Figures for 'A Joint Confidence Region for an Overall Ranking of Populations'

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2021-02-07

This vignette shows how to reproduce the main figures in "A Joint Confidence Region for an Overall Ranking of Populations" (Klein, Wright, and Wieczorek, 2020, *Journal of the Royal Statistical Society: Series C*).

Note: For this vignette itself, we automatically save the figures below using the `knitr` package with option `dev="tikz"` instead of saving them individually. For an example of how to save individual plots using the `tikz()` function in the `tikzDevice` package, please see the `Primer` vignette: `vignette("primer", package = "RankingProject")`

Workflow to reproduce figures from the article

First, we load the package and the `TravelTime2011.1dec` dataset used in the paper. Note that we are using the version of the data where estimates and Margins of Error have been rounded to 1 decimal place, causing some ranks to be tied.

```
library(RankingProject)
data(TravelTime2011.1dec)
USdata <- TravelTime2011.1dec
head(USdata)
```

```
##   Rank        State Estimate.1dec MOE.1dec Abbreviation  Region
## 1    2 South Dakota          16.9      0.5           SD MIDWEST
## 2    2 North Dakota          16.9      0.6           ND MIDWEST
## 3    4      Wyoming          18.1      0.8           WY    WEST
## 4    4     Nebraska          18.1      0.3           NE MIDWEST
## 5    5      Montana          18.2      0.5           MT    WEST
## 6    6       Alaska          18.4      0.5           AK PACIFIC
##   FIPS
## 1   46
## 2   38
## 3   56
## 4   31
## 5   30
## 6    2
```

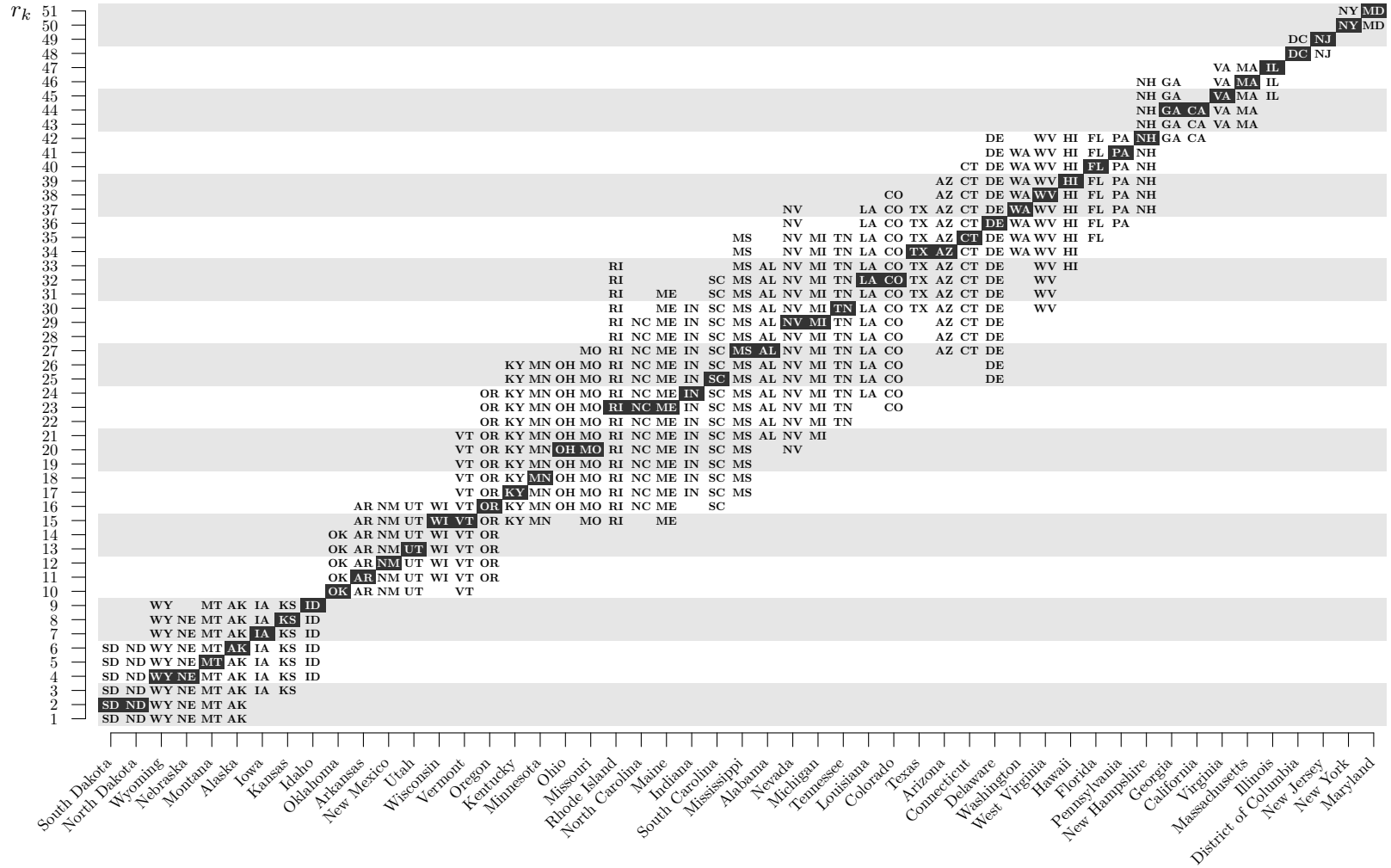
```
n = nrow(USdata)
alpha = 0.1
Z = qnorm(1-alpha/2)
Z.Indep = qnorm(1-(1-(1-alpha)^(1/n))/2) # around 3.081
USdata$IndepCiLo = with(USdata, round(Estimate.1dec - Z.Indep/Z*MOE.1dec, 1))
USdata$IndepCiHi = with(USdata, round(Estimate.1dec + Z.Indep/Z*MOE.1dec, 1))
attach(USdata)
```

```
## We could have used a Bonferroni correction instead.
## Not run:
# Z.Bonf = qnorm(1-alpha/(n*2)) # around 3.096
# USdata$BonfCiLo = with(USdata, round(Estimate.1dec - Z.Bonf/Z*MOE.1dec, 1))
# USdata$BonfCiHi = with(USdata, round(Estimate.1dec + Z.Bonf/Z*MOE.1dec, 1))
```

Reproduce Figure 1, the plot of the 90% joint confidence region for the overall ranking:

```
par(xpd = TRUE, mar = c(6.3, 2.8, 0.3, 0.3) + 0.1)
plot(c(0, n+1), c(0, n), type='n', bty='n', xaxt='n', yaxt='n', xlab='', ylab='',
     xaxs = 'i', yaxs = 'i')
text(-3.5, n, "$r_k$", cex = 1, pos = 4)
wd = 0.5; ht = 0.5
for(ii in seq(1, n-2, by = 6)){
  polygon(c(1-wd, n+wd, n+wd, 1-wd),
          c(ii-ht, ii-ht, ii+ht+2, ii+ht+2),
          border = NA, col = "grey90")
}
for(ii in 1:n){
  SigDiffLo = sum(IndepCiHi <= IndepCiLo[ii])
  SigDiffHi = sum(IndepCiLo >= IndepCiHi[ii])

  NotSigDiff = (SigDiffLo+1):(n-SigDiffHi)
  mycex = 0.5
  ## Add text
  text(ii, (1:n)[NotSigDiff], Abbreviation[ii], cex = mycex, family = "mono", font = 2)
  ## Draw box
  wd = .5
  ht = .5
  polygon(c(ii-wd, ii+wd, ii+wd, ii-wd),
          c(Rank[ii]-ht, Rank[ii]-ht, Rank[ii]+ht, Rank[ii]+ht),
          border = NA, col = "grey20")
  text(ii, Rank[ii], Abbreviation[ii], cex = mycex, family = "mono", font = 2, col = "white")
}
axis(1, at = 1:n, labels = FALSE)
text(1:n + 0.5, par("usr")[3] - 2.0, labels = State, srt = 45, pos = 2, xpd = TRUE, cex = 0.7)
axis(2, at = 1:n, las = 2, cex.axis = 0.7)
```


r_k
51 NY MD
50 NY MD
49 DC NJ
48 DC NJ
47 VA MA IL
46 NH GA VA MA IL
45 NH GA VA MA IL
44 NH GA CA VA MA
43 NH GA CA VA MA
42 DE WV HI FL PA NH GA CA
41 DE WA WV HI FL PA NH
40 CT DE WA WV HI FL PA NH
39 AZ CT DE WA WV HI FL PA NH
38 CO AZ CT DE WA WV HI FL PA NH
37 NV LA CO TX AZ CT DE WA WV HI FL PA NH
36 NV LA CO TX AZ CT DE WA WV HI FL PA
35 MS NV MI TN LA CO TX AZ CT DE WA WV HI FL
34 MS NV MI TN LA CO TX AZ CT DE WA WV HI
33 RI MS AL NV MI TN LA CO TX AZ CT DE WV HI
32 RI SC MS AL NV MI TN LA CO TX AZ CT DE WV
31 RI ME SC MS AL NV MI TN LA CO TX AZ CT DE WV
30 RI ME IN SC MS AL NV MI TN LA CO TX AZ CT DE WV
29 RI NC ME IN SC MS AL NV MI TN LA CO AZ CT DE
28 RI NC ME IN SC MS AL NV MI TN LA CO AZ CT DE
27 MO RI NC ME IN SC MS AL NV MI TN LA CO AZ CT DE
26 KY MN OH MO RI NC ME IN SC MS AL NV MI TN LA CO DE
25 KY MN OH MO RI NC ME IN SC MS AL NV MI TN LA CO DE
24 OR KY MN OH MO RI NC ME IN SC MS AL NV MI TN LA CO
23 OR KY MN OH MO RI NC ME IN SC MS AL NV MI TN CO
22 OR KY MN OH MO RI NC ME IN SC MS AL NV MI TN
21 VT OR KY MN OH MO RI NC ME IN SC MS AL NV MI
20 VT OR KY MN OH MO RI NC ME IN SC MS NV
19 VT OR KY MN OH MO RI NC ME IN SC MS
18 VT OR KY MN OH MO RI NC ME IN SC MS
17 VT OR KY MN OH MO RI NC ME IN SC MS
16 AR NM UT WI VT OR KY MN OH MO RI NC ME SC
15 AR NM UT WI VT OR KY MN MO RI ME
14 OK AR NM UT WI VT OR
13 OK AR NM UT WI VT OR
12 OK AR NM UT WI VT OR
11 OK AR NM UT WI VT OR
10 OK AR NM UT VT
9 WY MT AK IA KS ID
8 WY NE MT AK IA KS ID
7 WY NE MT AK IA KS ID
6 SD ND WY NE MT AK IA KS ID
5 SD ND WY NE MT AK IA KS ID
4 SD ND WY NE MT AK IA KS ID
3 SD ND WY NE MT AK IA KS
2 SD ND WY NE MT AK
1 SD ND WY NE MT AK
South Dakota
North Dakota
Wyoming
Nebraska
Montana
Alaska
Iowa
Kansas
Idaho
Oklahoma
Arkansas
New Mexico
Utah
Wisconsin
Vermont
Oregon
Kentucky
Minnesota
Ohio
Missouri
Rhode Island
North Carolina
Maine
Indiana
South Carolina
Mississippi
Alabama
Nevada
Michigan
Tennessee
Louisiana
Colorado
Texas
Arizona
Connecticut
Delaware
Washington
West Virginia
Hawaii
Florida
Pennsylvania
New Hampshire
Georgia
California
Virginia
Massachusetts
Illinois
District of Columbia
New Jersey
New York
Maryland

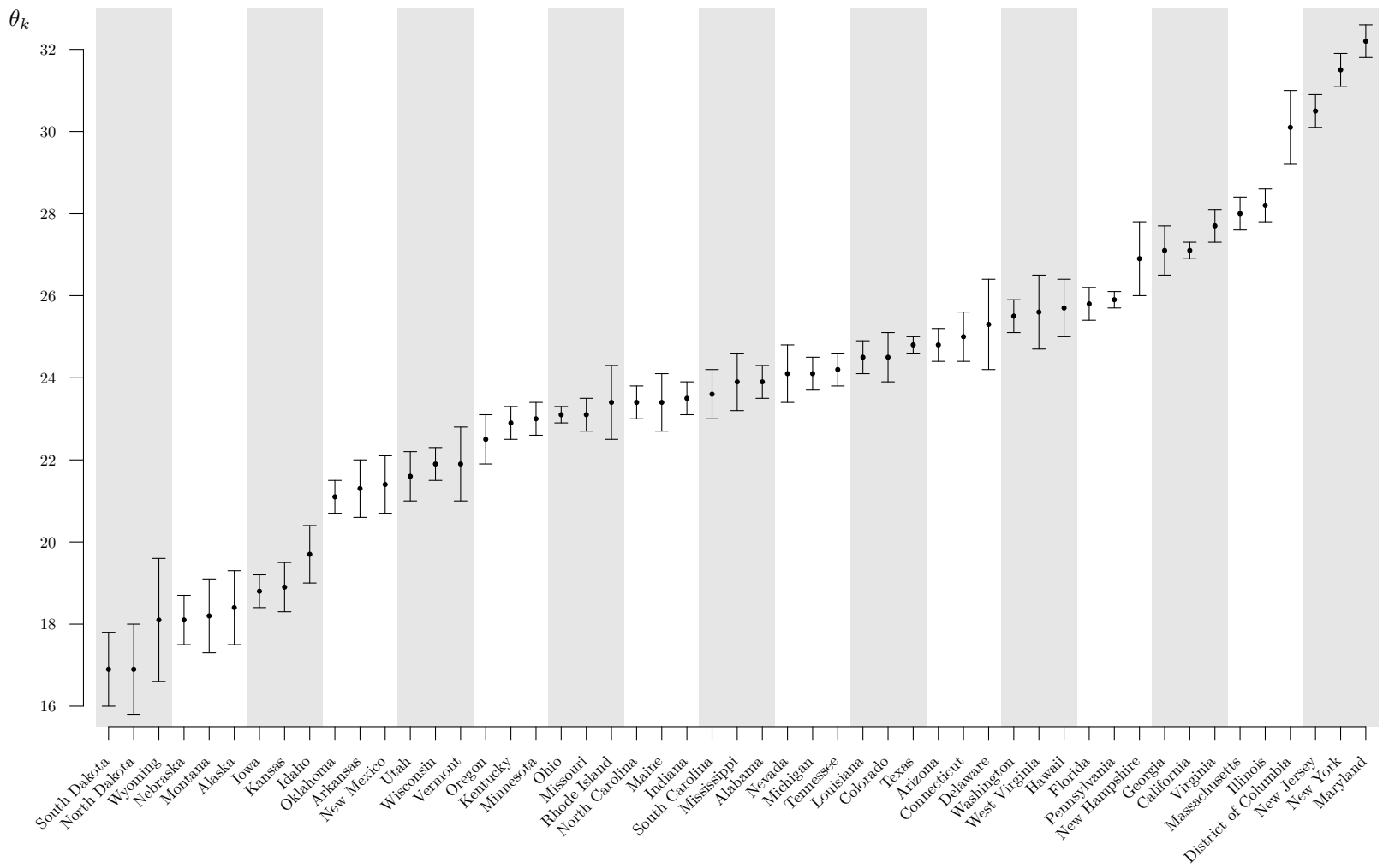
Reproduce Figure 2, the plot of 90% joint confidence intervals for the travel times:

```
stopifnot(15 <= min(IndepCiLo) & max(IndepCiHi) <= 35)
thetamin = 15.5
thetamax = 33
mycex = 0.5
tickWidth = 2/n

par(xpd = TRUE, mar = c(6.3, 2.8, 0.3, 0.3) + 0.1)
plot(c(0, n+1), c(thetamin, thetamax),
     type='n', bty='n', xaxt='n', yaxt='n', xlab='', ylab='',
     xaxs = 'i', yaxs = 'i')
wd = 0.5; ht = 0.5
for(ii in seq(1, n-2, by = 6)){
  polygon(c(ii-ht, ii-ht, ii+ht+2, ii+ht+2),
          c(thetamin, thetamax, thetamax, thetamin),
          border = NA, col = "grey90")
}
text(-3.5, thetamax - 0.3, "$\\theta_k$", cex = 1, pos = 4)

for(ii in 1:n){
  points(ii, Estimate.1dec[ii], pch=16, cex=mycex)
  arrows(y0 = Estimate.1dec[ii], x0 = ii, y1 = IndepCiLo[ii],
         angle = 90, length = tickWidth)
  arrows(y0 = Estimate.1dec[ii], x0 = ii, y1 = IndepCiHi[ii],
         angle = 90, length = tickWidth)
}

axis(1, at = 1:n, labels = FALSE)
text(1:n + 0.5, par("usr")[3] - 0.8, labels = State, srt = 45, pos = 2, xpd = TRUE, cex = 0.7)
axis(2, at = seq(16, 32, by = 2), las = 2, cex.axis = 0.7)
```


θ_k
32
30
28
26
24
22
20
18
16
South Dakota
North Dakota
Wyoming
Nebraska
Montana
Alaska
Iowa
Kansas
Idaho
Oklahoma
Arkansas
New Mexico
Utah
Wisconsin
Vermont
Oregon
Kentucky
Minnesota
Ohio
Missouri
Rhode Island
North Carolina
Maine
Indiana
South Carolina
Mississippi
Alabama
Nevada
Michigan
Tennessee
Louisiana
Colorado
Texas
Arizona
Connecticut
Delaware
Washington
West Virginia
Hawaii
Florida
Pennsylvania
New Hampshire
Georgia
California
Virginia
Massachusetts
Illinois
District of Columbia
New Jersey
New York
Maryland