### 4)Bonus Problem (10 points)

#### Use the Sacremento data from the caret library by running data(Sacremento) after loading caret. This data is about housing prices in Sacramento, California. Remove the zip and city variables.

#### Explore the variables to see if they have reasonable distributions and show your work. We will be predicting the type variable – does that mean we have a class imbalance?

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(caret)

## Loading required package: ggplot2

## Loading required package: lattice

library(tidyverse)

## ── Attaching packages  
## ───────────────────────────────────────  
## tidyverse 1.3.2 ──

## ✔ tibble 3.1.8 ✔ purrr 0.3.4  
## ✔ tidyr 1.2.1 ✔ stringr 1.4.1  
## ✔ readr 2.1.2 ✔ forcats 0.5.2  
## ── Conflicts ────────────────────────────────────────── tidyverse\_conflicts() ──  
## ✖ dplyr::filter() masks stats::filter()  
## ✖ dplyr::lag() masks stats::lag()  
## ✖ purrr::lift() masks caret::lift()

data("Sacramento")   
Sacr\_df <-as.data.frame(Sacramento)  
#removing specified columns  
Sacr\_df\_rv <-select(Sacr\_df, -c(city,zip))  
summary(Sacr\_df\_rv)

## beds baths sqft type   
## Min. :1.000 Min. :1.000 Min. : 484 Condo : 53   
## 1st Qu.:3.000 1st Qu.:2.000 1st Qu.:1167 Multi\_Family: 13   
## Median :3.000 Median :2.000 Median :1470 Residential :866   
## Mean :3.276 Mean :2.053 Mean :1680   
## 3rd Qu.:4.000 3rd Qu.:2.000 3rd Qu.:1954   
## Max. :8.000 Max. :5.000 Max. :4878   
## price latitude longitude   
## Min. : 30000 Min. :38.24 Min. :-121.6   
## 1st Qu.:156000 1st Qu.:38.48 1st Qu.:-121.4   
## Median :220000 Median :38.62 Median :-121.4   
## Mean :246662 Mean :38.59 Mean :-121.4   
## 3rd Qu.:305000 3rd Qu.:38.69 3rd Qu.:-121.3   
## Max. :884790 Max. :39.02 Max. :-120.6

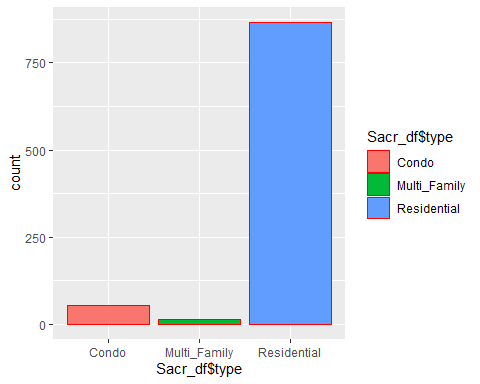
#summary of categorical variable   
summary(Sacr\_df$type)

## Condo Multi\_Family Residential   
## 53 13 866

typegroup\_Sdf<- Sacr\_df%>%  
 group\_by(Sacr\_df$type) %>%  
 summarise(count = n(), .groups = 'drop')   
typegroup\_Sdf

## # A tibble: 3 × 2  
## `Sacr\_df$type` count  
## <fct> <int>  
## 1 Condo 53  
## 2 Multi\_Family 13  
## 3 Residential 866

ggplot(typegroup\_Sdf, aes(x = `Sacr\_df$type`, y = count))+  
 geom\_bar(  
 aes(fill = `Sacr\_df$type`), stat = "identity", color = "red",  
 position = position\_dodge(0.9))



### There are lots of options for working on the data to try to improve the performance of SVM, including (1) removing other variables that you know should not be part of the prediction, (2) dealing with extreme variations in some variables with smoothing, normalization or a log transform, (3) applying PCA, and (4) to removing outliers. Pick one now and continue.

Sacr\_df\_svm <- select(Sacr\_df,-c('latitude','longitude'))  
set.seed(123)  
# Fit the model  
svm\_grid <- train(type ~., data = Sacr\_df\_svm, method = "svmLinear")

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# Evaluate fit  
svm\_grid

## Support Vector Machines with Linear Kernel   
##   
## 932 samples  
## 6 predictor  
## 3 classes: 'Condo', 'Multi\_Family', 'Residential'   
##   
## No pre-processing  
## Resampling: Bootstrapped (25 reps)   
## Summary of sample sizes: 932, 932, 932, 932, 932, 932, ...   
## Resampling results:  
##   
## Accuracy Kappa   
## 0.5738031 0.03422571  
##   
## Tuning parameter 'C' was held constant at a value of 1

### c. Use SVM to predict type and use grid search to get the best accuracy you can. The accuracy may be good, but look at the confusion matrix as well. Report what you find. Note that the kappa value provided with your SVM results can also help you see this. It is a measure of how well the classifier performed that takes into account the frequency of the classes.

searchgrid <- expand.grid(C = 10^seq(-5,2,0.5))  
train\_control = trainControl(method = "cv", number = 10)  
svmgrid<- train(type ~., data = Sacr\_df, method = "svmLinear",  
 trControl = train\_control, tuneGrid = searchgrid)

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svmgrid

## Support Vector Machines with Linear Kernel   
##   
## 932 samples  
## 8 predictor  
## 3 classes: 'Condo', 'Multi\_Family', 'Residential'   
##   
## No pre-processing  
## Resampling: Cross-Validated (10 fold)   
## Summary of sample sizes: 840, 838, 840, 839, 839, 839, ...   
## Resampling results across tuning parameters:  
##   
## C Accuracy Kappa   
## 1.000000e-05 0.9292237 0.00000000  
## 3.162278e-05 0.9292237 0.00000000  
## 1.000000e-04 0.9271075 0.08298072  
## 3.162278e-04 0.8989053 0.02732978  
## 1.000000e-03 0.8025790 0.08494919  
## 3.162278e-03 0.7166403 0.07811152  
## 1.000000e-02 0.6783715 0.03050776  
## 3.162278e-02 0.6895231 0.07325406  
## 1.000000e-01 0.6376061 0.04981558  
## 3.162278e-01 0.6376655 0.04312885  
## 1.000000e+00 0.6398382 0.06888248  
## 3.162278e+00 0.6689992 0.06268332  
## 1.000000e+01 0.6625593 0.06287167  
## 3.162278e+01 0.6540601 0.08186894  
## 1.000000e+02 0.6014381 0.03923833  
##   
## Accuracy was used to select the optimal model using the largest value.  
## The final value used for the model was C = 1e-05.

#confusion Matrix  
set.seed(123)  
index = createDataPartition(y=Sacr\_df\_svm$type, p=0.7, list=FALSE)   
trains = Sacr\_df[index,]  
tests = Sacr\_df[-index,]  
svmsplit <- train(type ~., data = trains, method = "svmLinear")

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predsplit <- predict(svmsplit, tests)   
confusionMatrix(tests$type, predsplit)

## Confusion Matrix and Statistics  
##   
## Reference  
## Prediction Condo Multi\_Family Residential  
## Condo 14 1 0  
## Multi\_Family 1 2 0  
## Residential 98 88 73  
##   
## Overall Statistics  
##   
## Accuracy : 0.3213   
## 95% CI : (0.2667, 0.3798)  
## No Information Rate : 0.4079   
## P-Value [Acc > NIR] : 0.9988   
##   
## Kappa : 0.0676   
##   
## Mcnemar's Test P-Value : <2e-16   
##   
## Statistics by Class:  
##   
## Class: Condo Class: Multi\_Family Class: Residential  
## Sensitivity 0.12389 0.02198 1.00000  
## Specificity 0.99390 0.99462 0.08824  
## Pos Pred Value 0.93333 0.66667 0.28185  
## Neg Pred Value 0.62214 0.67518 1.00000  
## Prevalence 0.40794 0.32852 0.26354  
## Detection Rate 0.05054 0.00722 0.26354  
## Detection Prevalence 0.05415 0.01083 0.93502  
## Balanced Accuracy 0.55890 0.50830 0.54412

### Return to (b) and try at least one other way to try to improve the data before running SVM again, as in (c).

ds1 <- select(Sacr\_df\_svm,-c('baths','beds'))  
set.seed(123)  
svm1 <- train(type ~., data = ds1, method = "svmLinear")

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# Evaluate fit  
svm1

## Support Vector Machines with Linear Kernel   
##   
## 932 samples  
## 4 predictor  
## 3 classes: 'Condo', 'Multi\_Family', 'Residential'   
##   
## No pre-processing  
## Resampling: Bootstrapped (25 reps)   
## Summary of sample sizes: 932, 932, 932, 932, 932, 932, ...   
## Resampling results:  
##   
## Accuracy Kappa   
## 0.554367 -0.001028349  
##   
## Tuning parameter 'C' was held constant at a value of 1

#grid search  
train\_control\_boot = trainControl(method = "boot", number = 100)   
grid\_search <- expand.grid(C = 10^seq(-5,2,0.5))  
svm\_grid\_search<- train(type ~., data = ds1, method = "svmLinear",  
 trControl = train\_control, tuneGrid = grid\_search)

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svm\_grid\_search

## Support Vector Machines with Linear Kernel   
##   
## 932 samples  
## 4 predictor  
## 3 classes: 'Condo', 'Multi\_Family', 'Residential'   
##   
## No pre-processing  
## Resampling: Cross-Validated (10 fold)   
## Summary of sample sizes: 840, 838, 840, 839, 839, 839, ...   
## Resampling results across tuning parameters:  
##   
## C Accuracy Kappa   
## 1.000000e-05 0.9292237 0.000000000  
## 3.162278e-05 0.9292237 0.000000000  
## 1.000000e-04 0.8939913 0.054289022  
## 3.162278e-04 0.8906021 0.056502330  
## 1.000000e-03 0.8270747 0.087836075  
## 3.162278e-03 0.7531893 0.034428426  
## 1.000000e-02 0.6346217 0.024561012  
## 3.162278e-02 0.6555295 0.006270059  
## 1.000000e-01 0.6135237 0.022077703  
## 3.162278e-01 0.5666701 0.035517965  
## 1.000000e+00 0.5740257 0.014439757  
## 3.162278e+00 0.6106408 0.039135864  
## 1.000000e+01 0.5544473 0.035632058  
## 3.162278e+01 0.5662397 0.052205068  
## 1.000000e+02 0.5393809 0.018720299  
##   
## Accuracy was used to select the optimal model using the largest value.  
## The final value used for the model was C = 1e-05.

#Using Bootstrap  
train\_control\_boot = trainControl(method = "boot", number = 100)   
boot\_type <- train(type ~., data = trains, method = "svmLinear",trControl = train\_control\_boot)

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boot\_type

## Support Vector Machines with Linear Kernel   
##   
## 655 samples  
## 8 predictor  
## 3 classes: 'Condo', 'Multi\_Family', 'Residential'   
##   
## No pre-processing  
## Resampling: Bootstrapped (100 reps)   
## Summary of sample sizes: 655, 655, 655, 655, 655, 655, ...   
## Resampling results:  
##   
## Accuracy Kappa   
## 0.5938387 0.03983164  
##   
## Tuning parameter 'C' was held constant at a value of 1

pred\_split <- predict(boot\_type, tests)   
confusionMatrix(tests$type, pred\_split)

## Confusion Matrix and Statistics  
##   
## Reference  
## Prediction Condo Multi\_Family Residential  
## Condo 14 1 0  
## Multi\_Family 1 2 0  
## Residential 98 88 73  
##   
## Overall Statistics  
##   
## Accuracy : 0.3213   
## 95% CI : (0.2667, 0.3798)  
## No Information Rate : 0.4079   
## P-Value [Acc > NIR] : 0.9988   
##   
## Kappa : 0.0676   
##   
## Mcnemar's Test P-Value : <2e-16   
##   
## Statistics by Class:  
##   
## Class: Condo Class: Multi\_Family Class: Residential  
## Sensitivity 0.12389 0.02198 1.00000  
## Specificity 0.99390 0.99462 0.08824  
## Pos Pred Value 0.93333 0.66667 0.28185  
## Neg Pred Value 0.62214 0.67518 1.00000  
## Prevalence 0.40794 0.32852 0.26354  
## Detection Rate 0.05054 0.00722 0.26354  
## Detection Prevalence 0.05415 0.01083 0.93502  
## Balanced Accuracy 0.55890 0.50830 0.54412

### In the end, some data are just so imbalanced that a classifier is never going to predict the minority class. Dealing with this is a huge topic. One simple possibility is to conclude that we do not have enough data to support predicting the very infrequent class(es) and remove them. If they are not actually important to the reason we are making the prediction, that could be fine. Another approach is to force the data to be more even by sampling.

ds1<-Sacr\_df\_svm  
#removing price from the data.  
ds1 <- select(ds1,-c('price'))  
set.seed(123)  
train\_control\_boot = trainControl(method = "boot", number = 100)   
# Fit the model  
svm1 <- train(type ~., data = Sacr\_df\_svm, method = "svmLinear")

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# Evaluate fit  
svm1

## Support Vector Machines with Linear Kernel   
##   
## 932 samples  
## 6 predictor  
## 3 classes: 'Condo', 'Multi\_Family', 'Residential'   
##   
## No pre-processing  
## Resampling: Bootstrapped (25 reps)   
## Summary of sample sizes: 932, 932, 932, 932, 932, 932, ...   
## Resampling results:  
##   
## Accuracy Kappa   
## 0.5738031 0.03422571  
##   
## Tuning parameter 'C' was held constant at a value of 1

#grid search  
grid\_search <- expand.grid(C = 10^seq(-5,2,0.5))  
svm\_grid\_search<- train(type ~., data = Sacr\_df\_svm, method = "svmLinear",  
 trControl = train\_control, tuneGrid = grid\_search)

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svm\_grid\_search

## Support Vector Machines with Linear Kernel   
##   
## 932 samples  
## 6 predictor  
## 3 classes: 'Condo', 'Multi\_Family', 'Residential'   
##   
## No pre-processing  
## Resampling: Cross-Validated (10 fold)   
## Summary of sample sizes: 840, 838, 840, 839, 839, 839, ...   
## Resampling results across tuning parameters:  
##   
## C Accuracy Kappa   
## 1.000000e-05 0.9292237 0.000000000  
## 3.162278e-05 0.9238474 -0.005681818  
## 1.000000e-04 0.9206213 0.071318385  
## 3.162278e-04 0.8402092 0.105071734  
## 1.000000e-03 0.7459013 0.132978883  
## 3.162278e-03 0.7823063 0.073767032  
## 1.000000e-02 0.5936165 0.053341991  
## 3.162278e-02 0.6050071 0.065813416  
## 1.000000e-01 0.5824038 0.054362601  
## 3.162278e-01 0.5705873 0.055562073  
## 1.000000e+00 0.5060826 0.082564034  
## 3.162278e+00 0.4862590 0.090105235  
## 1.000000e+01 0.5479837 0.081574875  
## 3.162278e+01 0.5416117 0.069731098  
## 1.000000e+02 0.5098005 0.071963785  
##   
## Accuracy was used to select the optimal model using the largest value.  
## The final value used for the model was C = 1e-05.

#confusionMatrix  
set.seed(123)  
index = createDataPartition(y=ds1$type, p=0.7, list=FALSE)   
train\_set = ds1[index,]  
test\_set = ds1[-index,]  
svm\_split <- train(type ~., data = trains, method = "svmLinear")

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pred\_split <- predict(svm\_split, tests)   
confusionMatrix(tests$type, pred\_split)

## Confusion Matrix and Statistics  
##   
## Reference  
## Prediction Condo Multi\_Family Residential  
## Condo 14 1 0  
## Multi\_Family 1 2 0  
## Residential 98 88 73  
##   
## Overall Statistics  
##   
## Accuracy : 0.3213   
## 95% CI : (0.2667, 0.3798)  
## No Information Rate : 0.4079   
## P-Value [Acc > NIR] : 0.9988   
##   
## Kappa : 0.0676   
##   
## Mcnemar's Test P-Value : <2e-16   
##   
## Statistics by Class:  
##   
## Class: Condo Class: Multi\_Family Class: Residential  
## Sensitivity 0.12389 0.02198 1.00000  
## Specificity 0.99390 0.99462 0.08824  
## Pos Pred Value 0.93333 0.66667 0.28185  
## Neg Pred Value 0.62214 0.67518 1.00000  
## Prevalence 0.40794 0.32852 0.26354  
## Detection Rate 0.05054 0.00722 0.26354  
## Detection Prevalence 0.05415 0.01083 0.93502  
## Balanced Accuracy 0.55890 0.50830 0.54412