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Title Univariate Pseudo-Random Number Generation

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Description Pseudo-random number generation of 17 univariate distributions proposed by Demirtas. (2005) <DOI:10.22237/jmasm/1114907220>.

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UnivRNG-package *Univariate Pseudo-Random Number Generation*

Description

This package implements the algorithms described in Demirtas (2005) for pseudo-random number generation of 17 univariate distributions. The following distributions are available: Left Truncated Gamma, Laplace, Inverse Gaussian, Von Mises, Zeta (Zipf), Logarithmic, Beta-Binomial, Rayleigh, Pareto, Non-central t, Non-central Chi-squared, Doubly non-central F, Standard t, Weibull, Gamma with α<1, Gamma with α>1, and Beta with α<1 and β<1. For some distributions, functions that have similar capabilities exist in the base package; the functions herein should be regarded as complementary tools.

The methodology for each random-number generation procedure varies and each distribution has its own function. `draw.left.truncated.gamma`, `draw.von.mises`, `draw.inverse.gaussian`, `draw.zeta`, `draw.gamma.alpha.less.than.one`, and `draw.beta.alphabeta.less.than.one` are based on acceptance/rejection region techniques. `draw.rayleigh`, `draw.pareto`, and `draw.weibull` utilize the inverse CDF method. The chop-down method is used for `draw.logarithmic`. In `draw.laplace`, a sample from an exponential distribution with mean $1/\lambda$ is generated and subsequently the sign is changed with probability 0.5 and all variables are shifted by α. For the Beta-Binomial distribution in `draw.beta.binomial`, π is generated as the appropriate β and used as the success probability for the binomial portion. `draw.noncentral.t` utilizes on arithmetic functions of normal and chi-squared random variables. `draw.noncentral.chisquared` is based on the sum of squared random normal variables, and `draw.noncentral.F` is a ratio of chi-squared random variables generated via `draw.noncentral.chisquared`. `draw.t` employs a rejection polar method developed by Bailey (1994). `draw.gamma.alpha.greater.than.one` uses a ratio of uniforms method by Cheng and Feast (1979).

Details

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Author(s)

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References

Bailey, R. W. (1994). Polar generation of random variates with the t-distribution. *Mathematics of Computation*, **62**, 779-781.

Cheng, R. C. H., & Feast, G. M. (1979). Some simple gamma variate generation. *Applied Statistics*, **28**, 290-295.

Demirtas, H. (2005). Pseudo-random number generation in R for some univariate distributions. *Journal of Modern Applied Statistical Methods*, **4(1)**, 300-311.

`draw.beta.alphabeta.less.than.one`
Generates variates from Beta distribution with max$(\alpha, \beta) < 1$

Description

This function implements pseudo-random number generation for a Beta distribution for $\max(\alpha, \beta) < 1$ with pdf

$$f(x|\alpha, \beta) = \frac{1}{B(\alpha, \beta)} x^{\alpha-1}(1-x)^{\beta-1}$$

for $0 \le x \le 1$, $0 < \alpha < 1$, and $0 < \beta < 1$ where α and β are the shape parameters and $B(\alpha, \beta)$ is the complete beta function.

Usage

```
draw.beta.alphabeta.less.than.one(nrep,alpha,beta)
```

Arguments

`nrep`	Number of data points to generate.
`alpha`	First shape parameter. Must be less than 1.
`beta`	Second shape parameter. Must be less than 1.

Value

A list of length five containing generated data, the theoretical mean, the empirical mean, the theoretical variance, and the empirical variance with names y, theo.mean, emp.mean, theo.var, and emp.var, respectively.

References

Jhonk, M. D. (1964). Erzeugung von betaverteilter und gammaverteilter zufallszahlen. *Metrika*, **8**, 5-15.

Examples

```
draw.beta.alphabeta.less.than.one(nrep=100000,alpha=0.7,beta=0.4)
```

draw.beta.binomial *Generates variates from Beta-binomial distribution*

Description

This function implements pseudo-random number generation for a Beta-binomial distribution with pmf

$$f(x|n,\alpha,\beta) = \frac{n!}{x!(n-x)!B(\alpha,\beta)} \int_0^1 \pi^{\alpha-1+x}(1-\pi)^{n+\beta-1-x} d\pi$$

for $x = 0, 1, 2, ...$, $\alpha > 0$, and $\beta > 0$, where n is the sample size, α and β are the shape parameters and $B(\alpha, \beta)$ is the complete beta function.

Usage

```
draw.beta.binomial(nrep,alpha,beta,n)
```

Arguments

nrep	Number of data points to generate.
alpha	First shape parameter.
beta	Second shape parameter.
n	Number of trials.

Value

A list of length five containing generated data, the theoretical mean, the empirical mean, the theoretical variance, and the empirical variance with names y, theo.mean, emp.mean, theo.var, and emp.var, respectively.

Examples

```
draw.beta.binomial(nrep=100000,alpha=0.2,beta=0.25,n=10)

draw.beta.binomial(nrep=100000,alpha=2,beta=3,n=10)

draw.beta.binomial(nrep=100000,alpha=600,beta=400,n=20)
```

`draw.gamma.alpha.greater.than.one`
Generates variation from Gamma distribution with $\alpha > 1$

Description

This function implements pseudo-random number generation for a Gamma distribution for $\alpha > 1$ with pdf

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

for $0 \leq x < \infty$ and $\min(\alpha, \beta) > 0$ where α and β are the shape and scale parameters, respectively.

Usage

```
draw.gamma.alpha.greater.than.one(nrep,alpha,beta)
```

Arguments

`nrep`	Number of data points to generate.
`alpha`	Shape parameter for desired gamma distribution. Must be greater than 1.
`beta`	Scale parameter for desired gamma distribution.

Value

A list of length five containing generated data, the theoretical mean, the empirical mean, the theoretical variance, and the empirical variance with names y, theo.mean, emp.mean, theo.var, and emp.var, respectively.

References

Cheng, R. C. H., & Feast, G. M. (1979). Some simple gamma variate generation. *Applied Statistics*, **28**, 290-295.

Examples

```
draw.gamma.alpha.greater.than.one(nrep=100000,alpha=2,beta=2)

draw.gamma.alpha.greater.than.one(nrep=100000,alpha=3,beta=0.4)
```

`draw.gamma.alpha.less.than.one` *Generates variation from Gamma distribution with $\alpha < 1$*

Description

This function implements pseudo-random number generation for a gamma distribution for $\alpha < 1$ with pdf

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

for $0 \le x < \infty$ and $\min(\alpha,\beta) > 0$ where α and β are the shape and scale parameters, respectively.

Usage

```
draw.gamma.alpha.less.than.one(nrep,alpha,beta)
```

Arguments

`nrep`	Number of data points to generate.
`alpha`	Shape parameter for desired gamma distribution. Must be less than 1.
`beta`	Scale parameter for desired gamma distribution.

Value

A list of length five containing generated data, the theoretical mean, the empirical mean, the theoretical variance, and the empirical variance with names y, theo.mean, emp.mean, theo.var, and emp.var, respectively.

References

Ahrens, J. H., & Dieter, U. (1974). Computer methods for sampling from gamma, beta, poisson and binomial distributions. *Computing*, **1**, 223-246.

Examples

```
draw.gamma.alpha.less.than.one(nrep=100000,alpha=0.5,beta=2)
```

draw.inverse.gaussian *Generates variation from inverse Gaussian distribution*

Description

This function implements pseudo-random number generation for an inverse Gaussian distribution with pdf

$$f(x|\mu,\lambda) = (\frac{\lambda}{2\pi})^{1/2} x^{-3/2} e^{-\frac{\lambda(x-\mu)^2}{2\mu^2 x}}$$

for $x > 0$, $\mu > 0$, and $\lambda > 0$ where μ and λ are the location and scale parameters, respectively.

Usage

```
draw.inverse.gaussian(nrep,mu,lambda)
```

Arguments

`nrep`	Number of data points to generate.
`mu`	Location parameter for the desired inverse Gaussian distribution.
`lambda`	Scale parameter for the desired inverse Gaussian distribution.

Value

A list of length five containing generated data, the theoretical mean, the empirical mean, the theoretical variance, and the empirical variance with names y, theo.mean, emp.mean, theo.var, and emp.var, respectively.

References

Michael, J. R., William, R. S., & Haas, R. W. (1976). Generating random variates using transformations with multiple roots. *The American Statistician*, **30**, 88-90.

Examples

```
draw.inverse.gaussian(nrep=100000,mu=1,lambda=1)

draw.inverse.gaussian(nrep=100000,mu=3,lambda=1)
```

`draw.laplace` *Generates variates from Laplace distribution*

Description

This function implements pseudo-random number generation for a Laplace (double exponential) distribution with pdf

$$f(x|\lambda, \alpha) = \frac{\lambda}{2} e^{-\lambda|x-\alpha|}$$

for λ>0 where α and λ are the location and scale parameters, respectively.

Usage

```
draw.laplace(nrep, alpha, lambda)
```

Arguments

`nrep`	Number of data points to generate.
`alpha`	Location parameter for the desired Laplace distribution.
`lambda`	Scale parameter for the desired Laplace distribution.

Value

A list of length five containing generated data, the theoretical mean, the empirical mean, the theoretical variance, and the empirical variance with names y, theo.mean, emp.mean, theo.var, and emp.var, respectively.

Examples

```
draw.laplace(nrep=100000, alpha=4, lambda=2)

draw.laplace(nrep=100000, alpha=-5, lambda=4)
```

`draw.left.truncated.gamma` *Generates variates from left truncated Gamma distribution*

Description

This function implements pseudo-random number generation for a left-truncated gamma distribution with pdf

$$f(x|\alpha, \beta) = \frac{1}{(\Gamma(\alpha) - \Gamma_{\tau/\beta}(\alpha))\beta^{\alpha}} x^{\alpha-1} e^{-x/\beta}$$

for $0 < \tau \leq x$, and min(τ, β)>0 where α and β are the shape and scale parameters, respectively, τ is the cutoff point at which truncation occurs, and $\Gamma_{\tau/\beta}$ is the incomplete gamma function.

Usage

```
draw.left.truncated.gamma(nrep,alpha,beta,tau)
```

Arguments

`nrep`	Number of data points to generate.
`alpha`	Shape parameter for the desired gamma distribution.
`beta`	Scale parameter fot the desired gamma distribution.
`tau`	Point of left truncation.

Value

A list of length five containing generated data, the theoretical mean, the empirical mean, the theoretical variance, and the empirical variance with names y, theo.mean, emp.mean, theo.var, and emp.var, respectively.

References

Dagpunar, J. S. (1978). Sampling of variates from a truncated gamma distribution. *Journal of Statistical Computation and Simulation*, **8**, 59-64.

Examples

```
draw.left.truncated.gamma(nrep=100000,alpha=5,beta=1,tau=0.5)

draw.left.truncated.gamma(nrep=100000,alpha=2,beta=2,tau=0.1)
```

`draw.logarithmic` *Generates variates from logarithmic distribution*

Description

This function implements pseudo-random number generation for a logarithmic distribution with pmf

$$f(x|\theta) = -\frac{\theta^x}{x\log(1-\theta)}$$

for $x = 1, 2, 3, ...$ and $0 < \theta < 1$.

Usage

```
draw.logarithmic(nrep,theta)
```

Arguments

`nrep`	Number of data points to generate.
`theta`	Rate parameter of the desired logarithmic distribution.

Value

A list of length five containing generated data, the theoretical mean, the empirical mean, the theoretical variance, and the empirical variance with names y, theo.mean, emp.mean, theo.var, and emp.var, respectively.

References

Kemp, A. W. Efficient generation of logarithmically distributed pseudo-random variables. *Applied Statistics*, **30**, 249-253.

Examples

```
draw.logarithmic(nrep=100000,theta=0.33)

draw.logarithmic(nrep=100000,theta=0.66)
```

`draw.noncentral.chisquared` *Generates variates from non-central chi-squared distribution*

Description

This function implements pseudo-random number generation for a non-central chi-squared distribution with pdf

$$f(x|\lambda,\nu) = \frac{e^{-(x+\lambda)/2}x^{\nu/2-1}}{2^{\nu/2}} \sum_{k=0}^{\infty} \frac{(\lambda x)^k}{4^k k! \Gamma(k+\nu/2)}$$

for $0 \leq x < \infty$, $\lambda > 0$, and $\nu > 1$, where λ is the non-centrality parameter and ν is the degrees of freedom.

Usage

```
draw.noncentral.chisquared(nrep,dof,ncp)
```

Arguments

`nrep`	Number of data points to generate.
`dof`	Degrees of freedom of the desired non-central chi-squared distribution.
`ncp`	Non-centrality parameter of the desired non-central chi-squared distribution.

Value

A list of length five containing generated data, the theoretical mean, the empirical mean, the theoretical variance, and the empirical variance with names y, theo.mean, emp.mean, theo.var, and emp.var, respectively.

Examples

```
draw.noncentral.chisquared(nrep=100000,dof=2,ncp=1)

draw.noncentral.chisquared(nrep=100000,dof=5,ncp=2)
```

`draw.noncentral.F` *Generates variates from doubly non-central F distribution*

Description

This function implements pseudo-random number generation for a doubly non-central F distribution

$$F = \frac{X_1^2/n}{X_2^2/m}$$

where $X_1^2 \sim \chi^2(n, \lambda_1)$, $X_2^2 \sim \chi^2(m, \lambda_2)$, n and m are numerator and denominator degrees of freedom, respectively, and λ_1 and λ_2 are the numerator and denominator non-centrality parameters, respectively. It includes central and singly non-central F distributions as a special case.

Usage

```
draw.noncentral.F(nrep,dof1,dof2,ncp1,ncp2)
```

Arguments

`nrep`	Number of data points to generate.
`dof1`	Numerator degress of freedom.
`dof2`	Denominator degrees of freedom.
`ncp1`	Numerator non-centrality parameter.
`ncp2`	Denominator non-centrality parameter.

Value

A vector containing generated data.

See Also

`draw.noncentral.chisquared`

Examples

```
draw.noncentral.F(nrep=100000,dof1=2,dof2=4,ncp1=2,ncp2=4)
```

draw.noncentral.t *Generates variates from doubly non-central t distribution*

Description

This function implements pseudo-random number generation for a non-central t distribution

$$\frac{Y}{\sqrt{U/\nu}}$$

where U is a central chi-square random variable with ν degrees of freedom and Y is an independent, normally distributed random variable with variance 1 and mean λ.

Usage

```
draw.noncentral.t(nrep,nu,lambda)
```

Arguments

`nrep`	Number of data points to generate.
`nu`	Degrees of freedom of the desired non-central t distribution.
`lambda`	Non-centrality parameter of the desired non-central t distribution.

Value

A list of length five containing generated data, the theoretical mean, the empirical mean, the theoretical variance, and the empirical variance with names y, theo.mean, emp.mean, theo.var, and emp.var, respectively.

Examples

```
draw.noncentral.t(nrep=100000,nu=4,lambda=2)

draw.noncentral.t(nrep=100000,nu=5,lambda=1)
```

draw.pareto *Generates variates from Pareto distribution*

Description

This function implements pseudo-random number generation for a Pareto distribution with pdf

$$f(x|\alpha,\beta) = \frac{ab^a}{x^{a+1}}$$

for $0 < b \leq x < \infty$ and $a > 0$ where a and b are the shape and location parameters, respectively.

Usage

```
draw.pareto(nrep,shape,location)
```

Arguments

`nrep`	Number of data points to generate.
`shape`	Shape parameter of the desired Pareto distribution.
`location`	Location parameter of the desired Pareto distribution.

Value

A list of length five containing generated data, the theoretical mean, the empirical mean, the theoretical variance, and the empirical variance with names y, theo.mean, emp.mean, theo.var, and emp.var, respectively.

Examples

```
draw.pareto(nrep=100000,shape=11,location=11)

draw.pareto(nrep=100000,shape=8,location=10)
```

`draw.rayleigh` *Generates variates from Rayleigh distribution*

Description

This function implements pseudo-random number generation for a Rayleigh distribution with pdf

$$f(x|\sigma) = \frac{x}{\sigma^2} e^{-x^2/2\sigma^2}$$

for $x \geq 0$ and $\sigma > 0$ where σ is the scale parameter.

Usage

```
draw.rayleigh(nrep,sigma)
```

Arguments

`nrep`	Number of data points to generate.
`sigma`	Scale parameter of the desired Rayleigh distribution.

Value

A list of length five containing generated data, the theoretical mean, the empirical mean, the theoretical variance, and the empirical variance with names y, theo.mean, emp.mean, theo.var, and emp.var, respectively.

Examples

```
draw.rayleigh(nrep=100000,sigma=0.5)

draw.rayleigh(nrep=100000,sigma=3)
```

---

draw.t *Generates variates from standard t distribution*

Description

This function implements pseudo-random number generation for a standard-t distribution with pdf

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

for $-\infty < x < \infty$ where ν is the degrees of freedom.

Usage

```
draw.t(nrep,dof)
```

Arguments

nrep	Number of data points to generate.
dof	Degrees of freedom of the desired t distribution.

Value

A list of length five containing generated data, the theoretical mean, the empirical mean, the theoretical variance, and the empirical variance with names y, theo.mean, emp.mean, theo.var, and emp.var, respectively.

References

Bailey, R. W. (1994). Polar generation of random variates with the t-distribution. *Mathematics of Computation*, **62**, 779-781.

Examples

```
draw.t(nrep=100000,dof=2)

draw.t(nrep=100000,dof=6)
```

`draw.von.mises` *Generates variates from Von Mises distribution*

Description

This function implements pseudo-random number generation for a Von Mises distribution with pdf

$$f(x|K) = \frac{1}{2\pi I_0(K)} e^{Kcos(x)}$$

for $-\pi \leq x \leq \pi$ and $K > 0$ where $I_0(K)$ is a modified Bessel function of the first kind of order 0.

Usage

```
draw.von.mises(nrep,K)
```

Arguments

`nrep`	Number of data points to generate.
`K`	Parameter of the desired von Mises distribution.

Value

A list of length three containing generated data, the theoretical mean, and the empirical mean with names y, theo.mean, and emp.mean, respectively.

References

Best, D. J., & Fisher, N. I. (1979). Efficient simulation of the von mises distribution. *Applied Statistics*, **28**, 152-157.

Examples

```
draw.von.mises(nrep=100000,K=10)

draw.von.mises(nrep=100000,K=0.5)
```

`draw.weibull` *Generates variates from Weibull distribution*

Description

This function implements pseudo-random number generation for a Weibull distribution with pdf

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

for $0 \leq x < \infty$ and $\min(\alpha,\beta) > 0$ where α and β are the shape and scale parameters, respectively.

Usage

```
draw.weibull(nrep, alpha, beta)
```

Arguments

nrep	Number of data points to generate.
alpha	Shape parameter of the desired Weibull distribution.
beta	Scale parameter of the desired Weibull distribution.

Value

A list of length five containing generated data, the theoretical mean, the empirical mean, the theoretical variance, and the empirical variance with names y, theo.mean, emp.mean, theo.var, and emp.var, respectively.

Examples

```
draw.weibull(nrep=100000, alpha=0.5, beta=1)

draw.weibull(nrep=100000, alpha=5, beta=1)
```

`draw.zeta` *Generates variates from Zeta (Zipf) distribution*

Description

This function implements pseudo-random number generation for a Zeta (Zipf) distribution with pmf

$$f(x|\alpha) = \frac{1}{\zeta(\alpha) x^\alpha}$$

for $x = 1, 2, 3, ...$ and $\alpha > 1$ where $\zeta(\alpha) = \sum_{x=1}^{\infty} x^{-\alpha}$.

Usage

```
draw.zeta(nrep, alpha)
```

Arguments

`nrep`	Number of data points to generate.
`alpha`	Parameter of the desired zeta distribution.

Value

A list of length five containing generated data, the theoretical mean, the empirical mean, the theoretical variance, and the empirical variance with names y, theo.mean, emp.mean, theo.var, and emp.var, respectively.

References

Devroye, L. (1986). *Non-Uniform random variate generation*. New York: Springer-Verlag.

Examples

```
draw.zeta(nrep=100000,alpha=4)
```

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