Package 'mlCopulaSelection'

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Type Package

Title Copula selection and fitting using maximum likelihood

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Description Use numerical maximum likelihood to choose and fit a bivariate copula model (from a library of 40 models) to the data.

License GPL-2

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R topics documented:

`mlCopulaSelection-package`

Copula selection and fitting using maximum likelihood

Description

Use numerical maximum likelihood to choose and fit a bivariate copula model (from a library of 40 models) to the data. The copula models in the library correspond to BB1, BB2,...,BB10 from Joe, H., (1997) and its 90, 180 and 270 degree rotations.

Details

Package:	mlCopulaSelection
Type:	Package
Version:	1.3
Date:	2006-08-12
License:	GPL version 2.

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

Maintainer: Jesus Garcia <jg@ime.unicamp.br>

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
# The Data (the margins are uniform)
U <- c( 0.43, 0.1, 0.2, 0.33, 0.24, 0.29, 0.14, 0.4, 0.39, 0.8, 0.63, 0.16, 0.24, 0.14,0.71,
V <- c(0.01, 0.26, 0.2, 0.36, 0.34, 0.43, 0.27, 0.61, 0.08, 0.25, 0.72, 0.15, 0.14, 0.12, 0.
# find the maximun likelihood estimates
res<-mlcbbsel(U,V)
```

```
#the best fitting copula model:
res$copmax
#the parameters for the best fitting copula model:
res$parmax
#the log-likelihood of the best fitting copula model with those parameters:
res$llmax
```

`dcbb1` *BB1 copula density function*

Description

Calculate the value of the BB1 density.

Usage

```
dcbb1(theta, delta, u, v)
```

Arguments

`theta`	Parameter `theta` of the BB1. (0<`theta`)
`delta`	Parameter `delta` of the BB1. (1<`delta`)
`u`	First coordenate where de density will be evaluated. (0<`u`<1)
`v`	Second coordenate where de density will be evaluated. (0<`v`<1)

Value

value of de density BB1 for the parameters `theta` and `delta` on (`u` , `v`)

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
res<-dcbb1(0.5,1.5,0.90,0.85)

## The function is currently defined as
function(theta,delta,u,v)
{S<-u^(-theta)-1;
T<-v^(-theta)-1;-10**(4)
W<-S^(delta)+T^(delta);
```

```
DuS<-(-theta)*u^(-theta-1);
DuW<-delta*S^(delta-1)*DuS;
DvT<-(-theta)*v^(-theta-1);
DvW<-delta*T^(delta-1)*DvT;
densi<-(-1/(theta*delta))*(-1/theta-1)*(1+W^(1/delta))^(-1/theta-2)*(1/delta)*W^(1/delta-1)*
  }
```

---

dcbb10 *BB10 copula density function*

Description

Calculate the value of the BB10 density.

Usage

```
dcbb10(theta, delta, u, v)
```

Arguments

theta	Parameter theta of the BB10, (0<theta<1).
delta	Parameter delta of the BB10, (0<delta).
u	First coordenate where de density will be evaluated. (0<u<1)
v	Second coordenate where de density will be evaluated. (0<v<1)

Value

value of de density BB10 for the parameters theta and delta on (u , v)

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
res<-dcbb10(1.5,1.5,0.75,0.6)


## The function is currently defined as
function(theta,delta,u,v)
{S<-1-u^(1/delta);
T<-1-v^(1/delta);
W<-theta*S*T;
```

```
C<-u*v*(1-W)^(-delta);
DuS<-(-1/delta)*u^(1/delta-1);
DuW<-theta*T*DuS;
DvT<-(-1/delta)*v^(1/delta-1);
DvW<-theta*S*DvT;
DvuW<-theta*DuS*DvT;
densi<-(1-W)^(-delta)+v*(-delta)*(1-W)^(-delta-1)*(-1)*DvW+u*delta*(1-W)^(-delta-1)*DuW+u*v*
  }
```

`dcbb2` *BB2 copula density function*

Description

Calculate the value of the BB2 density.

Usage

```
dcbb2(theta, delta, u, v)
```

Arguments

`theta`	Parameter `theta` of the BB2, (0<`theta`).
`delta`	Parameter `delta` of the BB2, (0<`delta`).
`u`	First coordenate where de density will be evaluated. (0<`u`<1)
`v`	Second coordenate where de density will be evaluated. (0<`v`<1)

Value

value of de density BB2 for the parameters `theta` and `delta` on (`u` , `v`)

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
res<-dcbb2(0.5,0.5,0.75,0.6)

## The function is currently defined as
function(theta,delta,u,v)
{k<-exp(theta*(u^(-delta)-1));
t<-exp(theta*(v^(-delta)-1));
S<-k+t-1;
h<-(1/theta)*log(S);
duk<--k*(theta*delta)*u^(-delta-1);
dvt<--t*(theta*delta)*v^(-delta-1);
duS<-duk;
dvS<-dvt;
duh<-(1/theta)*duS/S;
dvh<-(1/theta)*dvS/S;
dvuh<-(-1/theta)*duS*dvS/S^2;
densi<-(1/delta)*(1+1/delta)*(1+h)^(-2-1/delta)*dvh*duh-(1/delta)*(1+h)^(-1-1/delta)*dvuh
        }
```

`dcbb3` *BB3 copula density function*

Description

Calculate the value of the BB3 density.

Usage

```
dcbb3(theta, delta, u, v)
```

Arguments

`theta`	Parameter `theta` of the BB3, (0<`theta`).
`delta`	Parameter `delta` of the BB3, (1<`delta`).
`u`	First coordenate where de density will be evaluated. (0<`u`<1)
`v`	Second coordenate where de density will be evaluated. (0<`v`<1)

Value

value of de density BB3 for the parameters `theta` and `delta` on (`u` , `v`)

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
res<-dcbb3(1.5,1.5,0.75,0.6)

## The function is currently defined as
function(theta,delta,u,v){W<-exp(theta*(-log(u))^(delta));
P<-exp(theta*(-log(v))^(delta));
S<-W+P-1;
h<-(1/theta)*log(S);
F<-exp(-h^(1/delta));
duS<-exp((-log(u))^(delta)*theta)*(-theta*delta/u)*(-log(u))^(delta-1);
dvS<-exp((-log(v))^(delta)*theta)*(-theta*delta/v)*(-log(v))^(delta-1);
dvuh<-(-1/theta)/S^2*duS*dvS;
duh<-(1/theta)*duS/S;
dvh<-(1/theta)*dvS/S;
densi<-F*(1/delta^2)*(h^(1/delta-1))^2*dvh*duh+F*(-1/delta)*(1/delta-1)*(h)^(1/delta-2)*(dvh
  }
```

`dcbb4` *BB4 copula density function*

Description

Calculate the value of the BB4 density.

Usage

```
dcbb4(theta, delta, u, v)
```

Arguments

`theta`	Parameter `theta` of the BB4, (0<`theta`).
`delta`	Parameter `delta` of the BB4, (0<`delta`).
`u`	First coordenate where de density will be evaluated. (0<`u`<1)
`v`	Second coordenate where de density will be evaluated. (0<`v`<1)

Value

value of de density BB4 for the parameters `theta` and `delta` on (`u` , `v`)

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
res<-dcbb4(1.5,1.5,0.75,0.6)

## The function is currently defined as
function(theta,delta,u,v)
{VV<-(u^(-theta)-1)^(-delta);
        WW<-(v^(-theta)-1)^(-delta);
        h<-VV+WW;
        S<-u^(-theta)+v^(-theta)-1;
        duh<-delta*theta*u^(-theta-1)*(u^(-theta)-1)^(-delta-1);
        dvh<-delta*theta*v^(-theta-1)*(v^(-theta)-1)^(-delta-1);
        duS<-(-theta)*u^(-theta-1);
        dvS<-(-theta)*v^(-theta-1);
        densi<-(1/theta)*(1/theta+1)*(S-h^(-1/delta))^(-1/theta-2)*(dvS+1/delta*h^(-1/delta-
        }
```

`dcbb5` *BB5 copula density function*

Description

Calculate the value of the BB5 density.

Usage

```
dcbb5(theta, delta, u, v)
```

Arguments

`theta`	Parameter `theta` of the BB5, (1<`theta`).
`delta`	Parameter `delta` of the BB5, (0<`delta`).
`u`	First coordenate where de density will be evaluated. (0<`u`<1)
`v`	Second coordenate where de density will be evaluated. (0<`v`<1)

Value

value of de density BB5 for the parameters `theta` and `delta` on (`u` , `v`)

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
res<-dcbb5(1.5,1.5,0.75,0.6)

## The function is currently defined as
function(theta,delta,u,v)
{t<-(-log(u))^(-theta*delta)+(-log(v))^(-theta*delta);
        dut<-(theta*delta/u)*(-log(u))^(-theta*delta-1);
        dvt<-(theta*delta/v)*(-log(v))^(-theta*delta-1);
        S<-(-log(u))^(theta)+(-log(v))^(theta);
        duS<-(-theta/u)*(-log(u))^(theta-1);
        dvS<-(-theta/v)*(-log(v))^(theta-1);
        h<-S-t^(-1/delta);
        duh<-duS+(1/delta)*(t)^(-1/delta-1)*(dut);
        dvh<-dvS+(1/delta)*(t)^(-1/delta-1)*(dvt);
        dvuh<--1/delta*(1/delta+1)*t^(-1/delta-2)*dut*dvt;
        densi<-exp(-h^(1/theta))*(1/theta)^2*(h^(1/theta-1))^2*dvh*duh+exp(-h^(1/theta))*(-1
        }
```

`dcbb6` *BB6 copula density function*

Description

Calculate the value of the BB6 density.

Usage

```
dcbb6(t, d, u, v)
```

Arguments

`t`	Parameter `t` of the BB6, (1<`t`).
`d`	Parameter `d` of the BB6, (1<`d`).
`u`	First coordenate where de density will be evaluated. (0<`u`<1)
`v`	Second coordenate where de density will be evaluated. (0<`v`<1)

Value

value of de density BB6 for the parameters `t` and `d` on (`u` , `v`)

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
res<-dcbb6(1.5,1.5,0.75,0.6)


## The function is currently defined as
function(t,d,u,v)
{

  t19 = (d*t*(-log(-(-u+1.)**t+1.))**(d-1.)*(-log(-(-v+1.)**t+1.))**(d-1.)*exp(-(-log(-(-u+1
  }
```

`dcbb7` *BB7 copula density function*

Description

Calculate the value of the BB7 density.

Usage

```
dcbb7(theta, delta, u, v)
```

Arguments

`theta`	Parameter `theta` of the BB7, (1<`theta`).
`delta`	Parameter `delta` of the BB7, (0<`delta`).
`u`	First coordenate where de density will be evaluated. (0<`u`<1)
`v`	Second coordenate where de density will be evaluated. (0<`v`<1)

Value

value of de density BB7 for the parameters `theta` and `delta` on (`u` , `v`)

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
res<-dcbb7(1.5,1.5,0.75,0.6)


## The function is currently defined as
function(theta,delta,u,v)
{WU<-(1-(1-u)^(theta))^(-delta);
        WV<-(1-(1-v)^(theta))^(-delta);
        duWU<-(-delta*theta)*(1-(1-u)^(theta))^(-delta-1)*(1-u)^(theta-1);
        dvWV<-(-delta*theta)*(1-(1-v)^(theta))^(-delta-1)*(1-v)^(theta-1);
        K<-WU+WV;
        duK<-duWU;
        dvK<-dvWV;
        S<-K-1;
        duS<-duK;
        dvS<-dvK;
        h<-1-S^(-1/delta);
        duh<-(1/delta)*S^(-1/delta-1)*duS;
        dvh<-(1/delta)*S^(-1/delta-1)*dvS;
        dvuh<-(1/delta)*(-1/delta-1)*(S)^(-1/delta-2)*(dvS)*(duS);
        densi<-(-1/theta)*(1/theta-1)*h^(1/theta-2)*dvh*duh-(1/theta)*h^(1/theta-1)*dvuh
        }
```

`dcbb8` *BB8 copula density function*

Description

Calculate the value of the BB8 density.

Usage

```
dcbb8(theta, delta, u, v)
```

Arguments

`theta`	Parameter `theta` of the BB8, (1<`theta`).
`delta`	Parameter `delta` of the BB8, (0<`delta`<1).
`u`	First coordenate where de density will be evaluated. (0<`u`<1)
`v`	Second coordenate where de density will be evaluated. (0<`v`<1)

Value

value of de density BB8 for the parameters `theta` and `delta` on (`u` , `v`)

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
res<-dcbb8(1.5,0.5,0.75,0.6)

## The function is currently defined as
function(theta,delta,u,v)
{
S<-1-(1-delta*u)^(theta);
T<-1-(1-delta*v)^(theta);
K<-(1-(1-delta)^(theta))^(-1);
W<-1-K*S*T;
DuS<-theta*delta*(1-delta*u)^(theta-1);
DuW<--K*T*DuS;
DvT<-theta*delta*(1-delta*v)^(theta-1);
DvW<--K*S*DvT;
DvuW<--K*DuS*DvT;
densi<--delta^(-1)*(1/theta)*(1/theta-1)*W^(1/theta-2)*DvW*DuW-delta^(-1)*(1/theta)*W^(1/the
  }
```

`dcbb9` *BB9 copula density function*

Description

Calculate the value of the BB9 density.

Usage

```
dcbb9(theta, delta, u, v)
```

Arguments

`theta`	Parameter `theta` of the BB9, (1<`theta`).
`delta`	Parameter `delta` of the BB9, (0<`delta`).
`u`	First coordenate where de density will be evaluated. (0<`u`<1)
`v`	Second coordenate where de density will be evaluated. (0<`v`<1)

Value

value of de density BB9 for the parameters `theta` and `delta` on (`u` , `v`)

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
res<-dcbb9(1.5,1.5,0.75,0.6)

## The function is currently defined as
function(theta,delta,u,v)
{S<-delta-log(u);
T<-delta-log(v);
W<-S^(theta)+T^(theta)-delta^(theta);
C<-exp(-W^(1/theta)+delta);
DuS<--1/u;
DuW<-theta*S^(theta-1)*DuS;
DvT<--1/v;
DvW<-theta*T^(theta-1)*DvT;
densi<-C*(1/theta^2)*(W^(1/theta-1))^2*DvW*DuW+C*(-1/theta)*(1/theta-1)*W^(1/theta-2)*DvW*Du
  }
```

---

llbb1 *BB1's log-likelihood function*

Description

Calculate the log-likelihood for the BB1 density.

Usage

```
llbb1(param, u, v)
```

Arguments

param	bidimensional vector with parameters c(theta,delta) (0<theta and 1<delta)
u	vector with the first coordenate of the bivariate data
v	vector with the second coordenate of the bivariate data (same size asu)

Details

(u,v) margins must have Uniform(0,1) marginal distribution

Value

BB1's log-likelihood function for the sample

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
# The data:
u <- c( 0.43, 0.1, 0.2, 0.33, 0.24, 0.29, 0.14, 0.4, 0.39, 0.8, 0.63, 0.16, 0.24, 0.14,0.71,
v <- c(0.01, 0.26, 0.2, 0.36, 0.34, 0.43, 0.27, 0.61, 0.08, 0.25, 0.72, 0.15, 0.14, 0.12, 0.
# The log-likelihood
r<-llbb1(c(0.5,1.5),u,v)

## The function is currently defined as
function(param,u,v)
{
n<-sum(u>=-1)
s<-0.
for(i in 1:n) { s<-s+log( dcbb1(param[1],param[2],u[i],v[i]) );if(is.nan(s)) {break};}
if(is.finite(s)) {res<-s} else {res<- -10**(64)}
  }
```

`llbb1` *BB2's log-likelihood function*

Description

Calculate the log-likelihood for the BB2 density.

Usage

```
llbb2(param, u, v)
```

Arguments

`param`	bidimensional vector with parameters c(`theta`,`delta`) (0<`theta` and 0<`delta`)
`u`	vector with the first coordenate of the bivariate data
`v`	vector with the second coordenate of the bivariate data (same size as`u`)

Details

(u,v) margins must have Uniform(0,1) marginal distribution

Value

BB2's log-likelihood function for the sample

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
# The data:
u <- c( 0.43, 0.1, 0.2, 0.33, 0.24, 0.29, 0.14, 0.4, 0.39, 0.8, 0.63, 0.16, 0.24, 0.14,0.71,
v <- c(0.01, 0.26, 0.2, 0.36, 0.34, 0.43, 0.27, 0.61, 0.08, 0.25, 0.72, 0.15, 0.14, 0.12, 0.
# The log-likelihood
r<-llbb2(c(0.5,1.5),u,v)


## The function is currently defined as
function(param,u,v)
{
n<-sum(u>=-1)
s<-0.
for(i in 1:n) { s<-s+log(dcbb2(param[1],param[2],u[i],v[i]));if(is.nan(s)) {break};  }
if(is.finite(s)) {res<-s} else {res<- -10**(64)}
  }
```

`llbb1` *BB3's log-likelihood function*

Description

Calculate the log-likelihood for the BB3 density.

Usage

```
llbb3(param, u, v)
```

Arguments

`param`	bidimensional vector with parameters c(`theta`,`delta`) (0<`theta` and 1<`delta`)
`u`	vector with the first coordenate of the bivariate data
`v`	vector with the second coordenate of the bivariate data (same size as`u`)

Details

(u,v) margins must have Uniform(0,1) marginal distribution

Value

BB3's log-likelihood function for the sample

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
# The data:
u <- c( 0.43, 0.1, 0.2, 0.33, 0.24, 0.29, 0.14, 0.4, 0.39, 0.8, 0.63, 0.16, 0.24, 0.14,0.71,
v <- c(0.01, 0.26, 0.2, 0.36, 0.34, 0.43, 0.27, 0.61, 0.08, 0.25, 0.72, 0.15, 0.14, 0.12, 0.
# The log-likelihood
r<-llbb3(c(1.5,1.5),u,v)



## The function is currently defined as
function(param,u,v)
{
n<-sum(u>=-1)
s<-0.
for(i in 1:n) { s<-s+log(dcbb3(param[1],param[2],u[i],v[i]));if(is.nan(s)) {break};  }
if(is.finite(s)) {res<-s} else {res<- -10**(64)}
  }
```

---

llbb1 *BB4's log-likelihood function*

Description

Calculate the log-likelihood for the BB4 density.

Usage

```
llbb4(param, u, v)
```

Arguments

`param`	bidimensional vector with parameters c(`theta`,`delta`) (0<`theta` and 0<`delta`)
`u`	vector with the first coordenate of the bivariate data
`v`	vector with the second coordenate of the bivariate data (same size as`u`)

Details

(u,v) margins must have Uniform(0,1) marginal distribution

Value

BB4's log-likelihood function for the sample

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
# The data:
u <- c( 0.43, 0.1, 0.2, 0.33, 0.24, 0.29, 0.14, 0.4, 0.39, 0.8, 0.63, 0.16, 0.24, 0.14,0.71,
v <- c(0.01, 0.26, 0.2, 0.36, 0.34, 0.43, 0.27, 0.61, 0.08, 0.25, 0.72, 0.15, 0.14, 0.12, 0.
# The log-likelihood
r<-llbb4(c(0.5,1.5),u,v)


## The function is currently defined as
function(param,u,v)
{
n<-sum(u>=-1)
s<-0.
for(i in 1:n) { s<-s+log(dcbb4(param[1],param[2],u[i],v[i]));if(is.nan(s)) {break};  }
if(is.finite(s)) {res<-s} else {res<- -10**(64)}
  }
```

---

llbb10 *BB10's log-likelihood function*

Description

Calculate the log-likelihood for the BB10 density.

Usage

```
llbb10(param, u, v)
```

Arguments

`param`	bidimensional vector with parameters c(`theta`,`delta`) (0<`theta`<1 and 0<`delta`)
`u`	vector with the first coordenate of the bivariate data
`v`	vector with the second coordenate of the bivariate data (same size as`u`)

Details

(u,v) margins must have Uniform(0,1) marginal distribution

Value

BB10's log-likelihood function for the sample

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
# The data:
u <- c( 0.43, 0.1, 0.2, 0.33, 0.24, 0.29, 0.14, 0.4, 0.39, 0.8, 0.63, 0.16, 0.24, 0.14,0.71,
v <- c(0.01, 0.26, 0.2, 0.36, 0.34, 0.43, 0.27, 0.61, 0.08, 0.25, 0.72, 0.15, 0.14, 0.12, 0.
# The log-likelihood
r<-llbb10(c(0.5,1.5),u,v)


## The function is currently defined as
function(param,u,v)
{
n<-sum(u>=-1)
s<-0.
for(i in 1:n) { s<-s+log(dcbb10(param[1],param[2],u[i],v[i]));if(is.nan(s)) {break};  }
if(is.finite(s)) {res<-s} else {res<- -10**(64)}
  }
```

---

llbb5 *BB5's log-likelihood function*

Description

Calculate the log-likelihood for the BB5 density.

Usage

```
llbb5(param, u, v)
```

Arguments

`param`	bidimensional vector with parameters c(`theta`,`delta`) (1<`theta` and 0<`delta`)
`u`	vector with the first coordenate of the bivariate data
`v`	vector with the second coordenate of the bivariate data (same size as`u`)

Details

(u,v) margins must have Uniform(0,1) marginal distribution

Value

BB5's log-likelihood function for the sample

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
# The data:
u <- c( 0.43, 0.1, 0.2, 0.33, 0.24, 0.29, 0.14, 0.4, 0.39, 0.8, 0.63, 0.16, 0.24, 0.14,0.71,
v <- c(0.01, 0.26, 0.2, 0.36, 0.34, 0.43, 0.27, 0.61, 0.08, 0.25, 0.72, 0.15, 0.14, 0.12, 0.
# The log-likelihood
r<-llbb5(c(1.5,1.5),u,v)

## The function is currently defined as
function(param,u,v)
{
n<-sum(u>=-1)
s<-0.
for(i in 1:n) { s<-s+log(dcbb5(param[1],param[2],u[i],v[i]));if(is.nan(s)) {break}; }
if(is.finite(s)) {res<-s} else {res<- -10**(64)}
  }
```

---

llbb6 *BB6's log-likelihood function*

Description

Calculate the log-likelihood for the BB6 density.

Usage

```
llbb6(param, u, v)
```

Arguments

param	bidimensional vector with parameters c(theta,delta) (1<theta and 1<delta)
u	vector with the first coordenate of the bivariate data
v	vector with the second coordenate of the bivariate data (same size asu)

Details

(u,v) margins must have Uniform(0,1) marginal distribution

Value

BB6's log-likelihood function for the sample

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
# The data:
u <- c( 0.43, 0.1, 0.2, 0.33, 0.24, 0.29, 0.14, 0.4, 0.39, 0.8, 0.63, 0.16, 0.24, 0.14,0.71,
v <- c(0.01, 0.26, 0.2, 0.36, 0.34, 0.43, 0.27, 0.61, 0.08, 0.25, 0.72, 0.15, 0.14, 0.12, 0.
# The log-likelihood
r<-llbb6(c(1.5,1.5),u,v)

## The function is currently defined as
function(param,u,v)
{
n<-sum(u>=-1)
s<-0.
for(i in 1:n) { s<-s+log(dcbb6(param[1],param[2],u[i],v[i]));if(is.nan(s)) {break};  }
if(is.finite(s)) {res<-s} else {res<- -10**(64)}
  }
```

---

llbb7 *BB7's log-likelihood function*

Description

Calculate the log-likelihood for the BB7 density.

Usage

```
llbb7(param, u, v)
```

Arguments

`param`	bidimensional vector with parameters c(`theta`,`delta`) (1<`theta` and 0<`delta`)
`u`	vector with the first coordenate of the bivariate data
`v`	vector with the second coordenate of the bivariate data (same size as`u`)

Details

(u,v) margins must have Uniform(0,1) marginal distribution

Value

BB7's log-likelihood function for the sample

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
# The data:
u <- c( 0.43, 0.1, 0.2, 0.33, 0.24, 0.29, 0.14, 0.4, 0.39, 0.8, 0.63, 0.16, 0.24, 0.14,0.71,
v <- c(0.01, 0.26, 0.2, 0.36, 0.34, 0.43, 0.27, 0.61, 0.08, 0.25, 0.72, 0.15, 0.14, 0.12, 0.
# The log-likelihood
r<-llbb7(c(1.5,1.5),u,v)

## The function is currently defined as
function(param,u,v)
{
n<-sum(u>=-1)
s<-0.
for(i in 1:n) { s<-s+log(dcbb7(param[1],param[2],u[i],v[i]));if(is.nan(s)) {break};  }
if(is.finite(s)) {res<-s} else {res<- -10**(64)}
  }
```

---

llbb8 *BB8's log-likelihood function*

Description

Calculate the log-likelihood for the BB8 density.

Usage

```
llbb8(param, u, v)
```

Arguments

param	bidimensional vector with parameters c(theta,delta) (1<theta and 0<delta<1)
u	vector with the first coordenate of the bivariate data
v	vector with the second coordenate of the bivariate data (same size asu)

Details

(u,v) margins must have Uniform(0,1) marginal distribution

Value

BB8's log-likelihood function for the sample

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
# The data:
u <- c( 0.43, 0.1, 0.2, 0.33, 0.24, 0.29, 0.14, 0.4, 0.39, 0.8, 0.63, 0.16, 0.24, 0.14,0.71,
v <- c(0.01, 0.26, 0.2, 0.36, 0.34, 0.43, 0.27, 0.61, 0.08, 0.25, 0.72, 0.15, 0.14, 0.12, 0.
# The log-likelihood
r<-llbb8(c(1.5,0.5),u,v)

## The function is currently defined as
function(param,u,v)
{
n<-sum(u>=-1)
s<-0.
for(i in 1:n) { s<-s+log(dcbb8(param[1],param[2],u[i],v[i]));if(is.nan(s)) {break};  }
if(is.finite(s)) {res<-s} else {res<- -10**(64)}
  }
```

---

llbb9 *BB9's log-likelihood function*

Description

Calculate the log-likelihood for the BB9 density.

Usage

```
llbb9(param, u, v)
```

Arguments

param	bidimensional vector with parameters c(theta,delta) (1<theta and 0<delta)
u	vector with the first coordenate of the bivariate data
v	vector with the second coordenate of the bivariate data (same size asu)

Details

(u,v) margins must have Uniform(0,1) marginal distribution

Value

BB9's log-likelihood function for the sample

Author(s)

Jesus Garcia, IMECC-UNICAMP and Veronica Gonzalez-Lopez, IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hall.

Examples

```
# The data:
u <- c( 0.43, 0.1, 0.2, 0.33, 0.24, 0.29, 0.14, 0.4, 0.39, 0.8, 0.63, 0.16, 0.24, 0.14,0.71,
v <- c(0.01, 0.26, 0.2, 0.36, 0.34, 0.43, 0.27, 0.61, 0.08, 0.25, 0.72, 0.15, 0.14, 0.12, 0.
# The log-likelihood
r<-llbb9(c(1.5,1.5),u,v)


## The function is currently defined as
function(param,u,v)
{
n<-sum(u>=-1)
s<-0.
for(i in 1:n) { s<-s+log(dcbb9(param[1],param[2],u[i],v[i]));if(is.nan(s)) {break};  }
if(is.finite(s)) {res<-s} else {res<- -10**(64)}
  }
```

---

mlcbbsel *Function for maximum likelihood copula selection and fitting*

Description

Use numerical maximum likelihood to choose and fit a bivariate copula model (from a library of 40 models) to the data.

Usage

```
mlcbbsel(U, V)
```

Arguments

U	vector with the first coordenate of the bivariate data
V	vector with the second coordenate of the bivariate data (same size asU)

Details

(U,V) margins must have Uniform(0,1) marginal distribution

Value

It return a LIST with,

copmax	the best fitting copula model. The copula models in the library correspond to BB1, BB2,...,BB10 from Joe, H., (1997) and its 90, 180 and 270 degree rotations.
parmax	the maximum likelihood estimates of the parameters for the best fitting copula
llmax	the log-likelihood on the estimated parameters for the best copula
todo	contain a matrix with the maximum likelihood ressults for all the copula models. The first column is the copulamodel number (from 1 to 40), the second column is the maximum log-likelihood for that particular model and the third and fourth column contain the parameters values for which that maximum log-likelihood was attained.

Author(s)

Jesus Garcia. IMECC-UNICAMP and Veronica Gonzalez-Lopez. IMECC-UNICAMP

References

Joe, H., (1997). Multivariate Models and Dependence Concepts. Monogra. Stat. Appl. Probab. 73, London: Chapman and Hal l.

Examples

```
# The Data (the margins are uniform)
U <- c( 0.43, 0.1, 0.2, 0.33, 0.24, 0.29, 0.14, 0.4, 0.39, 0.8, 0.63, 0.16, 0.24, 0.14,0.71,
V <- c(0.01, 0.26, 0.2, 0.36, 0.34, 0.43, 0.27, 0.61, 0.08, 0.25, 0.72, 0.15, 0.14, 0.12, 0.
# find the maximun likelihood estimates
res<-mlcbbsel(U,V)
#the best fitting copula model:
res$copmax
#the parameters for the best fitting copula model:
res$parmax
#the log-likelihood of the best fitting copula model with those parameters:
res$llmax
```

```
## The function is currently defined as
function(U,V)
{

model=c("CBB1","CBB2" , "CBB3","CBB4","CBB5","CBB6", "CBB7","CBB8", "CBB9", "CBB10","CMM1",

respmodel=c("CBB1","CBB2" , "CBB3","CBB4","CBB5","CBB6", "CBB7","CBB8", "CBB9", "CBB10",
"180 degree rotation of CBB1","180 degree rotation of CBB2" , "180 degree rotation of CBB3",
"90 degree rotation of CBB1","90 degree rotation of CBB2" , "90 degree rotation of CBB3","90
"270 degree rotation of CBB1","270 degree rotation of CBB2" , "270 degree rotation of CBB3",


ncop<-1

TODOCOP <-c(1:40)
TODOPV  <-c(1:2)*0
TODOTET <-c(1:2)*0
TODODEL <-c(1:2)*0
PVMAX<- -10**(100)
pmax<-10

n<-sum(U != -10**200)

for(nmodel in 1:40)
{
RES   <- mlcbb(U,V,copulamodel=model[nmodel])
PV <- RES$value
PAR<- RES$par
if (PV>PVMAX) {PVMAX<-PV;PARMAX<-PAR;COPMAX<-nmodel;LLMAX<-PV}
TODOPV[nmodel]<- PV
TODOTET[nmodel] <-PAR[1]
TODODEL[nmodel] <-PAR[2]
  }

ORDEN<-order(TODOPV,TODOCOP,decreasing= TRUE)

TODO<-matrix(c(1:40*4)*0,40,4)

TODO[,1]<-respmodel[TODOCOP[ORDEN]]
TODO[,2]<-TODOPV[ORDEN]
TODO[,3]<-TODOTET[ORDEN]
TODO[,4]<-TODODEL[ORDEN]

result <- list(todo=TODO,copmax=respmodel[COPMAX],parmax=PARMAX,llmax=LLMAX)
  }
```

Index