R-code for Chapter 6: Simulating regular vine copulas and distributions

Claudia Czado
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Required R-packages

- VineCopula
- rafalib

Section 6.3: Simulating from C-vine copulas

Example 6.4: Simulating from a five dimensional C-vine copula

Table 6.1: R-vine specification: Chosen pair copula families, their family name abbreviations in VineCopula, parameter value and corresponding Kendall’s τ value.

```
MatrixC = c(1,1,1,1, 0,2,2,2, 0,0,3,3, 0,0,0,4,4,0,0,0,0,5)
MatrixC = t(matrix(MatrixC,5,5))
MatrixC
```
familyC = c(0,1,3,24,4,0,0,23,24,1,0,0,0,4,0,0,0,3,0,0,0,0,0)
familyC = matrix(familyC,5,5)
parC = c(0,0.2,0.9,-6.5,3.9,0,-5.1,-2.6,1.9,0.9,0.5,0,0,0,0,0,0,0,0)
parC = matrix(parC,5,5)
par2C = matrix(0,5,5)
RVMC = RVineMatrix(Matrix=MatrixC,family=familyC,par=parC,par2=par2C, names=c("V1","V2","V3","V4","V5"))

# C-vine copula with the following pair-copulas:
# Tree 1:
# 1,5 Gumbel (par = 3.9, tau = 0.74)
# 1,4 Gaussian (par = 0.9, tau = 0.71)
# 1,3 Gaussian (par = 0.5, tau = 0.33)
# 1,2 Clayton (par = 4.8, tau = 0.71)

# Tree 2:
# 2,5;1 Rotated Gumbel 90 degrees (par = -6.5, tau = -0.85)
# 2,4;1 Rotated Gumbel 90 degrees (par = -2.6, tau = -0.62)
# 2,3;1 Gumbel (par = 1.9, tau = 0.47)

# Tree 3:
# 3,5;2,1 Clayton (par = 0.9, tau = 0.31)
# 3,4;2,1 Rotated Clayton 90 degrees (par = -5.1, tau = -0.72)

# Tree 4:
# 4,5;3,2,1 Gaussian (par = 0.2, tau = 0.13)

## ---
# 1 <-> V1,  2 <-> V2,  3 <-> V3,  4 <-> V4,  5 <-> V5
Figure 6.2: C-vine tree plots: Tree sequence with families and Kendall’s $\tau$ values

```
bigpar(2,2)
plot(RVMC,type=0, edge.labels = "family-par")
```

![C-vine tree plots](image)

Figure 6.3: Normalized contours: Normalized theoretical contour plots of all pair copulas specified in the C-vine tree sequence given in Figure 6.2.

```
bigpar(2,2)
contour(RVMC)
```
Figure 6.4: C-vine simulation: A simulated sample of size 1000 from the C-vine specified in Table 6.1 (upper triangle: pair scatter plot of copula data, diagonal: marginal histograms of copula data, lower triangle: empirical normalized contour plots).

cdata = as.copuladata(RVineSim(1000,RVMC))
pairs(cdata)
Section 6.5: Simulating from regular vine copulas

Ex 6.7 Sampling from a specified R-vine copula.

Define 5-dimensional R-vine tree structure matrix

\[
\text{Matrix} = c(2, 5, 3, 1, 4, 0, 3, 5, 1, 4, 0, 0, 4, 5, 1, 0, 0, 5, 1, 0, 0, 0, 1)
\]

\[
\text{Matrix} = \text{matrix}(\text{Matrix}, 5, 5)
\]

\[
\text{Matrix}
\]

<table>
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<th></th>
<th></th>
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<td>1</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
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</table>
Define R-vine pair-copula family matrix

```r
define family = c(0,1,3,24,4,0,0,23,24,1,0,0,4,1,0,0,0,3,0,0,0,0,0)
family = matrix(family,5,5)
family
```

```
## [1,] 0 0 0 0 0
## [2,] 1 0 0 0 0
## [3,] 3 23 0 0 0
## [4,] 24 24 4 0 0
## [5,] 4 1 1 3 0
```

Define R-vine pair-copula parameter matrix

```r
define par = c(0,0.2,0.9,-6.5,3.9,0,0,-5.1,-2.6,0.9,0,0,0,1.9,0.5,0,0,0,0,4.8,0,0,0,0,0)
par = matrix(par,5,5)
par
```

```
## [1,] 0.0 0.0 0.0 0.0 0
## [2,] 0.2 0.0 0.0 0.0 0
## [3,] 0.9 -5.1 0.0 0.0 0
## [4,] -6.5 -2.6 1.9 0.0 0
## [5,] 3.9 0.9 0.5 4.8 0
```

Define second R-vine pair-copula parameter matrix

```r
define par2 = matrix(0,5,5)
```

Define RVineMatrix object

```r
RVM = RVineMatrix(Matrix=Matrix,family=family,par=par,par2=par2,
                  names=c("V1","V2","V3","V4","V5"))
RVM
```

```
# R-vine copula with the following pair-copulas:
# Tree 1:
# 4,2 Gumbel (par = 3.9, tau = 0.74)
# 4,3 Gaussian (par = 0.9, tau = 0.71)
# 1,4 Gaussian (par = 0.5, tau = 0.33)
# 1,5 Clayton (par = 4.8, tau = 0.71)
# Tree 2:
# 1,2;4 Rotated Gumbel 90 degrees (par = -6.5, tau = -0.85)
# 1,3;4 Rotated Gumbel 90 degrees (par = -2.6, tau = -0.62)
# 5,4;1 Gumbel (par = 1.9, tau = 0.47)
```
## Tree 3:
- $3,2;1,4$ Clayton ($par = 0.9, \tau = 0.31$)
- $5,3;1,4$ Rotated Clayton 90 degrees ($par = -5.1, \tau = -0.72$)

## Tree 4:
- $5,2;3,1,4$ Gaussian ($par = 0.2, \tau = 0.13$)

---

1 <-> V1, 2 <-> V2, 3 <-> V3, 4 <-> V4, 5 <-> V5

Figure 6.5: R-vine tree plots: with copula families and Kendall’s $\tau$ values.

```r
bigpar(2,2)
plot(RVM,type=0, edge.labels = "family-par")
```
Figure 6.6: Normalized contours: Theoretical normalized contour plots of the specified pair copulas

bigpar(2,2)
contour(RVM)
Figure 6.7: R-vine simulation: Pairwise scatter plots (upper triangular), marginal histograms (diagonal) and pairwise normalized contour plots (lower triangular) of 1000 simulated realizations of the R-vine copula specified in Example 6.7.

rdata = as.copuladata(RVineSim(1000,RVM))
pairs(rdata)
<table>
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<th>V3</th>
<th>V4</th>
<th>V5</th>
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