Package 'fitPS'

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Type Package

Title Fit Zeta Distributions to Forensic Data

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Description Fits Zeta distributions (discrete power laws) to data that arises from forensic surveys of clothing on the presence of glass and paint in various populations. The general method is described to some extent in Coulson, S.A., Buckleton, J.S., Gummer, A.B., and Triggs, C.M. (2001) <doi:10.1016/S1355-0306(01)71847-3>, although the implementation differs.

License GPL (>= 2)

Encoding UTF-8

LazyData true

Depends foreach, R (>= 4.0.0)

Imports doParallel, dplyr, Hmisc, iterators, knitr, ks, methods, pbapply, Rdpack, readxl, VGAM

RdMacros Rdpack

RoxygenNote 7.2.3

URL https://github.com/jmcurran/fitPS

BugReports https://github.com/jmcurran/fitPS/issues

Suggests rmarkdown, sp

VignetteBuilder knitr

NeedsCompilation no

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R topics documented:

`==.psData` *S3 method for objects of class* `psData`

Description

Tests to see if two objects of class `psData` are equal. That is their `type` is the same, and the data contained in `data` is the same. See `readData` for a description of the `psData` class.

Usage

```
## S3 method for class 'psData'
lhs == rhs
```

Arguments

`lhs`	an object of class `psData`.
`rhs`	an object of class `psData`.

Details

NOTE: the `notes` member variable is ignored in this function as it is unlikely that a user would want to see if the notes are the same.

Value

TRUE if the two objects are equal

Examples

```
p = readData(system.file("extdata", "p.xlsx", package = "fitPS"))
p1 = makePSData(n = 0:2, count = c(98, 1, 1), type = "P")
p2 = makePSData(n = 0:2, count = c(97, 2, 1), type = "P")
p == p1 ## TRUE
p == p2 ## FALSE
p1 == p2 ## FALSE
```

---

as.data.frame.psData *Converts an object of class* psData *to a* data.frame

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Description

Converts an object of class psData—see readData—to a data.frame that can be used with in functions in other packages such as vglm to fit more complicated models.

Usage

```
## S3 method for class 'psData'
as.data.frame(x, ...)
```

Arguments

x	an object of class psData—see readDatafor more details.
...	any other arguments passed to data.frame.

Details

If x is a psData object of type "P", i.e. it relates to numbers of groups of glass, then a data.frame with a single variable count will be return where count = rep(x$data$n + 1, x$data$rn). The counts have one added to them because the Zeta distribution requires that the counts are greater than or equal to one. If x is a psData object of type "P", i.e. it relates to group sizes, then a data.frame with a single variable count will be return where count = rep(x$data$n, x$data$rn).

Value

a data.frame with a single variable count. The number of rows in the data.frame is equal to sum(x$data$rn).

Examples

```
p = readData(system.file("extdata", "p.xlsx", package = "fitPS"))
p.df = as.data.frame(p)
table(p.df$count)
p$data
```

bootCI *Bootstrap confidence intervals or regions*

Description

Use boostrapping to generate confidence intervals, or confidence regions in the case of the zero-inflated model.

Usage

```
bootCI(x, ...)

## Default S3 method:
bootCI(
  x,
  level = 0.95,
  B = 2000,
  model = c("zeta", "zi.zeta"),
  silent = FALSE,
  plot = FALSE,
  parallel = TRUE,
  progressBar = FALSE,
  pbopts = list(type = "txt"),
  ...
)

## S3 method for class 'psData'
bootCI(x, ...)

## S3 method for class 'psFit'
bootCI(x, ...)
```

Arguments

x	a object of class psFit—see readData for more details.
...	other arguments.
level	the confidence level required—restricted to [0.75, 1). This may be a vector, in which case multiple intervals, or confidence regions will be returned.
B	the number of bootstrap samples to take.
model	which model to fit to the data, either "zeta" or "zi.zeta". Maybe abbreviated to "z" and "zi". Default is "zeta".
silent	if TRUE, then no output will be displayed whilst the bootstrapping is being undertaken. plot if TRUE then the contours for the confidence region will be plotted. This only works if model = "zi.zeta". It is ignored otherwise. parallel if TRUE then the bootstrapping is performed in parallel.

plot	if TRUE and model == "zi.zeta", then a plot of the bootstrapped values will be produced and confidence contour lines will be drawn for each value in level.
parallel	if TRUE, then the package will attempt to use multiple cores to speed up computation.
progressBar	if TRUE, then progress bars will be displayed to show progress on the bootstrapping.
pbopts	a list of arguments for the pboptions function that affect the progress bars. Ignored if progressBar = FALSE.

Details

This function uses bootstrapping to compute a confidence interval for the shape parameter in the case of the zeta model and a confidence region in the case of the zero-inflated zeta model. A smoothed bootstrap approach is taken rather than a simple percentile method. The kernel density estimation is performed by the ks package using a smoothed cross-validated bandwidth selection procedure.

Value

If model == "zeta", then either a vector or a data.frame with elements/columns named "lower" and "upper" representing the lower and upper bounds of the confidence interval(s). Multiple bounds are returned in a data.frame when level has more than one value. If model == "zi.zeta", then a list with length equal to the length of level is returned. The name of each element in the list is the level with level == 0.95, then the list has a single element named "95%". Each element of the list consists of a list with elements named pi and shape which specify the coordinates of the contour for that level. There is a third element named level which gives the height of the kernel density estimate at that contour.

Methods (by class)

- bootCI(default): Bootstrap confidence intervals or regions
- bootCI(psData): Bootstrap confidence intervals or regions
- bootCI(psFit): Bootstrap confidence intervals or regions

Examples

```
## Not run:
data(Psurveys)
roux = Psurveys$roux
confRegion = bootCI(roux, model = "zi.zeta", parallel = FALSE, plot = TRUE)

## This will not work unless you have the sp package installed
## Count how many of the points lie within the 95% confidence region
table(sp::point.in.polygon(fit$pi,fit$shape, confRegion$pi, confRegion$shape))

## End(Not run)
```

confint.psFit *S3 confint method for objects of class psFit*

Description

S3 confint method for objects of class psFit

Usage

```
## S3 method for class 'psFit'
confint(object, parm, level = 0.95, ...)
```

Arguments

object	an object of class psFit—see fitDist for more details
parm	added for compatibility. Should be left empty as it is ignored.
level	the confidence level required—restricted to [0.75, 1)
...	in theory other parameters to be passed to confint, but in reality ignored.

Value

a list with two items: wald and prof containing the Wald and profile likelihood confidence intervals respectively for the shape parameter of the fitted Zeta distribution. In general these should be relatively close to each other. **NOTE** These values are for the **VGAM** parameterisation of the Zeta distribution which uses $s' = s - 1$. This means they can be used without alteration in dzeta.

Examples

```
data(Psurveys)
roux = Psurveys$roux
fit = fitDist(roux)
confint(fit)
```

createPSData *Manually create psData*

Description

A mechanism for manually creating P or S data sets for use with fitDist.

Usage

```
createPSData(n, rn, type = c("P", "S"), notes = NULL)
```

Arguments

n	a vector of lables for the number of groups or size of groups of glass.
rn	a vector of counts corresponding to each element of n. All entries must be greater than zero.
type	either "P" or "S".
notes	a character string or a bibentry.

Value

an object of class psData. See readData for more details

Examples

```
p = createPSData(0:2, c(98, 1, 1), type = "P")
p
```

---

fitDist *Fit a Zeta Distribution to Forensic Data*

Description

This function uses maximum likelihood estimation (MLE) to estimate the shape parameter of a Zeta distribution from a set of observed counts for either the number of groups/sources of forensically interesting material (mostly glass or paint) recovered from clothing, or the number of fragments/particles in each group. This, in turn, allows the estimation of the P and S probabilities, as described by Evett and Buckleton (1990), which used in computing the likelihood ratio (LR) for activity level propositions. The data itself arises from clothing surveys. The general method is described in Coulson et al. (2001), although poor typesetting, and a lack of definition of terms makes it hard to see. This package improves on the estimation in that linear interpolation is not required, and standard numerical optimisation is used instead. The Zeta distribution has probability mass function

$$p(k) = \frac{k^{-s}}{\zeta(s)}$$

where $\zeta(s)$ is the Reimann Zeta function. Coulson et al. (2001) did not have an easy way to rapidly compute this quantity, hence their use of linear interpolation.

Usage

```
fitDist(x, nterms = 10, start = 1, ...)
```

Arguments

x	an object of type psData, usually obtained from readData.
nterms	the number of terms to compute the probability distribution for.
start	a starting value for the optimiser.
...	other parameters - not currently used.

Details

The function returns an object of class psFit which is a list contains four elements:

- psData – an object of class psData–see readData,
- fit – the fitted object from nlminb,
- shape – the maximum likelihood estimate of the shape parameter,
- var.shape - the maximum likelihood estimate of the shape parameter,
- fitted - a named vector containing the first nterms of the fitted distribution.

. The output can be used in a variety of ways. If the interest is just in the shape parameter estimate, then the shape member of the psFit object contains this information. It is also displayed along with a number of fitted probabilities by the print.psFit method. The fitted object can also be plotted using the plot method plot.psFit, and to create a probability function with probfun. **NOTE** The value of the shape parameter that is printed (if you print the fitted object) is different from that value that is stored in shape. The stored value is for the **VGAM** parameterisation of the Zeta distribution which uses $s' = s - 1$. Therefore the printed value is $s = s' + 1$. If you intend to use the fitted value with dzeta, then you should use the stored value s'.

If start is not specified, then it is chosen randomly from (0.5, 1). The reason the lower value is not zero is that small starting values seem to cause instability in the likelihood. If you specify your own starting value, it would be sensible to keep it above 0.5.

Value

an object of class psFit–see Details.

References

Coulson, S. A., Buckleton, J. S., Gummer, A. B., and Triggs, C.M., "Glass on clothing and shoes of members of the general population and people suspected of breaking crimes", Science & Justice 2001: 41(1): 39–48.

Evett, I. W. and Buckleton, J. S., "The interpretation of glass evidence. A practical approach", Journal of the Forensic Science Society 1990: 30(4): 215–223.

See Also

plot.psFit, print.psFit, probfun.

Examples

```
p = readData(system.file("extdata", "p.xlsx", package = "fitPS"))
fit = fitDist(p)
fit
```

fitted.psData *S3 fitted method for an object of class* psFit

Description

S3 fitted method for an object of class psFit

Usage

```
## S3 method for class 'psData'
fitted(object, ...)
```

Arguments

object	an object of class psFit, usually from fitDist
...	other arguments passed to fittedf—not used

Value

a named vector of fitted probabilities

makePSData *Create a survey data set manually*

Description

Create a survey data set from the command line rather than reading data in from a file. This function is likely to be only useful where there are a very small number of group sizes, or sizes of groups of glass.

Usage

```
makePSData(n, count, type = c("P", "S"), notes = NULL)

makeData(n, count, type = c("P", "S"), notes = NULL)
```

Arguments

n	Either the number of groups of glass or the size of different groups of glass.
count	Either the number of people in the survey sample who had n groups of glass on their clothing, or the number of people who had a group of glass of size n.
type	either "P" or "S"
notes	a bibentry or a character string which allows extra information about the data to be stored, such as the source, or reference. NULL by default.

Value

an object of type psData—see readData for more details.

Functions

- makeData(): Create a survey data set manually

See Also

readData

Examples

```
## recreate the data read in the readData example
p1 = makePSData(n = c(0, 1, 2), count = c(98, 1, 1), type = "P")
s1 = makePSData(n = 1:3, count = c(1, 1, 1), type = "S")
p1
s1
```

---

plot.psFit *S3 plot method for an object of class* psFit

Description

S3 plot method for an object of class psFit

Usage

```
## S3 method for class 'psFit'
plot(
  x,
  ylim = c(0, 1),
  conf = FALSE,
  conf.level = 0.95,
  ci.type = c("wald", "prof"),
  log.scale = FALSE,
  ...
)
```

Arguments

x	an object of class psFit, usually from fitDist
ylim	the limits of the y-axis
conf	if TRUE, then confidence intervals (based on the standard error of the shape parameter) are drawn on the plot

conf.level	the confidence level for the confidence intervals. Must be between 0.75 and 0.99.
ci.type	Specifies the type of confidence interval. If conf == TRUE, then then ci.type can be either "wald" "prof" (or an abbreviation), depending on whether the Wald interval or the profile likelihood interval should be used. Note that these are intervals on the shape parameter and not the density heights. Therefore the intervals around the probabilities should not really be thought of as confidence intervals but rather something more similar to a "sensitivity" interval.
log.scale	if TRUE the y-axis is changed to a logarithmic axis.
...	other arguments passed to plot.

Value

No return value, called for side effects

Examples

```
p = readData(system.file("extdata", "p.xlsx", package = "fitPS"))
fit = fitDist(p)
plot(fit)

## An example with Wald generated intervals
plot(fit, conf = TRUE)

plot(fit, conf = TRUE, ci.type = "p")
```

---

predict.psFit *S3 predict method for an object of class* psFit

---

Description

S3 predict method for an object of class psFit

Usage

```
## S3 method for class 'psFit'
predict(
  object,
  newdata,
  interval = c("none", "prof", "wald"),
  level = 0.95,
  ...
)
```

Arguments

object	an object of class psFit, usually from fitDist
newdata	an optional vector of integers at which to calculate $\Pr(X = x)$
interval	either "none", "prof", or "wald" and can be abbreviated. If "prof" or "wald" then an interval, based on the bounds of a 100 * level confidence interval for the shape parameter, is given for each predicted probability. The interval is provided based on either a Profile Likelihood, or a Wald, confidence interval for the shape, and therefore cannot really be regarded as a confidence interval for the probabilities. The intervals might be more sensibly regarded as a measure of how sensitive the probabilities are to the choice of shape parameter.
level	the level of a confidence interval. Ignored if interval == "none".
...	other arguments passed to predict—not used

Value

either a named vector of fitted probabilities, or a data.frame with columns predicted, lower, and upper and the row names set to show what terms are being calculatd

Examples

```
data(Psurveys)
roux = Psurveys$roux
fit = fitDist(roux)
predict(fit, interval = "prof")
```

---

print.psData *S3 print method for an object of class* psData

Description

S3 print method for an object of class psData

Usage

```
## S3 method for class 'psData'
print(x, ...)
```

Arguments

x	an object of class psData, usually from readData or makePSData
...	other arguments passed to print

Value

No return value, called for side effects

print.psFit *S3 print method for an object of class* psFit

Description

S3 print method for an object of class psFit

Usage

```
## S3 method for class 'psFit'
print(x, ...)
```

Arguments

x	an object of class psFit, usually from fitDist
...	other arguments passed to print

Value

No return value, called for side effects

probfun *Probability Functions*

Description

Creates a probability function that allows the computation of any P or S term.

Usage

```
probfun(psFitobj)
```

Arguments

psFitobj	an object of class psFit–see fitDist.

Value

a function that can be used to calculate any P or S term.

Examples

```
p = readData(system.file("extdata", "p.xlsx", package = "fitPS"))
fit = fitDist(p)
P = probfun(fit)
P(0:5)
```

`Psurveys` *Number of Groups of Glass Data*

Description

Count data from five different surveys looking at the number of sources/groups of glass found on the upper surfaces of clothing taken from the general public.

Usage

```
data(Psurveys)
```

Format

A `list` with six objects of class `psData`—see `readData` for more details. The elements of the list are named: `coulson`, `jackson`, `lau`, `pettard`, `ross`, and `roux`, corresponding to the lead author in each of the references given below. `lau`, `pettard`, and `ross` were taken from Coulson et al. (2001) rather than the original source.

Source

Coulson, S. A., Buckleton, J. S., Gummer, A. B., and Triggs, C. M. (2001) <doi:10.1016/S1355-0306(01)71847-3> Glass on clothing and shoes of members of the general population and people suspected of breaking crimes, Science & Justice, 41(1):39–48.

References

Lau L, Beveridge AD, Callowhill BC, Conners N, Foster K, Groves RJ, Ohashi KN, Sumner AM, Wong H (1997). "The Frequency of Occurrence of Paint and Glass on the Clothing of High School Students." *Canadian Society of Forensic Science Journal*, **30**(4), 233-240. doi:10.1080/00085030.1997.10757103.

Petterd CI, McCallum I, Bradford L, Brinch K, Stewart S (1998). "Glass particles in the clothing of the general population in Canberra—a survey." In *Proceedings of the 14th International Symposium on the Forensic Sciences*.

Ross P, Nguyen H (1998). "A survey of clothing for the presence of glass fragments." In *Proceedings of the 14th International Symposium on the Forensic Sciences*.

Roux C, Kirk R, Benson S, Van Haren T, Petterd CI (2001). "Glass particles in footwear of members of the public in south-eastern Australia—a survey." *Forensic Science International*, **116**(2), 149–156. doi:10.1016/S03790738(00)003558.

Jackson F, Maynard P, Cavanagh-Steer K, Dusting T, Roux C (2013). "A survey of glass found on the headwear and head hair of a random population vs. people working with glass." *Forensic Science International*, **226**(1), 125–131. doi:10.1016/j.forsciint.2012.12.017.

readData *Read count data from file*

Description

Reads observed counts of either the number of groups or the size of the groups. The file must have only two columns. One of the columns must be labelled P or S and the other count. It does not matter if the column names are in upper case or not. The P column can have labels 0, 1, 2, ... representing the observation of 0, 1, 2, or more groups. The corresponding count column should contain a positive (non-zero) count for each number of groups. Similarly, if the file contains S counts, then the S column can contain labels 1, 2, ... representing the observation of 1, 2, ... fragments in a group. Note that zeros are neither allowed, or useful, in the file as they both simply result in log-likelihood terms of zero, and therefore make no difference.

Usage

```
readData(fileName, notes = NULL, ...)
```

Arguments

fileName	the name of the file to be read. Must be either a modern (xlsx) Excel file or a csv file.
notes	any additional information about the data, such as the source or a reference.
...	any additional parameters which will be passed to either read_excel or read.csv depending on the extension of your input file.

Value

an object of class psData which is a list containing member variables:

- type – either "P" or "S"
- data – a data.frame which contains columns n and rn, representing the number of groups/fragments, and the number of times that was seen, respectively.
- notes — either a bibentry or a character string which allows extra information about the data to be stored, such as the source, or reference.

Examples

```
p = readData(system.file("extdata", "p.xlsx", package = "fitPS"))
p
s = readData(system.file("extdata", "s.xlsx", package = "fitPS"))
s
```

`Ssurveys` *Size of Groups of Glass Data*

Description

Count data from six different surveys looking at the number of sources/groups of glass found on the upper surfaces of clothing taken from the general public.

Usage

```
data(Psurveys)
```

Format

A `list` with five objects of class `psData`—see `readData` for more details. The elements of the list are named: `jackson`, `lau`, `pettard`, `ross`, and `roux`, corresponding to the lead author in each of the references given below. `lau`, `pettard`, and `ross` were taken from Coulson et al. (2001) rather than the original source.

Source

Coulson, S. A., Buckleton, J. S., Gummer, A. B., and Triggs, C. M. (2001) <doi:10.1016/S1355-0306(01)71847-3> Glass on clothing and shoes of members of the general population and people suspected of breaking crimes, Science & Justice, 41(1):39–48.

References

Lau L, Beveridge AD, Callowhill BC, Conners N, Foster K, Groves RJ, Ohashi KN, Sumner AM, Wong H (1997). "The Frequency of Occurrence of Paint and Glass on the Clothing of High School Students." *Canadian Society of Forensic Science Journal*, **30**(4), 233-240. doi:10.1080/00085030.1997.10757103. Petterd CI, McCallum I, Bradford L, Brinch K, Stewart S (1998). "Glass particles in the clothing of the general population in Canberra—a survey." In *Proceedings of the 14th International Symposium on the Forensic Sciences*. Ross P, Nguyen H (1998). "A survey of clothing for the presence of glass fragments." In *Proceedings of the 14th International Symposium on the Forensic Sciences*. Coulson SA, Buckleton JS, Gummer AB, Triggs CM (20011). "Glass on clothing and shoes of members of the general population and people suspected of breaking crimes." *Science & Justice*, **41**(1), 39–48. doi:10.1016/S13550306(01)718473. Roux C, Kirk R, Benson S, Van Haren T, Petterd CI (2001). "Glass particles in footwear of members of the public in south-eastern Australia—a survey." *Forensic Science International*, **116**(2), 149–156. doi:10.1016/S03790738(00)003558. Jackson F, Maynard P, Cavanagh-Steer K, Dusting T, Roux C (2013). "A survey of glass found on the headwear and head hair of a random population vs. people working with glass." *Forensic Science International*, **226**(1), 125–131. doi:10.1016/j.forsciint.2012.12.017.

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