Funmi\_Esuruoso\_HW 7

Funmi Esuruoso

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# Instructions

In this homework, you will use SVMs, kNN, and Random Forest algorithms for handwriting recognition, and compare their performance with the naïve Bayes and decision tree models you built in previous week.

## Section 1: Load packages, import data, and prep-process

Describe data pre-processing steps and the chosen evaluation method and measures(s).

#we first load our packages  
require(caret)

## Loading required package: caret

## Loading required package: lattice

## Loading required package: ggplot2

require(e1071)

## Loading required package: e1071

require(rpart)

## Loading required package: rpart

require(dplyr)

## Loading required package: 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

require(stringr)

## Loading required package: stringr

require(randomForest)

## Loading required package: randomForest

## randomForest 4.6-14

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

##   
## Attaching package: 'randomForest'

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

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

# Load the train dataset.   
digittrain <- read.csv(‘/Volumes/STORE N GO/00 - Graduate School/00 - SYR In Session/00 - Fall 2019/IST 707 - Data Analytics Wed9PM/Deliverables/HWs/HW6/digittrain.csv".csv')  
  
#we view the dimension and structure and observe the training dataset has 42,000 observation and 785 variables. This is the data loaded from the previous homework. We begin by viewing our first 10 rows   
dim(digittrain)

## [1] 42000 785

str(digittrain[, 1:10])

## 'data.frame': 42000 obs. of 10 variables:  
## $ label : int 1 0 1 4 0 0 7 3 5 3 ...  
## $ pixel0: int 0 0 0 0 0 0 0 0 0 0 ...  
## $ pixel1: int 0 0 0 0 0 0 0 0 0 0 ...  
## $ pixel2: int 0 0 0 0 0 0 0 0 0 0 ...  
## $ pixel3: int 0 0 0 0 0 0 0 0 0 0 ...  
## $ pixel4: int 0 0 0 0 0 0 0 0 0 0 ...  
## $ pixel5: int 0 0 0 0 0 0 0 0 0 0 ...  
## $ pixel6: int 0 0 0 0 0 0 0 0 0 0 ...  
## $ pixel7: int 0 0 0 0 0 0 0 0 0 0 ...  
## $ pixel8: int 0 0 0 0 0 0 0 0 0 0 ...

summary(digittrain [, 1:10])

## label pixel0 pixel1 pixel2 pixel3   
## Min. :0.000 Min. :0 Min. :0 Min. :0 Min. :0   
## 1st Qu.:2.000 1st Qu.:0 1st Qu.:0 1st Qu.:0 1st Qu.:0   
## Median :4.000 Median :0 Median :0 Median :0 Median :0   
## Mean :4.457 Mean :0 Mean :0 Mean :0 Mean :0   
## 3rd Qu.:7.000 3rd Qu.:0 3rd Qu.:0 3rd Qu.:0 3rd Qu.:0   
## Max. :9.000 Max. :0 Max. :0 Max. :0 Max. :0   
## pixel4 pixel5 pixel6 pixel7 pixel8   
## Min. :0 Min. :0 Min. :0 Min. :0 Min. :0   
## 1st Qu.:0 1st Qu.:0 1st Qu.:0 1st Qu.:0 1st Qu.:0   
## Median :0 Median :0 Median :0 Median :0 Median :0   
## Mean :0 Mean :0 Mean :0 Mean :0 Mean :0   
## 3rd Qu.:0 3rd Qu.:0 3rd Qu.:0 3rd Qu.:0 3rd Qu.:0   
## Max. :0 Max. :0 Max. :0 Max. :0 Max. :0

#now we view our first (5) rows  
head(digittrain [, 1:10], n = 5)

## label pixel0 pixel1 pixel2 pixel3 pixel4 pixel5 pixel6 pixel7 pixel8  
## 1 1 0 0 0 0 0 0 0 0 0  
## 2 0 0 0 0 0 0 0 0 0 0  
## 3 1 0 0 0 0 0 0 0 0 0  
## 4 4 0 0 0 0 0 0 0 0 0  
## 5 0 0 0 0 0 0 0 0 0 0

# Begin Data Preprocessing

This assignment asks for us to utilize the models Support Vector Machines(SVM), k Nearest Neighbors (kNN), and Random Forest for the handwriting recognition. The random forest was predicated by the decision tree model built in the previous homework assignment (6) and submitted to Kaggle.

Once again due to the large size of our dataset (42,000 observations and 785 variables), we will be working with a sample of the data (about 30%) and then selecting a portion of this subset to for training (around 80%) and the remaining 20% for testing. We will randomize this sample by initially setting our seed.

## Steps

We first need to select only the relevant columns.

We then have to identify our nas and then we replace them with the number for data quality (we do not want to delete the rows) and fill these columns that have 0

digittrain [is.na(digittrain)] <- 0 #if it is NA, replace with 0  
cols <- ncol(digittrain)  
vars <- list() #create empty list  
  
# # identify which have no variance by looping over the c"columns"  
for(i in 2:cols){  
 colVar <- var(digittrain [[i]])  
 if(colVar == 0){  
 vars <- append(vars, i)  
 }  
}  
  
#we don’t want the columns with no variance in both datasets (training and testing)   
dropcols <- unlist(vars)  
digittrain <- digittrain [, -dropcols]  
  
#as we did with the previous hw, we only want a sample of our data (around 20% of both datasets).  
set.seed(750)  
  
dsplit <- sample(nrow(digittrain), nrow(digittrain) \* .3)  
subdata <- digittrain [dsplit, ]  
  
#we set our seed set.seed(525)  
#we focus on our subsets now for our training and testing data.   
trainsplit <- sample(nrow(subdata), nrow(subdata) \* 2/3)  
trainSet <- subdata[trainsplit, ]  
testSet <- subdata[-trainsplit, ]

We now have our training data (2/3) and test data (1/3). We see that we have 8,400 observations for our training set and 4,200 observation in our testing set.

# We now begin training and testing our models

## k-Nearest Neighbours (kNN)

We will follow the same sample sizes for our kNN model. 2/3 for training and 1/3 for testing.

#discretization: we first have to convert the current (label) column into a factor.   
trainSet$label <- factor(paste0('X', trainSet$label), levels = c('X0', 'X1', 'X2', 'X3', 'X4', 'X5', 'X6', 'X7', 'X8', 'X9'))  
testSet$label <- factor(paste0('X', testSet$label), levels = c('X0', 'X1', 'X2', 'X3', 'X4', 'X5', 'X6', 'X7', 'X8', 'X9'))  
  
#we will be using a threefold for our kNN model  
set.seed(113)  
x <- trainControl(method = 'repeatedcv', repeats = 3, classProbs = TRUE)  
knnTrain <- train(label ~ ., data = trainSet, method = 'knn', preProcess = c('center', 'scale'), trControl = x, metric = 'ROC', tuneLength = 3)

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

## Warning in preProcess.default(thresh = 0.95, k = 5, freqCut = 19, uniqueCut  
## = 10, : These variables have zero variances: pixel12, pixel13, pixel14,  
## pixel15, pixel32, pixel50, pixel51, pixel59, pixel110, pixel113, pixel167,  
## pixel169, pixel224, pixel252, pixel280, pixel308, pixel336, pixel364,  
## pixel393, pixel587, pixel588, pixel615, pixel616, pixel617, pixel643,  
## pixel698, pixel702, pixel724, pixel725, pixel726, pixel752, pixel753,  
## pixel777, pixel778, pixel779  
  
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## pixel280, pixel308, pixel336, pixel364, pixel504, pixel587, pixel588,  
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## pixel336, pixel364, pixel447, pixel531, pixel559, pixel587, pixel588,  
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## pixel15, pixel32, pixel49, pixel50, pixel51, pixel59, pixel110, pixel113,  
## pixel167, pixel169, pixel224, pixel252, pixel280, pixel308, pixel336,  
## pixel364, pixel447, pixel475, pixel504, pixel559, pixel587, pixel588,  
## pixel615, pixel616, pixel617, pixel642, pixel643, pixel698, pixel724,  
## pixel725, pixel726, pixel752, pixel753, pixel777, pixel778, pixel779  
  
## Warning in preProcess.default(thresh = 0.95, k = 5, freqCut = 19, uniqueCut  
## = 10, : These variables have zero variances: pixel12, pixel13, pixel14,  
## pixel15, pixel32, pixel49, pixel50, pixel51, pixel59, pixel110, pixel113,  
## pixel167, pixel169, pixel224, pixel252, pixel280, pixel308, pixel336,  
## pixel364, pixel447, pixel475, pixel504, pixel559, pixel587, pixel588,  
## pixel615, pixel616, pixel617, pixel642, pixel643, pixel698, pixel724,  
## pixel725, pixel726, pixel752, pixel753, pixel777, pixel778, pixel779

## Warning in preProcess.default(thresh = 0.95, k = 5, freqCut = 19, uniqueCut  
## = 10, : These variables have zero variances: pixel12, pixel13, pixel14,  
## pixel15, pixel32, pixel50, pixel51, pixel59, pixel60, pixel80, pixel81,  
## pixel110, pixel113, pixel167, pixel169, pixel224, pixel252, pixel280,  
## pixel308, pixel336, pixel364, pixel587, pixel588, pixel615, pixel616,  
## pixel617, pixel643, pixel698, pixel724, pixel725, pixel726, pixel752,  
## pixel753, pixel761, pixel777, pixel778, pixel779  
  
## Warning in preProcess.default(thresh = 0.95, k = 5, freqCut = 19, uniqueCut  
## = 10, : These variables have zero variances: pixel12, pixel13, pixel14,  
## pixel15, pixel32, pixel50, pixel51, pixel59, pixel60, pixel80, pixel81,  
## pixel110, pixel113, pixel167, pixel169, pixel224, pixel252, pixel280,  
## pixel308, pixel336, pixel364, pixel587, pixel588, pixel615, pixel616,  
## pixel617, pixel643, pixel698, pixel724, pixel725, pixel726, pixel752,  
## pixel753, pixel761, pixel777, pixel778, pixel779  
  
## Warning in preProcess.default(thresh = 0.95, k = 5, freqCut = 19, uniqueCut  
## = 10, : These variables have zero variances: pixel12, pixel13, pixel14,  
## pixel15, pixel32, pixel50, pixel51, pixel59, pixel60, pixel80, pixel81,  
## pixel110, pixel113, pixel167, pixel169, pixel224, pixel252, pixel280,  
## pixel308, pixel336, pixel364, pixel587, pixel588, pixel615, pixel616,  
## pixel617, pixel643, pixel698, pixel724, pixel725, pixel726, pixel752,  
## pixel753, pixel761, pixel777, pixel778, pixel779

## Warning in preProcess.default(thresh = 0.95, k = 5, freqCut = 19, uniqueCut  
## = 10, : These variables have zero variances: pixel12, pixel13, pixel14,  
## pixel15, pixel32, pixel50, pixel51, pixel59, pixel110, pixel113, pixel167,  
## pixel169, pixel224, pixel252, pixel280, pixel308, pixel336, pixel364,  
## pixel533, pixel587, pixel588, pixel615, pixel616, pixel617, pixel643,  
## pixel698, pixel724, pixel725, pixel726, pixel752, pixel753, pixel777,  
## pixel778, pixel779  
  
## Warning in preProcess.default(thresh = 0.95, k = 5, freqCut = 19, uniqueCut  
## = 10, : These variables have zero variances: pixel12, pixel13, pixel14,  
## pixel15, pixel32, pixel50, pixel51, pixel59, pixel110, pixel113, pixel167,  
## pixel169, pixel224, pixel252, pixel280, pixel308, pixel336, pixel364,  
## pixel533, pixel587, pixel588, pixel615, pixel616, pixel617, pixel643,  
## pixel698, pixel724, pixel725, pixel726, pixel752, pixel753, pixel777,  
## pixel778, pixel779  
  
## Warning in preProcess.default(thresh = 0.95, k = 5, freqCut = 19, uniqueCut  
## = 10, : These variables have zero variances: pixel12, pixel13, pixel14,  
## pixel15, pixel32, pixel50, pixel51, pixel59, pixel110, pixel113, pixel167,  
## pixel169, pixel224, pixel252, pixel280, pixel308, pixel336, pixel364,  
## pixel533, pixel587, pixel588, pixel615, pixel616, pixel617, pixel643,  
## pixel698, pixel724, pixel725, pixel726, pixel752, pixel753, pixel777,  
## pixel778, pixel779

## Warning in preProcess.default(thresh = 0.95, k = 5, freqCut = 19, uniqueCut  
## = 10, : These variables have zero variances: pixel12, pixel13, pixel14,  
## pixel15, pixel32, pixel50, pixel51, pixel59, pixel110, pixel113, pixel167,  
## pixel169, pixel224, pixel252, pixel280, pixel308, pixel336, pixel364,  
## pixel587, pixel588, pixel615, pixel616, pixel617, pixel643, pixel698,  
## pixel724, pixel725, pixel726, pixel752, pixel753, pixel777, pixel778,  
## pixel779

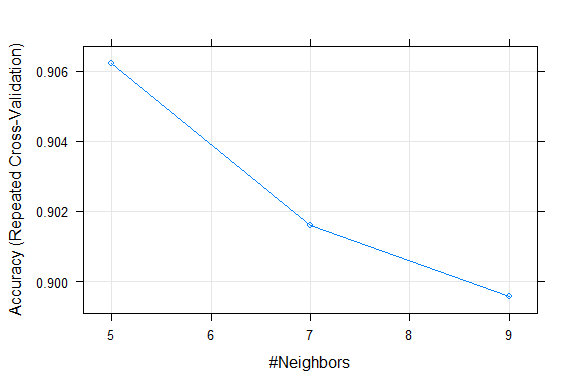
#I received A LOT of warning messages when I ran this model. It took quite a long time before the model actually ran.

#summarize the kNN model

knnTrain

## k-Nearest Neighbors   
##   
## 8400 samples  
## 708 predictor  
## 10 classes: 'X0', 'X1', 'X2', 'X3', 'X4', 'X5', 'X6', 'X7', 'X8', 'X9'   
##   
## Pre-processing: centered (708), scaled (708)   
## Resampling: Cross-Validated (10 fold, repeated 3 times)   
## Summary of sample sizes: 7561, 7558, 7562, 7559, 7562, 7560, ...   
## Resampling results across tuning parameters:  
##   
## k Accuracy Kappa   
## 5 0.9062305 0.8957703  
## 7 0.9015868 0.8906054  
## 9 0.8995636 0.8883551  
##   
## Accuracy was used to select the optimal model using the largest value.  
## The final value used for the model was k = 5.

plot(knnTrain)



#our model is very good. I received a great prediction of the label class. I now want to do the test set to see what the output is.   
digitknnpred <- predict(knnTrain, testSet, type = 'prob')  
digitknnpred <- as.data.frame(digitknnpred)  
  
#we want to view our maximum prediction showing our class label.  
knnPredictedValues <- data.frame(apply(digitknnpred, 1, which.max) - 1)   
colnames(knnPredictedValues) <- 'prediction'  
  
#now we do the comparison  
knnoutput <- testSet %>% select(label) %>% mutate(real = str\_remove(label, 'X')) %>% bind\_cols(knnPredictedValues) %>% mutate(real = as.factor(real), prediction = as.factor(prediction))

#we want to build a confusion matrix and examine  
confusionMatrix(knnoutput$real, knnoutput$prediction)

## Confusion Matrix and Statistics  
##   
## Reference  
## Prediction 0 1 2 3 4 5 6 7 8 9  
## 0 396 0 0 3 0 2 2 0 1 1  
## 1 0 476 1 0 1 0 0 0 0 0  
## 2 5 9 412 5 5 1 3 2 3 0  
## 3 1 7 8 368 0 12 1 7 4 2  
## 4 0 11 3 0 358 0 1 4 0 18  
## 5 2 6 5 17 1 319 11 2 6 12  
## 6 8 0 6 0 2 3 425 0 0 0  
## 7 1 11 2 1 9 0 0 380 2 18  
## 8 3 15 4 18 5 31 4 4 307 3  
## 9 1 5 2 7 19 1 0 29 2 358  
##   
## Overall Statistics  
##   
## Accuracy : 0.9045   
## 95% CI : (0.8952, 0.9132)  
## No Information Rate : 0.1286   
## P-Value [Acc > NIR] : < 2.2e-16   
##   
## Kappa : 0.8938   
## Mcnemar's Test P-Value : NA   
##   
## Statistics by Class:  
##   
## Class: 0 Class: 1 Class: 2 Class: 3 Class: 4 Class: 5  
## Sensitivity 0.94964 0.8815 0.9300 0.87828 0.89500 0.86450  
## Specificity 0.99762 0.9995 0.9912 0.98889 0.99026 0.98382  
## Pos Pred Value 0.97778 0.9958 0.9258 0.89756 0.90633 0.83727  
## Neg Pred Value 0.99447 0.9828 0.9917 0.98654 0.98896 0.98691  
## Prevalence 0.09929 0.1286 0.1055 0.09976 0.09524 0.08786  
## Detection Rate 0.09429 0.1133 0.0981 0.08762 0.08524 0.07595  
## Detection Prevalence 0.09643 0.1138 0.1060 0.09762 0.09405 0.09071  
## Balanced Accuracy 0.97363 0.9405 0.9606 0.93359 0.94263 0.92416  
## Class: 6 Class: 7 Class: 8 Class: 9  
## Sensitivity 0.9508 0.88785 0.94462 0.86893  
## Specificity 0.9949 0.98834 0.97755 0.98258  
## Pos Pred Value 0.9572 0.89623 0.77919 0.84434  
## Neg Pred Value 0.9941 0.98729 0.99527 0.98570  
## Prevalence 0.1064 0.10190 0.07738 0.09810  
## Detection Rate 0.1012 0.09048 0.07310 0.08524  
## Detection Prevalence 0.1057 0.10095 0.09381 0.10095  
## Balanced Accuracy 0.9729 0.93809 0.96108 0.92575

I had to leave the model running for several hours but it was well worth it. We have a 90% (approximate) accuracy for our class labels. When comparing the models build in last week’s homework, this is by far the best model in comparison.

## Support Vector Machines (SVM)

We now build our SVM.

#we will do a 3 fold for this and our cross validation (as we did in our last homework)   
svmtrain <- svm(label ~ ., data = trainSet, type = 'C', kernel = 'linear', cross = 3, probability = TRUE)

## Warning in svm.default(x, y, scale = scale, ..., na.action = na.action):  
## Variable(s) 'pixel12' and 'pixel13' and 'pixel14' and 'pixel15' and  
## 'pixel32' and 'pixel50' and 'pixel51' and 'pixel59' and 'pixel110' and  
## 'pixel113' and 'pixel167' and 'pixel169' and 'pixel224' and 'pixel252' and  
## 'pixel280' and 'pixel308' and 'pixel336' and 'pixel364' and 'pixel587' and  
## 'pixel588' and 'pixel615' and 'pixel616' and 'pixel617' and 'pixel643' and  
## 'pixel698' and 'pixel724' and 'pixel725' and 'pixel726' and 'pixel752' and  
## 'pixel753' and 'pixel777' and 'pixel778' and 'pixel779' constant. Cannot  
## scale data.

summary(svmtrain)

##   
## Call:  
## svm(formula = label ~ ., data = trainSet, type = "C", kernel = "linear",   
## cross = 3, probability = TRUE)  
##   
##   
## Parameters:  
## SVM-Type: C-classification   
## SVM-Kernel: linear   
## cost: 1   
## gamma: 0.001412429   
##   
## Number of Support Vectors: 2365  
##   
## ( 286 221 128 235 184 283 249 287 320 172 )  
##   
##   
## Number of Classes: 10   
##   
## Levels:   
## X0 X1 X2 X3 X4 X5 X6 X7 X8 X9  
##   
## 3-fold cross-validation on training data:  
##   
## Total Accuracy: 91.33333   
## Single Accuracies:  
## 91.32143 91.28571 91.39286

Once again, we have a really good model with a high accuracy. I want to view the testing set now.

svmPred <- predict(svmTrain, testset, type = 'prob')  
svmPred <- as.data.frame(svmPred)  
colnames(svmPred) <- 'results'  
  
#comparison of the models  
svmoutput <- testset %>% select(label) %>% bind\_cols(svmPred) %>% mutate(real = factor(as.character(str\_remove(label, 'X'))), prediction = factor(as.character(str\_remove(results, 'X'))))  
  
confusionMatrix(svmoutput$real, svmoutput$prediction)

## Confusion Matrix and Statistics  
##   
## Reference  
## Prediction 0 1 2 3 4 5 6 7 8 9  
## 0 392 0 2 0 1 4 4 1 1 0  
## 1 0 469 0 1 1 1 0 1 5 0  
## 2 1 3 408 3 8 1 5 4 12 0  
## 3 1 5 10 351 1 22 2 4 10 4  
## 4 1 3 1 0 369 0 2 3 1 15  
## 5 5 2 4 21 5 319 8 1 12 4  
## 6 3 0 4 0 8 4 419 0 6 0  
## 7 2 3 6 2 6 1 0 387 2 15  
## 8 4 11 8 9 1 16 4 3 333 5  
## 9 0 3 2 6 16 2 0 23 6 366  
##   
## Overall Statistics  
##   
## Accuracy : 0.9079   
## 95% CI : (0.8987, 0.9164)  
## No Information Rate : 0.1188   
## P-Value [Acc > NIR] : < 2.2e-16   
##   
## Kappa : 0.8976   
## Mcnemar's Test P-Value : NA   
##   
## Statistics by Class:  
##   
## Class: 0 Class: 1 Class: 2 Class: 3 Class: 4 Class: 5  
## Sensitivity 0.95844 0.9399 0.91685 0.89313 0.88702 0.86216  
## Specificity 0.99657 0.9976 0.99015 0.98450 0.99313 0.98381  
## Pos Pred Value 0.96790 0.9812 0.91685 0.85610 0.93418 0.83727  
## Neg Pred Value 0.99552 0.9919 0.99015 0.98892 0.98765 0.98665  
## Prevalence 0.09738 0.1188 0.10595 0.09357 0.09905 0.08810  
## Detection Rate 0.09333 0.1117 0.09714 0.08357 0.08786 0.07595  
## Detection Prevalence 0.09643 0.1138 0.10595 0.09762 0.09405 0.09071  
## Balanced Accuracy 0.97750 0.9687 0.95350 0.93882 0.94007 0.92299  
## Class: 6 Class: 7 Class: 8 Class: 9  
## Sensitivity 0.94369 0.90632 0.85825 0.89487  
## Specificity 0.99334 0.99019 0.98400 0.98470  
## Pos Pred Value 0.94369 0.91274 0.84518 0.86321  
## Neg Pred Value 0.99334 0.98941 0.98555 0.98861  
## Prevalence 0.10571 0.10167 0.09238 0.09738  
## Detection Rate 0.09976 0.09214 0.07929 0.08714  
## Detection Prevalence 0.10571 0.10095 0.09381 0.10095  
## Balanced Accuracy 0.96852 0.94826 0.92112 0.93978

Here we see another good model with a 91% accuracy (approximate).

## Random Forest

Now we complete the Random Forest model

x <- trainControl(method = 'repeatedcv', number = 3, repeats = 3)  
RFTrain <- train(label ~ ., data = trainSet, method = 'rf', metric = 'Accuracy', trControl = x, type = 'C')  
  
RFTrain

## Random Forest   
##   
## 8400 samples  
## 708 predictor  
## 10 classes: 'X0', 'X1', 'X2', 'X3', 'X4', 'X5', 'X6', 'X7', 'X8', 'X9'   
##   
## No pre-processing  
## Resampling: Cross-Validated (3 fold, repeated 3 times)   
## Summary of sample sizes: 5601, 5599, 5600, 5600, 5601, 5599, ...   
## Resampling results across tuning parameters:  
##   
## mtry Accuracy Kappa   
## 2 0.8767850 0.8629762  
## 37 0.9452385 0.9391393  
## 707 0.9253181 0.9170037  
##   
## Accuracy was used to select the optimal model using the largest value.  
## The final value used for the model was mtry = 37.

#we can increase our model to change the minimum accuracy

This is our best model so far (94%)

#we test our rf model  
RFPred <- predict(RFTrain, testset, type = 'prob')  
RFPred <- as.data.frame(RFPred)  
  
RFPredictedValues <- data.frame(apply(RFPred, 1, which.max) - 1)   
colnames(RFPredictedValues) <- 'results'  
  
#build new models to view   
rfoutput <- testset %>% select(label) %>% bind\_cols (RFredictedValues) %>% mutate(real = factor(as.character(str\_remove(label, 'X'))), prediction = factor(results))  
  
confusionMatrix(rfoutput$real, rfoutput$prediction)

## Confusion Matrix and Statistics  
##   
## Reference  
## Prediction 0 1 2 3 4 5 6 7 8 9  
## 0 398 0 1 0 0 1 2 0 3 0  
## 1 0 470 2 1 1 2 1 0 0 1  
## 2 1 1 424 1 6 0 3 3 4 2  
## 3 2 6 12 368 1 8 0 4 6 3  
## 4 0 1 2 0 379 0 3 0 0 10  
## 5 4 1 1 9 0 359 6 0 1 0  
## 6 4 1 0 0 1 2 432 1 3 0  
## 7 0 2 6 2 2 0 1 403 2 6  
## 8 2 7 0 8 2 5 5 1 359 5  
## 9 3 2 0 9 7 4 1 12 5 381  
##   
## Overall Statistics  
##   
## Accuracy : 0.946   
## 95% CI : (0.9387, 0.9526)  
## No Information Rate : 0.1169   
## P-Value [Acc > NIR] : < 2.2e-16   
##   
## Kappa : 0.9399   
## Mcnemar's Test P-Value : NA   
##   
## Statistics by Class:  
##   
## Class: 0 Class: 1 Class: 2 Class: 3 Class: 4 Class: 5  
## Sensitivity 0.96135 0.9572 0.9464 0.92462 0.94987 0.94226  
## Specificity 0.99815 0.9978 0.9944 0.98895 0.99579 0.99424  
## Pos Pred Value 0.98272 0.9833 0.9528 0.89756 0.95949 0.94226  
## Neg Pred Value 0.99578 0.9944 0.9936 0.99208 0.99474 0.99424  
## Prevalence 0.09857 0.1169 0.1067 0.09476 0.09500 0.09071  
## Detection Rate 0.09476 0.1119 0.1010 0.08762 0.09024 0.08548  
## Detection Prevalence 0.09643 0.1138 0.1060 0.09762 0.09405 0.09071  
## Balanced Accuracy 0.97975 0.9775 0.9704 0.95679 0.97283 0.96825  
## Class: 6 Class: 7 Class: 8 Class: 9  
## Sensitivity 0.9515 0.95047 0.93734 0.93382  
## Specificity 0.9968 0.99444 0.99083 0.98866  
## Pos Pred Value 0.9730 0.95047 0.91117 0.89858  
## Neg Pred Value 0.9941 0.99444 0.99369 0.99285  
## Prevalence 0.1081 0.10095 0.09119 0.09714  
## Detection Rate 0.1029 0.09595 0.08548 0.09071  
## Detection Prevalence 0.1057 0.10095 0.09381 0.10095  
## Balanced Accuracy 0.9742 0.97246 0.96408 0.96124

Another good model.

# 

# Conclusion

We received very good results for our models this week (all were around 90%). This is better than the 50%-to 80% accuracy we received from our models last week. I would still like to tune my models a bit more. The issue of the size of our dataset is of concern, with us only using around 30% of our data. In the future, I will consider modifying the size used. I also only used the training set this time due to the class labels. Setting the seed was also important to randomize my observations.