

Package ‘conf’

August 24, 2020

Type Package

Title Visualization and Analysis of Statistical Measures of Confidence

Version 1.7.0

Maintainer Christopher Weld <ceweld@email.wm.edu>

Imports graphics, stats, statmod, STAR, fitdistrplus, pracma,
rootSolve, utils

Description Enables: (1) plotting two-dimensional confidence regions, (2) coverage analysis of confidence region simulations and (3) calculating confidence intervals and the associated actual coverage for binomial proportions. Each is given in greater detail next.

(1) Plots the two-dimensional confidence region for probability distribution parameters (supported distribution suffixes: cauchy, gamma, invgauss, logis, llogis, lnorm, norm, unif, weibull) corresponding to a user-given complete or right-censored dataset and level of significance. The `crplot()` algorithm plots more points in areas of greater curvature to ensure a smooth appearance throughout the confidence region boundary. An alternative heuristic plots a specified number of points at roughly uniform intervals along its boundary. Both heuristics build upon the radial profile log-likelihood ratio technique for plotting confidence regions given by Jaeger (2016) <doi:10.1080/00031305.2016.1182946>, and are detailed in a publication by Weld (2019) <doi:10.1080/00031305.2018.1564696>.

(2) Performs confidence region coverage simulations for a random sample drawn from a user-specified parametric population distribution, or for a user-specified dataset and point of interest with `coversim()`. (3) Calculates confidence interval bounds for a binomial proportion with `binomTest()`, calculates the actual coverage with `binomTestCoverage()`, and plots the actual coverage with `binomTestCoveragePlot()`. Calculates confidence interval bounds for the binomial proportion using an ensemble of constituent confidence intervals with `binomTestEnsemble()`. Calculates confidence interval bounds for the binomial proportion using a complete enumeration of all possible transitions from one actual coverage acceptance curve to another which minimizes the root mean square error for $n \leq 15$ and follows the transitions for well-known confidence intervals for $n > 15$ using `binomTestMSE()`.

Depends R (>= 3.2.0)

License GPL (<= 2)

Encoding UTF-8

LazyData true

RoxygenNote 7.1.0

Suggests knitr, rmarkdown

VignetteBuilder knitr

NeedsCompilation no

Author Christopher Weld [aut, cre] (<<https://orcid.org/0000-0001-5902-9738>>),
 Hayeon Park [aut],
 Kexin Feng [aut],
 Heather Sasinowska [aut],
 Lawrence Leemis [aut],
 Andrew Loh [ctb],
 Yuan Chang [ctb],
 Brock Crook [ctb],
 Xin Zhang [ctb]

Repository CRAN

Date/Publication 2020-08-24 14:30:08 UTC

R topics documented:

binomTest	2
binomTestCoverage	4
binomTestCoveragePlot	5
binomTestEnsemble	7
binomTestMSE	9
conf	10
coversim	11
crplot	16
Index	22

binomTest

Confidence Intervals for Binomial Proportions

Description

Generates lower and upper confidence interval limits for a binomial proportion using different types of confidence intervals.

Usage

```
binomTest(n, x,
          alpha = 0.05,
          intervalType = "Clopper-Pearson")
```

Arguments

n	sample size
x	number of successes
alpha	significance level for confidence interval
intervalType	type of confidence interval used; either "Clopper-Pearson", "Wald", "Wilson-Score", "Jeffreys", "Agresti-Coull", "Arcsine", or "Blaker"

Details

Generates a lower and upper confidence interval limit for a binomial proportion using

- various types of confidence intervals,
- various sample sizes, and
- various numbers of successes.

When the `binomTest` function is called, it returns a two-element vector in which

- the first element is the lower bound of the confidence interval, and
- the second element is the upper bound of the confidence interval.

This confidence interval is constructed by calculating lower and upper bounds associated with the confidence interval procedure specified by the `intervalType` argument. Lower bounds that are negative are set to 0 and upper bounds that are greater than 1 are set to 1.

Author(s)

Hayeon Park (<hpark03@email.wm.edu>), Larry Leemis (<leemis@math.wm.edu>)

See Also

[dbinom](#)

Examples

```
binomTest(10, 6)
binomTest(100, 30, intervalType = "Agresti-Coull")
```

binomTestCoverage *Actual Coverage Calculation for Binomial Proportions*

Description

Calculates the actual coverage of a confidence interval for a binomial proportion for a particular sample size n and a particular value of the probability of success p for several confidence interval procedures.

Usage

```
binomTestCoverage(n, p,
                 alpha = 0.05,
                 intervalType = "Clopper-Pearson")
```

Arguments

n	sample size
p	population probability of success
alpha	significance level for confidence interval
intervalType	type of confidence interval used; either "Clopper-Pearson", "Wald", "Wilson-Score", "Jeffreys", "Agresti-Coull", "Arcsine", or "Blaker"

Details

Calculates the actual coverage of a confidence interval procedure at a particular value of p for

- various types of confidence intervals,
- various probabilities of success p , and
- various sample sizes n .

The actual coverage for a particular value of p , the probability of success of interest, is

$$c(p) = \sum_{x=0}^n I(x, p) \binom{n}{x} p^x (1-p)^{n-x},$$

where $I(x, p)$ is an indicator function that determines whether a confidence interval covers p when $X = x$ (see Vollset, 1993).

The binomial distribution with arguments $\text{size} = n$ and $\text{prob} = p$ has probability mass function

$$p(x) = \binom{n}{x} p^x (1-p)^{n-x}$$

for $x = 0, 1, 2, \dots, n$.

The algorithm for computing the actual coverage for a particular probability of success begins by calculating all possible lower and upper bounds associated with the confidence interval procedure specified by the `intervalType` argument. The appropriate binomial probabilities are summed to determine the actual coverage at p .

Author(s)

Hayeon Park (<hpark03@email.wm.edu>), Larry Leemis (<leemis@math.wm.edu>)

References

Vollset, S.E. (1993). Confidence Intervals for a Binomial Proportion. *Statistics in Medicine*, 12, 809-824.

See Also

[dbinom](#)

Examples

```
binomTestCoverage(6, 0.4)
binomTestCoverage(n = 10, p = 0.3, alpha = 0.01, intervalType = "Wilson-Score")
```

binomTestCoveragePlot *Coverage Plots for Binomial Proportions*

Description

Generates plots for the actual coverage of a binomial proportion using various types of confidence intervals. Plots the actual coverage for a given sample size and stated nominal coverage $1 - \alpha$.

Usage

```
binomTestCoveragePlot(n,
                      alpha = 0.05,
                      intervalType = "Clopper-Pearson",
                      plo = 0,
                      phi = 1,
                      clo = 1 - 2 * alpha,
                      chi = 1,
                      points = 5 + floor(250 / n),
                      showTrueCoverage = TRUE,
                      gridCurves = FALSE)
```

Arguments

n	sample size
alpha	significance level for confidence interval
intervalType	type of confidence interval used; either "Clopper-Pearson", "Wald", "Wilson-Score", "Jeffreys", "Agresti-Coull", "Arcsine", or "Blaker"
plo	lower limit for percentile (horizontal axis)
phi	upper limit for percentile (horizontal axis)

clo	lower limit for coverage (vertical axis)
chi	upper limit for coverage (vertical axis)
points	number of points plotted in each segment of the plot; if default, varies with 'n' (see above)
showTrueCoverage	logical; if TRUE (default), a solid red line will appear at 1- alpha
gridCurves	logical; if TRUE, display acceptance curves in gray

Details

Generates an actual coverage plot for binomial proportions using

- various types of confidence intervals, and
- various sample sizes.

When the function is called with default arguments,

- the horizontal axis is the percentile at which the coverage is evaluated,
- the vertical axis is the actual coverage percentage at each percentile, that is, the probability that the true value at a percentile is contained in the corresponding confidence interval, and
- the solid red line is the stated coverage of 1- alpha.

The actual coverage for a particular value of p , the percentile of interest, is

$$c(p) = \sum_{x=0}^n I(x, p) \binom{n}{x} p^x (1-p)^{n-x},$$

where $I(x, p)$ is an indicator function that determines whether a confidence interval covers p when $X = x$ (see Vollset, 1993).

The binomial distribution with arguments $\text{size} = n$ and $\text{prob} = p$ has probability mass function

$$p(x) = \binom{n}{x} p^x (1-p)^{n-x}$$

for $x = 0, 1, \dots, n$.

The algorithm for plotting the actual coverage begins by calculating all possible lower and upper bounds associated with the confidence interval procedure specified by the `intervalType` argument. These values are concatenated into a vector which is sorted. Negative values and values that exceed 1 are removed from this vector. These values are the breakpoints in the actual coverage function. The `points` argument gives the number of points plotted on each segment of the graph of the actual coverage.

The `plo` and `phi` arguments can be used to expand or compress the plots horizontally.

The `clo` and `chi` arguments can be used to expand or compress the plots vertically.

By default, the `showTrueCoverage` argument plots a solid horizontal red line at the height of the stated coverage. The actual coverage is plotted with solid black lines for each segment of the actual coverage.

The `gridCurves` argument is assigned a logical value which indicates whether the acceptance curves giving all possible actual coverage values should be displayed as gray curves.

Author(s)

Hayeon Park (<hpark03@email.wm.edu>), Larry Leemis (<leemis@math.wm.edu>)

References

Vollset, S.E. (1993). Confidence Intervals for a Binomial Proportion. *Statistics in Medicine*, 12, 809–824.

See Also

[dbinom](#)

Examples

```
binomTestCoveragePlot(6)
binomTestCoveragePlot(10, intervalType = "Wilson-Score", clo = 0.8)
binomTestCoveragePlot(n = 100, intervalType = "Wald", clo = 0, chi = 1, points = 30)
```

binomTestEnsemble	<i>Ensemble Confidence Intervals for Binomial Proportions</i>
-------------------	---

Description

Generates lower and upper confidence interval limits for a binomial proportion using an ensemble of confidence intervals.

Usage

```
binomTestEnsemble(n, x,
                  alpha = 0.05,
                  CP = TRUE,
                  WS = TRUE,
                  JF = TRUE,
                  AC = TRUE,
                  AR = TRUE)
```

Arguments

n	sample size
x	number of successes
alpha	significance level for confidence interval
CP	logical; if TRUE (default), include Clopper-Pearson confidence interval procedure in the ensemble
WS	logical; if TRUE (default), include Wilson-Score confidence interval procedure in the ensemble

JF	logical; if TRUE (default), include Jeffreys confidence interval procedure in the ensemble
AC	logical; if TRUE (default), include Agresti-Coull confidence interval procedure in the ensemble
AR	logical; if TRUE (default), include Arcsine confidence interval procedure in the ensemble

Details

Generates lower and upper confidence interval limits for a binomial proportions using

- various sample sizes,
- various numbers of successes, and
- various combinations of confidence intervals.

When the `binomTestEnsemble` function is called, it returns a two-element vector in which

- the first element is the lower bound of the Ensemble confidence interval, and
- the second element is the upper bound of the Ensemble confidence interval.

To construct an Ensemble confidence interval that attains an actual coverage that is close to the stated coverage, the five constituent confidence interval procedures can be combined. Since these intervals vary in width, the lower limits and the actual coverage of the constituent confidence intervals at the maximum likelihood estimator are calculated. Likewise, the upper limits and the actual coverage of the constituent confidence intervals at the maximum likelihood estimator are calculated. The centroids of the lower and upper constituent confidence intervals for points falling below and above the stated coverage are connected with a line segment. The point of intersection of these line segments and the stated coverage gives the lower and upper bound of the Ensemble confidence interval. Special cases to this approach are given in the case of (a) the actual coverages all fall above or below the stated coverage, and (b) the slope of the line connecting the centroids is infinite.

If only one of the logical arguments is TRUE, the code returns a simple confidence interval of that one procedure.

The Wald confidence interval is omitted because it degenerates in actual coverage for $x = 0$ and $x = n$.

Author(s)

Hayeon Park (<hpark03@email.wm.edu>), Larry Leemis (<leemis@math.wm.edu>)

Examples

```
binomTestEnsemble(10, 3)
binomTestEnsemble(100, 82, CP = FALSE, AR = FALSE)
binomTestEnsemble(33, 1, CP = FALSE, JF = FALSE, AC = FALSE, AR = FALSE)
```

binomTestMSE

RMSE-Minimizing Confidence Intervals for Binomial Proportions

Description

Generates lower and upper confidence interval limits for a binomial proportion that minimizes the root mean square error (RMSE) of the actual coverage function.

Usage

```
binomTestMSE(n, x,
             alpha = 0.05,
             smooth = 1,
             showRMSE = TRUE,
             showAll = FALSE)
```

Arguments

n	sample size
x	number of successes
alpha	significance level for confidence interval
smooth	smoothness index
showRMSE	a logical variable indicating whether to show the value of RSME
showAll	a logical variable indicating whether to show confidence intervals of all possible number of successes

Details

Generates lower and upper confidence interval limits for a binomial proportion for

- various sample sizes,
- various numbers of successes.

When the binomTestMSE function is called, it returns a two-element vector in which

- the first element is the lower bound of the RMSE-minimizing confidence interval, and
- the second element is the upper bound of the RMSE-minimizing confidence interval.

An RMSE-minimizing two-sided $100 * (1 - \alpha)$ percent confidence interval for p is constructed from a random sample of size n from a Bernoulli(p) population. The parameter x gives the number of successes in the n mutually independent Bernoulli trials. For $n \leq 15$, all possible jumps between acceptance curves associated with the actual coverage function are enumerated based on their one-to-one relationship with the symmetric Dyck paths. For each sequence of jumps between acceptance curves, the confidence interval bounds that are returned are associated with discontinuities in the actual coverage function that together result in the lowest possible RMSE. A set of smoothness constraints that build on four existing non-conservative confidence intervals (Wilson-score,

Jeffreys, Arcsine, and Agresti-Coull) is used if the smoothness index `smooth` is set to one. These constraints ensure that the RMSE-confidence interval achieves smoothness, a preferable property of the binomial confidence interval that is related to lower bound differences for adjacent values of x . There is a trade-off between the RMSE and the smoothness. For $n > 100$, smoothness is required. The RMSE usually increases if the smoothness constraints are used. For $n > 15$, only the symmetric Dyck paths associated with the Wilson-score, Jeffreys, Arcsine, and Agresti-Coull confidence interval procedures are used instead of enumerating because the computation time increases in a factorial fashion in n . The minimal RMSE is not guaranteed for $n > 15$ because another symmetric Dyck path other than those associated with the four existing confidence interval procedures might prove to be optimal. However, this procedure does ensure a lower RMSE than any of the four existing confidence intervals for all n .

Author(s)

Kexin Feng (<kfeng01@email.wm.edu>), Larry Leemis (<lleemis@math.wm.edu>), Heather Sasinowska (<hdsasinowska@wm.edu>)

Examples

```
binomTestMSE(10, 3)
```

conf

conf: Visualization and Analysis of Statistical Measures of Confidence

Description

Enables:

1. confidence region plots in two-dimensions corresponding to a user given dataset, level of significance, and parametric probability distribution (supported distribution suffixes: `cauchy`, `gamma`, `invgauss`, `lnorm`, `llogis`, `logis`, `norm`, `unif`, `weibull`),
2. coverage simulations (if a point of interest is within or outside of a confidence region boundary) for either random samples drawn from a user-specified parametric distribution or for a user-specified dataset and point of interest, and
3. calculating confidence intervals and the associated actual coverage for binomial proportions.

Request from authors: Please properly cite any use of this package and/or its algorithms, which are detailed in the corresponding publication by Weld (2018) <doi:10.1080/00031305.2018.1564696>. Additionally, we welcome and appreciate your feedback and insights as to how this resource is being leveraged to improve whatever it is you do. Please include your name and academic and/or business affiliation in your correspondence.

Details

This package includes the functions:

- confidence region plots: `crplot`,
- confidence region coverage analysis: `coversim`,

- confidence intervals for binomial proportions: [binomTest](#),
- actual coverage calculation for binomial proportions: [binomTestCoverage](#),
- actual coverage plots for binomial proportions: [binomTestCoveragePlot](#), and
- ensemble confidence intervals for binomial proportions: [binomTestEnsemble](#).

Vignettes

The CRAN website <https://CRAN.R-project.org/package=conf> contains links for vignettes on the [crplot](#) and [coversim](#) functions.

Acknowledgments

The lead author thanks The Omar Bradley Fellowship for Research in Mathematics for funding that partially supported this work.

Author(s)

Christopher Weld, Hayeon Park, Larry Leemis
 Maintainer: Christopher Weld <ceweld@email.wm.edu>

coversim

Confidence Region Coverage

Description

Creates a confidence region and determines coverage results for a corresponding point of interest. Iterates through a user specified number of trials. Each trial uses a random dataset with user-specified parameters (default) or a user specified dataset matrix ('n' samples per column, 'iter' columns) and returns the corresponding actual coverage results. See the CRAN website <https://CRAN.R-project.org/package=conf> for a link to a coversim vignette.

Usage

```
coversim(alpha, distn,
          n      = NULL,
          iter   = NULL,
          dataset = NULL,
          point  = NULL,
          seed   = NULL,
          a      = NULL,
          b      = NULL,
          kappa  = NULL,
          lambda = NULL,
          mu     = NULL,
          s      = NULL,
          sigma  = NULL,
```

```

theta      = NULL,
heuristic  = 1,
maxdeg     = 5,
ellipse_n  = 4,
pts        = FALSE,
mlelab     = TRUE,
sf         = c(5, 5),
mar        = c(4, 4.5, 2, 1.5),
xlab       = "",
ylab       = "",
main       = "",
xlas       = 0,
ylas       = 0,
origin     = FALSE,
xlim       = NULL,
ylim       = NULL,
tol        = .Machine$double.eps ^ 1,
info       = FALSE,
returnsamp = FALSE,
returnquant = FALSE,
repair     = TRUE,
exact      = FALSE,
showplot   = FALSE,
delay      = 0 )

```

Arguments

alpha	significance level; scalar or vector; resulting plot illustrates a $100(1 - \alpha)\%$ confidence region.
distn	distribution to fit the dataset to; accepted values: 'cauchy', 'gamma', 'invgauss', 'logis', 'llogis', 'lnorm', 'norm', 'unif', 'weibull'.
n	trial sample size (producing each confidence region); scalar or vector; needed if a dataset is not given.
iter	iterations (or replications) of individual trials per parameterization; needed if a dataset is not given.
dataset	a 'n' x 'iter' matrix of dataset values, or a vector of length 'n' (for a single iteration).
point	coverage is assessed relative to this point.
seed	random number generator seed.
a	distribution parameter (when applicable).
b	distribution parameter (when applicable).
kappa	distribution parameter (when applicable).
lambda	distribution parameter (when applicable).
mu	distribution parameter (when applicable).
s	distribution parameter (when applicable).

sigma	distribution parameter (when applicable).
theta	distribution parameter (when applicable).
heuristic	numeric value selecting method for plotting: 0 for elliptic-oriented point distribution, and 1 for smoothing boundary search heuristic.
maxdeg	maximum angle tolerance between consecutive plot segments in degrees.
ellipse_n	number of roughly equidistant confidence region points to plot using the elliptic-oriented point distribution (must be a multiple of four because its algorithm exploits symmetry in the quadrants of an ellipse).
pts	displays confidence region boundary points if TRUE (applies to confidence region plots in which showplot = TRUE).
mlelab	logical argument to include the maximum likelihood estimate coordinate point (default is TRUE, applies to confidence region plots when showplot = TRUE).
sf	significant figures in axes labels specified using <code>sf = c(x, y)</code> , where <code>x</code> and <code>y</code> represent the optional digits argument in the R function <code>round</code> as it pertains the horizontal and vertical labels.
mar	specifies margin values for <code>par(mar = c())</code> (see <code>mar</code> in par).
xlab	string specifying the horizontal axis label (applies to confidence region plots when showplot = TRUE).
ylab	string specifying the vertical axis label (applies to confidence region plots when showplot = TRUE).
main	string specifying the plot title (applies to confidence region plots when showplot = TRUE).
xlas	numeric in 0, 1, 2, 3 specifying the style of axis labels (see <code>las</code> in par , applies to confidence region plots when showplot = TRUE).
ylas	numeric in 0, 1, 2, 3 specifying the style of axis labels (see <code>las</code> in par , applies to confidence region plots when showplot = TRUE).
origin	logical argument to include the plot origin (applies to confidence region plots when showplot = TRUE).
xlim	two element vector containing horizontal axis minimum and maximum values (applies to confidence region plots when showplot = TRUE).
ylim	two element vector containing vertical axis minimum and maximum values (applies to confidence region plots when showplot = TRUE).
tol	the <code>uniroot</code> parameter specifying its required accuracy.
info	logical argument to return coverage information in a list; includes <code>alpha</code> value(s), <code>n</code> value(s), coverage and error results per iteration, and <code>returnsamp</code> and/or <code>returnquant</code> when requested.
returnsamp	logical argument; if TRUE returns random samples used in a matrix with <code>n</code> rows, <code>iter</code> cols.
returnquant	logical argument; if TRUE returns random quantiles used in a matrix with <code>n</code> rows, <code>iter</code> cols.
repair	logical argument to repair regions inaccessible using a radial angle from its MLE (multiple root azimuths).

exact	logical argument specifying if alpha value is adjusted to compensate for negative coverage bias in order to achieve (1 - alpha) coverage probability using previously recorded Monte Carlo simulation results; available for limited values of alpha (roughly $\leq 0.2-0.3$), n (typically $n = 4, 5, \dots, 50$) and distributions (distn suffixes: weibull, llogis, norm).
showplot	logical argument specifying if each coverage trial produces a plot.
delay	numeric value of delay (in seconds) between trials so its plot can be seen (applies when showplot = TRUE).

Details

Parameterizations for supported distributions are given following the default axes convention in use by crplot and coversim, which are:

Distribution	Horizontal Axis	Vertical Axis
Cauchy	a	s
gamma	θ	κ
inverse Gaussian	μ	λ
log logistic	λ	κ
log normal	μ	σ
logistic	μ	σ
normal	μ	σ
uniform	a	b
Weibull	κ	λ

Each respective distribution is defined below.

- The Cauchy distribution for the real-numbered location parameter a , scale parameter s , and x is a real number, has the probability density function

$$1/(s\pi(1 + ((x - a)/s)^2)).$$

- The gamma distribution for shape parameter $\kappa > 0$, scale parameter $\theta > 0$, and $x > 0$, has the probability density function

$$1/(Gamma(\kappa)\theta^\kappa)x^{(\kappa-1)}exp(-x/\theta).$$

- The inverse Gaussian distribution for mean $\mu > 0$, shape parameter $\lambda > 0$, and $x > 0$, has the probability density function

$$\sqrt{(\lambda/(2\pi x^3))}exp(-\lambda(x - \mu)^2/(2\mu^2 x)).$$

- The log logistic distribution for scale parameter $\lambda > 0$, shape parameter $\kappa > 0$, and $x \geq 0$, has a probability density function

$$(\kappa\lambda)(x\lambda)^{(\kappa-1)}/(1 + (\lambda x)^\kappa)^2.$$

- The log normal distribution for the real-numbered mean μ of the logarithm, standard deviation $\sigma > 0$ of the logarithm, and $x > 0$, has the probability density function

$$1/(x\sigma\sqrt{2\pi})exp(-(\log x - \mu)^2/(2\sigma^2)).$$

- The logistic distribution for the real-numbered location parameter μ , scale parameter σ , and x is a real number, has the probability density function

$$(1/\sigma)\exp((x - \mu)/\sigma)(1 + \exp((x - \mu)/\sigma))^{-2}$$

- The normal distribution for the real-numbered mean μ , standard deviation $\sigma > 0$, and x is a real number, has the probability density function

$$1/\sqrt{(2\pi\sigma^2)}\exp(-(x - \mu)^2/(2\sigma^2)).$$

- The uniform distribution for real-valued parameters a and b where $a < b$ and $a \leq x \leq b$, has the probability density function

$$1/(b - a).$$

- The Weibull distribution for scale parameter $\lambda > 0$, shape parameter $\kappa > 0$, and $x > 0$, has the probability density function

$$\kappa(\lambda^\kappa)x^{(\kappa-1)}\exp(-(\lambda x)^\kappa).$$

Value

If the optional argument `info = TRUE` is included then a list of coverage results is returned. That list includes alpha value(s), n value(s), coverage and error results per iteration. Additionally, `returnsamp = TRUE` and/or `returnquant = TRUE` will result in an n row, iter column matrix of sample and/or sample cdf values.

Author(s)

Christopher Weld (<ceweld@email.wm.edu>)

Lawrence Leemis (<leemis@math.wm.edu>)

References

Weld, C., Loh, A., Leemis, L. (in press), "Plotting Likelihood-Ratio Based Confidence Regions for Two-Parameter Univariate Probability Models", *The American Statistician*.

See Also

[crplot](#), [uniroot](#)

Examples

```
## assess actual coverage at various alpha = {0.5, 0.1} given n = 30 samples, completing
## 10 trials per parameterization (iter) for a normal(mean = 2, sd = 3) rv
coversim(alpha = c(0.5, 0.1), "norm", n = 30, iter = 10, mu = 2, sigma = 3)
```

```
## show plots for 5 iterations of 30 samples each from a Weibull(2, 3)
coversim(0.5, "weibull", n = 30, iter = 5, lambda = 1.5, kappa = 0.5, showplot = TRUE,
origin = TRUE)
```

Description

Plots the two-dimensional confidence region for probability distribution parameters (supported distribution suffixes: cauchy, gamma, invgauss, lnorm, llogis, logis, norm, unif, weibull) corresponding to a user given complete or right-censored dataset and level of significance. See the CRAN website <https://CRAN.R-project.org/package=conf> for a link to two crplot vignettes.

Usage

```
crplot(dataset, alpha, distn,
        cen      = rep(1, length(dataset)),
        heuristic = 1,
        maxdeg   = 5,
        ellipse_n = 4,
        pts      = TRUE,
        mlelab   = TRUE,
        sf       = NULL,
        mar      = c(4, 4.5, 2, 1.5),
        xyswap   = FALSE,
        xlab     = "",
        ylab     = "",
        main     = "",
        xlas     = 0,
        ylas     = 0,
        origin   = FALSE,
        xlim     = NULL,
        ylim     = NULL,
        tol      = .Machine$double.eps ^ 1,
        info     = FALSE,
        maxcount = 30,
        repair   = TRUE,
        jumpshift = 0.5,
        jumpuphill = min(alpha, 0.01),
        jumpinfo = FALSE,
        showjump = FALSE,
        showplot = TRUE,
        animate  = FALSE,
        delay    = 0.5,
        exact    = FALSE,
        silent   = FALSE )
```

Arguments

dataset a 1 x n vector of data values.

alpha	significance level; resulting plot illustrates a $100(1 - \alpha)\%$ confidence region.
distn	distribution to fit the dataset to; accepted values: 'cauchy', 'gamma', 'invgauss', 'logis', 'llogis', 'lnorm', 'norm', 'unif', 'weibull'.
cen	a vector of binary values specifying if the corresponding data values are right-censored (0), or observed (1, default); its length must match length(dataset).
heuristic	numeric value selecting method for plotting: 0 for elliptic-oriented point distribution, and 1 for smoothing boundary search heuristic.
maxdeg	maximum angle tolerance between consecutive plot segments in degrees.
ellipse_n	number of roughly equidistant confidence region points to plot using the elliptic-oriented point distribution (must be a multiple of four because its algorithm exploits symmetry in the quadrants of an ellipse).
pts	displays confidence region boundary points identified if TRUE.
mlelab	logical argument to include the maximum likelihood estimate coordinate point (default is TRUE).
sf	significant figures in axes labels specified using $sf = c(x, y)$, where x and y represent the optional digits argument in the R function <code>round</code> as it pertains to the horizontal and vertical labels.
mar	specifies margin values for <code>par(mar = c())</code> (see <code>mar</code> in par).
xyswap	logical argument to switch the axes that the distribution parameter are shown.
xlab	string specifying the x axis label.
ylab	string specifying the y axis label.
main	string specifying the plot title.
xlas	numeric in 0, 1, 2, 3 specifying the style of axis labels (see <code>las</code> in par).
ylas	numeric in 0, 1, 2, 3 specifying the style of axis labels (see <code>las</code> in par).
origin	logical argument to include the plot origin (default is FALSE).
xlim	two-element vector containing horizontal axis minimum and maximum values.
ylim	two-element vector containing vertical axis minimum and maximum values.
tol	the <code>uniroot</code> parameter specifying its required accuracy.
info	logical argument to return plot information: MLE is returned as a list; (x, y) plot point coordinates and corresponding phi angles (with respect to MLE) are returned as a list.
maxcount	integer value specifying the number of smoothing search iterations before terminating with maxdeg not met.
repair	logical argument to repair regions inaccessible using a radial angle from its MLE due to multiple roots at select ϕ angles.
jumpshift	see vignette "conf Advanced Options" for details; location (as a fractional value between 0 and 1) along the vertical or horizontal "gap" (near an uncharted region) to locate a jump-center toward; can be either a scalar value (uniformly applied to all jump-centers) or vector of length four (with unique values for its respective quadrants, relative to the MLE).

jumpuphill	see vignette "conf Advanced Options" for details; significance level increase to alpha for the jump-center (corresponds to an "uphill" location on its likelihood function); can be either a scalar value (uniformly applied to all jump-centers) or vector of length four (with unique values for its respective quadrants, relative to the MLE).
jumpinfo	logical argument to return plot info (see info argument) and jump-center info; returned within 'repair' attribute are jumpuphill value, jumpshift value, "l" or "-" gap type, jump-center(s) coordinates, and coordinates of points left & right of the inaccessible region.
showjump	logical argument specifying if jump-center repair reference points appear on the confidence region plot.
showplot	logical argument specifying if a plot is output; altering from its default of TRUE is only logical assuming crplot is run for its data only (see the info argument).
animate	logical argument specifying if an animated plot build will display; the animation sequence is given in successive plots.
delay	numeric value of delay (in seconds) between successive plots when animate = TRUE.
exact	logical argument specifying if alpha value is adjusted to compensate for negative coverage bias to achieve $(1 - \alpha)$ coverage probability using previously recorded Monte Carlo simulation results; available for limited values of alpha (roughly $\leq 0.2-0.3$), n (typically $n = 4, 5, \dots, 50$) and distributions (distn suffixes: weibull, llogis, norm).
silent	logical argument specifying if console output should be suppressed.

Details

This function plots a confidence region for a variety of two-parameter distributions. It requires:

- a vector of dataset values,
- the level of significance (alpha), and
- a population distribution to fit the data to.

Plots display according to probability density function parameterization given later in this section. Two heuristics (and their associated combination) are available to plot confidence regions. Along with their descriptions, they are:

1. *Smoothing Boundary Search Heuristic (default)*. This heuristic plots more points in areas of greater curvature to ensure a smooth appearance throughout the confidence region boundary. Its maxdeg parameter specifies the maximum tolerable angle between three successive points. Lower values of maxdeg result in smoother plots, and its default value of 5 degrees provides adequate smoothing in most circumstances. Values of $\text{maxdeg} \leq 3$ are not recommended due to their complicating implications to trigonometric numerical approximations near 0 and 1; their use may result in plot errors.
2. *Elliptic-Oriented Point Distribution*. This heuristic allows the user to specify a number of points to plot along the confidence region boundary at roughly uniform intervals. Its name is derived from the technique it uses to choose these points—an extension of the Steiner generation of a non-degenerate conic section, also known as the parallelogram method—which

identifies points along an ellipse that are approximately equidistant. To exploit the computational benefits of ellipse symmetry over its four quadrants, `ellipse_n` value must be divisible by four.

By default, `crplot` implements the smoothing boundary search heuristic. Alternatively, the user can plot using the elliptic-oriented point distribution algorithm, or a combination of them both. Combining the two techniques initializes the plot using the elliptic-oriented point distribution algorithm, and then subsequently populates additional points in areas of high curvature (those outside of the maximum angle tolerance parameterization) in accordance with the smoothing boundary search heuristic. This combination results when the smoothing boundary search heuristic is specified in conjunction with an `ellipse_n` value greater than four.

Both of the aforementioned heuristics use a radial profile log likelihood function to identify points along the confidence region boundary. It cuts the log likelihood function in a directional azimuth from its MLE, and locates the associated confidence region boundary point using the asymptotic results associated with the ratio test statistic $-2[\log L(\theta) - \log L(\hat{\theta})]$ which converges in distribution to the chi-square distribution with two degrees of freedom (for a two parameter distribution).

The default axes convention in use by `crplot` are

Distribution	Horizontal Axis	Vertical Axis
Cauchy	a	s
gamma	θ	κ
inverse Gaussian	μ	λ
log logistic	λ	κ
log normal	μ	σ
logistic	μ	σ
normal	μ	σ
uniform	a	b
Weibull	κ	λ

where each respective distribution is defined below.

- The Cauchy distribution for the real-numbered location parameter a , scale parameter s , and x is a real number, has the probability density function

$$1/(s\pi(1 + ((x - a)/s)^2)).$$

- The gamma distribution for shape parameter $\kappa > 0$, scale parameter $\theta > 0$, and $x > 0$, has the probability density function

$$1/(Gamma(\kappa)\theta^\kappa)x^{(\kappa-1)}exp(-x/\theta).$$

- The inverse Gaussian distribution for mean $\mu > 0$, shape parameter $\lambda > 0$, and $x > 0$, has the probability density function

$$\sqrt{(\lambda/(2\pi x^3))}exp(-\lambda(x - \mu)^2/(2\mu^2 x)).$$

- The log logistic distribution for scale parameter $\lambda > 0$, shape parameter $\kappa > 0$, and $x \geq 0$, has a probability density function

$$(\kappa\lambda)(x\lambda)^{(\kappa-1)}/(1 + (\lambda x)^\kappa)^2.$$

- The log normal distribution for the real-numbered mean μ of the logarithm, standard deviation $\sigma > 0$ of the logarithm, and $x > 0$, has the probability density function

$$1/(x\sigma\sqrt{(2\pi)})\exp(-(\log x - \mu)^2/(2\sigma^2)).$$

- The logistic distribution for the real-numbered location parameter μ , scale parameter σ , and x is a real number, has the probability density function

$$(1/\sigma)\exp((x - \mu)/\sigma)(1 + \exp((x - \mu)/\sigma))^{-2}$$

- The normal distribution for the real-numbered mean μ , standard deviation $\sigma > 0$, and x is a real number, has the probability density function

$$1/\sqrt{(2\pi\sigma^2)}\exp(-(x - \mu)^2/(2\sigma^2)).$$

- The uniform distribution for real-valued parameters a and b where $a < b$ and $a \leq x \leq b$, has the probability density function

$$1/(b - a).$$

- The Weibull distribution for scale parameter $\lambda > 0$, shape parameter $\kappa > 0$, and $x > 0$, has the probability density function

$$\kappa(\lambda^\kappa)x^{(\kappa-1)}\exp(-(\lambda x)^\kappa).$$

Value

If the optional argument `info = TRUE` is included then a list is returned with:

- `parm1*`: a vector containing the associated confidence region boundary values for parameter 1
- `parm2*`: a vector containing the associated confidence region boundary values for parameter 2
- `phi`: a vector containing the angles used
- `parm1hat*`: the MLE for parameter 1
- `parm2hat*`: the MLE for parameter 2

*Note: "param1" and "param2" are placeholders that will be replaced with the appropriate parameter names based on the probability distribution.

Author(s)

Christopher Weld (<ceweld@email.wm.edu>)

Lawrence Leemis (<leemis@math.wm.edu>)

References

Jaeger, A. (2016), "Computation of Two- and Three-Dimensional Confidence Regions with the Likelihood Ratio", *The American Statistician*, 49, 48–53.

Weld, C., Loh, A., Leemis, L. (in press), "Plotting Likelihood-Ratio Based Confidence Regions for Two-Parameter Univariate Probability Models", *The American Statistician*.

See Also[coversim](#), [uniroot](#)**Examples**

```
## plot the 95% confidence region for Weibull shape and scale parameters
## corresponding to the given ballbearing dataset
ballbearing <- c(17.88, 28.92, 33.00, 41.52, 42.12, 45.60, 48.48, 51.84,
                51.96, 54.12, 55.56, 67.80, 68.64, 68.64, 68.88, 84.12,
                93.12, 98.64, 105.12, 105.84, 127.92, 128.04, 173.40)
crplot(dataset = ballbearing, distn = "weibull", alpha = 0.05)

## repeat this plot using the elliptic-oriented point distribution heuristic
crplot(dataset = ballbearing, distn = "weibull", alpha = 0.05,
        heuristic = 0, ellipse_n = 80)

## combine the two heuristics, compensating any elliptic-oriented point vertices whose apparent
## angles > 6 degrees with additional points, and expand the plot area to include the origin
crplot(dataset = ballbearing, distn = "weibull", alpha = 0.05,
        maxdeg = 6, ellipse_n = 80, origin = TRUE)

## next use the inverse Gaussian distribution and show no plot points
crplot(dataset = ballbearing, distn = "invgauss", alpha = 0.05,
        pts = FALSE)
```

Index

- * **Agresti-Coull**
 - binomTest, 2
 - binomTestCoverage, 4
 - binomTestCoveragePlot, 5
 - binomTestEnsemble, 7
- * **Arcsine**
 - binomTest, 2
 - binomTestCoverage, 4
 - binomTestCoveragePlot, 5
 - binomTestEnsemble, 7
- * **Blaker**
 - binomTest, 2
 - binomTestCoverage, 4
 - binomTestCoveragePlot, 5
- * **Clopper-Pearson**
 - binomTest, 2
 - binomTestCoverage, 4
 - binomTestCoveragePlot, 5
 - binomTestEnsemble, 7
- * **Dyck words**
 - binomTestMSE, 9
- * **Ensemble**
 - binomTestEnsemble, 7
- * **Jeffreys**
 - binomTest, 2
 - binomTestCoverage, 4
 - binomTestCoveragePlot, 5
 - binomTestEnsemble, 7
- * **RMSE**
 - binomTestMSE, 9
- * **Wald**
 - binomTest, 2
 - binomTestCoverage, 4
 - binomTestCoveragePlot, 5
 - binomTestEnsemble, 7
- * **Wilson-Score**
 - binomTest, 2
 - binomTestCoverage, 4
 - binomTestCoveragePlot, 5
- binomTestEnsemble, 7
- * **actual coverage function**
 - binomTestMSE, 9
- * **actual coverage**
 - binomTestCoverage, 4
- * **binomial distribution**
 - binomTest, 2
 - binomTestCoverage, 4
 - binomTestCoveragePlot, 5
 - binomTestEnsemble, 7
- * **binomial proportion**
 - binomTest, 2
 - binomTestCoverage, 4
 - binomTestCoveragePlot, 5
 - binomTestEnsemble, 7
 - binomTestMSE, 9
- * **confidence intervals for binomial proportions**
 - binomTest, 2
 - binomTestCoverage, 4
 - binomTestCoveragePlot, 5
 - binomTestEnsemble, 7
 - binomTestMSE, 9
- * **confidence interval**
 - binomTest, 2
 - binomTestCoverage, 4
 - binomTestCoveragePlot, 5
 - binomTestEnsemble, 7
 - binomTestMSE, 9
- * **confidence region plot graphics visualization coverage parameter estimation**
 - coversim, 11
 - crplot, 16
- * **distribution**
 - coversim, 11
 - crplot, 16
- * **models**
 - coversim, 11

crplot, 16

* **univar**

- coversim, 11
- crplot, 16

binomTest, 2, 11

binomTestCoverage, 4, 11

binomTestCoveragePlot, 5, 11

binomTestEnsemble, 7, 11

binomTestMSE, 9

conf, 10

coversim, 10, 11, 11, 21

crplot, 10, 11, 15, 16

dbinom, 3, 5, 7

par, 13, 17

round, 13, 17

uniroot, 13, 15, 17, 21