Package ‘distributional’

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Title Vectorised Probability Distributions

Version 0.2.0

Description Vectorised distribution objects with tools for manipulating, visualising, and using probability distributions. Designed to allow model prediction outputs to return distributions rather than their parameters, allowing users to directly interact with predictive distributions in a data-oriented workflow. In addition to providing generic replacements for p/d/q/r functions, other useful statistics can be computed including means, variances, intervals, and highest density regions.

License GPL-3

Imports vctrs (>= 0.3.0),
rlang (>= 0.4.5),
generics,
ellipsis,
stats,
numDeriv,
ggplot2,
scales,
farver,
digest,
utils,
lifecycle

Suggests testthat (>= 2.1.0),
covr,
mvtnorm,
actuar,
ggdist

RdMacros lifecycle

URL https://pkg.mitchelloharawild.com/distributional/, https://github.com/mitchelloharawild/distributional

BugReports https://github.com/mitchelloharawild/distributional/issues

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LazyData true

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R topics documented:

`autoplot.distribution` *Plot a distribution*

Description

Deprecated

Usage

```
## S3 method for class 'distribution'
autoplot(
  x,
  type = c("pdf", "cdf"),
  n = 100,
  quantile_range = c(0.001, 0.999),
  ...
)
```

Arguments

`x`	The distribution(s) to plot.
`type`	The type of plot to make (must be either `"pdf"` or `"cdf"`).
`n`	The resolution (number of points) used to display the distribution.
`quantile_range`	The range of the distribution (specified as quantiles).
`...`	Unused.

Details

Visualise distribution(s) by plotting its probability density function (`density()`) or cumulative distribution function (`cdf()`). Note: This function currently only works for continuous distributions.

Examples

```
library(ggplot2)
dist <- c(dist_normal(mu = 0, sigma = 1), dist_student_t(df = 3))
autoplot(dist, type = "pdf")
autoplot(dist, type = "cdf")
```

cdf — *The cumulative distribution function*

Description

Stable

Usage

```
cdf(x, q, ..., log = FALSE)

## S3 method for class 'distribution'
cdf(x, q, ...)
```

Arguments

`x`	The distribution(s).
`q`	The quantile at which the cdf is calculated.
`...`	Additional arguments passed to methods.
`log`	If `TRUE`, probabilities will be given as log probabilities.

density.distribution — *The probability density/mass function*

Description

Stable

Usage

```
## S3 method for class 'distribution'
density(x, at, ..., log = FALSE)
```

Arguments

`x`	The distribution(s).
`at`	The point at which to compute the density/mass.
`...`	Additional arguments passed to methods.
`log`	If `TRUE`, probabilities will be given as log probabilities.

Details

Computes the probability density function for a continuous distribution, or the probability mass function for a discrete distribution.

`dist_bernoulli` *The Bernoulli distribution*

Description

Stable

Usage

```
dist_bernoulli(prob)
```

Arguments

`prob`	The probability of success on each trial, `prob` can be any value in [0, 1].

Details

Bernoulli distributions are used to represent events like coin flips when there is single trial that is either successful or unsuccessful. The Bernoulli distribution is a special case of the `Binomial()` distribution with `n = 1`.

We recommend reading this documentation on https://pkg.mitchelloharawild.com/distributional/, where the math will render nicely.

In the following, let X be a Bernoulli random variable with parameter `p` = p. Some textbooks also define $q = 1 - p$, or use π instead of p.

The Bernoulli probability distribution is widely used to model binary variables, such as 'failure' and 'success'. The most typical example is the flip of a coin, when p is thought as the probability of flipping a head, and $q = 1 - p$ is the probability of flipping a tail.

Support: $\{0, 1\}$

Mean: p

Variance: $p \cdot (1 - p) = p \cdot q$

Probability mass function (p.m.f):

$$P(X = x) = p^x(1 - p)^{1-x} = p^x q^{1-x}$$

Cumulative distribution function (c.d.f):

$$P(X \le x) = \begin{cases} 0 & x < 0 \\ 1 - p & 0 \le x < 1 \\ 1 & x \ge 1 \end{cases}$$

Moment generating function (m.g.f):

$$E(e^{tX}) = (1 - p) + pe^t$$

Examples

```
dist <- dist_bernoulli(prob = c(0.05, 0.5, 0.3, 0.9, 0.1))

dist
mean(dist)
variance(dist)
skewness(dist)
kurtosis(dist)

generate(dist, 10)

density(dist, 2)
density(dist, 2, log = TRUE)

cdf(dist, 4)

quantile(dist, 0.7)
```

---

dist_beta *The Beta distribution*

Description

Maturing

Usage

```
dist_beta(shape1, shape2)
```

Arguments

shape1, shape2	The non-negative shape parameters of the Beta distribution.

See Also

stats::Beta

Examples

```
dist <- dist_beta(shape1 = c(0.5, 5, 1, 2, 2), shape2 = c(0.5, 1, 3, 2, 5))

dist
mean(dist)
variance(dist)
skewness(dist)
kurtosis(dist)

generate(dist, 10)

density(dist, 2)
density(dist, 2, log = TRUE)

cdf(dist, 4)
```

```
quantile(dist, 0.7)
```

`dist_binomial` *The Binomial distribution*

Description

Stable

Usage

```
dist_binomial(size, prob)
```

Arguments

`size`	The number of trials. Must be an integer greater than or equal to one. When `size = 1L`, the Binomial distribution reduces to the Bernoulli distribution. Often called `n` in textbooks.
`prob`	The probability of success on each trial, `prob` can be any value in [0, 1].

Details

Binomial distributions are used to represent situations can that can be thought as the result of n Bernoulli experiments (here the n is defined as the `size` of the experiment). The classical example is n independent coin flips, where each coin flip has probability `p` of success. In this case, the individual probability of flipping heads or tails is given by the Bernoulli(p) distribution, and the probability of having x equal results (x heads, for example), in n trials is given by the Binomial(n, p) distribution. The equation of the Binomial distribution is directly derived from the equation of the Bernoulli distribution.

We recommend reading this documentation on https://pkg.mitchelloharawild.com/distributional/, where the math will render nicely.

The Binomial distribution comes up when you are interested in the portion of people who do a thing. The Binomial distribution also comes up in the sign test, sometimes called the Binomial test (see `stats::binom.test()`), where you may need the Binomial C.D.F. to compute p-values.

In the following, let X be a Binomial random variable with parameter `size` = n and `p` = p. Some textbooks define $q = 1 - p$, or called π instead of p.

Support: $\{0, 1, 2, ..., n\}$

Mean: np

Variance: $np \cdot (1 - p) = np \cdot q$

Probability mass function (p.m.f):

$$P(X = k) = \binom{n}{k} p^k (1 - p)^{n-k}$$

Cumulative distribution function (c.d.f):

$$P(X \le k) = \sum_{i=0}^{\lfloor k \rfloor} \binom{n}{i} p^i (1-p)^{n-i}$$

Moment generating function (m.g.f):

$$E(e^{tX}) = (1 - p + pe^t)^n$$

Examples

```
dist <- dist_binomial(size = 1:5, prob = c(0.05, 0.5, 0.3, 0.9, 0.1))

dist
mean(dist)
variance(dist)
skewness(dist)
kurtosis(dist)

generate(dist, 10)

density(dist, 2)
density(dist, 2, log = TRUE)

cdf(dist, 4)

quantile(dist, 0.7)
```

---

dist_burr *The Burr distribution*

Description

Stable

Usage

```
dist_burr(shape1, shape2, rate = 1)
```

Arguments

shape1	parameters. Must be strictly positive.
shape2	parameters. Must be strictly positive.
rate	an alternative way to specify the scale.

See Also

actuar::Burr

Examples

```
dist_burr(shape1 = c(1,1,1,2,3,0.5), shape2 = c(1,2,3,1,1,2))
```

`dist_cauchy` *The Cauchy distribution*

Description

Maturing

Usage

```
dist_cauchy(location, scale)
```

Arguments

`location`	location and scale parameters.
`scale`	location and scale parameters.

Details

The Cauchy distribution is the student's t distribution with one degree of freedom. The Cauchy distribution does not have a well defined mean or variance. Cauchy distributions often appear as priors in Bayesian contexts due to their heavy tails.

We recommend reading this documentation on https://pkg.mitchelloharawild.com/distributional/, where the math will render nicely.

In the following, let X be a Cauchy variable with mean `location` = x_0 and `scale` = γ.

Support: R, the set of all real numbers

Mean: Undefined.

Variance: Undefined.

Probability density function (p.d.f):

$$f(x) = \frac{1}{\pi\gamma\left[1 + \left(\frac{x-x_0}{\gamma}\right)^2\right]}$$

Cumulative distribution function (c.d.f):

$$F(t) = \frac{1}{\pi}\arctan\left(\frac{t-x_0}{\gamma}\right) + \frac{1}{2}$$

Moment generating function (m.g.f):

Does not exist.

See Also

stats::Cauchy

Examples

```
dist <- dist_cauchy(location = c(0, 0, 0, -2), scale = c(0.5, 1, 2, 1))

dist
mean(dist)
variance(dist)
skewness(dist)
kurtosis(dist)

generate(dist, 10)

density(dist, 2)
density(dist, 2, log = TRUE)

cdf(dist, 4)

quantile(dist, 0.7)
```

---

dist_chisq *The (non-central) Chi-Squared Distribution*

Description

Stable

Usage

```
dist_chisq(df, ncp = 0)
```

Arguments

df	degrees of freedom (non-negative, but can be non-integer).
ncp	non-centrality parameter (non-negative).

Details

Chi-square distributions show up often in frequentist settings as the sampling distribution of test statistics, especially in maximum likelihood estimation settings.

We recommend reading this documentation on https://pkg.mitchelloharawild.com/distributional/, where the math will render nicely.

In the following, let X be a χ^2 random variable with `df` = k.

Support: R^+, the set of positive real numbers

Mean: k

Variance: $2k$

Probability density function (p.d.f):

$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(x-\mu)^2/2\sigma^2}$$

Cumulative distribution function (c.d.f):

The cumulative distribution function has the form

$$F(t) = \int_{-\infty}^{t} \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(x-\mu)^2/2\sigma^2} dx$$

but this integral does not have a closed form solution and must be approximated numerically. The c.d.f. of a standard normal is sometimes called the "error function". The notation $\Phi(t)$ also stands for the c.d.f. of a standard normal evaluated at t. Z-tables list the value of $\Phi(t)$ for various t.

Moment generating function (m.g.f):

$$E(e^{tX}) = e^{\mu t + \sigma^2 t^2/2}$$

See Also

stats::Chisquare

Examples

```
dist <- dist_chisq(df = c(1,2,3,4,6,9))

dist
mean(dist)
variance(dist)
skewness(dist)
kurtosis(dist)

generate(dist, 10)

density(dist, 2)
density(dist, 2, log = TRUE)

cdf(dist, 4)

quantile(dist, 0.7)
```

`dist_degenerate` *The degenerate distribution*

Description

Stable

Usage

```
dist_degenerate(x)
```

Arguments

x	The value of the distribution.

Details

The degenerate distribution takes a single value which is certain to be observed. It takes a single parameter, which is the value that is observed by the distribution.

We recommend reading this documentation on https://pkg.mitchelloharawild.com/distributional/, where the math will render nicely.

In the following, let X be a degenerate random variable with value x = k_0.

Support: R, the set of all real numbers

Mean: k_0

Variance: 0

Probability density function (p.d.f):

$$f(x) = 1 for x = k_0$$

$$f(x) = 0 for x \neq k_0$$

Cumulative distribution function (c.d.f):

The cumulative distribution function has the form

$$F(x) = 0 for x < k_0$$

$$F(x) = 1 for x \ge k_0$$

Moment generating function (m.g.f):

$$E(e^{tX}) = e^{k_0 t}$$

Examples

```
dist_degenerate(x = 1:5)
```

---

dist_exponential — *The Exponential Distribution*

Description

Stable

Usage

```
dist_exponential(rate)
```

Arguments

rate	vector of rates.

See Also

stats::Exponential

Examples

```
dist <- dist_exponential(rate = c(2, 1, 2/3))

dist
mean(dist)
variance(dist)
skewness(dist)
kurtosis(dist)

generate(dist, 10)

density(dist, 2)
density(dist, 2, log = TRUE)

cdf(dist, 4)

quantile(dist, 0.7)
```

`dist_f` *The F Distribution*

Description

Stable

Usage

```
dist_f(df1, df2, ncp = NULL)
```

Arguments

`df1`	degrees of freedom. `Inf` is allowed.
`df2`	degrees of freedom. `Inf` is allowed.
`ncp`	non-centrality parameter. If omitted the central F is assumed.

Details

We recommend reading this documentation on https://pkg.mitchelloharawild.com/distributional/, where the math will render nicely.

In the following, let X be a Gamma random variable with parameters `shape` = α and `rate` = β.

Support: $x \in (0, \infty)$

Mean: $\frac{\alpha}{\beta}$

Variance: $\frac{\alpha}{\beta^2}$

Probability density function (p.m.f):

$$f(x) = \frac{\beta^\alpha}{\Gamma(\alpha)} x^{\alpha-1} e^{-\beta x}$$

Cumulative distribution function (c.d.f):

$$f(x) = \frac{\Gamma(\alpha, \beta x)}{\Gamma \alpha}$$

Moment generating function (m.g.f):

$$E(e^{tX}) = \left(\frac{\beta}{\beta - t}\right)^{\alpha}, t < \beta$$

See Also

stats::FDist

Examples

```
dist <- dist_f(df1 = c(1,2,5,10,100), df2 = c(1,1,2,1,100))

dist
mean(dist)
variance(dist)
skewness(dist)
kurtosis(dist)

generate(dist, 10)

density(dist, 2)
density(dist, 2, log = TRUE)

cdf(dist, 4)

quantile(dist, 0.7)
```

---

dist_gamma *The Gamma distribution*

Description

Stable

Usage

```
dist_gamma(shape, rate)
```

Arguments

shape	shape and scale parameters. Must be positive, `scale` strictly.
rate	an alternative way to specify the scale.

Details

Several important distributions are special cases of the Gamma distribution. When the shape parameter is 1, the Gamma is an exponential distribution with parameter $1/\beta$. When the $shape = n/2$ and $rate = 1/2$, the Gamma is a equivalent to a chi squared distribution with n degrees of freedom. Moreover, if we have X_1 is $Gamma(\alpha_1, \beta)$ and X_2 is $Gamma(\alpha_2, \beta)$, a function of these two variables of the form $\frac{X_1}{X_1+X_2}$ $Beta(\alpha_1, \alpha_2)$. This last property frequently appears in another distributions, and it has extensively been used in multivariate methods. More about the Gamma distribution will be added soon.

We recommend reading this documentation on https://pkg.mitchelloharawild.com/distributional/, where the math will render nicely.

In the following, let X be a Gamma random variable with parameters shape = α and rate = β.

Support: $x \in (0, \infty)$

Mean: $\frac{\alpha}{\beta}$

Variance: $\frac{\alpha}{\beta^2}$

Probability density function (p.m.f):

$$f(x) = \frac{\beta^\alpha}{\Gamma(\alpha)} x^{\alpha-1} e^{-\beta x}$$

Cumulative distribution function (c.d.f):

$$f(x) = \frac{\Gamma(\alpha, \beta x)}{\Gamma \alpha}$$

Moment generating function (m.g.f):

$$E(e^{tX}) = \left(\frac{\beta}{\beta - t}\right)^\alpha, t < \beta$$

See Also

stats::GammaDist

Examples

```
dist <- dist_gamma(shape = c(1,2,3,5,9,7.5,0.5), rate = c(0.5,0.5,0.5,1,2,1,1))

dist
mean(dist)
variance(dist)
skewness(dist)
kurtosis(dist)

generate(dist, 10)

density(dist, 2)
density(dist, 2, log = TRUE)

cdf(dist, 4)

quantile(dist, 0.7)
```

`dist_geometric` *The Geometric Distribution*

Description

The Geometric distribution can be thought of as a generalization of the `dist_bernoulli()` distribution where we ask: "if I keep flipping a coin with probability `p` of heads, what is the probability I need k flips before I get my first heads?" The Geometric distribution is a special case of Negative Binomial distribution. **Stable**

Usage

```
dist_geometric(prob)
```

Arguments

`prob`	probability of success in each trial. `0` < `prob` <= `1`.

Details

We recommend reading this documentation on `https://pkg.mitchelloharawild.com/distributional/`, where the math will render nicely.

In the following, let X be a Geometric random variable with success probability `p` = p. Note that there are multiple parameterizations of the Geometric distribution.

Support: $0 < \text{p} < 1$, $x = 0, 1, \dots$

Mean: $\frac{1-p}{p}$

Variance: $\frac{1-p}{p^2}$

Probability mass function (p.m.f):

$$P(X = x) = p(1-p)^x,$$

Cumulative distribution function (c.d.f):

$$P(X \le x) = 1 - (1-p)^{x+1}$$

Moment generating function (m.g.f):

$$E(e^{tX}) = \frac{pe^t}{1-(1-p)e^t}$$

See Also

stats::Geometric

Examples

```
dist <- dist_geometric(prob = c(0.2, 0.5, 0.8))

dist
mean(dist)
variance(dist)
skewness(dist)
kurtosis(dist)

generate(dist, 10)

density(dist, 2)
density(dist, 2, log = TRUE)

cdf(dist, 4)

quantile(dist, 0.7)
```

`dist_gumbel` *The Gumbel distribution*

Description

Stable

Usage

```
dist_gumbel(alpha, scale)
```

Arguments

`alpha`	location parameter.
`scale`	parameter. Must be strictly positive.

Details

The Gumbel distribution is a special case of the Generalized Extreme Value distribution, obtained when the GEV shape parameter ξ is equal to 0. It may be referred to as a type I extreme value distribution.

We recommend reading this documentation on https://pkg.mitchelloharawild.com/distributional/, where the math will render nicely.

In the following, let X be a Gumbel random variable with location parameter `mu` = μ, scale parameter `sigma` = σ.

Support: R, the set of all real numbers.

Mean: $\mu + \sigma\gamma$, where γ is Euler's constant, approximately equal to 0.57722.

Median: $\mu - \sigma \ln(\ln 2)$.

Variance: $\sigma^2\pi^2/6$.

Probability density function (p.d.f):

$$f(x) = \sigma^{-1} \exp[-(x - \mu)/\sigma] \exp\{-\exp[-(x - \mu)/\sigma]\}$$

for x in R, the set of all real numbers.

Cumulative distribution function (c.d.f):

In the $\xi = 0$ (Gumbel) special case

$$F(x) = \exp\{-\exp[-(x-\mu)/\sigma]\}$$

for x in R, the set of all real numbers.

See Also

actuar::Gumbel

Examples

```
dist <- dist_gumbel(alpha = c(0.5, 1, 1.5, 3), scale = c(2, 2, 3, 4))

dist
mean(dist)
variance(dist)
skewness(dist)
kurtosis(dist)

generate(dist, 10)

density(dist, 2)
density(dist, 2, log = TRUE)

cdf(dist, 4)

quantile(dist, 0.7)
```

---

dist_hypergeometric *The Hypergeometric distribution*

Description

Stable

Usage

```
dist_hypergeometric(m, n, k)
```

Arguments

m	The number of type I elements available.
n	The number of type II elements available.
k	The size of the sample taken.

Details

To understand the HyperGeometric distribution, consider a set of r objects, of which m are of the type I and n are of the type II. A sample with size k ($k < r$) with no replacement is randomly chosen. The number of observed type I elements observed in this sample is set to be our random variable X.

We recommend reading this documentation on https://pkg.mitchelloharawild.com/distributional/, where the math will render nicely.

In the following, let X be a HyperGeometric random variable with success probability `p` = $p = m/(m+n)$.

Support: $x \in \{\max(0, k-n), \dots, \min(k, m)\}$

Mean: $\frac{km}{n+m} = kp$

Variance: $\frac{km(n)(n+m-k)}{(n+m)^2(n+m-1)} = kp(1-p)(1 - \frac{k-1}{m+n-1})$

Probability mass function (p.m.f):

$$P(X = x) = \frac{\binom{m}{x}\binom{n}{k-x}}{\binom{m+n}{k}}$$

Cumulative distribution function (c.d.f):

$$P(X \le k) \approx \Phi\Big(\frac{x - kp}{\sqrt{kp(1-p)}}\Big)$$

See Also

stats::Hypergeometric

Examples

```
dist <- dist_hypergeometric(m = rep(500, 3), n = c(50, 60, 70), k = c(100, 200, 300))

dist
mean(dist)
variance(dist)
skewness(dist)
kurtosis(dist)

generate(dist, 10)

density(dist, 2)
density(dist, 2, log = TRUE)

cdf(dist, 4)

quantile(dist, 0.7)
```

dist_inflated — *Inflate a value of a probability distribution*

Description

Maturing

Usage

```
dist_inflated(dist, prob, x = 0)
```

Arguments

dist	The distribution(s) to inflate.
prob	The added probability of observing x.
x	The value to inflate. The default of x = 0 is for zero-inflation.

dist_inverse_exponential — *The Inverse Exponential distribution*

Description

Stable

Usage

```
dist_inverse_exponential(rate)
```

Arguments

rate	an alternative way to specify the scale.

See Also

actuar::InverseExponential

Examples

```
dist_inverse_exponential(rate = 1:5)
```

dist_inverse_gamma *The Inverse Gamma distribution*

Description

Stable

Usage

```
dist_inverse_gamma(shape, rate = 1/scale, scale)
```

Arguments

shape	parameters. Must be strictly positive.
rate	an alternative way to specify the scale.
scale	parameters. Must be strictly positive.

See Also

actuar::InverseGamma

Examples

```
dist_inverse_gamma(shape = c(1,2,3,3), rate = c(1,1,1,2))
```

dist_inverse_gaussian *The Inverse Gaussian distribution*

Description

Stable

Usage

```
dist_inverse_gaussian(mean, shape)
```

Arguments

mean	parameters. Must be strictly positive. Infinite values are supported.
shape	parameters. Must be strictly positive. Infinite values are supported.

See Also

actuar::InverseGaussian

Examples

```
dist_inverse_gaussian(mean = c(1,1,1,3,3), shape = c(0.2, 1, 3, 0.2, 1))
```

dist_logarithmic — *The Logarithmic distribution*

Description

Stable

Usage

```
dist_logarithmic(prob)
```

Arguments

prob	parameter. 0 <= prob < 1.

See Also

actuar::Logarithmic

Examples

```
dist_logarithmic(prob = c(0.33, 0.66, 0.99))
```

dist_logistic — *The Logistic distribution*

Description

Stable

Usage

```
dist_logistic(location, scale)
```

Arguments

location	location and scale parameters.
scale	location and scale parameters.

Details

A continuous distribution on the real line. For binary outcomes the model given by $P(Y = 1|X) = F(X\beta)$ where F is the Logistic `cdf()` is called *logistic regression*.

We recommend reading this documentation on https://pkg.mitchelloharawild.com/distributional/, where the math will render nicely.

In the following, let X be a Logistic random variable with `location` = μ and `scale` = s.

Support: R, the set of all real numbers

Mean: μ

Variance: $s^2\pi^2/3$

Probability density function (p.d.f):

$$f(x) = \frac{e^{-(\frac{x-\mu}{s})}}{s[1+\exp(-(\frac{x-\mu}{s}))]^2}$$

Cumulative distribution function (c.d.f):

$$F(t) = \frac{1}{1+e^{-(\frac{t-\mu}{s})}}$$

Moment generating function (m.g.f):

$$E(e^{tX}) = e^{\mu t}\beta(1-st, 1+st)$$

where $\beta(x, y)$ is the Beta function.

See Also

stats::Logistic

Examples

```
dist <- dist_logistic(location = c(5,9,9,6,2), scale = c(2,3,4,2,1))

dist
mean(dist)
variance(dist)
skewness(dist)
kurtosis(dist)

generate(dist, 10)

density(dist, 2)
density(dist, 2, log = TRUE)

cdf(dist, 4)

quantile(dist, 0.7)
```

---

dist_mixture *Create a mixture of distributions*

Description

Experimental

Usage

```
dist_mixture(..., weights = numeric())
```

Arguments

`...`	Distributions to be used in the mixture.
`weights`	The weight of each distribution passed to `...`.

Examples

```
dist_mixture(dist_normal(0, 1), dist_normal(5, 2), weights = c(0.3, 0.7))
```

`dist_multinomial` *The Multinomial distribution*

Description

Maturing

Usage

```
dist_multinomial(size, prob)
```

Arguments

`size`	integer, say N, specifying the total number of objects that are put into K boxes in the typical multinomial experiment. For `dmultinom`, it defaults to `sum(x)`.
`prob`	numeric non-negative vector of length K, specifying the probability for the K classes; is internally normalized to sum 1. Infinite and missing values are not allowed.

Details

The multinomial distribution is a generalization of the binomial distribution to multiple categories. It is perhaps easiest to think that we first extend a `dist_bernoulli()` distribution to include more than two categories, resulting in a categorical distribution. We then extend repeat the Categorical experiment several (n) times.

We recommend reading this documentation on https://pkg.mitchelloharawild.com/distributional/, where the math will render nicely.

In the following, let $X = (X_1, ..., X_k)$ be a Multinomial random variable with success probability `p` = p. Note that p is vector with k elements that sum to one. Assume that we repeat the Categorical experiment `size` = n times.

Support: Each X_i is in $0, 1, 2, ..., n$.

Mean: The mean of X_i is np_i.

Variance: The variance of X_i is $np_i(1 - p_i)$. For $i \neq j$, the covariance of X_i and X_j is $-np_ip_j$.

Probability mass function (p.m.f):

$$P(X_1 = x_1, ..., X_k = x_k) = \frac{n!}{x_1!x_2!...x_k!} p_1^{x_1} \cdot p_2^{x_2} \cdot ... \cdot p_k^{x_k}$$

Cumulative distribution function (c.d.f):

Omitted for multivariate random variables for the time being.

Moment generating function (m.g.f):

$$E(e^{tX}) = \left(\sum_{i=1}^{k} p_i e^{t_i}\right)^n$$

See Also

stats::Multinomial

Examples

```
dist <- dist_multinomial(size = c(4, 3), prob = list(c(0.3, 0.5, 0.2), c(0.1, 0.5, 0.4)))

dist
mean(dist)
variance(dist)

generate(dist, 10)

# TODO: Needs fixing to support multiple inputs
# density(dist, 2)
# density(dist, 2, log = TRUE)
```

---

dist_multivariate_normal

The multivariate normal distribution

Description

Maturing

Usage

```
dist_multivariate_normal(mu = 0, sigma = diag(1))
```

Arguments

mu	A list of numeric vectors for the distribution's mean.
sigma	A list of matrices for the distribution's variance-covariance matrix.

Examples

```
dist_multivariate_normal(mu = list(c(1,2)), sigma = list(matrix(c(4,2,2,3), ncol=2)))
```

`dist_negative_binomial` *The Negative Binomial distribution*

Description

Stable

Usage

```
dist_negative_binomial(size, prob)
```

Arguments

`size`	target for number of successful trials, or dispersion parameter (the shape parameter of the gamma mixing distribution). Must be strictly positive, need not be integer.
`prob`	probability of success in each trial. `0` < `prob` <= `1`.

Details

A generalization of the geometric distribution. It is the number of successes in a sequence of i.i.d. Bernoulli trials before a specified number (r) of failures occurs.

We recommend reading this documentation on https://pkg.mitchelloharawild.com/distributional/, where the math will render nicely.

In the following, let X be a Negative Binomial random variable with success probability `p` = p.

Support: $\{0, 1, 2, 3, ...\}$

Mean: $\frac{pr}{1-p}$

Variance: $\frac{pr}{(1-p)^2}$

Probability mass function (p.m.f):

$$f(k) = \binom{k + r - 1}{k} \cdot (1-p)^r p^k$$

Cumulative distribution function (c.d.f):

Too nasty, omitted.

Moment generating function (m.g.f):

$$\left(\frac{1-p}{1-pe^t}\right)^r, t < -\log p$$

See Also

stats::NegBinomial

Examples

```
dist <- dist_negative_binomial(size = 10, prob = 0.5)

dist
mean(dist)
variance(dist)
skewness(dist)
kurtosis(dist)

generate(dist, 10)

density(dist, 2)
density(dist, 2, log = TRUE)

cdf(dist, 4)

quantile(dist, 0.7)
```

---

dist_normal — *The Normal distribution*

Description

Stable

Usage

```
dist_normal(mu = 0, sigma = 1)
```

Arguments

mu	The mean (location parameter) of the distribution, which is also the mean of the distribution. Can be any real number.
sigma	The standard deviation (scale parameter) of the distribution. Can be any positive number. If you would like a Normal distribution with **variance** σ^2, be sure to take the square root, as this is a common source of errors.

Details

The Normal distribution is ubiquitous in statistics, partially because of the central limit theorem, which states that sums of i.i.d. random variables eventually become Normal. Linear transformations of Normal random variables result in new random variables that are also Normal. If you are taking an intro stats course, you'll likely use the Normal distribution for Z-tests and in simple linear regression. Under regularity conditions, maximum likelihood estimators are asymptotically Normal. The Normal distribution is also called the gaussian distribution.

We recommend reading this documentation on https://pkg.mitchelloharawild.com/distributional/, where the math will render nicely.

In the following, let X be a Normal random variable with mean `mu` = μ and standard deviation `sigma` = σ.

Support: R, the set of all real numbers

Mean: μ

Variance: σ^2

Probability density function (p.d.f):

$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(x-\mu)^2/2\sigma^2}$$

Cumulative distribution function (c.d.f):

The cumulative distribution function has the form

$$F(t) = \int_{-\infty}^{t} \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(x-\mu)^2/2\sigma^2} dx$$

but this integral does not have a closed form solution and must be approximated numerically. The c.d.f. of a standard Normal is sometimes called the "error function". The notation $\Phi(t)$ also stands for the c.d.f. of a standard Normal evaluated at t. Z-tables list the value of $\Phi(t)$ for various t.

Moment generating function (m.g.f):

$$E(e^{tX}) = e^{\mu t + \sigma^2 t^2/2}$$

See Also

stats::Normal

Examples

```
dist <- dist_normal(mu = 1:5, sigma = 3)

dist
mean(dist)
variance(dist)
skewness(dist)
kurtosis(dist)

generate(dist, 10)

density(dist, 2)
density(dist, 2, log = TRUE)

cdf(dist, 4)

quantile(dist, 0.7)
```

`dist_pareto` *The Pareto distribution*

Description

Questioning

Usage

```
dist_pareto(shape, scale)
```

Arguments

shape	parameters. Must be strictly positive.
scale	parameters. Must be strictly positive.

See Also

actuar::Pareto

Examples

```
dist_pareto(shape = c(10, 3, 2, 1), scale = rep(1, 4))
```

`dist_percentile` *Percentile distribution*

Description

Maturing

Usage

```
dist_percentile(x, percentile)
```

Arguments

x	A list of values
percentile	A list of percentiles

Examples

```
dist <- dist_normal()
percentiles <- seq(0.01, 0.99, by = 0.01)
x <- vapply(percentiles, quantile, double(1L), x = dist)
dist_percentile(list(x), list(percentiles*100))
```

`dist_poisson` *The Poisson Distribution*

Description

Stable

Usage

```
dist_poisson(lambda)
```

Arguments

`lambda`	vector of (non-negative) means.

Details

Poisson distributions are frequently used to model counts.

We recommend reading this documentation on https://pkg.mitchelloharawild.com/distributional/, where the math will render nicely.

In the following, let X be a Poisson random variable with parameter `lambda` = λ.

Support: $\{0, 1, 2, 3, ...\}$

Mean: λ

Variance: λ

Probability mass function (p.m.f):

$$P(X = k) = \frac{\lambda^k e^{-\lambda}}{k!}$$

Cumulative distribution function (c.d.f):

$$P(X \le k) = e^{-\lambda} \sum_{i=0}^{\lfloor k \rfloor} \frac{\lambda^i}{i!}$$

Moment generating function (m.g.f):

$$E(e^{tX}) = e^{\lambda(e^t - 1)}$$

See Also

stats::Poisson

Examples

```
dist <- dist_poisson(lambda = c(1, 4, 10))

dist
mean(dist)
variance(dist)
skewness(dist)
kurtosis(dist)

generate(dist, 10)

density(dist, 2)
density(dist, 2, log = TRUE)

cdf(dist, 4)

quantile(dist, 0.7)
```

`dist_poisson_inverse_gaussian` *The Poisson-Inverse Gaussian distribution*

Description

Stable

Usage

```
dist_poisson_inverse_gaussian(mean, shape)
```

Arguments

`mean`	parameters. Must be strictly positive. Infinite values are supported.
`shape`	parameters. Must be strictly positive. Infinite values are supported.

See Also

actuar::PoissonInverseGaussian

Examples

```
dist_poisson_inverse_gaussian(mean = rep(0.1, 3), shape = c(0.4, 0.8, 1))
```

`dist_sample` *Sampling distribution*

Description

Stable

Usage

```
dist_sample(x)
```

Arguments

`x`	A list of sampled values.

Examples

```
dist_sample(x = list(rnorm(100), rnorm(100, 10)))
```

`dist_studentized_range` *The Studentized Range distribution*

Description

Stable

Usage

```
dist_studentized_range(nmeans, df, nranges)
```

Arguments

`nmeans`	sample size for range (same for each group).
`df`	degrees of freedom for s (see below).
`nranges`	number of *groups* whose **maximum** range is considered.

Details

Tukey's studentized range distribution, used for Tukey's honestly significant differences test in ANOVA.

We recommend reading this documentation on https://pkg.mitchelloharawild.com/distributional/, where the math will render nicely.

Support: R^+, the set of positive real numbers.

Other properties of Tukey's Studentized Range Distribution are omitted, largely because the distribution is not fun to work with.

See Also

stats::Tukey

Examples

```
dist <- dist_studentized_range(nmeans = c(6, 2), df = c(5, 4), nranges = c(1, 1))

dist

cdf(dist, 4)

quantile(dist, 0.7)
```

---

dist_student_t — *The (non-central) location-scale Student t Distribution*

Description

Stable

Usage

```
dist_student_t(df, mu = 0, sigma = 1, ncp = NULL)
```

Arguments

df	degrees of freedom (> 0, maybe non-integer). `df = Inf` is allowed.
mu	The location parameter of the distribution. If `ncp == 0` (or `NULL`), this is the median.
sigma	The scale parameter of the distribution.
ncp	non-centrality parameter δ; currently except for `rt()`, only for `abs(ncp) <= 37.62`. If omitted, use the central t distribution.

Details

The Student's T distribution is closely related to the `Normal()` distribution, but has heavier tails. As ν increases to ∞, the Student's T converges to a Normal. The T distribution appears repeatedly throughout classic frequentist hypothesis testing when comparing group means.

We recommend reading this documentation on https://pkg.mitchelloharawild.com/distributional/, where the math will render nicely.

In the following, let X be a **central** Students T random variable with `df` = ν.

Support: R, the set of all real numbers

Mean: Undefined unless $\nu \geq 2$, in which case the mean is zero.

Variance:

$$\frac{\nu}{\nu - 2}$$

Undefined if $\nu < 1$, infinite when $1 < \nu \leq 2$.

Probability density function (p.d.f):

$$f(x) = \frac{\Gamma(\frac{\nu+1}{2})}{\sqrt{\nu\pi}\Gamma(\frac{\nu}{2})}(1 + \frac{x^2}{\nu})^{-\frac{\nu+1}{2}}$$

See Also

stats::TDist

Examples

```
dist <- dist_student_t(df = c(1,2,5), mu = c(0,1,2), sigma = c(1,2,3))

dist
mean(dist)
variance(dist)

generate(dist, 10)

density(dist, 2)
density(dist, 2, log = TRUE)

cdf(dist, 4)

quantile(dist, 0.7)
```

---

dist_transformed — *Modify a distribution with a transformation*

Description

Experimental

Usage

```
dist_transformed(dist, transform, inverse)
```

Arguments

`dist`	A univariate distribution vector.
`transform`	A function used to transform the distribution. This transformation should be monotonic over appropriate domain.
`inverse`	The inverse of the `transform` function.

Details

The `density()`, `mean()`, and `variance()` methods are approximate as they are based on numerical derivatives.

Examples

```
# Create a log normal distribution
dist <- dist_transformed(dist_normal(0, 0.5), exp, log)
density(dist, 1) # dlnorm(1, 0, 0.5)
cdf(dist, 4) # plnorm(4, 0, 0.5)
quantile(dist, 0.1) # qlnorm(0.1, 0, 0.5)
generate(dist, 10) # rlnorm(10, 0, 0.5)
```

---

dist_truncated *Truncate a distribution*

Description

Experimental

Usage

```
dist_truncated(dist, lower = -Inf, upper = Inf)
```

Arguments

dist	The distribution(s) to truncate.
lower, upper	The range of values to keep from a distribution.

Details

Note that the samples are generated using inverse transform sampling, and the means and variances are estimated from samples.

---

dist_uniform *The Uniform distribution*

Description

Stable

Usage

```
dist_uniform(min, max)
```

Arguments

min	lower and upper limits of the distribution. Must be finite.
max	lower and upper limits of the distribution. Must be finite.

Details

A distribution with constant density on an interval.

We recommend reading this documentation on https://pkg.mitchelloharawild.com/distributional/, where the math will render nicely.

In the following, let X be a Poisson random variable with parameter `lambda` = λ.

Support: $[a, b]$

Mean: $\frac{1}{2}(a + b)$

Variance: $\frac{1}{12}(b - a)^2$

Probability mass function (p.m.f):

$$f(x) = \frac{1}{b - a} for x \in [a, b]$$

$$f(x) = 0 otherwise$$

Cumulative distribution function (c.d.f):

$$F(x) = 0 for x < a$$

$$F(x) = \frac{x - a}{b - a} for x \in [a, b]$$

$$F(x) = 1 for x > b$$

Moment generating function (m.g.f):

$$E(e^{tX}) = \frac{e^{tb} - e^{ta}}{t(b - a)} for t \neq 0$$

$$E(e^{tX}) = 1 for t = 0$$

See Also

stats::Uniform

Examples

```
dist <- dist_uniform(min = c(3, -2), max = c(5, 4))

dist
mean(dist)
variance(dist)
skewness(dist)
kurtosis(dist)

generate(dist, 10)

density(dist, 2)
density(dist, 2, log = TRUE)

cdf(dist, 4)

quantile(dist, 0.7)
```

`dist_weibull` *The Weibull distribution*

Description

Stable

Usage

```
dist_weibull(shape, scale)
```

Arguments

`shape`	shape and scale parameters, the latter defaulting to 1.
`scale`	shape and scale parameters, the latter defaulting to 1.

Details

Generalization of the gamma distribution. Often used in survival and time-to-event analyses.

We recommend reading this documentation on https://pkg.mitchelloharawild.com/distributional/, where the math will render nicely.

In the following, let X be a Weibull random variable with success probability p = p.

Support: R^+ and zero.

Mean: $\lambda\Gamma(1 + 1/k)$, where Γ is the gamma function.

Variance: $\lambda[\Gamma(1 + \frac{2}{k}) - (\Gamma(1 + \frac{1}{k}))^2]$

Probability density function (p.d.f):

$$f(x) = \frac{k}{\lambda}(\frac{x}{\lambda})^{k-1}e^{-(x/\lambda)^k}, x \ge 0$$

Cumulative distribution function (c.d.f):

$$F(x) = 1 - e^{-(x/\lambda)^k}, x \ge 0$$

Moment generating function (m.g.f):

$$\sum_{n=0}^{\infty} \frac{t^n\lambda^n}{n!}\Gamma(1 + n/k), k \ge 1$$

See Also

stats::Weibull

Examples

```
dist <- dist_weibull(shape = c(0.5, 1, 1.5, 5), scale = rep(1, 4))

dist
mean(dist)
variance(dist)
skewness(dist)
kurtosis(dist)

generate(dist, 10)

density(dist, 2)
density(dist, 2, log = TRUE)

cdf(dist, 4)

quantile(dist, 0.7)
```

---

dist_wrap *Create a distribution from p/d/q/r style functions*

Description

Experimental

Usage

```
dist_wrap(dist, ..., package = "stats")
```

Arguments

dist	The name of the distribution used in the functions (name that is prefixed by p/d/q/r)
...	Named arguments used to parameterise the distribution.
package	The package from which the distribution is provided.

Details

If a distribution is not yet supported, you can vectorise p/d/q/r functions using this function. `dist_wrap()` stores the distributions parameters, and provides wrappers which call the appropriate p/d/q/r functions.

Using this function to wrap a distribution should only be done if the distribution is not yet available in this package. If you need a distribution which isn't in the package yet, consider making a request at https://github.com/mitchelloharawild/distributional/issues.

Examples

```
dist <- dist_wrap("norm", mean = 1:3, sd = c(3, 9, 2))

density(dist, 1) # dnorm()
cdf(dist, 4) # pnorm()
quantile(dist, 0.975) # qnorm()
generate(dist, 10) # rnorm()

library(actuar)
dist <- dist_wrap("invparalogis", package = "actuar", shape = 2, rate = 2)
density(dist, 1) # actuar::dinvparalogis()
cdf(dist, 4) # actuar::pinvparalogis()
quantile(dist, 0.975) # actuar::qinvparalogis()
generate(dist, 10) # actuar::rinvparalogis()
```

---

generate.distribution *Randomly sample values from a distribution*

Description

Stable

Usage

```
## S3 method for class 'distribution'
generate(x, times, ...)
```

Arguments

x	The distribution(s).
times	The number of samples.
...	Additional arguments used by methods.

Details

Generate random samples from probability distributions.

---

geom_hilo_linerange *Line ranges for hilo intervals*

Description

Experimental

Usage

```
geom_hilo_linerange(
  mapping = NULL,
  data = NULL,
  stat = "identity",
  position = "identity",
  na.rm = FALSE,
  show.legend = NA,
  inherit.aes = TRUE,
  ...
)
```

Arguments

mapping	Set of aesthetic mappings created by aes() or aes_(). If specified and inherit.aes = TRUE (the default), it is combined with the default mapping at the top level of the plot. You must supply mapping if there is no plot mapping.
data	The data to be displayed in this layer. There are three options: If NULL, the default, the data is inherited from the plot data as specified in the call to ggplot(). A data.frame, or other object, will override the plot data. All objects will be fortified to produce a data frame. See fortify() for which variables will be created. A function will be called with a single argument, the plot data. The return value must be a data.frame, and will be used as the layer data. A function can be created from a formula (e.g. ~ head(.x,10)).
stat	The statistical transformation to use on the data for this layer, as a string.
position	Position adjustment, either as a string, or the result of a call to a position adjustment function.
na.rm	If FALSE, the default, missing values are removed with a warning. If TRUE, missing values are silently removed.
show.legend	logical. Should this layer be included in the legends? NA, the default, includes if any aesthetics are mapped. FALSE never includes, and TRUE always includes. It can also be a named logical vector to finely select the aesthetics to display.
inherit.aes	If FALSE, overrides the default aesthetics, rather than combining with them. This is most useful for helper functions that define both data and aesthetics and shouldn't inherit behaviour from the default plot specification, e.g. borders().
...	Other arguments passed on to layer(). These are often aesthetics, used to set an aesthetic to a fixed value, like colour = "red" or size = 3. They may also be parameters to the paired geom/stat.

Details

geom_hilo_linerange() displays the interval defined by a hilo object. The luminance of the shaded area indicates its confidence level. The shade colour can be controlled by the fill aesthetic, however the luminance will be overwritten to represent the confidence level.

See Also

geom_hilo_ribbon() for continuous hilo intervals (ribbons)

Examples

```
dist <- dist_normal(1:3, 1:3)
library(ggplot2)
ggplot(
  data.frame(x = rep(1:3, 2), interval = c(hilo(dist, 80), hilo(dist, 95)))
) +
  geom_hilo_linerange(aes(x = x, hilo = interval))
```

---

geom_hilo_ribbon *Ribbon plots for hilo intervals*

Description

Maturing

Usage

```
geom_hilo_ribbon(
  mapping = NULL,
  data = NULL,
  stat = "identity",
  position = "identity",
  na.rm = FALSE,
  show.legend = NA,
  inherit.aes = TRUE,
  ...
)
```

Arguments

mapping	Set of aesthetic mappings created by `aes()` or `aes_()`. If specified and `inherit.aes = TRUE` (the default), it is combined with the default mapping at the top level of the plot. You must supply `mapping` if there is no plot mapping.
data	The data to be displayed in this layer. There are three options: If `NULL`, the default, the data is inherited from the plot data as specified in the call to `ggplot()`. A `data.frame`, or other object, will override the plot data. All objects will be fortified to produce a data frame. See `fortify()` for which variables will be created. A `function` will be called with a single argument, the plot data. The return value must be a `data.frame`, and will be used as the layer data. A `function` can be created from a `formula` (e.g. `~ head(.x,10)`).
stat	The statistical transformation to use on the data for this layer, as a string.
position	Position adjustment, either as a string, or the result of a call to a position adjustment function.
na.rm	If `FALSE`, the default, missing values are removed with a warning. If `TRUE`, missing values are silently removed.

`show.legend`	logical. Should this layer be included in the legends? `NA`, the default, includes if any aesthetics are mapped. `FALSE` never includes, and `TRUE` always includes. It can also be a named logical vector to finely select the aesthetics to display.
`inherit.aes`	If `FALSE`, overrides the default aesthetics, rather than combining with them. This is most useful for helper functions that define both data and aesthetics and shouldn't inherit behaviour from the default plot specification, e.g. `borders()`.
`...`	Other arguments passed on to `layer()`. These are often aesthetics, used to set an aesthetic to a fixed value, like `colour = "red"` or `size = 3`. They may also be parameters to the paired geom/stat.

Details

`geom_hilo_ribbon()` displays the interval defined by a hilo object. The luminance of the shaded area indicates its confidence level. The shade colour can be controlled by the `fill` aesthetic, however the luminance will be overwritten to represent the confidence level.

See Also

`geom_hilo_linerange()` for discrete hilo intervals (vertical lines)

Examples

```
dist <- dist_normal(1:3, 1:3)
library(ggplot2)
ggplot(
  data.frame(x = rep(1:3, 2), interval = c(hilo(dist, 80), hilo(dist, 95)))
) +
  geom_hilo_ribbon(aes(x = x, hilo = interval))
```

---

guide_level *Level shade bar guide*

Description

The level guide shows the colour from the forecast intervals which is blended with the series colour.

Usage

```
guide_level(title = waiver(), max_discrete = 5, ...)
```

Arguments

`title`	A character string or expression indicating a title of guide. If `NULL`, the title is not shown. By default (`waiver()`), the name of the scale object or the name specified in `labs()` is used for the title.
`max_discrete`	The maximum number of levels to be shown using `guide_legend`. If the number of levels exceeds this value, level shades are shown with `guide_colourbar`.
`...`	Further arguments passed onto either `guide_colourbar` or `guide_legend`

hdr — *Compute highest density regions*

Description

Used to extract a specified prediction interval at a particular confidence level from a distribution.

Usage

```
hdr(x, ...)
```

Arguments

`x`	Object to create hilo from.
`...`	Additional arguments used by methods.

hdr.distribution — *Highest density regions of probability distributions*

Description

Experimental

Usage

```
## S3 method for class 'distribution'
hdr(x, size = 95, n = 512, ...)
```

Arguments

`x`	The distribution(s).
`size`	The size of the interval (between 0 and 100).
`n`	The resolution used to estimate the distribution's density.
`...`	Additional arguments used by methods.

Details

This function is highly experimental and will change in the future. In particular, improved functionality for object classes and visualisation tools will be added in a future release.

Computes minimally sized probability intervals highest density regions.

hilo *Compute intervals*

Description

Used to extract a specified prediction interval at a particular confidence level from a distribution.

Usage

```
hilo(x, ...)
```

Arguments

`x`	Object to create hilo from.
`...`	Additional arguments used by methods.

hilo.distribution *Probability intervals of a probability distribution*

Description

Maturing

Usage

```
## S3 method for class 'distribution'
hilo(x, size = 95, ...)
```

Arguments

`x`	The distribution(s).
`size`	The size of the interval (between 0 and 100).
`...`	Additional arguments used by methods.

Details

Returns a `hilo` central probability interval with probability coverage of `size`. By default, the distribution's `quantile()` will be used to compute the lower and upper bound for a centered interval

See Also

`hdr.distribution()`

`is_hdr` *Is the object a hdr*

Description

Is the object a hdr

Usage

```
is_hdr(x)
```

Arguments

`x`	An object.

`is_hilo` *Is the object a hilo*

Description

Is the object a hilo

Usage

```
is_hilo(x)
```

Arguments

`x`	An object.

`kurtosis` *Kurtosis of a probability distribution*

Description

Stable

Usage

```
kurtosis(x, ...)

## S3 method for class 'distribution'
kurtosis(x, ...)
```

Arguments

`x`	The distribution(s).
`...`	Additional arguments used by methods.

`likelihood` *The (log) likelihood of a sample matching a distribution*

Description

Maturing

Usage

```
likelihood(x, ...)

## S3 method for class 'distribution'
likelihood(x, sample, ..., log = FALSE)
```

Arguments

`x`	The distribution(s).
`...`	Additional arguments used by methods.
`sample`	A list of sampled values to compare to distribution(s).
`log`	If `TRUE`, the log-likelihood will be computed.

`mean.distribution` *Mean of a probability distribution*

Description

Stable

Usage

```
## S3 method for class 'distribution'
mean(x, ...)
```

Arguments

`x`	The distribution(s).
`...`	Additional arguments used by methods.

Details

Returns the empirical mean of the probability distribution. If the method does not exist, the mean of a random sample will be returned.

`median.distribution` *Median of a probability distribution*

Description

Stable

Usage

```
## S3 method for class 'distribution'
median(x, na.rm = FALSE, ...)
```

Arguments

`x`	The distribution(s).
`na.rm`	a logical value indicating whether `NA` values should be stripped before the computation proceeds.
`...`	Additional arguments used by methods.

Details

Returns the median (50th percentile) of a probability distribution. This is equivalent to `quantile(x,p=0.5)`.

`new_dist` *Create a new distribution*

Description

Create a new distribution

Usage

```
new_dist(..., class = NULL, dimnames = NULL)
```

Arguments

`...`	Parameters of the distribution (named).
`class`	The class of the distribution for S3 dispatch.
`dimnames`	The names of the variables in the distribution (optional).

new_hdr *Construct hdr intervals*

Description

Construct hdr intervals

Usage

```
new_hdr(x = list())
```

Arguments

x	A list of hilo() objects.

Value

A "hdr" vector

Author(s)

Mitchell O'Hara-Wild

new_hilo *Construct hilo intervals*

Description

Construct hilo intervals

Usage

```
new_hilo(lower = double(), upper = double(), size = double())
```

Arguments

lower, upper	A numeric vector of values for lower and upper limits.
size	Size of the interval between [0, 100].

Value

A "hilo" vector

Author(s)

Earo Wang & Mitchell O'Hara-Wild

Examples

```
new_hilo(lower = rnorm(10), upper = rnorm(10) + 5, size = 95)
```

quantile.distribution *Distribution Quantiles*

Description

Stable

Usage

```
## S3 method for class 'distribution'
quantile(x, p, ..., log = FALSE)
```

Arguments

x	The distribution(s).
p	The probability of the quantile.
...	Additional arguments passed to methods.
log	If TRUE, probabilities will be given as log probabilities.

Details

Computes the quantiles of a distribution.

scale_hilo_continuous *Hilo interval scales*

Description

Hilo interval scales

Usage

```
scale_hilo_continuous(
  name = waiver(),
  breaks = waiver(),
  minor_breaks = waiver(),
  n.breaks = NULL,
  labels = waiver(),
  limits = NULL,
  expand = waiver(),
  oob = identity,
  na.value = NA,
  trans = "identity",
  guide = waiver(),
  position = "left",
  sec.axis = waiver()
)
```

Arguments

`name`
: The name of the scale. Used as the axis or legend title. If `waiver()`, the default, the name of the scale is taken from the first mapping used for that aesthetic. If `NULL`, the legend title will be omitted.

`breaks`
: One of:
  - `NULL` for no breaks
  - `waiver()` for the default breaks computed by the transformation object
  - A numeric vector of positions
  - A function that takes the limits as input and returns breaks as output (e.g., a function returned by `scales::extended_breaks()`)

`minor_breaks`
: One of:
  - `NULL` for no minor breaks
  - `waiver()` for the default breaks (one minor break between each major break)
  - A numeric vector of positions
  - A function that given the limits returns a vector of minor breaks.

`n.breaks`
: An integer guiding the number of major breaks. The algorithm may choose a slightly different number to ensure nice break labels. Will only have an effect if `breaks = waiver()`. Use `NULL` to use the default number of breaks given by the transformation.

`labels`
: One of:
  - `NULL` for no labels
  - `waiver()` for the default labels computed by the transformation object
  - A character vector giving labels (must be same length as `breaks`)
  - A function that takes the breaks as input and returns labels as output

`limits`
: One of:
  - `NULL` to use the default scale range
  - A numeric vector of length two providing limits of the scale. Use `NA` to refer to the existing minimum or maximum
  - A function that accepts the existing (automatic) limits and returns new limits Note that setting limits on positional scales will **remove** data outside of the limits. If the purpose is to zoom, use the limit argument in the coordinate system (see `coord_cartesian()`).

`expand`
: For position scales, a vector of range expansion constants used to add some padding around the data to ensure that they are placed some distance away from the axes. Use the convenience function `expansion()` to generate the values for the expand argument. The defaults are to expand the scale by 5% on each side for continuous variables, and by 0.6 units on each side for discrete variables.

`oob`
: One of:
  - Function that handles limits outside of the scale limits (out of bounds).
  - The default (`scales::censor()`) replaces out of bounds values with `NA`.
  - `scales::squish()` for squishing out of bounds values into range.
  - `scales::squish_infinite()` for squishing infinite values into range.

`na.value`
: Missing values will be replaced with this value.

`trans`	For continuous scales, the name of a transformation object or the object itself. Built-in transformations include "asn", "atanh", "boxcox", "date", "exp", "hms", "identity", "log", "log10", "log1p", "log2", "logit", "modulus", "probability", "probit", "pseudo_log", "reciprocal", "reverse", "sqrt" and "time". A transformation object bundles together a transform, its inverse, and methods for generating breaks and labels. Transformation objects are defined in the scales package, and are called <name>_trans (e.g., `scales::boxcox_trans()`). You can create your own transformation with `scales::trans_new()`.
`guide`	A function used to create a guide or its name. See `guides()` for more information.
`position`	For position scales, The position of the axis. `left` or `right` for y axes, `top` or `bottom` for x axes.
`sec.axis`	`sec_axis()` is used to specify a secondary axis.

`scale_level` *level luminance scales*

Description

This set of scales defines new scales for prob geoms equivalent to the ones already defined by ggplot2. This allows the shade of confidence intervals to work with the legend output.

Usage

```
scale_level_continuous(..., guide = "level")
```

Arguments

`...` Arguments passed on to `continuous_scale`

`scale_name` The name of the scale that should be used for error messages associated with this scale.

`palette` A palette function that when called with a numeric vector with values between 0 and 1 returns the corresponding output values (e.g., `scales::area_pal()`).

`name` The name of the scale. Used as the axis or legend title. If `waiver()`, the default, the name of the scale is taken from the first mapping used for that aesthetic. If `NULL`, the legend title will be omitted.

`breaks` One of:

- `NULL` for no breaks
- `waiver()` for the default breaks computed by the transformation object
- A numeric vector of positions
- A function that takes the limits as input and returns breaks as output (e.g., a function returned by `scales::extended_breaks()`)

`minor_breaks` One of:

- `NULL` for no minor breaks
- `waiver()` for the default breaks (one minor break between each major break)
- A numeric vector of positions
- A function that given the limits returns a vector of minor breaks.

`n.breaks` An integer guiding the number of major breaks. The algorithm may choose a slightly different number to ensure nice break labels. Will only have an effect if `breaks = waiver()`. Use `NULL` to use the default number of breaks given by the transformation.

`labels` One of:

- `NULL` for no labels
- `waiver()` for the default labels computed by the transformation object
- A character vector giving labels (must be same length as `breaks`)
- A function that takes the breaks as input and returns labels as output

`limits` One of:

- `NULL` to use the default scale range
- A numeric vector of length two providing limits of the scale. Use `NA` to refer to the existing minimum or maximum
- A function that accepts the existing (automatic) limits and returns new limits Note that setting limits on positional scales will **remove** data outside of the limits. If the purpose is to zoom, use the limit argument in the coordinate system (see `coord_cartesian()`).

`rescaler` A function used to scale the input values to the range [0, 1]. This is always `scales::rescale()`, except for diverging and n colour gradients (i.e., `scale_colour_gradient2()`, `scale_colour_gradientn()`). The `rescaler` is ignored by position scales, which always use `scales::rescale()`.

`oob` One of:

- Function that handles limits outside of the scale limits (out of bounds).
- The default (`scales::censor()`) replaces out of bounds values with `NA`.
- `scales::squish()` for squishing out of bounds values into range.
- `scales::squish_infinite()` for squishing infinite values into range.

`trans` For continuous scales, the name of a transformation object or the object itself. Built-in transformations include "asn", "atanh", "boxcox", "date", "exp", "hms", "identity", "log", "log10", "log1p", "log2", "logit", "modulus", "probability", "probit", "pseudo_log", "reciprocal", "reverse", "sqrt" and "time".
A transformation object bundles together a transform, its inverse, and methods for generating breaks and labels. Transformation objects are defined in the scales package, and are called <name>_trans (e.g., `scales::boxcox_trans()`). You can create your own transformation with `scales::trans_new()`.

`expand` For position scales, a vector of range expansion constants used to add some padding around the data to ensure that they are placed some distance away from the axes. Use the convenience function `expansion()` to generate the values for the `expand` argument. The defaults are to expand the scale by 5% on each side for continuous variables, and by 0.6 units on each side for discrete variables.

`position` For position scales, The position of the axis. `left` or `right` for y axes, `top` or `bottom` for x axes.

`super` The super class to use for the constructed scale

`guide` Type of legend. Use `"colourbar"` for continuous colour bar, or `"legend"` for discrete colour legend.

Value

A ggproto object inheriting from `Scale`

`skewness` *Skewness of a probability distribution*

Description

Stable

Usage

```
skewness(x, ...)

## S3 method for class 'distribution'
skewness(x, ...)
```

Arguments

`x`	The distribution(s).
`...`	Additional arguments used by methods.

`variance` *Variance*

Description

A generic function for computing the variance of an object. The default method will use `stats::var()` to compute the variance.

Usage

```
variance(x, ...)
```

Arguments

`x`	An object.
`...`	Additional arguments used by methods.

See Also

`variance.distribution()`

variance.distribution *Variance of a probability distribution*

Description

Stable

Usage

```
## S3 method for class 'distribution'
variance(x, ...)
```

Arguments

`x`	The distribution(s).
`...`	Additional arguments used by methods.

Details

Returns the empirical variance of the probability distribution. If the method does not exist, the variance of a random sample will be returned.

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