# Online Appendix 13.A: FROC vs. AFROC

This code generates book figures 13.6, 13.7 and 13.8. The code comparing the two operating characteristics is in file mainFrocVsAfroc.R the listing of which follows:

## Online Appendix 13.A.1: Code Listing

# mainFrocVsAfroc.R

rm(list = ls())

library(RJafroc)

library(ggplot2)

library(abind)

seed <- 1;set.seed(seed)

# following parameters do not change between RAD and CAD observers

nu <- 1;lambda <- 1;K1 <- 500;K2 <- 700

Lmax <- 2;Lk2 <- floor(runif(K2, 1, Lmax + 1)) # do

######################### CAD ################################

mu <- 1;zeta1 <- -1 # these are CAD parameters, 13.6 plot a, b

#mu <- 1;zeta1 <- -Inf # these are CAD parameters 13.6 plot c, d

#mu <- 1;zeta1 <- -1 # these are CAD parameters, 13.7 plot a, b

#mu <- 1;zeta1 <- -Inf # these are CAD parameters, 13.7 plot c, d

cat("constant parameters:",

"\nnu = ", nu,

"\nlambda = ", lambda,

"\nK1 = ", K1,

"\nK2 = ", K2,

"\n")

cat("CAD parameters: \nmu = ", mu,

"\nzeta1 = ", zeta1 ,"\n")

frocDataCad <- SimulateFrocDataset(

mu = mu, lambda = lambda, nu = nu,

I = 1, J = 1, K1 = K1, K2 = K2, lesionNum = Lk2, zeta1 = zeta1

)

######################### RAD ################################

mu <- 1.5;zeta1 <- 1.5 # these are RAD parameters 13.6 a, b

#mu <- 1.5;zeta1 <- -Inf # these are RAD parameters, 13.6 plots c,d

mu <- 2;zeta1 <- 2 # these are RAD parameters, plots 13.7, a, b

mu <- 2;zeta1 <- -Inf # these are RAD parameters, plots 13.7, c, d

mu <- 1.1;zeta1 <- -1 # these are RAD parameters, 13.8 plot a, b

#mu <- 1.1;zeta1 <- -Inf # these are RAD parameters, 13.8 plot c,d

cat("RAD parameters: \nmu = ", mu,

"\nzeta1 = ", zeta1 ,"\n")

set.seed(seed)

frocDataRad <- SimulateFrocDataset(

mu = mu, lambda = lambda, nu = nu,

I = 1, J = 1, K1 = K1, K2 = K2, lesionNum = Lk2, zeta1 = zeta1

)

numNL1 <- dim(frocDataCad$NL)[4]

numNL2 <- dim(frocDataRad$NL)[4]

numNL <- max(numNL1, numNL2) # the max number of NLs in the combined dataset

if (numNL1 < numNL){ # dataset 1 has smaller number of NLs

NL <- frocDataCad$NL

# add more -Inf NLs to make the number of NL in two datasets consistent

NL <- abind(NL, array(-Inf, dim = c(1, 1, K1 + K2, numNL - numNL1)))

NL <- abind(NL, frocDataRad$NL, along = 2) # combine the two NLs

}else if (numNL2 < numNL){ # dataset 2 has smaller number of NLs

NL <- frocDataRad$NL

NL <- abind(NL, array(-Inf, dim = c(1, 1, K1 + K2, numNL - numNL2)))

NL <- abind(frocDataCad$NL, NL, along = 2)

}else{ # the number of NLs in the two datasets are same, combine them directly

NL <- frocDataCad$NL

NL <- abind(NL, frocDataRad$NL, along = 2)

}

LL <- frocDataCad$LL

LL <- abind(LL, frocDataRad$LL, along = 2) # combine the two LLs

attr(NL, "dimnames") <- NULL; attr(LL, "dimnames") <- NULL

frocDataRaw <- Df2RJafrocDataset(NL, LL, lesionNum = Lk2)

wAfroc <- UtilFigureOfMerit(frocDataRaw);cat("wAfroc = ", wAfroc, "\n")

froc <- PlotEmpiricalOperatingCharacteristics(frocDataRaw, trts= 1, rdrs = c(1, 2), opChType = "FROC")

combinedPlot <- froc$Plot + scale\_color\_manual(labels = c("CAD", "RAD"), values = c("black","darkgrey")) +

theme(axis.title.y = element\_text(size = 25,face="bold"),

axis.title.x = element\_text(size = 30,face="bold"),

legend.position = c(0.8,0.1), legend.direction = "horizontal",

legend.text = element\_text(size = 15, face = "bold"),legend.key.width = unit(1.5, "cm")) +

scale\_x\_continuous(expand = c(0, 0)) +

scale\_y\_continuous(limits = c(0,1), expand = c(0, 0))

combinedPlot$layers[[1]]$aes\_params$size <- 2 # line

#combinedPlot$layers[[2]]$aes\_params$size <- 5 # points

print(combinedPlot)

afroc <- PlotEmpiricalOperatingCharacteristics(frocDataRaw, trts= 1, rdrs = c(1, 2), opChType = "AFROC")

combinedPlot <- afroc$Plot + scale\_color\_manual(labels = c("CAD", "RAD"), values = c("black","darkgrey")) +

theme(axis.title.y = element\_text(size = 25,face="bold"),

axis.title.x = element\_text(size = 30,face="bold"),

legend.position = c(0.8,0.1), legend.direction = "horizontal",

legend.text = element\_text(size = 15, face = "bold"),legend.key.width = unit(1.5, "cm")) +

scale\_x\_continuous(expand = c(0, 0)) +

scale\_y\_continuous(expand = c(0, 0))

combinedPlot$layers[[1]]$aes\_params$size <- 2 # line

#combinedPlot$layers[[2]]$aes\_params$size <- 5 # points

print(combinedPlot)

Line 9 - 10 sets parameters that do not change: nu = 1, lambda = 1, K1 = 500 and K2 = 700. Line 13 sets the values corresponding to the CAD observers in book Figure 13.6 (a) and (b): mu = 1 and zeta1 = -1. Line 25 - 28 simulates the CAD dataset and saves it to frocDataCad. Line 15 sets the values corresponding to the radiologist observers in book Figure 13.6 (a) and (b): mu = 1.5 and zeta1 = 1.5. Line 41 - 44 simulates the RAD dataset and saves it to frocDataRad. Line 46 – 69 combines the two datasets so that they appear as two treatments in the combined dataset frocDataRaw. This is done for convenience of plotting the two datasets on the same plot. Line 71 calculates the areas under the two AFROC curves in book Figure 13.6 (b) and prints out the values. Lines 73 – 83 calculate and display the two FROC plots and line 85 – 96 calculates and displays the two AFROC plots. By appropriately commenting/uncommenting lines in blocks 13 – 16 and 31 – 36 the user can reproduce the plots in book Figures 13.6, 13.7 and 13.8.

## Online Appendix 13.A.2: Code Listing

The following code is the binned version of the code mainOCsRaw.R shown in book section 13.10.1.

rm(list = ls()) # mainOCsBinned.R

library(RJafroc);library(ggplot2)

seed <- 1;set.seed(seed)

mu <- 1;lambda <- 1;nu <- 1

zeta1 <- -1;K1 <- 50;K2 <- 70

Lmax <- 2;Lk2 <- floor(runif(K2, 1, Lmax + 1))

frocDataRaw <- SimulateFrocDataset(

mu = mu, lambda = lambda, nu = nu, I = 1, J = 1,

K1 = K1, K2 = K2, lesionNum = Lk2, zeta1 = zeta1)

frocDataBin <- DfBinDataset(frocDataRaw, desiredNumBins = 5, opChType = "FROC")

plotFROC <- PlotEmpiricalOperatingCharacteristics(

dataset = frocDataBin,

trts= 1,

rdrs = 1,

opChType = "FROC")

p <- plotFROC$Plot +

theme(legend.position="none") +

theme(axis.title.y = element\_text(size = 25,face="bold"),

axis.title.x = element\_text(size = 30,face="bold"))

p$layers[[1]]$aes\_params$size <- 2 # line

p$layers[[2]]$aes\_params$size <- 5 # points

print(p)

afrocDataRaw <- DfFroc2Afroc(frocDataRaw)

afrocDataBin <- DfBinDataset(afrocDataRaw, desiredNumBins = 5, opChType = "AFROC")

plotAFROC <- PlotEmpiricalOperatingCharacteristics(

dataset = afrocDataBin,

trts= 1,

rdrs = 1,

opChType = "AFROC"

)

p <- plotAFROC$Plot +

theme(legend.position="none") +

theme(axis.title.y = element\_text(size = 25,face="bold"),

axis.title.x = element\_text(size = 30,face="bold"))

p$layers[[1]]$aes\_params$size <- 2 # line

p$layers[[2]]$aes\_params$size <- 5 # points

print(p)

rocDataRaw <- DfFroc2Roc(frocDataRaw)

rocDataBin <- DfBinDataset(rocDataRaw, desiredNumBins = 5, opChType = "ROC")

plotROC <- PlotEmpiricalOperatingCharacteristics(

dataset = rocDataBin,

trts= 1,

rdrs = 1,

opChType = "ROC")

p <- plotROC$Plot +

theme(legend.position="none") +

theme(axis.title.y = element\_text(size = 25,face="bold"),

axis.title.x = element\_text(size = 30,face="bold"))

p$layers[[1]]$aes\_params$size <- 2 # line

p$layers[[2]]$aes\_params$size <- 5 # points

print(p)

As in the previous chapter, the binned plots may not match those shown in the book. The need for the improved binning code is discussed in online chapter 21. Note that whenever the binning function DfBinDataset is called, it must be supplied with an opChType argument telling it what type of operating characteristic the binning procedure is to be applied to. For example, it is called at line 13 with opChType = "FROC", at line 28 with opChType = "AFROC" and at line 44 with opChType = "ROC".