Package ‘cpd’

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Title Complex Pearson Distributions

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Description Probability mass function, distribution function, quantile function and random generation for the Complex Triparametric Pearson (CTP) and Complex Biparametric Pearson (CBP) distributions developed by Rodriguez-Avi et al (2003) <doi:10.1007/s00362-002-0134-7>, Rodriguez-Avi et al (2004) <doi:10.1007/BF02778271> and Olmo-Jimenez et al (2018) <doi:10.1080/00949655.2018.1482897>. The package also contains maximum-likelihood fitting functions for these models.

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cbp — *The Complex Biparametric Pearson (CBP) Distribution*

Description

Probability mass function, distribution function, quantile function and random generation for the Complex Biparametric Pearson (CBP) distribution with parameters b and γ.

Usage

```
dcbp(x, b, gamma)

pcbp(q, b, gamma, lower.tail = TRUE)

qcbp(p, b, gamma, lower.tail = TRUE)

rcbp(n, b, gamma)

pcbp(q, b, gamma, lower.tail = TRUE)

qcbp(p, b, gamma, lower.tail = TRUE)

rcbp(n, b, gamma)
```

Arguments

`x`	vector of (non-negative integer) quantiles.
`b`	parameter b (real)
`gamma`	parameter gamma (positive)
`q`	vector of quantiles.
`lower.tail`	if TRUE (default), probabilities are $P(X <= x)$, otherwise, $P(X > x)$.
`p`	vector of probabilities.
`n`	number of observations. If `length(n) > 1`, the length is taken to be the number required.

Details

The CBP distribution with parameters b and γ has pmf

$$f(x|b,\gamma) = C\Gamma(ib+x)\Gamma(-ib+x)/(\Gamma(\gamma+x)x!), x = 0, 1, 2, ...$$

where i is the imaginary unit, $\Gamma()$ the gamma function and

$$C = \Gamma(\gamma-ib)\Gamma(\gamma+ib)/(\Gamma(\gamma)\Gamma(ib)\Gamma(-ib))$$

the normalizing constant.

The CBP is a particular case of the CTP when $a = 0$.

The mean and the variance of the CBP distribution are $E(X) = \mu = b^2/(\gamma - 1)$ and $Var(X) = \mu(\mu + \gamma - 1)/(\gamma - 2)$ so $\gamma > 2$.

It is always overdispersed.

Value

dcbp gives the pmf, pcbp gives the distribution function, qcbp gives the quantile function and rcbp generates random values.

References

Jose Rodriguez-Avi J, Conde-Sanchez A and Saez-Castillo AJ (2003). "A new class of discrete distributions with complex parameters." *Stat. Pap.*, **44**, pp. 67–88. doi: 10.1007/s0036200201347.

See Also

Probability mass function, distribution function, quantile function and random generation for the CTP distribution: dctp, pctp, qctp and rctp. Functions for maximum-likelihood fitting of the CBP distribution: fitcbp.

Examples

```
# Examples for the function dcbp
dcbp(3,2,5)
dcbp(c(3,4),2,5)

# Examples for the function pcbp
pcbp(3,2,3)
pcbp(c(3,4),2,3)
# Examples for the function qcbp
qcbp(0.5,2,3)
qcbp(c(.8,.9),2,3)
# Examples for the function rcbp(4,1,3)
```

---

ctp *The Complex Triparametric Pearson (CTP) Distribution*

Description

Probability mass function, distribution function, quantile function and random generation for the Complex Triparametric Pearson (CTP) distribution with parameters a, b and γ.

Usage

```
dctp(x, a, b, gamma)

pctp(q, a, b, gamma, lower.tail = TRUE)

qctp(p, a, b, gamma, lower.tail = TRUE)

rctp(n, a, b, gamma)

pctp(q, a, b, gamma, lower.tail = TRUE)

qctp(p, a, b, gamma, lower.tail = TRUE)

rctp(n, a, b, gamma)
```

Arguments

`x`	vector of (non-negative integer) quantiles.
`a`	parameter a (real)
`b`	parameter b (real)
`gamma`	parameter γ (positive)
`q`	vector of quantiles.
`lower.tail`	if TRUE (default), probabilities are $P(X <= x)$, otherwise, $P(X > x)$.
`p`	vector of probabilities.
`n`	number of observations. If `length(n) > 1`, the length is taken to be the number required.

Details

The CTP distribution with parameters a, b and γ has pmf

$$f(x|a, b, \gamma) = C\Gamma(a + ib + x)\Gamma(a - ib + x)/(\Gamma(\gamma + x)x!), x = 0, 1, 2, ...$$

where i is the imaginary unit, $\Gamma()$ the gamma function and

$$C = \Gamma(\gamma - a - ib)\Gamma(\gamma - a + ib)/(\Gamma(\gamma - 2a)\Gamma(a + ib)\Gamma(a - ib))$$

the normalizing constant.

If $a = 0$ the CTP is a Complex Biparametric Pearson (CBP) distribution, so the pmf of the CBP distribution is obtained.

The mean and the variance of the CTP distribution are $E(X) = \mu = (a^2 + b^2)/(\gamma - 2a - 1)$ and $Var(X) = \mu(\mu + \gamma - 1)/(\gamma - 2a - 2)$ so $\gamma > 2a + 2$.

It is underdispersed if $a < -(\mu + 1)/2$, equidispersed if $a = -(\mu + 1)/2$ or overdispersed if $a > -(\mu + 1)/2$. In particular, if $a >= 0$ the CTP is always overdispersed.

Value

`dctp` gives the pmf, `pctp` gives the distribution function, `qctp` gives the quantile function and `rctp` generates random values.

If $a = 0$ the probability mass function, distribution function, quantile function and random generation function for the CBP distribution arise.

References

Jose Rodriguez-Avi J, Conde-Sanchez A and Saez-Castillo AJ (2003). "A new class of discrete distributions with complex parameters." *Stat. Pap.*, **44**, pp. 67–88. doi: 10.1007/s0036200201347.

Rodriguez-Avi J, Conde-Sanchez A, Saez-Castillo AJ and Olmo-Jimenez MJ (2004). "A triparametric discrete distribution with complex parameters." *Stat. Pap.*, **45**, pp. 81–95. doi: 10.1007/BF02778271.

Olmo-Jimenez MJ, Rodriguez-Avi J and Cueva-Lopez V (2018). "A review of the CTP distribution: a comparison with other over- and underdispersed count data models." *Journal of Statistical Computation and Simulation*, **88**(14), pp. 2684-2706. doi: 10.1080/00949655.2018.1482897.

See Also

Functions for maximum-likelihood fitting of the CTP and CBP distributions: `fitctp` and `fitcbp`.

Examples

```
# Examples for the function dctp
dctp(3,1,2,5)
dctp(c(3,4),1,2,5)

# Examples for the function pctp
pctp(3,1,2,3)
pctp(c(3,4),1,2,3)
# Examples for the function qctp
qctp(0.5,1,2,3)
qctp(c(.8,.9),1,2,3)
# Examples for the function rctp
rctp(4,1,1,3)
```

`fitcbp` *Maximum-likelihood fitting of the Complex Biparametric Pearson (CBP) distribution*

Description

Maximum-likelihood fitting of the Complex Biparametric Pearson (CBP) distribution with parameters b and γ.

Usage

```
fitcbp(x, bstart = 1, gammastart = 1.1, method = "L-BFGS-B",
       moments = FALSE, hessian = TRUE, control = list(), ...)
```

Arguments

x	A numeric vector of length at least one containing only finite values.
bstart	An starting value for the parameter b; by default 1.
gammastart	An starting value for the parameter γ; by default 1.1.
method	The method to be used in fitting the model. The default method is "L-BFGS-B" (optim).
moments	If TRUE the estimates of b and γ by the method of moments are used as starting values (if it is posible). By default this argument is FALSE.
hessian	If TRUE the hessian of the objective function at the minimum is returned.
control	A list of parameters for controlling the fitting process.
...	Additional parameters.

Value

An object of class "fitcbp" is a list containing the following components:

- n, the number of observations,
- initialValues, a vector with the starting values used,
- coefficients, the parameter ML estimates of the CTP distribution,
- se, a vector of the standard error estimates,
- hessian, a symmetric matrix giving an estimate of the Hessian at the solution found in the optimization of the log-likelihood function,
- cov, an estimate of the covariance matrix of the model coefficients,
- corr, an estimate of the correlation matrix of the model estimates,
- loglik, the maximized log-likelihood,
- aic, Akaike Information Criterion, minus twice the maximized log-likelihood plus twice the number of parameters,
- bic, Bayesian Information Criterion, minus twice the maximized log-likelihood plus twice the number of parameters,
- code, a code that indicates successful convergence of the fitter function used (see nlm and optim helps),
- converged, logical value that indicates if the optimization algorithms succesfull,
- method, the name of the fitter function used.

References

Jose Rodriguez-Avi J, Conde-Sanchez A and Saez-Castillo AJ (2003). “A new class of discrete distributions with complex parameters.” *Stat. Pap.*, **44**, pp. 67–88. doi: 10.1007/s0036200201347.

See Also

Maximum-likelihood fitting for the CTP distribution: fitctp.

Examples

```
set.seed(123)
x <- rcbp(500, 1.75, 3.5)
fitcbp(x)
fitcbp(x, bstart = 1.1, gammastart = 3)
fitcbp(x, moments = TRUE)
```

---

fitctp — *Maximum-likelihood fitting of the Complex Triparametric Pearson (CTP) distribution*

Description

Maximum-likelihood fitting of the Complex Triparametric Pearson (CTP) distribution with parameters a, b and γ.

Usage

```
fitctp(x, astart = 0, bstart = 1, gammastart = 1.1, method = "L-BFGS-B",
       moments = FALSE, hessian = TRUE, control = list(), ...)
```

Arguments

x	A numeric vector of length at least one containing only finite values.
astart	An starting value for the parameter a; by default 0.
bstart	An starting value for the parameter b; by default 1.
gammastart	An starting value for the parameter γ; by default 1.1.
method	The method to be used in fitting the model. The default method is "L-BFGS-B" (optim).
moments	If TRUE the estimates of a, b and γ by the method of moments are used as starting values (if it is posible). By default this argument is FALSE.
hessian	If TRUE the hessian of the objective function at the minimum is returned.
control	A list of parameters for controlling the fitting process.
...	Additional parameters.

Value

An object of class "fitctp" is a list containing the following components:

- `n`, the number of observations,
- `initialValues`, a vector with the starting values used,
- `coefficients`, the parameter ML estimates of the CTP distribution,
- `se`, a vector of the standard error estimates,
- `hessian`, a symmetric matrix giving an estimate of the Hessian at the solution found in the optimization of the log-likelihood function,
- `cov`, an estimate of the covariance matrix of the model coefficients,
- `corr`, an estimate of the correlation matrix of the model estimates,
- `loglik`, the maximized log-likelihood,
- `aic`, Akaike Information Criterion, minus twice the maximized log-likelihood plus twice the number of parameters,
- `bic`, Bayesian Information Criterion, minus twice the maximized log-likelihood plus twice the number of parameters,
- `code`, a code that indicates successful convergence of the fitter function used (see nlm and optim helps),
- `converged`, logical value that indicates if the optimization algorithms succesfull,
- `method`, the name of the fitter function used.

References

Rodriguez-Avi J, Conde-Sanchez A, Saez-Castillo AJ and Olmo-Jimenez MJ (2004). "A triparametric discrete distribution with complex parameters." *Stat. Pap.*, **45**, pp. 81–95. doi: 10.1007/BF02778271.

Olmo-Jimenez MJ, Rodriguez-Avi J and Cueva-Lopez V (2018). "A review of the CTP distribution: a comparison with other over- and underdispersed count data models." *Journal of Statistical Computation and Simulation*, **88**(14), pp. 2684-2706. doi: 10.1080/00949655.2018.1482897.

See Also

Maximum-likelihood fitting for the CBP distribution: `fitcbp`.

Examples

```
set.seed(123)
x <- rctp(500, -0.5, 1, 2)
fitctp(x)
fitctp(x, astart = 1, bstart = 1.1, gammastart = 3)
fitctp(x, moments = TRUE)
```

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