Lab 7

Ransom notes keep falling

Alice Chang

The data

```r
library(MASS)
library(gbm)
```

```
## Loaded gbm 2.1.5
```

```r
#load data
lettersdf <- read.csv("https://raw.githubusercontent.com/stat-learning/course-materials/master/data/let
                      header = FALSE)

#subset training data
set.seed(1)
train <- sample(1:nrow(lettersdf), nrow(lettersdf) * .75)
```
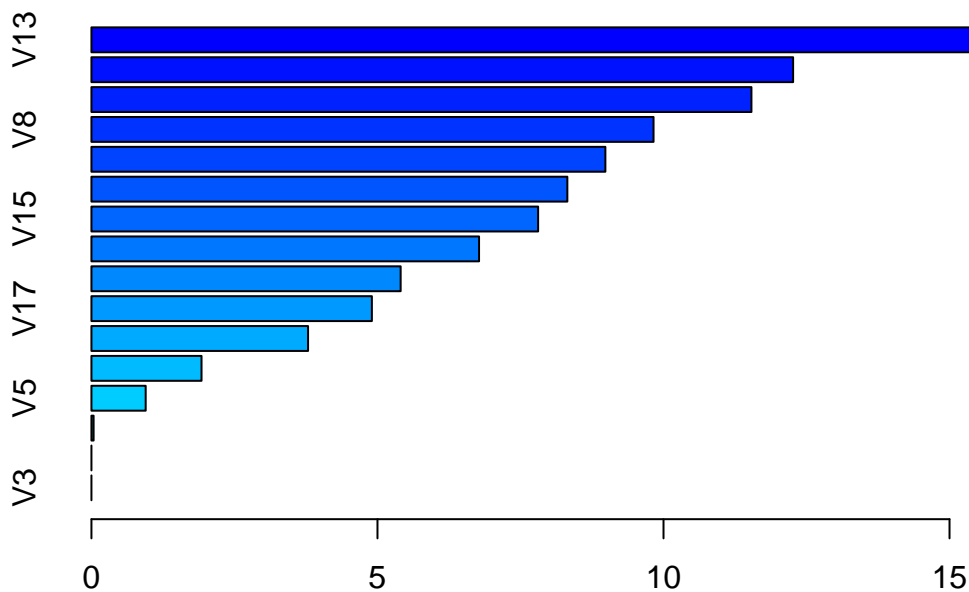
Building a boosted tree

```r
boost.letters = gbm(V1 ~., data = lettersdf[train,], distribution = "multinomial", n.trees = 50, intera
```

```r
summary(boost.letters)
```


Relative influence

```
##      var      rel.inf
## V13 V13 17.47975897
## V12 V12 12.26575586
```

```
## V14 V14 11.53730240
## V8   V8   9.82580683
## V10 V10  8.98367860
## V11 V11  8.31923619
## V15 V15  7.80833554
## V9   V9   6.77590463
## V16 V16  5.40537511
## V17 V17  4.90210556
## V7   V7   3.78671390
## V4   V4   1.92421542
## V5   V5   0.94803360
## V6   V6   0.03777739
## V2   V2   0.00000000
## V3   V3   0.00000000
```

V13 (the measure of the correlation of the vertical variance with the horizontal position) is the most important variable.

Assessing predictions

```r
#Predict letters
yhat.boost = predict(boost.letters,newdata = lettersdf[-train,], n.trees = 50, type = "response")
pred_letters<- LETTERS[apply(yhat.boost, 1, which.max)]
pred_letters
```

```
##    [1] "T" "J" "K" "B" "E" "Q" "X" "X" "G" "W" "L" "Q" "H" "J" "R" "B" "W"
##   [18] "N" "Y" "D" "T" "P" "U" "N" "R" "Q" "C" "A" "C" "Z" "M" "A" "H" "B"
##   [35] "V" "D" "B" "N" "S" "I" "M" "P" "O" "C" "Z" "O" "L" "C" "B" "X" "B"
##   [52] "D" "P" "Z" "S" "C" "M" "L" "F" "T" "R" "G" "V" "B" "M" "A" "O" "H"
##   [69] "I" "S" "M" "V" "X" "V" "A" "P" "O" "D" "F" "B" "K" "U" "Y" "R" "Q"
##   [86] "B" "M" "D" "R" "S" "V" "X" "C" "J" "D" "D" "J" "I" "J" "M" "J" "Z"
##  [103] "N" "C" "Z" "W" "J" "M" "U" "B" "B" "N" "M" "B" "M" "D" "B" "S" "O"
##  [120] "B" "O" "N" "J" "S" "V" "B" "O" "Y" "X" "N" "E" "R" "V" "J" "A" "P"
##  [137] "O" "S" "N" "G" "T" "W" "F" "V" "B" "M" "M" "G" "B" "W" "K" "Y" "Q"
##  [154] "R" "D" "P" "X" "P" "H" "P" "D" "T" "J" "Q" "A" "S" "I" "Y" "F" "P"
##  [171] "G" "I" "X" "E" "K" "Y" "X" "U" "O" "D" "X" "B" "A" "Y" "A" "Z" "P"
##  [188] "Q" "H" "T" "G" "L" "F" "Y" "S" "N" "G" "N" "B" "R" "G" "G" "S" "L"
##  [205] "G" "F" "R" "S" "I" "G" "K" "B" "K" "L" "T" "Y" "C" "Y" "S" "T" "S"
##  [222] "E" "L" "P" "N" "M" "S" "R" "D" "D" "T" "M" "Z" "O" "L" "E" "K" "N"
##  [239] "D" "R" "T" "F" "W" "Y" "Y" "M" "A" "F" "A" "F" "S" "T" "A" "G" "O"
##  [256] "Z" "J" "E" "A" "C" "B" "D" "G" "N" "S" "J" "G" "H" "O" "B" "B" "J"
##  [273] "T" "D" "U" "Z" "P" "D" "T" "F" "B" "Y" "V" "E" "E" "X" "Z" "W" "P"
##  [290] "O" "X" "O" "G" "K" "X" "Z" "K" "I" "W" "C" "Y" "O" "T" "F" "S" "Q"
##  [307] "Y" "V" "B" "O" "C" "A" "T" "H" "C" "J" "M" "I" "O" "V" "M" "Y" "I"
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##  [341] "Y" "M" "M" "D" "K" "D" "D" "A" "X" "V" "N" "X" "R" "N" "Y" "W" "D"
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##  [409] "V" "H" "O" "A" "V" "G" "W" "Z" "W" "G" "N" "K" "P" "L" "K" "G" "X"
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##  [460] "V" "W" "B" "N" "N" "M" "Y" "W" "K" "O" "A" "Q" "E" "U" "O" "S" "N"
##  [477] "L" "H" "R" "G" "J" "K" "F" "G" "U" "D" "X" "I" "O" "P" "A" "K" "G"
##  [494] "K" "A" "T" "Q" "Y" "R" "F" "R" "Q" "F" "G" "Q" "D" "C" "L" "M" "W"
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```
##  [511] "B" "C" "T" "C" "G" "X" "Q" "Y" "D" "R" "I" "D" "V" "B" "V" "C" "F"
##  [528] "A" "U" "J" "U" "S" "O" "R" "F" "O" "M" "Y" "M" "R" "E" "O" "J" "S"
##  [545] "Q" "G" "Z" "C" "F" "S" "M" "P" "R" "C" "D" "Z" "X" "H" "U" "Q" "W"
##  [562] "W" "G" "G" "U" "A" "R" "M" "U" "C" "U" "P" "J" "Z" "M" "I" "J" "P"
##  [579] "P" "Z" "A" "J" "J" "B" "G" "B" "K" "L" "O" "D" "I" "M" "N" "B" "H"
##  [596] "O" "S" "W" "F" "B" "U" "N" "T" "L" "G" "E" "O" "D" "K" "Q" "D" "N"
##  [613] "Q" "J" "A" "M" "Q" "B" "M" "V" "Q" "Z" "R" "B" "Z" "T" "Y" "R" "R"
##  [630] "X" "C" "Q" "F" "G" "P" "G" "R" "N" "B" "J" "R" "O" "B" "R" "H" "Y"
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##  [664] "F" "X" "M" "L" "Y" "P" "S" "C" "X" "E" "L" "T" "B" "K" "V" "S" "H"
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##  [936] "K" "Y" "X" "W" "Y" "G" "T" "Z" "G" "P" "Q" "N" "M" "T" "B" "O" "I"
##  [953] "K" "Z" "A" "M" "I" "U" "O" "X" "D" "O" "S" "Q" "Y" "D" "U" "R" "R"
##  [970] "Z" "A" "T" "G" "B" "X" "J" "R" "Z" "W" "B" "C" "M" "R" "Y" "R" "S"
##  [987] "N" "E" "J" "G" "B" "F" "D" "Q" "K" "Q" "Z" "R" "W" "H" "D" "T" "I"
## [1004] "C" "J" "N" "G" "M" "Z" "N" "L" "B" "K" "J" "C" "P" "U" "J" "N" "B"
## [1021] "E" "P" "D" "X" "T" "K" "J" "J" "F" "A" "P" "O" "C" "Y" "S" "W" "D"
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## [1106] "U" "N" "Z" "I" "K" "F" "U" "R" "X" "F" "O" "R" "B" "N" "V" "Q" "C"
## [1123] "B" "R" "L" "S" "Y" "M" "B" "G" "H" "Y" "B" "X" "S" "B" "A" "B" "Q"
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## [1157] "T" "Z" "M" "U" "E" "U" "W" "M" "R" "V" "B" "T" "O" "P" "T" "W" "R"
## [1174] "P" "X" "R" "K" "D" "R" "L" "B" "R" "T" "J" "U" "B" "Z" "Y" "I" "Q"
## [1191] "A" "T" "D" "Q" "A" "J" "B" "K" "C" "U" "L" "P" "F" "Y" "Y" "G" "C"
## [1208] "A" "F" "O" "D" "M" "Q" "O" "F" "D" "F" "M" "A" "J" "R" "V" "W" "F"
## [1225] "E" "V" "M" "I" "H" "M" "I" "O" "S" "B" "B" "B" "O" "S" "R" "K" "J"
## [1242] "T" "N" "Y" "M" "F" "C" "H" "K" "Q" "Y" "S" "E" "I" "F" "O" "H" "Q"
## [1259] "U" "M" "S" "N" "E" "V" "N" "E" "Q" "J" "A" "D" "G" "U" "S" "U" "G"
## [1276] "Q" "Z" "E" "M" "D" "I" "U" "D" "Y" "D" "T" "K" "D" "T" "J" "A" "S"
## [1293] "P" "M" "I" "B" "C" "X" "G" "B" "C" "S" "L" "W" "K" "X" "A" "T" "D"
## [1310] "V" "R" "Z" "Y" "P" "X" "D" "R" "X" "S" "U" "M" "N" "V" "O" "T" "G"
## [1327] "W" "B" "W" "N" "B" "G" "Q" "M" "Z" "U" "T" "K" "O" "U" "M" "M" "G"
## [1344] "G" "X" "X" "T" "V" "X" "L" "H" "F" "I" "H" "G" "W" "A" "S" "D" "L"
## [1361] "W" "A" "P" "Y" "K" "M" "W" "N" "M" "Z" "B" "E" "Z" "W" "O" "K" "J"
## [1378] "G" "U" "X" "F" "C" "S" "B" "X" "U" "W" "T" "A" "C" "Q" "W" "N" "K"
## [1395] "B" "S" "V" "B" "P" "U" "O" "S" "F" "N" "B" "R" "O" "T" "R" "X" "X"
## [1412] "E" "N" "V" "S" "K" "S" "T" "L" "D" "C" "X" "R" "Y" "Q" "C" "S" "I"
```

```
## [1429] "Y" "A" "P" "X" "S" "W" "C" "D" "U" "M" "S" "Y" "O" "B" "C" "A" "U"
## [1446] "M" "O" "S" "D" "S" "C" "N" "D" "X" "B" "O" "S" "S" "A" "Z" "M" "J"
## [1463] "I" "O" "X" "M" "N" "B" "X" "R" "P" "P" "M" "O" "T" "D" "B" "G" "B"
## [1480] "M" "X" "Z" "R" "I" "S" "T" "N" "H" "B" "V" "I" "R" "G" "W" "B" "F"
## [1497] "D" "S" "I" "B" "U" "Q" "K" "R" "L" "X" "W" "P" "Y" "K" "D" "S" "G"
## [1514] "O" "V" "V" "O" "E" "D" "H" "Q" "E" "X" "R" "J" "W" "V" "E" "A" "H"
## [1531] "I" "F" "S" "E" "K" "B" "K" "T" "L" "O" "X" "M" "O" "Q" "X" "R" "V"
## [1548] "G" "R" "S" "T" "K" "M" "Z" "C" "A" "M" "V" "C" "X" "W" "B" "W" "U"
## [1565] "N" "U" "M" "W" "M" "D" "O" "K" "B" "L" "L" "S" "O" "I" "D" "U" "Z"
## [1582] "J" "T" "A" "F" "D" "Z" "F" "W" "X" "Y" "K" "R" "L" "C" "S" "U" "O"
## [1599] "X" "K" "U" "L" "B" "U" "C" "S" "I" "Q" "I" "B" "O" "V" "W" "P" "E"
## [1616] "U" "P" "V" "G" "U" "J" "L" "D" "A" "C" "K" "Y" "F" "E" "O" "E" "P"
## [1633] "N" "Y" "S" "Z" "P" "L" "N" "M" "F" "L" "S" "M" "D" "C" "V" "R" "K"
## [1650] "R" "Q" "N" "T" "A" "F" "J" "U" "C" "B" "B" "D" "J" "O" "R" "C" "D"
## [1667] "E" "O" "S" "J" "X" "A" "W" "D" "Y" "N" "Y" "H" "Q" "I" "K" "I" "Y"
## [1684] "X" "U" "R" "W" "Q" "M" "O" "X" "F" "H" "C" "S" "D" "Q" "U" "J" "M"
## [1701] "D" "G" "L" "X" "D" "N" "O" "B" "C" "S" "R" "R" "S" "M" "W" "H" "Q"
## [1718] "G" "J" "Q" "H" "M" "Q" "V" "C" "D" "X" "K" "R" "P" "K" "Y" "Y" "V"
## [1735] "T" "X" "X" "O" "Q" "D" "A" "K" "T" "D" "R" "Z" "F" "L" "O" "L" "C"
## [1752] "C" "R" "R" "Z" "B" "O" "H" "Y" "O" "R" "O" "T" "Y" "N" "K" "S" "L"
## [1769] "N" "X" "V" "W" "A" "O" "K" "G" "M" "M" "B" "R" "O" "N" "R" "V" "Y"
## [1786] "S" "Y" "I" "W" "C" "D" "Y" "W" "A" "Z" "M" "T" "G" "O" "K" "F" "Q"
## [1803] "H" "U" "R" "I" "X" "R" "T" "I" "C" "M" "D" "B" "E" "C" "I" "O" "O"
## [1820] "K" "J" "P" "U" "H" "E" "F" "V" "I" "T" "O" "H" "V" "S" "G" "I" "D"
## [1837] "S" "S" "L" "X" "P" "T" "W" "N" "R" "Q" "W" "B" "C" "S" "O" "V" "R"
## [1854] "P" "J" "D" "J" "V" "B" "J" "S" "B" "G" "Z" "J" "R" "Q" "N" "X" "F"
## [1871] "P" "Q" "U" "F" "T" "K" "V" "M" "Q" "M" "A" "Y" "A" "E" "C" "C" "M"
## [1888] "N" "G" "H" "A" "K" "R" "X" "B" "Y" "R" "C" "G" "P" "U" "T" "H" "O"
## [1905] "E" "D" "P" "O" "R" "Y" "G" "R" "P" "F" "E" "N" "B" "N" "N" "H" "C"
## [1922] "Z" "Y" "R" "P" "E" "K" "S" "B" "L" "S" "P" "D" "R" "U" "S" "Z" "D"
## [1939] "Z" "X" "M" "U" "N" "F" "K" "L" "V" "Z" "K" "I" "L" "C" "U" "J" "G"
## [1956] "X" "T" "K" "P" "S" "O" "W" "O" "E" "S" "O" "K" "C" "T" "F" "N" "X"
## [1973] "H" "M" "L" "P" "N" "E" "I" "W" "P" "S" "X" "H" "X" "G" "U" "Z" "F"
## [1990] "N" "N" "D" "B" "S" "A" "B" "V" "D" "W" "O" "W" "Q" "B" "Q" "W" "U"
## [2007] "B" "A" "R" "X" "L" "E" "C" "B" "E" "U" "T" "P" "B" "N" "D" "I" "B"
## [2024] "T" "L" "A" "P" "P" "W" "Q" "V" "R" "C" "P" "T" "R" "A" "A" "X" "L"
## [2041] "A" "M" "T" "W" "G" "P" "E" "B" "W" "L" "P" "D" "Z" "B" "H" "Q" "R"
## [2058] "Y" "J" "P" "F" "B" "R" "K" "P" "N" "B" "X" "N" "K" "O" "U" "P" "C"
## [2075] "B" "Z" "R" "W" "X" "H" "L" "E" "W" "P" "N" "Z" "S" "C" "Y" "G" "M"
## [2092] "B" "R" "M" "M" "T" "C" "X" "P" "B" "Q" "D" "D" "V" "U" "U" "X" "M"
## [2109] "S" "S" "D" "L" "I" "P" "M" "P" "R" "O" "X" "Z" "M" "V" "W" "F" "U"
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## [2160] "N" "O" "Z" "R" "C" "S" "N" "D" "W" "G" "J" "U" "Z" "Z" "B" "X" "W"
## [2177] "I" "O" "Q" "F" "V" "U" "P" "A" "Q" "M" "Y" "C" "D" "Y" "O" "H" "N"
## [2194] "N" "D" "B" "W" "C" "P" "F" "B" "L" "P" "M" "L" "F" "F" "Z" "X" "U"
## [2211] "K" "M" "D" "Y" "B" "J" "V" "B" "O" "M" "T" "M" "D" "X" "C" "I" "K"
## [2228] "O" "R" "P" "M" "R" "H" "A" "P" "O" "B" "V" "N" "B" "N" "A" "Y" "V"
## [2245] "A" "I" "T" "N" "Q" "U" "O" "D" "Q" "A" "I" "M" "Z" "R" "T" "R" "B"
## [2262] "A" "X" "F" "Y" "O" "W" "I" "R" "X" "X" "Y" "U" "F" "D" "C" "Q" "I"
## [2279] "T" "D" "N" "F" "B" "U" "B" "C" "Z" "S" "I" "U" "N" "M" "B" "U" "D"
## [2296] "I" "M" "Z" "Z" "X" "C" "P" "W" "O" "A" "B" "N" "N" "W" "S" "N" "K"
## [2313] "Q" "Z" "M" "T" "S" "L" "Z" "F" "I" "M" "B" "C" "Q" "C" "A" "V" "D"
## [2330] "D" "R" "D" "F" "Q" "T" "Z" "M" "C" "N" "O" "N" "G" "R" "C" "T" "R"
```

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## [2347] "C" "G" "A" "I" "S" "B" "Z" "F" "O" "I" "O" "S" "V" "L" "W" "M" "F"
## [2364] "V" "P" "L" "C" "Y" "O" "S" "I" "T" "P" "R" "W" "N" "X" "M" "A" "O"
## [2381] "C" "I" "V" "G" "W" "B" "Q" "X" "V" "Q" "V" "N" "U" "L" "O" "E" "F"
## [2398] "I" "G" "T" "D" "W" "M" "O" "K" "C" "O" "G" "K" "I" "C" "O" "W" "G"
## [2415] "Z" "B" "H" "F" "M" "V" "W" "X" "C" "D" "V" "R" "K" "M" "H" "S" "W"
## [2432] "S" "E" "A" "M" "Q" "B" "W" "L" "O" "L" "Q" "W" "P" "O" "B" "Z" "C"
## [2449] "R" "J" "U" "Q" "W" "P" "L" "M" "B" "I" "C" "B" "R" "Q" "R" "Y" "O"
## [2466] "V" "A" "U" "C" "K" "L" "U" "J" "B" "C" "G" "S" "D" "H" "I" "I" "O"
## [2483] "D" "N" "O" "I" "S" "O" "L" "C" "I" "J" "D" "R" "F" "X" "T" "B" "D"
## [2500] "Q" "B" "M" "R" "V" "M" "B" "M" "C" "Z" "R" "S" "Q" "Q" "F" "U" "A"
## [2517] "U" "V" "S" "H" "W" "K" "T" "O" "X" "A" "I" "X" "T" "R" "B" "W" "C"
## [2534] "V" "J" "D" "L" "L" "R" "U" "F" "M" "C" "M" "Y" "N" "V" "M" "G" "Q"
## [2551] "Q" "V" "M" "Q" "N" "H" "A" "O" "U" "C" "K" "X" "F" "E" "J" "M" "N"
## [2568] "Z" "O" "M" "X" "D" "J" "Y" "H" "G" "N" "I" "G" "B" "T" "L" "Q" "V"
## [2585] "R" "Q" "J" "D" "E" "J" "B" "W" "R" "S" "V" "L" "N" "E" "B" "Y" "R"
## [2602] "G" "O" "C" "U" "G" "L" "V" "W" "L" "R" "M" "U" "O" "C" "V" "X" "T"
## [2619] "W" "P" "B" "T" "A" "R" "G" "G" "N" "M" "L" "O" "W" "S" "X" "M" "C"
## [2636] "T" "R" "U" "X" "S" "A" "T" "A" "O" "D" "K" "S" "R" "N" "C" "Q" "B"
## [2653] "A" "H" "M" "B" "T" "B" "F" "X" "R" "O" "N" "W" "W" "K" "G" "R" "O"
## [2670] "N" "O" "O" "P" "O" "B" "C" "R" "V" "F" "N" "L" "D" "Y" "L" "K" "X"
## [2687] "R" "M" "R" "B" "A" "X" "A" "H" "P" "W" "L" "L" "O" "Y" "S" "V" "W"
## [2704] "F" "X" "V" "O" "Y" "X" "K" "M" "D" "S" "C" "G" "E" "D" "R" "I" "J"
## [2721] "G" "N" "P" "N" "O" "G" "S" "W" "P" "M" "X" "Y" "D" "D" "E" "M" "W"
## [2738] "N" "G" "D" "L" "U" "E" "O" "R" "A" "Q" "M" "N" "D" "C" "X" "A" "X"
## [2755] "C" "I" "Y" "W" "Z" "P" "O" "B" "D" "X" "B" "M" "K" "O" "B" "P" "D"
## [2772] "L" "D" "A" "N" "Z" "A" "O" "V" "M" "B" "K" "N" "B" "X" "H" "H" "X"
## [2789] "T" "I" "J" "P" "W" "M" "X" "Q" "J" "D" "S" "O" "O" "Q" "I" "L" "A"
## [2806] "T" "P" "M" "K" "X" "E" "D" "J" "W" "K" "T" "R" "N" "N" "O" "R" "O"
## [2823] "X" "P" "D" "G" "O" "O" "S" "M" "N" "V" "E" "R" "Q" "R" "R" "X" "X"
## [2840] "D" "S" "E" "C" "D" "W" "M" "E" "M" "E" "C" "N" "B" "W" "S" "V" "R"
## [2857] "M" "G" "G" "J" "T" "P" "H" "B" "N" "Q" "J" "V" "M" "M" "Y" "T" "I"
## [2874] "O" "M" "F" "T" "A" "W" "E" "Y" "D" "R" "K" "R" "K" "Z" "K" "K" "S"
## [2891] "B" "H" "N" "Z" "C" "P" "E" "Z" "X" "J" "U" "R" "V" "Y" "B" "P" "C"
## [2908] "S" "A" "C" "A" "W" "L" "R" "R" "D" "S" "S" "A" "U" "U" "Y" "H" "Z"
## [2925] "P" "O" "J" "B" "R" "X" "U" "N" "X" "U" "X" "S" "B" "N" "A" "E" "I"
## [2942] "M" "N" "A" "F" "Y" "Y" "R" "U" "N" "X" "W" "I" "Y" "G" "R" "V" "X"
## [2959] "O" "B" "T" "U" "M" "Q" "W" "M" "L" "R" "N" "R" "R" "X" "V" "W" "Q"
## [2976] "R" "K" "B" "Z" "T" "L" "L" "W" "W" "B" "O" "V" "J" "B" "N" "V" "S"
## [2993] "S" "N" "T" "B" "G" "P" "E" "W" "D" "C" "P" "Z" "U" "C" "A" "R" "V"
## [3010] "S" "O" "X" "W" "W" "Q" "G" "J" "L" "B" "A" "R" "I" "Q" "V" "A" "L"
## [3027] "J" "G" "S" "I" "F" "R" "O" "V" "P" "M" "D" "S" "B" "J" "B" "Y" "H"
## [3044] "N" "L" "C" "N" "X" "D" "F" "D" "Y" "G" "L" "G" "K" "D" "P" "W" "Q"
## [3061] "P" "A" "O" "E" "O" "Y" "D" "D" "O" "X" "D" "I" "V" "G" "C" "D" "P"
## [3078] "C" "M" "G" "S" "D" "S" "C" "R" "N" "M" "D" "M" "E" "G" "L" "V" "D"
## [3095] "Q" "S" "V" "Z" "R" "U" "A" "U" "F" "W" "G" "B" "X" "X" "V" "I" "Q"
## [3112] "T" "A" "L" "O" "T" "M" "M" "T" "J" "S" "X" "N" "B" "Q" "E" "G" "C"
## [3129] "Y" "Y" "H" "N" "Z" "J" "U" "Z" "S" "S" "D" "R" "Q" "O" "D" "L" "H"
## [3146] "C" "I" "B" "W" "W" "X" "M" "A" "O" "O" "Y" "I" "G" "U" "M" "R" "S"
## [3163] "J" "K" "E" "E" "H" "O" "O" "N" "S" "B" "P" "Z" "P" "T" "Q" "W" "B"
## [3180] "U" "C" "R" "O" "P" "P" "N" "P" "L" "R" "X" "P" "M" "K" "Q" "Z" "R"
## [3197] "O" "U" "I" "O" "B" "E" "K" "C" "A" "W" "R" "U" "O" "S" "F" "A" "Y"
## [3214] "N" "D" "L" "L" "R" "F" "O" "P" "M" "N" "K" "Q" "P" "O" "U" "K" "G"
## [3231] "C" "X" "S" "V" "S" "E" "V" "A" "A" "O" "O" "C" "U" "S" "V" "F" "F"
## [3248] "J" "X" "B" "J" "K" "T" "A" "I" "D" "W" "N" "T" "X" "S" "C" "J" "M"
```

5

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## [3265] "B" "Y" "P" "Z" "S" "Y" "R" "W" "M" "B" "F" "N" "F" "O" "B" "J" "N"
## [3282] "A" "L" "I" "B" "S" "A" "U" "T" "U" "Z" "W" "D" "K" "H" "L" "W" "J"
## [3299] "S" "G" "B" "O" "M" "R" "M" "M" "P" "D" "G" "H" "W" "E" "J" "Y" "W"
## [3316] "Z" "I" "M" "R" "Z" "A" "I" "Y" "Y" "K" "V" "O" "E" "R" "O" "P" "Q"
## [3333] "T" "B" "N" "J" "D" "E" "B" "X" "J" "U" "E" "S" "V" "P" "I" "C" "T"
## [3350] "E" "P" "L" "U" "Q" "G" "D" "A" "V" "A" "O" "M" "U" "Q" "E" "I" "V"
## [3367] "W" "T" "S" "E" "K" "Y" "F" "B" "I" "T" "M" "X" "F" "A" "Y" "B" "V"
## [3384] "B" "O" "J" "K" "C" "D" "P" "B" "F" "K" "P" "H" "V" "F" "C" "B" "Z"
## [3401] "L" "K" "V" "W" "Y" "U" "X" "R" "P" "C" "Z" "T" "C" "R" "J" "M" "N"
## [3418] "S" "E" "I" "Y" "S" "L" "O" "I" "K" "C" "F" "G" "P" "N" "N" "J" "W"
## [3435] "D" "L" "D" "L" "F" "P" "O" "P" "Q" "B" "G" "K" "H" "B" "R" "Q" "R"
## [3452] "P" "D" "C" "O" "I" "P" "O" "A" "V" "M" "N" "J" "J" "K" "F" "S" "Z"
## [3469] "X" "S" "P" "O" "E" "X" "D" "Z" "X" "F" "U" "K" "F" "K" "P" "Y" "O"
## [3486] "U" "G" "I" "H" "N" "S" "I" "C" "C" "M" "Y" "O" "K" "I" "B" "I" "J"
## [3503] "V" "H" "O" "D" "B" "D" "K" "D" "O" "U" "H" "F" "W" "B" "X" "J" "I"
## [3520] "Q" "V" "S" "Q" "C" "Y" "D" "M" "S" "B" "C" "Q" "O" "T" "F" "E" "F"
## [3537] "K" "V" "J" "L" "X" "S" "P" "Y" "L" "O" "Y" "D" "U" "F" "X" "K" "X"
## [3554] "T" "L" "L" "L" "L" "F" "X" "E" "K" "C" "Z" "U" "G" "Z" "M" "T" "R"
## [3571] "L" "C" "Q" "R" "R" "B" "Q" "W" "A" "B" "S" "Y" "C" "P" "W" "P" "Q"
## [3588] "U" "O" "O" "T" "X" "D" "W" "V" "D" "O" "Y" "M" "O" "Q" "T" "Z" "G"
## [3605] "V" "D" "R" "A" "M" "P" "J" "Q" "W" "O" "E" "C" "Q" "D" "D" "P" "Y"
## [3622] "R" "Q" "O" "W" "L" "W" "R" "M" "D" "H" "C" "A" "N" "O" "U" "O" "H"
## [3639] "M" "R" "P" "K" "G" "R" "F" "U" "A" "W" "X" "Z" "O" "M" "M" "U" "V"
## [3656] "C" "M" "B" "G" "W" "A" "S" "T" "L" "L" "P" "Z" "L" "Z" "W" "J" "R"
## [3673] "T" "M" "A" "F" "B" "A" "F" "R" "F" "R" "A" "R" "G" "N" "D" "S" "R"
## [3690] "O" "J" "N" "B" "A" "U" "T" "H" "U" "N" "F" "F" "N" "V" "V" "F" "V"
## [3707] "I" "W" "M" "Z" "P" "O" "V" "F" "A" "B" "P" "D" "O" "F" "A" "I" "N"
## [3724] "M" "A" "L" "I" "J" "Y" "R" "L" "W" "O" "Z" "X" "Y" "R" "N" "F" "R"
## [3741] "V" "Y" "I" "A" "O" "P" "N" "M" "K" "T" "N" "I" "M" "N" "W" "B" "G"
## [3758] "J" "U" "D" "U" "R" "O" "E" "T" "B" "A" "R" "M" "W" "F" "G" "Z" "A"
## [3775] "A" "P" "D" "O" "B" "W" "Q" "S" "Z" "M" "F" "N" "Z" "M" "M" "F" "E"
## [3792] "V" "L" "R" "G" "W" "I" "B" "J" "A" "W" "G" "M" "B" "T" "L" "Y" "O"
## [3809] "N" "S" "U" "D" "K" "D" "H" "G" "C" "I" "S" "N" "G" "W" "A" "W" "C"
## [3826] "I" "S" "W" "M" "L" "N" "F" "D" "A" "U" "W" "U" "A" "G" "P" "I" "L"
## [3843] "D" "Z" "Z" "N" "Z" "C" "O" "A" "Y" "L" "W" "N" "C" "G" "G" "J" "B"
## [3860] "J" "M" "G" "Y" "A" "K" "N" "L" "O" "M" "U" "M" "B" "T" "L" "O" "A"
## [3877] "C" "N" "K" "Y" "H" "B" "L" "Q" "Y" "I" "W" "P" "D" "N" "Z" "M" "Z"
## [3894] "W" "I" "W" "N" "K" "D" "J" "U" "O" "X" "U" "Q" "B" "Y" "O" "P" "S"
## [3911] "R" "P" "F" "U" "L" "L" "K" "Z" "W" "T" "G" "G" "V" "O" "Z" "R" "J"
## [3928] "K" "R" "U" "B" "L" "C" "N" "M" "X" "J" "Y" "B" "A" "X" "R" "B" "K"
## [3945] "Y" "U" "R" "B" "G" "M" "F" "S" "Q" "L" "U" "O" "R" "A" "U" "I" "E"
## [3962] "K" "U" "J" "X" "P" "V" "F" "U" "G" "G" "Z" "N" "S" "A" "B" "H" "K"
## [3979] "S" "I" "A" "E" "O" "A" "W" "D" "X" "O" "E" "D" "V" "Y" "W" "N" "R"
## [3996] "Z" "P" "B" "X" "O" "P" "E" "D" "R" "D" "T" "W" "I" "Z" "F" "W" "N"
## [4013] "Y" "G" "L" "Q" "R" "N" "D" "C" "B" "O" "R" "H" "C" "A" "N" "H" "E"
## [4030] "B" "O" "O" "W" "Q" "H" "T" "I" "D" "O" "G" "M" "Y" "S" "A" "I" "X"
## [4047] "R" "I" "W" "X" "J" "P" "G" "G" "L" "V" "U" "K" "U" "W" "T" "P" "P"
## [4064] "U" "I" "B" "U" "E" "A" "Y" "S" "K" "O" "K" "G" "E" "L" "J" "O" "J"
## [4081] "L" "R" "L" "G" "O" "V" "X" "I" "J" "N" "B" "S" "K" "P" "K" "K" "Q"
## [4098] "N" "Y" "U" "D" "O" "C" "D" "D" "H" "H" "S" "C" "M" "N" "Z" "W" "Y"
## [4115] "J" "V" "N" "R" "T" "M" "W" "F" "S" "B" "D" "O" "N" "Z" "B" "A" "N"
## [4132] "X" "F" "L" "B" "W" "Q" "S" "R" "L" "F" "Z" "J" "C" "T" "E" "R" "D"
## [4149] "F" "X" "G" "K" "A" "R" "N" "B" "N" "I" "B" "W" "D" "E" "M" "G" "L"
## [4166] "X" "Z" "N" "H" "C" "L" "D" "I" "D" "J" "O" "K" "A" "Y" "L" "I" "N"
```

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## [4183] "L" "W" "E" "R" "O" "X" "F" "H" "V" "M" "O" "Z" "U" "T" "D" "D" "C"
## [4200] "K" "N" "A" "K" "M" "W" "D" "S" "D" "Y" "I" "B" "P" "F" "E" "O" "S"
## [4217] "W" "D" "L" "D" "P" "E" "U" "R" "B" "R" "H" "M" "O" "I" "M" "O" "J"
## [4234] "A" "B" "C" "J" "J" "J" "V" "Z" "B" "Y" "D" "K" "Y" "X" "F" "R" "S"
## [4251] "B" "U" "T" "K" "B" "B" "E" "A" "A" "C" "B" "I" "M" "T" "W" "Q" "B"
## [4268] "G" "O" "R" "Y" "W" "C" "V" "R" "O" "Z" "R" "K" "N" "B" "V" "X" "J"
## [4285] "L" "N" "Q" "A" "R" "Q" "Q" "Y" "P" "X" "S" "L" "J" "D" "Q" "V" "X"
## [4302] "Q" "B" "G" "Q" "U" "A" "Z" "X" "T" "J" "T" "Y" "J" "M" "D" "R" "W"
## [4319] "V" "A" "X" "A" "Y" "T" "B" "B" "U" "D" "V" "B" "J" "F" "L" "I" "D"
## [4336] "I" "I" "R" "I" "X" "F" "O" "Q" "F" "X" "X" "S" "N" "Z" "O" "Y" "U"
## [4353] "G" "R" "R" "F" "P" "Q" "E" "M" "H" "V" "V" "P" "Y" "K" "B" "C" "O"
## [4370] "Y" "W" "S" "Q" "Z" "P" "P" "A" "R" "F" "X" "M" "L" "Z" "O" "N" "M"
## [4387] "C" "S" "X" "M" "M" "O" "B" "M" "O" "X" "X" "Z" "A" "C" "E" "K" "L"
## [4404] "Y" "P" "P" "Z" "S" "V" "X" "R" "Z" "K" "W" "W" "X" "F" "Q" "F" "T"
## [4421] "K" "X" "D" "I" "L" "B" "K" "R" "D" "M" "L" "M" "U" "R" "U" "U" "Q"
## [4438] "K" "F" "Q" "I" "B" "V" "V" "B" "N" "B" "X" "S" "A" "S" "Q" "Q" "J"
## [4455] "G" "T" "S" "A" "C" "B" "G" "Q" "Z" "T" "W" "I" "I" "P" "S" "H" "N"
## [4472] "H" "F" "G" "W" "I" "A" "A" "D" "I" "Q" "S" "G" "W" "D" "W" "C" "Q"
## [4489] "K" "I" "R" "O" "A" "G" "J" "U" "I" "T" "B" "W" "D" "A" "H" "F" "U"
## [4506] "M" "Q" "D" "D" "Z" "W" "T" "L" "X" "G" "X" "J" "H" "K" "C" "M" "W"
## [4523] "D" "N" "B" "C" "Z" "R" "A" "I" "K" "P" "Y" "B" "R" "K" "D" "R" "Q"
## [4540] "K" "I" "R" "I" "Q" "W" "U" "X" "G" "M" "G" "B" "F" "R" "D" "D" "J"
## [4557] "Z" "J" "K" "Z" "O" "W" "T" "D" "P" "H" "Y" "R" "W" "Y" "P" "U" "S"
## [4574] "N" "B" "F" "C" "V" "C" "J" "Z" "G" "Z" "S" "E" "N" "N" "B" "Z" "M"
## [4591] "E" "A" "J" "A" "K" "Z" "I" "S" "T" "N" "L" "M" "O" "L" "Y" "J" "K"
## [4608] "T" "T" "V" "R" "B" "R" "C" "X" "R" "C" "A" "M" "Q" "T" "G" "L" "A"
## [4625] "M" "A" "Z" "U" "N" "B" "L" "A" "I" "O" "D" "T" "Z" "M" "G" "C" "W"
## [4642] "U" "M" "M" "B" "W" "X" "V" "L" "S" "F" "B" "K" "Z" "N" "B" "B" "X"
## [4659] "V" "N" "Z" "C" "X" "I" "W" "O" "A" "K" "D" "O" "G" "N" "M" "Z" "W"
## [4676] "S" "M" "F" "X" "Y" "Q" "W" "S" "F" "G" "F" "I" "X" "O" "X" "X" "A"
## [4693] "I" "D" "O" "R" "I" "N" "S" "Y" "T" "D" "T" "X" "C" "I" "F" "N" "V"
## [4710] "I" "X" "Q" "B" "Y" "P" "U" "A" "O" "C" "S" "H" "Z" "G" "D" "S" "D"
## [4727] "I" "C" "N" "C" "R" "R" "C" "O" "A" "V" "G" "N" "W" "B" "X" "B" "V"
## [4744] "J" "Z" "C" "U" "S" "C" "J" "O" "B" "V" "T" "M" "G" "X" "B" "K" "G"
## [4761] "B" "Y" "X" "C" "M" "E" "M" "J" "L" "A" "K" "A" "Y" "G" "K" "N" "Z"
## [4778] "M" "I" "K" "G" "R" "Q" "N" "D" "J" "W" "W" "U" "C" "O" "A" "M" "P"
## [4795] "S" "M" "S" "A" "D" "A" "T" "J" "D" "D" "P" "N" "F" "D" "W" "R" "D"
## [4812] "X" "I" "G" "X" "D" "H" "C" "O" "X" "K" "R" "R" "G" "B" "W" "D" "Y"
## [4829] "D" "F" "T" "N" "E" "W" "A" "Y" "S" "R" "R" "F" "M" "W" "Y" "M" "F"
## [4846] "N" "D" "K" "Z" "L" "D" "U" "B" "G" "I" "G" "L" "G" "U" "R" "O" "B"
## [4863] "U" "V" "T" "J" "I" "F" "O" "P" "N" "W" "P" "T" "M" "J" "B" "F" "T"
## [4880] "O" "L" "P" "Z" "J" "D" "W" "F" "Y" "V" "K" "B" "B" "D" "Y" "R" "B"
## [4897] "S" "W" "A" "G" "F" "J" "F" "C" "B" "V" "S" "Z" "R" "T" "B" "R" "M"
## [4914] "T" "V" "A" "C" "P" "D" "Y" "R" "W" "E" "R" "G" "X" "M" "C" "E" "B"
## [4931] "D" "M" "F" "L" "J" "Q" "D" "C" "N" "L" "Q" "X" "J" "O" "S" "T" "M"
## [4948] "T" "B" "J" "R" "E" "R" "G" "I" "G" "F" "J" "I" "G" "W" "P" "J" "O"
## [4965] "D" "T" "Y" "M" "E" "J" "R" "M" "Z" "Y" "E" "X" "M" "Y" "Q" "J" "E"
## [4982] "Y" "Y" "N" "G" "X" "X" "O" "J" "L" "D" "K" "W" "S" "M" "O" "X" "X"
## [4999] "T" "A"
```

```r
#Build confusion matrix
conf_letters <- table(pred_letters, lettersdf[-train,]$V1)
conf_letters
```

```
##
```

```
## pred_letters   A   B   C   D   E   F   G   H   I   J   K   L   M   N   O
##            A 176   0   0   0   0   0   1   0   1   0   2  10   5   0   0
##            B   0 129   0  26   5  15   3   7  12  17   2   3   1   5   1
##            C   3   0 130   0  26   0  15   0   1   3   7   7   1   3   1
##            D   0  20   0 131   0  13   6  10   6   6   4   0   1   4  10
##            E   0   0  11   1  72   1   3   0   0   0   5   1   0   0   0
##            F   0   0   3   0   0 119   0   1   2   3   0   0   0   0   0
##            G   1   2   6   0  22   6 112   4   1   0   4   8   0   0   5
##            H   0   0   0   1   0   0   1  82   0   0   4   0   1   1   0
##            I   0   0   0   0   0   4   0   0 148   2   0   0   0   0   0
##            J   3   0   0   7   0   2   0   1   9 131   0   0   0   1   0
##            K   0   1  17   2  10   0   4  13   0   0 108   3   3   0   1
##            L   2   0   0   0   0   0   2   0   0   0   1 146   0   0   3
##            M   3   7   0   1   0   1   0   3   0   3   6   0 178   8   0
##            N   0   2   0   4   1   0   0   5   0   0   5   0   5 157   1
##            O   5   1   9   7   0   0   1  28   0   4   0   0   5   8 147
##            P   0   0   0   8   0  14   0   0   3   3   0   0   0   9   0
##            Q   1   1   1   0   8   0  19   6   1   5   0   2   1   0   5
##            R   0  12   0   7   7   3  13   9   2   7  17   2   1   2   2
##            S   2   5   4   6   9   5   6   2   2   7   0   3   1   0   0
##            T   0   0   0   2   0   6   0   2   0   0   0   0   0   0   0
##            U   0   0   2   0   2   1   0  12   0   0   0   0   0   1   2
##            V   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
##            W   0   1   2   0   0   0   6   6   0   0   2   0   4   4  10
##            X   5   3   0   0  31   2   0   3   5   0  10   1   0   0   0
##            Y   2   0   0   0   2   5   0   0   0   0   2   8   0   5   0
##            Z   1   0   1   0  11   0   2   0   0   0   0   0   0   0   0
##
## pred_letters   P   Q   R   S   T   U   V   W   X   Y   Z
##            A   0   0   0   8   0   0   0   0   0   0   0
##            B   6   8  16  13   2   1   0   0   8   1   4
##            C   0   6   0   0   0   1   0   0   0   0   0
##            D  13   0   8   5   0   1   0   0   4   4   1
##            E   1   1   5   2   4   3   0   0   2   0   7
##            F  16   0   0   2  15   0   4   4   0   5   0
##            G   3  14   1   1   0   1   0   0   0   0   1
##            H   0   0   0   2   0   0   0   0  12   0   0
##            I   1   0   0   4   5   0   0   0   0   2   0
##            J   2   2   0   1   0   0   0   0   0   0   2
##            K   0   0   2   0   2   2   0   0   8   0   1
##            L   0  11   0   1   0   0   0   0   0   0   0
##            M   0   1   9   0   0  13   2  13   1   1   0
##            N   0   0   2   0   5  15   7   4   0   0   0
##            O  10  16   3   3   3  11   1   4   4   1   0
##            P 134   0   0   0   1   0   2   0   0   1   0
##            Q   1  98   1   3   0   3   4   0   0   8   1
##            R   0   1 152  11   0   0   0   1   1   0   4
##            S   0   6   0 122   0   0   1   0   4   4  17
##            T   0   0   0   2 137   2   5   0   0  11   3
##            U   0   0   0   1   5 145   3   0   0   3   0
##            V   0   0   0   0  10   5 127   2   0  15   0
##            W   9   1   3   0   0   1  14 142   0   2   0
##            X   0   0   3  15   8   0   0   0 128   0   3
##            Y   4   1   0   1  11   2   4   0   9 120   0
```

```
##              Z   0   0   0   3   2   0   0   0   5   0 133
```

```
#Calculate misclassification rate
correct_letters <- sum(diag(conf_letters))
correct_letters
```

```
## [1] 3404
```

```
letters_mis <- (sum(conf_letters) - correct_letters)/sum(conf_letters)
letters_mis
```
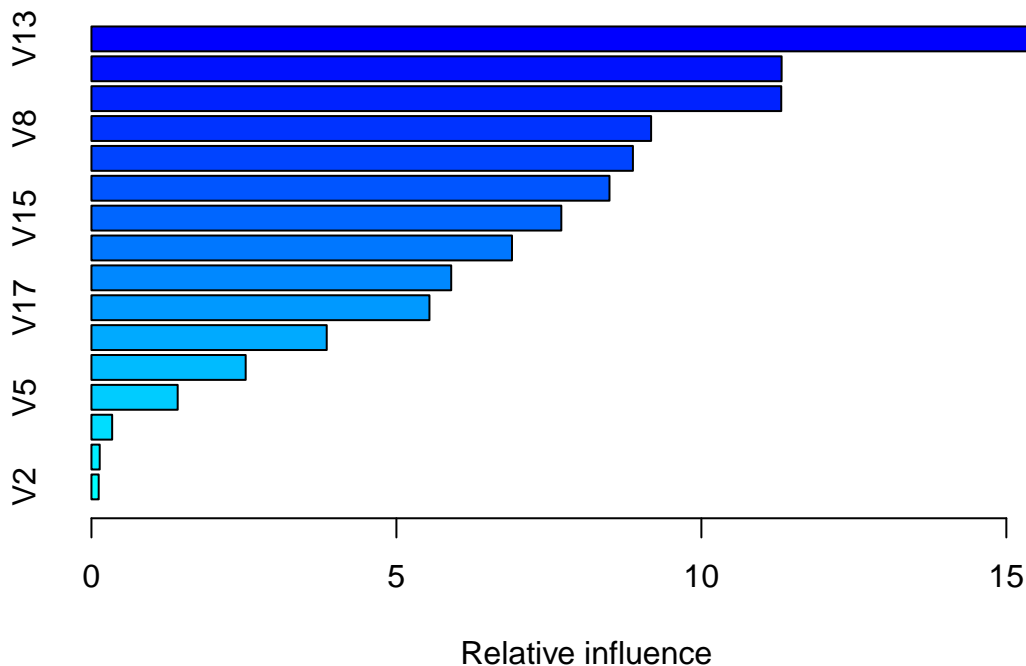
```
## [1] 0.3192
```

- The miscclassification rate of my model is 0.3056. #### Slow the learning
- H was the most difficult letter to distinguish
- E and X, H and O, Q ans G, Z and S, and T and Y seem to be the letter pairs that were the most difficult to distinguish from one another respectively.

Slow the learning

```
#Build second model
boost.slow = gbm(V1 ~., data = lettersdf[train,], distribution = "multinomial", n.trees = 300, interacti
```

```
summary(boost.slow)
```


Relative influence

```
##      var     rel.inf
## V13 V13 16.3942550
## V12 V12 11.3154730
## V14 V14 11.3093569
## V8   V8  9.1758330
## V11 V11  8.8777372
## V10 V10  8.4935047
## V15 V15  7.7039223
## V9   V9  6.8948968
## V16 V16  5.8984772
```

```
## V17  V17  5.5415323
## V7   V7   3.8574848
## V4   V4   2.5290409
## V5   V5   1.4140654
## V6   V6   0.3398394
## V3   V3   0.1355118
## V2   V2   0.1190694
```

```r
#Predict letters
yhat.slow = predict(boost.slow, newdata = lettersdf[-train,], n.trees = 300, type = "response")
pred_slow<- LETTERS[apply(yhat.slow, 1, which.max)]
pred_slow
```

```
##     [1] "T" "K" "G" "B" "E" "H" "X" "X" "G" "W" "L" "Q" "H" "J" "R" "B" "W"
##    [18] "N" "Y" "D" "T" "T" "U" "N" "R" "Q" "E" "A" "L" "Z" "M" "A" "H" "B"
##    [35] "V" "S" "B" "N" "S" "I" "B" "P" "O" "K" "Z" "O" "L" "Q" "J" "X" "P"
##    [52] "P" "P" "Z" "S" "C" "M" "L" "T" "T" "R" "G" "V" "Z" "M" "A" "O" "H"
##    [69] "I" "S" "T" "T" "X" "V" "A" "P" "O" "D" "F" "B" "K" "T" "Y" "X" "Q"
##    [86] "F" "M" "D" "Z" "S" "V" "X" "C" "J" "D" "D" "J" "I" "J" "M" "J" "Z"
##   [103] "N" "C" "Z" "W" "J" "M" "U" "B" "B" "N" "M" "B" "P" "D" "B" "S" "O"
##   [120] "B" "O" "N" "J" "S" "V" "B" "O" "Y" "X" "N" "E" "E" "V" "J" "A" "P"
##   [137] "O" "X" "N" "G" "T" "W" "F" "V" "B" "M" "M" "G" "B" "H" "K" "Y" "Q"
##   [154] "R" "B" "P" "S" "P" "H" "P" "D" "T" "J" "O" "A" "E" "I" "Y" "P" "P"
##   [171] "G" "I" "Y" "E" "K" "V" "X" "U" "D" "D" "Z" "X" "A" "Y" "A" "Z" "P"
##   [188] "S" "H" "T" "G" "L" "T" "Y" "S" "N" "G" "N" "B" "S" "G" "G" "S" "L"
##   [205] "G" "S" "R" "Q" "I" "G" "K" "Z" "K" "L" "T" "Y" "C" "Y" "S" "T" "S"
##   [222] "E" "L" "N" "N" "M" "S" "R" "D" "P" "T" "M" "Z" "S" "Q" "K" "K" "N"
##   [239] "D" "R" "T" "F" "W" "Y" "Y" "M" "A" "F" "A" "F" "S" "T" "A" "G" "O"
##   [256] "Z" "J" "E" "A" "C" "B" "D" "G" "U" "S" "J" "E" "H" "M" "B" "B" "Z"
##   [273] "T" "D" "U" "Z" "P" "D" "Y" "F" "B" "Y" "V" "E" "E" "X" "E" "Y" "P"
##   [290] "P" "X" "O" "G" "K" "X" "Z" "K" "I" "B" "C" "K" "O" "T" "F" "S" "J"
##   [307] "Y" "V" "B" "O" "E" "A" "T" "H" "C" "J" "J" "I" "U" "V" "M" "V" "I"
##   [324] "C" "R" "A" "E" "C" "F" "F" "Z" "H" "K" "A" "Q" "P" "G" "A" "T" "Q"
##   [341] "V" "G" "M" "B" "K" "D" "D" "A" "E" "V" "N" "X" "R" "N" "Y" "W" "D"
##   [358] "U" "S" "D" "Z" "L" "B" "U" "P" "R" "E" "I" "Q" "Q" "U" "K" "S" "T"
##   [375] "Z" "D" "C" "H" "K" "X" "P" "B" "Q" "G" "U" "J" "P" "I" "C" "I" "B"
##   [392] "M" "X" "P" "N" "O" "F" "O" "D" "V" "K" "W" "M" "K" "Z" "A" "C" "A"
##   [409] "V" "H" "O" "A" "T" "G" "W" "Z" "W" "G" "N" "K" "P" "L" "K" "K" "X"
##   [426] "S" "S" "H" "N" "H" "Q" "E" "R" "Y" "A" "U" "L" "O" "E" "K" "C" "T"
##   [443] "U" "N" "E" "J" "K" "S" "D" "H" "Y" "W" "F" "U" "N" "X" "V" "G" "C"
##   [460] "Y" "W" "B" "N" "N" "M" "L" "W" "C" "O" "A" "Q" "C" "U" "O" "S" "H"
##   [477] "L" "H" "R" "G" "A" "K" "O" "G" "U" "D" "X" "I" "O" "P" "A" "K" "G"
##   [494] "K" "A" "T" "Q" "Y" "R" "F" "R" "Y" "F" "G" "Q" "B" "C" "L" "N" "W"
##   [511] "B" "E" "T" "C" "E" "S" "Q" "Y" "D" "R" "I" "D" "V" "B" "V" "E" "F"
##   [528] "A" "U" "I" "O" "S" "T" "R" "F" "O" "M" "V" "K" "R" "K" "O" "J" "S"
##   [545] "Q" "G" "Z" "C" "W" "S" "M" "P" "R" "C" "D" "Z" "K" "H" "U" "Q" "W"
##   [562] "W" "Q" "G" "U" "A" "R" "M" "U" "C" "U" "P" "J" "Z" "M" "I" "S" "N"
##   [579] "P" "Z" "A" "J" "J" "B" "G" "B" "K" "L" "O" "D" "I" "M" "N" "B" "O"
##   [596] "O" "S" "W" "F" "B" "U" "N" "T" "L" "E" "E" "O" "D" "K" "Q" "B" "H"
##   [613] "Q" "J" "A" "M" "Q" "B" "M" "T" "Q" "Z" "R" "B" "Z" "T" "Y" "R" "N"
##   [630] "X" "C" "Q" "F" "E" "P" "G" "R" "N" "F" "S" "R" "G" "B" "R" "H" "Y"
##   [647] "A" "J" "Q" "W" "G" "T" "L" "K" "S" "C" "E" "A" "K" "M" "I" "N" "X"
##   [664] "F" "T" "M" "L" "V" "P" "S" "C" "X" "E" "L" "T" "B" "K" "V" "S" "H"
##   [681] "S" "V" "J" "L" "D" "O" "O" "E" "S" "T" "C" "A" "O" "L" "N" "T" "Z"
##   [698] "N" "P" "I" "E" "F" "I" "F" "Y" "Q" "T" "J" "L" "S" "X" "H" "G" "P"
```

```
## [715]  "A" "B" "V" "A" "R" "G" "D" "U" "U" "M" "R" "C" "B" "G" "M" "Z" "P"
## [732]  "K" "A" "M" "B" "Q" "Q" "M" "F" "X" "N" "R" "R" "M" "X" "Q" "R" "C"
## [749]  "B" "U" "U" "S" "W" "T" "Z" "J" "T" "Q" "O" "H" "D" "F" "O" "Q" "J"
## [766]  "Y" "I" "V" "C" "Q" "Y" "K" "F" "I" "Q" "N" "B" "V" "Y" "Z" "F" "R"
## [783]  "I" "P" "H" "F" "Y" "E" "C" "O" "F" "E" "Y" "D" "W" "M" "L" "Y" "H"
## [800]  "R" "D" "E" "O" "D" "F" "A" "C" "V" "T" "S" "Y" "W" "T" "K" "B" "L"
## [817]  "O" "G" "C" "Z" "I" "O" "U" "J" "G" "S" "T" "V" "O" "Q" "H" "T" "R"
## [834]  "R" "G" "J" "E" "B" "K" "R" "S" "U" "K" "Z" "I" "D" "H" "W" "B" "S"
## [851]  "V" "O" "U" "E" "U" "J" "G" "C" "O" "D" "C" "K" "A" "F" "E" "M" "W"
## [868]  "Q" "A" "F" "H" "N" "E" "M" "H" "T" "I" "X" "L" "W" "U" "Q" "F" "C"
## [885]  "S" "X" "S" "Z" "J" "W" "I" "I" "Y" "V" "O" "R" "K" "J" "F" "S" "G"
## [902]  "T" "P" "U" "W" "C" "S" "L" "S" "A" "M" "S" "M" "X" "H" "Q" "S" "F"
## [919]  "X" "X" "L" "O" "T" "N" "D" "O" "R" "O" "V" "N" "M" "K" "O" "B" "G"
## [936]  "K" "Y" "S" "W" "Y" "G" "T" "E" "G" "P" "Q" "N" "M" "T" "B" "O" "I"
## [953]  "K" "Z" "A" "M" "I" "U" "H" "X" "B" "H" "S" "Q" "X" "D" "U" "R" "R"
## [970]  "Z" "A" "V" "G" "B" "X" "J" "J" "Z" "W" "B" "C" "M" "R" "Y" "R" "S"
## [987]  "N" "E" "J" "G" "S" "F" "N" "Q" "K" "Q" "Z" "R" "W" "D" "B" "T" "J"
## [1004] "C" "J" "U" "G" "M" "Z" "N" "L" "R" "K" "I" "K" "P" "U" "I" "N" "B"
## [1021] "X" "P" "U" "X" "T" "K" "J" "F" "F" "L" "P" "P" "C" "Y" "S" "Q" "D"
## [1038] "O" "A" "F" "F" "X" "L" "A" "P" "E" "T" "M" "Y" "G" "U" "I" "H" "G"
## [1055] "R" "A" "B" "R" "F" "P" "R" "K" "Y" "R" "B" "C" "J" "P" "A" "U" "C"
## [1072] "F" "A" "B" "Y" "A" "F" "H" "N" "L" "Z" "E" "N" "O" "S" "G" "T" "M"
## [1089] "S" "C" "G" "B" "Y" "V" "Y" "T" "I" "L" "P" "U" "E" "R" "M" "Q" "X"
## [1106] "U" "N" "Z" "I" "K" "F" "U" "R" "X" "F" "O" "R" "B" "N" "V" "Q" "K"
## [1123] "B" "R" "L" "S" "Y" "M" "B" "E" "H" "Y" "B" "X" "S" "B" "A" "B" "N"
## [1140] "E" "C" "W" "V" "H" "Z" "D" "G" "L" "G" "R" "L" "T" "C" "L" "X" "A"
## [1157] "Y" "Z" "M" "U" "E" "U" "W" "M" "R" "V" "B" "T" "O" "P" "F" "W" "R"
## [1174] "P" "X" "R" "K" "D" "R" "L" "B" "R" "T" "J" "U" "E" "Z" "Y" "I" "Q"
## [1191] "A" "T" "D" "Q" "A" "J" "F" "L" "C" "U" "I" "P" "F" "Y" "V" "G" "J"
## [1208] "A" "U" "O" "D" "M" "Q" "O" "Y" "D" "F" "M" "L" "J" "R" "V" "M" "F"
## [1225] "E" "V" "Y" "I" "H" "R" "I" "A" "S" "B" "B" "J" "O" "O" "D" "G" "J"
## [1242] "T" "N" "Y" "H" "F" "C" "H" "K" "L" "Y" "S" "E" "I" "F" "O" "O" "Q"
## [1259] "U" "M" "S" "N" "E" "V" "N" "T" "Q" "J" "A" "D" "G" "U" "S" "U" "G"
## [1276] "Q" "T" "E" "M" "D" "I" "E" "D" "Y" "O" "T" "H" "B" "T" "J" "A" "S"
## [1293] "P" "M" "I" "N" "C" "X" "Q" "B" "C" "S" "L" "O" "K" "S" "A" "T" "B"
## [1310] "V" "R" "Z" "Y" "T" "X" "D" "K" "X" "S" "U" "M" "N" "T" "D" "T" "G"
## [1327] "W" "H" "W" "N" "B" "G" "Q" "M" "Z" "U" "T" "K" "O" "U" "R" "M" "G"
## [1344] "G" "X" "X" "T" "V" "X" "L" "H" "P" "I" "H" "E" "W" "A" "S" "D" "L"
## [1361] "W" "A" "P" "N" "K" "M" "R" "N" "M" "Z" "B" "E" "Z" "W" "H" "K" "J"
## [1378] "B" "U" "X" "F" "C" "S" "D" "X" "U" "W" "T" "A" "C" "H" "W" "N" "K"
## [1395] "B" "S" "V" "B" "P" "U" "O" "U" "F" "N" "B" "R" "O" "F" "R" "X" "Z"
## [1412] "L" "O" "V" "A" "K" "S" "T" "L" "P" "C" "X" "R" "Y" "Q" "C" "S" "I"
## [1429] "Y" "A" "F" "E" "J" "W" "C" "B" "U" "M" "F" "Y" "Q" "B" "E" "A" "U"
## [1446] "M" "O" "B" "D" "S" "C" "N" "D" "X" "B" "O" "S" "S" "A" "Z" "M" "J"
## [1463] "I" "O" "E" "M" "N" "B" "X" "R" "N" "P" "M" "O" "T" "D" "B" "G" "D"
## [1480] "S" "E" "Z" "E" "I" "S" "T" "N" "K" "B" "V" "I" "K" "G" "W" "G" "F"
## [1497] "D" "S" "I" "Q" "U" "N" "K" "R" "L" "X" "V" "P" "Y" "K" "D" "S" "G"
## [1514] "C" "V" "V" "O" "E" "D" "H" "Q" "E" "E" "R" "J" "W" "V" "E" "A" "H"
## [1531] "I" "F" "S" "E" "K" "Z" "K" "T" "L" "O" "L" "M" "O" "Q" "X" "R" "V"
## [1548] "I" "K" "S" "Y" "G" "M" "Z" "C" "L" "M" "T" "C" "X" "W" "B" "W" "U"
## [1565] "N" "U" "X" "W" "M" "D" "O" "K" "B" "L" "L" "S" "O" "I" "D" "U" "X"
## [1582] "J" "T" "A" "F" "D" "Z" "W" "V" "X" "Y" "K" "E" "L" "C" "G" "U" "O"
## [1599] "X" "K" "O" "L" "E" "U" "C" "O" "I" "Q" "I" "B" "O" "V" "W" "P" "E"
## [1616] "E" "F" "V" "G" "U" "J" "L" "D" "A" "C" "K" "Y" "F" "E" "O" "E" "P"
```

```
## [1633] "N" "Y" "S" "Z" "P" "L" "W" "M" "F" "L" "S" "M" "D" "C" "V" "R" "K"
## [1650] "R" "G" "N" "T" "L" "F" "J" "U" "C" "B" "B" "D" "J" "O" "R" "C" "D"
## [1667] "E" "O" "S" "J" "X" "A" "V" "D" "Y" "N" "A" "H" "Y" "T" "K" "I" "Y"
## [1684] "X" "U" "R" "W" "Q" "M" "O" "X" "F" "H" "C" "S" "I" "N" "U" "J" "M"
## [1701] "D" "G" "L" "X" "D" "N" "O" "H" "C" "S" "R" "R" "S" "J" "W" "H" "Q"
## [1718] "G" "J" "G" "H" "J" "P" "V" "C" "D" "X" "K" "R" "F" "K" "T" "Y" "T"
## [1735] "T" "X" "E" "O" "Q" "D" "A" "K" "T" "P" "R" "X" "F" "L" "O" "L" "C"
## [1752] "L" "R" "R" "Z" "B" "O" "H" "Y" "O" "R" "O" "T" "Y" "N" "K" "Z" "L"
## [1769] "N" "X" "V" "Q" "A" "O" "K" "G" "M" "M" "B" "R" "O" "N" "R" "V" "T"
## [1786] "S" "Y" "I" "W" "C" "D" "N" "W" "A" "Z" "M" "T" "G" "O" "K" "F" "Q"
## [1803] "H" "U" "R" "I" "X" "R" "T" "I" "C" "M" "D" "Z" "E" "L" "I" "H" "O"
## [1820] "K" "A" "P" "U" "H" "E" "F" "V" "I" "T" "O" "H" "Y" "S" "Q" "T" "D"
## [1837] "F" "S" "L" "E" "P" "T" "W" "N" "R" "Q" "W" "B" "C" "J" "O" "V" "R"
## [1854] "P" "J" "D" "J" "V" "H" "J" "S" "B" "G" "Z" "J" "R" "Q" "U" "S" "F"
## [1871] "P" "Q" "F" "F" "T" "K" "V" "M" "Q" "M" "A" "Y" "A" "E" "K" "C" "M"
## [1888] "W" "G" "O" "A" "K" "E" "X" "B" "Y" "R" "C" "G" "P" "U" "T" "H" "O"
## [1905] "E" "D" "P" "O" "R" "Y" "G" "R" "P" "F" "E" "N" "O" "N" "N" "H" "C"
## [1922] "Z" "Y" "K" "P" "E" "K" "S" "B" "L" "S" "P" "D" "R" "U" "S" "Z" "D"
## [1939] "Z" "X" "M" "U" "N" "F" "K" "L" "V" "Z" "K" "S" "L" "C" "U" "J" "G"
## [1956] "X" "T" "K" "P" "S" "O" "W" "O" "E" "S" "O" "K" "K" "T" "F" "N" "S"
## [1973] "H" "M" "L" "P" "N" "U" "I" "W" "F" "S" "X" "H" "X" "G" "U" "Z" "F"
## [1990] "N" "N" "D" "B" "S" "A" "B" "V" "D" "W" "O" "W" "Q" "B" "J" "W" "U"
## [2007] "K" "A" "R" "X" "L" "E" "C" "J" "C" "U" "T" "P" "B" "N" "D" "I" "B"
## [2024] "T" "L" "A" "P" "P" "W" "Q" "V" "R" "C" "P" "T" "R" "A" "A" "K" "L"
## [2041] "A" "U" "T" "W" "G" "P" "E" "B" "V" "L" "P" "D" "Z" "B" "H" "Q" "K"
## [2058] "N" "J" "P" "F" "B" "R" "K" "P" "N" "B" "X" "N" "K" "O" "U" "P" "J"
## [2075] "B" "Z" "G" "V" "S" "U" "L" "U" "W" "P" "N" "Z" "Z" "C" "Y" "G" "E"
## [2092] "B" "R" "M" "M" "Y" "C" "H" "P" "B" "Q" "D" "D" "V" "U" "U" "X" "M"
## [2109] "S" "E" "D" "L" "I" "P" "M" "P" "R" "D" "X" "Z" "M" "V" "W" "F" "U"
## [2126] "O" "Q" "Z" "F" "I" "H" "L" "H" "P" "J" "Q" "E" "H" "A" "E" "G" "Q"
## [2143] "H" "V" "G" "T" "S" "U" "Y" "D" "E" "Z" "N" "J" "K" "G" "L" "R" "A"
## [2160] "N" "O" "Z" "K" "C" "F" "K" "D" "W" "G" "J" "H" "Z" "Z" "B" "S" "W"
## [2177] "I" "O" "Q" "F" "V" "U" "P" "L" "Q" "M" "Y" "C" "D" "Y" "O" "H" "H"
## [2194] "U" "D" "B" "X" "C" "P" "F" "B" "L" "P" "M" "L" "F" "F" "Z" "X" "D"
## [2211] "C" "M" "D" "Y" "B" "J" "V" "D" "O" "M" "T" "M" "I" "X" "C" "I" "K"
## [2228] "O" "R" "P" "M" "R" "H" "A" "P" "O" "S" "V" "F" "F" "X" "A" "Y" "V"
## [2245] "A" "I" "T" "N" "Q" "U" "O" "D" "J" "A" "I" "M" "Z" "R" "T" "R" "B"
## [2262] "A" "X" "F" "V" "O" "W" "I" "R" "X" "X" "Y" "U" "F" "D" "N" "S" "I"
## [2279] "T" "D" "R" "F" "B" "U" "B" "K" "Z" "S" "I" "U" "N" "M" "R" "E" "P"
## [2296] "I" "M" "Z" "Z" "X" "C" "P" "W" "O" "A" "G" "U" "N" "W" "V" "N" "K"
## [2313] "Q" "Z" "M" "T" "S" "L" "Z" "F" "I" "M" "P" "C" "Q" "C" "A" "V" "D"
## [2330] "D" "R" "D" "F" "Q" "T" "Z" "M" "C" "N" "O" "N" "G" "G" "C" "Y" "R"
## [2347] "C" "G" "A" "I" "S" "B" "Z" "F" "O" "I" "O" "S" "V" "L" "W" "M" "F"
## [2364] "Y" "P" "L" "N" "Y" "O" "S" "I" "T" "P" "R" "W" "N" "X" "M" "A" "M"
## [2381] "C" "I" "T" "G" "W" "B" "Q" "X" "Y" "Q" "V" "N" "U" "L" "O" "E" "F"
## [2398] "I" "G" "T" "P" "Q" "M" "O" "H" "C" "O" "E" "Q" "I" "C" "O" "O" "E"
## [2415] "Z" "B" "H" "Y" "M" "V" "W" "X" "K" "R" "V" "N" "K" "M" "H" "V" "W"
## [2432] "S" "X" "A" "M" "Q" "B" "W" "L" "O" "L" "U" "W" "P" "O" "B" "Z" "C"
## [2449] "R" "J" "U" "Q" "W" "F" "L" "M" "B" "I" "C" "E" "J" "Q" "R" "T" "O"
## [2466] "V" "A" "V" "C" "K" "S" "U" "J" "D" "L" "E" "G" "D" "H" "I" "I" "O"
## [2483] "D" "N" "N" "I" "S" "O" "L" "C" "I" "J" "D" "R" "F" "X" "T" "B" "D"
## [2500] "Q" "B" "M" "R" "V" "M" "B" "M" "C" "Z" "S" "S" "Q" "Q" "F" "U" "A"
## [2517] "U" "V" "Z" "O" "W" "K" "T" "D" "X" "A" "I" "X" "T" "R" "B" "W" "C"
## [2534] "V" "J" "D" "L" "L" "R" "U" "F" "M" "C" "M" "A" "N" "V" "M" "G" "O"
```

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## [2551] "J" "T" "M" "Q" "U" "H" "M" "O" "H" "C" "K" "X" "P" "Z" "J" "M" "N"
## [2568] "Z" "O" "O" "X" "D" "J" "Y" "P" "G" "W" "I" "G" "Q" "Y" "L" "Q" "V"
## [2585] "R" "Q" "J" "D" "K" "J" "B" "W" "R" "Q" "V" "L" "N" "E" "B" "Y" "R"
## [2602] "Q" "O" "M" "U" "G" "L" "V" "W" "L" "R" "M" "U" "O" "C" "V" "X" "T"
## [2619] "W" "P" "B" "T" "A" "R" "E" "G" "N" "M" "L" "O" "W" "S" "X" "M" "E"
## [2636] "T" "R" "U" "Y" "S" "A" "T" "A" "O" "S" "K" "S" "R" "N" "C" "Q" "E"
## [2653] "A" "H" "M" "S" "T" "B" "F" "E" "Q" "O" "N" "W" "V" "K" "B" "X" "O"
## [2670] "N" "O" "O" "P" "O" "B" "C" "R" "V" "F" "N" "L" "D" "Y" "L" "K" "L"
## [2687] "R" "M" "R" "B" "A" "X" "A" "H" "P" "W" "L" "L" "P" "X" "S" "V" "W"
## [2704] "F" "X" "V" "O" "Y" "X" "K" "M" "D" "S" "C" "G" "E" "D" "R" "I" "J"
## [2721] "G" "N" "P" "N" "H" "G" "S" "W" "P" "M" "X" "Y" "D" "D" "E" "M" "W"
## [2738] "N" "E" "D" "L" "U" "E" "O" "R" "A" "Q" "M" "N" "D" "C" "K" "A" "H"
## [2755] "C" "F" "Y" "W" "Z" "P" "O" "B" "D" "X" "B" "K" "K" "O" "B" "P" "B"
## [2772] "L" "D" "A" "N" "G" "A" "O" "V" "M" "M" "X" "M" "F" "X" "O" "H" "X"
## [2789] "T" "I" "J" "P" "W" "M" "X" "Q" "J" "D" "X" "O" "O" "G" "I" "L" "A"
## [2806] "T" "P" "M" "K" "X" "E" "X" "J" "W" "K" "T" "R" "D" "N" "H" "R" "O"
## [2823] "X" "P" "T" "G" "O" "O" "S" "M" "U" "T" "E" "R" "V" "J" "R" "S" "X"
## [2840] "P" "J" "E" "C" "D" "W" "M" "E" "M" "E" "E" "N" "B" "W" "S" "V" "K"
## [2857] "M" "G" "O" "K" "T" "I" "H" "B" "N" "Q" "J" "V" "M" "M" "Y" "T" "I"
## [2874] "O" "M" "F" "T" "A" "W" "E" "V" "D" "R" "K" "R" "C" "Z" "K" "K" "S"
## [2891] "B" "H" "N" "Z" "C" "P" "E" "Z" "X" "J" "U" "R" "V" "Y" "B" "D" "C"
## [2908] "S" "A" "C" "A" "W" "L" "R" "R" "O" "S" "S" "A" "U" "H" "Y" "K" "G"
## [2925] "P" "U" "J" "B" "R" "X" "U" "N" "X" "U" "X" "B" "B" "N" "A" "E" "I"
## [2942] "M" "N" "A" "F" "Y" "Y" "R" "U" "N" "X" "W" "I" "Y" "K" "R" "V" "X"
## [2959] "O" "B" "T" "U" "M" "Q" "W" "M" "L" "R" "M" "R" "G" "X" "V" "W" "Q"
## [2976] "R" "K" "B" "Z" "T" "L" "L" "W" "W" "B" "O" "V" "I" "B" "H" "V" "J"
## [2993] "S" "W" "T" "B" "G" "P" "E" "W" "D" "C" "P" "Z" "U" "C" "A" "B" "V"
## [3010] "S" "O" "X" "W" "W" "Q" "U" "J" "L" "B" "A" "R" "I" "Q" "V" "A" "L"
## [3027] "J" "G" "S" "I" "F" "R" "O" "Y" "P" "M" "D" "S" "J" "J" "B" "Y" "H"
## [3044] "N" "L" "C" "N" "S" "J" "F" "D" "Y" "G" "Q" "G" "K" "D" "P" "W" "Q"
## [3061] "P" "L" "O" "U" "O" "Y" "D" "D" "O" "X" "D" "I" "V" "G" "E" "D" "P"
## [3078] "C" "M" "G" "S" "D" "S" "C" "R" "N" "M" "D" "M" "K" "G" "L" "V" "D"
## [3095] "Q" "S" "V" "Z" "R" "U" "A" "U" "F" "W" "K" "B" "X" "X" "V" "I" "Q"
## [3112] "T" "A" "L" "G" "T" "M" "M" "T" "J" "X" "X" "N" "V" "Q" "E" "G" "C"
## [3129] "Y" "Y" "H" "N" "E" "J" "U" "Z" "S" "S" "D" "X" "Q" "O" "D" "L" "O"
## [3146] "C" "I" "B" "W" "W" "S" "M" "A" "H" "O" "Y" "I" "G" "U" "M" "R" "S"
## [3163] "J" "K" "G" "E" "H" "O" "P" "N" "S" "B" "P" "Z" "P" "T" "Q" "W" "P"
## [3180] "U" "C" "R" "O" "P" "I" "N" "P" "L" "R" "X" "P" "M" "K" "Q" "Z" "K"
## [3197] "O" "U" "I" "O" "E" "E" "K" "C" "A" "W" "R" "H" "O" "S" "W" "A" "Y"
## [3214] "N" "K" "L" "L" "R" "F" "O" "T" "M" "E" "K" "Q" "P" "O" "U" "K" "G"
## [3231] "C" "X" "S" "V" "S" "E" "U" "A" "A" "O" "O" "K" "U" "S" "V" "F" "F"
## [3248] "J" "K" "B" "J" "K" "T" "A" "I" "D" "W" "N" "T" "X" "E" "C" "J" "N"
## [3265] "B" "Y" "P" "Z" "S" "V" "J" "W" "M" "B" "F" "N" "F" "O" "R" "J" "N"
## [3282] "A" "L" "I" "B" "P" "A" "Y" "T" "U" "Z" "Y" "D" "K" "H" "L" "W" "J"
## [3299] "S" "G" "B" "O" "M" "G" "M" "M" "P" "D" "G" "H" "W" "E" "J" "Y" "W"
## [3316] "Z" "I" "M" "R" "Z" "A" "I" "Y" "Y" "L" "V" "O" "E" "R" "O" "P" "Q"
## [3333] "T" "B" "N" "J" "D" "E" "P" "Z" "J" "U" "U" "S" "V" "P" "I" "C" "T"
## [3350] "E" "P" "L" "U" "Q" "H" "D" "A" "V" "A" "R" "M" "U" "Q" "E" "I" "V"
## [3367] "W" "T" "S" "E" "K" "Y" "F" "X" "I" "T" "M" "X" "I" "A" "Y" "B" "V"
## [3384] "B" "N" "J" "K" "C" "D" "P" "B" "F" "K" "P" "H" "V" "P" "E" "B" "Z"
## [3401] "L" "E" "V" "W" "Y" "U" "X" "R" "P" "E" "X" "T" "C" "D" "J" "M" "N"
## [3418] "S" "C" "I" "Y" "S" "L" "O" "I" "K" "E" "F" "G" "P" "N" "N" "J" "W"
## [3435] "D" "L" "D" "L" "F" "D" "O" "P" "Q" "B" "G" "E" "O" "B" "R" "Q" "R"
## [3452] "P" "D" "L" "O" "I" "P" "O" "A" "V" "M" "N" "Q" "J" "K" "F" "S" "Z"
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## [3469] "X" "S" "P" "O" "E" "X" "D" "Z" "K" "T" "U" "K" "F" "K" "P" "Y" "O"
## [3486] "U" "G" "I" "O" "H" "S" "I" "C" "C" "M" "Y" "O" "E" "I" "B" "I" "Z"
## [3503] "V" "H" "O" "D" "B" "D" "K" "D" "H" "U" "T" "F" "W" "B" "X" "J" "I"
## [3520] "Q" "V" "S" "Q" "C" "Y" "D" "M" "S" "B" "C" "E" "H" "T" "F" "E" "F"
## [3537] "G" "V" "H" "L" "X" "S" "P" "Y" "L" "O" "Y" "D" "U" "F" "X" "K" "S"
## [3554] "F" "L" "L" "L" "L" "F" "X" "X" "K" "Q" "Z" "U" "Q" "Z" "M" "T" "R"
## [3571] "L" "C" "Q" "R" "R" "S" "Q" "B" "A" "B" "S" "Y" "C" "P" "W" "P" "Q"
## [3588] "U" "O" "O" "T" "X" "R" "H" "V" "D" "O" "Y" "M" "O" "Q" "T" "Z" "Q"
## [3605] "V" "D" "R" "A" "G" "P" "J" "Q" "W" "H" "E" "C" "Q" "D" "I" "V" "Y"
## [3622] "K" "Q" "O" "W" "L" "W" "R" "M" "D" "H" "C" "A" "N" "U" "U" "O" "H"
## [3639] "M" "R" "F" "K" "G" "R" "F" "U" "A" "W" "X" "Z" "O" "M" "M" "U" "V"
## [3656] "C" "H" "B" "C" "W" "A" "S" "T" "L" "L" "P" "Z" "L" "Z" "W" "J" "R"
## [3673] "T" "M" "A" "F" "I" "A" "F" "E" "F" "R" "A" "R" "G" "N" "D" "S" "R"
## [3690] "O" "J" "N" "B" "A" "Q" "Y" "H" "U" "N" "F" "F" "N" "V" "V" "F" "V"
## [3707] "I" "W" "M" "Z" "P" "E" "V" "P" "L" "J" "P" "D" "O" "F" "A" "I" "N"
## [3724] "M" "A" "D" "I" "B" "T" "R" "L" "W" "O" "E" "X" "E" "R" "N" "F" "R"
## [3741] "V" "Y" "I" "A" "O" "P" "N" "M" "L" "T" "N" "I" "M" "N" "W" "B" "G"
## [3758] "S" "U" "D" "U" "G" "O" "E" "T" "B" "A" "H" "M" "W" "F" "G" "Z" "A"
## [3775] "A" "P" "D" "H" "B" "B" "Q" "H" "Z" "M" "F" "H" "Z" "M" "M" "F" "E"
## [3792] "V" "L" "R" "G" "W" "I" "B" "J" "A" "W" "G" "M" "B" "T" "L" "Y" "Q"
## [3809] "E" "S" "U" "D" "K" "D" "H" "G" "C" "I" "S" "N" "G" "O" "A" "W" "E"
## [3826] "I" "S" "W" "M" "L" "N" "F" "I" "A" "U" "W" "U" "A" "G" "P" "I" "L"
## [3843] "I" "Z" "Z" "N" "Z" "C" "O" "A" "Y" "L" "W" "N" "C" "G" "Q" "J" "B"
## [3860] "J" "M" "G" "Y" "A" "K" "N" "L" "O" "B" "U" "M" "S" "T" "L" "F" "A"
## [3877] "C" "N" "K" "Y" "H" "B" "L" "Q" "Y" "I" "W" "F" "D" "N" "Z" "M" "Z"
## [3894] "W" "I" "W" "N" "K" "J" "J" "H" "O" "X" "U" "Q" "B" "Y" "O" "P" "S"
## [3911] "R" "P" "F" "U" "L" "L" "K" "Z" "W" "T" "G" "G" "V" "O" "Z" "R" "L"
## [3928] "K" "R" "U" "B" "L" "C" "N" "M" "X" "J" "Y" "S" "A" "X" "R" "I" "K"
## [3945] "Y" "U" "R" "J" "G" "M" "F" "S" "Q" "L" "U" "O" "B" "A" "U" "I" "E"
## [3962] "K" "U" "J" "X" "P" "V" "F" "U" "C" "G" "Z" "N" "S" "A" "B" "H" "K"
## [3979] "S" "I" "A" "E" "G" "M" "T" "N" "X" "O" "E" "D" "T" "Y" "W" "N" "R"
## [3996] "Z" "P" "B" "E" "O" "P" "E" "D" "J" "B" "T" "W" "I" "Z" "F" "M" "N"
## [4013] "Y" "G" "L" "Q" "R" "R" "D" "C" "B" "R" "R" "H" "C" "A" "N" "H" "E"
## [4030] "X" "Q" "O" "W" "Q" "H" "T" "I" "D" "O" "G" "B" "Y" "S" "A" "I" "X"
## [4047] "K" "I" "W" "X" "J" "P" "G" "G" "L" "V" "U" "K" "U" "W" "F" "P" "P"
## [4064] "U" "I" "B" "U" "X" "A" "Y" "S" "K" "O" "K" "G" "E" "L" "J" "O" "J"
## [4081] "G" "G" "L" "G" "Q" "V" "X" "I" "I" "N" "H" "S" "C" "P" "K" "K" "H"
## [4098] "N" "Y" "U" "D" "O" "C" "B" "D" "O" "H" "S" "K" "O" "N" "Z" "W" "Y"
## [4115] "I" "V" "N" "S" "T" "M" "W" "F" "S" "B" "B" "O" "N" "Z" "H" "A" "N"
## [4132] "X" "T" "L" "B" "W" "V" "S" "R" "L" "F" "Z" "J" "C" "T" "E" "X" "D"
## [4149] "F" "E" "G" "K" "A" "R" "R" "B" "N" "I" "B" "W" "I" "E" "M" "K" "L"
## [4166] "S" "Z" "N" "H" "C" "L" "D" "I" "D" "J" "H" "K" "A" "Y" "L" "I" "N"
## [4183] "L" "W" "E" "R" "O" "X" "T" "H" "V" "M" "S" "Z" "U" "T" "D" "D" "C"
## [4200] "K" "N" "A" "K" "M" "W" "D" "S" "D" "Y" "I" "B" "P" "F" "E" "O" "S"
## [4217] "W" "D" "L" "D" "P" "E" "U" "R" "B" "R" "H" "M" "O" "Y" "M" "S" "J"
## [4234] "A" "B" "C" "J" "J" "J" "V" "Z" "X" "Y" "D" "K" "Y" "X" "F" "R" "B"
## [4251] "B" "U" "T" "K" "B" "B" "E" "A" "A" "J" "R" "I" "R" "T" "W" "G" "B"
## [4268] "G" "O" "R" "Y" "W" "C" "V" "R" "O" "X" "G" "K" "N" "H" "V" "X" "J"
## [4285] "L" "N" "Q" "A" "R" "P" "Q" "Y" "P" "R" "S" "L" "J" "D" "Q" "V" "E"
## [4302] "Q" "B" "Q" "Q" "U" "A" "Z" "X" "T" "J" "T" "Y" "J" "M" "D" "H" "W"
## [4319] "W" "A" "X" "A" "N" "T" "B" "B" "U" "D" "V" "N" "J" "F" "L" "I" "D"
## [4336] "I" "I" "R" "I" "X" "F" "O" "Q" "F" "C" "X" "Q" "N" "Z" "Q" "Y" "U"
## [4353] "G" "R" "R" "F" "P" "Q" "X" "B" "H" "T" "V" "P" "Y" "K" "E" "C" "H"
## [4370] "V" "W" "S" "Q" "Z" "P" "D" "A" "R" "F" "X" "M" "L" "Z" "O" "N" "M"
```

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```
## [4387] "E" "S" "E" "M" "M" "O" "B" "X" "H" "S" "X" "Z" "A" "C" "S" "K" "L"
## [4404] "L" "P" "P" "Z" "S" "V" "X" "R" "S" "K" "W" "V" "X" "F" "Q" "F" "T"
## [4421] "K" "X" "O" "I" "L" "B" "K" "R" "F" "M" "L" "M" "F" "R" "U" "U" "Q"
## [4438] "K" "I" "Q" "T" "B" "V" "V" "S" "N" "B" "X" "Z" "A" "S" "Q" "Q" "J"
## [4455] "G" "T" "S" "L" "C" "B" "G" "Q" "Z" "T" "W" "I" "T" "P" "S" "H" "N"
## [4472] "H" "P" "G" "R" "I" "A" "A" "B" "I" "Q" "S" "G" "W" "D" "W" "L" "Q"
## [4489] "K" "I" "R" "O" "A" "G" "J" "U" "I" "T" "F" "W" "D" "A" "H" "F" "U"
## [4506] "W" "Q" "D" "I" "Z" "W" "Y" "L" "X" "G" "X" "J" "H" "K" "C" "M" "G"
## [4523] "D" "U" "B" "E" "Z" "R" "A" "I" "K" "P" "G" "B" "R" "K" "D" "R" "Q"
## [4540] "K" "I" "R" "F" "Q" "W" "U" "X" "E" "M" "G" "B" "F" "R" "D" "D" "J"
## [4557] "Z" "J" "K" "Z" "O" "Y" "T" "D" "P" "H" "Y" "X" "W" "Y" "P" "U" "S"
## [4574] "N" "T" "F" "G" "V" "C" "J" "Z" "G" "Z" "S" "X" "N" "H" "B" "Z" "M"
## [4591] "E" "A" "J" "A" "K" "Z" "I" "S" "T" "N" "L" "M" "O" "L" "Y" "J" "K"
## [4608] "T" "T" "V" "R" "Z" "R" "C" "X" "H" "C" "A" "M" "E" "T" "E" "L" "A"
## [4625] "M" "A" "Z" "V" "N" "B" "L" "A" "I" "O" "J" "T" "Z" "M" "G" "E" "W"
## [4642] "U" "O" "M" "B" "W" "X" "V" "L" "A" "F" "B" "K" "Z" "N" "B" "B" "X"
## [4659] "V" "N" "Z" "C" "X" "I" "W" "O" "A" "K" "D" "O" "G" "N" "M" "Z" "W"
## [4676] "S" "M" "F" "X" "Y" "Q" "W" "Q" "F" "G" "F" "I" "X" "U" "X" "X" "A"
## [4693] "I" "B" "O" "R" "I" "N" "S" "Y" "T" "D" "T" "X" "C" "I" "F" "U" "V"
## [4710] "I" "X" "Q" "F" "Y" "P" "U" "A" "H" "C" "S" "H" "Z" "Q" "D" "S" "D"
## [4727] "I" "C" "N" "C" "R" "R" "L" "O" "L" "U" "G" "N" "W" "B" "X" "Z" "W"
## [4744] "J" "Z" "K" "U" "E" "C" "J" "O" "S" "V" "T" "M" "O" "X" "B" "K" "G"
## [4761] "B" "Y" "H" "C" "M" "E" "M" "R" "L" "A" "K" "A" "E" "Q" "K" "N" "T"
## [4778] "M" "I" "K" "G" "R" "Q" "N" "D" "J" "W" "W" "V" "C" "O" "A" "M" "P"
## [4795] "S" "M" "Q" "A" "D" "A" "T" "J" "B" "R" "P" "N" "F" "D" "W" "R" "D"
## [4812] "X" "I" "Q" "E" "D" "H" "C" "O" "X" "K" "R" "R" "G" "B" "W" "D" "Y"
## [4829] "D" "F" "T" "H" "U" "H" "A" "Y" "S" "H" "R" "P" "M" "W" "X" "M" "W"
## [4846] "N" "D" "K" "Z" "L" "D" "U" "B" "G" "I" "E" "L" "G" "U" "R" "H" "E"
## [4863] "U" "V" "T" "J" "I" "F" "O" "N" "H" "W" "P" "U" "M" "J" "B" "F" "T"
## [4880] "O" "L" "P" "Z" "J" "D" "G" "F" "Y" "V" "K" "D" "N" "I" "Y" "R" "B"
## [4897] "S" "N" "A" "B" "F" "J" "F" "C" "R" "V" "Z" "Z" "D" "T" "B" "R" "M"
## [4914] "T" "V" "A" "C" "P" "D" "T" "E" "W" "E" "Q" "G" "X" "M" "C" "E" "X"
## [4931] "D" "M" "F" "L" "J" "Q" "D" "C" "N" "H" "Q" "X" "J" "O" "S" "T" "M"
## [4948] "T" "S" "J" "K" "E" "R" "G" "I" "K" "F" "J" "I" "G" "W" "P" "I" "P"
## [4965] "D" "T" "V" "M" "G" "J" "R" "M" "X" "Y" "E" "X" "M" "Y" "Q" "J" "G"
## [4982] "K" "Y" "N" "G" "X" "K" "O" "J" "Q" "F" "K" "W" "S" "M" "O" "X" "X"
## [4999] "T" "A"
```

```
#Build congudion mmatrix
conf_slow<- table(pred_slow, lettersdf[-train,]$V1)
conf_slow
```

```
## 
## pred_slow   A   B   C   D   E   F   G   H   I   J   K   L   M   N   O   P
##         A 181   0   0   0   0   0   1   1   1   0   2   2   3   0   0   0
##         B   0 140   0  17   0   8   3  11   7   4   4   1   1   2   0   5
##         C   3   0 134   0   9   0  15   0   2   0   0   3   0   1   1   0
##         D   0   8   0 144   0   1   4   9   4   3   5   0   1   4   8   3
##         E   0   1   7   0 132   4   1   0   0   0   2   2   0   0   0   3
##         F   0   1   0   5   0 135   0   3   1   5   0   0   0   0   0  14
##         G   0   1  10   0   8   7 128   1   0   0   2   6   2   0   3   3
##         H   0   1   0   7   0   0   2 121   1   0   7   0   2   0   1   0
##         I   1   0   0   0   0   9   0   0 162   3   0   0   0   0   0   2
##         J   1   0   0   5   0   1   0   0   3 153   0   0   0   1   0   1
##         K   1   1  16   5  10   1   1  11   0   0 134   1   3   1   0   0
```

```
##        L   1   0   1   1   6   0   1   0   0   0   0 161   0   0   3   0
##        M   2   5   0   0   0   0   0   2   0   0   1   0 183   4   1   0
##        N   0   3   0   1   0   1   0   0   0   1   4   0   4 172   0   0
##        O   1   1   8   2   0   0   1  12   0   3   0   0   4   7 154   4
##        P   0   0   0   4   0  11   0   1   1   4   0   0   0   4   0 152
##        Q   3   1   1   0   9   0  20   2   0   2   0   4   0   0   5   0
##        R   0  14   0   5   0   1   6   7   0   3   8   1   1   5   4   0
##        S   4   3   6   2   8   6   5   0   3   4   0   2   0   0   0   0
##        T   0   0   0   5   3   5   0   1   0   0   1   0   0   0   0   0
##        U   1   0   1   0   0   0   2   7   1   1   0   0   0   1   0   0
##        V   0   2   0   0   0   1   0   0   0   0   1   0   0   0   0   2
##        W   0   1   0   0   0   1   3   3   0   0   1   0   3   3   8   4
##        X   3   1   1   0  15   2   0   2   6   2   6   5   0   0   0   0
##        Y   2   0   0   0   0   3   0   0   0   0   0   6   0   3   0   7
##        Z   0   0   1   0   6   0   1   0   1   3   1   0   0   0   0   0
##
## pred_slow   Q   R   S   T   U   V   W   X   Y   Z
##        A   0   0   8   0   0   0   0   0   0   0
##        B   1  15   7   2   1   0   1   4   0   2
##        C   3   0   0   0   1   0   0   0   0   0
##        D   0   7   4   1   1   1   0   2   3   0
##        E   3   3   5   7   0   0   1   2   0   6
##        F   0   1   2   8   0   1   0   0   6   0
##        G   6   1   2   2   1   0   0   0   0   0
##        H   1   1   2   1   0   0   1   1   0   0
##        I   0   0   3   1   0   0   0   0   1   0
##        J   0   0   0   0   0   0   0   0   0   4
##        K   0   2   0   2   2   0   0  13   0   0
##        L   9   0   2   0   0   0   0   0   0   2
##        M   1   4   0   0  12   0  11   0   0   0
##        N   0   1   0   0   7   6   0   0   0   0
##        O  14   0   0   1   8   1   5  15   1   0
##        P   0   0   0   0   0   5   0   1   2   0
##        Q 118   0   3   0   3   1   0   0   6   2
##        R   0 163   6   0   0   0   1   1   0   2
##        S   6   1 144   3   0   1   0   2   3  13
##        T   0   0   3 167   3   2   0   0   3   3
##        U   0   0   0   6 162   1   0   0   3   0
##        V   0   0   1   0   2 143   0   1  15   0
##        W   0   0   0   0   0   8 150   0   0   0
##        X   0   6   1   7   1   1   0 140   0   2
##        Y   1   0   1   2   2   3   0   4 135   0
##        Z   3   0   6   0   0   0   0   0   0 141
```

```r
#Calculate misclassification rate
correct_slow <- sum(diag(conf_slow))
correct_slow
```

```
## [1] 3849
```

```r
slow_mis <- (sum(conf_slow) - correct_slow)/sum(conf_slow)
slow_mis
```

```
## [1] 0.2302
```

1. The slower learner yieled a lower misclassification rate of 0.213.

2. Most of the letter pairs that were difficult to distinguish before become easier to distinguish or remained about the same. The letter pairs that were most difficult to distinguish from one another in the previous model (E and X, H and O, Q ans G, Z and S, and T and Y) all became easier to distinguish. The capacity to distinguish betwen T and Y seemed to improve the most in this model.

Communities and Crime

One last boost

```
#load data

#Build model

#Predict rate

#Compute test MSE
```

Chapter 8 exercises