# Phil's Code in Markdown

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```
#Group 1: Diabetes Dataset
#Members: Phil, Ron, Kelly, Jane

#Libraries used
library(caret) #ML Model buidling package
```

```
## Loading required package: ggplot2

## Loading required package: lattice
```

```
library(tidyverse) #ggplot and dplyr
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.1 --

## v tibble  3.1.6     v dplyr   1.0.7
## v tidyr   1.1.4     v stringr 1.4.0
## v readr   2.1.1     v forcats 0.5.1
## v purrr   0.3.4

## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## x purrr::lift()   masks caret::lift()
```

```
library(MASS) #Modern Applied Statistics with S
```

```
##
## Attaching package: 'MASS'

## The following object is masked from 'package:dplyr':
##
##     select
```

```
library(mlbench) #data sets from the UCI repository.
library(summarytools)
```

```
##
## Attaching package: 'summarytools'

## The following object is masked from 'package:tibble':
##
##     view
```

```
library(corrplot) #Correlation plot
```

```
## corrplot 0.92 loaded
```

```r
library(gridExtra) #Multiple plot in single grip space
```

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

```r
library(timeDate)
library(pROC) #ROC
```

```
## Type 'citation("pROC")' for a citation.
##
## Attaching package: 'pROC'
## The following objects are masked from 'package:stats':
##
##     cov, smooth, var
```

```r
library(caTools) #AUC
library(rpart.plot) #CART Decision Tree
```

```
## Loading required package: rpart
```

```r
library(e1071) #imports graphics, grDevices, class, stats, methods, utils
```

```
##
## Attaching package: 'e1071'
## The following objects are masked from 'package:timeDate':
##
##     kurtosis, skewness
```

```r
library(doParallel)
```

```
## Loading required package: foreach
##
## Attaching package: 'foreach'
## The following objects are masked from 'package:purrr':
##
##     accumulate, when
## Loading required package: iterators
## Loading required package: parallel
```

```r
library(AppliedPredictiveModeling)
library(rpart)
library(partykit)
```

```
## Loading required package: grid
## Loading required package: libcoin
## Loading required package: mvtnorm
```

```r
library(randomForest)
```

```
## randomForest 4.6-14
```

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

##
## Attaching package: 'randomForest'

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

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

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

```
registerDoParallel(cores=7)

set.seed(100)


#Pima Indians Diabetes Dataset Found Inside Caret Function
data(PimaIndiansDiabetes)# There are two of them, versions
df <- PimaIndiansDiabetes
df
```

```
##     pregnant glucose pressure triceps insulin mass pedigree age diabetes
## 1          6     148       72      35       0 33.6    0.627  50      pos
## 2          1      85       66      29       0 26.6    0.351  31      neg
## 3          8     183       64       0       0 23.3    0.672  32      pos
## 4          1      89       66      23      94 28.1    0.167  21      neg
## 5          0     137       40      35     168 43.1    2.288  33      pos
## 6          5     116       74       0       0 25.6    0.201  30      neg
## 7          3      78       50      32      88 31.0    0.248  26      pos
## 8         10     115        0       0       0 35.3    0.134  29      neg
## 9          2     197       70      45     543 30.5    0.158  53      pos
## 10         8     125       96       0       0  0.0    0.232  54      pos
## 11         4     110       92       0       0 37.6    0.191  30      neg
## 12        10     168       74       0       0 38.0    0.537  34      pos
## 13        10     139       80       0       0 27.1    1.441  57      neg
## 14         1     189       60      23     846 30.1    0.398  59      pos
## 15         5     166       72      19     175 25.8    0.587  51      pos
## 16         7     100        0       0       0 30.0    0.484  32      pos
## 17         0     118       84      47     230 45.8    0.551  31      pos
## 18         7     107       74       0       0 29.6    0.254  31      pos
## 19         1     103       30      38      83 43.3    0.183  33      neg
## 20         1     115       70      30      96 34.6    0.529  32      pos
## 21         3     126       88      41     235 39.3    0.704  27      neg
## 22         8      99       84       0       0 35.4    0.388  50      neg
## 23         7     196       90       0       0 39.8    0.451  41      pos
## 24         9     119       80      35       0 29.0    0.263  29      pos
## 25        11     143       94      33     146 36.6    0.254  51      pos
## 26        10     125       70      26     115 31.1    0.205  41      pos
## 27         7     147       76       0       0 39.4    0.257  43      pos
## 28         1      97       66      15     140 23.2    0.487  22      neg
## 29        13     145       82      19     110 22.2    0.245  57      neg
```

```
## 30           5     117       92       0       0 34.1     0.337  38       neg
## 31           5     109       75      26       0 36.0     0.546  60       neg
## 32           3     158       76      36     245 31.6     0.851  28       pos
## 33           3      88       58      11      54 24.8     0.267  22       neg
## 34           6      92       92       0       0 19.9     0.188  28       neg
## 35          10     122       78      31       0 27.6     0.512  45       neg
## 36           4     103       60      33     192 24.0     0.966  33       neg
## 37          11     138       76       0       0 33.2     0.420  35       neg
## 38           9     102       76      37       0 32.9     0.665  46       pos
## 39           2      90       68      42       0 38.2     0.503  27       pos
## 40           4     111       72      47     207 37.1     1.390  56       pos
## 41           3     180       64      25      70 34.0     0.271  26       neg
## 42           7     133       84       0       0 40.2     0.696  37       neg
## 43           7     106       92      18       0 22.7     0.235  48       neg
## 44           9     171      110      24     240 45.4     0.721  54       pos
## 45           7     159       64       0       0 27.4     0.294  40       neg
## 46           0     180       66      39       0 42.0     1.893  25       pos
## 47           1     146       56       0       0 29.7     0.564  29       neg
## 48           2      71       70      27       0 28.0     0.586  22       neg
## 49           7     103       66      32       0 39.1     0.344  31       pos
## 50           7     105        0       0       0  0.0     0.305  24       neg
## 51           1     103       80      11      82 19.4     0.491  22       neg
## 52           1     101       50      15      36 24.2     0.526  26       neg
## 53           5      88       66      21      23 24.4     0.342  30       neg
## 54           8     176       90      34     300 33.7     0.467  58       pos
## 55           7     150       66      42     342 34.7     0.718  42       neg
## 56           1      73       50      10       0 23.0     0.248  21       neg
## 57           7     187       68      39     304 37.7     0.254  41       pos
## 58           0     100       88      60     110 46.8     0.962  31       neg
## 59           0     146       82       0       0 40.5     1.781  44       neg
## 60           0     105       64      41     142 41.5     0.173  22       neg
## 61           2      84        0       0       0  0.0     0.304  21       neg
## 62           8     133       72       0       0 32.9     0.270  39       pos
## 63           5      44       62       0       0 25.0     0.587  36       neg
## 64           2     141       58      34     128 25.4     0.699  24       neg
## 65           7     114       66       0       0 32.8     0.258  42       pos
## 66           5      99       74      27       0 29.0     0.203  32       neg
## 67           0     109       88      30       0 32.5     0.855  38       pos
## 68           2     109       92       0       0 42.7     0.845  54       neg
## 69           1      95       66      13      38 19.6     0.334  25       neg
## 70           4     146       85      27     100 28.9     0.189  27       neg
## 71           2     100       66      20      90 32.9     0.867  28       pos
## 72           5     139       64      35     140 28.6     0.411  26       neg
## 73          13     126       90       0       0 43.4     0.583  42       pos
## 74           4     129       86      20     270 35.1     0.231  23       neg
## 75           1      79       75      30       0 32.0     0.396  22       neg
## 76           1       0       48      20       0 24.7     0.140  22       neg
## 77           7      62       78       0       0 32.6     0.391  41       neg
## 78           5      95       72      33       0 37.7     0.370  27       neg
## 79           0     131        0       0       0 43.2     0.270  26       pos
## 80           2     112       66      22       0 25.0     0.307  24       neg
## 81           3     113       44      13       0 22.4     0.140  22       neg
## 82           2      74        0       0       0  0.0     0.102  22       neg
## 83           7      83       78      26      71 29.3     0.767  36       neg
```

```
## 84          0     101      65      28       0 24.6     0.237  22        neg
## 85          5     137     108       0       0 48.8     0.227  37        pos
## 86          2     110      74      29     125 32.4     0.698  27        neg
## 87         13     106      72      54       0 36.6     0.178  45        neg
## 88          2     100      68      25      71 38.5     0.324  26        neg
## 89         15     136      70      32     110 37.1     0.153  43        pos
## 90          1     107      68      19       0 26.5     0.165  24        neg
## 91          1      80      55       0       0 19.1     0.258  21        neg
## 92          4     123      80      15     176 32.0     0.443  34        neg
## 93          7      81      78      40      48 46.7     0.261  42        neg
## 94          4     134      72       0       0 23.8     0.277  60        pos
## 95          2     142      82      18      64 24.7     0.761  21        neg
## 96          6     144      72      27     228 33.9     0.255  40        neg
## 97          2      92      62      28       0 31.6     0.130  24        neg
## 98          1      71      48      18      76 20.4     0.323  22        neg
## 99          6      93      50      30      64 28.7     0.356  23        neg
## 100         1     122      90      51     220 49.7     0.325  31        pos
## 101         1     163      72       0       0 39.0     1.222  33        pos
## 102         1     151      60       0       0 26.1     0.179  22        neg
## 103         0     125      96       0       0 22.5     0.262  21        neg
## 104         1      81      72      18      40 26.6     0.283  24        neg
## 105         2      85      65       0       0 39.6     0.930  27        neg
## 106         1     126      56      29     152 28.7     0.801  21        neg
## 107         1      96     122       0       0 22.4     0.207  27        neg
## 108         4     144      58      28     140 29.5     0.287  37        neg
## 109         3      83      58      31      18 34.3     0.336  25        neg
## 110         0      95      85      25      36 37.4     0.247  24        pos
## 111         3     171      72      33     135 33.3     0.199  24        pos
## 112         8     155      62      26     495 34.0     0.543  46        pos
## 113         1      89      76      34      37 31.2     0.192  23        neg
## 114         4      76      62       0       0 34.0     0.391  25        neg
## 115         7     160      54      32     175 30.5     0.588  39        pos
## 116         4     146      92       0       0 31.2     0.539  61        pos
## 117         5     124      74       0       0 34.0     0.220  38        pos
## 118         5      78      48       0       0 33.7     0.654  25        neg
## 119         4      97      60      23       0 28.2     0.443  22        neg
## 120         4      99      76      15      51 23.2     0.223  21        neg
## 121         0     162      76      56     100 53.2     0.759  25        pos
## 122         6     111      64      39       0 34.2     0.260  24        neg
## 123         2     107      74      30     100 33.6     0.404  23        neg
## 124         5     132      80       0       0 26.8     0.186  69        neg
## 125         0     113      76       0       0 33.3     0.278  23        pos
## 126         1      88      30      42      99 55.0     0.496  26        pos
## 127         3     120      70      30     135 42.9     0.452  30        neg
## 128         1     118      58      36      94 33.3     0.261  23        neg
## 129         1     117      88      24     145 34.5     0.403  40        pos
## 130         0     105      84       0       0 27.9     0.741  62        pos
## 131         4     173      70      14     168 29.7     0.361  33        pos
## 132         9     122      56       0       0 33.3     1.114  33        pos
## 133         3     170      64      37     225 34.5     0.356  30        pos
## 134         8      84      74      31       0 38.3     0.457  39        neg
## 135         2      96      68      13      49 21.1     0.647  26        neg
## 136         2     125      60      20     140 33.8     0.088  31        neg
## 137         0     100      70      26      50 30.8     0.597  21        neg
```

```
## 138        0     93      60      25       92 28.7     0.532  22        neg
## 139        0    129      80       0        0 31.2     0.703  29        neg
## 140        5    105      72      29      325 36.9     0.159  28        neg
## 141        3    128      78       0        0 21.1     0.268  55        neg
## 142        5    106      82      30        0 39.5     0.286  38        neg
## 143        2    108      52      26       63 32.5     0.318  22        neg
## 144       10    108      66       0        0 32.4     0.272  42        pos
## 145        4    154      62      31      284 32.8     0.237  23        neg
## 146        0    102      75      23        0  0.0     0.572  21        neg
## 147        9     57      80      37        0 32.8     0.096  41        neg
## 148        2    106      64      35      119 30.5     1.400  34        neg
## 149        5    147      78       0        0 33.7     0.218  65        neg
## 150        2     90      70      17        0 27.3     0.085  22        neg
## 151        1    136      74      50      204 37.4     0.399  24        neg
## 152        4    114      65       0        0 21.9     0.432  37        neg
## 153        9    156      86      28      155 34.3     1.189  42        pos
## 154        1    153      82      42      485 40.6     0.687  23        neg
## 155        8    188      78       0        0 47.9     0.137  43        pos
## 156        7    152      88      44        0 50.0     0.337  36        pos
## 157        2     99      52      15       94 24.6     0.637  21        neg
## 158        1    109      56      21      135 25.2     0.833  23        neg
## 159        2     88      74      19       53 29.0     0.229  22        neg
## 160       17    163      72      41      114 40.9     0.817  47        pos
## 161        4    151      90      38        0 29.7     0.294  36        neg
## 162        7    102      74      40      105 37.2     0.204  45        neg
## 163        0    114      80      34      285 44.2     0.167  27        neg
## 164        2    100      64      23        0 29.7     0.368  21        neg
## 165        0    131      88       0        0 31.6     0.743  32        pos
## 166        6    104      74      18      156 29.9     0.722  41        pos
## 167        3    148      66      25        0 32.5     0.256  22        neg
## 168        4    120      68       0        0 29.6     0.709  34        neg
## 169        4    110      66       0        0 31.9     0.471  29        neg
## 170        3    111      90      12       78 28.4     0.495  29        neg
## 171        6    102      82       0        0 30.8     0.180  36        pos
## 172        6    134      70      23      130 35.4     0.542  29        pos
## 173        2     87       0      23        0 28.9     0.773  25        neg
## 174        1     79      60      42       48 43.5     0.678  23        neg
## 175        2     75      64      24       55 29.7     0.370  33        neg
## 176        8    179      72      42      130 32.7     0.719  36        pos
## 177        6     85      78       0        0 31.2     0.382  42        neg
## 178        0    129     110      46      130 67.1     0.319  26        pos
## 179        5    143      78       0        0 45.0     0.190  47        neg
## 180        5    130      82       0        0 39.1     0.956  37        pos
## 181        6     87      80       0        0 23.2     0.084  32        neg
## 182        0    119      64      18       92 34.9     0.725  23        neg
## 183        1      0      74      20       23 27.7     0.299  21        neg
## 184        5     73      60       0        0 26.8     0.268  27        neg
## 185        4    141      74       0        0 27.6     0.244  40        neg
## 186        7    194      68      28        0 35.9     0.745  41        pos
## 187        8    181      68      36      495 30.1     0.615  60        pos
## 188        1    128      98      41       58 32.0     1.321  33        pos
## 189        8    109      76      39      114 27.9     0.640  31        pos
## 190        5    139      80      35      160 31.6     0.361  25        pos
## 191        3    111      62       0        0 22.6     0.142  21        neg
```

```
## 192        9     123      70      44      94 33.1     0.374  40       neg
## 193        7     159      66       0       0 30.4     0.383  36       pos
## 194       11     135       0       0       0 52.3     0.578  40       pos
## 195        8      85      55      20       0 24.4     0.136  42       neg
## 196        5     158      84      41     210 39.4     0.395  29       pos
## 197        1     105      58       0       0 24.3     0.187  21       neg
## 198        3     107      62      13      48 22.9     0.678  23       pos
## 199        4     109      64      44      99 34.8     0.905  26       pos
## 200        4     148      60      27     318 30.9     0.150  29       pos
## 201        0     113      80      16       0 31.0     0.874  21       neg
## 202        1     138      82       0       0 40.1     0.236  28       neg
## 203        0     108      68      20       0 27.3     0.787  32       neg
## 204        2      99      70      16      44 20.4     0.235  27       neg
## 205        6     103      72      32     190 37.7     0.324  55       neg
## 206        5     111      72      28       0 23.9     0.407  27       neg
## 207        8     196      76      29     280 37.5     0.605  57       pos
## 208        5     162     104       0       0 37.7     0.151  52       pos
## 209        1      96      64      27      87 33.2     0.289  21       neg
## 210        7     184      84      33       0 35.5     0.355  41       pos
## 211        2      81      60      22       0 27.7     0.290  25       neg
## 212        0     147      85      54       0 42.8     0.375  24       neg
## 213        7     179      95      31       0 34.2     0.164  60       neg
## 214        0     140      65      26     130 42.6     0.431  24       pos
## 215        9     112      82      32     175 34.2     0.260  36       pos
## 216       12     151      70      40     271 41.8     0.742  38       pos
## 217        5     109      62      41     129 35.8     0.514  25       pos
## 218        6     125      68      30     120 30.0     0.464  32       neg
## 219        5      85      74      22       0 29.0     1.224  32       pos
## 220        5     112      66       0       0 37.8     0.261  41       pos
## 221        0     177      60      29     478 34.6     1.072  21       pos
## 222        2     158      90       0       0 31.6     0.805  66       pos
## 223        7     119       0       0       0 25.2     0.209  37       neg
## 224        7     142      60      33     190 28.8     0.687  61       neg
## 225        1     100      66      15      56 23.6     0.666  26       neg
## 226        1      87      78      27      32 34.6     0.101  22       neg
## 227        0     101      76       0       0 35.7     0.198  26       neg
## 228        3     162      52      38       0 37.2     0.652  24       pos
## 229        4     197      70      39     744 36.7     2.329  31       neg
## 230        0     117      80      31      53 45.2     0.089  24       neg
## 231        4     142      86       0       0 44.0     0.645  22       pos
## 232        6     134      80      37     370 46.2     0.238  46       pos
## 233        1      79      80      25      37 25.4     0.583  22       neg
## 234        4     122      68       0       0 35.0     0.394  29       neg
## 235        3      74      68      28      45 29.7     0.293  23       neg
## 236        4     171      72       0       0 43.6     0.479  26       pos
## 237        7     181      84      21     192 35.9     0.586  51       pos
## 238        0     179      90      27       0 44.1     0.686  23       pos
## 239        9     164      84      21       0 30.8     0.831  32       pos
## 240        0     104      76       0       0 18.4     0.582  27       neg
## 241        1      91      64      24       0 29.2     0.192  21       neg
## 242        4      91      70      32      88 33.1     0.446  22       neg
## 243        3     139      54       0       0 25.6     0.402  22       pos
## 244        6     119      50      22     176 27.1     1.318  33       pos
## 245        2     146      76      35     194 38.2     0.329  29       neg
```

```
## 246          9      184         85        15          0 30.0      1.213  49         pos
## 247         10      122         68         0          0 31.2      0.258  41         neg
## 248          0      165         90        33        680 52.3      0.427  23         neg
## 249          9      124         70        33        402 35.4      0.282  34         neg
## 250          1      111         86        19          0 30.1      0.143  23         neg
## 251          9      106         52         0          0 31.2      0.380  42         neg
## 252          2      129         84         0          0 28.0      0.284  27         neg
## 253          2       90         80        14         55 24.4      0.249  24         neg
## 254          0       86         68        32          0 35.8      0.238  25         neg
## 255         12       92         62         7        258 27.6      0.926  44         pos
## 256          1      113         64        35          0 33.6      0.543  21         pos
## 257          3      111         56        39          0 30.1      0.557  30         neg
## 258          2      114         68        22          0 28.7      0.092  25         neg
## 259          1      193         50        16        375 25.9      0.655  24         neg
## 260         11      155         76        28        150 33.3      1.353  51         pos
## 261          3      191         68        15        130 30.9      0.299  34         neg
## 262          3      141          0         0          0 30.0      0.761  27         pos
## 263          4       95         70        32          0 32.1      0.612  24         neg
## 264          3      142         80        15          0 32.4      0.200  63         neg
## 265          4      123         62         0          0 32.0      0.226  35         pos
## 266          5       96         74        18         67 33.6      0.997  43         neg
## 267          0      138          0         0          0 36.3      0.933  25         pos
## 268          2      128         64        42          0 40.0      1.101  24         neg
## 269          0      102         52         0          0 25.1      0.078  21         neg
## 270          2      146          0         0          0 27.5      0.240  28         pos
## 271         10      101         86        37          0 45.6      1.136  38         pos
## 272          2      108         62        32         56 25.2      0.128  21         neg
## 273          3      122         78         0          0 23.0      0.254  40         neg
## 274          1       71         78        50         45 33.2      0.422  21         neg
## 275         13      106         70         0          0 34.2      0.251  52         neg
## 276          2      100         70        52         57 40.5      0.677  25         neg
## 277          7      106         60        24          0 26.5      0.296  29         pos
## 278          0      104         64        23        116 27.8      0.454  23         neg
## 279          5      114         74         0          0 24.9      0.744  57         neg
## 280          2      108         62        10        278 25.3      0.881  22         neg
## 281          0      146         70         0          0 37.9      0.334  28         pos
## 282         10      129         76        28        122 35.9      0.280  39         neg
## 283          7      133         88        15        155 32.4      0.262  37         neg
## 284          7      161         86         0          0 30.4      0.165  47         pos
## 285          2      108         80         0          0 27.0      0.259  52         pos
## 286          7      136         74        26        135 26.0      0.647  51         neg
## 287          5      155         84        44        545 38.7      0.619  34         neg
## 288          1      119         86        39        220 45.6      0.808  29         pos
## 289          4       96         56        17         49 20.8      0.340  26         neg
## 290          5      108         72        43         75 36.1      0.263  33         neg
## 291          0       78         88        29         40 36.9      0.434  21         neg
## 292          0      107         62        30         74 36.6      0.757  25         pos
## 293          2      128         78        37        182 43.3      1.224  31         pos
## 294          1      128         48        45        194 40.5      0.613  24         pos
## 295          0      161         50         0          0 21.9      0.254  65         neg
## 296          6      151         62        31        120 35.5      0.692  28         neg
## 297          2      146         70        38        360 28.0      0.337  29         pos
## 298          0      126         84        29        215 30.7      0.520  24         neg
## 299         14      100         78        25        184 36.6      0.412  46         pos
```

```
## 300          8     112       72       0       0 23.6     0.840  58       neg
## 301          0     167        0       0       0 32.3     0.839  30       pos
## 302          2     144       58      33     135 31.6     0.422  25       pos
## 303          5      77       82      41      42 35.8     0.156  35       neg
## 304          5     115       98       0       0 52.9     0.209  28       pos
## 305          3     150       76       0       0 21.0     0.207  37       neg
## 306          2     120       76      37     105 39.7     0.215  29       neg
## 307         10     161       68      23     132 25.5     0.326  47       pos
## 308          0     137       68      14     148 24.8     0.143  21       neg
## 309          0     128       68      19     180 30.5     1.391  25       pos
## 310          2     124       68      28     205 32.9     0.875  30       pos
## 311          6      80       66      30       0 26.2     0.313  41       neg
## 312          0     106       70      37     148 39.4     0.605  22       neg
## 313          2     155       74      17      96 26.6     0.433  27       pos
## 314          3     113       50      10      85 29.5     0.626  25       neg
## 315          7     109       80      31       0 35.9     1.127  43       pos
## 316          2     112       68      22      94 34.1     0.315  26       neg
## 317          3      99       80      11      64 19.3     0.284  30       neg
## 318          3     182       74       0       0 30.5     0.345  29       pos
## 319          3     115       66      39     140 38.1     0.150  28       neg
## 320          6     194       78       0       0 23.5     0.129  59       pos
## 321          4     129       60      12     231 27.5     0.527  31       neg
## 322          3     112       74      30       0 31.6     0.197  25       pos
## 323          0     124       70      20       0 27.4     0.254  36       pos
## 324         13     152       90      33      29 26.8     0.731  43       pos
## 325          2     112       75      32       0 35.7     0.148  21       neg
## 326          1     157       72      21     168 25.6     0.123  24       neg
## 327          1     122       64      32     156 35.1     0.692  30       pos
## 328         10     179       70       0       0 35.1     0.200  37       neg
## 329          2     102       86      36     120 45.5     0.127  23       pos
## 330          6     105       70      32      68 30.8     0.122  37       neg
## 331          8     118       72      19       0 23.1     1.476  46       neg
## 332          2      87       58      16      52 32.7     0.166  25       neg
## 333          1     180        0       0       0 43.3     0.282  41       pos
## 334         12     106       80       0       0 23.6     0.137  44       neg
## 335          1      95       60      18      58 23.9     0.260  22       neg
## 336          0     165       76      43     255 47.9     0.259  26       neg
## 337          0     117        0       0       0 33.8     0.932  44       neg
## 338          5     115       76       0       0 31.2     0.343  44       pos
## 339          9     152       78      34     171 34.2     0.893  33       pos
## 340          7     178       84       0       0 39.9     0.331  41       pos
## 341          1     130       70      13     105 25.9     0.472  22       neg
## 342          1      95       74      21      73 25.9     0.673  36       neg
## 343          1       0       68      35       0 32.0     0.389  22       neg
## 344          5     122       86       0       0 34.7     0.290  33       neg
## 345          8      95       72       0       0 36.8     0.485  57       neg
## 346          8     126       88      36     108 38.5     0.349  49       neg
## 347          1     139       46      19      83 28.7     0.654  22       neg
## 348          3     116        0       0       0 23.5     0.187  23       neg
## 349          3      99       62      19      74 21.8     0.279  26       neg
## 350          5       0       80      32       0 41.0     0.346  37       pos
## 351          4      92       80       0       0 42.2     0.237  29       neg
## 352          4     137       84       0       0 31.2     0.252  30       neg
## 353          3      61       82      28       0 34.4     0.243  46       neg
```

```
## 354         1     90       62       12       43 27.2    0.580  24        neg
## 355         3     90       78        0        0 42.7    0.559  21        neg
## 356         9    165       88        0        0 30.4    0.302  49        pos
## 357         1    125       50       40      167 33.3    0.962  28        pos
## 358        13    129        0       30        0 39.9    0.569  44        pos
## 359        12     88       74       40       54 35.3    0.378  48        neg
## 360         1    196       76       36      249 36.5    0.875  29        pos
## 361         5    189       64       33      325 31.2    0.583  29        pos
## 362         5    158       70        0        0 29.8    0.207  63        neg
## 363         5    103      108       37        0 39.2    0.305  65        neg
## 364         4    146       78        0        0 38.5    0.520  67        pos
## 365         4    147       74       25      293 34.9    0.385  30        neg
## 366         5     99       54       28       83 34.0    0.499  30        neg
## 367         6    124       72        0        0 27.6    0.368  29        pos
## 368         0    101       64       17        0 21.0    0.252  21        neg
## 369         3     81       86       16       66 27.5    0.306  22        neg
## 370         1    133      102       28      140 32.8    0.234  45        pos
## 371         3    173       82       48      465 38.4    2.137  25        pos
## 372         0    118       64       23       89  0.0    1.731  21        neg
## 373         0     84       64       22       66 35.8    0.545  21        neg
## 374         2    105       58       40       94 34.9    0.225  25        neg
## 375         2    122       52       43      158 36.2    0.816  28        neg
## 376        12    140       82       43      325 39.2    0.528  58        pos
## 377         0     98       82       15       84 25.2    0.299  22        neg
## 378         1     87       60       37       75 37.2    0.509  22        neg
## 379         4    156       75        0        0 48.3    0.238  32        pos
## 380         0     93      100       39       72 43.4    1.021  35        neg
## 381         1    107       72       30       82 30.8    0.821  24        neg
## 382         0    105       68       22        0 20.0    0.236  22        neg
## 383         1    109       60        8      182 25.4    0.947  21        neg
## 384         1     90       62       18       59 25.1    1.268  25        neg
## 385         1    125       70       24      110 24.3    0.221  25        neg
## 386         1    119       54       13       50 22.3    0.205  24        neg
## 387         5    116       74       29        0 32.3    0.660  35        pos
## 388         8    105      100       36        0 43.3    0.239  45        pos
## 389         5    144       82       26      285 32.0    0.452  58        pos
## 390         3    100       68       23       81 31.6    0.949  28        neg
## 391         1    100       66       29      196 32.0    0.444  42        neg
## 392         5    166       76        0        0 45.7    0.340  27        pos
## 393         1    131       64       14      415 23.7    0.389  21        neg
## 394         4    116       72       12       87 22.1    0.463  37        neg
## 395         4    158       78        0        0 32.9    0.803  31        pos
## 396         2    127       58       24      275 27.7    1.600  25        neg
## 397         3     96       56       34      115 24.7    0.944  39        neg
## 398         0    131       66       40        0 34.3    0.196  22        pos
## 399         3     82       70        0        0 21.1    0.389  25        neg
## 400         3    193       70       31        0 34.9    0.241  25        pos
## 401         4     95       64        0        0 32.0    0.161  31        pos
## 402         6    137       61        0        0 24.2    0.151  55        neg
## 403         5    136       84       41       88 35.0    0.286  35        pos
## 404         9     72       78       25        0 31.6    0.280  38        neg
## 405         5    168       64        0        0 32.9    0.135  41        pos
## 406         2    123       48       32      165 42.1    0.520  26        neg
## 407         4    115       72        0        0 28.9    0.376  46        pos
```

```
## 408           0     101        62        0        0 21.9     0.336   25       neg
## 409           8     197        74        0        0 25.9     1.191   39       pos
## 410           1     172        68       49      579 42.4     0.702   28       pos
## 411           6     102        90       39        0 35.7     0.674   28       neg
## 412           1     112        72       30      176 34.4     0.528   25       neg
## 413           1     143        84       23      310 42.4     1.076   22       neg
## 414           1     143        74       22       61 26.2     0.256   21       neg
## 415           0     138        60       35      167 34.6     0.534   21       pos
## 416           3     173        84       33      474 35.7     0.258   22       pos
## 417           1      97        68       21        0 27.2     1.095   22       neg
## 418           4     144        82       32        0 38.5     0.554   37       pos
## 419           1      83        68        0        0 18.2     0.624   27       neg
## 420           3     129        64       29      115 26.4     0.219   28       pos
## 421           1     119        88       41      170 45.3     0.507   26       neg
## 422           2      94        68       18       76 26.0     0.561   21       neg
## 423           0     102        64       46       78 40.6     0.496   21       neg
## 424           2     115        64       22        0 30.8     0.421   21       neg
## 425           8     151        78       32      210 42.9     0.516   36       pos
## 426           4     184        78       39      277 37.0     0.264   31       pos
## 427           0      94         0        0        0  0.0     0.256   25       neg
## 428           1     181        64       30      180 34.1     0.328   38       pos
## 429           0     135        94       46      145 40.6     0.284   26       neg
## 430           1      95        82       25      180 35.0     0.233   43       pos
## 431           2      99         0        0        0 22.2     0.108   23       neg
## 432           3      89        74       16       85 30.4     0.551   38       neg
## 433           1      80        74       11       60 30.0     0.527   22       neg
## 434           2     139        75        0        0 25.6     0.167   29       neg
## 435           1      90        68        8        0 24.5     1.138   36       neg
## 436           0     141         0        0        0 42.4     0.205   29       pos
## 437          12     140        85       33        0 37.4     0.244   41       neg
## 438           5     147        75        0        0 29.9     0.434   28       neg
## 439           1      97        70       15        0 18.2     0.147   21       neg
## 440           6     107        88        0        0 36.8     0.727   31       neg
## 441           0     189       104       25        0 34.3     0.435   41       pos
## 442           2      83        66       23       50 32.2     0.497   22       neg
## 443           4     117        64       27      120 33.2     0.230   24       neg
## 444           8     108        70        0        0 30.5     0.955   33       pos
## 445           4     117        62       12        0 29.7     0.380   30       pos
## 446           0     180        78       63       14 59.4     2.420   25       pos
## 447           1     100        72       12       70 25.3     0.658   28       neg
## 448           0      95        80       45       92 36.5     0.330   26       neg
## 449           0     104        64       37       64 33.6     0.510   22       pos
## 450           0     120        74       18       63 30.5     0.285   26       neg
## 451           1      82        64       13       95 21.2     0.415   23       neg
## 452           2     134        70        0        0 28.9     0.542   23       pos
## 453           0      91        68       32      210 39.9     0.381   25       neg
## 454           2     119         0        0        0 19.6     0.832   72       neg
## 455           2     100        54       28      105 37.8     0.498   24       neg
## 456          14     175        62       30        0 33.6     0.212   38       pos
## 457           1     135        54        0        0 26.7     0.687   62       neg
## 458           5      86        68       28       71 30.2     0.364   24       neg
## 459          10     148        84       48      237 37.6     1.001   51       pos
## 460           9     134        74       33       60 25.9     0.460   81       neg
## 461           9     120        72       22       56 20.8     0.733   48       neg
```

```
## 462          1     71        62      0       0 21.8     0.416  26       neg
## 463          8     74        70     40      49 35.3     0.705  39       neg
## 464          5     88        78     30       0 27.6     0.258  37       neg
## 465         10    115        98      0       0 24.0     1.022  34       neg
## 466          0    124        56     13     105 21.8     0.452  21       neg
## 467          0     74        52     10      36 27.8     0.269  22       neg
## 468          0     97        64     36     100 36.8     0.600  25       neg
## 469          8    120         0      0       0 30.0     0.183  38       pos
## 470          6    154        78     41     140 46.1     0.571  27       neg
## 471          1    144        82     40       0 41.3     0.607  28       neg
## 472          0    137        70     38       0 33.2     0.170  22       neg
## 473          0    119        66     27       0 38.8     0.259  22       neg
## 474          7    136        90      0       0 29.9     0.210  50       neg
## 475          4    114        64      0       0 28.9     0.126  24       neg
## 476          0    137        84     27       0 27.3     0.231  59       neg
## 477          2    105        80     45     191 33.7     0.711  29       pos
## 478          7    114        76     17     110 23.8     0.466  31       neg
## 479          8    126        74     38      75 25.9     0.162  39       neg
## 480          4    132        86     31       0 28.0     0.419  63       neg
## 481          3    158        70     30     328 35.5     0.344  35       pos
## 482          0    123        88     37       0 35.2     0.197  29       neg
## 483          4     85        58     22      49 27.8     0.306  28       neg
## 484          0     84        82     31     125 38.2     0.233  23       neg
## 485          0    145         0      0       0 44.2     0.630  31       pos
## 486          0    135        68     42     250 42.3     0.365  24       pos
## 487          1    139        62     41     480 40.7     0.536  21       neg
## 488          0    173        78     32     265 46.5     1.159  58       neg
## 489          4     99        72     17       0 25.6     0.294  28       neg
## 490          8    194        80      0       0 26.1     0.551  67       neg
## 491          2     83        65     28      66 36.8     0.629  24       neg
## 492          2     89        90     30       0 33.5     0.292  42       neg
## 493          4     99        68     38       0 32.8     0.145  33       neg
## 494          4    125        70     18     122 28.9     1.144  45       pos
## 495          3     80         0      0       0  0.0     0.174  22       neg
## 496          6    166        74      0       0 26.6     0.304  66       neg
## 497          5    110        68      0       0 26.0     0.292  30       neg
## 498          2     81        72     15      76 30.1     0.547  25       neg
## 499          7    195        70     33     145 25.1     0.163  55       pos
## 500          6    154        74     32     193 29.3     0.839  39       neg
## 501          2    117        90     19      71 25.2     0.313  21       neg
## 502          3     84        72     32       0 37.2     0.267  28       neg
## 503          6      0        68     41       0 39.0     0.727  41       pos
## 504          7     94        64     25      79 33.3     0.738  41       neg
## 505          3     96        78     39       0 37.3     0.238  40       neg
## 506         10     75        82      0       0 33.3     0.263  38       neg
## 507          0    180        90     26      90 36.5     0.314  35       pos
## 508          1    130        60     23     170 28.6     0.692  21       neg
## 509          2     84        50     23      76 30.4     0.968  21       neg
## 510          8    120        78      0       0 25.0     0.409  64       neg
## 511         12     84        72     31       0 29.7     0.297  46       pos
## 512          0    139        62     17     210 22.1     0.207  21       neg
## 513          9     91        68      0       0 24.2     0.200  58       neg
## 514          2     91        62      0       0 27.3     0.525  22       neg
## 515          3     99        54     19      86 25.6     0.154  24       neg
```

```
## 516          3      163         70         18        105 31.6      0.268   28         pos
## 517          9      145         88         34        165 30.3      0.771   53         pos
## 518          7      125         86          0          0 37.6      0.304   51         neg
## 519         13       76         60          0          0 32.8      0.180   41         neg
## 520          6      129         90          7        326 19.6      0.582   60         neg
## 521          2       68         70         32         66 25.0      0.187   25         neg
## 522          3      124         80         33        130 33.2      0.305   26         neg
## 523          6      114          0          0          0  0.0      0.189   26         neg
## 524          9      130         70          0          0 34.2      0.652   45         pos
## 525          3      125         58          0          0 31.6      0.151   24         neg
## 526          3       87         60         18          0 21.8      0.444   21         neg
## 527          1       97         64         19         82 18.2      0.299   21         neg
## 528          3      116         74         15        105 26.3      0.107   24         neg
## 529          0      117         66         31        188 30.8      0.493   22         neg
## 530          0      111         65          0          0 24.6      0.660   31         neg
## 531          2      122         60         18        106 29.8      0.717   22         neg
## 532          0      107         76          0          0 45.3      0.686   24         neg
## 533          1       86         66         52         65 41.3      0.917   29         neg
## 534          6       91          0          0          0 29.8      0.501   31         neg
## 535          1       77         56         30         56 33.3      1.251   24         neg
## 536          4      132          0          0          0 32.9      0.302   23         pos
## 537          0      105         90          0          0 29.6      0.197   46         neg
## 538          0       57         60          0          0 21.7      0.735   67         neg
## 539          0      127         80         37        210 36.3      0.804   23         neg
## 540          3      129         92         49        155 36.4      0.968   32         pos
## 541          8      100         74         40        215 39.4      0.661   43         pos
## 542          3      128         72         25        190 32.4      0.549   27         pos
## 543         10       90         85         32          0 34.9      0.825   56         pos
## 544          4       84         90         23         56 39.5      0.159   25         neg
## 545          1       88         78         29         76 32.0      0.365   29         neg
## 546          8      186         90         35        225 34.5      0.423   37         pos
## 547          5      187         76         27        207 43.6      1.034   53         pos
## 548          4      131         68         21        166 33.1      0.160   28         neg
## 549          1      164         82         43         67 32.8      0.341   50         neg
## 550          4      189        110         31          0 28.5      0.680   37         neg
## 551          1      116         70         28          0 27.4      0.204   21         neg
## 552          3       84         68         30        106 31.9      0.591   25         neg
## 553          6      114         88          0          0 27.8      0.247   66         neg
## 554          1       88         62         24         44 29.9      0.422   23         neg
## 555          1       84         64         23        115 36.9      0.471   28         neg
## 556          7      124         70         33        215 25.5      0.161   37         neg
## 557          1       97         70         40          0 38.1      0.218   30         neg
## 558          8      110         76          0          0 27.8      0.237   58         neg
## 559         11      103         68         40          0 46.2      0.126   42         neg
## 560         11       85         74          0          0 30.1      0.300   35         neg
## 561          6      125         76          0          0 33.8      0.121   54         pos
## 562          0      198         66         32        274 41.3      0.502   28         pos
## 563          1       87         68         34         77 37.6      0.401   24         neg
## 564          6       99         60         19         54 26.9      0.497   32         neg
## 565          0       91         80          0          0 32.4      0.601   27         neg
## 566          2       95         54         14         88 26.1      0.748   22         neg
## 567          1       99         72         30         18 38.6      0.412   21         neg
## 568          6       92         62         32        126 32.0      0.085   46         neg
## 569          4      154         72         29        126 31.3      0.338   37         neg
```

```
## 570          0     121        66       30       165 34.3      0.203  33        pos
## 571          3      78        70        0         0 32.5      0.270  39        neg
## 572          2     130        96        0         0 22.6      0.268  21        neg
## 573          3     111        58       31        44 29.5      0.430  22        neg
## 574          2      98        60       17       120 34.7      0.198  22        neg
## 575          1     143        86       30       330 30.1      0.892  23        neg
## 576          1     119        44       47        63 35.5      0.280  25        neg
## 577          6     108        44       20       130 24.0      0.813  35        neg
## 578          2     118        80        0         0 42.9      0.693  21        pos
## 579         10     133        68        0         0 27.0      0.245  36        neg
## 580          2     197        70       99         0 34.7      0.575  62        pos
## 581          0     151        90       46         0 42.1      0.371  21        pos
## 582          6     109        60       27         0 25.0      0.206  27        neg
## 583         12     121        78       17         0 26.5      0.259  62        neg
## 584          8     100        76        0         0 38.7      0.190  42        neg
## 585          8     124        76       24       600 28.7      0.687  52        pos
## 586          1      93        56       11         0 22.5      0.417  22        neg
## 587          8     143        66        0         0 34.9      0.129  41        pos
## 588          6     103        66        0         0 24.3      0.249  29        neg
## 589          3     176        86       27       156 33.3      1.154  52        pos
## 590          0      73         0        0         0 21.1      0.342  25        neg
## 591         11     111        84       40         0 46.8      0.925  45        pos
## 592          2     112        78       50       140 39.4      0.175  24        neg
## 593          3     132        80        0         0 34.4      0.402  44        pos
## 594          2      82        52       22       115 28.5      1.699  25        neg
## 595          6     123        72       45       230 33.6      0.733  34        neg
## 596          0     188        82       14       185 32.0      0.682  22        pos
## 597          0      67        76        0         0 45.3      0.194  46        neg
## 598          1      89        24       19        25 27.8      0.559  21        neg
## 599          1     173        74        0         0 36.8      0.088  38        pos
## 600          1     109        38       18       120 23.1      0.407  26        neg
## 601          1     108        88       19         0 27.1      0.400  24        neg
## 602          6      96         0        0         0 23.7      0.190  28        neg
## 603          1     124        74       36         0 27.8      0.100  30        neg
## 604          7     150        78       29       126 35.2      0.692  54        pos
## 605          4     183         0        0         0 28.4      0.212  36        pos
## 606          1     124        60       32         0 35.8      0.514  21        neg
## 607          1     181        78       42       293 40.0      1.258  22        pos
## 608          1      92        62       25        41 19.5      0.482  25        neg
## 609          0     152        82       39       272 41.5      0.270  27        neg
## 610          1     111        62       13       182 24.0      0.138  23        neg
## 611          3     106        54       21       158 30.9      0.292  24        neg
## 612          3     174        58       22       194 32.9      0.593  36        pos
## 613          7     168        88       42       321 38.2      0.787  40        pos
## 614          6     105        80       28         0 32.5      0.878  26        neg
## 615         11     138        74       26       144 36.1      0.557  50        pos
## 616          3     106        72        0         0 25.8      0.207  27        neg
## 617          6     117        96        0         0 28.7      0.157  30        neg
## 618          2      68        62       13        15 20.1      0.257  23        neg
## 619          9     112        82       24         0 28.2      1.282  50        pos
## 620          0     119         0        0         0 32.4      0.141  24        pos
## 621          2     112        86       42       160 38.4      0.246  28        neg
## 622          2      92        76       20         0 24.2      1.698  28        neg
## 623          6     183        94        0         0 40.8      1.461  45        neg
```

```
## 624          0     94      70     27     115 43.5     0.347  21        neg
## 625          2    108      64      0       0 30.8     0.158  21        neg
## 626          4     90      88     47      54 37.7     0.362  29        neg
## 627          0    125      68      0       0 24.7     0.206  21        neg
## 628          0    132      78      0       0 32.4     0.393  21        neg
## 629          5    128      80      0       0 34.6     0.144  45        neg
## 630          4     94      65     22       0 24.7     0.148  21        neg
## 631          7    114      64      0       0 27.4     0.732  34        pos
## 632          0    102      78     40      90 34.5     0.238  24        neg
## 633          2    111      60      0       0 26.2     0.343  23        neg
## 634          1    128      82     17     183 27.5     0.115  22        neg
## 635         10     92      62      0       0 25.9     0.167  31        neg
## 636         13    104      72      0       0 31.2     0.465  38        pos
## 637          5    104      74      0       0 28.8     0.153  48        neg
## 638          2     94      76     18      66 31.6     0.649  23        neg
## 639          7     97      76     32      91 40.9     0.871  32        pos
## 640          1    100      74     12      46 19.5     0.149  28        neg
## 641          0    102      86     17     105 29.3     0.695  27        neg
## 642          4    128      70      0       0 34.3     0.303  24        neg
## 643          6    147      80      0       0 29.5     0.178  50        pos
## 644          4     90       0      0       0 28.0     0.610  31        neg
## 645          3    103      72     30     152 27.6     0.730  27        neg
## 646          2    157      74     35     440 39.4     0.134  30        neg
## 647          1    167      74     17     144 23.4     0.447  33        pos
## 648          0    179      50     36     159 37.8     0.455  22        pos
## 649         11    136      84     35     130 28.3     0.260  42        pos
## 650          0    107      60     25       0 26.4     0.133  23        neg
## 651          1     91      54     25     100 25.2     0.234  23        neg
## 652          1    117      60     23     106 33.8     0.466  27        neg
## 653          5    123      74     40      77 34.1     0.269  28        neg
## 654          2    120      54      0       0 26.8     0.455  27        neg
## 655          1    106      70     28     135 34.2     0.142  22        neg
## 656          2    155      52     27     540 38.7     0.240  25        pos
## 657          2    101      58     35      90 21.8     0.155  22        neg
## 658          1    120      80     48     200 38.9     1.162  41        neg
## 659         11    127     106      0       0 39.0     0.190  51        neg
## 660          3     80      82     31      70 34.2     1.292  27        pos
## 661         10    162      84      0       0 27.7     0.182  54        neg
## 662          1    199      76     43       0 42.9     1.394  22        pos
## 663          8    167     106     46     231 37.6     0.165  43        pos
## 664          9    145      80     46     130 37.9     0.637  40        pos
## 665          6    115      60     39       0 33.7     0.245  40        pos
## 666          1    112      80     45     132 34.8     0.217  24        neg
## 667          4    145      82     18       0 32.5     0.235  70        pos
## 668         10    111      70     27       0 27.5     0.141  40        pos
## 669          6     98      58     33     190 34.0     0.430  43        neg
## 670          9    154      78     30     100 30.9     0.164  45        neg
## 671          6    165      68     26     168 33.6     0.631  49        neg
## 672          1     99      58     10       0 25.4     0.551  21        neg
## 673         10     68     106     23      49 35.5     0.285  47        neg
## 674          3    123     100     35     240 57.3     0.880  22        neg
## 675          8     91      82      0       0 35.6     0.587  68        neg
## 676          6    195      70      0       0 30.9     0.328  31        pos
## 677          9    156      86      0       0 24.8     0.230  53        pos
```

```
## 678        0     93      60      0      0 35.3   0.263  25     neg
## 679        3    121      52      0      0 36.0   0.127  25     pos
## 680        2    101      58     17    265 24.2   0.614  23     neg
## 681        2     56      56     28     45 24.2   0.332  22     neg
## 682        0    162      76     36      0 49.6   0.364  26     pos
## 683        0     95      64     39    105 44.6   0.366  22     neg
## 684        4    125      80      0      0 32.3   0.536  27     pos
## 685        5    136      82      0      0  0.0   0.640  69     neg
## 686        2    129      74     26    205 33.2   0.591  25     neg
## 687        3    130      64      0      0 23.1   0.314  22     neg
## 688        1    107      50     19      0 28.3   0.181  29     neg
## 689        1    140      74     26    180 24.1   0.828  23     neg
## 690        1    144      82     46    180 46.1   0.335  46     pos
## 691        8    107      80      0      0 24.6   0.856  34     neg
## 692       13    158     114      0      0 42.3   0.257  44     pos
## 693        2    121      70     32     95 39.1   0.886  23     neg
## 694        7    129      68     49    125 38.5   0.439  43     pos
## 695        2     90      60      0      0 23.5   0.191  25     neg
## 696        7    142      90     24    480 30.4   0.128  43     pos
## 697        3    169      74     19    125 29.9   0.268  31     pos
## 698        0     99       0      0      0 25.0   0.253  22     neg
## 699        4    127      88     11    155 34.5   0.598  28     neg
## 700        4    118      70      0      0 44.5   0.904  26     neg
## 701        2    122      76     27    200 35.9   0.483  26     neg
## 702        6    125      78     31      0 27.6   0.565  49     pos
## 703        1    168      88     29      0 35.0   0.905  52     pos
## 704        2    129       0      0      0 38.5   0.304  41     neg
## 705        4    110      76     20    100 28.4   0.118  27     neg
## 706        6     80      80     36      0 39.8   0.177  28     neg
## 707       10    115       0      0      0  0.0   0.261  30     pos
## 708        2    127      46     21    335 34.4   0.176  22     neg
## 709        9    164      78      0      0 32.8   0.148  45     pos
## 710        2     93      64     32    160 38.0   0.674  23     pos
## 711        3    158      64     13    387 31.2   0.295  24     neg
## 712        5    126      78     27     22 29.6   0.439  40     neg
## 713       10    129      62     36      0 41.2   0.441  38     pos
## 714        0    134      58     20    291 26.4   0.352  21     neg
## 715        3    102      74      0      0 29.5   0.121  32     neg
## 716        7    187      50     33    392 33.9   0.826  34     pos
## 717        3    173      78     39    185 33.8   0.970  31     pos
## 718       10     94      72     18      0 23.1   0.595  56     neg
## 719        1    108      60     46    178 35.5   0.415  24     neg
## 720        5     97      76     27      0 35.6   0.378  52     pos
## 721        4     83      86     19      0 29.3   0.317  34     neg
## 722        1    114      66     36    200 38.1   0.289  21     neg
## 723        1    149      68     29    127 29.3   0.349  42     pos
## 724        5    117      86     30    105 39.1   0.251  42     neg
## 725        1    111      94      0      0 32.8   0.265  45     neg
## 726        4    112      78     40      0 39.4   0.236  38     neg
## 727        1    116      78     29    180 36.1   0.496  25     neg
## 728        0    141      84     26      0 32.4   0.433  22     neg
## 729        2    175      88      0      0 22.9   0.326  22     neg
## 730        2     92      52      0      0 30.1   0.141  22     neg
## 731        3    130      78     23     79 28.4   0.323  34     pos
```

```
## 732        8     120       86       0      0 28.4     0.259  22       pos
## 733        2     174       88      37    120 44.5     0.646  24       pos
## 734        2     106       56      27    165 29.0     0.426  22       neg
## 735        2     105       75       0      0 23.3     0.560  53       neg
## 736        4      95       60      32      0 35.4     0.284  28       neg
## 737        0     126       86      27    120 27.4     0.515  21       neg
## 738        8      65       72      23      0 32.0     0.600  42       neg
## 739        2      99       60      17    160 36.6     0.453  21       neg
## 740        1     102       74       0      0 39.5     0.293  42       pos
## 741       11     120       80      37    150 42.3     0.785  48       pos
## 742        3     102       44      20     94 30.8     0.400  26       neg
## 743        1     109       58      18    116 28.5     0.219  22       neg
## 744        9     140       94       0      0 32.7     0.734  45       pos
## 745       13     153       88      37    140 40.6     1.174  39       neg
## 746       12     100       84      33    105 30.0     0.488  46       neg
## 747        1     147       94      41      0 49.3     0.358  27       pos
## 748        1      81       74      41     57 46.3     1.096  32       neg
## 749        3     187       70      22    200 36.4     0.408  36       pos
## 750        6     162       62       0      0 24.3     0.178  50       pos
## 751        4     136       70       0      0 31.2     1.182  22       pos
## 752        1     121       78      39     74 39.0     0.261  28       neg
## 753        3     108       62      24      0 26.0     0.223  25       neg
## 754        0     181       88      44    510 43.3     0.222  26       pos
## 755        8     154       78      32      0 32.4     0.443  45       pos
## 756        1     128       88      39    110 36.5     1.057  37       pos
## 757        7     137       90      41      0 32.0     0.391  39       neg
## 758        0     123       72       0      0 36.3     0.258  52       pos
## 759        1     106       76       0      0 37.5     0.197  26       neg
## 760        6     190       92       0      0 35.5     0.278  66       pos
## 761        2      88       58      26     16 28.4     0.766  22       neg
## 762        9     170       74      31      0 44.0     0.403  43       pos
## 763        9      89       62       0      0 22.5     0.142  33       neg
## 764       10     101       76      48    180 32.9     0.171  63       neg
## 765        2     122       70      27      0 36.8     0.340  27       neg
## 766        5     121       72      23    112 26.2     0.245  30       neg
## 767        1     126       60       0      0 30.1     0.349  47       pos
## 768        1      93       70      31      0 30.4     0.315  23       neg
```

```
str(df)
```

```
## 'data.frame':    768 obs. of  9 variables:
##  $ pregnant: num  6 1 8 1 0 5 3 10 2 8 ...
##  $ glucose : num  148 85 183 89 137 116 78 115 197 125 ...
##  $ pressure: num  72 66 64 66 40 74 50 0 70 96 ...
##  $ triceps : num  35 29 0 23 35 0 32 0 45 0 ...
##  $ insulin : num  0 0 0 94 168 0 88 0 543 0 ...
##  $ mass    : num  33.6 26.6 23.3 28.1 43.1 25.6 31 35.3 30.5 0 ...
##  $ pedigree: num  0.627 0.351 0.672 0.167 2.288 ...
##  $ age     : num  50 31 32 21 33 30 26 29 53 54 ...
##  $ diabetes: Factor w/ 2 levels "neg","pos": 2 1 2 1 2 1 2 1 2 2 ...
```

```
#Summary Statistics
summary(df)
```

```
##     pregnant         glucose         pressure         triceps
##  Min.   : 0.000   Min.   :  0.0   Min.   :  0.00   Min.   : 0.00
```

```
##  1st Qu.: 1.000   1st Qu.: 99.0   1st Qu.: 62.00   1st Qu.: 0.00  
##  Median : 3.000   Median :117.0   Median : 72.00   Median :23.00  
##  Mean   : 3.845   Mean   :120.9   Mean   : 69.11   Mean   :20.54  
##  3rd Qu.: 6.000   3rd Qu.:140.2   3rd Qu.: 80.00   3rd Qu.:32.00  
##  Max.   :17.000   Max.   :199.0   Max.   :122.00   Max.   :99.00  
##     insulin           mass          pedigree           age        diabetes 
##  Min.   :  0.0   Min.   : 0.00   Min.   :0.0780   Min.   :21.00   neg:500  
##  1st Qu.:  0.0   1st Qu.:27.30   1st Qu.:0.2437   1st Qu.:24.00   pos:268  
##  Median : 30.5   Median :32.00   Median :0.3725   Median :29.00            
##  Mean   : 79.8   Mean   :31.99   Mean   :0.4719   Mean   :33.24            
##  3rd Qu.:127.2   3rd Qu.:36.60   3rd Qu.:0.6262   3rd Qu.:41.00            
##  Max.   :846.0   Max.   :67.10   Max.   :2.4200   Max.   :81.00
```

```
#Confirmation of No Near Zero Variance for Predictor Variables
predictors <- PimaIndiansDiabetes[ , -(9)]
print(nearZeroVar(predictors))
```

```
## integer(0)
```

```
#Check for missing values
#Confirmed No Missing Values
sapply(df, function(x) sum(is.na(x)))
```

```
## pregnant  glucose pressure  triceps  insulin     mass pedigree      age 
##        0        0        0        0        0        0        0        0 
## diabetes 
##        0
```

```
#List Zero Markers: 6 out of 9 Variables have zero markers for Predictor Variables
list( Column = colSums(df==0),
      Row = sum(rowSums(df==0)))
```

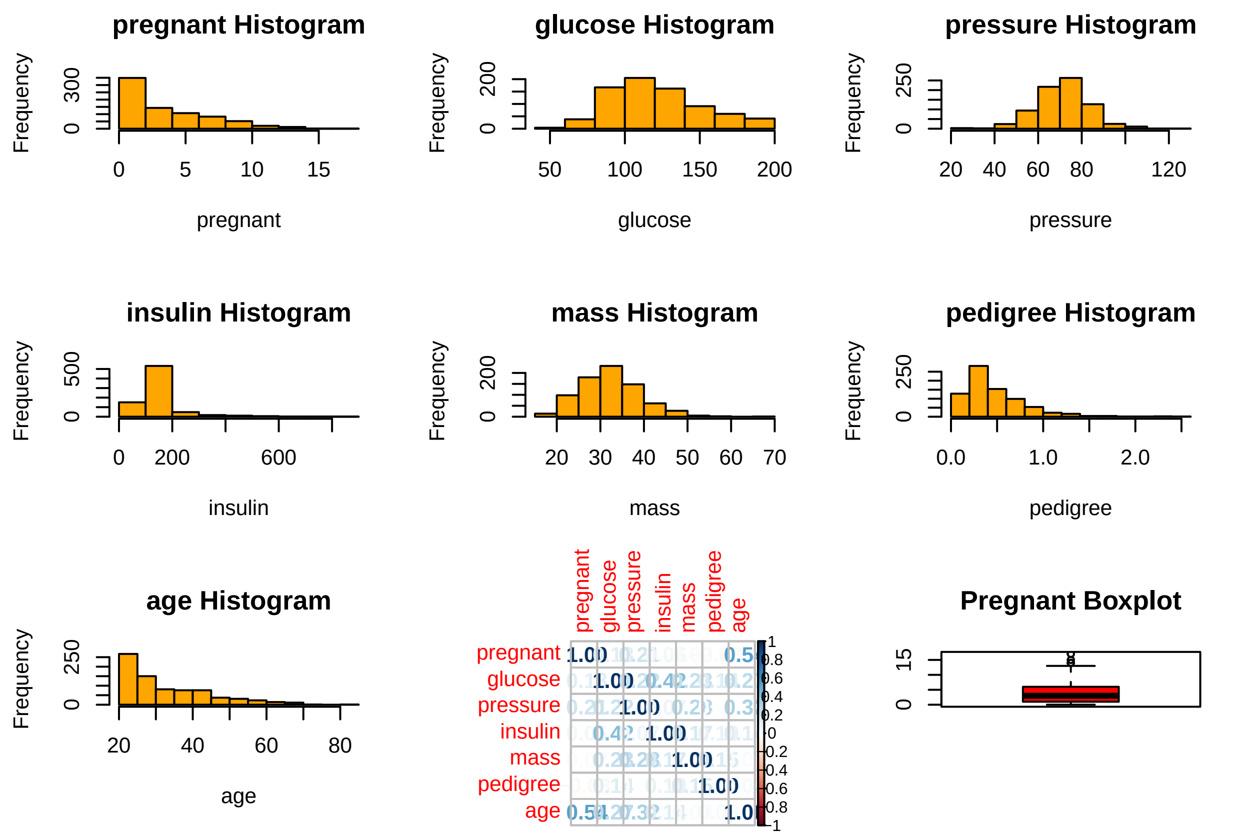
```
## $Column
## pregnant  glucose pressure  triceps  insulin     mass pedigree      age 
##      111        5       35      227      374       11        0        0 
## diabetes 
##        0 
## 
## $Row
## [1] 763
```

```
#Logic Behind 6 Zero Markers
#pregnant- not all woman have a baby, likely 0 is a true value, will keep predictor variable
#glucose- only 5 values are missing, will keep predictor variable, will use numerical mean
#pressure- only 35 values are missing, will keep predictor variable, will use numerical mean
#triceps- approximately 30% of the data contains 0 values, will keep predictor variable, will use numer
#insulin- almost 50% of the data has 0 values, will keep predictor variable, will use numerical mean
#mass- only 11 values are missing, will keep predictor variable

#Predictor Variables After Review of Summary Statistics and Zero Markers
#1.pregnant
#2.glucose
#3.pressure
#4.mass
#5.pedigree
#6.age
#7.triceps
```

```r
#8.insulin

#Outcome Variable
#1.diabetes

#Replace All Zeros
df[df == 0] <- NA

#Return Pregnant NA back to 0(zer0)
df$pregnant[is.na(df$pregnant)] <- 0
#df

#Replace NA Values with Mean from respective columns: glucose, pressure, mass, insulin & triceps
df$glucose[is.na(df$glucose)]<-mean(df$glucose,na.rm=TRUE) #glucose
df$pressure[is.na(df$pressure)]<-mean(df$pressure,na.rm=TRUE) #pressure
df$mass[is.na(df$mass)]<-mean(df$mass,na.rm=TRUE) #mass
df$insulin[is.na(df$insulin)]<-mean(df$insulin,na.rm=TRUE) #insulin
df$triceps[is.na(df$triceps)]<-mean(df$triceps,na.rm=TRUE) #triceps
df <- df[,-4]
#df


#Updated Summary Statistics After replacing NA Values with Mean from respective columns: glucose, press
summary(df)
```

```
##     pregnant         glucose          pressure          insulin
##  Min.   : 0.000   Min.   : 44.00   Min.   : 24.00   Min.   : 14.0
##  1st Qu.: 1.000   1st Qu.: 99.75   1st Qu.: 64.00   1st Qu.:121.5
##  Median : 3.000   Median :117.00   Median : 72.20   Median :155.5
##  Mean   : 3.845   Mean   :121.69   Mean   : 72.41   Mean   :155.5
##  3rd Qu.: 6.000   3rd Qu.:140.25   3rd Qu.: 80.00   3rd Qu.:155.5
##  Max.   :17.000   Max.   :199.00   Max.   :122.00   Max.   :846.0
##       mass          pedigree           age         diabetes
##  Min.   :18.20   Min.   :0.0780   Min.   :21.00   neg:500
##  1st Qu.:27.50   1st Qu.:0.2437   1st Qu.:24.00   pos:268
##  Median :32.40   Median :0.3725   Median :29.00
##  Mean   :32.46   Mean   :0.4719   Mean   :33.24
##  3rd Qu.:36.60   3rd Qu.:0.6262   3rd Qu.:41.00
##  Max.   :67.10   Max.   :2.4200   Max.   :81.00
```

```r
#Histograms of Diabetes: Predictor Variables
n <-df[,1:(ncol(df)-1)] #Predictors are variables 1-8
par(mfrow = c(3,3)) #Histograms will be 3x3
for (i in 1:ncol(n))
{hist(n[ ,i], xlab = names(n[i]), main = paste(names(n[i]), "Histogram"), col="orange")
}

#Correlation Plot of Diabetes: Predictor Variables
x <- cor(df[1:ncol(df)-1])
corrplot(x, method="number")

#Box Plots of Diabetes: Predictor Variables
boxplot(df$pregnant, main = "Pregnant Boxplot", col = "red")
```




```r
boxplot(df$glucose, main = "Glucose Boxplot", col = "red")
boxplot(df$pressure, main = "Pressure Boxplot", col = "red")
#boxplot(df$triceps, main = "Triceps Boxplot", col = "red")
boxplot(df$insulin, main = "Insulin Boxplot", col = "red")
boxplot(df$mass, main = "Mass Boxplot", col = "red")
boxplot(df$pedigree, main = "Pedigree Boxplot", col = "red")
boxplot(df$age, main = "Age Boxplot", col = "red")


#Split Training and Test Data, 80/20
set.seed(100)
split <- caret::createDataPartition(y = df$diabetes, times = 1, p = 0.8, list = FALSE)

#Train_data Split, 80%
train_data <- df[split,]

#Test_data Split, 20%
test_data <- df[-split,]

#Summary Statistics
summary(train_data)
```

```
##     pregnant         glucose         pressure         insulin
##  Min.   : 0.000   Min.   : 56.0   Min.   : 24.00   Min.   : 15.0
##  1st Qu.: 1.000   1st Qu.: 99.0   1st Qu.: 64.00   1st Qu.:125.0
##  Median : 3.000   Median :117.0   Median : 72.41   Median :155.5
```

```
##  Mean   : 3.881   Mean   :121.9   Mean   : 72.62   Mean   :155.1
##  3rd Qu.: 6.000   3rd Qu.:140.0   3rd Qu.: 80.00   3rd Qu.:155.5
##  Max.   :17.000   Max.   :199.0   Max.   :122.00   Max.   :846.0
##       mass          pedigree            age          diabetes
##  Min.   :18.2   Min.   :0.0780   Min.   :21.00   neg:400
##  1st Qu.:27.6   1st Qu.:0.2370   1st Qu.:24.00   pos:215
##  Median :32.4   Median :0.3640   Median :29.00
##  Mean   :32.6   Mean   :0.4647   Mean   :33.41
##  3rd Qu.:36.8   3rd Qu.:0.6110   3rd Qu.:41.00
##  Max.   :67.1   Max.   :2.2880   Max.   :81.00
```

```
#################Training Models########################
#Logistic Regression: Training Model
#No Tuning Parameters for Simple Logistic Regression
lr_train_data <- caret::train(diabetes ~., data = train_data,
                          method = "glm",
                          metric = "ROC",
                          tuneLength = 10,
                          trControl = trainControl(method = "cv", number = 10,
                                            classProbs = T, summaryFunction = twoClassSummary),
                          preProcess = c("center","scale"))

lr_train_data
```

```
## Generalized Linear Model
##
## 615 samples
##   7 predictor
##   2 classes: 'neg', 'pos'
##
## Pre-processing: centered (7), scaled (7)
## Resampling: Cross-Validated (10 fold)
## Summary of sample sizes: 553, 553, 554, 553, 554, 554, ...
## Resampling results:
##
##   ROC        Sens   Spec
##   0.8446807  0.885  0.5900433
```

```
summary(lr_train_data)
```

```
##
## Call:
## NULL
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -2.6733  -0.7046  -0.3818   0.6726   2.4367
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept) -0.86976    0.11010  -7.900  2.8e-15 ***
## pregnant     0.43851    0.12451   3.522 0.000428 ***
## glucose      1.16594    0.13312   8.758  < 2e-16 ***
## pressure    -0.10367    0.11925  -0.869 0.384630
## insulin     -0.01707    0.11357  -0.150 0.880496
```

```
## mass         0.68502    0.12187   5.621  1.9e-08 ***
## pedigree     0.34252    0.10753   3.185 0.001445 **
## age          0.13217    0.12639   1.046 0.295677
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 796.05  on 614  degrees of freedom
## Residual deviance: 556.89  on 607  degrees of freedom
## AIC: 572.89
##
## Number of Fisher Scoring iterations: 5
```

```
#Random Forest: Training Model
rf_train_data <- caret::train(diabetes ~., data = train_data,
                             method = "ranger",
                             metric = "ROC",
                             trControl = trainControl(method = "cv", number = 10,
                                                      classProbs = T, summaryFunction = twoClassSummary)
                             preProcess = c("center","scale"))
rf_train_data
```

```
## Random Forest
##
## 615 samples
##   7 predictor
##   2 classes: 'neg', 'pos'
##
## Pre-processing: centered (7), scaled (7)
## Resampling: Cross-Validated (10 fold)
## Summary of sample sizes: 554, 553, 554, 553, 553, 553, ...
## Resampling results across tuning parameters:
##
##   mtry  splitrule   ROC        Sens    Spec
##   2     gini        0.8345509  0.8525  0.6183983
##   2     extratrees  0.8445536  0.8800  0.5911255
##   4     gini        0.8339935  0.8550  0.6515152
##   4     extratrees  0.8420049  0.8700  0.6279221
##   7     gini        0.8291288  0.8500  0.6651515
##   7     extratrees  0.8415368  0.8600  0.6324675
##
## Tuning parameter 'min.node.size' was held constant at a value of 1
## ROC was used to select the optimal model using the largest value.
## The final values used for the model were mtry = 2, splitrule = extratrees
##  and min.node.size = 1.
```

```
plot(rf_train_data)

FinalTree = rf_train_data$finalModel$importance.mode


#K Nearest Neighbor: Training Model
knn_train_data <- caret::train(diabetes ~., data = train_data,
                          method = "knn",
```

```r
                          metric = "ROC",
                          tuneGrid = expand.grid(.k = c(3:10)),
                          trControl = trainControl(method = "cv", number = 10,
                                                   classProbs = T, summaryFunction = twoClassSummary),
                          preProcess = c("center","scale"))

knn_train_data
```

```
## k-Nearest Neighbors
##
## 615 samples
##   7 predictor
##   2 classes: 'neg', 'pos'
##
## Pre-processing: centered (7), scaled (7)
## Resampling: Cross-Validated (10 fold)
## Summary of sample sizes: 554, 554, 554, 553, 553, 554, ...
## Resampling results across tuning parameters:
##
##   k   ROC        Sens    Spec
##    3  0.7554437  0.7975  0.5679654
##    4  0.7794183  0.8275  0.5722944
##    5  0.7857495  0.8350  0.5816017
##    6  0.8004518  0.8325  0.5543290
##    7  0.8020292  0.8275  0.5913420
##    8  0.8062716  0.8425  0.5956710
##    9  0.8168236  0.8400  0.6145022
##   10  0.8220996  0.8625  0.5731602
##
## ROC was used to select the optimal model using the largest value.
## The final value used for the model was k = 10.
```

```r
plot(knn_train_data)


#Classification and Regression Trees (CART): Training Model
cart_train_data <- caret::train(diabetes ~., data = train_data,
                           method = "rpart",
                           metric = "ROC",
                           tuneLength = 20,
                           trControl = trainControl(method = "cv", number = 10,
                                                    classProbs = TRUE, summaryFunction = twoClassSumma
                           preProcess = c("center","scale", "pca"))

cart_train_data
```

```
## CART
##
## 615 samples
##   7 predictor
##   2 classes: 'neg', 'pos'
##
## Pre-processing: centered (7), scaled (7), principal component signal
##  extraction (7)
## Resampling: Cross-Validated (10 fold)
```

```
## Summary of sample sizes: 554, 554, 553, 554, 553, 553, ...
## Resampling results across tuning parameters:
##
##   cp          ROC        Sens    Spec
##   0.00000000  0.7626028  0.7950  0.56774892
##   0.01223990  0.7785092  0.8200  0.57662338
##   0.02447980  0.7706034  0.8225  0.60043290
##   0.03671971  0.7689935  0.8325  0.55865801
##   0.04895961  0.7709253  0.8350  0.55865801
##   0.06119951  0.7712825  0.8375  0.55389610
##   0.07343941  0.7697944  0.8100  0.59675325
##   0.08567931  0.7697944  0.8100  0.59675325
##   0.09791922  0.7604924  0.7825  0.60670996
##   0.11015912  0.7585606  0.7625  0.65670996
##   0.12239902  0.7556629  0.7450  0.67943723
##   0.13463892  0.7502462  0.7175  0.71277056
##   0.14687882  0.7429167  0.6750  0.76731602
##   0.15911873  0.7432738  0.6600  0.80541126
##   0.17135863  0.7071374  0.6725  0.74177489
##   0.18359853  0.6580465  0.7425  0.57359307
##   0.19583843  0.6341829  0.7675  0.50086580
##   0.20807834  0.6114448  0.8125  0.41038961
##   0.22031824  0.5216071  0.9575  0.08571429
##   0.23255814  0.5000000  1.0000  0.00000000
##
## ROC was used to select the optimal model using the largest value.
## The final value used for the model was cp = 0.0122399.
```

```
FinalTree = cart_train_data$finalModel

rpartTree = as.party(FinalTree)
dev.new()
plot(rpartTree)

#Neural Net
registerDoParallel(cores=7)
nnetGrid <- expand.grid(.decay = c(0, 0.01, 0.1),
                        .size = c(1:10),
                        .bag = FALSE
)
nnet_train_data <- caret::train(diabetes ~., data = train_data,
                                method = "avNNet",
                                tuneGrid = nnetGrid,
                                metric = "ROC",
                                trControl = trainControl(method = "cv", number = 10,
                                                         classProbs = TRUE, summaryFunction = twoClassSu
                                preProcess = c("center","scale"),
                                linout = TRUE,
                                trace = FALSE,
                                MaxNWts = 10 * (ncol(train_data) + 1) + 10 + 1,
                                maxit = 500)
```

```
## Warning in nominalTrainWorkflow(x = x, y = y, wts = weights, info = trainInfo, :
## There were missing values in resampled performance measures.
```

```
## Warning in train.default(x, y, weights = w, ...): missing values found in
## aggregated results
```

```r
nnet_train_data
```

```
## Model Averaged Neural Network
##
## 615 samples
##   7 predictor
##   2 classes: 'neg', 'pos'
##
## Pre-processing: centered (7), scaled (7)
## Resampling: Cross-Validated (10 fold)
## Summary of sample sizes: 554, 554, 553, 554, 553, 554, ...
## Resampling results across tuning parameters:
##
##   decay  size  ROC        Sens    Spec
##   0.00    1    0.8476569  0.8600  0.6229437
##   0.00    2    0.8470076  0.8500  0.6043290
##   0.00    3    0.8393723  0.8525  0.6225108
##   0.00    4    0.8307576  0.8450  0.6034632
##   0.00    5    0.8203409  0.8550  0.5714286
##   0.00    6    0.8144102  0.8325  0.5857143
##   0.00    7    0.8255087  0.8575  0.5995671
##   0.00    8    0.8115747  0.8425  0.6093074
##   0.00    9    0.8081872  0.8225  0.6127706
##   0.00   10          NaN     NaN        NaN
##   0.01    1    0.8476569  0.8625  0.6231602
##   0.01    2    0.8501948  0.8525  0.6367965
##   0.01    3    0.8438745  0.8600  0.6088745
##   0.01    4    0.8347673  0.8675  0.5904762
##   0.01    5    0.8371861  0.8625  0.6041126
##   0.01    6    0.8318452  0.8250  0.6136364
##   0.01    7    0.8316234  0.8500  0.5904762
##   0.01    8    0.8236364  0.8450  0.5906926
##   0.01    9    0.8211201  0.8475  0.5902597
##   0.01   10          NaN     NaN        NaN
##   0.10    1    0.8478896  0.8625  0.6231602
##   0.10    2    0.8518994  0.8650  0.5861472
##   0.10    3    0.8530790  0.8700  0.5906926
##   0.10    4    0.8437771  0.8525  0.5941558
##   0.10    5    0.8357522  0.8500  0.5857143
##   0.10    6    0.8319210  0.8475  0.5954545
##   0.10    7    0.8302814  0.8425  0.5580087
##   0.10    8    0.8321212  0.8500  0.5854978
##   0.10    9    0.8249188  0.8375  0.5807359
##   0.10   10          NaN     NaN        NaN
##
## Tuning parameter 'bag' was held constant at a value of FALSE
## ROC was used to select the optimal model using the largest value.
## The final values used for the model were size = 3, decay = 0.1 and bag = FALSE.
```

```r
plot(nnet_train_data)
```

```r
################# Support Vector Machines ####################

svmFit <- train(diabetes ~., data = train_data,
                method = "svmRadial",
                metric = "ROC",
                tuneLength = 14,
                preProcess = c("center","scale"),
                trControl = trainControl(method = "cv", number = 10,
                                         classProbs = TRUE, summaryFunction = twoClassSummary))
svmFit
```

```
## Support Vector Machines with Radial Basis Function Kernel
##
## 615 samples
##   7 predictor
##   2 classes: 'neg', 'pos'
##
## Pre-processing: centered (7), scaled (7)
## Resampling: Cross-Validated (10 fold)
## Summary of sample sizes: 554, 553, 554, 553, 553, 553, ...
## Resampling results across tuning parameters:
##
##   C        ROC        Sens    Spec
##      0.25  0.8425271  0.8800  0.6088745
##      0.50  0.8415043  0.8850  0.5900433
##      1.00  0.8384199  0.8875  0.5621212
##      2.00  0.8345184  0.8950  0.5149351
##      4.00  0.8201245  0.8850  0.5432900
##      8.00  0.8038366  0.8850  0.5012987
##     16.00  0.7779221  0.8750  0.4922078
##     32.00  0.7582684  0.8800  0.4411255
##     64.00  0.7406872  0.8775  0.3768398
##    128.00  0.7341721  0.8975  0.3536797
##    256.00  0.7264989  0.9000  0.3112554
##    512.00  0.7167803  0.9100  0.2839827
##   1024.00  0.7156061  0.9175  0.2707792
##   2048.00  0.7101732  0.8975  0.2935065
##
## Tuning parameter 'sigma' was held constant at a value of 0.1441702
## ROC was used to select the optimal model using the largest value.
## The final values used for the model were sigma = 0.1441702 and C = 0.25.
```

```r
plot(svmFit)

################# Boosted ####################

gbmGrid <- expand.grid(.interaction.depth = seq(1, 7, by = 2),
                       .n.trees = seq(100, 1000, by = 50),
                       .shrinkage = c(0.01, 0.1),
                       .n.minobsinnode = 10)

gbmFit <- train(diabetes ~., data = train_data,
                method = "gbm",
                tuneGrid = gbmGrid,
```

```r
                 preProcess = c("center","scale"),
                 verbose = FALSE,
                 trControl = trainControl(method = "cv", number = 10,
                                          classProbs = TRUE, summaryFunction = twoClassSummary))
```

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

```r
gbmFit
```

```
## Stochastic Gradient Boosting
##
## 615 samples
##   7 predictor
##   2 classes: 'neg', 'pos'
##
## Pre-processing: centered (7), scaled (7)
## Resampling: Cross-Validated (10 fold)
## Summary of sample sizes: 553, 553, 553, 554, 554, 554, ...
## Resampling results across tuning parameters:
##
##   shrinkage  interaction.depth  n.trees  ROC        Sens    Spec
##   0.01       1                   100     0.8122078  0.9425  0.3722944
##   0.01       1                   150     0.8209578  0.9300  0.4190476
##   0.01       1                   200     0.8273295  0.9175  0.4653680
##   0.01       1                   250     0.8333144  0.9075  0.5110390
##   0.01       1                   300     0.8362013  0.8975  0.5294372
##   0.01       1                   350     0.8386742  0.8950  0.5339827
##   0.01       1                   400     0.8420563  0.8900  0.5387446
##   0.01       1                   450     0.8427922  0.8900  0.5389610
##   0.01       1                   500     0.8457197  0.8850  0.5296537
##   0.01       1                   550     0.8472457  0.8850  0.5482684
##   0.01       1                   600     0.8483117  0.8850  0.5577922
##   0.01       1                   650     0.8484253  0.8850  0.5577922
##   0.01       1                   700     0.8480519  0.8850  0.5718615
##   0.01       1                   750     0.8480574  0.8800  0.5766234
##   0.01       1                   800     0.8482089  0.8825  0.5766234
##   0.01       1                   850     0.8485552  0.8800  0.5813853
##   0.01       1                   900     0.8477435  0.8775  0.5859307
##   0.01       1                   950     0.8480952  0.8725  0.5859307
##   0.01       1                  1000     0.8478896  0.8725  0.5952381
##   0.01       3                   100     0.8378842  0.9200  0.4829004
##   0.01       3                   150     0.8409037  0.8975  0.5158009
##   0.01       3                   200     0.8405952  0.8875  0.5435065
##   0.01       3                   250     0.8439610  0.8800  0.5482684
##   0.01       3                   300     0.8438799  0.8775  0.5668831
##   0.01       3                   350     0.8439340  0.8700  0.5809524
##   0.01       3                   400     0.8446861  0.8700  0.5857143
##   0.01       3                   450     0.8445617  0.8700  0.5904762
##   0.01       3                   500     0.8436742  0.8675  0.6041126
##   0.01       3                   550     0.8437716  0.8700  0.6088745
##   0.01       3                   600     0.8432197  0.8675  0.6181818
##   0.01       3                   650     0.8403571  0.8700  0.6181818
##   0.01       3                   700     0.8362987  0.8700  0.6136364
```

```
##   0.01        3                  750      0.8352597  0.8675  0.6134199
##   0.01        3                  800      0.8352489  0.8650  0.6136364
##   0.01        3                  850      0.8340801  0.8675  0.6365801
##   0.01        3                  900      0.8343074  0.8650  0.6181818
##   0.01        3                  950      0.8343182  0.8625  0.6227273
##   0.01        3                 1000      0.8337229  0.8575  0.6318182
##   0.01        5                  100      0.8459361  0.9075  0.5017316
##   0.01        5                  150      0.8475379  0.8875  0.5389610
##   0.01        5                  200      0.8483983  0.8850  0.5666667
##   0.01        5                  250      0.8490422  0.8825  0.5852814
##   0.01        5                  300      0.8470942  0.8775  0.5945887
##   0.01        5                  350      0.8432684  0.8750  0.5948052
##   0.01        5                  400      0.8417641  0.8675  0.6088745
##   0.01        5                  450      0.8413041  0.8650  0.6134199
##   0.01        5                  500      0.8387229  0.8650  0.6086580
##   0.01        5                  550      0.8364286  0.8700  0.6179654
##   0.01        5                  600      0.8366667  0.8625  0.6086580
##   0.01        5                  650      0.8354870  0.8625  0.6274892
##   0.01        5                  700      0.8341126  0.8500  0.6322511
##   0.01        5                  750      0.8329491  0.8500  0.6274892
##   0.01        5                  800      0.8312121  0.8525  0.6274892
##   0.01        5                  850      0.8310931  0.8500  0.6320346
##   0.01        5                  900      0.8299459  0.8475  0.6415584
##   0.01        5                  950      0.8287771  0.8450  0.6367965
##   0.01        5                 1000      0.8276245  0.8425  0.6277056
##   0.01        7                  100      0.8457684  0.9050  0.5158009
##   0.01        7                  150      0.8460606  0.8825  0.5666667
##   0.01        7                  200      0.8470022  0.8750  0.5991342
##   0.01        7                  250      0.8462229  0.8750  0.6138528
##   0.01        7                  300      0.8455574  0.8700  0.6183983
##   0.01        7                  350      0.8423160  0.8725  0.6231602
##   0.01        7                  400      0.8402597  0.8675  0.6326840
##   0.01        7                  450      0.8395671  0.8625  0.6233766
##   0.01        7                  500      0.8373918  0.8650  0.6231602
##   0.01        7                  550      0.8358658  0.8625  0.6279221
##   0.01        7                  600      0.8337662  0.8575  0.6279221
##   0.01        7                  650      0.8324188  0.8525  0.6233766
##   0.01        7                  700      0.8317262  0.8525  0.6233766
##   0.01        7                  750      0.8317208  0.8525  0.6140693
##   0.01        7                  800      0.8302327  0.8425  0.6140693
##   0.01        7                  850      0.8292478  0.8425  0.6183983
##   0.01        7                  900      0.8277273  0.8400  0.6138528
##   0.01        7                  950      0.8264448  0.8400  0.6140693
##   0.01        7                 1000      0.8256223  0.8375  0.6090909
##   0.10        1                  100      0.8444210  0.8650  0.5958874
##   0.10        1                  150      0.8391396  0.8600  0.6277056
##   0.10        1                  200      0.8363961  0.8600  0.6090909
##   0.10        1                  250      0.8355465  0.8475  0.6093074
##   0.10        1                  300      0.8349188  0.8600  0.5904762
##   0.10        1                  350      0.8332143  0.8600  0.6051948
##   0.10        1                  400      0.8292749  0.8550  0.6093074
##   0.10        1                  450      0.8287554  0.8475  0.6283550
##   0.10        1                  500      0.8285498  0.8450  0.5911255
##   0.10        1                  550      0.8251461  0.8400  0.6006494
```

```
##   0.10        1                  600      0.8237771  0.8475  0.6006494
##   0.10        1                  650      0.8205465  0.8450  0.6054113
##   0.10        1                  700      0.8231223  0.8425  0.6149351
##   0.10        1                  750      0.8216180  0.8400  0.6054113
##   0.10        1                  800      0.8220671  0.8375  0.6196970
##   0.10        1                  850      0.8217911  0.8400  0.5917749
##   0.10        1                  900      0.8197835  0.8400  0.5870130
##   0.10        1                  950      0.8207955  0.8425  0.5961039
##   0.10        1                 1000      0.8178571  0.8425  0.6054113
##   0.10        3                  100      0.8354600  0.8550  0.6231602
##   0.10        3                  150      0.8274297  0.8450  0.6090909
##   0.10        3                  200      0.8184253  0.8400  0.5948052
##   0.10        3                  250      0.8130032  0.8300  0.6000000
##   0.10        3                  300      0.8111201  0.8400  0.5906926
##   0.10        3                  350      0.8090152  0.8300  0.6002165
##   0.10        3                  400      0.8059091  0.8375  0.5954545
##   0.10        3                  450      0.8001840  0.8250  0.5948052
##   0.10        3                  500      0.7996320  0.8225  0.5950216
##   0.10        3                  550      0.8006764  0.8225  0.5857143
##   0.10        3                  600      0.7979221  0.8200  0.5995671
##   0.10        3                  650      0.7941504  0.8225  0.5900433
##   0.10        3                  700      0.7941558  0.8150  0.5989177
##   0.10        3                  750      0.7937554  0.8050  0.6086580
##   0.10        3                  800      0.7897565  0.8075  0.6086580
##   0.10        3                  850      0.7909957  0.8100  0.6043290
##   0.10        3                  900      0.7891234  0.8100  0.6045455
##   0.10        3                  950      0.7886959  0.8025  0.6088745
##   0.10        3                 1000      0.7902976  0.8025  0.6138528
##   0.10        5                  100      0.8233496  0.8350  0.6419913
##   0.10        5                  150      0.8148701  0.8400  0.6329004
##   0.10        5                  200      0.8105628  0.8350  0.6093074
##   0.10        5                  250      0.8093344  0.8350  0.6240260
##   0.10        5                  300      0.8061580  0.8275  0.6004329
##   0.10        5                  350      0.8074188  0.8350  0.6051948
##   0.10        5                  400      0.8020887  0.8275  0.5958874
##   0.10        5                  450      0.7997781  0.8250  0.5909091
##   0.10        5                  500      0.8000541  0.8175  0.6002165
##   0.10        5                  550      0.8015801  0.8200  0.5956710
##   0.10        5                  600      0.7981872  0.8125  0.5906926
##   0.10        5                  650      0.7943615  0.8175  0.5865801
##   0.10        5                  700      0.7963799  0.8100  0.6000000
##   0.10        5                  750      0.7990747  0.8100  0.5909091
##   0.10        5                  800      0.7976353  0.8150  0.5952381
##   0.10        5                  850      0.7966126  0.8025  0.5954545
##   0.10        5                  900      0.7960065  0.8025  0.5956710
##   0.10        5                  950      0.7942478  0.8025  0.5956710
##   0.10        5                 1000      0.7940693  0.8000  0.5956710
##   0.10        7                  100      0.8148377  0.8275  0.6188312
##   0.10        7                  150      0.8056169  0.8200  0.5997835
##   0.10        7                  200      0.7975379  0.8125  0.5941558
##   0.10        7                  250      0.7982900  0.8075  0.6090909
##   0.10        7                  300      0.8018561  0.8150  0.5950216
##   0.10        7                  350      0.7985335  0.8050  0.6136364
##   0.10        7                  400      0.7969697  0.8100  0.6132035
```

```
##   0.10       7                    450     0.7948701  0.8025  0.6043290
##   0.10       7                    500     0.7956926  0.8025  0.6181818
##   0.10       7                    550     0.7964123  0.8050  0.6134199
##   0.10       7                    600     0.7932143  0.8000  0.6179654
##   0.10       7                    650     0.7961526  0.8075  0.5945887
##   0.10       7                    700     0.7954762  0.8100  0.6086580
##   0.10       7                    750     0.7951569  0.7975  0.5995671
##   0.10       7                    800     0.7946916  0.8025  0.6090909
##   0.10       7                    850     0.7911797  0.8050  0.5950216
##   0.10       7                    900     0.7905844  0.8025  0.5948052
##   0.10       7                    950     0.7931494  0.7975  0.6038961
##   0.10       7                   1000     0.7927165  0.8000  0.6038961
##
## Tuning parameter 'n.minobsinnode' was held constant at a value of 10
## ROC was used to select the optimal model using the largest value.
## The final values used for the model were n.trees = 250, interaction.depth =
##  5, shrinkage = 0.01 and n.minobsinnode = 10.
```

```r
################# Elastinet #####################
glmnGrid <- expand.grid(.alpha = c(0, .1, .2, .4, .6, .8, 1),
                        .lambda = seq(.01, .2, length = 40))

glmnFit <- train(diabetes ~., data = train_data,
                method = "glmnet",
                tuneGrid = glmnGrid,
                preProcess = c("center","scale"),
                metric = "ROC",
                trControl = trainControl(method = "cv", number = 10,
                                         classProbs = TRUE, summaryFunction = twoClassSummary))


glmnFit
```

```
## glmnet
##
## 615 samples
##   7 predictor
##   2 classes: 'neg', 'pos'
##
## Pre-processing: centered (7), scaled (7)
## Resampling: Cross-Validated (10 fold)
## Summary of sample sizes: 553, 554, 554, 554, 553, 553, ...
## Resampling results across tuning parameters:
##
##   alpha  lambda      ROC        Sens    Spec
##   0.0    0.01000000  0.8499351  0.8925  0.558008658
##   0.0    0.01487179  0.8499351  0.8925  0.558008658
##   0.0    0.01974359  0.8499351  0.8925  0.558008658
##   0.0    0.02461538  0.8498214  0.8925  0.558008658
##   0.0    0.02948718  0.8498160  0.8950  0.548701299
##   0.0    0.03435897  0.8496753  0.8950  0.548701299
##   0.0    0.03923077  0.8501569  0.8950  0.553463203
##   0.0    0.04410256  0.8501515  0.8975  0.553463203
##   0.0    0.04897436  0.8503842  0.8975  0.548917749
##   0.0    0.05384615  0.8505249  0.8975  0.548917749
```

```
##    0.0    0.05871795  0.8499459  0.9025  0.539393939
##    0.0    0.06358974  0.8505357  0.9025  0.539393939
##    0.0    0.06846154  0.8502922  0.9025  0.539393939
##    0.0    0.07333333  0.8500703  0.9050  0.539393939
##    0.0    0.07820513  0.8504275  0.9050  0.539393939
##    0.0    0.08307692  0.8503030  0.9075  0.539393939
##    0.0    0.08794872  0.8500541  0.9100  0.539393939
##    0.0    0.09282051  0.8498268  0.9100  0.534848485
##    0.0    0.09769231  0.8497132  0.9100  0.530303030
##    0.0    0.10256410  0.8497132  0.9125  0.525541126
##    0.0    0.10743590  0.8497186  0.9125  0.516450216
##    0.0    0.11230769  0.8491342  0.9125  0.516450216
##    0.0    0.11717949  0.8487879  0.9125  0.516450216
##    0.0    0.12205128  0.8480952  0.9125  0.511904762
##    0.0    0.12692308  0.8480898  0.9125  0.511904762
##    0.0    0.13179487  0.8483225  0.9125  0.511904762
##    0.0    0.13666667  0.8483225  0.9150  0.511904762
##    0.0    0.14153846  0.8485606  0.9150  0.507142857
##    0.0    0.14641026  0.8485660  0.9200  0.493073593
##    0.0    0.15128205  0.8484470  0.9200  0.493073593
##    0.0    0.15615385  0.8484470  0.9225  0.493073593
##    0.0    0.16102564  0.8486742  0.9225  0.493073593
##    0.0    0.16589744  0.8482035  0.9225  0.493073593
##    0.0    0.17076923  0.8483171  0.9225  0.488528139
##    0.0    0.17564103  0.8480790  0.9300  0.488528139
##    0.0    0.18051282  0.8475054  0.9300  0.488528139
##    0.0    0.18538462  0.8475054  0.9300  0.483982684
##    0.0    0.19025641  0.8476245  0.9300  0.479220779
##    0.0    0.19512821  0.8473972  0.9300  0.474458874
##    0.0    0.20000000  0.8469426  0.9300  0.474458874
##    0.1    0.01000000  0.8497998  0.8850  0.571645022
##    0.1    0.01487179  0.8497998  0.8900  0.562554113
##    0.1    0.01974359  0.8494589  0.8900  0.562554113
##    0.1    0.02461538  0.8496807  0.8900  0.562554113
##    0.1    0.02948718  0.8502706  0.8925  0.553246753
##    0.1    0.03435897  0.8506223  0.8950  0.543939394
##    0.1    0.03923077  0.8502760  0.9025  0.539177489
##    0.1    0.04410256  0.8506169  0.9025  0.539177489
##    0.1    0.04897436  0.8507359  0.9075  0.539177489
##    0.1    0.05384615  0.8505032  0.9075  0.539177489
##    0.1    0.05871795  0.8506277  0.9075  0.530086580
##    0.1    0.06358974  0.8509740  0.9100  0.530086580
##    0.1    0.06846154  0.8509740  0.9125  0.530086580
##    0.1    0.07333333  0.8508550  0.9125  0.534848485
##    0.1    0.07820513  0.8509740  0.9125  0.530086580
##    0.1    0.08307692  0.8514502  0.9150  0.525541126
##    0.1    0.08794872  0.8516829  0.9150  0.520995671
##    0.1    0.09282051  0.8508658  0.9150  0.520995671
##    0.1    0.09769231  0.8503950  0.9150  0.520995671
##    0.1    0.10256410  0.8500541  0.9150  0.520995671
##    0.1    0.10743590  0.8502868  0.9150  0.520995671
##    0.1    0.11230769  0.8504113  0.9200  0.520995671
##    0.1    0.11717949  0.8500595  0.9200  0.516450216
##    0.1    0.12205128  0.8499405  0.9200  0.516450216
```

```
##    0.1    0.12692308  0.8499405  0.9200  0.511904762
##    0.1    0.13179487  0.8498268  0.9200  0.507359307
##    0.1    0.13666667  0.8495996  0.9200  0.507359307
##    0.1    0.14153846  0.8496050  0.9200  0.493506494
##    0.1    0.14641026  0.8490260  0.9200  0.493506494
##    0.1    0.15128205  0.8492641  0.9250  0.493506494
##    0.1    0.15615385  0.8493723  0.9250  0.493506494
##    0.1    0.16102564  0.8493723  0.9250  0.493506494
##    0.1    0.16589744  0.8493777  0.9250  0.488961039
##    0.1    0.17076923  0.8493723  0.9300  0.484199134
##    0.1    0.17564103  0.8491450  0.9300  0.474675325
##    0.1    0.18051282  0.8489123  0.9300  0.469913420
##    0.1    0.18538462  0.8487933  0.9300  0.469913420
##    0.1    0.19025641  0.8487987  0.9300  0.465151515
##    0.1    0.19512821  0.8485660  0.9300  0.460389610
##    0.1    0.20000000  0.8483279  0.9300  0.446320346
##    0.2    0.01000000  0.8496699  0.8875  0.571645022
##    0.2    0.01487179  0.8505032  0.8900  0.567099567
##    0.2    0.01974359  0.8503896  0.8900  0.562554113
##    0.2    0.02461538  0.8502652  0.8950  0.557792208
##    0.2    0.02948718  0.8499080  0.8975  0.553030303
##    0.2    0.03435897  0.8497890  0.9025  0.543722944
##    0.2    0.03923077  0.8498972  0.9050  0.539177489
##    0.2    0.04410256  0.8496591  0.9050  0.534632035
##    0.2    0.04897436  0.8501299  0.9125  0.534632035
##    0.2    0.05384615  0.8503680  0.9125  0.534632035
##    0.2    0.05871795  0.8502543  0.9125  0.534632035
##    0.2    0.06358974  0.8497835  0.9125  0.530086580
##    0.2    0.06846154  0.8494318  0.9125  0.520779221
##    0.2    0.07333333  0.8494156  0.9125  0.520779221
##    0.2    0.07820513  0.8494156  0.9125  0.516233766
##    0.2    0.08307692  0.8494210  0.9125  0.516233766
##    0.2    0.08794872  0.8494210  0.9125  0.516233766
##    0.2    0.09282051  0.8489556  0.9175  0.516233766
##    0.2    0.09769231  0.8489610  0.9200  0.516233766
##    0.2    0.10256410  0.8488528  0.9200  0.506926407
##    0.2    0.10743590  0.8488528  0.9200  0.506926407
##    0.2    0.11230769  0.8488582  0.9225  0.506926407
##    0.2    0.11717949  0.8488690  0.9225  0.506926407
##    0.2    0.12205128  0.8491071  0.9225  0.502380952
##    0.2    0.12692308  0.8487554  0.9225  0.497619048
##    0.2    0.13179487  0.8489827  0.9250  0.492857143
##    0.2    0.13666667  0.8492100  0.9250  0.483766234
##    0.2    0.14153846  0.8491017  0.9250  0.479004329
##    0.2    0.14641026  0.8488636  0.9250  0.464935065
##    0.2    0.15128205  0.8487392  0.9250  0.464935065
##    0.2    0.15615385  0.8485065  0.9275  0.464935065
##    0.2    0.16102564  0.8482792  0.9300  0.464935065
##    0.2    0.16589744  0.8478139  0.9300  0.460389610
##    0.2    0.17076923  0.8475758  0.9375  0.460389610
##    0.2    0.17564103  0.8473431  0.9375  0.455844156
##    0.2    0.18051282  0.8468615  0.9400  0.446753247
##    0.2    0.18538462  0.8469913  0.9400  0.442207792
##    0.2    0.19025641  0.8461797  0.9425  0.437662338
```

```
##    0.2    0.19512821  0.8460714  0.9425  0.423376623
##    0.2    0.20000000  0.8459578  0.9475  0.409307359
##    0.4    0.01000000  0.8506061  0.8950  0.571645022
##    0.4    0.01487179  0.8497998  0.8950  0.562337662
##    0.4    0.01974359  0.8503626  0.9000  0.562337662
##    0.4    0.02461538  0.8496699  0.9025  0.553246753
##    0.4    0.02948718  0.8501299  0.9025  0.543722944
##    0.4    0.03435897  0.8502489  0.9050  0.543722944
##    0.4    0.03923077  0.8499134  0.9075  0.543722944
##    0.4    0.04410256  0.8500271  0.9125  0.539177489
##    0.4    0.04897436  0.8502543  0.9150  0.534415584
##    0.4    0.05384615  0.8494426  0.9150  0.534415584
##    0.4    0.05871795  0.8490855  0.9150  0.529870130
##    0.4    0.06358974  0.8485065  0.9150  0.525108225
##    0.4    0.06846154  0.8479221  0.9175  0.520562771
##    0.4    0.07333333  0.8469859  0.9200  0.515800866
##    0.4    0.07820513  0.8468777  0.9200  0.515800866
##    0.4    0.08307692  0.8467695  0.9200  0.511038961
##    0.4    0.08794872  0.8461797  0.9200  0.511038961
##    0.4    0.09282051  0.8452489  0.9200  0.506493506
##    0.4    0.09769231  0.8448972  0.9225  0.501948052
##    0.4    0.10256410  0.8447727  0.9250  0.497186147
##    0.4    0.10743590  0.8439502  0.9250  0.492640693
##    0.4    0.11230769  0.8437175  0.9275  0.487878788
##    0.4    0.11717949  0.8424351  0.9300  0.469480519
##    0.4    0.12205128  0.8420617  0.9350  0.464935065
##    0.4    0.12692308  0.8418074  0.9350  0.455627706
##    0.4    0.13179487  0.8408658  0.9425  0.446536797
##    0.4    0.13666667  0.8406115  0.9425  0.441991342
##    0.4    0.14153846  0.8391180  0.9450  0.432683983
##    0.4    0.14641026  0.8385335  0.9475  0.428138528
##    0.4    0.15128205  0.8375703  0.9475  0.414069264
##    0.4    0.15615385  0.8360552  0.9525  0.395670996
##    0.4    0.16102564  0.8351190  0.9575  0.386363636
##    0.4    0.16589744  0.8346591  0.9575  0.367748918
##    0.4    0.17076923  0.8338420  0.9575  0.358658009
##    0.4    0.17564103  0.8331494  0.9600  0.349350649
##    0.4    0.18051282  0.8312879  0.9625  0.340043290
##    0.4    0.18538462  0.8303571  0.9625  0.335497835
##    0.4    0.19025641  0.8289827  0.9650  0.330735931
##    0.4    0.19512821  0.8276948  0.9650  0.330735931
##    0.4    0.20000000  0.8274784  0.9675  0.316450216
##    0.6    0.01000000  0.8495563  0.8950  0.576406926
##    0.6    0.01487179  0.8494264  0.9025  0.562337662
##    0.6    0.01974359  0.8496591  0.9025  0.557792208
##    0.6    0.02461538  0.8500000  0.9025  0.553030303
##    0.6    0.02948718  0.8502219  0.9050  0.548268398
##    0.6    0.03435897  0.8498972  0.9075  0.538961039
##    0.6    0.03923077  0.8487338  0.9100  0.534415584
##    0.6    0.04410256  0.8478084  0.9100  0.529870130
##    0.6    0.04897436  0.8469751  0.9100  0.529870130
##    0.6    0.05384615  0.8460335  0.9075  0.520562771
##    0.6    0.05871795  0.8456818  0.9150  0.515800866
##    0.6    0.06358974  0.8453139  0.9175  0.511038961
```

```
## 0.6 0.06846154 0.8447403 0.9200 0.511038961
## 0.6 0.07333333 0.8426136 0.9225 0.506277056
## 0.6 0.07820513 0.8418939 0.9225 0.501731602
## 0.6 0.08307692 0.8411797 0.9225 0.492424242
## 0.6 0.08794872 0.8401407 0.9250 0.487662338
## 0.6 0.09282051 0.8382468 0.9275 0.483116883
## 0.6 0.09769231 0.8373106 0.9325 0.473809524
## 0.6 0.10256410 0.8353355 0.9325 0.455411255
## 0.6 0.10743590 0.8335985 0.9400 0.450865801
## 0.6 0.11230769 0.8323106 0.9425 0.446320346
## 0.6 0.11717949 0.8299729 0.9425 0.432251082
## 0.6 0.12205128 0.8280249 0.9450 0.409307359
## 0.6 0.12692308 0.8274513 0.9500 0.400000000
## 0.6 0.13179487 0.8241126 0.9500 0.381818182
## 0.6 0.13666667 0.8244481 0.9550 0.372510823
## 0.6 0.14153846 0.8245617 0.9600 0.363203463
## 0.6 0.14641026 0.8237960 0.9625 0.349350649
## 0.6 0.15128205 0.8226542 0.9625 0.330735931
## 0.6 0.15615385 0.8225352 0.9650 0.326190476
## 0.6 0.16102564 0.8223079 0.9675 0.316883117
## 0.6 0.16589744 0.8210200 0.9675 0.307575758
## 0.6 0.17076923 0.8200839 0.9700 0.298051948
## 0.6 0.17564103 0.8199540 0.9725 0.283982684
## 0.6 0.18051282 0.8183306 0.9725 0.274675325
## 0.6 0.18538462 0.8166748 0.9725 0.265584416
## 0.6 0.19025641 0.8151596 0.9725 0.256277056
## 0.6 0.19512821 0.8133144 0.9725 0.242207792
## 0.6 0.20000000 0.8114367 0.9725 0.228138528
## 0.8 0.01000000 0.8496429 0.8975 0.571645022
## 0.8 0.01487179 0.8496483 0.9025 0.557792208
## 0.8 0.01974359 0.8498701 0.9025 0.557792208
## 0.8 0.02461538 0.8500054 0.9000 0.548268398
## 0.8 0.02948718 0.8487284 0.9000 0.538961039
## 0.8 0.03435897 0.8469589 0.9025 0.538961039
## 0.8 0.03923077 0.8461418 0.9050 0.529653680
## 0.8 0.04410256 0.8456710 0.9075 0.525108225
## 0.8 0.04897436 0.8448377 0.9075 0.520346320
## 0.8 0.05384615 0.8424675 0.9100 0.515584416
## 0.8 0.05871795 0.8411634 0.9100 0.510822511
## 0.8 0.06358974 0.8398972 0.9100 0.496969697
## 0.8 0.06846154 0.8379004 0.9150 0.492207792
## 0.8 0.07333333 0.8355628 0.9175 0.483116883
## 0.8 0.07820513 0.8333550 0.9250 0.473809524
## 0.8 0.08307692 0.8301894 0.9275 0.460173160
## 0.8 0.08794872 0.8278842 0.9350 0.460173160
## 0.8 0.09282051 0.8256818 0.9350 0.446320346
## 0.8 0.09769231 0.8247998 0.9375 0.432251082
## 0.8 0.10256410 0.8244264 0.9375 0.418398268
## 0.8 0.10743590 0.8231602 0.9450 0.413852814
## 0.8 0.11230769 0.8226596 0.9475 0.404978355
## 0.8 0.11717949 0.8212473 0.9525 0.386580087
## 0.8 0.12205128 0.8200785 0.9575 0.354112554
## 0.8 0.12692308 0.8187960 0.9600 0.349350649
## 0.8 0.13179487 0.8166802 0.9675 0.330952381
```

```
##   0.8    0.13666667  0.8152733  0.9700  0.316666667
##   0.8    0.14153846  0.8124919  0.9700  0.307575758
##   0.8    0.14641026  0.8106196  0.9700  0.298484848
##   0.8    0.15128205  0.8080709  0.9725  0.288961039
##   0.8    0.15615385  0.8063285  0.9725  0.265367965
##   0.8    0.16102564  0.8034064  0.9725  0.256060606
##   0.8    0.16589744  0.8030601  0.9775  0.232683983
##   0.8    0.17076923  0.8019183  0.9775  0.232683983
##   0.8    0.17564103  0.8012338  0.9775  0.204978355
##   0.8    0.18051282  0.8010552  0.9800  0.177056277
##   0.8    0.18538462  0.8010552  0.9825  0.162987013
##   0.8    0.19025641  0.8013393  0.9850  0.153896104
##   0.8    0.19512821  0.8013393  0.9900  0.130519481
##   0.8    0.20000000  0.8013393  0.9925  0.097619048
##   1.0    0.01000000  0.8496483  0.9000  0.571645022
##   1.0    0.01487179  0.8492857  0.8950  0.557792208
##   1.0    0.01974359  0.8501028  0.8975  0.548268398
##   1.0    0.02461538  0.8486039  0.8975  0.543722944
##   1.0    0.02948718  0.8466071  0.9000  0.543506494
##   1.0    0.03435897  0.8455574  0.9000  0.529653680
##   1.0    0.03923077  0.8432900  0.9075  0.524891775
##   1.0    0.04410256  0.8415152  0.9100  0.529653680
##   1.0    0.04897436  0.8394156  0.9100  0.524891775
##   1.0    0.05384615  0.8366180  0.9100  0.501515152
##   1.0    0.05871795  0.8342803  0.9150  0.501515152
##   1.0    0.06358974  0.8303030  0.9175  0.492207792
##   1.0    0.06846154  0.8277652  0.9200  0.483333333
##   1.0    0.07333333  0.8252381  0.9250  0.474242424
##   1.0    0.07820513  0.8239502  0.9250  0.469696970
##   1.0    0.08307692  0.8234443  0.9350  0.451082251
##   1.0    0.08794872  0.8214800  0.9350  0.437229437
##   1.0    0.09282051  0.8202029  0.9375  0.423593074
##   1.0    0.09769231  0.8185633  0.9425  0.404978355
##   1.0    0.10256410  0.8163231  0.9425  0.391125541
##   1.0    0.10743590  0.8130763  0.9475  0.381818182
##   1.0    0.11230769  0.8105005  0.9500  0.358874459
##   1.0    0.11717949  0.8077246  0.9600  0.335281385
##   1.0    0.12205128  0.8051542  0.9625  0.321428571
##   1.0    0.12692308  0.8024865  0.9650  0.316883117
##   1.0    0.13179487  0.8019129  0.9675  0.302813853
##   1.0    0.13666667  0.8018561  0.9700  0.284199134
##   1.0    0.14153846  0.8013393  0.9775  0.265367965
##   1.0    0.14641026  0.8013393  0.9775  0.237229437
##   1.0    0.15128205  0.8013393  0.9775  0.223376623
##   1.0    0.15615385  0.8013393  0.9800  0.200432900
##   1.0    0.16102564  0.8013393  0.9825  0.167748918
##   1.0    0.16589744  0.8013393  0.9875  0.149134199
##   1.0    0.17076923  0.8013393  0.9925  0.106926407
##   1.0    0.17564103  0.8013393  0.9925  0.074675325
##   1.0    0.18051282  0.8013393  0.9975  0.037229437
##   1.0    0.18538462  0.8013393  1.0000  0.004761905
##   1.0    0.19025641  0.8013393  1.0000  0.000000000
##   1.0    0.19512821  0.8013393  1.0000  0.000000000
##   1.0    0.20000000  0.8013393  1.0000  0.000000000
```

```
##
## ROC was used to select the optimal model using the largest value.
## The final values used for the model were alpha = 0.1 and lambda = 0.08794872.
```

```r
############################ Nearest Shrunken Centroids ##############################
nscGrid <- data.frame(.threshold = 0:25)
nscFit <- train(diabetes ~., data = train_data,
                method = "pam",
                tuneGrid = nscGrid,
                preProcess = c("center","scale"),
                metric = "ROC",
                trControl = trainControl(method = "cv", number = 10,
                                         classProbs = TRUE, summaryFunction = twoClassSummary))
```

```
## 1
```

```r
nscFit
```

```
## Nearest Shrunken Centroids
##
## 615 samples
##   7 predictor
##   2 classes: 'neg', 'pos'
##
## Pre-processing: centered (7), scaled (7)
## Resampling: Cross-Validated (10 fold)
## Summary of sample sizes: 553, 553, 554, 554, 553, 554, ...
## Resampling results across tuning parameters:
##
##   threshold  ROC        Sens    Spec
##    0         0.8380682  0.9550  0.31580087
##    1         0.8430844  0.9775  0.19047619
##    2         0.8351299  0.9925  0.04155844
##    3         0.8158820  1.0000  0.00000000
##    4         0.7968642  1.0000  0.00000000
##    5         0.7967505  1.0000  0.00000000
##    6         0.7967505  1.0000  0.00000000
##    7         0.5000000  1.0000  0.00000000
##    8         0.5000000  1.0000  0.00000000
##    9         0.5000000  1.0000  0.00000000
##   10         0.5000000  1.0000  0.00000000
##   11         0.5000000  1.0000  0.00000000
##   12         0.5000000  1.0000  0.00000000
##   13         0.5000000  1.0000  0.00000000
##   14         0.5000000  1.0000  0.00000000
##   15         0.5000000  1.0000  0.00000000
##   16         0.5000000  1.0000  0.00000000
##   17         0.5000000  1.0000  0.00000000
##   18         0.5000000  1.0000  0.00000000
##   19         0.5000000  1.0000  0.00000000
##   20         0.5000000  1.0000  0.00000000
##   21         0.5000000  1.0000  0.00000000
##   22         0.5000000  1.0000  0.00000000
##   23         0.5000000  1.0000  0.00000000
##   24         0.5000000  1.0000  0.00000000
##   25         0.5000000  1.0000  0.00000000
```

```
##
## ROC was used to select the optimal model using the largest value.
## The final value used for the model was threshold = 1.
```

```
############################ LDA ##############################
ldaFit <- train(diabetes ~., data = train_data,
                method = "lda",
                metric = "ROC",
                preProcess = c("center","scale"),
                trControl = trainControl(method = "cv", number = 10,
                                         classProbs = TRUE, summaryFunction = twoClassSummary))

ldaFit
```

```
## Linear Discriminant Analysis
##
## 615 samples
##   7 predictor
##   2 classes: 'neg', 'pos'
##
## Pre-processing: centered (7), scaled (7)
## Resampling: Cross-Validated (10 fold)
## Summary of sample sizes: 553, 554, 553, 554, 554, 554, ...
## Resampling results:
##
##   ROC        Sens    Spec
##   0.8461472  0.8875  0.5722944
```

```
#Compare ROC Value by Training Model
allmodels <- list(Logistic_Regression = lr_train_data, Random_Forest = rf_train_data, KNN = knn_train_da
trainresults <- resamples(allmodels)

#Box Plot: Training Models' ROC Values
#Logistic Regression Performed Best on Training Data
bwplot(trainresults, metric="ROC")


###########################Test Data###########################
#Logistic Regression: Testing Data
lrpredict <- predict(lr_train_data, test_data)
#Confusion Matrix Accuracy
lrconfusion <- confusionMatrix(lrpredict, test_data$diabetes, positive="pos")
lrconfusion
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction neg pos
##        neg  86  26
##        pos  14  27
##
##                Accuracy : 0.7386
##                  95% CI : (0.6615, 0.8062)
##     No Information Rate : 0.6536
##     P-Value [Acc > NIR] : 0.01536
##
```

```
##                   Kappa : 0.3902
##
##  Mcnemar's Test P-Value : 0.08199
##
##             Sensitivity : 0.5094
##             Specificity : 0.8600
##          Pos Pred Value : 0.6585
##          Neg Pred Value : 0.7679
##              Prevalence : 0.3464
##          Detection Rate : 0.1765
##    Detection Prevalence : 0.2680
##       Balanced Accuracy : 0.6847
##
##        'Positive' Class : pos
##
```

```
#Random Forest: Testing Data
rfpredict <- predict(rf_train_data, test_data)
#Confusion Matrix Accuracy
rfconfusion <- confusionMatrix(rfpredict, test_data$diabetes, positive="pos")
rfconfusion
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction neg pos
##        neg  84  22
##        pos  16  31
##
##                Accuracy : 0.7516
##                  95% CI : (0.6754, 0.8179)
##     No Information Rate : 0.6536
##     P-Value [Acc > NIR] : 0.005891
##
##                   Kappa : 0.4365
##
##  Mcnemar's Test P-Value : 0.417304
##
##             Sensitivity : 0.5849
##             Specificity : 0.8400
##          Pos Pred Value : 0.6596
##          Neg Pred Value : 0.7925
##              Prevalence : 0.3464
##          Detection Rate : 0.2026
##    Detection Prevalence : 0.3072
##       Balanced Accuracy : 0.7125
##
##        'Positive' Class : pos
##
```

```
#K Nearest Neighbor: Testing Data
knnpredict <- predict(knn_train_data, test_data)
#Confusion Matrix Accuracy
knnconfusion <- confusionMatrix(knnpredict, test_data$diabetes, positive="pos")
knnconfusion
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction neg pos
##        neg  80  22
##        pos  20  31
##
##                Accuracy : 0.7255
##                  95% CI : (0.6476, 0.7945)
##     No Information Rate : 0.6536
##     P-Value [Acc > NIR] : 0.03543
##
##                   Kappa : 0.3883
##
##  Mcnemar's Test P-Value : 0.87737
##
##             Sensitivity : 0.5849
##             Specificity : 0.8000
##          Pos Pred Value : 0.6078
##          Neg Pred Value : 0.7843
##              Prevalence : 0.3464
##          Detection Rate : 0.2026
##    Detection Prevalence : 0.3333
##       Balanced Accuracy : 0.6925
##
##        'Positive' Class : pos
##
```

```r
#Classification and Regression Trees (CART): Testing Data
cartpredict <- predict(cart_train_data, test_data)
#Confusion Matrix Accuracy
cartconfusion <- confusionMatrix(cartpredict, test_data$diabetes, positive="pos")
cartconfusion
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction neg pos
##        neg  85  19
##        pos  15  34
##
##                Accuracy : 0.7778
##                  95% CI : (0.7036, 0.8409)
##     No Information Rate : 0.6536
##     P-Value [Acc > NIR] : 0.000586
##
##                   Kappa : 0.5004
##
##  Mcnemar's Test P-Value : 0.606905
##
##             Sensitivity : 0.6415
##             Specificity : 0.8500
##          Pos Pred Value : 0.6939
##          Neg Pred Value : 0.8173
##              Prevalence : 0.3464
```

```
##          Detection Rate : 0.2222
##    Detection Prevalence : 0.3203
##       Balanced Accuracy : 0.7458
##
##        'Positive' Class : pos
##
```

```r
#Neural Net: Testing Data
nnetpredict <- predict(nnet_train_data, test_data)
#Confusion Matrix Accuracy
nnetconfusion <- confusionMatrix(nnetpredict, test_data$diabetes, positive="pos")
nnetconfusion
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction neg pos
##        neg  82  25
##        pos  18  28
##
##                Accuracy : 0.719
##                  95% CI : (0.6407, 0.7886)
##     No Information Rate : 0.6536
##     P-Value [Acc > NIR] : 0.05152
##
##                   Kappa : 0.3595
##
##  Mcnemar's Test P-Value : 0.36020
##
##             Sensitivity : 0.5283
##             Specificity : 0.8200
##          Pos Pred Value : 0.6087
##          Neg Pred Value : 0.7664
##              Prevalence : 0.3464
##          Detection Rate : 0.1830
##    Detection Prevalence : 0.3007
##       Balanced Accuracy : 0.6742
##
##        'Positive' Class : pos
##
```

```r
#Support Vector Machines
svmpredict <- predict(svmFit, test_data)
#Confusion Matrix Accuracy
svmconfusion <- confusionMatrix(svmpredict, test_data$diabetes, positive="pos")
svmconfusion
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction neg pos
##        neg  81  24
##        pos  19  29
##
##                Accuracy : 0.719
##                  95% CI : (0.6407, 0.7886)
```

```
##     No Information Rate : 0.6536
##     P-Value [Acc > NIR] : 0.05152
##
##                   Kappa : 0.3653
##
##  Mcnemar's Test P-Value : 0.54187
##
##             Sensitivity : 0.5472
##             Specificity : 0.8100
##          Pos Pred Value : 0.6042
##          Neg Pred Value : 0.7714
##              Prevalence : 0.3464
##          Detection Rate : 0.1895
##    Detection Prevalence : 0.3137
##       Balanced Accuracy : 0.6786
##
##        'Positive' Class : pos
##
```

```
#Boost
gbmpredict <- predict(gbmFit, test_data)
#Confusion Matrix Accuracy
gbmconfusion <- confusionMatrix(gbmpredict, test_data$diabetes, positive="pos")
gbmconfusion
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction neg pos
##        neg  85  25
##        pos  15  28
##
##                Accuracy : 0.7386
##                  95% CI : (0.6615, 0.8062)
##     No Information Rate : 0.6536
##     P-Value [Acc > NIR] : 0.01536
##
##                   Kappa : 0.3959
##
##  Mcnemar's Test P-Value : 0.15473
##
##             Sensitivity : 0.5283
##             Specificity : 0.8500
##          Pos Pred Value : 0.6512
##          Neg Pred Value : 0.7727
##              Prevalence : 0.3464
##          Detection Rate : 0.1830
##    Detection Prevalence : 0.2810
##       Balanced Accuracy : 0.6892
##
##        'Positive' Class : pos
##
```

```
# Elastinet
glmnpredict <- predict(glmnFit, test_data)
```

```r
#Confusion Matrix Accuracy
glmnconfusion <- confusionMatrix(glmnpredict, test_data$diabetes, positive="pos")
glmnconfusion
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction neg pos
##        neg  90  28
##        pos  10  25
##
##                Accuracy : 0.7516
##                  95% CI : (0.6754, 0.8179)
##     No Information Rate : 0.6536
##     P-Value [Acc > NIR] : 0.005891
##
##                   Kappa : 0.4039
##
##  Mcnemar's Test P-Value : 0.005820
##
##             Sensitivity : 0.4717
##             Specificity : 0.9000
##          Pos Pred Value : 0.7143
##          Neg Pred Value : 0.7627
##              Prevalence : 0.3464
##          Detection Rate : 0.1634
##    Detection Prevalence : 0.2288
##       Balanced Accuracy : 0.6858
##
##        'Positive' Class : pos
##
```

```r
# Nearest Shrunken Centroid
nscpredict <- predict(nscFit, test_data)
#Confusion Matrix Accuracy
nscconfusion <- confusionMatrix(nscpredict, test_data$diabetes, positive="pos")
nscconfusion
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction neg pos
##        neg  99  46
##        pos   1   7
##
##                Accuracy : 0.6928
##                  95% CI : (0.6132, 0.7648)
##     No Information Rate : 0.6536
##     P-Value [Acc > NIR] : 0.1753
##
##                   Kappa : 0.1525
##
##  Mcnemar's Test P-Value : 1.38e-10
##
##             Sensitivity : 0.13208
```

```
##             Specificity : 0.99000
##          Pos Pred Value : 0.87500
##          Neg Pred Value : 0.68276
##              Prevalence : 0.34641
##          Detection Rate : 0.04575
##    Detection Prevalence : 0.05229
##       Balanced Accuracy : 0.56104
##
##        'Positive' Class : pos
##
```

```
#Boost
ldapredict <- predict(ldaFit, test_data)
#Confusion Matrix Accuracy
ldaconfusion <- confusionMatrix(ldapredict, test_data$diabetes, positive="pos")
ldaconfusion
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction neg pos
##        neg  86  28
##        pos  14  25
##
##                Accuracy : 0.7255
##                  95% CI : (0.6476, 0.7945)
##     No Information Rate : 0.6536
##     P-Value [Acc > NIR] : 0.03543
##
##                   Kappa : 0.3537
##
##  Mcnemar's Test P-Value : 0.04486
##
##             Sensitivity : 0.4717
##             Specificity : 0.8600
##          Pos Pred Value : 0.6410
##          Neg Pred Value : 0.7544
##              Prevalence : 0.3464
##          Detection Rate : 0.1634
##    Detection Prevalence : 0.2549
##       Balanced Accuracy : 0.6658
##
##        'Positive' Class : pos
##
```

```
#Comparing Test Results
lrfinal<- c(lrconfusion$byClass['Sensitivity'], lrconfusion$byClass['Specificity'], lrconfusion$byClass
            lrconfusion$byClass['Recall'], lrconfusion$byClass['F1'])
rffinal <- c(rfconfusion$byClass['Sensitivity'], rfconfusion$byClass['Specificity'], rfconfusion$byClas
             rfconfusion$byClass['Recall'], rfconfusion$byClass['F1'])

knnfinal <- c(knnconfusion$byClass['Sensitivity'], knnconfusion$byClass['Specificity'], knnconfusion$by
              knnconfusion$byClass['Recall'], knnconfusion$byClass['F1'])

cartfinal <- c(cartconfusion$byClass['Sensitivity'], cartconfusion$byClass['Specificity'], cartconfusio
```

```r
              cartconfusion$byClass['Recall'], cartconfusion$byClass['F1'])

nnetfinal <- c(nnetconfusion$byClass['Sensitivity'], nnetconfusion$byClass['Specificity'], nnetconfusion
              nnetconfusion$byClass['Recall'], nnetconfusion$byClass['F1'])

svmfinal <- c(svmconfusion$byClass['Sensitivity'], svmconfusion$byClass['Specificity'], svmconfusion$by
              svmconfusion$byClass['Recall'], svmconfusion$byClass['F1'])

gbmfinal <- c(gbmconfusion$byClass['Sensitivity'], gbmconfusion$byClass['Specificity'], gbmconfusion$by
              gbmconfusion$byClass['Recall'], gbmconfusion$byClass['F1'])

glmnfinal <- c(glmnconfusion$byClass['Sensitivity'], glmnconfusion$byClass['Specificity'], glmnconfusion
              glmnconfusion$byClass['Recall'], glmnconfusion$byClass['F1'])

nscfinal <- c(nscconfusion$byClass['Sensitivity'], nscconfusion$byClass['Specificity'], nscconfusion$by
              nscconfusion$byClass['Recall'], nscconfusion$byClass['F1'])

ldafinal <- c(ldaconfusion$byClass['Sensitivity'], ldaconfusion$byClass['Specificity'], ldaconfusion$by
              ldaconfusion$byClass['Recall'], ldaconfusion$byClass['F1'])

allmodelsfinal <- data.frame(rbind(lrfinal, rffinal, knnfinal, cartfinal, nnetfinal, svmfinal, gbmfinal
names(allmodelsfinal) <- c("Sensitivity", "Specificity", "Precision", "Recall", "F1")
allmodelsfinal
```

```
##           Sensitivity Specificity Precision    Recall        F1
## lrfinal     0.5094340        0.86 0.6585366 0.5094340 0.5744681
## rffinal     0.5849057        0.84 0.6595745 0.5849057 0.6200000
## knnfinal    0.5849057        0.80 0.6078431 0.5849057 0.5961538
## cartfinal   0.6415094        0.85 0.6938776 0.6415094 0.6666667
## nnetfinal   0.5283019        0.82 0.6086957 0.5283019 0.5656566
## svmfinal    0.5471698        0.81 0.6041667 0.5471698 0.5742574
## gbmfinal    0.5283019        0.85 0.6511628 0.5283019 0.5833333
## nscfinal    0.1320755        0.99 0.8750000 0.1320755 0.2295082
## ldafinal    0.4716981        0.86 0.6410256 0.4716981 0.5434783
```