Project 2

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dim(BreastCancer)

## [1] 699 11

BreastCancer <- na.omit(BreastCancer)   
BreastCancer$Id <- NULL

head(BreastCancer)

## Cl.thickness Cell.size Cell.shape Marg.adhesion Epith.c.size Bare.nuclei  
## 1 5 1 1 1 2 1  
## 2 5 4 4 5 7 10  
## 3 3 1 1 1 2 2  
## 4 6 8 8 1 3 4  
## 5 4 1 1 3 2 1  
## 6 8 10 10 8 7 10  
## Bl.cromatin Normal.nucleoli Mitoses Class  
## 1 3 1 1 benign  
## 2 3 2 1 benign  
## 3 3 1 1 benign  
## 4 3 7 1 benign  
## 5 3 1 1 benign  
## 6 9 7 1 malignant

set.seed(2)  
train.index <- sample(row.names(BreastCancer), 0.6\*dim(BreastCancer)[1])   
valid.index <- setdiff(row.names(BreastCancer), train.index)   
train.df <- BreastCancer[train.index, ]  
valid.df <- BreastCancer[valid.index, ]

library(caret)

## Warning: package 'caret' was built under R version 4.0.3

## Loading required package: lattice

## Loading required package: ggplot2

library(MASS)

#SVM

library(e1071)

## Warning: package 'e1071' was built under R version 4.0.3

mysvm <- svm(Class ~ ., train.df)  
mysvm.pred <- predict(mysvm, valid.df)  
table(mysvm.pred,valid.df$Class)

##   
## mysvm.pred benign malignant  
## benign 167 4  
## malignant 7 96

confusionMatrix(as.factor(mysvm.pred), as.factor(valid.df$Class))

## Confusion Matrix and Statistics  
##   
## Reference  
## Prediction benign malignant  
## benign 167 4  
## malignant 7 96  
##   
## Accuracy : 0.9599   
## 95% CI : (0.9293, 0.9798)  
## No Information Rate : 0.635   
## P-Value [Acc > NIR] : <2e-16   
##   
## Kappa : 0.9139   
##   
## Mcnemar's Test P-Value : 0.5465   
##   
## Sensitivity : 0.9598   
## Specificity : 0.9600   
## Pos Pred Value : 0.9766   
## Neg Pred Value : 0.9320   
## Prevalence : 0.6350   
## Detection Rate : 0.6095   
## Detection Prevalence : 0.6241   
## Balanced Accuracy : 0.9599   
##   
## 'Positive' Class : benign   
##

#Naive Bayes

library(klaR)

## Warning: package 'klaR' was built under R version 4.0.4

mynb <- NaiveBayes(Class ~ ., train.df)  
mynb.pred <- predict(mynb, valid.df)

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 1

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 6

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 7

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 9

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 10

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 16

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 19

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 22

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 23

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 24

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 28

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 33

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 37

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 38

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 44

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 45

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 46

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 47

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 49

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 53

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 54

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 60

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 68

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 70

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 72

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 77

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 80

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 87

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 89

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 92

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 98

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 100

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 107

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 109

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 111

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 112

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 113

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 114

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 115

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 121

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 124

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 135

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 136

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 152

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 157

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 160

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 161

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 165

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 170

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 175

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 176

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 180

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 189

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 191

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 197

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 200

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 219

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 226

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 227

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 233

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 244

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 255

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 261

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 262

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 272

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 273

## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with  
## observation 274

table(mynb.pred$class,valid.df$Class)

##   
## benign malignant  
## benign 168 2  
## malignant 6 98

#Neural Net

library(nnet)

## Warning: package 'nnet' was built under R version 4.0.4

mynnet <- nnet(Class ~ ., train.df, size=1)

## # weights: 83  
## initial value 284.084673   
## iter 10 value 52.464496  
## iter 20 value 30.043361  
## iter 30 value 24.877245  
## iter 40 value 24.815740  
## iter 50 value 24.812211  
## iter 60 value 24.809461  
## iter 70 value 24.807359  
## iter 80 value 24.807284  
## iter 90 value 24.806856  
## iter 100 value 24.806750  
## final value 24.806750   
## stopped after 100 iterations

mynnet.pred <- predict(mynnet,valid.df ,type="class")  
table(mynnet.pred,valid.df$Class)

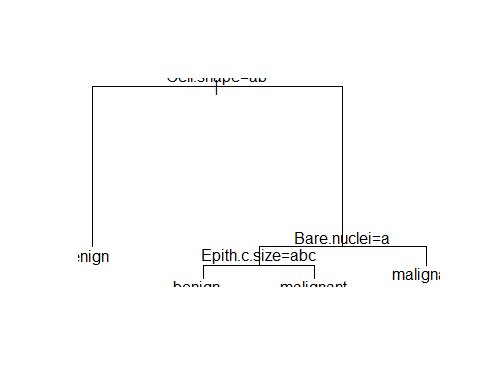
##   
## mynnet.pred benign malignant  
## benign 168 5  
## malignant 6 95

#Decision Trees

library(rpart)

## Warning: package 'rpart' was built under R version 4.0.3

mytree <- rpart(Class ~ ., train.df)  
plot(mytree); text(mytree) # in "iris\_tree.ps"



summary(mytree)

## Call:  
## rpart(formula = Class ~ ., data = train.df)  
## n= 409   
##   
## CP nsplit rel error xerror xstd  
## 1 0.7841727 0 1.00000000 1.0000000 0.06891485  
## 2 0.0647482 1 0.21582734 0.2589928 0.04122201  
## 3 0.0100000 3 0.08633094 0.1870504 0.03549847  
##   
## Variable importance  
## Cell.shape Cell.size Bare.nuclei Epith.c.size Normal.nucleoli   
## 21 18 15 15 14   
## Bl.cromatin Marg.adhesion Cl.thickness   
## 14 2 2   
##   
## Node number 1: 409 observations, complexity param=0.7841727  
## predicted class=benign expected loss=0.3398533 P(node) =1  
## class counts: 270 139  
## probabilities: 0.660 0.340   
## left son=2 (248 obs) right son=3 (161 obs)  
## Primary splits:  
## Cell.shape splits as LLRRRRRRRR, improve=132.0473, (0 missing)  
## Cell.size splits as LLRRRRRRRR, improve=130.3476, (0 missing)  
## Bl.cromatin splits as LLLRRRRRRR, improve=119.5903, (0 missing)  
## Bare.nuclei splits as LLRRRRRRRR, improve=115.0287, (0 missing)  
## Normal.nucleoli splits as LLRRRRRRRR, improve=111.7000, (0 missing)  
## Surrogate splits:  
## Cell.size splits as LLRRRRRRRR, agree=0.922, adj=0.801, (0 split)  
## Bl.cromatin splits as LLLRRRRRRR, agree=0.870, adj=0.671, (0 split)  
## Normal.nucleoli splits as LLRRRRRRRR, agree=0.868, adj=0.665, (0 split)  
## Bare.nuclei splits as LLRRRRRRRR, agree=0.866, adj=0.658, (0 split)  
## Epith.c.size splits as LLRRRRRRRR, agree=0.863, adj=0.652, (0 split)  
##   
## Node number 2: 248 observations  
## predicted class=benign expected loss=0.01612903 P(node) =0.606357  
## class counts: 244 4  
## probabilities: 0.984 0.016   
##   
## Node number 3: 161 observations, complexity param=0.0647482  
## predicted class=malignant expected loss=0.1614907 P(node) =0.393643  
## class counts: 26 135  
## probabilities: 0.161 0.839   
## left son=6 (27 obs) right son=7 (134 obs)  
## Primary splits:  
## Bare.nuclei splits as LRRRRRRRRR, improve=16.55771, (0 missing)  
## Cell.size splits as LLRRRRRRRR, improve=15.81880, (0 missing)  
## Bl.cromatin splits as LLRRRRRRRR, improve=15.39425, (0 missing)  
## Epith.c.size splits as LLRRRRRRRR, improve=12.84473, (0 missing)  
## Marg.adhesion splits as LRRRRRRRRR, improve=12.10579, (0 missing)  
## Surrogate splits:  
## Cell.size splits as LRRRRRRRRR, agree=0.894, adj=0.370, (0 split)  
## Bl.cromatin splits as LLRRRRRRRR, agree=0.882, adj=0.296, (0 split)  
## Cl.thickness splits as LRRRRRRRRR, agree=0.857, adj=0.148, (0 split)  
## Marg.adhesion splits as LRRRRRRRRR, agree=0.857, adj=0.148, (0 split)  
##   
## Node number 6: 27 observations, complexity param=0.0647482  
## predicted class=benign expected loss=0.3333333 P(node) =0.06601467  
## class counts: 18 9  
## probabilities: 0.667 0.333   
## left son=12 (18 obs) right son=13 (9 obs)  
## Primary splits:  
## Epith.c.size splits as LLLRRRRRRR, improve=12.000000, (0 missing)  
## Cell.size splits as LLLLLRRRRR, improve= 8.400000, (0 missing)  
## Marg.adhesion splits as LLLRRRRRRR, improve= 8.400000, (0 missing)  
## Normal.nucleoli splits as LLLRR--RRR, improve= 8.400000, (0 missing)  
## Cl.thickness splits as LLLLLLLRRR, improve= 6.671053, (0 missing)  
## Surrogate splits:  
## Cell.size splits as LLLRRRRRRR, agree=0.926, adj=0.778, (0 split)  
## Marg.adhesion splits as LLLRRRRRRR, agree=0.926, adj=0.778, (0 split)  
## Normal.nucleoli splits as LLLRR--RRR, agree=0.926, adj=0.778, (0 split)  
## Cl.thickness splits as LLLLLLLRRR, agree=0.889, adj=0.667, (0 split)  
## Cell.shape splits as LLLLRRRRRR, agree=0.889, adj=0.667, (0 split)  
##   
## Node number 7: 134 observations  
## predicted class=malignant expected loss=0.05970149 P(node) =0.3276284  
## class counts: 8 126  
## probabilities: 0.060 0.940   
##   
## Node number 12: 18 observations  
## predicted class=benign expected loss=0 P(node) =0.04400978  
## class counts: 18 0  
## probabilities: 1.000 0.000   
##   
## Node number 13: 9 observations  
## predicted class=malignant expected loss=0 P(node) =0.02200489  
## class counts: 0 9  
## probabilities: 0.000 1.000

mytree.pred <- predict(mytree,valid.df,type="class")  
table(mytree.pred,valid.df$Class)

##   
## mytree.pred benign malignant  
## benign 165 5  
## malignant 9 95

#Regularised Discriminant Analysis

myrda <- rda(Class ~ ., train.df)  
myrda.pred <- predict(myrda, valid.df)  
table(myrda.pred$class,valid.df$Class)

##   
## benign malignant  
## benign 168 2  
## malignant 6 98

#Random Forests

library(randomForest)

## Warning: package 'randomForest' was built under R version 4.0.3

## randomForest 4.6-14

## Type rfNews() to see new features/changes/bug fixes.

##   
## Attaching package: 'randomForest'

## The following object is masked from 'package:ggplot2':  
##   
## margin

myrf <- randomForest(Class ~ .,train.df)  
myrf.pred <- predict(myrf, valid.df)  
table(myrf.pred, valid.df$Class)

##   
## myrf.pred benign malignant  
## benign 169 3  
## malignant 5 97

#Ensembling of Classification Results

combine.classes<-data.frame(myrf.pred, myrda.pred$class,  
mytree.pred,mynnet.pred,mysvm.pred, mynb.pred$class, myrda.pred)

head(combine.classes)

## myrf.pred myrda.pred.class mytree.pred mynnet.pred mysvm.pred  
## 2 malignant malignant malignant malignant malignant  
## 3 benign benign benign benign benign  
## 5 benign benign benign benign benign  
## 10 benign benign benign benign benign  
## 11 benign benign benign benign benign  
## 15 malignant malignant malignant malignant malignant  
## mynb.pred.class class posterior.benign posterior.malignant  
## 2 malignant malignant 4.700725e-10 1.000000e+00  
## 3 benign benign 1.000000e+00 1.302252e-19  
## 5 benign benign 1.000000e+00 1.162585e-17  
## 10 benign benign 1.000000e+00 7.327231e-20  
## 11 benign benign 1.000000e+00 8.632687e-21  
## 15 malignant malignant 7.401227e-31 1.000000e+00

head(myrf.pred)

## 2 3 5 10 11 15   
## malignant benign benign benign benign malignant   
## Levels: benign malignant

head(myrda.pred)

## $class  
## [1] malignant benign benign benign benign malignant malignant  
## [8] benign malignant malignant malignant benign benign benign   
## [15] benign malignant benign benign malignant benign benign   
## [22] malignant malignant malignant benign malignant benign malignant  
## [29] malignant benign benign malignant malignant benign benign   
## [36] benign malignant malignant benign benign benign benign   
## [43] benign malignant malignant malignant malignant malignant malignant  
## [50] malignant benign benign benign malignant benign benign   
## [57] benign benign malignant malignant benign benign benign   
## [64] benign benign benign malignant malignant benign benign   
## [71] benign malignant benign malignant malignant benign malignant  
## [78] malignant benign malignant benign benign benign benign   
## [85] benign benign malignant benign malignant benign benign   
## [92] malignant malignant malignant benign malignant malignant malignant  
## [99] benign malignant malignant malignant benign benign malignant  
## [106] malignant malignant malignant malignant benign malignant malignant  
## [113] malignant malignant malignant malignant malignant benign benign   
## [120] malignant malignant benign malignant malignant malignant benign   
## [127] benign malignant malignant benign benign malignant benign   
## [134] benign malignant malignant benign benign benign benign   
## [141] benign malignant benign benign benign benign benign   
## [148] benign benign malignant benign benign benign benign   
## [155] benign benign malignant benign benign malignant malignant  
## [162] benign benign benign malignant benign benign benign   
## [169] benign malignant benign benign benign malignant malignant  
## [176] benign benign benign benign malignant benign benign   
## [183] benign benign benign malignant benign benign benign   
## [190] benign malignant benign benign benign benign benign   
## [197] malignant benign benign malignant benign malignant benign   
## [204] benign benign benign benign benign benign benign   
## [211] benign benign benign malignant benign benign benign   
## [218] benign malignant benign benign malignant malignant benign   
## [225] benign malignant malignant malignant benign benign benign   
## [232] benign malignant benign malignant malignant malignant benign   
## [239] benign benign benign benign benign malignant benign   
## [246] benign benign benign benign benign benign benign   
## [253] benign benign malignant benign benign benign benign   
## [260] benign malignant malignant benign benign benign benign   
## [267] malignant benign benign benign malignant malignant malignant  
## [274] malignant  
## Levels: benign malignant  
##   
## $posterior  
## benign malignant  
## [1,] 4.700725e-10 1.000000e+00  
## [2,] 1.000000e+00 1.302252e-19  
## [3,] 1.000000e+00 1.162585e-17  
## [4,] 1.000000e+00 7.327231e-20  
## [5,] 1.000000e+00 8.632687e-21  
## [6,] 7.401227e-31 1.000000e+00  
## [7,] 2.065675e-16 1.000000e+00  
## [8,] 1.000000e+00 3.037815e-21  
## [9,] 4.749177e-27 1.000000e+00  
## [10,] 2.839542e-22 1.000000e+00  
## [11,] 1.376163e-24 1.000000e+00  
## [12,] 1.000000e+00 5.144474e-22  
## [13,] 1.000000e+00 4.891056e-19  
## [14,] 1.000000e+00 3.343480e-22  
## [15,] 1.000000e+00 3.831295e-21  
## [16,] 2.982735e-25 1.000000e+00  
## [17,] 1.000000e+00 1.395212e-18  
## [18,] 1.000000e+00 3.343480e-22  
## [19,] 1.980561e-12 1.000000e+00  
## [20,] 1.000000e+00 3.974796e-23  
## [21,] 1.000000e+00 1.162585e-17  
## [22,] 9.731381e-07 9.999990e-01  
## [23,] 2.770818e-17 1.000000e+00  
## [24,] 2.961751e-12 1.000000e+00  
## [25,] 1.000000e+00 1.544573e-21  
## [26,] 1.543327e-14 1.000000e+00  
## [27,] 1.000000e+00 3.974796e-23  
## [28,] 6.972068e-07 9.999993e-01  
## [29,] 4.043646e-13 1.000000e+00  
## [30,] 1.000000e+00 2.707522e-16  
## [31,] 9.999784e-01 2.163986e-05  
## [32,] 6.746966e-24 1.000000e+00  
## [33,] 5.954915e-12 1.000000e+00  
## [34,] 1.000000e+00 1.171350e-14  
## [35,] 1.000000e+00 8.732369e-17  
## [36,] 1.000000e+00 2.060122e-15  
## [37,] 2.137962e-26 1.000000e+00  
## [38,] 8.355926e-18 1.000000e+00  
## [39,] 1.000000e+00 3.037815e-21  
## [40,] 1.000000e+00 5.144474e-22  
## [41,] 1.000000e+00 3.466305e-18  
## [42,] 1.000000e+00 4.027520e-21  
## [43,] 1.000000e+00 5.144474e-22  
## [44,] 6.599992e-33 1.000000e+00  
## [45,] 3.007352e-04 9.996993e-01  
## [46,] 2.138462e-05 9.999786e-01  
## [47,] 1.533024e-13 1.000000e+00  
## [48,] 3.170176e-18 1.000000e+00  
## [49,] 3.950487e-13 1.000000e+00  
## [50,] 6.960645e-19 1.000000e+00  
## [51,] 1.000000e+00 4.274952e-13  
## [52,] 1.000000e+00 1.083294e-18  
## [53,] 9.991055e-01 8.945270e-04  
## [54,] 2.287646e-26 1.000000e+00  
## [55,] 1.000000e+00 6.807176e-13  
## [56,] 1.000000e+00 5.250753e-17  
## [57,] 1.000000e+00 3.685628e-18  
## [58,] 1.000000e+00 1.030364e-16  
## [59,] 1.293121e-26 1.000000e+00  
## [60,] 4.881456e-21 1.000000e+00  
## [61,] 1.000000e+00 2.707522e-16  
## [62,] 1.000000e+00 1.713993e-22  
## [63,] 1.000000e+00 2.398651e-22  
## [64,] 1.000000e+00 4.031229e-21  
## [65,] 1.000000e+00 4.031229e-21  
## [66,] 1.000000e+00 1.083294e-18  
## [67,] 4.793572e-15 1.000000e+00  
## [68,] 1.572047e-29 1.000000e+00  
## [69,] 1.000000e+00 2.934315e-21  
## [70,] 1.000000e+00 6.241156e-12  
## [71,] 1.000000e+00 1.056751e-19  
## [72,] 1.027020e-26 1.000000e+00  
## [73,] 1.000000e+00 3.974796e-23  
## [74,] 2.074843e-21 1.000000e+00  
## [75,] 2.270711e-24 1.000000e+00  
## [76,] 1.000000e+00 4.027520e-21  
## [77,] 3.656961e-18 1.000000e+00  
## [78,] 1.862010e-06 9.999981e-01  
## [79,] 1.000000e+00 1.336478e-17  
## [80,] 4.108275e-20 1.000000e+00  
## [81,] 1.000000e+00 7.358839e-15  
## [82,] 1.000000e+00 3.342939e-21  
## [83,] 1.000000e+00 1.220313e-12  
## [84,] 1.000000e+00 1.293780e-22  
## [85,] 1.000000e+00 6.490203e-20  
## [86,] 1.000000e+00 5.144474e-22  
## [87,] 7.489319e-19 1.000000e+00  
## [88,] 1.000000e+00 8.632687e-21  
## [89,] 1.903806e-27 1.000000e+00  
## [90,] 1.000000e+00 5.144474e-22  
## [91,] 1.000000e+00 3.974796e-23  
## [92,] 9.132688e-26 1.000000e+00  
## [93,] 1.493585e-25 1.000000e+00  
## [94,] 7.930956e-31 1.000000e+00  
## [95,] 1.000000e+00 8.632687e-21  
## [96,] 4.939976e-24 1.000000e+00  
## [97,] 3.070886e-21 1.000000e+00  
## [98,] 5.544769e-26 1.000000e+00  
## [99,] 1.000000e+00 7.548126e-10  
## [100,] 6.338796e-16 1.000000e+00  
## [101,] 1.338499e-22 1.000000e+00  
## [102,] 1.543327e-14 1.000000e+00  
## [103,] 1.000000e+00 4.031229e-21  
## [104,] 1.000000e+00 1.293780e-22  
## [105,] 6.427330e-27 1.000000e+00  
## [106,] 7.754497e-25 1.000000e+00  
## [107,] 7.669517e-27 1.000000e+00  
## [108,] 8.793391e-09 1.000000e+00  
## [109,] 3.716453e-17 1.000000e+00  
## [110,] 1.000000e+00 5.144474e-22  
## [111,] 1.914608e-13 1.000000e+00  
## [112,] 3.393854e-03 9.966061e-01  
## [113,] 1.490807e-18 1.000000e+00  
## [114,] 9.694760e-16 1.000000e+00  
## [115,] 7.966490e-18 1.000000e+00  
## [116,] 3.625987e-29 1.000000e+00  
## [117,] 1.964741e-29 1.000000e+00  
## [118,] 1.000000e+00 2.484775e-19  
## [119,] 1.000000e+00 8.491422e-22  
## [120,] 6.961554e-25 1.000000e+00  
## [121,] 4.198399e-11 1.000000e+00  
## [122,] 1.000000e+00 5.144474e-22  
## [123,] 1.379884e-28 1.000000e+00  
## [124,] 7.910480e-25 1.000000e+00  
## [125,] 2.660443e-10 1.000000e+00  
## [126,] 1.000000e+00 5.193211e-18  
## [127,] 1.000000e+00 3.974796e-23  
## [128,] 2.742624e-14 1.000000e+00  
## [129,] 5.632634e-21 1.000000e+00  
## [130,] 1.000000e+00 5.202427e-18  
## [131,] 1.000000e+00 8.491422e-22  
## [132,] 5.253075e-24 1.000000e+00  
## [133,] 1.000000e+00 5.144474e-22  
## [134,] 1.000000e+00 8.491422e-22  
## [135,] 8.477883e-07 9.999992e-01  
## [136,] 8.027400e-09 1.000000e+00  
## [137,] 1.000000e+00 1.767870e-16  
## [138,] 1.000000e+00 4.027520e-21  
## [139,] 1.000000e+00 3.974796e-23  
## [140,] 1.000000e+00 4.027520e-21  
## [141,] 1.000000e+00 3.343480e-22  
## [142,] 1.230800e-27 1.000000e+00  
## [143,] 1.000000e+00 8.377844e-17  
## [144,] 1.000000e+00 6.434399e-17  
## [145,] 1.000000e+00 1.919831e-21  
## [146,] 1.000000e+00 1.340559e-21  
## [147,] 1.000000e+00 7.026513e-22  
## [148,] 1.000000e+00 2.252216e-11  
## [149,] 9.031438e-01 9.685619e-02  
## [150,] 6.186075e-30 1.000000e+00  
## [151,] 1.000000e+00 6.678790e-21  
## [152,] 9.999965e-01 3.530412e-06  
## [153,] 1.000000e+00 3.285117e-20  
## [154,] 1.000000e+00 1.654981e-20  
## [155,] 1.000000e+00 1.293780e-22  
## [156,] 1.000000e+00 2.030620e-21  
## [157,] 1.947393e-24 1.000000e+00  
## [158,] 1.000000e+00 3.974796e-23  
## [159,] 1.000000e+00 5.754734e-11  
## [160,] 3.677790e-03 9.963222e-01  
## [161,] 5.335830e-23 1.000000e+00  
## [162,] 1.000000e+00 3.974796e-23  
## [163,] 1.000000e+00 2.707522e-16  
## [164,] 9.999966e-01 3.427494e-06  
## [165,] 2.005117e-19 1.000000e+00  
## [166,] 1.000000e+00 3.974796e-23  
## [167,] 1.000000e+00 3.343480e-22  
## [168,] 1.000000e+00 1.490051e-09  
## [169,] 1.000000e+00 3.407374e-21  
## [170,] 1.023787e-18 1.000000e+00  
## [171,] 1.000000e+00 9.794197e-20  
## [172,] 1.000000e+00 1.028257e-09  
## [173,] 1.000000e+00 9.794197e-20  
## [174,] 2.536603e-25 1.000000e+00  
## [175,] 8.867690e-25 1.000000e+00  
## [176,] 9.999948e-01 5.164155e-06  
## [177,] 1.000000e+00 7.196503e-19  
## [178,] 1.000000e+00 6.266964e-14  
## [179,] 1.000000e+00 1.383146e-20  
## [180,] 6.864406e-26 1.000000e+00  
## [181,] 1.000000e+00 6.039327e-21  
## [182,] 1.000000e+00 6.514517e-22  
## [183,] 1.000000e+00 6.266964e-14  
## [184,] 1.000000e+00 7.922438e-16  
## [185,] 1.000000e+00 9.794197e-20  
## [186,] 8.398255e-22 1.000000e+00  
## [187,] 9.999995e-01 5.476805e-07  
## [188,] 1.000000e+00 3.351533e-15  
## [189,] 9.999354e-01 6.464987e-05  
## [190,] 1.000000e+00 8.491422e-22  
## [191,] 9.363628e-24 1.000000e+00  
## [192,] 1.000000e+00 3.831295e-21  
## [193,] 1.000000e+00 1.825658e-18  
## [194,] 1.000000e+00 2.398651e-22  
## [195,] 1.000000e+00 3.037815e-21  
## [196,] 1.000000e+00 8.491422e-22  
## [197,] 3.003231e-23 1.000000e+00  
## [198,] 1.000000e+00 9.794197e-20  
## [199,] 1.000000e+00 7.026513e-22  
## [200,] 1.821200e-14 1.000000e+00  
## [201,] 1.000000e+00 2.491782e-17  
## [202,] 4.697739e-27 1.000000e+00  
## [203,] 1.000000e+00 3.466305e-18  
## [204,] 1.000000e+00 6.039327e-21  
## [205,] 1.000000e+00 1.109300e-09  
## [206,] 1.000000e+00 2.404017e-20  
## [207,] 1.000000e+00 8.632687e-21  
## [208,] 1.000000e+00 3.155213e-14  
## [209,] 1.000000e+00 6.490203e-20  
## [210,] 1.000000e+00 4.031229e-21  
## [211,] 1.000000e+00 1.764734e-14  
## [212,] 1.000000e+00 2.398651e-22  
## [213,] 1.000000e+00 4.839390e-14  
## [214,] 2.006849e-22 1.000000e+00  
## [215,] 1.000000e+00 1.548701e-19  
## [216,] 1.000000e+00 1.316164e-19  
## [217,] 1.000000e+00 5.144474e-22  
## [218,] 1.000000e+00 1.767870e-16  
## [219,] 1.052857e-12 1.000000e+00  
## [220,] 1.000000e+00 3.156903e-19  
## [221,] 1.000000e+00 3.342939e-21  
## [222,] 9.707878e-23 1.000000e+00  
## [223,] 5.584351e-26 1.000000e+00  
## [224,] 1.000000e+00 3.153986e-08  
## [225,] 1.000000e+00 8.491422e-22  
## [226,] 2.071929e-13 1.000000e+00  
## [227,] 4.615500e-23 1.000000e+00  
## [228,] 3.053311e-16 1.000000e+00  
## [229,] 1.000000e+00 1.919831e-21  
## [230,] 1.000000e+00 1.293780e-22  
## [231,] 1.000000e+00 1.489289e-09  
## [232,] 1.000000e+00 1.293780e-22  
## [233,] 1.592781e-12 1.000000e+00  
## [234,] 1.000000e+00 8.491422e-22  
## [235,] 3.081902e-17 1.000000e+00  
## [236,] 3.225258e-17 1.000000e+00  
## [237,] 3.673456e-28 1.000000e+00  
## [238,] 1.000000e+00 3.633202e-17  
## [239,] 1.000000e+00 5.386413e-11  
## [240,] 1.000000e+00 2.259742e-17  
## [241,] 1.000000e+00 8.849342e-11  
## [242,] 1.000000e+00 8.491422e-22  
## [243,] 1.000000e+00 3.653863e-14  
## [244,] 5.996508e-29 1.000000e+00  
## [245,] 1.000000e+00 6.039327e-21  
## [246,] 1.000000e+00 1.293780e-22  
## [247,] 1.000000e+00 8.491422e-22  
## [248,] 1.000000e+00 1.293780e-22  
## [249,] 1.000000e+00 2.531077e-18  
## [250,] 1.000000e+00 1.293780e-22  
## [251,] 1.000000e+00 3.407374e-21  
## [252,] 1.000000e+00 2.398651e-22  
## [253,] 1.000000e+00 2.030620e-21  
## [254,] 1.000000e+00 1.293780e-22  
## [255,] 1.577539e-05 9.999842e-01  
## [256,] 1.000000e+00 8.491422e-22  
## [257,] 1.000000e+00 3.974796e-23  
## [258,] 1.000000e+00 3.092098e-18  
## [259,] 1.000000e+00 5.113861e-14  
## [260,] 1.000000e+00 2.030620e-21  
## [261,] 1.051658e-13 1.000000e+00  
## [262,] 9.088680e-20 1.000000e+00  
## [263,] 1.000000e+00 1.711437e-16  
## [264,] 1.000000e+00 3.974796e-23  
## [265,] 1.000000e+00 6.514517e-22  
## [266,] 1.000000e+00 6.678790e-21  
## [267,] 9.411993e-29 1.000000e+00  
## [268,] 1.000000e+00 8.491422e-22  
## [269,] 1.000000e+00 8.491422e-22  
## [270,] 1.000000e+00 2.531077e-18  
## [271,] 1.816829e-20 1.000000e+00  
## [272,] 1.715977e-16 1.000000e+00  
## [273,] 1.632446e-14 1.000000e+00  
## [274,] 4.813958e-20 1.000000e+00

str(combine.classes)

## 'data.frame': 274 obs. of 9 variables:  
## $ myrf.pred : Factor w/ 2 levels "benign","malignant": 2 1 1 1 1 2 2 1 2 2 ...  
## $ myrda.pred.class : Factor w/ 2 levels "benign","malignant": 2 1 1 1 1 2 2 1 2 2 ...  
## $ mytree.pred : Factor w/ 2 levels "benign","malignant": 2 1 1 1 1 2 2 1 2 1 ...  
## $ mynnet.pred : chr "malignant" "benign" "benign" "benign" ...  
## $ mysvm.pred : Factor w/ 2 levels "benign","malignant": 2 1 1 1 1 2 2 1 2 2 ...  
## $ mynb.pred.class : Factor w/ 2 levels "benign","malignant": 2 1 1 1 1 2 2 1 2 2 ...  
## $ class : Factor w/ 2 levels "benign","malignant": 2 1 1 1 1 2 2 1 2 2 ...  
## $ posterior.benign : num 4.7e-10 1.0 1.0 1.0 1.0 ...  
## $ posterior.malignant: num 1.00 1.30e-19 1.16e-17 7.33e-20 8.63e-21 ...

combine.classes$class<-as.numeric(combine.classes$class)

combine.classes$myrf.pred<-ifelse(combine.classes$myrf.pred=="benign", 0, 1)  
combine.classes[,2]<-ifelse(combine.classes[,2]=="benign", 0, 1)  
combine.classes[,3]<-ifelse(combine.classes[,3]=="benign", 0, 1)  
combine.classes[,4]<-ifelse(combine.classes[,4]=="benign", 0, 1)  
combine.classes[,5]<-ifelse(combine.classes[,5]=="benign", 0, 1)  
combine.classes[,6]<-ifelse(combine.classes[,6]=="benign", 0, 1)  
majority.vote=rowSums(combine.classes)

head(majority.vote)

## 2 3 5 10 11 15   
## 9 2 2 2 2 9

str(combine.classes)

## 'data.frame': 274 obs. of 9 variables:  
## $ myrf.pred : num 1 0 0 0 0 1 1 0 1 1 ...  
## $ myrda.pred.class : num 1 0 0 0 0 1 1 0 1 1 ...  
## $ mytree.pred : num 1 0 0 0 0 1 1 0 1 0 ...  
## $ mynnet.pred : num 1 0 0 0 0 1 1 0 1 1 ...  
## $ mysvm.pred : num 1 0 0 0 0 1 1 0 1 1 ...  
## $ mynb.pred.class : num 1 0 0 0 0 1 1 0 1 1 ...  
## $ class : num 2 1 1 1 1 2 2 1 2 2 ...  
## $ posterior.benign : num 4.7e-10 1.0 1.0 1.0 1.0 ...  
## $ posterior.malignant: num 1.00 1.30e-19 1.16e-17 7.33e-20 8.63e-21 ...

combine.classes[,7]<-rowSums(combine.classes)

combine.classes[,8]<-ifelse(combine.classes[,7]>=4, "malignant", "benign")

table(combine.classes[,8], combine.classes$class)

##   
## 2 3 5 6 7 8 9  
## benign 165 4 0 0 0 0 0  
## malignant 0 0 1 1 2 6 95

library(caretEnsemble)

## Warning: package 'caretEnsemble' was built under R version 4.0.4

##   
## Attaching package: 'caretEnsemble'

## The following object is masked from 'package:ggplot2':  
##   
## autoplot

my\_control<-trainControl(method = "boot", number = 25, savePredictions = "final", classProbs = TRUE, index = createResample(train.df$Class, 25), summaryFunction = twoClassSummary)

control\_stacking<-trainControl(method = "repeatedcv", number=5, repeats = 2, savePredictions = TRUE, classProbs = TRUE)  
alg <- c('rpart', 'knn', 'svmRadial')  
stacked<-caretList(Class ~., data = BreastCancer, trControl = my\_control , methodList = alg)

## Warning in train.default(x, y, weights = w, ...): The metric "Accuracy" was not  
## in the result set. ROC will be used instead.  
  
## Warning in train.default(x, y, weights = w, ...): The metric "Accuracy" was not  
## in the result set. ROC will be used instead.  
  
## Warning in train.default(x, y, weights = w, ...): The metric "Accuracy" was not  
## in the result set. ROC will be used instead.

## Warning in .local(x, ...): Variable(s) `' constant. Cannot scale data.  
  
## Warning in .local(x, ...): Variable(s) `' constant. Cannot scale data.  
  
## Warning in .local(x, ...): Variable(s) `' constant. Cannot scale data.  
  
## Warning in .local(x, ...): Variable(s) `' constant. Cannot scale data.  
  
## Warning in .local(x, ...): Variable(s) `' constant. Cannot scale data.  
  
## Warning in .local(x, ...): Variable(s) `' constant. Cannot scale data.  
  
## Warning in .local(x, ...): Variable(s) `' constant. Cannot scale data.  
  
## Warning in .local(x, ...): Variable(s) `' constant. Cannot scale data.  
  
## Warning in .local(x, ...): Variable(s) `' constant. Cannot scale data.  
  
## Warning in .local(x, ...): Variable(s) `' constant. Cannot scale data.  
  
## Warning in .local(x, ...): Variable(s) `' constant. Cannot scale data.  
  
## Warning in .local(x, ...): Variable(s) `' constant. Cannot scale data.  
  
## Warning in .local(x, ...): Variable(s) `' constant. Cannot scale data.  
  
## Warning in .local(x, ...): Variable(s) `' constant. Cannot scale data.  
  
## Warning in .local(x, ...): Variable(s) `' constant. Cannot scale data.

stacked<-resamples(stacked)

#stacking with CaretEnsemble only works with caret functions (not all classification models).

summary(stacked)

##   
## Call:  
## summary.resamples(object = stacked)  
##   
## Models: rpart, knn, svmRadial   
## Number of resamples: 25   
##   
## ROC   
## Min. 1st Qu. Median Mean 3rd Qu. Max. NA's  
## rpart 0.9226470 0.9433055 0.9558278 0.9531868 0.9642241 0.9709409 0  
## knn 0.9679491 0.9799583 0.9825129 0.9825357 0.9858642 0.9929272 0  
## svmRadial 0.9890142 0.9934295 0.9944617 0.9942695 0.9956310 0.9974070 0  
##   
## Sens   
## Min. 1st Qu. Median Mean 3rd Qu. Max. NA's  
## rpart 0.9163763 0.9309211 0.9527027 0.9478126 0.9657534 0.9758621 0  
## knn 0.9798658 0.9865772 0.9899329 0.9898072 0.9930556 0.9967105 0  
## svmRadial 0.9415808 0.9569536 0.9695946 0.9662323 0.9733333 0.9894366 0  
##   
## Spec   
## Min. 1st Qu. Median Mean 3rd Qu. Max. NA's  
## rpart 0.8346457 0.9219858 0.9398496 0.9346186 0.9609375 0.9855072 0  
## knn 0.7716535 0.8267717 0.8449612 0.8471951 0.8646617 0.8943089 0  
## svmRadial 0.9469697 0.9767442 0.9916667 0.9833985 0.9924812 1.0000000 0