Data Mining Final

# Main text

## Sequence of data analysis

1. load dataset, split dataset as train and validation using stratifed partition function
2. data modeling using caret to tune hyper parameter of candidate models
3. evaluate the models
4. choose models to use or to make ensemble
5. confime final model, predict class and posterior probability of Xtest

## 1. load and split dataset

## 2. data modeling

### 2-1. glmnet

### 2-2. support vector machine with rbf kernel

### 2-3. random forest

### 2-4. xgboost

## 3. evaluate the models

### 3-1. glmnet

### 3-2. support vector machine with rbf kernel

### 3-3. random forest

### 3-4. xgboost

## 4. choose models to use or to make ensemble

## 5. confime final model and predict class and posterior probability of Xtest

### 5-1. glmnet

### 5-2. support vector machine with rbf kernel

### 5-3. random forest

### 5-4. xgboost

### 5-5. ensemble

# Appendix : R code

## library package to use

library(caret)

## Warning: package 'caret' was built under R version 3.6.3

## Loading required package: lattice

## Loading required package: ggplot2

library(dplyr)

##   
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':  
##   
## filter, lag

## The following objects are masked from 'package:base':  
##   
## intersect, setdiff, setequal, union

library(ROCR) # for auc, acc, cutoff

## Warning: package 'ROCR' was built under R version 3.6.3

library(glmnet)

## Loading required package: Matrix

## Loading required package: foreach

## Loaded glmnet 2.0-18

library(kernlab) # for support vector machine

##   
## Attaching package: 'kernlab'

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

library(ranger) # for random forest as ranger

## Warning: package 'ranger' was built under R version 3.6.3

library(xgboost) # for xgboost

## Warning: package 'xgboost' was built under R version 3.6.3

##   
## Attaching package: 'xgboost'

## The following object is masked from 'package:dplyr':  
##   
## slice

library(writexl) # for exporting answer

## Warning: package 'writexl' was built under R version 3.6.3

library(ggplot2)  
library(corrplot)

## Warning: package 'corrplot' was built under R version 3.6.3

## corrplot 0.84 loaded

## 1. load and split dataset

load dataset, split dataset as train and validation using stratifed partition based on target variable

trainset = read.csv('./Train.csv', header=TRUE)  
testset = read.csv('./Xtest.csv', header=TRUE)  
  
train\_X = trainset[, 2:51]  
train\_Y = as.factor(trainset[, 52])  
test\_X = testset[, 2:51]  
  
  
  
  
student = 20152410  
train\_size = 0.75  
set.seed(student)  
train\_index = createDataPartition(train\_Y, p=train\_size)  
  
X\_train = train\_X[train\_index$Resample1, ]  
Y\_train = train\_Y[train\_index$Resample1]  
X\_val = train\_X[-train\_index$Resample1, ]  
Y\_val = train\_Y[-train\_index$Resample1]  
  
factor\_Y\_train = ifelse(Y\_train == '1', 'yes', 'no')  
  
# check wheter data is stratifed based on target  
  
cat(' ratio of trainset target :', summary(train\_Y)[1] / summary(train\_Y)[2],  
 '\n ratio of train target :', summary(Y\_train)[1] / summary(Y\_train)[2],  
 '\n ratio of validation target :', summary(Y\_val)[1] / summary(Y\_val)[2])

## ratio of trainset target : 1.533249   
## ratio of train target : 1.532489   
## ratio of validation target : 1.535533

## 2. data modeling

data modeling using caret to tune hyper parameter of candidate models candidate : glmnet, svmradial, random forest, xgboost

### 2-1. glmnet

glmnet\_tune\_length = 250  
glmnet\_fold\_number = 4  
glmnet\_train\_control = trainControl(method='cv',  
 number=glmnet\_fold\_number,  
 search='random',  
 classProbs = TRUE,  
 summaryFunction=twoClassSummary)  
  
glmnet\_start = Sys.time()  
  
set.seed(student)  
glmnet\_model = train(X\_train,  
 factor\_Y\_train,  
 method='glmnet',  
 trControl=glmnet\_train\_control,  
 metric='ROC',  
 tuneLength=glmnet\_tune\_length,  
 preProcess = c('center', 'scale'))  
  
glmnet\_train\_time = Sys.time() - glmnet\_start  
cat('Train time of glmnet model : '); glmnet\_train\_time

## Train time of glmnet model :

## Time difference of 13.29373 mins

glmnet\_model

## glmnet   
##   
## 3001 samples  
## 50 predictor  
## 2 classes: 'no', 'yes'   
##   
## Pre-processing: centered (50), scaled (50)   
## Resampling: Cross-Validated (4 fold)   
## Summary of sample sizes: 2251, 2251, 2251, 2250   
## Resampling results across tuning parameters:  
##   
## alpha lambda ROC Sens Spec   
## 0.006265211 0.272482622 0.9325998 0.9526432 0.6911286286  
## 0.009699477 0.787905250 0.9263131 0.9658590 0.5468337656  
## 0.014610337 0.023494567 0.9486622 0.9399780 0.8160205660  
## 0.014909376 0.075566096 0.9408098 0.9443833 0.7746553372  
## 0.020846702 3.982460867 0.9015823 1.0000000 0.0000000000  
## 0.025278696 0.278493511 0.9311037 0.9548458 0.6767818955  
## 0.033242658 0.049756715 0.9434765 0.9427313 0.7898466648  
## 0.035052143 6.895764214 0.5000000 1.0000000 0.0000000000  
## 0.043549569 0.017712371 0.9501154 0.9410793 0.8244579807  
## 0.043664746 0.013341609 0.9516580 0.9410793 0.8312090500  
## 0.044732111 1.220353005 0.9108358 0.9889868 0.1974901037  
## 0.045269195 4.655111885 0.5000000 1.0000000 0.0000000000  
## 0.047117302 2.422406751 0.8774846 1.0000000 0.0000000000  
## 0.053370468 0.043697449 0.9441527 0.9432819 0.7898466648  
## 0.070189434 0.167503105 0.9320999 0.9537445 0.6978740104  
## 0.072712358 0.007688305 0.9541775 0.9421806 0.8396493084  
## 0.073736244 0.007655685 0.9542035 0.9421806 0.8396493084  
## 0.086627450 0.002974697 0.9576995 0.9410793 0.8531542907  
## 0.092327813 0.002543285 0.9581843 0.9421806 0.8582161707  
## 0.093468232 0.339020619 0.9208239 0.9631057 0.5805777368  
## 0.093531826 5.196874625 0.5000000 1.0000000 0.0000000000  
## 0.095811646 0.553605214 0.9102323 0.9763216 0.4219332969  
## 0.111675326 0.004882510 0.9561752 0.9416300 0.8472478160  
## 0.112600095 0.485083594 0.9095549 0.9752203 0.4379663755  
## 0.112657785 0.067263819 0.9395452 0.9482379 0.7628395441  
## 0.113283120 0.008817638 0.9536982 0.9416300 0.8362766175  
## 0.113801020 0.055867816 0.9412247 0.9460352 0.7712769588  
## 0.114144946 0.021289592 0.9487501 0.9421806 0.8109501547  
## 0.115635284 0.839680588 0.8894715 0.9911894 0.0540170853  
## 0.118973954 0.053147831 0.9415406 0.9460352 0.7721215534  
## 0.120728005 0.185127877 0.9269786 0.9564978 0.6607431295  
## 0.120890825 0.008368714 0.9538932 0.9427313 0.8371212121  
## 0.121171229 0.013467870 0.9514933 0.9410793 0.8295198608  
## 0.123427993 0.247421254 0.9220401 0.9603524 0.6117879243  
## 0.123693594 7.152082747 0.5000000 1.0000000 0.0000000000  
## 0.127900540 0.167120258 0.9277201 0.9553965 0.6725646101  
## 0.130156654 0.012335983 0.9519338 0.9405286 0.8320536446  
## 0.131364835 0.019263891 0.9493485 0.9416300 0.8151731277  
## 0.136488002 0.018617983 0.9495120 0.9416300 0.8160177223  
## 0.137448626 0.006370647 0.9551197 0.9438326 0.8404910592  
## 0.138946098 6.364961767 0.5000000 1.0000000 0.0000000000  
## 0.140260260 0.001982172 0.9590223 0.9421806 0.8624306124  
## 0.154157052 0.003248733 0.9576921 0.9421806 0.8523096961  
## 0.154920287 0.766040510 0.8662909 0.9972467 0.0194171444  
## 0.167211165 0.824731645 0.8495388 0.9994493 0.0033783784  
## 0.172457835 0.001094660 0.9601856 0.9432819 0.8649615525  
## 0.177388077 0.248697190 0.9142231 0.9647577 0.5560930248  
## 0.177558214 0.867035633 0.8399330 1.0000000 0.0000000000  
## 0.177567763 3.883962469 0.5000000 1.0000000 0.0000000000  
## 0.179724336 0.029627005 0.9456145 0.9454846 0.7940696378  
## 0.181567008 0.087693394 0.9335748 0.9482379 0.7248839749  
## 0.187142368 0.016281750 0.9501626 0.9410793 0.8168594731  
## 0.190733231 0.003461709 0.9575342 0.9421806 0.8489370052  
## 0.191459686 0.001414240 0.9597991 0.9432819 0.8632752070  
## 0.193317344 0.005307017 0.9560284 0.9438326 0.8421802484  
## 0.199591300 5.817820328 0.5000000 1.0000000 0.0000000000  
## 0.201529454 0.023320342 0.9475249 0.9438326 0.8041962417  
## 0.203202060 2.165811692 0.5000000 1.0000000 0.0000000000  
## 0.204881374 0.103352279 0.9301741 0.9515419 0.6978825416  
## 0.206053626 2.166002790 0.5000000 1.0000000 0.0000000000  
## 0.211319153 0.456055086 0.8871659 0.9851322 0.1485178360  
## 0.213172371 0.088481113 0.9320047 0.9493392 0.7147630585  
## 0.219856605 4.987395365 0.5000000 1.0000000 0.0000000000  
## 0.225033909 0.054933712 0.9383545 0.9487885 0.7535632223  
## 0.227524906 0.037757246 0.9427814 0.9482379 0.7738050551  
## 0.237223931 0.001364053 0.9600424 0.9432819 0.8624306124  
## 0.241780823 0.613790520 0.8441311 0.9994493 0.0008445946  
## 0.243607923 0.017302008 0.9494951 0.9427313 0.8117947493  
## 0.251119553 0.003923375 0.9573078 0.9443833 0.8447140322  
## 0.259834806 0.001025849 0.9604569 0.9427313 0.8658061471  
## 0.261858385 0.003664093 0.9576013 0.9443833 0.8464032214  
## 0.270165900 0.003150851 0.9580544 0.9432819 0.8497787560  
## 0.271456334 0.297130901 0.8968301 0.9790749 0.3594844845  
## 0.277175019 0.007502409 0.9544741 0.9443833 0.8354320229  
## 0.279456443 0.067064233 0.9336381 0.9493392 0.7240422240  
## 0.281406238 0.005225634 0.9562989 0.9432819 0.8413356538  
## 0.283907752 0.952007031 0.5000000 1.0000000 0.0000000000  
## 0.284914147 7.310347504 0.5000000 1.0000000 0.0000000000  
## 0.289813023 0.004042945 0.9572558 0.9443833 0.8438694376  
## 0.290077487 0.002035284 0.9593430 0.9427313 0.8598968286  
## 0.291421617 0.003123113 0.9581455 0.9432819 0.8497815998  
## 0.293379836 0.309912676 0.8900827 0.9818282 0.2835221585  
## 0.296261597 0.034144835 0.9426970 0.9482379 0.7712769588  
## 0.298780398 0.336600615 0.8823390 0.9840308 0.1856373419  
## 0.299215004 0.386870866 0.8683885 0.9889868 0.0877582128  
## 0.300826944 5.167168793 0.5000000 1.0000000 0.0000000000  
## 0.301253799 0.071598122 0.9318630 0.9515419 0.7130767131  
## 0.302488496 0.188327985 0.9092748 0.9664097 0.5442772318  
## 0.305959326 0.001376210 0.9601484 0.9432819 0.8615860178  
## 0.314839585 3.298137301 0.5000000 1.0000000 0.0000000000  
## 0.315201727 1.757496807 0.5000000 1.0000000 0.0000000000  
## 0.319052681 0.003638812 0.9577277 0.9443833 0.8455586268  
## 0.320706758 1.874830505 0.5000000 1.0000000 0.0000000000  
## 0.330053163 0.001089189 0.9605014 0.9427313 0.8658061471  
## 0.335418310 0.027236956 0.9446077 0.9482379 0.7788754664  
## 0.340835824 0.027877373 0.9442862 0.9476872 0.7763416826  
## 0.341127220 0.166094516 0.9095823 0.9653084 0.5544038357  
## 0.342979297 0.005885060 0.9558567 0.9432819 0.8413384976  
## 0.351295430 2.219381331 0.5000000 1.0000000 0.0000000000  
## 0.382109020 0.670809136 0.5000000 1.0000000 0.0000000000  
## 0.389912370 0.019604903 0.9477334 0.9471366 0.7957531395  
## 0.405465481 6.748657495 0.5000000 1.0000000 0.0000000000  
## 0.409119769 5.318353927 0.5000000 1.0000000 0.0000000000  
## 0.410956310 0.042653373 0.9371387 0.9504405 0.7366940804  
## 0.412939824 0.008278342 0.9539351 0.9427313 0.8312118937  
## 0.414362573 0.095052310 0.9192784 0.9553965 0.6320439758  
## 0.415209477 6.178243336 0.5000000 1.0000000 0.0000000000  
## 0.416375450 0.020856930 0.9468296 0.9476872 0.7890020703  
## 0.419916316 0.012317467 0.9514389 0.9443833 0.8134810947  
## 0.420646971 0.018497324 0.9480270 0.9476872 0.7982840795  
## 0.421976987 0.065906687 0.9286230 0.9531938 0.6911229411  
## 0.422601855 0.808471973 0.5000000 1.0000000 0.0000000000  
## 0.426728097 0.607063206 0.5000000 1.0000000 0.0000000000  
## 0.427866428 0.355449328 0.8396434 0.9933921 0.0050675676  
## 0.434543333 0.550438676 0.5000000 1.0000000 0.0000000000  
## 0.442503444 0.017569383 0.9483504 0.9471366 0.7999732687  
## 0.449546005 0.309941353 0.8477345 0.9900881 0.0388200701  
## 0.451939014 0.009240763 0.9533513 0.9427313 0.8236133861  
## 0.454600163 0.005987407 0.9558780 0.9443833 0.8362766175  
## 0.478434908 3.724642114 0.5000000 1.0000000 0.0000000000  
## 0.479839390 0.529943068 0.5000000 1.0000000 0.0000000000  
## 0.479896537 0.012220984 0.9514220 0.9449339 0.8109501547  
## 0.482290360 0.011414884 0.9518367 0.9449339 0.8134810947  
## 0.483245083 0.001884240 0.9599339 0.9449339 0.8590550778  
## 0.483375502 7.533957002 0.5000000 1.0000000 0.0000000000  
## 0.486734160 0.084318442 0.9185740 0.9564978 0.6269820957  
## 0.491739537 0.559203761 0.5000000 1.0000000 0.0000000000  
## 0.497060154 0.007010819 0.9549924 0.9410793 0.8320564883  
## 0.503721734 2.472691655 0.5000000 1.0000000 0.0000000000  
## 0.505340455 0.025305399 0.9430001 0.9482379 0.7653761716  
## 0.509154859 0.006400649 0.9555732 0.9432819 0.8320564883  
## 0.519085642 0.003324174 0.9585238 0.9438326 0.8480895668  
## 0.521144451 1.067795913 0.5000000 1.0000000 0.0000000000  
## 0.526338981 0.436644873 0.5000000 1.0000000 0.0000000000  
## 0.530542014 3.149850323 0.5000000 1.0000000 0.0000000000  
## 0.536921020 0.020313521 0.9455848 0.9476872 0.7763388388  
## 0.538045959 0.006959916 0.9550713 0.9416300 0.8320564883  
## 0.540620974 3.394118312 0.5000000 1.0000000 0.0000000000  
## 0.542833706 0.697638501 0.5000000 1.0000000 0.0000000000  
## 0.543276836 0.592164223 0.5000000 1.0000000 0.0000000000  
## 0.549219434 0.009563828 0.9530296 0.9438326 0.8202350077  
## 0.552029131 3.413671612 0.5000000 1.0000000 0.0000000000  
## 0.552245391 0.146097817 0.8947817 0.9697137 0.4421865047  
## 0.565841655 0.127507546 0.8997966 0.9675110 0.5113721676  
## 0.572809581 0.002203290 0.9599377 0.9454846 0.8565241378  
## 0.574223329 0.018511619 0.9464033 0.9476872 0.7839401902  
## 0.574452326 0.348977591 0.5000000 1.0000000 0.0000000000  
## 0.575518546 0.037394945 0.9360623 0.9515419 0.7198107198  
## 0.578644972 0.039807428 0.9348365 0.9526432 0.7147488397  
## 0.584881566 0.158393996 0.8854860 0.9746696 0.3805765993  
## 0.585399537 0.054616312 0.9271047 0.9542952 0.6767676768  
## 0.585897295 0.003985963 0.9580666 0.9443833 0.8404967467  
## 0.588137920 0.306527826 0.7087817 1.0000000 0.0000000000  
## 0.590503159 0.729410688 0.5000000 1.0000000 0.0000000000  
## 0.593320029 0.080414670 0.9153168 0.9587004 0.6092512968  
## 0.593688449 0.184001349 0.8694226 0.9807269 0.2514616890  
## 0.602807915 0.051440370 0.9280602 0.9542952 0.6809906497  
## 0.605136453 0.001670090 0.9604885 0.9443833 0.8573687324  
## 0.611083985 0.003486239 0.9586334 0.9443833 0.8464032214  
## 0.617558016 0.002615739 0.9595084 0.9454846 0.8497702248  
## 0.620267878 5.776912409 0.5000000 1.0000000 0.0000000000  
## 0.621342938 0.278746173 0.7929849 0.9994493 0.0000000000  
## 0.633712140 0.005623603 0.9564037 0.9438326 0.8337428337  
## 0.634280130 0.292893728 0.7087817 1.0000000 0.0000000000  
## 0.644023644 0.087488098 0.9104769 0.9609031 0.5856225544  
## 0.647930102 0.042801510 0.9315319 0.9531938 0.6953345391  
## 0.650622020 0.002307345 0.9599059 0.9465859 0.8548377923  
## 0.650640503 0.012775215 0.9502032 0.9471366 0.8025098963  
## 0.652204551 0.001421317 0.9609010 0.9438326 0.8598996724  
## 0.656883277 1.460477089 0.5000000 1.0000000 0.0000000000  
## 0.660587868 6.484605624 0.5000000 1.0000000 0.0000000000  
## 0.663527391 0.897350454 0.5000000 1.0000000 0.0000000000  
## 0.663620678 0.497854812 0.5000000 1.0000000 0.0000000000  
## 0.664555445 4.582539726 0.5000000 1.0000000 0.0000000000  
## 0.665658168 0.056990132 0.9223432 0.9548458 0.6489159614  
## 0.678484043 0.046758770 0.9280571 0.9542952 0.6776151151  
## 0.679222818 0.048607355 0.9268779 0.9537445 0.6700194513  
## 0.685660752 1.391577237 0.5000000 1.0000000 0.0000000000  
## 0.687403098 0.059874490 0.9199737 0.9575991 0.6354109792  
## 0.688793834 0.012433799 0.9503816 0.9465859 0.8025098963  
## 0.694292453 0.025643026 0.9406510 0.9509912 0.7358466421  
## 0.695171368 0.583822578 0.5000000 1.0000000 0.0000000000  
## 0.706684399 1.711830951 0.5000000 1.0000000 0.0000000000  
## 0.713100569 6.480841898 0.5000000 1.0000000 0.0000000000  
## 0.713148771 0.295090190 0.5000000 1.0000000 0.0000000000  
## 0.716356689 0.331710522 0.5000000 1.0000000 0.0000000000  
## 0.736245310 0.005276637 0.9571182 0.9449339 0.8337428337  
## 0.739211640 0.581953111 0.5000000 1.0000000 0.0000000000  
## 0.739811396 0.053346600 0.9214938 0.9564978 0.6421620484  
## 0.741660409 0.011763017 0.9507906 0.9471366 0.8025098963  
## 0.741873592 0.004803648 0.9574822 0.9438326 0.8362766175  
## 0.747070696 0.012887722 0.9497139 0.9476872 0.7940696378  
## 0.749598374 0.275263662 0.5000000 1.0000000 0.0000000000  
## 0.752986161 0.319854726 0.5000000 1.0000000 0.0000000000  
## 0.753790000 0.003145780 0.9594351 0.9454846 0.8455557831  
## 0.755172368 5.962749377 0.5000000 1.0000000 0.0000000000  
## 0.768732164 0.024956960 0.9401342 0.9526432 0.7299373237  
## 0.770849574 2.150453777 0.5000000 1.0000000 0.0000000000  
## 0.771676147 0.356440710 0.5000000 1.0000000 0.0000000000  
## 0.775243020 1.001176118 0.5000000 1.0000000 0.0000000000  
## 0.791545583 0.139579394 0.8637316 0.9757709 0.2877621940  
## 0.792416466 3.832144912 0.5000000 1.0000000 0.0000000000  
## 0.792732671 0.137979532 0.8642891 0.9746696 0.2936658249  
## 0.806188084 0.001582523 0.9611007 0.9438326 0.8599025162  
## 0.809407717 1.644486344 0.5000000 1.0000000 0.0000000000  
## 0.811048355 0.326463632 0.5000000 1.0000000 0.0000000000  
## 0.812854446 0.004999652 0.9576961 0.9454846 0.8345874283  
## 0.819433523 1.984644952 0.5000000 1.0000000 0.0000000000  
## 0.821070882 2.980026944 0.5000000 1.0000000 0.0000000000  
## 0.825917137 0.007151851 0.9552224 0.9454846 0.8236133861  
## 0.827292155 0.039071202 0.9284926 0.9537445 0.6759230822  
## 0.827613321 1.875371519 0.5000000 1.0000000 0.0000000000  
## 0.836804618 0.946802463 0.5000000 1.0000000 0.0000000000  
## 0.840222875 0.014778280 0.9475077 0.9493392 0.7814120939  
## 0.840785737 6.379378536 0.5000000 1.0000000 0.0000000000  
## 0.841951752 0.420797339 0.5000000 1.0000000 0.0000000000  
## 0.843290935 0.144149674 0.8553761 0.9790749 0.2261380699  
## 0.844494053 0.007514695 0.9548823 0.9460352 0.8185458185  
## 0.848688038 0.309621059 0.5000000 1.0000000 0.0000000000  
## 0.848720256 0.001054157 0.9615493 0.9438326 0.8624277687  
## 0.853787693 2.876830564 0.5000000 1.0000000 0.0000000000  
## 0.855710277 0.335653844 0.5000000 1.0000000 0.0000000000  
## 0.855730424 4.568193978 0.5000000 1.0000000 0.0000000000  
## 0.866199465 0.041631655 0.9253930 0.9542952 0.6573590636  
## 0.868607535 0.255471437 0.5000000 1.0000000 0.0000000000  
## 0.880579132 0.804074409 0.5000000 1.0000000 0.0000000000  
## 0.882133342 0.032285807 0.9328069 0.9537445 0.6894280644  
## 0.888450428 6.513169914 0.5000000 1.0000000 0.0000000000  
## 0.896447932 0.916319191 0.5000000 1.0000000 0.0000000000  
## 0.915414804 0.334145034 0.5000000 1.0000000 0.0000000000  
## 0.915733309 0.116302924 0.8698352 0.9713656 0.3358585859  
## 0.917349652 0.060990117 0.9107831 0.9603524 0.5957491582  
## 0.917518559 3.789058899 0.5000000 1.0000000 0.0000000000  
## 0.919560802 0.011175253 0.9507179 0.9482379 0.7923804486  
## 0.919607803 0.168895795 0.8314246 0.9895374 0.0278488716  
## 0.919741503 0.010435527 0.9515301 0.9482379 0.7966005779  
## 0.920390483 0.008998438 0.9531959 0.9476872 0.8050436800  
## 0.928816951 0.105291075 0.8774038 0.9691630 0.3940673628  
## 0.936183455 0.058205390 0.9118686 0.9609031 0.6025002275  
## 0.937521837 0.015186489 0.9462511 0.9504405 0.7746610247  
## 0.940413293 0.001759999 0.9613282 0.9443833 0.8590550778  
## 0.943546914 0.004902344 0.9582981 0.9432819 0.8345845846  
## 0.949584906 1.418474895 0.5000000 1.0000000 0.0000000000  
## 0.950465326 3.712067683 0.5000000 1.0000000 0.0000000000  
## 0.955421598 0.028130948 0.9346528 0.9531938 0.6978626354  
## 0.957126620 0.001491034 0.9615987 0.9449339 0.8615860178  
## 0.964100410 1.507340877 0.5000000 1.0000000 0.0000000000  
## 0.966791743 0.016780510 0.9444732 0.9498899 0.7561026936  
## 0.989581804 0.046252919 0.9179603 0.9581498 0.6354138229  
## 0.991037088 0.052893436 0.9133573 0.9603524 0.6075649513  
##   
## ROC was used to select the optimal model using the largest value.  
## The final values used for the model were alpha = 0.9571266 and lambda  
## = 0.001491034.

best\_alpha = as.numeric(glmnet\_model$bestTune[1])  
best\_lambda = as.numeric(glmnet\_model$bestTune[2])  
  
glmnet\_pred = predict(glmnet\_model, newdata=X\_val, type='prob')  
  
glmnet\_best\_tune = glmnet\_model$results %>%   
 arrange(desc(ROC)) %>%   
 head(1)  
glmnet\_best\_tune

## alpha lambda ROC Sens Spec ROCSD SensSD  
## 1 0.9571266 0.001491034 0.9615987 0.9449339 0.861586 0.009071119 0.02112701  
## SpecSD  
## 1 0.02058914

### 2-2. support vector machine with rbf kernel

svm\_tune\_length = 250  
svm\_fold\_number = 4  
svm\_train\_control = trainControl(method='cv',  
 number=svm\_fold\_number,  
 search='random',  
 classProbs = TRUE,  
 summaryFunction=twoClassSummary)  
  
svm\_start = Sys.time()  
  
set.seed(student)  
svm\_model = train(X\_train,  
 factor\_Y\_train,  
 method='svmRadial',  
 trControl=svm\_train\_control,  
 metric='ROC',  
 tuneLength=svm\_tune\_length,  
 preProcess = c('center', 'scale'))  
  
svm\_train\_time = Sys.time() - svm\_start  
cat('Train time of svm model : '); svm\_train\_time

## Train time of svm model :

## Time difference of 38.41799 mins

svm\_model

## Support Vector Machines with Radial Basis Function Kernel   
##   
## 3001 samples  
## 50 predictor  
## 2 classes: 'no', 'yes'   
##   
## Pre-processing: centered (50), scaled (50)   
## Resampling: Cross-Validated (4 fold)   
## Summary of sample sizes: 2251, 2251, 2251, 2250   
## Resampling results across tuning parameters:  
##   
## sigma C ROC Sens Spec   
## 0.0007876702 7.090732e+00 0.9520809 0.9454846 0.8556881  
## 0.0008061993 2.025306e+00 0.9429850 0.9372247 0.8447169  
## 0.0008452992 2.029779e+01 0.9572865 0.9504405 0.8615889  
## 0.0008818564 5.545157e+02 0.9652166 0.9531938 0.8793140  
## 0.0009000912 3.820857e+00 0.9491226 0.9421806 0.8590665  
## 0.0009372495 4.988863e-02 0.9213786 0.8485683 0.8885875  
## 0.0009472982 1.200771e+00 0.9404070 0.9366740 0.8413413  
## 0.0009810709 4.926484e-01 0.9325125 0.9273128 0.8320622  
## 0.0010916132 1.147588e+02 0.9628101 0.9526432 0.8767859  
## 0.0011403118 3.516188e-02 0.9218489 0.8480176 0.8877429  
## 0.0011517965 8.494150e+00 0.9550555 0.9471366 0.8666564  
## 0.0011635912 7.805540e+00 0.9548475 0.9482379 0.8624306  
## 0.0011670318 8.256441e-01 0.9391804 0.9350220 0.8404996  
## 0.0011690203 3.949147e-01 0.9322652 0.9262115 0.8329068  
## 0.0011741404 1.916491e+00 0.9465365 0.9421806 0.8565298  
## 0.0012405962 4.723893e+00 0.9529339 0.9465859 0.8590608  
## 0.0012823254 1.140909e-01 0.9238379 0.8854626 0.8658061  
## 0.0013018782 1.154765e-01 0.9240032 0.8865639 0.8641198  
## 0.0013023049 6.090254e+01 0.9619950 0.9509912 0.8725629  
## 0.0013484037 3.019974e+00 0.9509430 0.9438326 0.8590608  
## 0.0013817128 2.056949e+01 0.9595984 0.9509912 0.8708794  
## 0.0014397717 2.805684e-01 0.9318174 0.9240088 0.8337485  
## 0.0014727373 7.166542e+02 0.9660647 0.9515419 0.8818449  
## 0.0014987779 4.994567e-01 0.9374079 0.9344714 0.8388132  
## 0.0015241808 2.357606e-01 0.9310292 0.9190529 0.8388132  
## 0.0015406292 5.648280e-02 0.9225740 0.8485683 0.8885875  
## 0.0016133193 1.224967e-01 0.9265458 0.9063877 0.8472507  
## 0.0016201124 2.641971e+00 0.9514614 0.9443833 0.8590608  
## 0.0016643642 3.060054e+00 0.9524582 0.9460352 0.8599054  
## 0.0016772654 6.308672e+01 0.9624124 0.9504405 0.8801529  
## 0.0016798589 4.361868e+01 0.9619340 0.9509912 0.8750910  
## 0.0016986841 1.488790e-01 0.9286521 0.9129956 0.8388076  
## 0.0016996775 6.595491e+01 0.9626874 0.9509912 0.8809975  
## 0.0017762559 1.206829e+01 0.9589501 0.9526432 0.8658118  
## 0.0018343973 8.738640e-01 0.9442043 0.9410793 0.8514679  
## 0.0018619282 1.665824e-01 0.9305050 0.9174009 0.8404967  
## 0.0019297556 5.232393e+02 0.9661209 0.9520925 0.8826895  
## 0.0019343821 2.056579e-01 0.9326628 0.9240088 0.8388132  
## 0.0019790522 9.034751e-01 0.9454488 0.9421806 0.8539960  
## 0.0020893509 1.099318e+01 0.9594428 0.9515419 0.8717183  
## 0.0021425828 3.868791e+02 0.9659269 0.9520925 0.8818449  
## 0.0021584457 3.206895e+00 0.9540184 0.9476872 0.8666479  
## 0.0021882206 6.656361e+00 0.9572459 0.9493392 0.8691817  
## 0.0022266181 9.510438e+02 0.9651710 0.9542952 0.8733990  
## 0.0022327642 2.047134e+01 0.9617871 0.9520925 0.8725601  
## 0.0022589656 4.035498e-01 0.9405849 0.9344714 0.8455643  
## 0.0023819121 4.123064e+02 0.9659605 0.9537445 0.8809946  
## 0.0024179431 2.210114e+01 0.9616335 0.9515419 0.8725601  
## 0.0024849355 8.847375e-01 0.9477545 0.9416300 0.8624391  
## 0.0025033530 1.610725e+01 0.9616704 0.9520925 0.8734075  
## 0.0026846752 3.015543e+02 0.9659179 0.9520925 0.8818449  
## 0.0027870999 1.897146e+02 0.9656921 0.9526432 0.8818449  
## 0.0029394774 2.446823e+02 0.9660257 0.9553965 0.8826895  
## 0.0035340602 4.611758e+02 0.9642160 0.9493392 0.8725601  
## 0.0035553828 1.162512e+01 0.9610541 0.9515419 0.8734047  
## 0.0036689415 1.163081e+01 0.9611695 0.9515419 0.8742492  
## 0.0036849372 1.132816e+02 0.9658761 0.9531938 0.8810003  
## 0.0037016362 1.553795e+02 0.9659383 0.9526432 0.8809975  
## 0.0037284961 1.005241e+03 0.9592423 0.9460352 0.8691703  
## 0.0038429571 3.541675e-02 0.9264915 0.8518722 0.8877429  
## 0.0039269876 1.197764e+00 0.9529701 0.9443833 0.8632837  
## 0.0040121481 7.807276e+01 0.9659091 0.9520925 0.8843730  
## 0.0040463085 2.665016e+00 0.9566994 0.9482379 0.8683428  
## 0.0041897159 1.346903e-01 0.9379806 0.9284141 0.8447283  
## 0.0042034628 2.345227e-01 0.9428901 0.9333700 0.8497844  
## 0.0043003913 5.246920e+02 0.9618582 0.9476872 0.8725515  
## 0.0044503146 1.195391e+02 0.9663042 0.9537445 0.8793083  
## 0.0048090458 8.581300e+01 0.9664133 0.9509912 0.8818421  
## 0.0052472014 8.891261e+02 0.9557733 0.9410793 0.8657919  
## 0.0053070721 3.255865e+01 0.9662003 0.9520925 0.8877485  
## 0.0054786086 5.146944e+00 0.9610173 0.9531938 0.8734047  
## 0.0055792940 3.555606e+02 0.9617654 0.9476872 0.8750825  
## 0.0056438387 2.075525e+02 0.9645213 0.9471366 0.8708709  
## 0.0058943768 2.693623e+00 0.9590159 0.9509912 0.8700291  
## 0.0064019357 5.984622e-02 0.9353613 0.9251101 0.8514679  
## 0.0065468212 1.490773e-01 0.9436298 0.9383260 0.8464118  
## 0.0066453313 1.162795e+01 0.9645448 0.9515419 0.8784722  
## 0.0066909577 5.967700e-02 0.9358764 0.9262115 0.8472563  
## 0.0069024652 1.257906e+02 0.9655182 0.9482379 0.8725629  
## 0.0071405949 8.352444e-02 0.9396452 0.9328194 0.8430391  
## 0.0071618709 3.405418e+00 0.9609431 0.9526432 0.8725572  
## 0.0072056583 6.325484e-01 0.9528906 0.9449339 0.8632837  
## 0.0073802661 2.734493e+00 0.9600848 0.9526432 0.8700291  
## 0.0074631710 1.048105e-01 0.9419645 0.9366740 0.8464146  
## 0.0075498126 4.931102e+01 0.9675403 0.9526432 0.8742464  
## 0.0076244326 1.216287e-01 0.9432377 0.9416300 0.8464118  
## 0.0077989499 9.127210e+00 0.9649501 0.9509912 0.8793168  
## 0.0080026101 1.259538e+01 0.9662874 0.9515419 0.8826867  
## 0.0080124624 8.952589e+02 0.9517996 0.9322687 0.8615633  
## 0.0081834333 4.009802e+00 0.9623255 0.9498899 0.8742492  
## 0.0082075637 1.311940e+00 0.9569896 0.9520925 0.8675010  
## 0.0086320394 1.050318e-01 0.9425349 0.9416300 0.8480981  
## 0.0090714010 4.749062e-02 0.9358789 0.9256608 0.8480953  
## 0.0097147795 1.740375e+01 0.9674602 0.9520925 0.8801500  
## 0.0099664662 2.171236e+01 0.9678749 0.9526432 0.8801557  
## 0.0100494756 7.951112e-01 0.9556681 0.9498899 0.8700320  
## 0.0102787172 1.421374e-01 0.9449079 0.9416300 0.8506262  
## 0.0103196784 1.760402e+00 0.9598409 0.9526432 0.8691817  
## 0.0111674506 6.963997e+01 0.9657808 0.9471366 0.8767802  
## 0.0113373913 9.669043e+00 0.9668507 0.9531938 0.8784665  
## 0.0113386979 1.423491e+01 0.9672897 0.9531938 0.8801529  
## 0.0114348763 1.681416e+02 0.9608246 0.9388767 0.8733876  
## 0.0115566878 6.286692e+02 0.9520659 0.9278634 0.8624221  
## 0.0115706281 1.822951e+01 0.9676596 0.9520925 0.8784665  
## 0.0121628762 1.748677e-01 0.9463698 0.9427313 0.8556852  
## 0.0124591370 7.323774e-01 0.9558723 0.9504405 0.8674982  
## 0.0127342038 3.654745e+01 0.9673990 0.9493392 0.8759384  
## 0.0135564726 1.584637e+02 0.9606072 0.9361233 0.8725345  
## 0.0137278340 1.257288e-01 0.9443758 0.9416300 0.8531571  
## 0.0137696843 2.666785e+02 0.9570072 0.9333700 0.8649445  
## 0.0138563332 2.091485e-01 0.9479249 0.9471366 0.8556881  
## 0.0143982014 4.626542e+02 0.9533810 0.9300661 0.8615661  
## 0.0144969351 1.712782e-01 0.9465203 0.9465859 0.8582162  
## 0.0146086977 2.200076e+01 0.9674779 0.9515419 0.8750938  
## 0.0155191670 2.492724e-01 0.9493412 0.9482379 0.8590608  
## 0.0156853597 2.970970e+00 0.9633616 0.9515419 0.8717183  
## 0.0158410005 9.295582e-02 0.9415986 0.9383260 0.8523097  
## 0.0160061537 7.297692e-02 0.9395591 0.9394273 0.8514651  
## 0.0166180919 1.971913e+02 0.9582496 0.9317181 0.8657919  
## 0.0188945003 5.256681e+02 0.9520524 0.9289648 0.8539875  
## 0.0191877048 7.313150e-02 0.9389784 0.9361233 0.8480924  
## 0.0198093814 3.461875e-01 0.9516252 0.9476872 0.8582190  
## 0.0198790456 2.900821e+00 0.9632905 0.9515419 0.8725572  
## 0.0200782273 3.392754e+00 0.9638561 0.9531938 0.8734018  
## 0.0203866151 2.373883e-01 0.9487373 0.9482379 0.8539960  
## 0.0209194561 7.678243e-02 0.9387777 0.9355727 0.8506262  
## 0.0210487343 6.195644e-01 0.9555344 0.9482379 0.8607443  
## 0.0214712476 1.067331e+01 0.9660135 0.9509912 0.8750938  
## 0.0222745228 2.533722e+00 0.9627684 0.9515419 0.8708709  
## 0.0234519746 5.896647e-02 0.9358758 0.9328194 0.8455672  
## 0.0242746273 2.624512e+00 0.9625031 0.9515419 0.8700263  
## 0.0245797495 1.190085e+02 0.9589408 0.9295154 0.8598798  
## 0.0256662831 7.860148e+01 0.9610867 0.9317181 0.8683257  
## 0.0258450110 4.536673e+02 0.9502470 0.9251101 0.8598911  
## 0.0262723168 2.892380e+01 0.9635233 0.9427313 0.8742379  
## 0.0266112732 6.724615e+00 0.9645310 0.9498899 0.8742549  
## 0.0266468685 4.274261e+02 0.9504053 0.9245595 0.8598911  
## 0.0270833943 6.394632e+01 0.9617919 0.9350220 0.8691732  
## 0.0280917283 9.042369e+00 0.9644610 0.9498899 0.8700320  
## 0.0281568735 2.464979e+02 0.9539396 0.9273128 0.8590465  
## 0.0282364807 9.848041e+01 0.9592387 0.9289648 0.8657919  
## 0.0293587273 9.264223e+02 0.9452946 0.9267621 0.8506148  
## 0.0294835102 1.702749e+02 0.9552045 0.9317181 0.8582048  
## 0.0300777697 9.835248e+00 0.9642323 0.9482379 0.8674896  
## 0.0303046016 2.274140e+00 0.9612414 0.9515419 0.8641226  
## 0.0309019483 1.772223e+02 0.9546032 0.9300661 0.8582048  
## 0.0309609368 3.112458e-01 0.9500692 0.9476872 0.8489370  
## 0.0317954166 4.111216e-01 0.9523722 0.9454846 0.8506262  
## 0.0327466244 3.512665e-01 0.9511752 0.9471366 0.8464061  
## 0.0331892284 2.681612e+02 0.9513048 0.9262115 0.8565156  
## 0.0341567669 1.099988e+02 0.9566342 0.9295154 0.8565156  
## 0.0344755468 1.381737e+00 0.9586797 0.9460352 0.8649672  
## 0.0347591493 7.735957e-02 0.9348715 0.9317181 0.8295312  
## 0.0369071071 4.214797e-02 0.9279895 0.9196035 0.8143285  
## 0.0375505415 5.026642e-01 0.9530358 0.9438326 0.8556852  
## 0.0377878320 3.020067e+00 0.9609187 0.9498899 0.8649729  
## 0.0381817189 1.304945e+02 0.9545414 0.9328194 0.8582048  
## 0.0391527719 1.208354e+01 0.9619098 0.9438326 0.8666479  
## 0.0431283685 5.407786e+00 0.9611345 0.9454846 0.8624335  
## 0.0431721575 3.411583e+01 0.9596933 0.9383260 0.8581963  
## 0.0435236373 1.484873e+00 0.9573843 0.9487885 0.8615945  
## 0.0448537650 6.828640e+02 0.9404003 0.9256608 0.8455586  
## 0.0458933297 8.279981e-02 0.9328225 0.9306167 0.8160263  
## 0.0495093167 5.503650e-01 0.9514053 0.9432819 0.8472421  
## 0.0516869194 2.954107e+02 0.9467291 0.9295154 0.8388047  
## 0.0564504751 3.848377e+02 0.9418723 0.9317181 0.8303645  
## 0.0570296475 6.942894e-01 0.9514186 0.9454846 0.8413300  
## 0.0610656457 4.397335e+00 0.9583771 0.9443833 0.8573659  
## 0.0614866199 1.035849e+02 0.9510255 0.9322687 0.8328897  
## 0.0619920796 2.934688e-01 0.9440461 0.9405286 0.8261472  
## 0.0653789393 5.181758e+01 0.9530659 0.9350220 0.8421802  
## 0.0665911489 1.344803e+02 0.9492018 0.9333700 0.8337485  
## 0.0670161101 9.178333e+02 0.9358813 0.9278634 0.8295398  
## 0.0685806893 4.666821e-02 0.9171101 0.9058370 0.7670796  
## 0.0696609131 4.482576e+01 0.9526587 0.9355727 0.8404911  
## 0.0734628900 2.304130e+02 0.9427026 0.9339207 0.8244665  
## 0.0747579434 7.400713e+02 0.9356496 0.9295154 0.8194046  
## 0.0754585540 1.780276e-01 0.9349485 0.9328194 0.7907026  
## 0.0771529755 6.097222e+01 0.9509468 0.9333700 0.8303730  
## 0.0774938182 2.667347e+02 0.9403110 0.9344714 0.8210910  
## 0.0780804896 4.280934e-02 0.9129316 0.8948238 0.7771920  
## 0.0784268267 7.287690e+02 0.9357738 0.9278634 0.8185657  
## 0.0788376407 6.578237e-01 0.9483817 0.9460352 0.8253083  
## 0.0799371508 3.062781e+02 0.9390490 0.9306167 0.8219441  
## 0.0814830083 1.205622e+01 0.9546991 0.9416300 0.8329011  
## 0.0827007186 3.698660e-01 0.9424642 0.9394273 0.8084249  
## 0.0898273633 1.153715e+01 0.9533009 0.9410793 0.8261585  
## 0.0936258315 2.343297e+02 0.9389675 0.9366740 0.8101255  
## 0.0968372417 4.625341e+02 0.9362719 0.9333700 0.8084477  
## 0.0975993255 6.104536e+01 0.9471581 0.9361233 0.8118118  
## 0.1017988022 4.709033e+02 0.9356066 0.9339207 0.8050664  
## 0.1031577483 8.568011e+00 0.9520660 0.9443833 0.8219384  
## 0.1058691913 3.703164e+02 0.9364846 0.9350220 0.8059082  
## 0.1113071661 6.016600e-01 0.9444671 0.9454846 0.7940782  
## 0.1168484561 4.771860e+02 0.9344913 0.9366740 0.7890305  
## 0.1180688216 7.740978e-01 0.9457928 0.9493392 0.7957674  
## 0.1202260121 1.120042e+01 0.9500234 0.9399780 0.8101198  
## 0.1243292110 5.981731e-01 0.9435618 0.9443833 0.7915501  
## 0.1266504983 1.831006e-01 0.9279856 0.9306167 0.7687432  
## 0.1268669880 3.472157e-02 0.9077758 0.8810573 0.7890049  
## 0.1398318739 1.990532e+00 0.9485979 0.9542952 0.7906998  
## 0.1435579653 4.358735e+00 0.9485343 0.9498899 0.7923947  
## 0.1465599044 5.545297e-02 0.9087078 0.8898678 0.7881603  
## 0.1524989078 3.663241e+02 0.9341853 0.9377753 0.7696162  
## 0.1570821992 4.630411e+01 0.9406484 0.9427313 0.7704551  
## 0.1583297756 3.552815e+01 0.9409416 0.9443833 0.7721358  
## 0.1637042505 1.039381e-01 0.9142354 0.9052863 0.7493346  
## 0.1647806891 2.402508e-01 0.9291739 0.9361233 0.7459505  
## 0.1666835809 9.456943e-02 0.9126189 0.9008811 0.7594555  
## 0.1695518413 3.565765e+01 0.9399944 0.9427313 0.7679100  
## 0.1748226710 9.126648e-02 0.9121752 0.8997797 0.7636785  
## 0.1808878470 4.972297e+00 0.9444427 0.9482379 0.7695991  
## 0.1825728431 3.417838e+01 0.9390525 0.9460352 0.7577805  
## 0.2072912797 1.070685e-01 0.9147315 0.8981278 0.7611504  
## 0.2173002419 6.572414e-01 0.9396369 0.9515419 0.7349679  
## 0.2176253249 5.312839e-01 0.9369707 0.9493392 0.7282225  
## 0.2249466951 1.319156e+02 0.9348769 0.9493392 0.7138787  
## 0.2281957838 1.231198e+02 0.9346649 0.9498899 0.7088111  
## 0.2287617911 5.640437e-02 0.9163943 0.9030837 0.7628452  
## 0.2299560571 7.228528e+00 0.9394588 0.9509912 0.7282282  
## 0.2311964043 3.611371e-01 0.9320354 0.9432819 0.7223047  
## 0.2336370568 2.599681e-01 0.9274326 0.9339207 0.7290643  
## 0.2340137005 3.622397e+01 0.9370205 0.9515419 0.7113506  
## 0.2379635240 1.679788e+02 0.9337892 0.9548458 0.6961706  
## 0.2393729022 1.255386e+01 0.9378394 0.9537445 0.7138843  
## 0.2449722953 2.894978e+02 0.9308051 0.9559471 0.6944899  
## 0.2490384676 2.357795e+00 0.9408578 0.9609031 0.7138929  
## 0.2544439912 5.486279e+02 0.9304855 0.9542952 0.6885892  
## 0.2553768019 7.767393e+00 0.9379822 0.9587004 0.7012268  
## 0.2567239317 5.325393e+02 0.9303353 0.9559471 0.6860525  
## 0.2586487722 4.233721e+01 0.9359054 0.9575991 0.6944786  
## 0.2630067201 1.093136e-01 0.9189580 0.9113436 0.7552353  
## 0.2661224680 3.409161e+00 0.9391889 0.9614537 0.7062915  
## 0.2695876102 2.420763e+02 0.9300693 0.9548458 0.6894224  
## 0.2823088735 8.515284e-02 0.9197581 0.9157489 0.7543908  
## 0.2989360888 3.486019e+00 0.9375110 0.9669604 0.6809821  
## 0.3011927377 1.106836e+00 0.9385561 0.9680617 0.6818239  
## 0.3026602183 1.621573e-01 0.9216799 0.9245595 0.7273865  
## 0.3081857064 8.715116e-01 0.9380233 0.9658590 0.6683189  
## 0.3163314142 1.936187e+00 0.9368487 0.9669604 0.6708612  
## 0.3220766919 6.994839e+01 0.9312088 0.9653084 0.6497492  
## 0.3267319630 7.284252e+01 0.9309860 0.9642070 0.6514526  
## 0.3423571201 9.910891e-01 0.9359503 0.9724670 0.6565145  
## 0.3533023716 1.562549e+00 0.9354171 0.9708150 0.6556756  
## 0.3642317017 1.169119e+00 0.9359038 0.9735683 0.6413175  
## 0.3717287265 3.289287e-01 0.9279198 0.9476872 0.6700081  
## 0.3793220091 1.976469e-01 0.9251912 0.9410793 0.6809963  
## 0.3864373777 7.567533e+01 0.9276811 0.9686123 0.6244398  
## 0.3986288593 4.454472e+00 0.9304039 0.9680617 0.6328886  
## 0.4152535033 2.653938e+01 0.9275066 0.9686123 0.6168583  
##   
## ROC was used to select the optimal model using the largest value.  
## The final values used for the model were sigma = 0.009966466 and C = 21.71236.

best\_sigma = as.numeric(svm\_model$bestTune[1])  
best\_C = as.numeric(svm\_model$bestTune[2])  
  
svm\_pred = predict(svm\_model, newdata=X\_val, type='prob')  
  
svm\_best\_tune = svm\_model$results %>%   
 arrange(desc(ROC)) %>%   
 head(1)  
svm\_best\_tune

## sigma C ROC Sens Spec ROCSD SensSD  
## 1 0.009966466 21.71236 0.9678749 0.9526432 0.8801557 0.003811696 0.0137555  
## SpecSD  
## 1 0.01510196

### 2-3. random forest

rf\_tune\_length = 250  
rf\_fold\_number = 4  
rf\_train\_control = trainControl(method='cv',  
 number=rf\_fold\_number,  
 search='random',  
 classProbs=TRUE,  
 summaryFunction=twoClassSummary)  
  
rf\_start = Sys.time()  
  
set.seed(student)  
rf\_model = train(X\_train,  
 factor\_Y\_train,  
 method='ranger',  
 trControl=rf\_train\_control,  
 metric='ROC',  
 tuneLength=rf\_tune\_length)  
  
rf\_train\_time = Sys.time() - rf\_start  
cat('Train time of random forest model : '); rf\_train\_time

## Train time of random forest model :

## Time difference of 41.18659 mins

rf\_model

## Random Forest   
##   
## 3001 samples  
## 50 predictor  
## 2 classes: 'no', 'yes'   
##   
## No pre-processing  
## Resampling: Cross-Validated (4 fold)   
## Summary of sample sizes: 2251, 2251, 2251, 2250   
## Resampling results across tuning parameters:  
##   
## min.node.size mtry splitrule ROC Sens Spec   
## 1 8 extratrees 0.9771253 0.9559471 0.9130750  
## 1 9 gini 0.9763543 0.9559471 0.9029342  
## 1 11 gini 0.9761272 0.9537445 0.9054680  
## 1 12 gini 0.9762883 0.9520925 0.9054708  
## 1 15 gini 0.9752118 0.9537445 0.9037788  
## 1 27 gini 0.9725587 0.9471366 0.9029342  
## 1 30 extratrees 0.9753971 0.9493392 0.9130693  
## 1 31 extratrees 0.9756892 0.9493392 0.9147557  
## 1 41 gini 0.9705265 0.9388767 0.9020924  
## 1 46 extratrees 0.9735313 0.9465859 0.9130636  
## 1 47 gini 0.9702998 0.9383260 0.9020953  
## 1 48 extratrees 0.9733633 0.9438326 0.9122247  
## 2 4 extratrees 0.9754245 0.9553965 0.8936579  
## 2 5 extratrees 0.9766570 0.9581498 0.8978808  
## 2 19 gini 0.9739214 0.9498899 0.9029370  
## 2 22 extratrees 0.9766568 0.9515419 0.9139168  
## 2 28 gini 0.9718584 0.9449339 0.9046234  
## 2 30 extratrees 0.9754829 0.9498899 0.9105384  
## 2 31 extratrees 0.9753791 0.9487885 0.9130665  
## 2 34 extratrees 0.9754108 0.9504405 0.9130693  
## 2 39 gini 0.9711716 0.9405286 0.9029427  
## 3 3 extratrees 0.9727281 0.9581498 0.8877542  
## 3 3 gini 0.9768726 0.9609031 0.8852261  
## 3 4 gini 0.9775219 0.9603524 0.8911298  
## 3 5 extratrees 0.9760031 0.9570485 0.8961916  
## 3 7 gini 0.9770224 0.9542952 0.9012564  
## 3 9 gini 0.9768317 0.9531938 0.8995672  
## 3 10 gini 0.9759934 0.9542952 0.9012507  
## 3 13 gini 0.9752736 0.9526432 0.9012535  
## 3 18 extratrees 0.9765404 0.9531938 0.9122276  
## 3 22 gini 0.9729504 0.9493392 0.9037845  
## 3 27 gini 0.9721763 0.9443833 0.9046234  
## 3 34 extratrees 0.9752380 0.9504405 0.9105384  
## 3 37 gini 0.9707731 0.9427313 0.9020924  
## 3 41 gini 0.9704583 0.9394273 0.8987197  
## 3 45 extratrees 0.9740772 0.9471366 0.9122276  
## 3 48 extratrees 0.9736162 0.9460352 0.9147585  
## 4 4 gini 0.9776480 0.9609031 0.8919687  
## 4 8 gini 0.9766889 0.9542952 0.9054765  
## 4 10 gini 0.9760317 0.9537445 0.9029427  
## 4 16 gini 0.9744505 0.9509912 0.9004061  
## 4 18 gini 0.9741755 0.9515419 0.9012507  
## 4 23 gini 0.9732413 0.9487885 0.9037845  
## 4 24 gini 0.9725730 0.9476872 0.9054708  
## 4 30 extratrees 0.9751663 0.9515419 0.9080103  
## 4 40 extratrees 0.9742759 0.9487885 0.9122304  
## 4 45 extratrees 0.9742083 0.9498899 0.9096938  
## 4 46 gini 0.9701280 0.9383260 0.9012564  
## 5 36 extratrees 0.9747645 0.9531938 0.9088549  
## 5 38 gini 0.9709644 0.9427313 0.9004118  
## 5 39 extratrees 0.9747098 0.9515419 0.9080074  
## 5 48 extratrees 0.9738004 0.9498899 0.9063183  
## 6 8 extratrees 0.9759971 0.9559471 0.9071628  
## 6 12 gini 0.9754711 0.9531938 0.9012535  
## 6 13 gini 0.9749300 0.9515419 0.9004061  
## 6 15 gini 0.9745491 0.9531938 0.9029342  
## 6 18 extratrees 0.9757450 0.9537445 0.9088549  
## 6 26 gini 0.9721571 0.9487885 0.9020953  
## 6 27 extratrees 0.9751874 0.9542952 0.9105441  
## 6 37 gini 0.9704557 0.9416300 0.8987254  
## 6 42 extratrees 0.9740071 0.9482379 0.9071628  
## 6 45 extratrees 0.9740310 0.9498899 0.9071600  
## 6 46 gini 0.9701053 0.9410793 0.9012535  
## 6 50 extratrees 0.9737719 0.9482379 0.9088492  
## 7 1 extratrees 0.9584442 0.9697137 0.8092723  
## 7 4 extratrees 0.9739261 0.9587004 0.8902880  
## 7 7 extratrees 0.9759617 0.9564978 0.9037902  
## 7 10 gini 0.9757166 0.9531938 0.8970334  
## 7 13 extratrees 0.9763139 0.9564978 0.9122276  
## 7 15 gini 0.9744123 0.9526432 0.8995643  
## 7 21 extratrees 0.9754937 0.9531938 0.9096995  
## 7 25 extratrees 0.9746502 0.9526432 0.9096995  
## 7 41 extratrees 0.9744872 0.9509912 0.9071628  
## 7 49 extratrees 0.9739515 0.9493392 0.9080074  
## 8 3 gini 0.9762159 0.9609031 0.8826924  
## 8 17 gini 0.9740643 0.9520925 0.9004061  
## 8 18 extratrees 0.9752596 0.9559471 0.9080103  
## 8 19 extratrees 0.9751206 0.9548458 0.9105412  
## 8 23 gini 0.9722261 0.9482379 0.8995615  
## 8 25 extratrees 0.9750162 0.9537445 0.9080074  
## 8 26 gini 0.9718490 0.9471366 0.9037816  
## 8 30 gini 0.9714484 0.9482379 0.9004032  
## 8 33 extratrees 0.9744288 0.9520925 0.9071657  
## 8 38 gini 0.9705037 0.9427313 0.9012507  
## 8 40 extratrees 0.9742526 0.9526432 0.9080103  
## 8 40 gini 0.9702588 0.9438326 0.9020981  
## 8 44 gini 0.9700700 0.9432819 0.9004089  
## 8 46 gini 0.9700320 0.9438326 0.9004089  
## 9 5 gini 0.9769016 0.9587004 0.9004089  
## 9 8 gini 0.9760491 0.9548458 0.9020981  
## 9 9 extratrees 0.9759266 0.9564978 0.9071628  
## 9 10 gini 0.9755472 0.9559471 0.8995700  
## 9 11 extratrees 0.9758079 0.9587004 0.9046376  
## 9 13 gini 0.9748057 0.9548458 0.9004089  
## 9 17 gini 0.9738403 0.9531938 0.9012478  
## 9 27 gini 0.9718377 0.9476872 0.8995615  
## 9 29 extratrees 0.9750662 0.9526432 0.9080103  
## 9 32 extratrees 0.9744286 0.9520925 0.9071657  
## 9 35 extratrees 0.9744572 0.9520925 0.9096966  
## 9 43 extratrees 0.9737286 0.9498899 0.9063211  
## 9 43 gini 0.9699255 0.9421806 0.8987226  
## 9 44 extratrees 0.9737188 0.9515419 0.9054737  
## 9 45 extratrees 0.9737395 0.9509912 0.9063154  
## 10 1 extratrees 0.9584528 0.9686123 0.8084277  
## 10 3 gini 0.9760497 0.9614537 0.8801643  
## 10 5 gini 0.9765743 0.9581498 0.8961916  
## 10 9 gini 0.9755595 0.9553965 0.8995643  
## 10 11 gini 0.9748873 0.9537445 0.9004089  
## 10 12 gini 0.9746848 0.9542952 0.8978751  
## 10 17 gini 0.9737998 0.9515419 0.8970306  
## 10 20 gini 0.9728110 0.9493392 0.8970277  
## 10 21 gini 0.9727734 0.9482379 0.9004061  
## 10 22 gini 0.9722850 0.9487885 0.8995643  
## 10 27 extratrees 0.9747006 0.9542952 0.9080103  
## 10 28 extratrees 0.9743396 0.9515419 0.9063239  
## 10 28 gini 0.9712089 0.9482379 0.8995615  
## 10 30 gini 0.9711323 0.9471366 0.8995643  
## 10 31 extratrees 0.9739216 0.9531938 0.9080074  
## 10 36 extratrees 0.9739008 0.9520925 0.9071685  
## 10 45 extratrees 0.9734807 0.9504405 0.9071657  
## 11 2 gini 0.9737824 0.9625551 0.8666564  
## 11 3 gini 0.9763303 0.9614537 0.8793140  
## 11 16 extratrees 0.9748803 0.9559471 0.9054850  
## 11 23 extratrees 0.9742925 0.9526432 0.9029512  
## 11 27 extratrees 0.9744586 0.9520925 0.9063239  
## 11 39 extratrees 0.9738008 0.9520925 0.9063239  
## 11 46 gini 0.9691230 0.9449339 0.8995700  
## 12 2 extratrees 0.9681637 0.9587004 0.8734132  
## 12 4 gini 0.9766023 0.9603524 0.8894349  
## 12 15 gini 0.9735470 0.9520925 0.8944996  
## 12 20 extratrees 0.9750719 0.9559471 0.9063211  
## 12 23 gini 0.9720266 0.9482379 0.9012507  
## 12 40 extratrees 0.9734994 0.9520925 0.9046347  
## 12 42 extratrees 0.9733283 0.9520925 0.9037930  
## 12 47 gini 0.9689523 0.9449339 0.8995672  
## 12 49 extratrees 0.9732877 0.9509912 0.9029427  
## 13 2 extratrees 0.9677902 0.9598018 0.8700377  
## 13 2 gini 0.9738767 0.9636564 0.8649616  
## 13 5 gini 0.9763721 0.9587004 0.8953471  
## 13 7 gini 0.9757533 0.9575991 0.9029399  
## 13 19 extratrees 0.9749394 0.9559471 0.9012621  
## 13 27 gini 0.9710742 0.9471366 0.8995586  
## 13 42 gini 0.9694006 0.9454846 0.8987226  
## 13 48 extratrees 0.9730870 0.9520925 0.9020981  
## 14 4 gini 0.9764233 0.9598018 0.8860679  
## 14 7 extratrees 0.9746436 0.9553965 0.8953471  
## 14 17 gini 0.9732235 0.9537445 0.8961860  
## 14 26 extratrees 0.9737107 0.9542952 0.9021067  
## 14 28 extratrees 0.9736724 0.9548458 0.9012621  
## 14 30 gini 0.9702603 0.9476872 0.8995615  
## 14 32 gini 0.9706343 0.9476872 0.8987197  
## 14 35 extratrees 0.9732800 0.9515419 0.9021067  
## 14 36 extratrees 0.9734599 0.9520925 0.9029427  
## 14 36 gini 0.9699128 0.9471366 0.8987197  
## 14 37 extratrees 0.9734587 0.9504405 0.8995672  
## 14 45 gini 0.9692790 0.9454846 0.8995615  
## 14 46 gini 0.9690711 0.9449339 0.8970362  
## 15 2 gini 0.9737353 0.9653084 0.8674982  
## 15 8 extratrees 0.9746044 0.9564978 0.8945025  
## 15 12 extratrees 0.9746771 0.9559471 0.8978837  
## 15 34 extratrees 0.9732912 0.9542952 0.8995700  
## 15 35 gini 0.9697709 0.9460352 0.8953414  
## 15 41 gini 0.9693690 0.9438326 0.8978780  
## 15 49 gini 0.9687781 0.9427313 0.8970362  
## 16 4 gini 0.9762200 0.9592511 0.8852176  
## 16 5 extratrees 0.9735354 0.9559471 0.8894434  
## 16 7 extratrees 0.9737996 0.9559471 0.8936607  
## 16 10 extratrees 0.9743124 0.9553965 0.8953499  
## 16 11 gini 0.9743280 0.9542952 0.8978780  
## 16 15 extratrees 0.9745103 0.9553965 0.8995700  
## 16 26 gini 0.9709103 0.9454846 0.8953414  
## 16 31 extratrees 0.9733526 0.9537445 0.8953499  
## 16 32 gini 0.9699087 0.9471366 0.8961831  
## 16 38 extratrees 0.9731124 0.9548458 0.8953499  
## 16 39 extratrees 0.9728991 0.9542952 0.8970419  
## 16 40 gini 0.9692541 0.9449339 0.8961831  
## 16 42 gini 0.9691822 0.9449339 0.8987226  
## 16 47 gini 0.9686167 0.9449339 0.8936550  
## 17 1 gini 0.9655214 0.9713656 0.7940839  
## 17 2 extratrees 0.9670453 0.9581498 0.8742521  
## 17 13 extratrees 0.9742685 0.9564978 0.8987311  
## 17 14 extratrees 0.9741977 0.9559471 0.8995700  
## 17 26 extratrees 0.9735883 0.9553965 0.8987283  
## 17 28 extratrees 0.9732870 0.9531938 0.8978837  
## 17 31 gini 0.9702524 0.9460352 0.8953414  
## 17 34 extratrees 0.9732090 0.9548458 0.9004089  
## 17 41 gini 0.9690436 0.9471366 0.8944996  
## 17 43 extratrees 0.9726278 0.9537445 0.8978808  
## 17 46 gini 0.9685432 0.9438326 0.8970306  
## 18 7 extratrees 0.9739411 0.9559471 0.8911326  
## 18 8 extratrees 0.9739612 0.9548458 0.8936607  
## 18 9 gini 0.9745504 0.9526432 0.8987169  
## 18 11 gini 0.9740917 0.9548458 0.8953442  
## 18 12 extratrees 0.9743743 0.9559471 0.8928161  
## 18 12 gini 0.9739359 0.9537445 0.8961888  
## 18 13 extratrees 0.9740860 0.9537445 0.8978808  
## 18 16 gini 0.9727605 0.9548458 0.8953414  
## 18 17 gini 0.9721678 0.9520925 0.8928076  
## 18 20 extratrees 0.9735701 0.9559471 0.8961945  
## 18 20 gini 0.9719067 0.9509912 0.8978723  
## 18 23 extratrees 0.9736832 0.9553965 0.8987283  
## 18 24 extratrees 0.9736719 0.9553965 0.8945053  
## 18 25 gini 0.9708455 0.9465859 0.8919630  
## 18 29 gini 0.9699676 0.9465859 0.8953414  
## 18 31 gini 0.9702447 0.9482379 0.8919630  
## 18 32 gini 0.9700348 0.9454846 0.8944939  
## 18 34 gini 0.9698950 0.9449339 0.8953385  
## 18 35 extratrees 0.9728316 0.9542952 0.8987283  
## 18 36 gini 0.9697263 0.9438326 0.8953414  
## 18 37 extratrees 0.9732911 0.9537445 0.8961945  
## 18 38 extratrees 0.9728820 0.9553965 0.8961945  
## 18 46 gini 0.9687931 0.9432819 0.8953442  
## 18 49 extratrees 0.9726611 0.9542952 0.8945053  
## 18 50 extratrees 0.9723745 0.9564978 0.8945053  
## 19 6 extratrees 0.9734376 0.9553965 0.8928190  
## 19 13 extratrees 0.9738072 0.9553965 0.8953499  
## 19 15 gini 0.9728009 0.9526432 0.8928104  
## 19 20 extratrees 0.9733782 0.9553965 0.8961945  
## 19 21 gini 0.9714926 0.9482379 0.8928047  
## 19 25 extratrees 0.9732609 0.9553965 0.8970391  
## 19 32 extratrees 0.9730861 0.9542952 0.8911269  
## 19 32 gini 0.9701461 0.9465859 0.8902738  
## 19 36 extratrees 0.9727833 0.9548458 0.8945053  
## 19 38 extratrees 0.9729973 0.9559471 0.8885960  
## 20 3 extratrees 0.9702490 0.9564978 0.8852261  
## 20 12 extratrees 0.9738726 0.9548458 0.8928161  
## 20 18 gini 0.9722307 0.9515419 0.8928047  
## 20 21 extratrees 0.9733219 0.9548458 0.8928161  
## 20 30 gini 0.9702514 0.9471366 0.8936522  
## 20 32 extratrees 0.9729526 0.9537445 0.8953499  
## 20 32 gini 0.9698883 0.9465859 0.8902738  
## 20 36 extratrees 0.9728448 0.9553965 0.8885960  
## 20 39 gini 0.9696994 0.9432819 0.8953328  
## 20 41 gini 0.9684530 0.9427313 0.8911155  
##   
## ROC was used to select the optimal model using the largest value.  
## The final values used for the model were mtry = 4, splitrule = gini  
## and min.node.size = 4.

best\_mtry = as.numeric(rf\_model$bestTune[1])  
best\_splitrule = as.character(rf\_model$bestTune[2][1, 1])  
best\_min.node.size = as.numeric(rf\_model$bestTune[3])  
  
rf\_pred = predict(rf\_model, newdata=X\_val, type='prob')  
  
rf\_best\_tune = rf\_model$results %>%   
 arrange(desc(ROC)) %>%   
 head(1)  
rf\_best\_tune

## min.node.size mtry splitrule ROC Sens Spec ROCSD  
## 1 4 4 gini 0.977648 0.9609031 0.8919687 0.00258328  
## SensSD SpecSD  
## 1 0.0136226 0.01978735

### 2-4. xgboost

xgb\_tune\_length = 250  
xgb\_fold\_number = 4  
xgb\_train\_control = trainControl(method='cv',  
 number=xgb\_fold\_number,  
 search='random',  
 classProbs=TRUE,  
 summaryFunction=twoClassSummary)  
  
xgb\_start = Sys.time()  
  
set.seed(student)  
xgb\_model = train(X\_train,  
 factor\_Y\_train,  
 method='xgbTree',  
 trControl=xgb\_train\_control,  
 metric='ROC',  
 tuneLength=xgb\_tune\_length)  
  
xgb\_train\_time = Sys.time() - xgb\_start  
cat('Train time of xgboost model : '); xgb\_train\_time

## Train time of xgboost model :

## Time difference of 37.58226 mins

xgb\_model

## eXtreme Gradient Boosting   
##   
## 3001 samples  
## 50 predictor  
## 2 classes: 'no', 'yes'   
##   
## No pre-processing  
## Resampling: Cross-Validated (4 fold)   
## Summary of sample sizes: 2251, 2251, 2251, 2250   
## Resampling results across tuning parameters:  
##   
## eta max\_depth gamma colsample\_bytree min\_child\_weight  
## 0.003162401 8 6.24760519 0.5801091 14   
## 0.003772681 4 6.61588294 0.4234561 20   
## 0.010055444 10 7.05617877 0.5783279 10   
## 0.014970712 9 0.93920842 0.4962853 0   
## 0.020804329 6 1.65946065 0.3933239 10   
## 0.020844658 5 7.79622232 0.6077618 20   
## 0.025295388 6 7.75608970 0.4685930 3   
## 0.025772216 10 1.66117204 0.4002752 2   
## 0.028281430 3 0.54911478 0.6202270 2   
## 0.028394415 6 8.64004377 0.3393719 19   
## 0.030477991 4 3.43562953 0.3334304 4   
## 0.032658118 6 6.75360848 0.6612491 12   
## 0.036659912 6 6.49047246 0.5996854 13   
## 0.038636930 4 1.16803854 0.4631461 20   
## 0.041004875 6 6.52901942 0.6616355 16   
## 0.043127533 10 2.86957413 0.6376104 9   
## 0.047085109 10 9.39278585 0.5530308 8   
## 0.047368171 1 1.34961052 0.5041353 0   
## 0.047625949 10 6.93514612 0.4098479 2   
## 0.048058414 8 6.67686160 0.5099935 19   
## 0.048076927 7 1.84295015 0.5095569 0   
## 0.051135656 9 1.90315590 0.4301961 0   
## 0.057965790 10 0.85166025 0.4719702 4   
## 0.058105893 2 2.50092027 0.3282733 10   
## 0.059784900 5 1.83214942 0.4886037 11   
## 0.066179960 8 0.46792364 0.5911241 16   
## 0.066678968 4 0.22814452 0.5966858 9   
## 0.070711628 7 3.45979620 0.5875875 15   
## 0.077914400 2 9.40321965 0.5356733 19   
## 0.084348746 6 4.60885584 0.4610438 7   
## 0.085290891 9 7.67236656 0.6408977 18   
## 0.087191858 4 3.95324937 0.3576732 1   
## 0.089966617 3 3.67002763 0.3849028 10   
## 0.090457556 8 8.76813074 0.6090557 18   
## 0.092576543 9 1.45373630 0.3281601 0   
## 0.093481877 5 1.63616264 0.5475397 8   
## 0.093621261 4 7.72127820 0.6560822 11   
## 0.094284776 2 5.95160517 0.4233034 5   
## 0.095910154 8 7.11898276 0.3228292 4   
## 0.098965368 5 2.55264180 0.6281050 4   
## 0.102734212 2 9.45088786 0.6856150 18   
## 0.106477063 3 5.11218311 0.4446591 20   
## 0.110059279 9 0.76028419 0.4145431 19   
## 0.112262744 1 8.22080142 0.3500781 6   
## 0.113189466 4 8.30895265 0.6366700 2   
## 0.113347663 2 3.46126357 0.3849333 9   
## 0.113776930 1 0.18772293 0.3431707 8   
## 0.116046734 10 7.97290936 0.4988069 3   
## 0.121623153 10 8.99479100 0.6740354 15   
## 0.129341721 5 2.78804725 0.6470802 5   
## 0.130472694 5 4.24546094 0.6257792 19   
## 0.131588640 4 7.73009988 0.6119831 0   
## 0.136260493 6 0.86628598 0.6570410 8   
## 0.141983739 9 5.61971961 0.6075141 13   
## 0.145300789 6 1.62549625 0.5758839 1   
## 0.150827255 6 1.57177476 0.3586940 13   
## 0.153342680 8 1.60561231 0.5601894 16   
## 0.161580500 4 9.77697303 0.5330208 3   
## 0.164874345 3 3.25447457 0.5425517 13   
## 0.165883549 1 3.06860036 0.4788350 14   
## 0.170523359 3 9.51717332 0.3065639 12   
## 0.174421087 1 7.43759832 0.4767042 9   
## 0.176473997 2 8.13748557 0.3171131 19   
## 0.180450606 5 7.37585068 0.6861738 13   
## 0.182366456 1 6.41601969 0.6447120 19   
## 0.182517349 3 4.35140274 0.5249108 17   
## 0.182943979 7 9.56085554 0.6135689 16   
## 0.183517543 8 2.18446129 0.3828614 9   
## 0.190125063 8 3.60847220 0.4812633 11   
## 0.191173180 8 3.20629044 0.6259555 10   
## 0.191358930 9 7.92469615 0.4324632 6   
## 0.191538933 2 9.44503428 0.6429478 2   
## 0.192688620 1 2.16221588 0.3668833 9   
## 0.197624994 5 3.82526554 0.6139249 13   
## 0.201073671 9 2.23495577 0.5254012 18   
## 0.202307259 9 8.55153976 0.3224199 18   
## 0.212261750 2 1.80049218 0.3827510 18   
## 0.214394074 8 3.52155148 0.5973163 17   
## 0.217517502 9 1.53735256 0.4192060 2   
## 0.219715033 4 0.91193348 0.6773200 11   
## 0.220108068 7 3.60838362 0.5993510 4   
## 0.221051019 9 4.45017811 0.5012413 19   
## 0.221519965 7 3.94052061 0.4542799 8   
## 0.227254054 9 2.84223842 0.6614081 3   
## 0.228249423 10 3.83276288 0.4952049 13   
## 0.228440457 8 1.45085871 0.3113043 19   
## 0.230610992 3 2.63985248 0.5452709 19   
## 0.232502981 6 5.07756892 0.4536220 10   
## 0.238408809 7 6.31888389 0.4602467 3   
## 0.239399892 9 8.72096784 0.4799285 12   
## 0.239429452 4 1.96004239 0.5118257 1   
## 0.240091918 1 8.47628095 0.4389267 14   
## 0.243289776 7 8.58486690 0.5286559 6   
## 0.244413209 2 1.95157892 0.3276834 5   
## 0.245275566 3 0.29569933 0.4094850 2   
## 0.248075314 6 2.40107787 0.6816361 17   
## 0.252556991 5 6.03446694 0.5754447 1   
## 0.254104333 9 3.83148490 0.3337395 8   
## 0.261319332 2 3.32256717 0.5992790 6   
## 0.261327387 10 2.61754094 0.6696850 3   
## 0.262989406 6 9.37828478 0.3709415 18   
## 0.266108101 2 6.95684860 0.6250992 18   
## 0.270690461 4 8.44378479 0.5796485 15   
## 0.271079687 5 1.53245512 0.3829155 12   
## 0.273893720 2 8.01347438 0.6995006 6   
## 0.279538335 9 0.15820089 0.5098061 17   
## 0.282360751 7 8.18717100 0.3901306 1   
## 0.283342106 7 7.84010401 0.5944586 4   
## 0.283651597 6 0.79111249 0.6157686 9   
## 0.285822465 10 0.40824783 0.6229261 8   
## 0.292660664 7 0.45402696 0.3125613 20   
## 0.294080899 7 9.37018806 0.5623021 19   
## 0.295232086 10 4.07030847 0.6088974 6   
## 0.299267582 7 0.43452730 0.4178012 10   
## 0.302104820 9 9.94632943 0.5539459 12   
## 0.302683774 8 4.66665863 0.5452198 5   
## 0.304787040 4 7.52200829 0.6180941 8   
## 0.305153281 5 9.52626684 0.5346875 2   
## 0.306207650 2 2.74482795 0.5175898 8   
## 0.310690586 5 7.98007572 0.6749888 0   
## 0.312675592 1 8.33673987 0.3714922 12   
## 0.318331068 9 2.61416577 0.4392823 3   
## 0.328908448 9 6.26908346 0.6835113 4   
## 0.331790909 2 5.44147819 0.3338149 4   
## 0.336486342 9 2.51665641 0.3073931 9   
## 0.338843076 10 6.93645354 0.3663283 9   
## 0.341108968 4 1.80670185 0.3405143 2   
## 0.341180760 2 5.58697578 0.4210884 4   
## 0.344160597 10 9.71346593 0.5241435 16   
## 0.344627270 5 8.90493646 0.3244928 1   
## 0.346752412 9 3.08180988 0.4036156 9   
## 0.353998438 7 2.58884160 0.4848948 9   
## 0.356178088 10 6.81482604 0.3283932 4   
## 0.360526662 4 0.31949612 0.3143752 12   
## 0.365288586 6 5.54364107 0.6679549 19   
## 0.367404930 8 8.24683464 0.3809155 1   
## 0.369373946 10 6.09760862 0.4146627 15   
## 0.372963858 3 2.00914155 0.5470490 1   
## 0.374848758 3 4.67942412 0.4287230 15   
## 0.381000331 3 7.62688132 0.6759038 9   
## 0.381111989 10 0.01147353 0.4874289 15   
## 0.381364928 2 0.34764078 0.3214538 4   
## 0.381968252 5 2.08955765 0.3792950 9   
## 0.385307475 8 6.12573601 0.5158651 18   
## 0.386446539 5 5.85885617 0.4973959 3   
## 0.389067848 7 2.88759429 0.3643774 3   
## 0.390808474 3 9.70125428 0.6897417 16   
## 0.391372319 1 2.08921379 0.5544679 2   
## 0.398469438 5 2.22094654 0.4091360 6   
## 0.400532509 7 2.85998647 0.6990525 2   
## 0.402713171 8 3.59112705 0.3859219 4   
## 0.402795984 9 5.41401475 0.3951754 20   
## 0.404832100 3 2.21283609 0.5748748 18   
## 0.405350124 5 3.21483128 0.5070411 1   
## 0.410722879 8 5.41581423 0.4801387 10   
## 0.412817199 7 6.96196076 0.3084115 1   
## 0.412946775 7 2.05103020 0.4227604 7   
## 0.415650277 8 7.89568476 0.6873321 5   
## 0.415870834 5 4.86218392 0.5344250 4   
## 0.416564668 4 0.32183095 0.6544047 15   
## 0.422701739 6 9.47426436 0.6299010 5   
## 0.428270570 7 9.26207341 0.3146178 0   
## 0.433452943 2 9.54198456 0.3122412 11   
## 0.433593360 6 1.86617849 0.6783123 11   
## 0.435147120 5 4.81965402 0.5772429 16   
## 0.435650893 6 3.01520164 0.6783683 11   
## 0.436252462 7 3.10409173 0.5381170 14   
## 0.437691165 8 3.66917381 0.5240935 8   
## 0.438131575 2 1.41715187 0.6236802 7   
## 0.438328421 10 6.80084559 0.4449307 18   
## 0.438881519 5 7.28577327 0.5081880 17   
## 0.439595816 2 3.42201103 0.5534855 20   
## 0.439771834 7 4.15710946 0.3945006 14   
## 0.442776859 10 4.89699683 0.3675547 4   
## 0.443314542 5 4.51692746 0.4550671 15   
## 0.443620831 6 0.95468358 0.3087938 4   
## 0.444862845 4 7.53930588 0.3713851 12   
## 0.445290408 4 4.34777167 0.6071416 10   
## 0.445723545 4 8.06805354 0.3782449 4   
## 0.448168694 2 7.84095191 0.3606035 3   
## 0.449483823 5 1.58587692 0.5296931 8   
## 0.458040618 6 1.14880590 0.3651622 2   
## 0.463484835 4 5.16039517 0.6753816 11   
## 0.464308302 8 0.10842420 0.5283060 4   
## 0.472063938 6 7.71772052 0.6587232 12   
## 0.474225324 1 6.15693489 0.6301274 2   
## 0.474810207 6 3.52747044 0.3834884 8   
## 0.476156402 8 8.34016160 0.5960799 20   
## 0.482796607 6 4.88841511 0.4523527 16   
## 0.485186332 7 6.10769853 0.3764435 9   
## 0.485759368 8 9.18629622 0.5866220 7   
## 0.486530463 2 9.73060291 0.5476236 6   
## 0.486615327 10 4.67705007 0.4846052 15   
## 0.488727422 1 3.28473516 0.4961510 18   
## 0.488776395 8 3.82871546 0.6375286 11   
## 0.490679582 6 1.26948260 0.3822703 7   
## 0.492238671 10 7.24702194 0.4557542 4   
## 0.492562520 10 2.74174372 0.4605131 12   
## 0.498732634 5 0.06506628 0.5406382 17   
## 0.502159385 10 0.75613649 0.5959983 19   
## 0.503930993 3 8.06156577 0.6734676 20   
## 0.507615788 7 9.76879822 0.6331103 0   
## 0.511085240 1 9.21813274 0.4235706 3   
## 0.512146750 7 9.56207398 0.6478747 12   
## 0.512911239 9 6.10277923 0.4124502 3   
## 0.514118237 8 7.32311328 0.6367724 8   
## 0.515126525 2 3.34504357 0.4437366 10   
## 0.519578579 9 5.26802459 0.5234344 5   
## 0.519917352 3 3.23075737 0.3398880 8   
## 0.520984347 10 4.59657741 0.4787273 11   
## 0.521212427 8 1.10693632 0.5218775 18   
## 0.521926003 2 7.13590341 0.4945367 10   
## 0.522181928 10 1.25855532 0.3113836 2   
## 0.527469899 6 5.88557735 0.6744387 11   
## 0.530477827 10 3.31822331 0.6825428 6   
## 0.532370910 4 5.50727530 0.3986675 13   
## 0.536369127 10 6.98164746 0.6722343 0   
## 0.537377140 9 2.19319570 0.5042724 20   
## 0.537609786 5 8.35352615 0.6012900 11   
## 0.538069766 6 4.56805210 0.5961509 20   
## 0.539932809 9 5.74473016 0.6616734 20   
## 0.548630099 1 1.05612465 0.3050119 16   
## 0.551224942 8 9.45455338 0.6095882 4   
## 0.553403764 10 1.94536112 0.4572570 17   
## 0.553612190 10 9.48173554 0.6411755 0   
## 0.554912444 7 8.25710862 0.3749502 13   
## 0.558033984 3 1.92197852 0.5586998 17   
## 0.558034667 1 5.06970273 0.6646948 17   
## 0.561721576 10 9.13029639 0.4925060 9   
## 0.567426379 5 1.91721581 0.5026780 6   
## 0.569857583 9 7.53300016 0.5669255 8   
## 0.572150881 6 8.15468259 0.3480359 2   
## 0.573714194 4 3.21084551 0.4264396 9   
## 0.578853306 9 8.18095719 0.5620705 0   
## 0.579110125 5 3.92687776 0.5418382 6   
## 0.579736555 1 0.60754874 0.4823639 6   
## 0.580955909 2 8.22384715 0.4781558 16   
## 0.581157832 8 5.94271129 0.6694244 5   
## 0.581245017 10 0.83577247 0.4739408 17   
## 0.581943249 5 0.84227641 0.4854101 11   
## 0.582880624 8 3.75300547 0.6170300 6   
## 0.583576490 4 0.13562291 0.5345779 7   
## 0.584278606 6 4.99720931 0.5351989 18   
## 0.585466603 9 8.71908998 0.5347536 0   
## 0.588637529 2 5.98528852 0.5136624 1   
## 0.590490627 5 7.50474933 0.5259274 16   
## 0.593688260 6 5.96629055 0.6408123 8   
## 0.595755926 5 3.89256571 0.3320222 7   
## 0.597496651 9 9.88024535 0.4597084 0   
## 0.597698459 3 5.67507096 0.4061154 19   
## subsample nrounds ROC Sens Spec   
## 0.4984862 978 0.9604428 0.9509912 0.8320593  
## 0.9943286 2 0.9028131 0.9405286 0.7071560  
## 0.9478736 412 0.9700330 0.9531938 0.8599082  
## 0.3785029 434 0.9782073 0.9575991 0.8911212  
## 0.7131799 495 0.9701427 0.9515419 0.8683399  
## 0.6398577 739 0.9603300 0.9493392 0.8354349  
## 0.6942000 383 0.9716697 0.9575991 0.8700348  
## 0.4411925 793 0.9769770 0.9504405 0.8970334  
## 0.8629352 657 0.9772698 0.9564978 0.8919601  
## 0.6337453 571 0.9592391 0.9542952 0.8261500  
## 0.8495050 374 0.9745549 0.9553965 0.8809946  
## 0.6704471 814 0.9682672 0.9493392 0.8548378  
## 0.4559108 778 0.9628237 0.9504405 0.8379630  
## 0.4402470 931 0.9531677 0.9427313 0.8227546  
## 0.8870326 601 0.9681848 0.9537445 0.8539960  
## 0.4950864 241 0.9683015 0.9498899 0.8615889  
## 0.9816190 216 0.9721109 0.9553965 0.8666507  
## 0.2709786 611 0.9689293 0.9515419 0.8632781  
## 0.9185029 24 0.9662804 0.9598018 0.8396465  
## 0.8860929 443 0.9663975 0.9509912 0.8506262  
## 0.6065019 11 0.9591930 0.9559471 0.8337343  
## 0.6286650 259 0.9792114 0.9575991 0.9054708  
## 0.2783548 411 0.9698602 0.9421806 0.8717297  
## 0.3044215 659 0.9585732 0.9465859 0.8396436  
## 0.7012202 403 0.9697958 0.9482379 0.8641198  
## 0.8748592 904 0.9681894 0.9432819 0.8734132  
## 0.4227573 959 0.9658536 0.9449339 0.8649729  
## 0.7586179 244 0.9672870 0.9498899 0.8607386  
## 0.8977084 342 0.9625640 0.9548458 0.8379601  
## 0.3098797 455 0.9651908 0.9487885 0.8539932  
## 0.9636335 287 0.9673228 0.9493392 0.8531514  
## 0.6186687 478 0.9760397 0.9581498 0.8826781  
## 0.4757685 609 0.9658666 0.9504405 0.8548378  
## 0.2531411 606 0.9238766 0.9223568 0.7898353  
## 0.9524782 338 0.9800166 0.9548458 0.9029370  
## 0.2745587 477 0.9627344 0.9460352 0.8506234  
## 0.8749439 537 0.9704773 0.9559471 0.8624335  
## 0.6360178 974 0.9721609 0.9564978 0.8675039  
## 0.6411709 204 0.9731561 0.9620044 0.8708709  
## 0.9672182 538 0.9769304 0.9537445 0.8944968  
## 0.6196925 85 0.9577942 0.9526432 0.8278250  
## 0.9835688 882 0.9662834 0.9537445 0.8455586  
## 0.5282920 484 0.9604934 0.9449339 0.8404882  
## 0.4335527 477 0.9642545 0.9553965 0.8413357  
## 0.3249729 703 0.9695679 0.9504405 0.8641170  
## 0.2971718 154 0.9573904 0.9487885 0.8337457  
## 0.4970714 656 0.9638686 0.9487885 0.8455558  
## 0.4003076 343 0.9712084 0.9581498 0.8658090  
## 0.2918808 324 0.9414865 0.9366740 0.8084107  
## 0.2706054 317 0.9667613 0.9460352 0.8615889  
## 0.2704341 822 0.9308278 0.9278634 0.7906884  
## 0.5365296 154 0.9725537 0.9564978 0.8658147  
## 0.6701173 937 0.9696082 0.9377753 0.8852148  
## 0.7758361 978 0.9696107 0.9476872 0.8683399  
## 0.5419917 136 0.9771657 0.9520925 0.8995586  
## 0.6470938 155 0.9665473 0.9520925 0.8523012  
## 0.6093814 510 0.9641347 0.9460352 0.8615832  
## 0.4236007 189 0.9684809 0.9570485 0.8497731  
## 0.7454909 234 0.9684763 0.9520925 0.8615860  
## 0.5787556 732 0.9603166 0.9509912 0.8413413  
## 0.6141427 885 0.9645587 0.9526432 0.8404967  
## 0.5713920 478 0.9634578 0.9564978 0.8396607  
## 0.3972942 633 0.9413816 0.9416300 0.7974509  
## 0.7884612 446 0.9683785 0.9531938 0.8607386  
## 0.6083150 834 0.9561574 0.9498899 0.8219384  
## 0.8209034 313 0.9669249 0.9526432 0.8539904  
## 0.8245549 978 0.9665048 0.9493392 0.8514679  
## 0.7344264 326 0.9708570 0.9482379 0.8776191  
## 0.6116227 816 0.9675204 0.9465859 0.8658090  
## 0.8270562 757 0.9704303 0.9487885 0.8784722  
## 0.9935951 97 0.9722591 0.9548458 0.8717012  
## 0.9083092 191 0.9697117 0.9587004 0.8590608  
## 0.4021018 39 0.9539350 0.9636564 0.7856379  
## 0.4621743 362 0.9625683 0.9493392 0.8506234  
## 0.7158537 48 0.9643262 0.9493392 0.8506148  
## 0.2874599 854 0.9304040 0.9328194 0.7805675  
## 0.8790622 896 0.9661999 0.9515419 0.8632724  
## 0.7573586 919 0.9668237 0.9471366 0.8607500  
## 0.8079802 622 0.9763358 0.9471366 0.9029370  
## 0.9068991 7 0.9533852 0.9449339 0.8117976  
## 0.3386532 368 0.9696932 0.9410793 0.8793054  
## 0.4331008 888 0.9527987 0.9388767 0.8101112  
## 0.6866188 382 0.9702300 0.9454846 0.8750910  
## 0.8912380 785 0.9772281 0.9460352 0.9079989  
## 0.8907587 907 0.9694019 0.9476872 0.8700291  
## 0.9152197 350 0.9666700 0.9449339 0.8548378  
## 0.8917670 795 0.9675507 0.9531938 0.8548349  
## 0.5609355 636 0.9670362 0.9471366 0.8607443  
## 0.6788821 411 0.9752398 0.9542952 0.8801443  
## 0.4522199 731 0.9624550 0.9454846 0.8480924  
## 0.3768874 291 0.9750191 0.9399780 0.9012478  
## 0.7375249 298 0.9616176 0.9542952 0.8421802  
## 0.5927981 635 0.9708531 0.9515419 0.8708766  
## 0.4303513 482 0.9690057 0.9421806 0.8666451  
## 0.4673342 755 0.9695768 0.9333700 0.8936522  
## 0.5106929 503 0.9587415 0.9399780 0.8531514  
## 0.3348337 753 0.9723337 0.9487885 0.8759299  
## 0.6558277 631 0.9695012 0.9465859 0.8759470  
## 0.4984689 670 0.9695619 0.9465859 0.8717069  
## 0.5511301 929 0.9728388 0.9443833 0.8894349  
## 0.8015452 868 0.9657031 0.9526432 0.8489285  
## 0.7701064 830 0.9648246 0.9520925 0.8464089  
## 0.6091050 606 0.9631205 0.9504405 0.8388104  
## 0.9396685 373 0.9701763 0.9421806 0.8683371  
## 0.7724563 759 0.9712457 0.9570485 0.8717098  
## 0.4142691 760 0.9505152 0.9295154 0.8303616  
## 0.7688655 466 0.9742306 0.9548458 0.8767717  
## 0.7078483 996 0.9736613 0.9515419 0.8818364  
## 0.4350873 774 0.9618147 0.9361233 0.8691817  
## 0.8883184 714 0.9694572 0.9361233 0.8911298  
## 0.6122504 784 0.9557972 0.9383260 0.8396436  
## 0.7864334 151 0.9633565 0.9493392 0.8405053  
## 0.9364254 588 0.9742362 0.9493392 0.8877571  
## 0.8068470 437 0.9686749 0.9377753 0.8759299  
## 0.4524729 362 0.9617458 0.9482379 0.8337571  
## 0.6270009 151 0.9726015 0.9487885 0.8826810  
## 0.3984041 562 0.9648370 0.9438326 0.8666564  
## 0.8943969 667 0.9736621 0.9553965 0.8691931  
## 0.6938676 653 0.9691445 0.9438326 0.8691732  
## 0.4058937 188 0.9713274 0.9564978 0.8733961  
## 0.8517535 175 0.9639054 0.9553965 0.8464032  
## 0.4539713 747 0.9704148 0.9394273 0.8877485  
## 0.6584902 35 0.9731286 0.9526432 0.8818392  
## 0.8049138 352 0.9729187 0.9553965 0.8750825  
## 0.5081298 675 0.9654703 0.9388767 0.8717268  
## 0.9890698 853 0.9718771 0.9564978 0.8750910  
## 0.8493523 939 0.9756294 0.9454846 0.8995672  
## 0.3331379 807 0.9680197 0.9482379 0.8658204  
## 0.8893250 131 0.9665539 0.9498899 0.8540046  
## 0.7673728 664 0.9740763 0.9548458 0.8767830  
## 0.9909768 769 0.9727237 0.9509912 0.8767802  
## 0.2733526 192 0.9563440 0.9372247 0.8362709  
## 0.7502435 74 0.9716272 0.9443833 0.8691817  
## 0.6043654 191 0.9642816 0.9427313 0.8582190  
## 0.3293123 328 0.9383821 0.9256608 0.7949142  
## 0.7583356 187 0.9742418 0.9542952 0.8835284  
## 0.3149696 850 0.9460143 0.9350220 0.8016767  
## 0.7981260 719 0.9764126 0.9509912 0.9020896  
## 0.7268408 793 0.9652703 0.9504405 0.8531458  
## 0.6519996 468 0.9680505 0.9581498 0.8624278  
## 0.5732399 645 0.9581697 0.9339207 0.8489228  
## 0.5827287 944 0.9672845 0.9317181 0.8860537  
## 0.3684242 594 0.9605982 0.9355727 0.8447169  
## 0.3405794 285 0.9366675 0.9245595 0.8016767  
## 0.4753902 249 0.9711728 0.9460352 0.8835142  
## 0.8481989 920 0.9744712 0.9383260 0.9046319  
## 0.4020672 339 0.9522617 0.9432819 0.8168680  
## 0.7214778 366 0.9716103 0.9443833 0.8860565  
## 0.7952486 219 0.9709109 0.9410793 0.8835426  
## 0.4074903 720 0.9702113 0.9322687 0.8885875  
## 0.7620901 113 0.9735804 0.9416300 0.8809946  
## 0.5864270 789 0.9589441 0.9454846 0.8379516  
## 0.7549346 753 0.9645413 0.9454846 0.8556881  
## 0.3059921 562 0.9697910 0.9350220 0.8902738  
## 0.4825954 569 0.9637931 0.9438326 0.8497788  
## 0.3041012 921 0.9702858 0.9476872 0.8750882  
## 0.5973081 792 0.9682261 0.9366740 0.8759413  
## 0.4069246 393 0.9699450 0.9504405 0.8666479  
## 0.4926298 227 0.9712383 0.9454846 0.8818307  
## 0.8047344 737 0.9602912 0.9339207 0.8607443  
## 0.8613520 250 0.9725551 0.9526432 0.8801500  
## 0.2624687 786 0.9671290 0.9460352 0.8556824  
## 0.9916295 576 0.9660429 0.9515419 0.8540046  
## 0.7424129 958 0.9676361 0.9394273 0.8717155  
## 0.5209607 263 0.9586782 0.9399780 0.8379743  
## 0.2955219 357 0.9514974 0.9355727 0.8278335  
## 0.9562869 343 0.9678634 0.9421806 0.8759413  
## 0.8907160 127 0.9720193 0.9410793 0.8869068  
## 0.9915897 636 0.9719206 0.9509912 0.8784552  
## 0.5903805 257 0.9588001 0.9443833 0.8295255  
## 0.4420878 727 0.9525208 0.9394273 0.8244694  
## 0.8227731 382 0.9638398 0.9476872 0.8523040  
## 0.7617234 671 0.9666513 0.9427313 0.8632951  
## 0.5582171 914 0.9715167 0.9421806 0.8869039  
## 0.8423417 833 0.9679472 0.9482379 0.8641255  
## 0.7165938 654 0.9705838 0.9377753 0.8970362  
## 0.6986699 73 0.9654802 0.9476872 0.8565298  
## 0.8856143 887 0.9703184 0.9520925 0.8750910  
## 0.4106850 657 0.9678596 0.9482379 0.8649644  
## 0.4021856 831 0.9702001 0.9515419 0.8708709  
## 0.6386631 212 0.9677519 0.9416300 0.8708595  
## 0.5014179 784 0.9707683 0.9394273 0.8944968  
## 0.5531200 876 0.9642519 0.9432819 0.8598997  
## 0.9990956 998 0.9718385 0.9405286 0.8928104  
## 0.6365729 439 0.9652078 0.9482379 0.8573716  
## 0.8607641 212 0.9692344 0.9559471 0.8658118  
## 0.9131800 483 0.9716245 0.9504405 0.8784665  
## 0.6976634 938 0.9619475 0.9421806 0.8480867  
## 0.7380738 991 0.9637244 0.9438326 0.8489313  
## 0.5328300 479 0.9666984 0.9421806 0.8506319  
## 0.5020806 950 0.9664608 0.9454846 0.8641170  
## 0.3655906 178 0.9635589 0.9515419 0.8463975  
## 0.2875087 6 0.9323741 0.9383260 0.7746724  
## 0.7807210 657 0.9598120 0.9487885 0.8421831  
## 0.4921954 397 0.9638734 0.9394273 0.8573602  
## 0.9921217 545 0.9724647 0.9460352 0.8894434  
## 0.2914400 42 0.9631791 0.9454846 0.8506091  
## 0.4335170 790 0.9598720 0.9460352 0.8489398  
## 0.5715892 973 0.9560532 0.9300661 0.8472364  
## 0.2835388 116 0.9268440 0.9240088 0.7780479  
## 0.4186721 927 0.9436113 0.9295154 0.8177098  
## 0.6067632 896 0.9710460 0.9465859 0.8717098  
## 0.4180414 630 0.9665445 0.9487885 0.8590636  
## 0.7178620 984 0.9673776 0.9427313 0.8598997  
## 0.4777972 418 0.9709185 0.9460352 0.8818364  
## 0.2819084 49 0.9578221 0.9410793 0.8354406  
## 0.8989874 538 0.9698943 0.9498899 0.8632809  
## 0.5979698 123 0.9710713 0.9498899 0.8725544  
## 0.9959409 71 0.9693485 0.9487885 0.8674868  
## 0.5141139 260 0.9614118 0.9438326 0.8556994  
## 0.6744028 615 0.9586619 0.9317181 0.8539790  
## 0.7886334 372 0.9684779 0.9548458 0.8624306  
## 0.5012306 745 0.9661658 0.9372247 0.8869011  
## 0.2760070 486 0.9512998 0.9388767 0.8185373  
## 0.9198047 676 0.9724535 0.9443833 0.8868954  
## 0.3255132 907 0.9481086 0.9284141 0.8252940  
## 0.7636267 947 0.9753839 0.9526432 0.9046205  
## 0.5434615 125 0.9575056 0.9388767 0.8362681  
## 0.9748352 455 0.9693164 0.9548458 0.8666507  
## 0.2901894 970 0.9306232 0.9196035 0.7966233  
## 0.5936539 658 0.9577920 0.9383260 0.8303815  
## 0.3608154 504 0.9414194 0.9361233 0.8058854  
## 0.8996124 558 0.9728575 0.9487885 0.8869011  
## 0.3271226 832 0.9320916 0.9212555 0.7898353  
## 0.3806973 596 0.9690043 0.9394273 0.8708623  
## 0.9102493 223 0.9674028 0.9476872 0.8607500  
## 0.4496784 430 0.9526901 0.9366740 0.8404825  
## 0.5173806 579 0.9531849 0.9443833 0.8143314  
## 0.4987937 16 0.9609967 0.9432819 0.8447197  
## 0.2716956 884 0.9503558 0.9284141 0.8371155  
## 0.8662236 515 0.9703586 0.9515419 0.8624249  
## 0.2529663 728 0.9646749 0.9383260 0.8632695  
## 0.8565613 873 0.9697788 0.9460352 0.8810032  
## 0.3911531 492 0.9687095 0.9432819 0.8725657  
## 0.7006478 338 0.9666493 0.9405286 0.8700263  
## 0.9589896 532 0.9704559 0.9454846 0.8826895  
## 0.3540248 196 0.9426945 0.9284141 0.7974565  
## 0.9715451 617 0.9732433 0.9460352 0.8911212  
## 0.9360080 446 0.9643865 0.9355727 0.8607528  
## 0.5973216 812 0.9567413 0.9262115 0.8573687  
## 0.4179233 994 0.9614766 0.9399780 0.8641255  
## 0.2923390 319 0.9475787 0.9223568 0.8430277  
## 0.8295151 448 0.9642556 0.9465859 0.8514537  
## 0.4929378 309 0.9714257 0.9454846 0.8793197  
## 0.4862327 880 0.9685645 0.9388767 0.8683342  
## 0.8744150 426 0.9652991 0.9471366 0.8548463  
## 0.6401431 703 0.9695288 0.9493392 0.8733904  
## 0.7746056 397 0.9686098 0.9399780 0.8801500  
## 0.4922099 600 0.9713895 0.9465859 0.8810145  
## 0.3803958 154 0.9396919 0.9295154 0.8008150  
##   
## ROC was used to select the optimal model using the largest value.  
## The final values used for the model were nrounds = 338, max\_depth = 9, eta  
## = 0.09257654, gamma = 1.453736, colsample\_bytree = 0.3281601,  
## min\_child\_weight = 0 and subsample = 0.9524782.

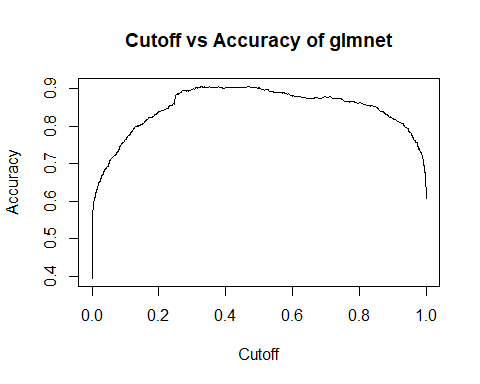
best\_nrounds = as.numeric(xgb\_model$bestTune[1])  
best\_max\_depth = as.numeric(xgb\_model$bestTune[2])  
best\_eta = as.numeric(xgb\_model$bestTune[3])  
best\_gamma = as.numeric(xgb\_model$bestTune[4])  
best\_colsample\_bytree = as.numeric(xgb\_model$bestTune[5])  
best\_min\_child\_weight = as.numeric(xgb\_model$bestTune[6])  
best\_subsample = as.numeric(xgb\_model$bestTune[7])  
  
xgb\_pred = predict(xgb\_model, newdata=X\_val, type='prob')  
  
xgb\_best\_tune = xgb\_model$results %>%   
 arrange(desc(ROC)) %>%   
 head(1)  
xgb\_best\_tune

## eta max\_depth gamma colsample\_bytree min\_child\_weight subsample  
## 1 0.09257654 9 1.453736 0.3281601 0 0.9524782  
## nrounds ROC Sens Spec ROCSD SensSD SpecSD  
## 1 338 0.9800166 0.9548458 0.902937 0.005578064 0.014218 0.01374313

## 3. evaluate the models

### 3-1. glmnet

glmnet\_prediction = prediction(glmnet\_pred['yes'], Y\_val)  
glmnet\_performance\_auc = performance(glmnet\_prediction, 'auc', 'cutoff')  
glmnet\_performance\_acc = performance(glmnet\_prediction, 'acc', 'cutoff')  
plot(glmnet\_performance\_acc, main='Cutoff vs Accuracy of glmnet')

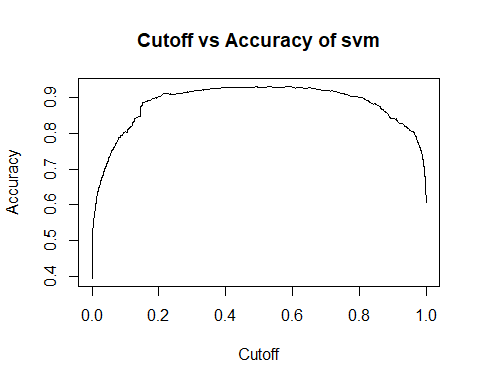


glmnet\_auc = glmnet\_performance\_auc@y.values[[1]]  
glmnet\_acc = max(glmnet\_performance\_acc@y.values[[1]])  
glmnet\_cutoff = glmnet\_performance\_acc@x.values[[1]][which.max(glmnet\_performance\_acc@y.values[[1]])]  
  
cat(' AUC of glmnet :', glmnet\_auc,  
 '\n Max Accuracy of glmnet :', glmnet\_acc,  
 '\n Cutoff of maximum accuracy of glmnet :', glmnet\_cutoff)

## AUC of glmnet : 0.9628162   
## Max Accuracy of glmnet : 0.9059059   
## Cutoff of maximum accuracy of glmnet : 0.326344

### 3-2. support vector machine with rbf kernel

svm\_prediction = prediction(svm\_pred['yes'], Y\_val)  
svm\_performance\_auc = performance(svm\_prediction, 'auc', 'cutoff')  
svm\_performance\_acc = performance(svm\_prediction, 'acc', 'cutoff')  
plot(svm\_performance\_acc, main='Cutoff vs Accuracy of svm')

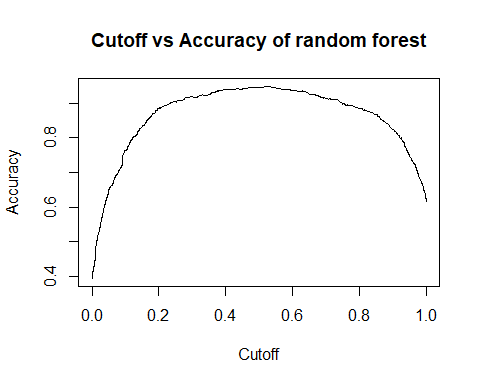


svm\_auc = svm\_performance\_auc@y.values[[1]]  
svm\_acc = max(svm\_performance\_acc@y.values[[1]])  
svm\_cutoff = svm\_performance\_acc@x.values[[1]][which.max(svm\_performance\_acc@y.values[[1]])]  
  
cat(' AUC of svm :', svm\_auc,  
 '\n Max Accuracy of svm :', svm\_acc,  
 '\n Cutoff of maximum accuracy of svm :', svm\_cutoff)

## AUC of svm : 0.9730314   
## Max Accuracy of svm : 0.9319319   
## Cutoff of maximum accuracy of svm : 0.5292952

### 3-3. random forest

rf\_prediction = prediction(rf\_pred['yes'], Y\_val)  
rf\_performance\_auc = performance(rf\_prediction, 'auc', 'cutoff')  
rf\_performance\_acc = performance(rf\_prediction, 'acc', 'cutoff')  
plot(rf\_performance\_acc, main='Cutoff vs Accuracy of random forest')

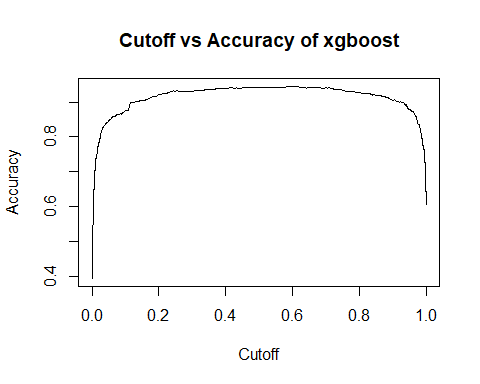


rf\_auc = rf\_performance\_auc@y.values[[1]]  
rf\_acc = max(rf\_performance\_acc@y.values[[1]])  
rf\_cutoff = rf\_performance\_acc@x.values[[1]][which.max(rf\_performance\_acc@y.values[[1]])]  
  
cat(' AUC of rf :', rf\_auc,  
 '\n Max Accuracy of rf :', rf\_acc,  
 '\n Cutoff of maximum accuracy of rf :', rf\_cutoff)

## AUC of rf : 0.9830914   
## Max Accuracy of rf : 0.9479479   
## Cutoff of maximum accuracy of rf : 0.5272259

### 3-4. xgboost

xgb\_prediction = prediction(xgb\_pred['yes'], Y\_val)  
xgb\_performance\_auc = performance(xgb\_prediction, 'auc', 'cutoff')  
xgb\_performance\_acc = performance(xgb\_prediction, 'acc', 'cutoff')  
plot(xgb\_performance\_acc, main='Cutoff vs Accuracy of xgboost')

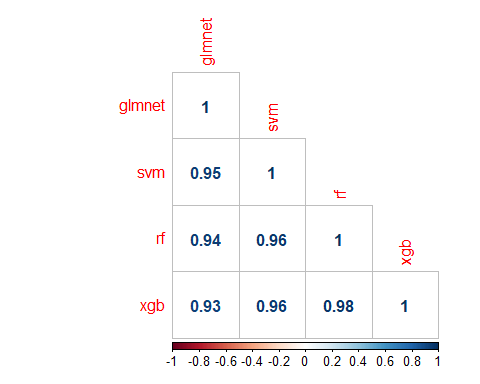


xgb\_auc = xgb\_performance\_auc@y.values[[1]]  
xgb\_acc = max(xgb\_performance\_acc@y.values[[1]])  
xgb\_cutoff = xgb\_performance\_acc@x.values[[1]][which.max(xgb\_performance\_acc@y.values[[1]])]  
  
cat(' AUC of xgb :', xgb\_auc,  
 '\n Max Accuracy of xgb :', xgb\_acc,  
 '\n Cutoff of maximum accuracy of xgb :', xgb\_cutoff)

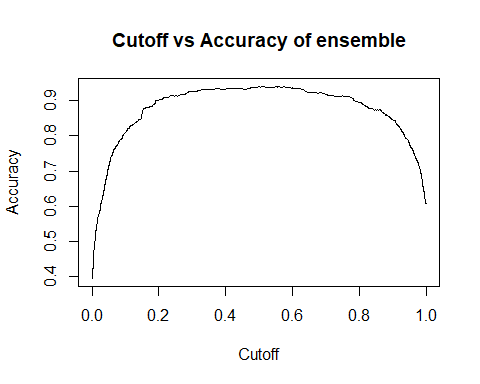
## AUC of xgb : 0.9832278   
## Max Accuracy of xgb : 0.9449449   
## Cutoff of maximum accuracy of xgb : 0.5992255

## 4. choose models to use or to make ensemble

validation\_pred = data.frame(glmnet\_pred['yes'],  
 svm\_pred['yes'],  
 rf\_pred['yes'],  
 xgb\_pred['yes'])  
colnames(validation\_pred) = c('glmnet', 'svm', 'rf', 'xgb')  
  
corr\_matrix = cor(validation\_pred)  
corrplot(corr\_matrix, method='number', type='lower')



validation\_pred = validation\_pred %>%   
 mutate(ensemble = (glmnet + svm + rf + xgb) / 4)  
  
ensemble\_prediction = prediction(validation\_pred$ensemble, Y\_val)  
ensemble\_performance\_auc = performance(ensemble\_prediction, 'auc', 'cutoff')  
ensemble\_performance\_acc = performance(ensemble\_prediction, 'acc', 'cutoff')  
plot(ensemble\_performance\_acc, main='Cutoff vs Accuracy of ensemble')



ensemble\_auc = ensemble\_performance\_auc@y.values[[1]]  
ensemble\_acc = max(ensemble\_performance\_acc@y.values[[1]])  
ensemble\_cutoff = ensemble\_performance\_acc@x.values[[1]][which.max(ensemble\_performance\_acc@y.values[[1]])]  
  
cat(' AUC of ensemble :', ensemble\_auc,  
 '\n Max Accuracy of ensemble :', ensemble\_acc,  
 '\n Cutoff of maximum accuracy of ensemble :', ensemble\_cutoff)

## AUC of ensemble : 0.9814973   
## Max Accuracy of ensemble : 0.9409409   
## Cutoff of maximum accuracy of ensemble : 0.516017

modeling\_result = data.frame(AUC = c(glmnet\_auc, svm\_auc, rf\_auc, xgb\_auc, ensemble\_auc),  
 Accuracy = c(glmnet\_acc, svm\_acc, rf\_acc, xgb\_acc, ensemble\_acc),  
 Cutoff = c(glmnet\_cutoff, svm\_cutoff, rf\_cutoff, xgb\_cutoff, ensemble\_cutoff))  
rownames(modeling\_result) = c('glmnet', 'svm', 'rf', 'xgb', 'ensemble')  
modeling\_result

## AUC Accuracy Cutoff  
## glmnet 0.9628162 0.9059059 0.3263440  
## svm 0.9730314 0.9319319 0.5292952  
## rf 0.9830914 0.9479479 0.5272259  
## xgb 0.9832278 0.9449449 0.5992255  
## ensemble 0.9814973 0.9409409 0.5160170

## 5. confime final model and predict class and posterior probability of Xtest

### 5-1. glmnet

final\_glmnet\_model = glmnet(x=as.matrix(train\_X),  
 y=train\_Y,  
 family='binomial',  
 alpha=best\_alpha,  
 lambda=best\_lambda,  
 standardize = TRUE)  
  
final\_glmnet\_pred = predict(final\_glmnet\_model, newx=as.matrix(test\_X), type='response')[, 1]  
  
final\_glmnet\_model

##   
## Call: glmnet(x = as.matrix(train\_X), y = train\_Y, family = "binomial", alpha = best\_alpha, lambda = best\_lambda, standardize = TRUE)   
##   
## Df %Dev Lambda  
## [1,] 47 0.6367 0.001491

### 5-2. support vector machine with rbf kernel

final\_svm\_model = ksvm(train\_Y ~ .,  
 data=cbind(train\_X, train\_Y),  
 scaled=TRUE,  
 type='C-svc',  
 kernel='rbfdot',  
 kpar=list(sigma=best\_sigma),  
 C=best\_C,  
 prob.model=TRUE)  
  
final\_svm\_pred = predict(final\_svm\_model, newdata=test\_X, type="probabilities")[, 2]  
  
final\_svm\_model

## Support Vector Machine object of class "ksvm"   
##   
## SV type: C-svc (classification)   
## parameter : cost C = 21.7123636978789   
##   
## Gaussian Radial Basis kernel function.   
## Hyperparameter : sigma = 0.00996646616396962   
##   
## Number of Support Vectors : 896   
##   
## Objective Function Value : -12279.39   
## Training error : 0.04625   
## Probability model included.

### 5-3. random forest

final\_rf\_model = ranger(train\_Y ~ .,  
 data=cbind(train\_X, train\_Y),  
 mtry=best\_mtry,  
 splitrule=best\_splitrule,  
 min.node.size=best\_min.node.size,  
 probability=TRUE)  
  
final\_rf\_pred\_ = predict(final\_rf\_model, data=test\_X, type="response",  
 num.trees=final\_rf\_model$num.trees)  
final\_rf\_pred = final\_rf\_pred\_$predictions[, 2]  
  
final\_rf\_model

## Ranger result  
##   
## Call:  
## ranger(train\_Y ~ ., data = cbind(train\_X, train\_Y), mtry = best\_mtry, splitrule = best\_splitrule, min.node.size = best\_min.node.size, probability = TRUE)   
##   
## Type: Probability estimation   
## Number of trees: 500   
## Sample size: 4000   
## Number of independent variables: 50   
## Mtry: 4   
## Target node size: 4   
## Variable importance mode: none   
## Splitrule: gini   
## OOB prediction error (Brier s.): 0.05036759

### 5-4. xgboost

temp\_train\_Y = ifelse(train\_Y == '1', 1, 0)  
final\_xgb\_model = xgboost(data=as.matrix(train\_X),  
 label=temp\_train\_Y,  
 objective='binary:logistic',  
 nrounds=best\_nrounds,  
 max\_depth=best\_max\_depth,  
 eta=best\_eta,  
 gamma=best\_gamma,  
 colsample\_bytree=best\_colsample\_bytree,  
 min\_child\_weight=best\_min\_child\_weight,  
 subsample=best\_subsample,  
 verbose=FALSE)  
  
final\_xgb\_pred = predict(final\_xgb\_model, newdata=as.matrix(test\_X), type="prob")  
  
final\_xgb\_model

## ##### xgb.Booster  
## raw: 1.3 Mb   
## call:  
## xgb.train(params = params, data = dtrain, nrounds = nrounds,   
## watchlist = watchlist, verbose = verbose, print\_every\_n = print\_every\_n,   
## early\_stopping\_rounds = early\_stopping\_rounds, maximize = maximize,   
## save\_period = save\_period, save\_name = save\_name, xgb\_model = xgb\_model,   
## callbacks = callbacks, objective = "binary:logistic", max\_depth = ..2,   
## eta = ..3, gamma = ..4, colsample\_bytree = ..5, min\_child\_weight = ..6,   
## subsample = ..7)  
## params (as set within xgb.train):  
## objective = "binary:logistic", max\_depth = "9", eta = "0.0925765427979641", gamma = "1.45373629638925", colsample\_bytree = "0.328160088695586", min\_child\_weight = "0", subsample = "0.95247815316543", silent = "1"  
## xgb.attributes:  
## niter  
## callbacks:  
## cb.evaluation.log()  
## # of features: 50   
## niter: 338  
## nfeatures : 50   
## evaluation\_log:  
## iter train\_error  
## 1 0.11950  
## 2 0.08475  
## ---   
## 337 0.01750  
## 338 0.01750

### 5-5. ensemble

final\_ensemble\_pred = (final\_glmnet\_pred + final\_svm\_pred + final\_rf\_pred + final\_xgb\_pred) / 4  
final\_ensemble\_class = ifelse(final\_ensemble\_pred >= ensemble\_cutoff, '1', '0')  
  
final\_ensemble\_ = data.frame(final\_ensemble\_class, final\_ensemble\_pred)  
final\_ensemble = cbind(rownames(final\_ensemble\_), final\_ensemble\_)  
colnames(final\_ensemble) = c('ID', 'yhat', 'prob')  
  
head(final\_ensemble)

## ID yhat prob  
## 1 1 1 0.99590291  
## 2 2 0 0.28749520  
## 3 3 0 0.01066789  
## 4 4 1 0.61025069  
## 5 5 1 0.94874179  
## 6 6 1 0.75386461

write\_xlsx(final\_ensemble, path='./final\_answer.xlsx')