

Package ‘truelies’

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Type Package

Title Bayesian Methods to Estimate the Proportion of Liars in Coin
Flip Experiments

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Description Implements Bayesian methods, described in
Hugh-Jones (2019) <[doi:10.1007/s40881-019-00069-x](https://doi.org/10.1007/s40881-019-00069-x)>, for estimating the
proportion of liars in coin flip-style experiments, where subjects
report a random outcome and are paid for reporting a ``good" outcome.

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URL <https://github.com/hughjonesd/truelies>

BugReports <https://github.com/hughjonesd/truelies/issues>

Imports hdrude

Suggests dplyr, ggplot2, MASS, purrr, tidyr

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compare_dists	<i>Calculate probability that one posterior is larger than another</i>
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Description

Given two distributions with density functions ϕ_1, ϕ_2 , this calculates:

$$\int_0^1 \int_0^{l_1} \phi_1(l_1) \phi_2(l_2) dl_2 dl_1,$$

the probability that the value of the first distribution is greater.

Usage

```
compare_dists(dist1, dist2)
```

Arguments

dist1	Density of distribution 1, as a one-argument function.
dist2	Density of distribution 2.

Value

A probability scalar.

Examples

```
d1 <- update_prior(30, 50, P = 0.5, prior = stats::dunif)
d2 <- update_prior(25, 40, P = 0.5, prior = stats::dunif)
compare_dists(d1, d2)
```

difference_dist	<i>Find density of the difference of two distributions</i>
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Description

Given two probability density functions `dist1` and `dist2`, `difference_dist` returns the density of “`dist1 - dist2`”.

Usage

```
difference_dist(dist1, dist2)
```

Arguments

`dist1, dist2` Probability density functions

Details

At the moment this only works when `dist1` and `dist2` are defined on $[0, 1]$.

Value

A probability density function defined on $[-1, 1]$.

Examples

```
d1 <- update_prior(30, 50, P = 0.5, prior = stats::dunif)
d2 <- update_prior(32, 40, P = 0.5, prior = stats::dunif)
dd <- difference_dist(d1, d2)
dist_hdr(dd, 0.95)
```

dist_hdr	<i>Compute highest density region for a density function</i>
----------	--

Description

This is a wrapper for `hdrcde::hdr`. The highest density region is the interval that covers `conf_level` of the data and has the highest average density. See:

Usage

```
dist_hdr(dist, conf_level, bounds = attr(dist, "limits"))
```

Arguments

dist	A one-argument function
conf_level	A scalar between 0 and 1
bounds	A length 2 vector of the bounds of the distribution's support

Details

Rob J Hyndman (1996) "Computing and graphing highest density regions". American Statistician, 50, 120-126.

Value

A length 2 vector of region endpoints

Examples

```
d1 <- update_prior(33, 50, P = 0.5, prior = stats::dunif)
dist_hdr(d1, 0.95)
```

dist_mean

Find mean of a probability density function

Description

Find mean of a probability density function

Usage

```
dist_mean(dist, l = attr(dist, "limits")[1], r = attr(dist,
  "limits")[2])
```

Arguments

dist	A one-argument function returned from update_prior()
l	Lower bound of the density's support
r	Upper bound of the density's support

Value

A scalar

Examples

```
d1 <- update_prior(10, 40, P = 5/6, prior = stats::dunif)
dist_mean(d1)
```

dist_quantile	<i>Find quantiles given a probability density function</i>
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Description

Find quantiles given a probability density function

Usage

```
dist_quantile(dist, probs, bounds = attr(dist, "limits"))
```

Arguments

dist	A one argument function
probs	A vector of probabilities
bounds	A length 2 vector of the bounds of the distribution's support

Value

A vector of quantiles

Examples

```
d1 <- update_prior(33, 50, P = 0.5, prior = stats::dunif)
dist_quantile(d1, c(0.025, 0.975))
```

empirical_bayes	<i>Estimate proportions of liars in multiple samples using empirical Bayes</i>
-----------------	--

Description

This function creates a prior by fitting a Beta distribution to the heads/N vector, using `MASS::fitdistr()`. The prior is then updated using data from each individual sample to give the posterior distributions.

Usage

```
empirical_bayes(heads, ...)

## Default S3 method:
empirical_bayes(heads, N, P, ...)

## S3 method for class 'formula'
empirical_bayes(formula, data, P, subset, ...)
```

Arguments

heads	A vector of numbers of the good outcome reported
...	Ignored
N	A vector of sample sizes
P	Probability of <i>bad</i> outcome
formula	A two-sided formula of the form heads ~ group. heads is a logical vector specifying whether the "good" outcome was reported. group specifies the sample.
data	A data frame or matrix. Each row represents one individual.
subset	A logical or numeric vector specifying the subset of data to use

Details

The formula interface allows calling the function directly on experimental data.

Value

A list with two components:

- prior, the calculated empirical prior (of class `densityFunction`).
- posterior, a list of posterior distributions (objects of class `densityFunction`). If heads was named, the list will have the same names.

Examples

```
heads <- c(Baseline = 30, Treatment1 = 38, Treatment2 = 45)
N <- c(50, 52, 57)
res <- empirical_bayes(heads, N, P = 0.5)

compare_dists(res$posteriors$Baseline, res$posteriors$Treatment1)
plot(res$prior, ylim = c(0, 4), col = "grey", lty = 2)
plot(res$posteriors$Baseline, add = TRUE, col = "blue")
plot(res$posteriors$Treatment1, add = TRUE, col = "orange")
plot(res$posteriors$Treatment2, add = TRUE, col = "red")

# starting from raw data:
raw_data <- data.frame(
  report = sample(c("heads", "tails"),
    size = 300,
    replace = TRUE,
    prob = c(.8, .2)
  ),
  group = rep(LETTERS[1:10], each = 30)
)
empirical_bayes(I(report == "heads") ~ group, data = raw_data, P = 0.5)
```

power_calc *Calculate power to detect non-zero lying*

Description

This uses simulations to estimate the power to detect a given level of lying in a sample of size N by this package's methods.

Usage

```
power_calc(N, P, lambda, alpha = 0.05, prior = stats::dunif,
           nsims = 200)
```

Arguments

N	Total number in sample
P	Probability of <i>bad</i> outcome
lambda	Probability of a subject lying
alpha	Significance level to use for the null hypothesis
prior	Prior over lambda. A function which takes a vector of values between 0 and 1, and returns the probability density. The default is the uniform distribution.
nsims	Number of simulations to run

Value

Estimated power, a scalar between 0 and 1.

Examples

```
power_calc(N = 50, P = 0.5, lambda = 0.2)
```

power_calc_difference *Estimate power to detect differences in lying between two samples*

Description

Using simulations, estimate power to detect differences in lying using `compare_dists()`, given values for λ , the probability of lying, in each sample.

Usage

```
power_calc_difference(N1, N2 = N1, P, lambda1, lambda2, alpha = 0.05,
                    alternative = c("two.sided", "greater", "less"),
                    prior = stats::dunif, nsims = 200)
```

Arguments

N1	N of sample 1
N2	N of sample 2
P	Probability of <i>bad</i> outcome
lambda1	Probability of lying in sample 1
lambda2	Probability of lying in sample 2
alpha	Significance level
alternative	"two.sided", "greater" (sample 1 is greater), or "less". Can be abbreviated
prior	Prior over lambda. A function which takes a vector of values between 0 and 1, and returns the probability density. The default is the uniform distribution.
nsims	Number of simulations to run

Value

Estimated power, a scalar between 0 and 1.

Examples

```
power_calc_difference(N1 = 100, P = 0.5, lambda = 0, lambda2 = 0.25)
```

`print.densityFunction` *Print/plot an object of class densityFunction.*

Description

Print/plot an object of class `densityFunction`.

Usage

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

## S3 method for class 'densityFunction'
plot(x, ...)
```

Arguments

x	The object
...	Unused

Examples

```
d1 <- update_prior(33, 50, P = 0.5, prior = stats::dunif)
d1
plot(d1)

# show the actual R code (techies only)
unclass(d1)
```

update_prior	<i>Calculate posterior distribution of the proportion of liars</i>
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Description

update_prior uses the equation for the posterior:

$$\phi(\lambda|R; N, P) = Pr(R|\lambda; N, P)\phi(\lambda) / \int Pr(R|\lambda'; N, P)\phi(\lambda')d\lambda'$$

where ϕ is the prior and $Pr(R|\lambda; N, P)$ is the probability of R reports of heads given that people lie with probability λ :

$$Pr(R|\lambda; N, P) = binom(N, (1 - P) + \lambda P)$$

Usage

```
update_prior(heads, N, P, prior = stats::dunif, npoints = 1000)
```

Arguments

heads	Number of good outcomes reported
N	Total number in sample
P	Probability of <i>bad</i> outcome
prior	Prior over lambda. A function which takes a vector of values between 0 and 1, and returns the probability density. The default is the uniform distribution.
npoints	How many points to integrate on?

Value

The probability density of the posterior distribution, as a one-argument function.

Examples

```
posterior <- update_prior(heads = 30, N = 50, P = 0.5, prior = stats::dunif)
plot(posterior)
```

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