SVM Classification

Jered Hightower, Haniyyah Hamid

https://www.kaggle.com/datasets/vicsuperman/prediction-of-music-genre

```
original <- read.csv("music_genre.csv")
original$key <- factor(original$key)
original$tempo <- as.numeric(original$tempo)
```

```
## Warning: NAs introduced by coercion
```

```
original$mode <- factor(original$mode)
original$music_genre <- factor(original$music_genre)

df <- original[, -c(1,2,3,7,8,16)]

df <- df[complete.cases(df),]

df$key <- droplevels(df$key)
df$mode <- droplevels(df$mode)
df$music_genre <- droplevels(df$music_genre)

str(df)
```

```
## 'data.frame':    45020 obs. of  12 variables:
##  $ popularity      : num  27 31 28 34 32 46 43 39 22 30 ...
##  $ acousticness    : num  0.00468 0.0127 0.00306 0.0254 0.00465 0.0289 0.0297 0.00299 0.00934 0.855
##  $ danceability    : num  0.652 0.622 0.62 0.774 0.638 0.572 0.809 0.509 0.578 0.607 ...
##  $ instrumentalness: num  7.92e-01 9.50e-01 1.18e-02 2.53e-03 9.09e-01 7.74e-06 9.03e-01 2.76e-04 1.
##  $ key             : Factor w/ 12 levels "A","A#","B","C",..: 2 6 12 5 10 3 11 9 1 10 ...
##  $ liveness        : num  0.115 0.124 0.534 0.157 0.157 0.106 0.0635 0.178 0.111 0.106 ...
##  $ loudness        : num  -5.2 -7.04 -4.62 -4.5 -6.27 ...
##  $ mode            : Factor w/ 2 levels "Major","Minor": 2 2 1 1 1 1 2 2 2 2 ...
##  $ speechiness     : num  0.0748 0.03 0.0345 0.239 0.0413 0.351 0.0484 0.268 0.173 0.0345 ...
##  $ tempo           : num  101 115 128 128 145 ...
##  $ valence         : num  0.759 0.531 0.333 0.27 0.323 0.23 0.761 0.273 0.203 0.307 ...
##  $ music_genre     : Factor w/ 10 levels "Alternative",..: 6 6 6 6 6 6 6 6 6 6 ...
```

Train, test, validate

```
set.seed(1234)
spec <- c(train=.6, test=.2, validate=.2)
i <- sample(cut(1:nrow(df), nrow(df) * cumsum(c(0, spec)), labels=names(spec)))

train <- df[i=="train",]
test <- df[i=="test",]
vald <- df[i=="validate",]
```

Data Exploration

```
# How is genre associated with key?

# How often each genre appears
round(table(train$music_genre)/nrow(train), 2)
```

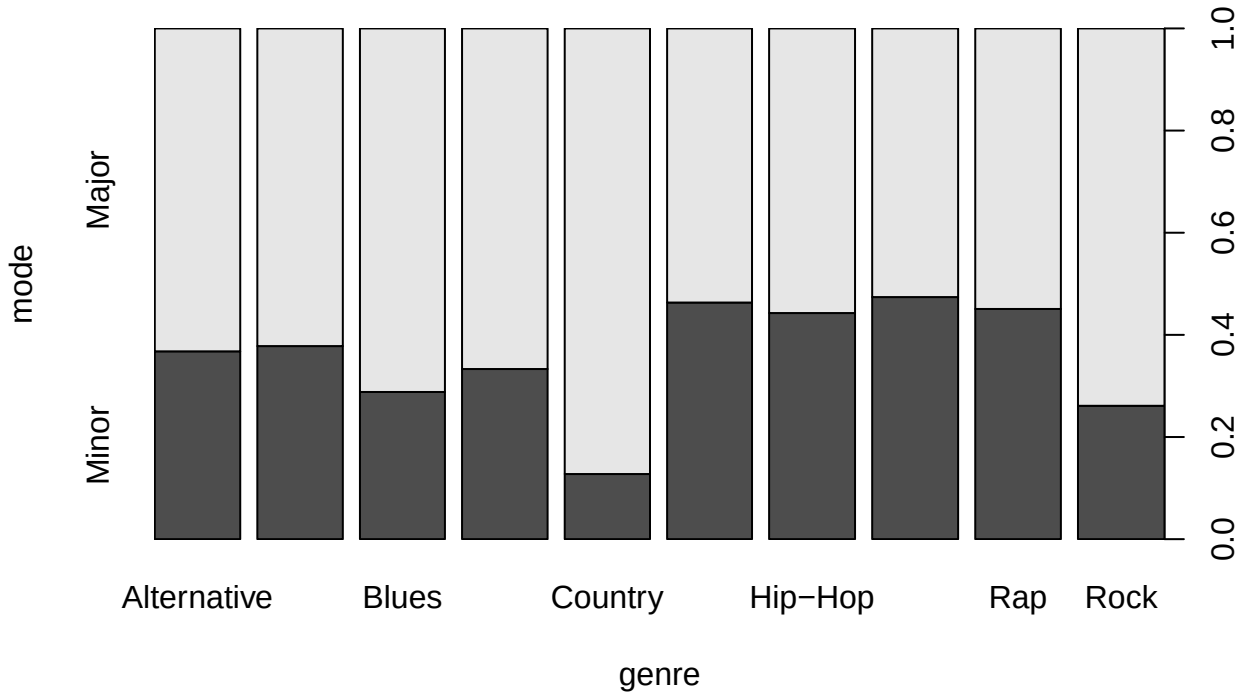
```
##
## Alternative       Anime       Blues   Classical     Country  Electronic
##         0.1         0.1         0.1         0.1         0.1         0.1
##     Hip-Hop        Jazz         Rap        Rock
##         0.1         0.1         0.1         0.1
```

```
# Proportion of Genre that is in a specific key
tr <- table(train$music_genre, train$key)
prop <- prop.table(tr, margin = 1)
round(prop, 2)
```

```
##
##                  A   A#    B    C   C#    D   D#    E    F   F#    G   G#
##   Alternative 0.10 0.05 0.09 0.11 0.10 0.10 0.03 0.08 0.09 0.07 0.11 0.06
##   Anime       0.09 0.05 0.07 0.13 0.10 0.11 0.04 0.08 0.09 0.07 0.11 0.07
##   Blues       0.13 0.05 0.07 0.13 0.06 0.13 0.02 0.09 0.09 0.04 0.14 0.05
##   Classical   0.09 0.07 0.05 0.12 0.08 0.12 0.06 0.09 0.09 0.05 0.12 0.06
##   Country     0.10 0.05 0.07 0.11 0.07 0.12 0.04 0.10 0.07 0.06 0.14 0.06
##   Electronic  0.09 0.08 0.09 0.10 0.14 0.09 0.02 0.07 0.08 0.08 0.11 0.07
##   Hip-Hop     0.08 0.08 0.09 0.09 0.18 0.08 0.02 0.05 0.09 0.07 0.08 0.09
##   Jazz        0.09 0.10 0.06 0.11 0.09 0.09 0.04 0.07 0.12 0.05 0.11 0.06
##   Rap         0.07 0.08 0.09 0.09 0.18 0.08 0.02 0.05 0.08 0.07 0.09 0.09
##   Rock        0.12 0.05 0.07 0.13 0.08 0.13 0.03 0.10 0.07 0.06 0.12 0.05
```

Data Exploration 2

```
# Alternative, Anime, Blues, Classical, Country, Electronic, Hip-Hop, Jazz, Rap, Rock
plot(df$music_genre, df$mode, xlab = "genre", ylab = "mode")
```



linear SVM

```
library(e1071)
svm1 <- svm(music_genre~., data=train, kernel="linear", cost=10, scale=TRUE)

summary(svm1)
```

```
##
## Call:
## svm(formula = music_genre ~ ., data = train, kernel = "linear", cost = 10,
##     scale = TRUE)
##
##
## Parameters:
##    SVM-Type:  C-classification
##  SVM-Kernel:  linear
##        cost:  10
##
## Number of Support Vectors:  22391
##
##  ( 1995 1956 2433 2679 2500 2639 2432 1945 1209 2603 )
##
##
## Number of Classes:  10
##
## Levels:
##  Alternative Anime Blues Classical Country Electronic Hip-Hop Jazz Rap Rock
```

evaluate

```
library(caret)
```

```
## Loading required package: ggplot2
```

```
## Loading required package: lattice
```

```
pred <- predict(svm1, newdata=test)
caret:: confusionMatrix(as.factor(pred), reference=test$music_genre)
```

```
## Confusion Matrix and Statistics
##
##              Reference
## Prediction    Alternative Anime Blues Classical Country Electronic Hip-Hop Jazz
##   Alternative         346    28    35        25      81         65      62   28
##   Anime                 3   584   156        34      15         77       0   35
##   Blues                17    83   388        21      84         53       2  103
##   Classical             4   118    24       756       1         13       0   66
##   Country             144    40   103        11     443         38      20   63
##   Electronic           54    62    58        19      28        512      10  125
##   Hip-Hop              97     2     2         0      20         38     475   23
##   Jazz                 49    18    99        32      55        101      12  409
##   Rap                  22     0     1         0       5          9     238    1
##   Rock                148     5    44         5     180         28      60   31
##              Reference
## Prediction    Rap Rock
##   Alternative  57   95
##   Anime         0    2
##   Blues         1    2
##   Classical     0    3
##   Country      11   65
##   Electronic    3   10
##   Hip-Hop     362   18
##   Jazz          8   35
##   Rap         290   40
##   Rock        103  653
##
## Overall Statistics
##
##                Accuracy : 0.5393
##                  95% CI : (0.529, 0.5497)
##     No Information Rate : 0.1044
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.4879
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Alternative Class: Anime Class: Blues
## Sensitivity                     0.39140      0.62128      0.42637
## Specificity                     0.94138      0.96007      0.95478
## Pos Pred Value                  0.42092      0.64459      0.51459
```

```
## Neg Pred Value                  0.93425      0.95604      0.93673
## Prevalence                      0.09818      0.10440      0.10107
## Detection Rate                  0.03843      0.06486      0.04309
## Detection Prevalence            0.09129      0.10062      0.08374
## Balanced Accuracy               0.66639      0.79067      0.69058
##                       Class: Classical Class: Country Class: Electronic
## Sensitivity                    0.83721         0.4857           0.54818
## Specificity                    0.97173         0.9388           0.95428
## Pos Pred Value                 0.76751         0.4723           0.58116
## Neg Pred Value                 0.98167         0.9419           0.94805
## Prevalence                     0.10029         0.1013           0.10373
## Detection Rate                 0.08396         0.0492           0.05686
## Detection Prevalence           0.10940         0.1042           0.09785
## Balanced Accuracy              0.90447         0.7123           0.75123
##                       Class: Hip-Hop Class: Jazz Class: Rap Class: Rock
## Sensitivity                  0.54039     0.46267    0.34731     0.70748
## Specificity                  0.93083     0.94963    0.96132     0.92526
## Pos Pred Value               0.45805     0.50000    0.47855     0.51949
## Neg Pred Value               0.94929     0.94197    0.93510     0.96515
## Prevalence                   0.09762     0.09818    0.09274     0.10251
## Detection Rate               0.05275     0.04542    0.03221     0.07252
## Detection Prevalence         0.11517     0.09085    0.06730     0.13960
## Balanced Accuracy            0.73561     0.70615    0.65431     0.81637
```

Tune

```
tune_svm1 <- tune(svm, music_genre~., data=vald, kernel="linear", ranges = list(cost=c(.001, .01, .1, 1
summary(tune_svm1)
```

```
##
## Parameter tuning of 'svm':
##
## - sampling method: 10-fold cross validation
##
## - best parameters:
##  cost
##    10
##
## - best performance: 0.4743467
##
## - Detailed performance results:
##    cost     error dispersion
## 1 1e-03 0.5432055 0.02023018
## 2 1e-02 0.4823425 0.01725347
## 3 1e-01 0.4752348 0.01623979
## 4 1e+00 0.4760120 0.01611908
## 5 5e+00 0.4752347 0.01695303
## 6 1e+01 0.4743467 0.01748528
## 7 1e+02 0.4752354 0.01729592
```

Evaluate on best linear svm

```
pred2 <- predict(tune_svm1$best.model, newdata=test)
caret:: confusionMatrix(as.factor(pred2), reference=test$music_genre)
```

```
## Confusion Matrix and Statistics
##
##              Reference
## Prediction    Alternative Anime Blues Classical Country Electronic Hip-Hop Jazz
##   Alternative         297    29    29        21      62         53      62   25
##   Anime                 5   588   144        52      25         71       0   36
##   Blues                 8    88   375        15      60         48       3   76
##   Classical             4   104    18       722       2         13       0   55
##   Country             164    40   115        11     479         43      30   69
##   Electronic           65    66    60        19      31        520      10  140
##   Hip-Hop              66     1     2         0      11         31     327   21
##   Jazz                 61    21   121        54      59        107      11  419
##   Rap                  45     1     1         0      13         15     378    3
##   Rock                169     2    45         9     170         33      58   40
##              Reference
## Prediction    Rap Rock
##   Alternative  62   75
##   Anime         0    2
##   Blues         0    4
##   Classical     0    2
##   Country      21   89
##   Electronic    5    9
##   Hip-Hop     226   11
##   Jazz          8   31
##   Rap         399   36
##   Rock        114  664
##
## Overall Statistics
##
##                Accuracy : 0.532
##                  95% CI : (0.5216, 0.5423)
##     No Information Rate : 0.1044
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.4799
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Alternative Class: Anime Class: Blues
## Sensitivity                     0.33597       0.6255      0.41209
## Specificity                     0.94852       0.9585      0.96269
## Pos Pred Value                  0.41538       0.6371      0.55391
## Neg Pred Value                  0.92918       0.9564      0.93575
## Prevalence                      0.09818       0.1044      0.10107
## Detection Rate                  0.03299       0.0653      0.04165
## Detection Prevalence            0.07941       0.1025      0.07519
## Balanced Accuracy               0.64225       0.7920      0.68739
```

```
##                      Class: Classical Class: Country Class: Electronic
## Sensitivity                   0.79956         0.5252           0.55675
## Specificity                   0.97556         0.9281           0.94981
## Pos Pred Value                0.78478         0.4515           0.56216
## Neg Pred Value                0.97761         0.9455           0.94876
## Prevalence                    0.10029         0.1013           0.10373
## Detection Rate                0.08019         0.0532           0.05775
## Detection Prevalence          0.10218         0.1178           0.10273
## Balanced Accuracy             0.88756         0.7266           0.75328
##                      Class: Hip-Hop Class: Jazz Class: Rap Class: Rock
## Sensitivity                 0.37201     0.47398    0.47784     0.71939
## Specificity                 0.95458     0.94175    0.93977     0.92080
## Pos Pred Value              0.46983     0.46973    0.44781     0.50920
## Neg Pred Value              0.93356     0.94268    0.94626     0.96636
## Prevalence                  0.09762     0.09818    0.09274     0.10251
## Detection Rate              0.03632     0.04653    0.04431     0.07375
## Detection Prevalence        0.07730     0.09907    0.09896     0.14482
## Balanced Accuracy           0.66330     0.70787    0.70881     0.82010
```

Try Polynomial Kernel

```
svm2 <- svm(music_genre~., data = train, kernel="polynomial", cost = 10, scale = TRUE)
summary(svm2)
```

```
##
## Call:
## svm(formula = music_genre ~ ., data = train, kernel = "polynomial",
##     cost = 10, scale = TRUE)
##
##
## Parameters:
##    SVM-Type:  C-classification
##  SVM-Kernel:  polynomial
##        cost:  10
##      degree:  3
##      coef.0:  0
##
## Number of Support Vectors:  22014
##
##  ( 1966 1713 2354 2661 2552 2643 2323 2147 1015 2640 )
##
##
## Number of Classes:  10
##
## Levels:
##  Alternative Anime Blues Classical Country Electronic Hip-Hop Jazz Rap Rock
```

Evaluate

```
pred3 <- predict(svm2, newdata=test)
caret:: confusionMatrix(as.factor(pred3), reference=test$music_genre)
```

```
## Confusion Matrix and Statistics
##
##              Reference
## Prediction    Alternative Anime Blues Classical Country Electronic Hip-Hop Jazz
##   Alternative         375    33    52        29      79         93      88   53
##   Anime                 3   613    69        36      17         44       0   16
##   Blues                15    83   466        26      66         59       0  120
##   Classical             2    72    13       732       0          3       0   42
##   Country             177    60   135        12     512         70      26   92
##   Electronic           39    48    58        16      17        509       9  114
##   Hip-Hop              86     2     1         0      15         32     493   16
##   Jazz                 36    25    77        48      48         93       7  405
##   Rap                  21     0     2         0       4          9     209    3
##   Rock                130     4    37         4     154         22      47   23
##              Reference
## Prediction    Rap Rock
##   Alternative  87  150
##   Anime         0    1
##   Blues         1    4
##   Classical     0    1
##   Country      23  115
##   Electronic    1    6
##   Hip-Hop     400   21
##   Jazz          4   28
##   Rap         215   21
##   Rock        104  576
##
## Overall Statistics
##
##                Accuracy : 0.5438
##                  95% CI : (0.5334, 0.5541)
##     No Information Rate : 0.1044
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.4929
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Alternative Class: Anime Class: Blues
## Sensitivity                     0.42421      0.65213      0.51209
## Specificity                     0.91823      0.97693      0.95379
## Pos Pred Value                  0.36092      0.76721      0.55476
## Neg Pred Value                  0.93610      0.96015      0.94561
## Prevalence                      0.09818      0.10440      0.10107
## Detection Rate                  0.04165      0.06808      0.05175
## Detection Prevalence            0.11539      0.08874      0.09329
## Balanced Accuracy               0.67122      0.81453      0.73294
##                      Class: Classical Class: Country Class: Electronic
## Sensitivity                   0.81063        0.56140           0.54497
## Specificity                   0.98358        0.91226           0.96183
## Pos Pred Value                0.84624        0.41899           0.62301
## Neg Pred Value                0.97899        0.94860           0.94809
```

```
## Prevalence                    0.10029        0.10129           0.10373
## Detection Rate                0.08130        0.05686           0.05653
## Detection Prevalence          0.09607        0.13572           0.09074
## Balanced Accuracy             0.89711        0.73683           0.75340
##                       Class: Hip-Hop Class: Jazz Class: Rap Class: Rock
## Sensitivity                  0.56086     0.45814    0.25749     0.62405
## Specificity                  0.92948     0.95493    0.96707     0.93503
## Pos Pred Value               0.46248     0.52529    0.44421     0.52316
## Neg Pred Value               0.95137     0.94182    0.92723     0.95609
## Prevalence                   0.09762     0.09818    0.09274     0.10251
## Detection Rate               0.05475     0.04498    0.02388     0.06397
## Detection Prevalence         0.11839     0.08563    0.05375     0.12228
## Balanced Accuracy            0.74517     0.70654    0.61228     0.77954
```

Tune hyperparameters (tried but it wouldn't converge: reaching max number of iterations)

```
#tune.poly <- tune(svm, music_genre~., data=vald, kernel="polynomial", ranges = #list(degree=c(3,4,5),
#summary(tune.poly)
```

Try a radial kernel

```
svm3 <- svm(music_genre~., data = train, kernel = "radial", cost=10, gamma=1, scale=TRUE)
summary(svm3)
```

```
##
## Call:
## svm(formula = music_genre ~ ., data = train, kernel = "radial", cost = 10,
##     gamma = 1, scale = TRUE)
##
##
## Parameters:
##    SVM-Type:  C-classification
##  SVM-Kernel:  radial
##        cost:  10
##
## Number of Support Vectors:  26211
##
##  ( 2592 2525 2707 2717 2561 2704 2638 2614 2385 2768 )
##
##
## Number of Classes:  10
##
## Levels:
##  Alternative Anime Blues Classical Country Electronic Hip-Hop Jazz Rap Rock
```

Tune hyperparameters

```
tune.out <- tune(svm, music_genre~., data=vald, kernel="radial", ranges = list(cost=c(.1, 1, 10, 100, 1
summary(tune.out)
```

```
##
## Parameter tuning of 'svm':
##
## - sampling method: 10-fold cross validation
##
## - best parameters:
##  cost gamma
##     1   0.5
##
## - best performance: 0.4845617
##
## - Detailed performance results:
##     cost gamma     error  dispersion
## 1  1e-01   0.5 0.5467579 0.019838168
## 2  1e+00   0.5 0.4845617 0.012282596
## 3  1e+01   0.5 0.5219863 0.018966673
## 4  1e+02   0.5 0.5246530 0.015294235
## 5  1e+03   0.5 0.5260962 0.016107082
## 6  1e-01   1.0 0.8539545 0.031574914
## 7  1e+00   1.0 0.5366506 0.012221481
## 8  1e+01   1.0 0.5525320 0.014559172
## 9  1e+02   1.0 0.5531988 0.015133087
## 10 1e+03   1.0 0.5535321 0.015714225
## 11 1e-01   2.0 0.8967151 0.009004451
## 12 1e+00   2.0 0.6748134 0.018811891
## 13 1e+01   2.0 0.6635943 0.014439464
## 14 1e+02   2.0 0.6642606 0.013905142
## 15 1e+03   2.0 0.6641495 0.014025805
## 16 1e-01   3.0 0.8970481 0.008361788
## 17 1e+00   3.0 0.7809890 0.015853133
## 18 1e+01   3.0 0.7633301 0.017486123
## 19 1e+02   3.0 0.7634411 0.017389498
## 20 1e+03   3.0 0.7634411 0.017389498
## 21 1e-01   4.0 0.8971591 0.008166518
## 22 1e+00   4.0 0.8227490 0.016482403
## 23 1e+01   4.0 0.8072004 0.016184528
## 24 1e+02   4.0 0.8074225 0.015877170
## 25 1e+03   4.0 0.8074225 0.015877170
```

Evaluate on best radial svm

```
pred4 <- predict(tune.out$best.model, newdata=test)
caret:: confusionMatrix(as.factor(pred4), reference=test$music_genre)
```

```
## Confusion Matrix and Statistics
##
##              Reference
## Prediction    Alternative Anime Blues Classical Country Electronic Hip-Hop Jazz
##   Alternative         309    37    39        28      87         45      34   34
##   Anime                 2   597   101        27      29         49       1   14
##   Blues                19    92   405        21      57         59       1   85
##   Classical             2    76    20       736       2          8       0   54
##   Country             105    26   109         7     422         36      10   56
```

```
##   Electronic           76    78    63        25      27        531      25  125
##   Hip-Hop              75     1     5         0      29         35     322   21
##   Jazz                 67    27   128        55      67        122      20  458
##   Rap                  55     0     0         0      13         21     407    8
##   Rock                174     6    40         4     179         28      59   29
##             Reference
## Prediction    Rap Rock
##   Alternative  39   99
##   Anime         1    3
##   Blues         0    6
##   Classical     0    6
##   Country      10   79
##   Electronic   21   12
##   Hip-Hop     308   17
##   Jazz          3   53
##   Rap         336   36
##   Rock        117  612
##
## Overall Statistics
##
##                Accuracy : 0.5251
##                  95% CI : (0.5147, 0.5355)
##     No Information Rate : 0.1044
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.4723
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Alternative Class: Anime Class: Blues
## Sensitivity                     0.34955      0.63511      0.44505
## Specificity                     0.94557      0.97185      0.95799
## Pos Pred Value                  0.41145      0.72451      0.54362
## Neg Pred Value                  0.93033      0.95807      0.93885
## Prevalence                      0.09818      0.10440      0.10107
## Detection Rate                  0.03432      0.06630      0.04498
## Detection Prevalence            0.08341      0.09151      0.08274
## Balanced Accuracy               0.64756      0.80348      0.70152
##                      Class: Classical Class: Country Class: Electronic
## Sensitivity                   0.81506        0.46272           0.56852
## Specificity                   0.97926        0.94587           0.94399
## Pos Pred Value                0.81416        0.49070           0.54018
## Neg Pred Value                0.97938        0.93983           0.94976
## Prevalence                    0.10029        0.10129           0.10373
## Detection Rate                0.08174        0.04687           0.05897
## Detection Prevalence          0.10040        0.09551           0.10917
## Balanced Accuracy             0.89716        0.70430           0.75626
##                      Class: Hip-Hop Class: Jazz Class: Rap Class: Rock
## Sensitivity                 0.36633     0.51810    0.40240     0.66306
## Specificity                 0.93957     0.93325    0.93390     0.92130
## Pos Pred Value              0.39606     0.45800    0.38356     0.49038
## Neg Pred Value              0.93200     0.94678    0.93861     0.95990
```

```
## Prevalence                0.09762     0.09818     0.09274     0.10251
## Detection Rate            0.03576     0.05087     0.03732     0.06797
## Detection Prevalence      0.09029     0.11106     0.09729     0.13861
## Balanced Accuracy         0.65295     0.72568     0.66815     0.79218
```