mv.gld](#), it should be noted that the theoretical moments may not exist. The length of object in len means how many observations should be generated in each simulation run, with the number of simulation runs governed by no.test.

### Value

A matrix with four columns showing the mean, variance, skewness and kurtosis of the fitted generalised lambda distribution mixtures using Monte Carlo simulation. Each row represents a simulation run.

### Author(s)

Steve Su

**See Also**

[fun.theo.bi.mv.gld](#), [fun.simu.bimodal](#), [fun.rawmoments](#)

**Examples**

```
## Fitting the first column of the Old Faithful Geyser data
# fit1<-fun.auto.bimodal.ml(faithful[,1],init1.sel="rmfmk1",init2.sel="rmfmk1",
# init1=c(-0.25,1.5),init2=c(-0.25,1.5),leap1=3,leap2=3)

## After fitting compute the monte carlo moments using fun.moments.bimodal
# fun.moments.bimodal(fit1$par[1:4],fit1$par[5:8],prop1=fit1$par[9],
# param1="fmk1",param2="fmk1")

## It is also possible to compare this with the moments of the original dataset:
# fun.moments(faithful[,1])
```

---

fun.moments.r

*Calculate mean, variance, skewness and kurtosis of a numerical vector*

---

**Description**

This function evaluates the mean, variance, skewness and kurtosis of a numerical vector. Missing values are automatically removed.

**Usage**

```
fun.moments.r(x, normalise = "N")
```

**Arguments**

x	A numeric vector
normalise	"Y" if you want kurtosis to be calculated with reference to kurtosis = 0 under Normal distribution. Default is "N".

**Value**

A vector of mean, variance, skewness and kurtosis.

**Note**

Please contact the author directly if you find a bug!

**Author(s)**

Steve Su



**See Also**[fun.theo.mv.gld](#)**Examples**

```
fun.moments.r(rnorm(1000))
fun.moments.r(rnorm(1000),normalise="Y")
```

---

fun.nclass.e	<i>Estimates the number of classes or bins to smooth over in the discretised method of fitting generalised lambda distribution to data.</i>
--------------	---

---

**Description**

Support function for discretised method of fitting distribution to data.

**Usage**

```
fun.nclass.e(x)
```

**Arguments**

x                      Vector of data.

**Details**

This function calculates the mean and variance of the discretised data from 1 to the very last observation and chooses the best number of categories that represent the mean and variance of the actual data set through the criterion of squared deviations.

**Value**

A numerical value suggesting the best number of class that can be used to represent the mean and variance of the original data set.

**Note**

This is not designed to be called directly by end user.

**Author(s)**

Steve Su

**See Also**[fun.disc.estimation](#)

**Examples**

```
fun.nclass.e(rnorm(100,3,2))
```

---

fun.plot.fit	<i>Plotting the univariate generalised lambda distribution fits on the data set.</i>
--------------	--

---

**Description**

This function is designed for univariate generalised lambda distribution fits only.

**Usage**

```
fun.plot.fit(fit.obj, data, nclass = 50, xlab = "", name = "", param.vec,
ylab="Density", main="")
```

**Arguments**

fit.obj	Fitted object from <a href="#">fun.data.fit.ml</a> , <a href="#">fun.data.fit.hs</a> , <a href="#">fun.data.fit.hs.nw</a> , <a href="#">fun.RPRS.ml</a> , <a href="#">fun.RMFMKL.ml</a> , <a href="#">fun.RPRS.hs</a> , <a href="#">fun.RMFMKL.hs</a> , <a href="#">fun.RPRS.hs.nw</a> , <a href="#">fun.RMFMKL.hs.nw</a>
data	Dataset to be plotted.
nclass	Number of class of histogram, the default is 50.
xlab	Label on the x axis.
name	Naming the type of distribution fits.
param.vec	A vector describing the type of generalised lambda distribution used in the fit.obj.
ylab	Label on the y axis.
main	Title of the graph.

**Value**

A graphical output showing the data and the resulting distributional fits.

**Note**

If the distribution fits over fits the peak of the distribution, it can be difficult to see the actual data set.

**Author(s)**

Steve Su

**See Also**

[fun.plot.fit.bm](#), [fun.data.fit.ml](#), [fun.data.fit.hs](#), [fun.data.fit.hs.nw](#), [fun.RPRS.ml](#), [fun.RMFMKL.ml](#), [fun.RPRS.hs](#), [fun.RMFMKL.hs](#), [fun.RPRS.hs.nw](#), [fun.RMFMKL.hs.nw](#)

**Examples**

```
## Generate Normally distribute random numbers as dataset
# junk<-rnorm(1000,3,2)

## Fit the data set using fun.data.fit.ml.
## Also, fun.data.fit.hs or fun.data.fit.hs.nw can be used.
# obj.fit<-fun.data.fit.ml(junk)

## Plot the resulting fits
# fun.plot.fit(obj.fit,junk,xlab="x",name=".ML",param.vec=c("rs","fmk1","fmk1"))

## This function also works for singular fits such as those by fun.RPRS.ml,
## fun.RMFMKL.ml, fun.RPRS.hs, fun.RMFMKL.hs, fun.RPRS.hs.nw, fun.RMFMKL.hs.nw
# junk<-rnorm(1000,3,2)
# obj.fit<-fun.RPRS.ml(junk)
# fun.plot.fit(obj.fit,junk,xlab="x",name="RPRS.ML",param.vec=c("rs"))
```

---

fun.plot.fit.bm	<i>Plotting mixture of two generalised lambda distributions on the data set.</i>
-----------------	--

---

**Description**

This function is designed for mixture of two generalised lambda distributions only.

**Usage**

```
fun.plot.fit.bm(fit.obj, data, nclass = 50, xlab = "", name = "", main="",
param.vec, ylab="Density")
```

**Arguments**

fit.obj	Fitted object from <a href="#">fun.auto.bimodal.ml</a> , <a href="#">fun.auto.bimodal.pml</a>
data	Dataset to be plotted.
nclass	Number of class of histogram, the default is 50.
xlab	Label on the x axis.
name	Legend, usually used to identify type of GLD used if main is provided. If main is not provided, then this is used in the title.
main	Title of the graph.
param.vec	A vector describing the type of generalised lambda distribution used in the fit.obj.
ylab	Label on the y axis.

**Value**

A graphical output showing the data and the resulting distributional fits.

**Note**

If the distribution fits over fits the peak of the distribution, it can be difficult to see the actual data set.

**Author(s)**

Steve Su

**See Also**

[fun.auto.bimodal.ml](#), [fun.auto.bimodal.pml](#), [fun.plot.fit](#)

**Examples**

```
# par(mfrow=c(2,1))

## Fitting mixture of generalised lambda distributions on the data set using
## both the maximum likelihood and partition maximum likelihood and plot
## the resulting fits

# junk<-fun.auto.bimodal.ml(faithful[,1],per.of.mix=0.1,clustering.m=clara,
# init1.sel="rprs",init2.sel="rmfmkl",init1=c(-1.5,1,5),init2=c(-0.25,1,5),
# leap1=3,leap2=3)
# fun.plot.fit.bm(nclass=50,fit.obj=junk,data=faithful[,1],
# name="Maximum likelihood using",xlab="faithful1",param.vec=c("rs","fmkl"))

# junk<-fun.auto.bimodal.pml(faithful[,1],clustering.m=clara,init1.sel="rprs",
# init2.sel="rmfmkl",init1=c(-1.5,1,5),init2=c(-0.25,1,5),leap1=3,leap2=3)
# fun.plot.fit.bm(nclass=50,fit.obj=junk,data=faithful[,1],
# name="Partition maximum likelihood using",xlab="faithful1",
# param.vec=c("rs","fmkl"))

# junk<-fun.auto.bimodal.ml(faithful[,1],per.of.mix=0.1,clustering.m=clara,
# init1.sel="rprs",init2.sel="rmfmkl",init1=c(-1.5,1,5),init2=c(-0.25,1,5),
# leap1=3,leap2=3)
# fun.plot.fit.bm(nclass=50,fit.obj=junk,data=faithful[,1],
# main="Mixture distribution fit",
# name="RS and FMKL GLD",xlab="faithful1",param.vec=c("rs","fmkl"))
```

---

fun.plot.many.gld      *Plotting many univariate generalised lambda distributions on one page.*

---

### Description

This is a variant of the [fun.plot.fit](#) function.

### Usage

```
fun.plot.many.gld(fit.obj, data, xlab="", ylab="Density", main="", legd="",  
param.vec)
```

### Arguments

fit.obj	A matrix of generalised lambda distributions parameters from <a href="#">fun.data.fit.ml</a> , <a href="#">fun.data.fit.hs</a> , <a href="#">fun.data.fit.hs.nw</a> , <a href="#">fun.RPRS.ml</a> , <a href="#">fun.RFMKL.ml</a> , <a href="#">fun.RPRS.hs</a> , <a href="#">fun.RFMKL.hs</a> , <a href="#">fun.RPRS.hs.nw</a> , <a href="#">fun.RFMKL.hs.nw</a> functions. Or a matrix of generalised lambda distribution parameters.
data	Dataset to be plotted or two values showing the ranges of value to be compared.
xlab	X-axis labels.
ylab	Y-axis labels.
main	Title for the plot.
legd	Legend for the plot.
param.vec	A vector showing the types of generalised lambda distributions. This can be "rs" or "fmkl", only needed if you want to put your own parameters for generalised lambda distributions which are not generated from a fitting algorithm in this package.

### Value

A graph showing the different distributions on the same page.

### Note

The data part of the function is not plotted, to see the dataset use the [fun.plot.fit](#) function.

### Author(s)

Steve Su

### See Also

[fun.plot.fit](#), [fun.plot.fit.bm](#)

## Examples

```
## Fit the dataset
# junk<-rnorm(1000,3,2)
# result.hs<-fun.data.fit.hs(junk,rs.default = "Y", fmk1.default = "Y",
# rs.leap=3, fmk1.leap=3,rs.init = c(-1.5, 1.5), fmk1.init = c(-0.25, 1.5),
# no.c.rs=50,no.c.fmk1=50)

# par(mfrow=c(2,2))

## Plot the entire data range
# fun.plot.many.gld(result.hs,junk,"x","density","",
# legd=c("RPRS.hs", "RMFMKL.hs"))

## Plot and compare parts of the distributions
# fun.plot.many.gld(result.hs,c(1,2),"x","density","",legd=c("RPRS.hs",
#"RMFMKL.hs"))
# fun.plot.many.gld(result.hs,c(0.1,0,2),"x","density","",legd=c("RPRS.hs",
#"RMFMKL.hs"))
# fun.plot.many.gld(result.hs,c(3,4),"x","density","",legd=c("RPRS.hs",
#"RMFMKL.hs"))
```

---

fun.rawmoments	<i>Computes the raw moments of the generalised lambda distribution up to 4th order.</i>
----------------	---

---

## Description

This function is of theoretical interest only.

## Usage

```
fun.rawmoments(L1, L2, L3, L4, param = "fmk1")
```

## Arguments

L1	Location parameter of the generalised lambda distribution.
L2	Scale parameter of the generalised lambda distribution.
L3	First shape parameter of the generalised lambda distribution.
L4	Second shape parameter of the generalised lambda distribution.
param	"rs" or "fmk1" specifying the type of the generalised lambda distribution.

## Details

This function is the building block for [fun.theo.bi.mv.gld](#).

**Value**

A vector showing the raw moments of the specified generalised lambda distribution up to the fourth order.

**Author(s)**

Steve Su

**References**

Freimer, M., Mudholkar, G. S., Kollia, G. & Lin, C. T. (1988), A study of the generalized tukey lambda family, *Communications in Statistics - Theory and Methods* \*17\*, 3547-3567.

Karian, Zaven A. and Dudewicz, Edward J. (2000), *Fitting statistical distributions: the Generalized Lambda Distribution and Generalized Bootstrap methods*, Chapman & Hall

Ramberg, J. S. & Schmeiser, B. W. (1974), An approximate method for generating asymmetric random variables, *Communications of the ACM* \*17\*, 78-82.

**See Also**

~~objects to See Also as [help](#), ~~~

**Examples**

```
## Generate some random numbers using FMKL and RS generalised lambda
## distributions and then compute the empirical and theoretical
## E(X), E(X^2), E(X^3), E(X^4)

junk<-rgl(100000,1,2,3,4)
mean(junk)
mean(junk^2)
mean(junk^3)
mean(junk^4)

junk<-rgl(100000,1,2,3,4,"rs")
mean(junk)
mean(junk^2)
mean(junk^3)
mean(junk^4)

fun.rawmoments(1,2,3,4)
fun.rawmoments(1,2,3,4,"rs")
```

---

fun.RMFMKL.hs	<i>Fit FMKL generalised distribution to data using discretised approach with weights.</i>
---------------	---

---

### Description

This function fits FMKL generalised distribution to data using discretised approach with weights. It is designed to act as a smoother device rather than as a definitive fit.

### Usage

```
fun.RMFMKL.hs(data, default = "Y", fmk1.init = c(-0.25, 1.5), no.c.fmk1 = 50,
  leap = 3, FUN="runif.sobol", no=10000)
```

### Arguments

data	Dataset to be fitted
default	If yes, this function uses the default method <a href="#">fun.nclass.e</a> to calculate number of classes required.
fmk1.init	Initial values for FMKL distribution optimization, $c(-0.25, 1.5)$ tends to work well.
no.c.fmk1	Number of classes or bins of histogram to be optimized over. This argument is ineffective if default="Y".
leap	Scrambling (0,1,2,3) for the Sobol sequence for the distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
FUN	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif".
no	Number of initial random values to find the best initial values for optimisation.

### Details

This function optimises the deviations of frequency of the bins to that of the theoretical so it has the effect of "fitting clothes" onto the data set. The user can decide the frequency of the bins they want the distribution to smooth over. The resulting fit may or may not be an adequate fit from a formal statistical point of view such as satisfying the goodness of fit for example, but it can be useful to suggest the range of different distributions exhibited by the data set. The default number of classes calculates the mean and variance after categorising the data into different bins and uses the number of classes that best matches the mean and variance of the original, ungrouped data. The weighting is designed to accentuate the peak or the dense part of the distribution and suppress the tails.

### Value

A vector representing four parameters of the FMKL generalised lambda distribution.

### Note

In some cases, the resulting fit may not converge, there are currently no checking mechanism in place to ensure global convergence.



**Author(s)**

Steve Su

**References**

Su, S. (2005). A Discretized Approach to Flexibly Fit Generalized Lambda Distributions to Data. Journal of Modern Applied Statistical Methods (November): 408-424.

Su (2007). Fitting Single and Mixture of Generalized Lambda Distributions to Data via Discretized and Maximum Likelihood Methods: GLDEX in R. Journal of Statistical Software: \*21\* 9.

**See Also**

[fun.RMFMKL.hs.nw](#), [fun.RPRS.hs.nw](#), [fun.RPRS.hs](#), [fun.data.fit.hs](#), [fun.data.fit.hs.nw](#)

**Examples**

```
## Using the default number of classes
# fun.RMFMKL.hs(data=rnorm(1000,3,2),default="Y",fml.init=c(-0.25,1.5),leap=3)
## Using 20 classes
# fun.RMFMKL.hs(data=rnorm(1000,3,2),default="N",fml.init=c(-0.25,1.5),
# no.c.fml=20,leap=3)
```

---

fun.RMFMKL.hs.nw	<i>Fit FMKL generalised distribution to data using discretised approach without weights.</i>
------------------	--

---

**Description**

This function fits FMKL generalised distribution to data using discretised approach without weights. It is designed to act as a smoother device rather than as a definitive fit.

**Usage**

```
fun.RMFMKL.hs.nw(data, default = "Y", fml.init = c(-0.25, 1.5),
no.c.fml = 50, leap = 3, FUN="runif.sobol", no=10000)
```

**Arguments**

data	Dataset to be fitted
default	If yes, this function uses the default method <a href="#">fun.nclass.e</a> to calculate number of classes required.
fml.init	Initial values for FMKL distribution optimization, c(-0.25, 1.5) tends to work well.
no.c.fml	Number of classes or bins of histogram to be optimized over. This argument is ineffective if default="Y".

leap	Scrambling (0,1,2,3) for the Sobol sequence for the distribution fit. See scrambling/leap argument for <code>runif.sobol</code> , <code>runif.halton</code> or <code>QUnif</code> .
FUN	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif".
no	Number of initial random values to find the best initial values for optimisation.

### Details

This function optimises the deviations of frequency of the bins to that of the theoretical so it has the effect of "fitting clothes" onto the data set. The user can decide the frequency of the bins they want the distribution to smooth over. The resulting fit may or may not be an adequate fit from a formal statistical point of view such as satisfying the goodness of fit for example, but it can be useful to suggest the range of different distributions exhibited by the data set. The default number of classes calculates the mean and variance after categorising the data into different bins and uses the number of classes that best matches the mean and variance of the original, ungrouped data.

### Value

A vector representing four parameters of the FMKL generalised lambda distribution.

### Note

In some cases, the resulting fit may not converge, there are currently no checking mechanism in place to ensure global convergence.

### Author(s)

Steve Su

### References

Su, S. (2005). A Discretized Approach to Flexibly Fit Generalized Lambda Distributions to Data. *Journal of Modern Applied Statistical Methods* (November): 408-424.

Su (2007). Fitting Single and Mixture of Generalized Lambda Distributions to Data via Discretized and Maximum Likelihood Methods: GLDEX in R. *Journal of Statistical Software*: \*21\* 9.

### See Also

[fun.RPRS.hs.nw](#), [fun.RMFMKL.hs](#), [fun.RPRS.hs](#), [fun.data.fit.hs](#), [fun.data.fit.hs.nw](#)

### Examples

```
## Using the default number of classes
# fun.RMFMKL.hs.nw(data=rnorm(1000,3,2),default="Y",
# fmk1.init=c(-0.25,1.5),leap=3)
## Using 20 classes
# fun.RMFMKL.hs.nw(data=rnorm(1000,6,5),default="N",fmkl.init=c(-0.25,1.5),
# no.c.fmk1=20,leap=3)
```

---

fun.RMFMKL.lm	<i>Fit FMKL generalised lambda distribution to data set using L moment matching</i>
---------------	---

---

### Description

This function fits FMKL generalised lambda distribution to data set using L moment matching

### Usage

```
fun.RMFMKL.lm(data, fmk1.init = c(-0.25, 1.5), leap = 3, FUN = "runif.sobol",
no = 10000)
```

### Arguments

data	Dataset to be fitted
fmk1.init	Initial values for FMKL distribution optimization, c(-0.25, 1.5) tends to work well.
leap	Scrambling (0,1,2,3) for the Sobol sequence for the distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
FUN	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif".
no	Number of initial random values to find the best initial values for optimisation.

### Details

This function provides method of L moment fitting scheme for FMKL GLD. Note this function can fail if there are no defined percentiles from the data set or if the initial values do not lead to a valid FMKL generalised lambda distribution.

This function is based on scheme detailed in the literature below but it has been modified by the author (Steve Su).

### Value

A vector representing four parameters of the FMKL generalised lambda distribution.

### Author(s)

Steve Su

### References

- Asquith, W. (2007). "L-moments and TL-moments of the generalized lambda distribution." *Computational Statistics and Data Analysis* 51(9): 4484-4496.
- Karvanen, J. and A. Nuutinen (2008). "Characterizing the generalized lambda distribution by L-moments." *Computational Statistics and Data Analysis* 52(4): 1971-1983.

**See Also**

[fun.RMFMKL.ml](#), [fun.RMFMKL.mm](#), [fun.RMFMKL.qs](#), [fun.data.fit.ml](#) [fun.data.fit.lm](#), [fun.data.fit.qs](#), [fun.data.fit.mm](#)

**Examples**

```
## Fitting the normal distribution
# fun.RMFMKL.lm(data=rnorm(1000,2,3),fml.init=c(-0.25,1.5),leap=3)
```

---

fun.RMFMKL.ml	<i>Fit FMKL generalised lambda distribution to data set using maximum likelihood estimation</i>
---------------	---

---

**Description**

This function fits FMKL generalised lambda distribution to data set using maximum likelihood estimation.

**Usage**

```
fun.RMFMKL.ml(data, fml.init = c(-0.25, 1.5), leap = 3, FUN="runif.sobol",
no=10000)
```

**Arguments**

data	Dataset to be fitted
fml.init	Initial values for FMKL distribution optimization, c(-0.25, 1.5) tends to work well.
leap	Scrambling (0,1,2,3) for the Sobol sequence for the distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
FUN	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif".
no	Number of initial random values to find the best initial values for optimisation.

**Details**

This function provides one of the definitive fit to data set using generalised lambda distributions.

**Value**

A vector representing four parameters of the FMKL generalised lambda distribution.

**Author(s)**

Steve Su

**References**

Su, S. (2007). Numerical Maximum Log Likelihood Estimation for Generalized Lambda Distributions. *Journal of Computational statistics and data analysis* 51(8) 3983-3998.

Su (2007). Fitting Single and Mixture of Generalized Lambda Distributions to Data via Discretized and Maximum Likelihood Methods: GLDEX in R. *Journal of Statistical Software: \*21\* 9.*

**See Also**

[fun.RPRS.ml](#), [fun.data.fit.ml](#), [fun.data.fit.qs](#)

**Examples**

```
## Fitting the normal distribution
# fun.RMFMKL.ml(data=rnorm(1000,2,3),fml.init=c(-0.25,1.5),leap=3)
```

---

fun.RMFMKL.ml.m	<i>Fit RS generalised lambda distribution to data set using maximum likelihood estimation</i>
-----------------	---

---

**Description**

This function fits FMKL generalised lambda distribution to data set using maximum likelihood estimation using faster implementation through C programming

**Usage**

```
fun.RMFMKL.ml.m(data, fml.init = c(-0.25, 1.5), leap = 3, FUN = "runif.sobol",
no = 10000)
```

**Arguments**

data	Dataset to be fitted
fml.init	Initial values for FMKL distribution optimization, c(-0.25, 1.5) tends to work well.
leap	Scrambling (0,1,2,3) for the Sobol sequence for the distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
FUN	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif".
no	Number of initial random values to find the best initial values for optimisation.

**Details**

This function provides one of the definitive fit to data set using generalised lambda distributions.

**Value**

A vector representing four parameters of the FMKL generalised lambda distribution.

**Author(s)**

Steve Su

**References**

Su, S. (2007). Numerical Maximum Log Likelihood Estimation for Generalized Lambda Distributions. *Journal of Computational statistics and data analysis* 51(8) 3983-3998.

Su (2007). Fitting Single and Mixture of Generalized Lambda Distributions to Data via Discretized and Maximum Likelihood Methods: GLDEX in R. *Journal of Statistical Software: \*21\* 9.*

**See Also**

[fun.RFMKLM.ml](#)

**Examples**

```
## Fitting the normal distribution
# fun.RFMKLM.ml.m(data=rnorm(1000,2,3),fml.init=c(-0.25,1.5),leap=3)
```

---

fun.RFMKLM.m	<i>Fit FMKL generalised lambda distribution to data set using moment matching</i>
--------------	---

---

**Description**

This function fits FMKL generalised lambda distribution to data set using moment matching

**Usage**

```
fun.RFMKLM.m(data, fml.init = c(-0.25, 1.5), leap = 3, FUN = "runif.sobol",
no = 10000)
```

**Arguments**

data	Dataset to be fitted
fml.init	Initial values for FMKL distribution optimization, c(-0.25, 1.5) tends to work well.
leap	Scrambling (0,1,2,3) for the Sobol sequence for the distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
FUN	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif".
no	Number of initial random values to find the best initial values for optimisation.

**Details**

This function provides method of moment fitting scheme for FMKL GLD. Note this function can fail if there are no defined percentiles from the data set or if the initial values do not lead to a valid FMKL generalised lambda distribution.

This function is based on scheme detailed in the literature below but it has been modified by the author (Steve Su).

**Value**

A vector representing four parameter of the FMKL generalised lambda distribution.

**Author(s)**

Steve Su

**References**

Karian, Z. and E. Dudewicz (2000). Fitting Statistical Distributions: The Generalized Lambda Distribution and Generalised Bootstrap Methods. New York, Chapman and Hall.

**See Also**

[fun.RMFMKL.ml](#), [fun.RMFMKL.lm](#), [fun.RMFMKL.qs](#), [fun.data.fit.ml](#), [fun.data.fit.lm](#), [fun.data.fit.qs](#), [fun.data.fit.mm](#)

**Examples**

```
## Fitting the normal distribution
# fun.RMFMKL.mm(data=rnorm(1000,2,3),fml.init=c(-0.25,1.5),leap=3)
```

---

fun.RMFMKL.qs	<i>Fit FMKL generalised lambda distribution to data set using quantile matching</i>
---------------	---

---

**Description**

This function fits FMKL generalised lambda distribution to data set using quantile matching

**Usage**

```
fun.RMFMKL.qs(data, fml.init = c(-0.25, 1.5), leap = 3, FUN = "runif.sobol",
  trial.n = 100, len = 1000, type = 7, no = 10000)
```

**Arguments**

data	Dataset to be fitted
fmk1.init	Initial values for FMKL distribution optimization, $c(-0.25, 1.5)$ tends to work well.
leap	Scrambling (0,1,2,3) for the Sobol sequence for the distribution fit. See scrambling/leap argument for <code>runif.sobol</code> , <code>runif.halton</code> or <code>QUnif</code> .
FUN	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif".
trial.n	Number of evenly spaced quantile ranging from 0 to 1 to be used in the checking phase, to find the best set of initial values for optimisation, this is intended to be lower than len to speed up the fitting algorithm. Default is 100.
len	Number of evenly spaced quantile ranging from 0 to 1 to be used, default is 1000
type	Type of quantile to be used, default is 7, see <code>quantile</code>
no	Number of initial random values to find the best initial values for optimisation.

**Details**

This function provides quantile matching fitting scheme for FMKL GLD. Note this function can fail if there are no defined percentiles from the data set or if the initial values do not lead to a valid FMKL generalised lambda distribution.

**Value**

A vector representing four parameters of the FMKL generalised lambda distribution.

**Author(s)**

Steve Su

**References**

Su (2008). Fitting GLD to data via quantile matching method. (Book chapter to appear)

**See Also**

`fun.RMFMKL.ml`, `fun.RMFMKL.lm`, `fun.RMFMKL.mm`, `fun.data.fit.ml`, `fun.data.fit.lm`, `fun.data.fit.qs`, `fun.data.fit.mm`

**Examples**

```
## Fitting the normal distribution
# fun.RMFMKL.qs(data=rnorm(1000,2,3),fmk1.init=c(-0.25,1.5),leap=3)
```



---

fun.RPRS.hs	<i>Fit RS generalised distribution to data using discretised approach with weights.</i>
-------------	---

---

### Description

This function fits RS generalised distribution to data using discretised approach with weights. It is designed to act as a smoother device rather than as a definitive fit.

### Usage

```
fun.RPRS.hs(data, default = "Y", rs.init = c(-1.5, 1.5), no.c.rs = 50,
  leap = 3, FUN="runif.sobol", no=10000)
```

### Arguments

data	Dataset to be fitted
default	If yes, this function uses the default method <a href="#">fun.nclass.e</a> to calculate number of classes required.
rs.init	Initial values for RS distribution optimization, <code>c(-1.5, 1.5)</code> tends to work well.
no.c.rs	Number of classes or bins of histogram to be optimized over. This argument is ineffective if <code>default="Y"</code> .
leap	Scrambling (0,1,2,3) for the Sobol sequence for the distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
FUN	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif".
no	Number of initial random values to find the best initial values for optimisation.

### Details

This function optimises the deviations of frequency of the bins to that of the theoretical so it has the effect of "fitting clothes" onto the data set. The user can decide the frequency of the bins they want the distribution to smooth over. The resulting fit may or may not be an adequate fit from a formal statistical point of view such as satisfying the goodness of fit for example, but it can be useful to suggest the range of different distributions exhibited by the data set. The default number of classes calculates the mean and variance after categorising the data into different bins and uses the number of classes that best matches the mean and variance of the original, ungrouped data. The weighting is designed to accentuate the peak or the dense part of the distribution and suppress the tails.

### Value

A vector representing four parameters of the RS generalised lambda distribution.

### Note

In some cases, the resulting fit may not converge, there are currently no checking mechanism in place to ensure global convergence. The RPRS method can sometimes fail if there are no valid percentiles in the data set or if initial values do not give a valid distribution.

**Author(s)**

Steve Su

**References**

Su, S. (2005). A Discretized Approach to Flexibly Fit Generalized Lambda Distributions to Data. *Journal of Modern Applied Statistical Methods* (November): 408-424.

Su (2007). Fitting Single and Mixture of Generalized Lambda Distributions to Data via Discretized and Maximum Likelihood Methods: GLDEX in R. *Journal of Statistical Software*: \*21\* 9.

**See Also**

[fun.RPRS.hs.nw](#), [fun.RMFMKL.hs.nw](#), [fun.RMFMKL.hs](#), [fun.data.fit.hs](#), [fun.data.fit.hs.nw](#)

**Examples**

```
## Using the default number of classes
# fun.RPRS.hs(data=rnorm(1000,2,3),default="Y",rs.init=c(-1.5,1.5),leap=3)
## Using 20 classes
# fun.RPRS.hs(data=rnorm(1000,2,3),default="N",rs.init=c(-1.5,1.5),
# no.c.rs=20,leap=3)
```

---

fun.RPRS.hs.nw	<i>Fit RS generalised distribution to data using discretised approach without weights.</i>
----------------	--

---

**Description**

This function fits RS generalised distribution to data using discretised approach without weights. It is designed to act as a smoother device rather than as a definitive fit.

**Usage**

```
fun.RPRS.hs.nw(data, default = "Y", rs.init = c(-1.5, 1.5), no.c.rs = 50,
leap = 3, FUN="runif.sobol", no=10000)
```

**Arguments**

data	Dataset to be fitted
default	If yes, this function uses the default method <a href="#">fun.nclass.e</a> to calculate number of classes required.
rs.init	Initial values for RS distribution optimization, $c(-1.5, 1.5)$ tends to work well.
no.c.rs	Number of classes or bins of histogram to be optimized over. This argument is ineffective if default="Y".
leap	Scrambling (0,1,2,3) for the Sobol sequence for the distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
FUN	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif".
no	Number of initial random values to find the best initial values for optimisation.

**Details**

This function optimises the deviations of frequency of the bins to that of the theoretical so it has the effect of "fitting clothes" onto the data set. The user can decide the frequency of the bins they want the distribution to smooth over. The resulting fit may or may not be an adequate fit from a formal statistical point of view such as satisfying the goodness of fit for example, but it can be useful to suggest the range of different distributions exhibited by the data set. The default number of classes calculates the mean and variance after categorising the data into different bins and uses the number of classes that best matches the mean and variance of the original, ungrouped data.

**Value**

A vector representing four parameters of the RS generalised lambda distribution.

**Note**

In some cases, the resulting fit may not converge, there are currently no checking mechanism in place to ensure global convergence. The RPRS method can sometimes fail if there are no valid percentiles in the data set or if initial values do not give a valid distribution.

**Author(s)**

Steve Su

**References**

Su, S. (2005). A Discretized Approach to Flexibly Fit Generalized Lambda Distributions to Data. *Journal of Modern Applied Statistical Methods* (November): 408-424.

Su (2007). Fitting Single and Mixture of Generalized Lambda Distributions to Data via Discretized and Maximum Likelihood Methods: GLDEX in R. *Journal of Statistical Software*: \*21\* 9.

**See Also**

[fun.RPRS.hs.nw](#), [fun.RPRS.hs](#), [fun.RFMKL.hs](#), [fun.data.fit.hs](#), [fun.data.fit.hs.nw](#)

**Examples**

```
## Using the default number of classes
# fun.RPRS.hs.nw(data=rnorm(1000,3,2),default="Y",rs.init=c(-1.5,1.5),leap=3)
## Using 20 classes
# fun.RPRS.hs.nw(data=rnorm(1000,3,2),default="N",rs.init=c(-1.5,1.5),
# no.c.rs=20,leap=3)
```

---

fun.RPRS.lm	<i>Fit RS generalised lambda distribution to data set using L moment matching</i>
-------------	---

---

### Description

This function fits RS generalised lambda distribution to data set using L moment matching

### Usage

```
fun.RPRS.lm(data, rs.init = c(-1.5, 1.5), leap = 3, FUN = "runif.sobol",
no = 10000)
```

### Arguments

data	Dataset to be fitted
rs.init	Initial values for RS distribution optimization, $c(-1.5, 1.5)$ tends to work well.
leap	Scrambling (0,1,2,3) for the Sobol sequence for the distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
FUN	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif".
no	Number of initial random values to find the best initial values for optimisation.

### Details

This function provides method of L moment fitting scheme for RS GLD. Note this function can fail if there are no defined percentiles from the data set or if the initial values do not lead to a valid RS generalised lambda distribution.

This function is based on scheme detailed in the literature below but it has been modified by the author (Steve Su).

### Value

A vector representing four parameters of the RS generalised lambda distribution.

### Author(s)

Steve Su

### References

Asquith, W. (2007). "L-moments and TL-moments of the generalized lambda distribution." *Computational Statistics and Data Analysis* 51(9): 4484-4496.

Karvanen, J. and A. Nuutinen (2008). "Characterizing the generalized lambda distribution by L-moments." *Computational Statistics and Data Analysis* 52(4): 1971-1983.

**See Also**

[fun.RPRS.ml](#), [fun.RPRS.mm](#), [fun.RPRS.qs](#), [fun.data.fit.ml](#), [fun.data.fit.lm](#), [fun.data.fit.qs](#), [fun.data.fit.mm](#)

**Examples**

```
## Fitting the normal distribution
# fun.RPRS.lm(data=rnorm(1000,2,3),rs.init=c(-1.5,1.5),leap=3)
```

---

fun.RPRS.ml	<i>Fit RS generalised lambda distribution to data set using maximum likelihood estimation</i>
-------------	---

---

**Description**

This function fits RS generalised lambda distribution to data set using maximum likelihood estimation.

**Usage**

```
fun.RPRS.ml(data, rs.init = c(-1.5, 1.5), leap = 3, FUN="runif.sobol", no=10000)
```

**Arguments**

data	Dataset to be fitted
rs.init	Initial values for RS distribution optimization, <code>c(-1.5, 1.5)</code> tends to work well.
leap	Scrambling (0,1,2,3) for the Sobol sequence for the distribution fit. See scrambling/leap argument for <code>runif.sobol</code> , <code>runif.halton</code> or <code>QUnif</code> .
FUN	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif".
no	Number of initial random values to find the best initial values for optimisation.

**Details**

This function provides one of the definitive fit to data set using generalised lambda distributions. Note this function can fail if there are no defined percentiles from the data set or if the initial values do not lead to a valid RS generalised lambda distribution.

**Value**

A vector representing four parameters of the RS generalised lambda distribution.

**Author(s)**

Steve Su

**References**

Su, S. (2007). Numerical Maximum Log Likelihood Estimation for Generalized Lambda Distributions. *Computational statistics and data analysis* 51(8) 3983-3998.

Su (2007). Fitting Single and Mixture of Generalized Lambda Distributions to Data via Discretized and Maximum Likelihood Methods: GLDEX in R. *Journal of Statistical Software*: \*21\* 9.

**See Also**

[fun.RMFMKL.ml](#), [fun.data.fit.ml](#), [fun.data.fit.qs](#)

**Examples**

```
## Fitting the normal distribution
# fun.RPRS.ml(data=rnorm(1000,2,3),rs.init=c(-1.5,1.5),leap=3)
```

---

fun.RPRS.ml.m	<i>Fit RS generalised lambda distribution to data set using maximum likelihood estimation</i>
---------------	---

---

**Description**

This function fits RS generalised lambda distribution to data set using maximum likelihood estimation using faster implementation through C programming

**Usage**

```
fun.RPRS.ml.m(data, rs.init = c(-1.5, 1.5), leap = 3, FUN = "runif.sobol",
no = 10000)
```

**Arguments**

data	Dataset to be fitted
rs.init	Initial values for RS distribution optimization, c(-1.5,1.5) tends to work well.
leap	Scrambling (0,1,2,3) for the Sobol sequence for the distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
FUN	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif".
no	Number of initial random values to find the best initial values for optimisation.

**Details**

This function provides one of the definitive fit to data set using generalised lambda distributions. Note this function can fail if there are no defined percentiles from the data set or if the initial values do not lead to a valid RS generalised lambda distribution.

**Value**

A vector representing four parameters of the RS generalised lambda distribution.

**Author(s)**

Steve Su

**References**

Su, S. (2007). Numerical Maximum Log Likelihood Estimation for Generalized Lambda Distributions. *Computational statistics and data analysis* 51(8) 3983-3998.

Su (2007). Fitting Single and Mixture of Generalized Lambda Distributions to Data via Discretized and Maximum Likelihood Methods: GLDEX in R. *Journal of Statistical Software: \*21\* 9.*

**See Also**

[fun.RPRS.ml](#)

**Examples**

```
## Fitting the normal distribution
# fun.RPRS.ml.m(data=rnorm(1000,2,3),rs.init=c(-1.5,1.5),leap=3)
```

---

fun.RPRS.mm	<i>Fit RS generalised lambda distribution to data set using moment matching</i>
-------------	---

---

**Description**

This function fits RS generalised lambda distribution to data set using moment matching

**Usage**

```
fun.RPRS.mm(data, rs.init = c(-1.5, 1.5), leap = 3, FUN = "runif.sobol",
no = 10000)
```

**Arguments**

data	Dataset to be fitted
rs.init	Initial values for RS distribution optimization, c(-1.5,1.5) tends to work well.
leap	Scrambling (0,1,2,3) for the Sobol sequence for the distribution fit. See scrambling/leap argument for <a href="#">runif.sobol</a> , <a href="#">runif.halton</a> or <a href="#">QUnif</a> .
FUN	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif".
no	Number of initial random values to find the best initial values for optimisation.

**Details**

This function provides method of moment fitting scheme for RS GLD. Note this function can fail if there are no defined percentiles from the data set or if the initial values do not lead to a valid RS generalised lambda distribution.

This function is based on scheme detailed in the literature below but it has been modified by the author (Steve Su).

**Value**

A vector representing four parameters of the RS generalised lambda distribution.

**Author(s)**

Steve Su

**References**

Karian, Z. and E. Dudewicz (2000). Fitting Statistical Distributions: The Generalized Lambda Distribution and Generalised Bootstrap Methods. New York, Chapman and Hall.

**See Also**

[fun.RPRS.ml](#), [fun.RPRS.lm](#), [fun.RPRS.qs](#), [fun.data.fit.ml](#) [fun.data.fit.lm](#), [fun.data.fit.qs](#), [fun.data.fit.mm](#)

**Examples**

```
## Fitting the normal distribution
# fun.RPRS.mm(data=rnorm(1000,2,3),rs.init=c(-1.5,1.5),leap=3)
```

---

fun.RPRS.qs	<i>Fit RS generalised lambda distribution to data set using quantile matching</i>
-------------	---

---

**Description**

This function fits RS generalised lambda distribution to data set using quantile matching

**Usage**

```
fun.RPRS.qs(data, rs.init = c(-1.5, 1.5), leap = 3, FUN = "runif.sobol",
  trial.n = 100, len = 1000, type = 7, no = 10000)
```

**Arguments**

data	Dataset to be fitted
rs.init	Initial values for RS distribution optimization, <code>c(-1.5, 1.5)</code> tends to work well.
leap	Scrambling (0,1,2,3) for the Sobol sequence for the distribution fit. See scrambling/leap argument for <code>runif.sobol</code> , <code>runif.halton</code> or <code>QUnif</code> .
FUN	A character string of either "runif.sobol" (default), "runif.halton" or "QUnif".
trial.n	Number of evenly spaced quantile ranging from 0 to 1 to be used in the checking phase, to find the best set of initial values for optimisation, this is intended to be lower than len to speed up the fitting algorithm. Default is 100.
len	Number of evenly spaced quantile ranging from 0 to 1 to be used, default is 1000
type	Type of quantile to be used, default is 7, see <code>quantile</code>
no	Number of initial random values to find the best initial values for optimisation.



**Details**

This function provides quantile matching fitting scheme for RS GLD. Note this function can fail if there are no defined percentiles from the data set or if the initial values do not lead to a valid RS generalised lambda distribution.

**Value**

A vector representing four parameters of the RS generalised lambda distribution.

**Author(s)**

Steve Su

**References**

Su (2008). Fitting GLD to data via quantile matching method. (Book chapter to appear)

**See Also**

[fun.RPRS.ml](#), [fun.RPRS.lm](#), [fun.RPRS.mm](#), [fun.data.fit.ml](#) [fun.data.fit.lm](#), [fun.data.fit.qs](#), [fun.data.fit.mm](#)

**Examples**

```
## Fitting the normal distribution
# fun.RPRS.qs(data=rnorm(1000,2,3),rs.init=c(-1.5,1.5),leap=3)
```

---

fun.simu.bimodal      *Simulate a mixture of two generalised lambda distributions.*

---

**Description**

This function allows the user to simulate observations from a mixture of two generalised lambda distributions. It can be very useful for sensitivity analysis.

**Usage**

```
fun.simu.bimodal(result1, result2, prop1, prop2, len = 1000,
no.test = 1000, param1, param2)
```

**Arguments**

result1	A vector comprising four values for the first generalised lambda distribution.
result2	A vector comprising four values for the second generalised lambda distribution.
prop1	Proportion of the first generalised lambda distribution
prop2	1-prop1, this can be left unspecified.
len	Length of object for each simulation run.

no.test	Number of simulation run.
param1	This can be "rs" or "fmkl", specifying the type of the first generalised lambda distribution.
param2	This can be "rs" or "fmkl", specifying the type of the second generalised lambda distribution.

### Details

The length of object in len means how many observations should be generated in each simulation run, with the number of simulation runs governed by no.test.

### Value

A list with length equal to the number of simulation runs. Each subset of the list has random observations equal to the the number specified in len.

### Author(s)

Steve Su

### See Also

[fun.theo.bi.mv.gld](#), [fun.moments.bimodal](#), [fun.rawmoments](#)

### Examples

```
# Generate random observations from FMKL generalised lambda distributions with
# parameters (1,2,3,4) and (4,3,2,1) with 50% of data from each distribution.
junk<-fun.simu.bimodal(c(1,2,3,4),c(4,3,2,1),prop1=0.5,param1="fmkl",
param2="fmkl")

# Calculate the maximum number from each simulation run
sapply(junk,max)

# Calculate the median from each simulation run
sapply(junk,median)
```

---

fun.theo.bi.mv.gld	<i>Calculates the theoretical mean, variance, skewness and kurtosis for mixture of two generalised lambda distributions.</i>
--------------------	--

---

### Description

This is the bimodal counterpart for [fun.comp.moments.ml.2](#) and [fun.comp.moments.ml](#).

### Usage

```
fun.theo.bi.mv.gld(L1, L2, L3, L4, param1, M1, M2, M3, M4, param2, p1,
normalise="N")
```

**Arguments**

L1	Location parameter of the first generalised lambda distribution. Or all the parameters of mixture distribution in the form of c(L1,L2,L3,L4,M1,M2,M3,M4,p), you still must specify param1 and param2.
L2	Scale parameter of the first generalised lambda distribution.
L3	First shape parameter of the first generalised lambda distribution.
L4	Second shape parameter of the first generalised lambda distribution.
param1	"rs" or "fmk1" specifying the type of the first generalised lambda distribution.
M1	Location parameter of the second generalised lambda distribution
M2	Scale parameter of the second generalised lambda distribution.
M3	First shape parameter of the second generalised lambda distribution.
M4	Second shape parameter of the second generalised lambda distribution.
param2	"rs" or "fmk1" specifying the type of the second generalised lambda distribution.
p1	Proportion of the first generalised lambda distribution.
normalise	"Y" if you want kurtosis to be calculated with reference to kurtosis = 0 under Normal distribution.

**Value**

A vector showing the theoretical mean, variance, skewness and kurtosis for mixture of two generalised lambda distributions.

**Note**

The theoretical moments may not always exist for generalised lambda distributions.

**Author(s)**

Steve Su

**References**

- Freimer, M., Mudholkar, G. S., Kollia, G. & Lin, C. T. (1988), A study of the generalized tukey lambda family, *Communications in Statistics - Theory and Methods* \*17\*, 3547-3567.
- Karian, Zaven A. and Dudewicz, Edward J. (2000), *Fitting statistical distributions: the Generalized Lambda Distribution and Generalized Bootstrap methods*, Chapman & Hall
- Ramberg, J. S. & Schmeiser, B. W. (1974), An approximate method for generating asymmetric random variables, *Communications of the ACM* \*17\*, 78-82.

**See Also**

[fun.moments.bimodal](#), [fun.simu.bimodal](#), [fun.rawmoments](#)

**Examples**

```
## Fits the Old Faithful geyser data (first column) using the maximum
## likelihood.
# fit1<-fun.auto.bimodal.ml(faithful[,1],init1.sel="rmfkm1",init2.sel="rmfkm1",
# init1=c(-0.25,1.5),init2=c(-0.25,1.5),leap1=3,leap2=3)

## Find the theoretical moments of the fit
# fun.theo.bi.mv.gld(fit1$par[1],fit1$par[2],fit1$par[3],fit1$par[4],"fkm1",
# fit1$par[5],fit1$par[6],fit1$par[7],fit1$par[8],"fkm1",fit1$par[9])

## Compare this with the empirical moments from the data set.
# fun.moments(faithful[,1])
```

---

fun.theo.mv.gld	<i>Find the theoretical first four moments of the generalised lambda distribution.</i>
-----------------	--

---

**Description**

Computes the "mean","variance","skewness","kurtosis" statistics from a given generalised lambda distribution.

**Usage**

```
fun.theo.mv.gld(L1, L2, L3, L4, param, normalise="N")
```

**Arguments**

L1	Lambda 1. Or c(Lambda 1,Lambda 2,Lambda 3,Lambda 4).
L2	Lambda 2.
L3	Lambda 3.
L4	Lambda 4.
param	"rs" or "fkm1" or "fkml"
normalise	"Y" if you want kurtosis to be calculated with reference to kurtosis = 0 under Normal distribution.

**Value**

A vector listing the values of mean, variance, skewness and kurtosis.

**Note**

Sometimes the theoretical moments may not exist, in those cases, NA is returned.

**Author(s)**

Steve Su

## References

Freimer, M., Mudholkar, G. S., Kollia, G. & Lin, C. T. (1988), A study of the generalized tukey lambda family, Communications in Statistics - Theory and Methods \*17\*, 3547-3567.

Gilchrist, Warren G. (2000), Statistical Modelling with Quantile Functions, Chapman & Hall

Karian, Z.A., Dudewicz, E.J., and McDonald, P. (1996), The extended generalized lambda distribution system for fitting distributions to data: history, completion of theory, tables, applications, the "Final Word" on Moment fits, Communications in Statistics - Simulation and Computation \*25\*, 611-642.

Karian, Zaven A. and Dudewicz, Edward J. (2000), Fitting statistical distributions: the Generalized Lambda Distribution and Generalized Bootstrap methods, Chapman & Hall

## See Also

[fun.comp.moments.ml](#), [fun.comp.moments.ml.2](#), [fun.lm.theo.gld](#)

## Examples

```
fun.theo.mv.gld(1, 2, 3, 4, "rs")
fun.theo.mv.gld(1, 2, 3, 4, "fmk1")
```

---

fun.which.zero	<i>Determine which values are zero.</i>
----------------	---

---

## Description

Returns an integer vector showing the position of zero values in the data.

## Usage

```
fun.which.zero(data)
```

## Arguments

data            A vector of data.

## Value

An integer vector showing the position of zero values in the data.

## Note

Any missing values will be returned as missing.

## Author(s)

Steve Su

**See Also**[fun.zero.omit](#)**Examples**

```
# Finding where the zeros are in this vector: c(0,1,2,3,4,0,2)
fun.which.zero(c(0,1,2,3,4,0,2))
# Finding where the zeros are in this vector: c(0,1,2,3,NA,0,2)
fun.which.zero(c(0,1,2,3,NA,0,2))
```

---

fun.zero.omit	<i>Returns a vector after removing all the zeros.</i>
---------------	---

---

**Description**

This function returns a vector after removing all the zeros.

**Usage**

```
fun.zero.omit(object)
```

**Arguments**

object            A vector of data.

**Value**

Returns a vector after removing zeros and also give information on the number of zeros in the data removed.

**Note**

Missing value and Inf values are not removed in this zero removing process.

**Author(s)**

Steve Su

**See Also**[fun.which.zero](#)**Examples**

```
# Removing zero entries from the vector c(0,1,2,3,4,0,2)
fun.zero.omit(c(0,1,2,3,4,0,2))
```

---

gl.check.lambda.alt     *Checks whether the parameters provided constitute a valid generalised lambda distribution.*

---

### Description

An alternative to the `gl.check.lambda` function in **gld** package.

### Usage

```
gl.check.lambda.alt(l1, l2, l3, l4, param = "fml")
```

### Arguments

l1	Lambda 1.
l2	Lambda 2.
l3	Lambda 3.
l4	Lambda 4.
param	"rs" or "fml" generalised lambda distribution.

### Details

This version differs from `gl.check.lambda` in **gld** library.

### Value

A logical value, TRUE or FALSE. TRUE indicates the parameters given is a valid probability distribution.

### Author(s)

Steve Su

### References

- Freimer, M., Mudholkar, G. S., Kollia, G. & Lin, C. T. (1988), A study of the generalized tukey lambda family, *Communications in Statistics - Theory and Methods* \*17\*, 3547-3567.
- Karian, Z.E., Dudewicz, E.J., and McDonald, P. (1996), The extended generalized lambda distribution system for fitting distributions to data: history, completion of theory, tables, applications, the "Final Word" on Moment fits, *Communications in Statistics - Simulation and Computation* \*25\*, 611-642.
- Ramberg, J. S. & Schmeiser, B. W. (1974), An approximate method for generating asymmetric random variables, *Communications of the ACM* \*17\*, 78-82.

### See Also

[gl.check.lambda.alt1](#)

**Examples**

```
gl.check.lambda.alt(0,1,.23,4.5,param="fmkl") ## TRUE
gl.check.lambda.alt(0,-1,.23,4.5,param="fmkl") ## FALSE
gl.check.lambda.alt(0,1,0.5,-0.5,param="rs") ## FALSE
```

---

gl.check.lambda.alt1     *Checks whether the parameters provided constitute a valid generalised lambda distribution.*

---

**Description**

A replacement to the gl.check.lambda function in **gld** package.

**Usage**

```
gl.check.lambda.alt1(l1, l2 = NULL, l3 = NULL, l4 = NULL,
  param = "fmkl", vect = FALSE)
```

**Arguments**

l1	Lambda 1.
l2	Lambda 2.
l3	Lambda 3.
l4	Lambda 4.
param	"rs" or "fmkl" generalised lambda distribution.
vect	A logical, set this to TRUE if the parameters are given in the vector form (it turns off checking of the format of 'lambdas' and the other lambda arguments)

**Details**

This is a modified gl.check.lambda function in replace of **gld** library's gl.check.lambda function to allow for 5 parameters FMKL distributions and vector input of parameter values into this function.

**Value**

A logical value, TRUE or FALSE. TRUE indicates the parameters given is a valid probability distribution.

**Author(s)**

Steve Su



## References

Freimer, M., Mudholkar, G. S., Kollia, G. & Lin, C. T. (1988), A study of the generalized tukey lambda family, *Communications in Statistics - Theory and Methods* \*17\*, 3547-3567.

Karian, Z.E., Dudewicz, E.J., and McDonald, P. (1996), The extended generalized lambda distribution system for fitting distributions to data: history, completion of theory, tables, applications, the “Final Word” on Moment fits, *Communications in Statistics - Simulation and Computation* \*25\*, 611-642.

Ramberg, J. S. & Schmeiser, B. W. (1974), An approximate method for generating asymmetric random variables, *Communications of the ACM* \*17\*, 78-82.

## See Also

[gl.check.lambda.alt](#)

## Examples

```
gl.check.lambda.alt1(c(0,1,.23,4.5),param="fmk1",vect=TRUE)
## TRUE, Using vector input of parameter values.
gl.check.lambda.alt1(0,-1,.23,4.5,param="fmk1") ## FALSE
gl.check.lambda.alt1(0,1,0.5,-0.5,param="rs") ## FALSE
```

---

GLD functions

*The Generalised Lambda Distribution Family*

---

## Description

Density, quantile density, distribution function, quantile function and random generation for the generalised lambda distribution (also known as the asymmetric lambda, or Tukey lambda). Works for both the “fmk1” and “rs” parameterisations. These functions originate from the **gld** library by Robert King and they are modified in this package to allow greater functionality and adaptability to new fitting methods. It does not give an error message for invalid distributions but will return NAs instead. To allow comparability with the `pkg(gld)` package, this package uses the same notation and description as those written by Robert King.

## Usage

```
dgl(x, lambda1 = 0, lambda2 = NULL, lambda3 = NULL, lambda4 = NULL,
    param = "fmk1", inverse.eps = 1e-08,
    max.iterations = 500)
pgl(q, lambda1 = 0, lambda2 = NULL, lambda3 = NULL, lambda4 = NULL,
    param = "fmk1", inverse.eps = 1e-08,
    max.iterations = 500)
qgl(p, lambda1, lambda2 = NULL, lambda3 = NULL, lambda4 = NULL,
    param = "fmk1")
rgl(n, lambda1=0, lambda2 = NULL, lambda3 = NULL, lambda4 = NULL,
    param = "fmk1")
```

**Arguments**

x	Vector of actual values for <code>dgl</code>
p	Vector of probabilities for <code>qgl</code> or <code>qdg1</code>
q	Vector of quantiles for <code>pgl</code>
n	Number of observations to be generated for <code>rgl</code>
lambda1	This can be either a single numeric value or a vector. If it is a vector, it must be of length 4 for parameterisations "fmk1" or "rs" and of length 5 for parameterisation "fm5" and the other 'lambda' arguments must be left as NULL. The numbering of the lambda parameters for the "fmk1" parameterisation is different to that used by Freimer, Mudholkar, Kollia and Lin (1988).
lambda2	Scale parameter
lambda3	First shape parameter
lambda4	Second shape parameter
param	"fmk1" or "fkm1" uses Freimer, Kollia, Mudholkar, and Lin (1988) and it is the default setting. "rs" uses Ramberg and Schmeiser (1974)
inverse.eps	Accuracy of calculation for the numerical determination of F(x), defaults to 1e-8
max.iterations	Maximum number of iterations in the numerical determination of F(x), defaults to 500

**Details**

The generalised lambda distribution, also known as the asymmetric lambda, or Tukey lambda distribution, is a distribution with a wide range of shapes. The distribution is defined by its quantile function, the inverse of the distribution function. The 'gld' package implements three parameterisations of the distribution. The default parameterisation (the FMKL) is that due to Freimer Mudholkar, Kollia and Lin (1988) (see references below), with a quantile function:

$$F^{-1}(u) = \lambda_1 + \frac{\frac{u^{\lambda_3} - 1}{\lambda_3} - \frac{(1-u)^{\lambda_4} - 1}{\lambda_4}}{\lambda_2}$$

for  $\lambda_2 > 0$ .

A second parameterisation, the RS, chosen by setting `param="rs"` is that due to Ramberg and Schmeiser (1974), with the quantile function:

$$F^{-1}(u) = \lambda_1 + \frac{u^{\lambda_3} - (1-u)^{\lambda_4}}{\lambda_2}$$

This parameterisation has a complex series of rules determining which values of the parameters produce valid statistical distributions. See `gl.check.lambda` for details.

**Value**

<code>dgl</code>	gives the density (based on the quantile density and a numerical solution to $F^{-1}(u) = x$ ,
<code>qdg1</code>	gives the quantile density,

pgl	gives the distribution function (based on a numerical solution to $F^{-1}(u) = x$ ,
qgl	gives the quantile function, and
rgl	generates random observations.

## References

- Freimer, M., Kollia, G., Mudholkar, G. S. & Lin, C. T. (1988), A study of the generalized tukey lambda family, *Communications in Statistics - Theory and Methods* \*17\*, 3547-3567.
- Gilchrist, Warren G. (2000), *Statistical Modelling with Quantile Functions*, Chapman & Hall
- Karian, Z.A., Dudewicz, E.J., and McDonald, P. (1996), The extended generalized lambda distribution system for fitting distributions to data: history, completion of theory, tables, applications, the "Final Word" on Moment fits, *Communications in Statistics - Simulation and Computation* \*25\*, 611-642.
- Karian, Zaven A. and Dudewicz, Edward J. (2000), *Fitting statistical distributions: the Generalized Lambda Distribution and Generalized Bootstrap methods*, Chapman & Hall
- Ramberg, J. S. & Schmeiser, B. W. (1974), An approximate method for generating asymmetric random variables, *Communications of the ACM* \*17\*, 78-82.

## Examples

```
qgl(seq(0,1,0.02),0,1,0.123,-4.3)
pgl(seq(-2,2,0.2),0,1,-.1,-.2,param="fml",inverse.eps=.Machine$double.eps)
```

---

histsu *Histogram with exact number of bins specified by the user*

---

## Description

The generic function histsu computes a histogram of the given data values.

## Usage

```
histsu(x, breaks = "Sturges", freq = NULL, probability = !freq,
include.lowest = TRUE, right = TRUE, density = NULL, angle = 45, col = NULL,
border = NULL, main = paste("Histogram of", xname), xlim = range(breaks),
ylim = NULL, xlab = xname, ylab, axes = TRUE, plot = TRUE, labels = FALSE,
nclass = NULL, ...)
```

## Arguments

- |        |   |
|--------|---|
| x      | A vector of values for which the histogram is desired.  |
| breaks | Either: 1) A vector giving the breakpoints between histogram cells, OR 2) A single number giving the number of cells for the histogram, OR 3) A character string naming an algorithm to compute the number of cells (see Details), OR 4) A function to compute the number of cells. |

freq	logical; if TRUE, the histogram graphic is a representation of frequencies, the counts component of the result; if FALSE, probability densities, component 'density', are plotted (so that the histogram has a total area of one). Defaults to TRUE iff 'breaks' are equidistant (and 'probability' is not specified).
probability	A logical value, TRUE means it is not a frequency graph.
include.lowest	If TRUE, an $x[i]$ equal to the 'breaks' value will be included in the first (or last, for <code>right=FALSE</code> ) bar. This will be ignored (with a warning) unless 'breaks' is a vector.
right	If TRUE, the histograms cells are right-closed (left open) intervals.
density	The density of shading lines, in lines per inch. The default value of NULL means that no shading lines are drawn. Non-positive values of 'density' also inhibit the drawing of shading lines.
angle	The slope of shading lines, given as an angle in degrees (counter-clockwise).
col	A colour to be used to fill the bars. The default of NULL yields unfilled bars.
border	The color of the border around the bars. The default is to use the standard foreground color.
main	Title of the graph.
xlim	A two valued vector specifying the lower and upper limits of the x axis.
ylim	A two valued vector specifying the lower and upper limits of the y axis.
xlab	X axis labels.
ylab	Y axis labels.
axes	Logical value, if TRUE, axis will be drawn.
plot	Logical value, if TRUE, plot will be drawn.
labels	Logical or character. Additionally draw labels on top of bars, if not FALSE; see <a href="#">plot.histogram</a> .
nclass	Number of bins of the histogram.
...	Other graphical parameters, see par for details.

### Details

See [hist](#) help file. This function forces the number of class of histogram to that as specified by the user.

### Value

An object of class "histogram" which is a list with components:

breaks	The $n+1$ cell boundaries (=breaks if that was a vector).
counts	$N$ integers; for each cell, the number of $x[]$ inside.
density	Values as estimated density values. If <code>all(diff(breaks) == 1)</code> , they are the relative frequencies counts/ $n$ .
intensities	Same as density, deprecated.
mids	The $n$ cell midpoints.
xname	A character string with the actual $x$ argument name.
equidist	Logical, indicating if the distances between breaks are all the same.

**Note**

Please see hist help file.

**Author(s)**

R development team with modifications by Steve Su

**References**

Venables, W. N. and Ripley. B. D. (2002) Modern Applied Statistics with S. Springer.

**See Also**

[hist](#)

**Examples**

```
# See hist for extended example:
junk<-rgamma(1000,5)
# Forcing the number of bins to be 10:
histsu(junk,nclass=10)
```

---

is.inf

*Returns a logical vector, TRUE if the value is Inf or -Inf.*

---

**Description**

This function works in similar fashion as in [is.na](#) and [is.notinf](#).

**Usage**

```
is.inf(x)
```

**Arguments**

x                    A numerical value or a vector of data.

**Value**

A logical vector, T if the value is Inf or -Inf.

**Note**

In the presence of missing value, the function will return a missing value.

**Author(s)**

Steve Su

**See Also**

[is.na](#), [is.notinf](#)

**Examples**

```
is.inf(c(Inf,2,2,1,-Inf))
```

---

is.notinf

*Returns a logical vector TRUE, if the value is not Inf or -Inf.*

---

**Description**

This function works in similar fashion as in [is.na](#) and [is.inf](#).

**Usage**

```
is.notinf(x)
```

**Arguments**

x                    A numerical value or a vector of data.

**Value**

A logical vector, T if the value is not Inf or -Inf.

**Note**

In the presence of missing value, the function will return a missing value.

**Author(s)**

Steve Su

**See Also**

[is.na](#), [is.inf](#)

**Examples**

```
is.notinf(c(Inf,2,2,1,-Inf))
```

ks.gof

*Kolmogorov-Smirnov test***Description**

Performs one or two sample Kolmogorov-Smirnov tests.

**Usage**

```
ks.gof(x, y, ..., alternative = c("two.sided", "less", "greater"),
exact = NULL)
```

**Arguments**

x	A numeric vector of data values.
y	Either a numeric vector of data values, or a character string naming a distribution function.
...	Parameters of the distribution specified (as a character string) by 'y'.
alternative	Indicates the alternative hypothesis and must be one of "two.sided" (default), "less", or "greater". You can specify just the initial letter.
exact	NULL or a logical indicating whether an exact p-value should be computed. See Details for the meaning of NULL. Not used for the one-sided two-sample case.

**Details**

If y is numeric, a two-sample test of the null hypothesis that x and y were drawn from the same continuous distribution is performed.

Alternatively, y can be a character string naming a continuous distribution function. In this case, a one-sample test is carried out of the null that the distribution function which generated x is distribution y with parameters specified by "...".

The possible values "two.sided" (default), "less" and "greater" of alternative specify the null hypothesis that the true distribution function of x is equal to, not less than or not greater than the hypothesized distribution function (one-sample case) or the distribution function of y (two-sample case), respectively.

Exact p-values are not available for the one-sided two-sample case, or in the case of ties. exact = NULL (the default), an exact p-value is computed if the sample size is less than 100 in the one-sample case, and if the product of the sample sizes is less than 10000 in the two-sample case. Otherwise, asymptotic distributions are used whose approximations may be inaccurate in small samples. In the one-sample two-sided case, exact p-values are obtained as described in Marsaglia, Tsang & Wang (2003). The formula of Birnbaum & Tingey (1951) is used for the one-sample one-sided case.

If a single-sample test is used, the parameters specified in "... " must be pre-specified and not estimated from the data. There is some more refined distribution theory for the KS test with estimated parameters (see Durbin, 1973), but that is not implemented in ks.gof.

**Value**

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

statistic	Value of test statistics.
p.value	P-value.
alternative	Character string describing the alternative hypothesis.
method	Character string indicating what type of test was performed.
data.name	Character string giving the name(s) of the data.

**Note**

This function handle ties by jittering, adding a very small uniform random number generated from the minimal value of the data set divided by  $1e+08$  to minimal value divided by  $1e+07$ .

**Author(s)**

R

**References**

Z. W. Birnbaum & Fred H. Tingey (1951), One-sided confidence contours for probability distribution functions. *The Annals of Mathematical Statistics*, \*22\*/4, 592-596.

William J. Conover (1971), *Practical nonparametric statistics*. New York: John Wiley & Sons. Pages 295-301 (one-sample "Kolmogorov" test), 309-314 (two-sample "Smirnov" test).

Durbin, J. (1973) *Distribution theory for tests based on the sample distribution function*. SIAM.

George Marsaglia, Wai Wan Tsang & Jingbo Wang (2003), Evaluating Kolmogorov's distribution. *Journal of Statistical Software*, \*8\*/18. <URL: <http://www.jstatsoft.org/v08/i18/>>.

**See Also**

[ks.test](#)

**Examples**

```
x <- rnorm(50)
y <- runif(30)
# Do x and y come from the same distribution?
ks.gof(x, y)
# Does x come from a shifted gamma distribution with shape 3 and rate 2?
ks.gof(x+2, "pgamma", 3, 2) # two-sided, exact
ks.gof(x+2, "pgamma", 3, 2, exact = FALSE)
ks.gof(x+2, "pgamma", 3, 2, alternative = "gr")
```



Lmoments

*L-moments***Description**

Calculates sample L-moments, L-coefficients and covariance matrix of L-moments.

**Usage**

```
Lmoments(data, rmax=4, na.rm=FALSE, returnobject=FALSE, trim=c(0,0))
Lcoefs(data, rmax=4, na.rm=FALSE, trim=c(0,0))
Lmomcov(data, rmax=4, na.rm=FALSE)
Lmoments_calc(data, rmax=4)
Lmomcov_calc(data, rmax=4)
```

**Arguments**

data	matrix or data frame.
rmax	maximum order of L-moments.
na.rm	a logical value indicating whether 'NA' values should be removed before the computation proceeds.
returnobject	a logical value indicating whether a list object should be returned instead of an array of L-moments.
trim	c(0,0) for ordinary L-moments and c(1,1) for trimmed (t=1) L-moments

**Value**

Lmoments	returns an array of L-moments containing a row for each variable in data, or if returnobject=TRUE, a list containing the following:
lambdas	an array of L-moments
ratios	an array of mean, L-scale and L-moment ratios
trim	the value of the parameter 'trim'
source	a string with value "Lmoments" or "t1lmoments"
Lcoefs	returns an array of L-coefficients (mean, L-scale, L-skewness, L-kurtosis, ...)
Lmomcov	returns the covariance matrix of L-moments or a list of covariance matrices if the input has multiple columns.
Lmoments_calc	is internal function.
Lmomcov_calc	is internal function.

**Note**

Functions Lmoments and Lcoefs calculate trimmed L-moments if you specify trim=c(1,1).

**Author(s)**

Juha Karvanen <<juha.karvanen@ktl.fi>>

**References**

- Karvanen, J. and A. Nuutinen (2008). "Characterizing the generalized lambda distribution by L-moments." *Computational Statistics and Data Analysis* 52(4): 1971-1983.
- Asquith, W. (2007). "L-moments and TL-moments of the generalized lambda distribution." *Computational Statistics and Data Analysis* 51(9): 4484-4496.
- Elamir, E. A., Seheult, A. H. 2004. "Exact variance structure of sample L-moments" *Journal of Statistical Planning and Inference* 124 (2) 337-359.
- Hosking, J. 1990. "L-moments: Analysis and estimation distributions using linear combinations of order statistics", *Journal of Royal Statistical Society B* 52, 105-124.

**See Also**

[t1lmoments](#) for trimmed L-moments

**Examples**

```
x<-rnorm(500)
Lmoments(x)
```

---

LowDiscrepancy

*Low Discrepancy Sequences*

---

**Description**

A collection and description of functions to compute Halton's and Sobol's low discrepancy sequences, distributed in form of a uniform or normal distribution.

The functions are:

runif.halton	Uniform Halton sequence,
rnorm.halton	Normal Halton sequence,
runif.sobol	Uniform scrambled Sobol sequence,
rnorm.sobol	Normal scrambled Sobol sequence,
runif.pseudo	Uniform pseudo random numbers,
norma.pseudo	Normal pseudo random numbers.

**Usage**

```
runif.halton(n, dimension, init)
rnorm.halton(n, dimension, init)
```

```
runif.sobol(n, dimension, init, scrambling, seed)
rnorm.sobol(n, dimension, init, scrambling, seed)
```

```
runif.pseudo(n, dimension, init)
rnorm.pseudo(n, dimension, init)
```

### Arguments

dimension	an integer value, the dimension of the sequence. The maximum value for the Sobol generator is 1111.
init	a logical, if TRUE the sequence is initialized and restarts, otherwise not. By default TRUE.
n	an integer value, the number of random deviates.
scrambling	an integer value, if 1, 2 or 3 the sequence is scrambled otherwise not. If 1, Owen type type of scrambling is applied, if 2, Faure-Tezuka type of scrambling, is applied, and if 3, both Owen+Faure-Tezuka type of scrambling is applied. By default 0.
seed	an integer value, the random seed for initialization of the scrambling process. By default 4711. On effective if scrambling>0.

### Details

#### Halton's Low Discrepancy Sequences:

Calculates a matrix of uniform or normal deviated halton low discrepancy numbers.

#### Scrambled Sobol's Low Discrepancy Sequences:

Calculates a matrix of uniform and normal deviated Sobol low discrepancy numbers. Optional scrambling of the sequence can be selected.

#### Pseudo Random Number Sequence:

Calculates a matrix of uniform or normal distributed pseudo random numbers. This is a helpful function for comparing investigations obtained from a low discrepancy series with those from a pseudo random number.

### Value

All generators return a numeric matrix of size n by dimension.

### Note

The global variables `runif.halton.seed` and `runif.sobol.seed` save the status to restart the generators. Note, that only one instance of a generators can be run at the same time.

The ACM Algorithm 659 implemented to generate scrambled Sobol sequences is under the License of the ACM restricted for academic and noncommercial usage. Please consult the ACM License agreement included in the doc directory.

### Author(s)

P. Bratley and B.L. Fox for the Fortran Sobol Algorithm 659,  
S. Joe for the Fortran extension to 1111 dimensions,  
Diethelm Wuertz for the Rmetrics R-port.

### References

Bratley P., Fox B.L. (1988); *Algorithm 659: Implementing Sobol's Quasirandom Sequence Generator*, ACM Transactions on Mathematical Software 14, 88–100.

Joe S., Kuo F.Y. (1998); *Remark on Algorithm 659: Implementing Sobol's Quasirandom Sequence Generator*.

### Examples

```
## *.halton -
par(mfrow = c(2, 2), cex = 0.75)
runif.halton(n = 10, dimension = 5)
hist(runif.halton(n = 5000, dimension = 1), main = "Uniform Halton",
     xlab = "x", col = "steelblue3", border = "white")
rnorm.halton(n = 10, dimension = 5)
hist(rnorm.halton(n = 5000, dimension = 1), main = "Normal Halton",
     xlab = "x", col = "steelblue3", border = "white")

## *.sobol -
runif.sobol(n = 10, dimension = 5, scrambling = 3)
hist(runif.sobol(5000, 1, scrambling = 2), main = "Uniform Sobol",
     xlab = "x", col = "steelblue3", border = "white")
rnorm.sobol(n = 10, dimension = 5, scrambling = 3)
hist(rnorm.sobol(5000, 1, scrambling = 2), main = "Normal Sobol",
     xlab = "x", col = "steelblue3", border = "white")

## *.pseudo -
runif.pseudo(n = 10, dimension = 5)
rnorm.pseudo(n = 10, dimension = 5)
```

---

```
pretty.su
```

```
An alternative to the normal pretty function in R.
```

---

### Description

Divide a range of values into equally spaced divisions. End points are given as output.

### Usage

```
pretty.su(x, nint = 5)
```

**Arguments**

x                    A vector of values.  
nint                Number of intervals required.

**Details**

This is also used for the plotting of histogram in the [histsu](#) function.

**Value**

A vector of endpoints dividing the data into equally spaced regions.

**Author(s)**

Steve Su

**See Also**

[pretty](#)

**Examples**

```
# Generate random numbers from normal distribution:  
junk<-rnorm(1000,2,3)  
  
# Cut them into 7 regions, 8 endpoints.  
pretty.su(junk,7)
```

---

qqplot.gld

*Do a quantile plot on the univariate distribution fits.*

---

**Description**

This plots the theoretical and actual data quantiles to allow the user to examine the adequacy of a single gld distribution fit.

**Usage**

```
qqplot.gld(data, fit, param, len = 10000, name = "",  
corner = "topleft", type="", range=c(0,1), xlab="", main="")
```

**Arguments**

data	Data fitted.
fit	Parameters of distribution fit.
param	Can be either "rs" or "fml".
len	Precision of the quantile calculatons. Default is 10000. This means 10000 points are taken from 0 to 1.
name	Name of the data set, added to the title of plot if main is missing.
corner	Can be "bottomright", "bottom", "bottomleft", "left", "topleft", "top", "topright", "right", "center" as in <a href="#">legend</a> .
type	This can be "" or "str.qqplot", the first produces the raw quantiles and the second plot them on a straight line. Default is "".
range	This is the range for which the quantiles are to be plotted. Default is $c(0, 1)$ .
xlab	x axis label, if left blank, then default is "Data".
main	Title of the plot, if left blank, a default title will be added.

**Value**

A plot is given.

**Author(s)**

Steve Su

**See Also**

[qqplot.gld.bi](#)

**Examples**

```
# set.seed(1000)

# junk<-rweibull(300,3,2)

## Fit the function using fun.data.fit.ml
# obj.fit1.ml<-fun.data.fit.ml(junk)

## Do a quantile plot on the raw quantiles
# qqplot.gld(junk,obj.fit1.ml[,1],param="rs",name="RS ML fit")

## Or a qq plot to examine deviation from straight line
# qqplot.gld(junk,obj.fit1.ml[,1],param="rs",name="RS ML fit",type="str.qqplot")
```

---

 qqplot.gld.bi

*Do a quantile plot on the bimodal distribution fits.*


---

### Description

This plots the theoretical and actual data quantiles to allow the user to examine the adequacy of two gld distributions mixture fit.

### Usage

```
qqplot.gld.bi(data, fit, param1, param2, len = 10000, name = "",
  corner = "topleft", type="", range=c(0,1), xlab="", main="")
```

### Arguments

data	Data fitted.
fit	Parameters of distribution fit.
param1	Can be either "rs" or "fml".
param2	Can be either "rs" or "fml".
len	Precision of the quantile calculatons. Default is 10000. This means 10000 points are taken from 0 to 1.
name	Name of the data set, added to the title of plot if main is missing.
corner	Can be "bottomright", "bottom", "bottomleft", "left", "topleft", "top", "topright", "right", "center" as in <a href="#">legend</a> .
type	This can be "" or "str.qqplot", the first produces the raw quantiles and the second plot them on a straight line. Default is "".
range	This is the range for which the quantiles are to be plotted. Default is c(0, 1).
xlab	x axis label, if left blank, then default is "Data"
main	Title of the plot, if left blank, a default title will be added.

### Value

A plot is given.

### Author(s)

Steve Su

### See Also

[qqplot.gld](#)

**Examples**

```
# set.seed(1000)

# junk<-rweibull(300,3,2)

## Fitting mixture of generalised lambda distributions on the data set using
## both the maximum likelihood and partition maximum likelihood and plot the
## resulting fits
# junk<-fun.auto.bimodal.ml(faithful[,1],per.of.mix=0.1,clustering.m=clara,
# init1.sel="rprs",init2.sel="rmfml",init1=c(-1.5,1.5),init2=c(-0.25,1.5),
# leap1=3,leap2=3)
# fun.plot.fit.bm(nclass=50,fit.obj=junk,data=faithful[,1],
# name="Maximum likelihood using",xlab="faithful1",param.vec=c("rs","fml"))

## Do a quantile plot on the raw quantiles
# qqplot.gld.bi(faithful[,1],junk$par,param1="rs",param2="fml",
# name="RS FML ML fit")

## Or a qq plot to examine deviation from straight line
# qqplot.gld.bi(faithful[,1],junk$par,param1="rs",param2="fml",
# name="RS FML ML fit",type="str.qqplot")
```

QUnif

*Quasi Random Numbers via Halton Sequences***Description**

These functions provide quasi random numbers or *space filling* or *low discrepancy* sequences in the  $p$ -dimensional unit cube.

**Usage**

```
sHalton(n.max, n.min = 1, base = 2, leap = 1)
QUnif (n, min = 0, max = 1, n.min = 1, p, leap = 1)
```

**Arguments**

n.max	maximal (sequence) number.
n.min	minimal sequence number.
n	number of $p$ -dimensional points generated in QUnif. By default, $n.min = 1$ , $leap = 1$ and the maximal sequence number is $n.max = n.min + (n-1)*leap$ .
base	integer $\geq 2$ : The base with respect to which the Halton sequence is built.
min, max	lower and upper limits of the univariate intervals. Must be of length 1 or $p$ .
p	dimensionality of space (the unit cube) in which points are generated.
leap	integer indicating (if $> 1$ ) if the series should be leaped, i.e., only every $leap$ th entry should be taken.



**Value**

sHalton(n,m) returns a numeric vector of length n-m+1 of values in [0, 1].

QUnif(n, min, max, n.min, p=p) generates n-n.min+1 p-dimensional points in  $[min, max]^p$  returning a numeric matrix with p columns.

**Note**

For leap Kocis and Whiten recommend values of  $L = 31, 61, 149, 409$ , and particularly the  $L = 409$  for dimensions up to 400.

**Author(s)**

Martin Maechler

**References**

James Gentle (1998) *Random Number Generation and Monte Carlo Simulation*; sec.\ 6.3. Springer.

Kocis, L. and Whiten, W.J. (1997) Computational Investigations of Low-Discrepancy Sequences. *ACM Transactions of Mathematical Software* **23**, 2, 266–294.

**Examples**

```
32*sHalton(20, base=2)
QUnif(n=10, p=2, leap=409)
```

---

skewness and kurtosis *Compute skewness and kurtosis statistics*

---

**Description**

This uses the S+ version directly.

**Usage**

```
skewness(x, na.rm = FALSE, method = "fisher")
kurtosis(x, na.rm = FALSE, method = "fisher")
```

**Arguments**

x	Any numerical object. Missing values NA are allowed.
na.rm	Logical flag: if na.rm=TRUE, missing values are removed from x before doing the computations. If na.rm=FALSE and x contains missing values, then the return value is NA.
method	Character string specifying the computation method. The two possible values are fisher for Fisher's g1 (skewness) and g2 (kurtosis) versions, and moment for the functional forms of the statistics. Only the first character of the string needs to be supplied.

**Details**

The moment forms are based on the definitions of skewness and kurtosis for distributions; these forms should be used when resampling (bootstrap or jackknife). The "fisher" forms correspond to the usual "unbiased" definition of sample variance, though in the case of skewness and kurtosis exact unbiasedness is not possible.

**Value**

A single value of skewness or kurtosis.

If  $y = x - \text{mean}(x)$ , then the "moment" method computes the skewness value as  $\text{mean}(y^3)/\text{mean}(y^2)^{1.5}$  and the kurtosis value as  $\text{mean}(y^4)/\text{mean}(y^2)^2 - 3$ . To see the "fisher" calculations, print out the functions.

**Author(s)**

Splus

**See Also**

var

**Examples**

```
x <- runif(30)
skewness(x)
skewness(x, method="moment")
kurtosis(x)
kurtosis(x, method="moment")
```

---

starship

*Carry out the "starship" estimation method for the generalised lambda distribution*

---

**Description**

Calculates estimates for the FMKL parameterisation of the generalised lambda distribution on the basis of data, using the starship method. The starship method is built on the fact that the generalised lambda distribution is a transformation of the uniform distribution. This method finds the parameters that transform the data closest to the uniform distribution. This function uses a grid-based search to find a suitable starting point (using `starship.adaptivegrid`) then uses `optim` to find the parameters that do this.

**Usage**

```
starship(data, optim.method = "Nelder-Mead", initgrid = NULL, param="FMKL",
optim.control=NULL)
```

**Arguments**

data	Data to be fitted, as a vector
optim.method	Optimisation method for <code>optim</code> to use, defaults to Nelder-Mead
initgrid	Grid of values of $\lambda_3$ and $\lambda_4$ to try, in <code>starship.adaptivegrid</code> . This should be a list with elements, <code>lcvect</code> , a vector of values for $\lambda_3$ , <code>ldvect</code> , a vector of values for $\lambda_4$ and <code>levect</code> , a vector of values for $\lambda_5$ ( <code>levect</code> is only required if <code>param</code> is <code>fm5</code> ). If it is left as NULL, the default grid depends on the parameterisation. For <code>fmk1</code> , both <code>lcvect</code> and <code>ldvect</code> default to: <pre>-1.5 -1 -0.5 -0.1 0 .1 .2 .4 .8 1 1.5</pre> ( <code>levect</code> is NULL). For <code>rs</code> , both <code>lcvect</code> and <code>ldvect</code> default to: <pre>.1 .2 .4 .8 1 1.5</pre> ( <code>levect</code> is NULL). For <code>fm5</code> , both <code>lcvect</code> and <code>ldvect</code> default to: <pre>-1.5 -1 -0.5 -0.1 0 .1 .2 .4 .8 1 1.5</pre> and <code>levect</code> defaults to: <pre>-0.5 0.25 0 0.25 0.5</pre>
param	choose parameterisation: <code>fmk1</code> uses <i>Freimer, Mudholkar, Kollia and Lin (1988)</i> (default). <code>rs</code> uses <i>Ramberg and Schmeiser (1974)</i> <code>fm5</code> uses the 5 parameter version of the FMKL parameterisation (paper to appear)
optim.control	List of options for the optimisation step. See <code>optim</code> for details. If left as NULL, the <code>parscale</code> control is set to scale $\lambda_1$ and $\lambda_2$ by the absolute value of their starting points.

**Details**

The starship method is described in King & MacGillivray, 1999 (see references). It is built on the fact that the generalised lambda distribution is a transformation of the uniform distribution. Thus the inverse of this transformation is the distribution function for the `gld`. The starship method applies different values of the parameters of the distribution to the distribution function, calculates the depths  $q$  corresponding to the data and chooses the parameters that make the depths closest to a uniform distribution.

The closeness to the uniform is assessed by calculating the Anderson-Darling goodness-of-fit test on the transformed data against the uniform, for a sample of size `length(data)`.

This is implemented in 2 stages in this function. First a grid search is carried out, over a small number of possible parameter values (see `starship.adaptivegrid` for details). Then the minimum

from this search is given as a starting point for an optimisation of the Anderson-Darling value using `optim`, with method given by `optim.method`

See references for details on parameterisations.

### Value

Returns a list, with

<code>lambda</code>	A vector of length 4, giving the estimated parameters, in order, $\lambda_1$ - location parameter $\lambda_2$ - scale parameter $\lambda_3$ - first shape parameter $\lambda_4$ - second shape parameter
<code>grid.results</code>	output from the grid search - see <a href="#">starship.adaptivegrid</a> for details
<code>optim</code>	output from the optim search - <a href="#">optim</a> for details

### Author(s)

Robert King, <[robert.king@newcastle.edu.au](mailto:robert.king@newcastle.edu.au)>, <http://tolstoy.newcastle.edu.au/~rking/>  
 Darren Wraith, <[Darren.Wraith@studentmail.newcastle.edu.au](mailto:Darren.Wraith@studentmail.newcastle.edu.au)>

### References

- Freimer, M., Mudholkar, G. S., Kollia, G. & Lin, C. T. (1988), *A study of the generalized tukey lambda family*, Communications in Statistics - Theory and Methods **17**, 3547–3567.
- Ramberg, J. S. & Schmeiser, B. W. (1974), *An approximate method for generating asymmetric random variables*, Communications of the ACM **17**, 78–82.
- King, R.A.R. & MacGillivray, H. L. (1999), *A starship method for fitting the generalised  $\lambda$  distributions*, Australian and New Zealand Journal of Statistics **41**, 353–374
- Owen, D. B. (1988), *The starship*, Communications in Statistics - Computation and Simulation **17**, 315–323.
- <http://tolstoy.newcastle.edu.au/~rking/gld/>

### See Also

[starship.adaptivegrid](#), [starship.obj](#)

### Examples

```
# data <- rgl(100,0,1,.2,.2)
# vstarship(data,optim.method="Nelder-Mead",initgrid=list(lcvect=(0:4)/10,
# ldvect=(0:4)/10))
```

---

starship.adaptivegrid *Carry out the “starship” estimation method for the generalised lambda distribution using a grid-based search*

---

## Description

Calculates estimates for the generalised lambda distribution on the basis of data, using the starship method. The starship method is built on the fact that the generalised lambda distribution is a transformation of the uniform distribution. This method finds the parameters that transform the data closest to the uniform distribution. This function uses a grid-based search.

## Usage

```
starship.adaptivegrid(data, initgrid=list(
  lcvect = c(-1.5, -1, -0.5, -0.1, 0, 0.1, 0.2, 0.4, 0.8, 1, 1.5),
  ldvect = c(-1.5, -1, -0.5, -0.1, 0, 0.1, 0.2, 0.4, 0.8, 1, 1.5),
  levect = c(-0.5, -0.25, 0, 0.25, 0.5)), param="FMKL")
```

## Arguments

data	Data to be fitted, as a vector
initgrid	A list with elements, <code>lcvect</code> , a vector of values for $\lambda_3$ , <code>ldvect</code> , a vector of values for $\lambda_4$ and <code>levect</code> , a vector of values for $\lambda_5$ ( <code>levect</code> is only required if <code>param</code> is <code>fm5</code> ). <i>Note:</i> if <code>param=rs</code> , the non-positive values are dropped from <code>lcvect</code> and <code>ldvect</code> .
param	choose parameterisation: <code>fmkl</code> uses <i>Freimer, Mudholkar, Kollia and Lin (1988)</i> (default). <code>rs</code> uses <i>Ramberg and Schmeiser (1974)</i> <code>fm5</code> uses the 5 parameter version of the FMKL parameterisation (paper to appear)

## Details

The starship method is described in King & MacGillivray, 1999 (see references). It is built on the fact that the generalised lambda distribution is a transformation of the uniform distribution. Thus the inverse of this transformation is the distribution function for the gld. The starship method applies different values of the parameters of the distribution to the distribution function, calculates the depths  $q$  corresponding to the data and chooses the parameters that make the depths closest to a uniform distribution.

The closeness to the uniform is assessed by calculating the Anderson-Darling goodness-of-fit test on the transformed data against the uniform, for a sample of size `length(data)`.

This function carries out a grid-based search. This was the original method of King & MacGillivray, 1999, but you are advised to instead use [starship](#) which uses a grid-based search together with an optimisation based search.

See references for details on parameterisations.

**Value**

response	The minimum “response value” — the result of the internal goodness-of-fit measure. This is the return value of starship.obj. See King & MacGillivray, 1999 for more details
lambda	A vector of length 4 giving the values of $\lambda_1$ to $\lambda_4$ that produce this minimum response, i.e. the estimates

**Author(s)**

Robert King, <robert.king@newcastle.edu.au>, <http://tolstoy.newcastle.edu.au/~rking/>  
 Darren Wraith, <Darren.Wraith@studentmail.newcastle.edu.au>

**References**

- Freimer, M., Mudholkar, G. S., Kollia, G. & Lin, C. T. (1988), *A study of the generalized tukey lambda family*, Communications in Statistics - Theory and Methods **17**, 3547–3567.
- Ramberg, J. S. & Schmeiser, B. W. (1974), *An approximate method for generating asymmetric random variables*, Communications of the ACM **17**, 78–82.
- King, R.A.R. & MacGillivray, H. L. (1999), *A starship method for fitting the generalised  $\lambda$  distributions*, Australian and New Zealand Journal of Statistics **41**, 353–374
- Owen, D. B. (1988), *The starship*, Communications in Statistics - Computation and Simulation **17**, 315–323.
- <http://tolstoy.newcastle.edu.au/~rking/gld/>

**See Also**

[starship](#), [starship.obj](#)

**Examples**

```
# data <- rgl(100,0,1,.2,.2)
# starship.adaptivegrid(data,list(lcvect=(0:4)/10,ldvect=(0:4)/10))
#
```

---

starship.obj

*Objective function that is minimised in starship estimation method*

---

**Description**

The starship is a method for fitting the generalised lambda distribution. See [starship](#) for more details.

This function is the objective function minimised in the methods. It is a goodness of fit measure carried out on the depths of the data.

**Usage**

```
starship.obj(par, data, param = "fmk1")
```

**Arguments**

par	parameters of the generalised lambda distribution, a vector of length 4, giving $\lambda_1$ to $\lambda_4$ . See references or <code>qgl</code> for details on the definitions of these parameters
data	Data — a vector
param	choose parameterisation: <code>fmk1</code> uses <i>Freimer, Mudholkar, Kollia and Lin (1988)</i> (default). <code>rs</code> uses <i>Ramberg and Schmeiser (1974)</i>

**Details**

The starship method is described in King & MacGillivray, 1999 (see references). It is built on the fact that the generalised lambda distribution is a transformation of the uniform distribution. Thus the inverse of this transformation is the distribution function for the gld. The starship method applies different values of the parameters of the distribution to the distribution function, calculates the depths  $q$  corresponding to the data and chooses the parameters that make the depths closest to a uniform distribution.

The closeness to the uniform is assessed by calculating the Anderson-Darling goodness-of-fit test on the transformed data against the uniform, for a sample of size `length(data)`.

This function returns that objective function. It is provided as a separate function to allow users to carry out minimisations using `optim` or other methods. The recommended method is to use the `link{starship}` function.

**Value**

The Anderson-Darling goodness of fit measure, computed on the transformed data, compared to a uniform distribution. *Note that this is NOT the goodness-of-fit measure of the generalised lambda distribution with the given parameter values to the data.*

**Author(s)**

Robert King, <[robert.king@newcastle.edu.au](mailto:robert.king@newcastle.edu.au)>, <http://tolstoy.newcastle.edu.au/~rking/>  
Darren Wraith, <[Darren.Wraith@studentmail.newcastle.edu.au](mailto:Darren.Wraith@studentmail.newcastle.edu.au)>

**References**

- Freimer, M., Mudholkar, G. S., Kollia, G. & Lin, C. T. (1988), *A study of the generalized tukey lambda family*, Communications in Statistics - Theory and Methods **17**, 3547–3567.
- Ramberg, J. S. & Schmeiser, B. W. (1974), *An approximate method for generating asymmetric random variables*, Communications of the ACM **17**, 78–82.
- King, R.A.R. & MacGillivray, H. L. (1999), *A starship method for fitting the generalised  $\lambda$  distributions*, Australian and New Zealand Journal of Statistics **41**, 353–374
- Owen, D. B. (1988), *The starship*, Communications in Statistics - Computation and Simulation **17**, 315–323.
- <http://tolstoy.newcastle.edu.au/~rking/gld/>

**See Also**

[starship](#) [starship.adaptivegrid](#),

**Examples**

```
# data <- rgl(100,0,1,.2,.2)
# starship.obj(c(0,1,.2,.2),data,"fmk1")
```

---

t1lmoments

*Trimmed L-moments*


---

**Description**

Calculates sample trimmed L-moments with trimming parameter 1.

**Usage**

```
t1lmoments(data,rmax=4)
```

**Arguments**

data	matrix or data frame.
rmax	maximum order of trimmed L-moments.

**Value**

array of trimmed L-moments (trimming parameter = 1) up to order 4 containing a row for each variable in data.

**Note**

Functions `link{Lmoments}` and `link{Lcoefs}` calculate trimmed L-moments if you specify `trim=c(1,1)`.

**Author(s)**

Juha Karvanen <juha.karvanen@ktl.fi>

**References**

Karvanen, J. and A. Nuutinen (2008). "Characterizing the generalized lambda distribution by L-moments." *Computational Statistics and Data Analysis* 52(4): 1971-1983.

Asquith, W. (2007). "L-moments and TL-moments of the generalized lambda distribution." *Computational Statistics and Data Analysis* 51(9): 4484-4496.

Elamir, E. A., Seheult, A. H. 2004. "Exact variance structure of sample L-moments" *Journal of Statistical Planning and Inference* 124 (2) 337-359.

Hosking, J. 1990. "L-moments: Analysis and estimation distributions using linear combinations of order statistics", *Journal of Royal Statistical Society B* 52, 105-124.



**See Also**

[Lmoments](#) for L-moments

**Examples**

```
x<-rnorm(500)
t11moments(x);
```

---

which.na	<i>Determine Missing Values</i>
----------	---------------------------------

---

**Description**

Returns a vector showing the position of missing values in a vector.

**Usage**

```
which.na(x)
```

**Arguments**

x                    An object which should be of logical, numeric, or complex

**Value**

This returns the indices of values in x which are missing or "Not a Number".

**Examples**

```
# A non-zero number divided by zero creates infinity,
# zero over zero creates a NaN
weird.values <- c(1/0, -2.9/0, 0/0, NA)
which.na(weird.values)
# Produces:
# [1] 3 4
```

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