Math 189: Homework 5

Auto Mileage

In this assignment you will develop a model to predict whether a given car gets high or low gas mileage based on the Auto data set. This data can be found in the ISLR package.

Introduction

In this learning assignment for Math 189, we use a dataset (Auto) from the ISLR library to build a model which predicts whether a given car will have high or low gas mileage. To build this classification model, we conducted an linear discriminant analysis (LDA) on our training data to find the linear combination of features which will characterize the cars into one of two classes (0 = low gas mileage, 1= high gas mileage). Finally, using the model, we classified the test data and measured its accuracy.

Data

This dataset is taken from the ISLR package library and is known as "Auto". It contains 392 observations on automobiles taken from various years. For each automobile, the miles per gallon (MPG), horsepower, weight, number of cylinders, displacement, acceleration, year, origin and name is recorded. [Insert head(Auto)]

Tasks

Analyze the dataset according to the following steps:

1. Create a binary variable, mgp01, that contains 1 if mpg contains a value above its median, and a 0 if mpg contains a value below its median. You can compute the median using the median() function.
2. Explore the data graphically in order to investigate the association between mgp01 and the other features. Which of the other features seem most likely to be useful in predicting mgp01? Scatterplots and boxplots may be useful tools to answer this question. Describe your findings.
3. Split the data into a training set of size 300 and a test set of size 92.
4. Perform LDA on the training data in order to predict mgp01 using the variables that seemed most associated with mgp01.
5. Classify the test data. Discuss the results in terms of the proportion of correctly classified records.

```
library(ISLR)
data(Auto)
head(Auto)
```

```
##   mpg cylinders displacement horsepower weight acceleration year origin
## 1  18         8          307        130   3504         12.0   70      1
## 2  15         8          350        165   3693         11.5   70      1
## 3  18         8          318        150   3436         11.0   70      1
```

```
## 4  16         8          304        150   3433         12.0   70      1
## 5  17         8          302        140   3449         10.5   70      1
## 6  15         8          429        198   4341         10.0   70      1
##                         name
## 1 chevrolet chevelle malibu
## 2         buick skylark 320
## 3        plymouth satellite
## 4             amc rebel sst
## 5               ford torino
## 6          ford galaxie 500
```

The dataset has 392 observations on automobiles. For each automobile, we record the miles per gallon (MPG), among other variables such as horsepower and weight.

Methods and Analysis

First, we had to create another column (mpg01) in which to put whether the mpg for each car was above or below the median (22.75mpg) using a for loop and if statements. Next, we demonstrate both a boxplot and a paired scatterplot in order to determine which variables would be most useful for predictions. We chose to use number of cylinders, displacement, horsepower, weight, and year as they seemed the most indicative toward mpg01. Then, we perform the whole process of LDA (Linear Discriminant Analysis). First, we separate the table into 300 training samples and 92 test samples for ease. We must then choose the prior for both mpg above 22.75 and mpg below 22.75. For this, we simply did training data priors by dividing the number of samples in each over the total. Then, we calculated the column means and covariance for each separated matrix of variable values. We then found the pooled sample covariance matrix from the two and found its inverse. Using matrix multiplication, we calculated alpha and beta using the mean matrices, the inverse pooled sample covariance matrix, and the log of the priors. Now, after we have all these matrices calculated, we have to do the predictions. For this, we estimate the linear discrimination function by adding alpha plus transpose beta and matrix multiplying by the transpose of the variables we used. Then, we classify the prediction into whichever group has the higher linear discrimination function. Finally, to easily view the results, we placed them into a table containing the number of total observations, the number of correct predictions, and the number of incorrect predictions for both mpg1 (above 22.75mpg) and mpg0 (below 22.75mpg).

```
med_mpg = median(Auto$mpg)
med_mpg
```

```
## [1] 22.75
```

```
Auto$mpg01 = NULL
head(Auto)
```

```
##   mpg cylinders displacement horsepower weight acceleration year origin
## 1  18         8          307        130   3504         12.0   70      1
## 2  15         8          350        165   3693         11.5   70      1
## 3  18         8          318        150   3436         11.0   70      1
## 4  16         8          304        150   3433         12.0   70      1
## 5  17         8          302        140   3449         10.5   70      1
## 6  15         8          429        198   4341         10.0   70      1
##                         name
## 1 chevrolet chevelle malibu
## 2         buick skylark 320
```

```
## 3        plymouth satellite
## 4             amc rebel sst
## 5               ford torino
## 6          ford galaxie 500
```

```
for(i in 1:392){
  if(Auto[i,1]>22.75){
    Auto[i,10] = 1
  }
  if(Auto[i,1]<22.75){
    Auto[i,10] = 0
  }
}
colnames(Auto)[10] = "mpg01"
Auto
```

```
##      mpg cylinders displacement horsepower weight acceleration year origin
## 1   18.0         8        307.0        130   3504         12.0   70      1
## 2   15.0         8        350.0        165   3693         11.5   70      1
## 3   18.0         8        318.0        150   3436         11.0   70      1
## 4   16.0         8        304.0        150   3433         12.0   70      1
## 5   17.0         8        302.0        140   3449         10.5   70      1
## 6   15.0         8        429.0        198   4341         10.0   70      1
## 7   14.0         8        454.0        220   4354          9.0   70      1
## 8   14.0         8        440.0        215   4312          8.5   70      1
## 9   14.0         8        455.0        225   4425         10.0   70      1
## 10  15.0         8        390.0        190   3850          8.5   70      1
## 11  15.0         8        383.0        170   3563         10.0   70      1
## 12  14.0         8        340.0        160   3609          8.0   70      1
## 13  15.0         8        400.0        150   3761          9.5   70      1
## 14  14.0         8        455.0        225   3086         10.0   70      1
## 15  24.0         4        113.0         95   2372         15.0   70      3
## 16  22.0         6        198.0         95   2833         15.5   70      1
## 17  18.0         6        199.0         97   2774         15.5   70      1
## 18  21.0         6        200.0         85   2587         16.0   70      1
## 19  27.0         4         97.0         88   2130         14.5   70      3
## 20  26.0         4         97.0         46   1835         20.5   70      2
## 21  25.0         4        110.0         87   2672         17.5   70      2
## 22  24.0         4        107.0         90   2430         14.5   70      2
## 23  25.0         4        104.0         95   2375         17.5   70      2
## 24  26.0         4        121.0        113   2234         12.5   70      2
## 25  21.0         6        199.0         90   2648         15.0   70      1
## 26  10.0         8        360.0        215   4615         14.0   70      1
## 27  10.0         8        307.0        200   4376         15.0   70      1
## 28  11.0         8        318.0        210   4382         13.5   70      1
## 29   9.0         8        304.0        193   4732         18.5   70      1
## 30  27.0         4         97.0         88   2130         14.5   71      3
## 31  28.0         4        140.0         90   2264         15.5   71      1
## 32  25.0         4        113.0         95   2228         14.0   71      3
## 34  19.0         6        232.0        100   2634         13.0   71      1
## 35  16.0         6        225.0        105   3439         15.5   71      1
## 36  17.0         6        250.0        100   3329         15.5   71      1
## 37  19.0         6        250.0         88   3302         15.5   71      1
## 38  18.0         6        232.0        100   3288         15.5   71      1
```

```
## 39  14.0         8        350.0        165   4209         12.0   71       1
## 40  14.0         8        400.0        175   4464         11.5   71       1
## 41  14.0         8        351.0        153   4154         13.5   71       1
## 42  14.0         8        318.0        150   4096         13.0   71       1
## 43  12.0         8        383.0        180   4955         11.5   71       1
## 44  13.0         8        400.0        170   4746         12.0   71       1
## 45  13.0         8        400.0        175   5140         12.0   71       1
## 46  18.0         6        258.0        110   2962         13.5   71       1
## 47  22.0         4        140.0         72   2408         19.0   71       1
## 48  19.0         6        250.0        100   3282         15.0   71       1
## 49  18.0         6        250.0         88   3139         14.5   71       1
## 50  23.0         4        122.0         86   2220         14.0   71       1
## 51  28.0         4        116.0         90   2123         14.0   71       2
## 52  30.0         4         79.0         70   2074         19.5   71       2
## 53  30.0         4         88.0         76   2065         14.5   71       2
## 54  31.0         4         71.0         65   1773         19.0   71       3
## 55  35.0         4         72.0         69   1613         18.0   71       3
## 56  27.0         4         97.0         60   1834         19.0   71       2
## 57  26.0         4         91.0         70   1955         20.5   71       1
## 58  24.0         4        113.0         95   2278         15.5   72       3
## 59  25.0         4         97.5         80   2126         17.0   72       1
## 60  23.0         4         97.0         54   2254         23.5   72       2
## 61  20.0         4        140.0         90   2408         19.5   72       1
## 62  21.0         4        122.0         86   2226         16.5   72       1
## 63  13.0         8        350.0        165   4274         12.0   72       1
## 64  14.0         8        400.0        175   4385         12.0   72       1
## 65  15.0         8        318.0        150   4135         13.5   72       1
## 66  14.0         8        351.0        153   4129         13.0   72       1
## 67  17.0         8        304.0        150   3672         11.5   72       1
## 68  11.0         8        429.0        208   4633         11.0   72       1
## 69  13.0         8        350.0        155   4502         13.5   72       1
## 70  12.0         8        350.0        160   4456         13.5   72       1
## 71  13.0         8        400.0        190   4422         12.5   72       1
## 72  19.0         3         70.0         97   2330         13.5   72       3
## 73  15.0         8        304.0        150   3892         12.5   72       1
## 74  13.0         8        307.0        130   4098         14.0   72       1
## 75  13.0         8        302.0        140   4294         16.0   72       1
## 76  14.0         8        318.0        150   4077         14.0   72       1
## 77  18.0         4        121.0        112   2933         14.5   72       2
## 78  22.0         4        121.0         76   2511         18.0   72       2
## 79  21.0         4        120.0         87   2979         19.5   72       2
## 80  26.0         4         96.0         69   2189         18.0   72       2
## 81  22.0         4        122.0         86   2395         16.0   72       1
## 82  28.0         4         97.0         92   2288         17.0   72       3
## 83  23.0         4        120.0         97   2506         14.5   72       3
## 84  28.0         4         98.0         80   2164         15.0   72       1
## 85  27.0         4         97.0         88   2100         16.5   72       3
## 86  13.0         8        350.0        175   4100         13.0   73       1
## 87  14.0         8        304.0        150   3672         11.5   73       1
## 88  13.0         8        350.0        145   3988         13.0   73       1
## 89  14.0         8        302.0        137   4042         14.5   73       1
## 90  15.0         8        318.0        150   3777         12.5   73       1
## 91  12.0         8        429.0        198   4952         11.5   73       1
## 92  13.0         8        400.0        150   4464         12.0   73       1
```

```
## 93  13.0         8        351.0        158   4363         13.0   73      1
## 94  14.0         8        318.0        150   4237         14.5   73      1
## 95  13.0         8        440.0        215   4735         11.0   73      1
## 96  12.0         8        455.0        225   4951         11.0   73      1
## 97  13.0         8        360.0        175   3821         11.0   73      1
## 98  18.0         6        225.0        105   3121         16.5   73      1
## 99  16.0         6        250.0        100   3278         18.0   73      1
## 100 18.0         6        232.0        100   2945         16.0   73      1
## 101 18.0         6        250.0         88   3021         16.5   73      1
## 102 23.0         6        198.0         95   2904         16.0   73      1
## 103 26.0         4         97.0         46   1950         21.0   73      2
## 104 11.0         8        400.0        150   4997         14.0   73      1
## 105 12.0         8        400.0        167   4906         12.5   73      1
## 106 13.0         8        360.0        170   4654         13.0   73      1
## 107 12.0         8        350.0        180   4499         12.5   73      1
## 108 18.0         6        232.0        100   2789         15.0   73      1
## 109 20.0         4         97.0         88   2279         19.0   73      3
## 110 21.0         4        140.0         72   2401         19.5   73      1
## 111 22.0         4        108.0         94   2379         16.5   73      3
## 112 18.0         3         70.0         90   2124         13.5   73      3
## 113 19.0         4        122.0         85   2310         18.5   73      1
## 114 21.0         6        155.0        107   2472         14.0   73      1
## 115 26.0         4         98.0         90   2265         15.5   73      2
## 116 15.0         8        350.0        145   4082         13.0   73      1
## 117 16.0         8        400.0        230   4278          9.5   73      1
## 118 29.0         4         68.0         49   1867         19.5   73      2
## 119 24.0         4        116.0         75   2158         15.5   73      2
## 120 20.0         4        114.0         91   2582         14.0   73      2
## 121 19.0         4        121.0        112   2868         15.5   73      2
## 122 15.0         8        318.0        150   3399         11.0   73      1
## 123 24.0         4        121.0        110   2660         14.0   73      2
## 124 20.0         6        156.0        122   2807         13.5   73      3
## 125 11.0         8        350.0        180   3664         11.0   73      1
## 126 20.0         6        198.0         95   3102         16.5   74      1
## 128 19.0         6        232.0        100   2901         16.0   74      1
## 129 15.0         6        250.0        100   3336         17.0   74      1
## 130 31.0         4         79.0         67   1950         19.0   74      3
## 131 26.0         4        122.0         80   2451         16.5   74      1
## 132 32.0         4         71.0         65   1836         21.0   74      3
## 133 25.0         4        140.0         75   2542         17.0   74      1
## 134 16.0         6        250.0        100   3781         17.0   74      1
## 135 16.0         6        258.0        110   3632         18.0   74      1
## 136 18.0         6        225.0        105   3613         16.5   74      1
## 137 16.0         8        302.0        140   4141         14.0   74      1
## 138 13.0         8        350.0        150   4699         14.5   74      1
## 139 14.0         8        318.0        150   4457         13.5   74      1
## 140 14.0         8        302.0        140   4638         16.0   74      1
## 141 14.0         8        304.0        150   4257         15.5   74      1
## 142 29.0         4         98.0         83   2219         16.5   74      2
## 143 26.0         4         79.0         67   1963         15.5   74      2
## 144 26.0         4         97.0         78   2300         14.5   74      2
## 145 31.0         4         76.0         52   1649         16.5   74      3
## 146 32.0         4         83.0         61   2003         19.0   74      3
## 147 28.0         4         90.0         75   2125         14.5   74      1
```

```
## 148 24.0        4         90.0         75   2108         15.5   74      2
## 149 26.0        4        116.0         75   2246         14.0   74      2
## 150 24.0        4        120.0         97   2489         15.0   74      3
## 151 26.0        4        108.0         93   2391         15.5   74      3
## 152 31.0        4         79.0         67   2000         16.0   74      2
## 153 19.0        6        225.0         95   3264         16.0   75      1
## 154 18.0        6        250.0        105   3459         16.0   75      1
## 155 15.0        6        250.0         72   3432         21.0   75      1
## 156 15.0        6        250.0         72   3158         19.5   75      1
## 157 16.0        8        400.0        170   4668         11.5   75      1
## 158 15.0        8        350.0        145   4440         14.0   75      1
## 159 16.0        8        318.0        150   4498         14.5   75      1
## 160 14.0        8        351.0        148   4657         13.5   75      1
## 161 17.0        6        231.0        110   3907         21.0   75      1
## 162 16.0        6        250.0        105   3897         18.5   75      1
## 163 15.0        6        258.0        110   3730         19.0   75      1
## 164 18.0        6        225.0         95   3785         19.0   75      1
## 165 21.0        6        231.0        110   3039         15.0   75      1
## 166 20.0        8        262.0        110   3221         13.5   75      1
## 167 13.0        8        302.0        129   3169         12.0   75      1
## 168 29.0        4         97.0         75   2171         16.0   75      3
## 169 23.0        4        140.0         83   2639         17.0   75      1
## 170 20.0        6        232.0        100   2914         16.0   75      1
## 171 23.0        4        140.0         78   2592         18.5   75      1
## 172 24.0        4        134.0         96   2702         13.5   75      3
## 173 25.0        4         90.0         71   2223         16.5   75      2
## 174 24.0        4        119.0         97   2545         17.0   75      3
## 175 18.0        6        171.0         97   2984         14.5   75      1
## 176 29.0        4         90.0         70   1937         14.0   75      2
## 177 19.0        6        232.0         90   3211         17.0   75      1
## 178 23.0        4        115.0         95   2694         15.0   75      2
## 179 23.0        4        120.0         88   2957         17.0   75      2
## 180 22.0        4        121.0         98   2945         14.5   75      2
## 181 25.0        4        121.0        115   2671         13.5   75      2
## 182 33.0        4         91.0         53   1795         17.5   75      3
## 183 28.0        4        107.0         86   2464         15.5   76      2
## 184 25.0        4        116.0         81   2220         16.9   76      2
## 185 25.0        4        140.0         92   2572         14.9   76      1
## 186 26.0        4         98.0         79   2255         17.7   76      1
## 187 27.0        4        101.0         83   2202         15.3   76      2
## 188 17.5        8        305.0        140   4215         13.0   76      1
## 189 16.0        8        318.0        150   4190         13.0   76      1
## 190 15.5        8        304.0        120   3962         13.9   76      1
## 191 14.5        8        351.0        152   4215         12.8   76      1
## 192 22.0        6        225.0        100   3233         15.4   76      1
## 193 22.0        6        250.0        105   3353         14.5   76      1
## 194 24.0        6        200.0         81   3012         17.6   76      1
## 195 22.5        6        232.0         90   3085         17.6   76      1
## 196 29.0        4         85.0         52   2035         22.2   76      1
## 197 24.5        4         98.0         60   2164         22.1   76      1
## 198 29.0        4         90.0         70   1937         14.2   76      2
## 199 33.0        4         91.0         53   1795         17.4   76      3
## 200 20.0        6        225.0        100   3651         17.7   76      1
## 201 18.0        6        250.0         78   3574         21.0   76      1
```

```
## 202 18.5         6        250.0        110   3645         16.2   76      1
## 203 17.5         6        258.0         95   3193         17.8   76      1
## 204 29.5         4         97.0         71   1825         12.2   76      2
## 205 32.0         4         85.0         70   1990         17.0   76      3
## 206 28.0         4         97.0         75   2155         16.4   76      3
## 207 26.5         4        140.0         72   2565         13.6   76      1
## 208 20.0         4        130.0        102   3150         15.7   76      2
## 209 13.0         8        318.0        150   3940         13.2   76      1
## 210 19.0         4        120.0         88   3270         21.9   76      2
## 211 19.0         6        156.0        108   2930         15.5   76      3
## 212 16.5         6        168.0        120   3820         16.7   76      2
## 213 16.5         8        350.0        180   4380         12.1   76      1
## 214 13.0         8        350.0        145   4055         12.0   76      1
## 215 13.0         8        302.0        130   3870         15.0   76      1
## 216 13.0         8        318.0        150   3755         14.0   76      1
## 217 31.5         4         98.0         68   2045         18.5   77      3
## 218 30.0         4        111.0         80   2155         14.8   77      1
## 219 36.0         4         79.0         58   1825         18.6   77      2
## 220 25.5         4        122.0         96   2300         15.5   77      1
## 221 33.5         4         85.0         70   1945         16.8   77      3
## 222 17.5         8        305.0        145   3880         12.5   77      1
## 223 17.0         8        260.0        110   4060         19.0   77      1
## 224 15.5         8        318.0        145   4140         13.7   77      1
## 225 15.0         8        302.0        130   4295         14.9   77      1
## 226 17.5         6        250.0        110   3520         16.4   77      1
## 227 20.5         6        231.0        105   3425         16.9   77      1
## 228 19.0         6        225.0        100   3630         17.7   77      1
## 229 18.5         6        250.0         98   3525         19.0   77      1
## 230 16.0         8        400.0        180   4220         11.1   77      1
## 231 15.5         8        350.0        170   4165         11.4   77      1
## 232 15.5         8        400.0        190   4325         12.2   77      1
## 233 16.0         8        351.0        149   4335         14.5   77      1
## 234 29.0         4         97.0         78   1940         14.5   77      2
## 235 24.5         4        151.0         88   2740         16.0   77      1
## 236 26.0         4         97.0         75   2265         18.2   77      3
## 237 25.5         4        140.0         89   2755         15.8   77      1
## 238 30.5         4         98.0         63   2051         17.0   77      1
## 239 33.5         4         98.0         83   2075         15.9   77      1
## 240 30.0         4         97.0         67   1985         16.4   77      3
## 241 30.5         4         97.0         78   2190         14.1   77      2
## 242 22.0         6        146.0         97   2815         14.5   77      3
## 243 21.5         4        121.0        110   2600         12.8   77      2
## 244 21.5         3         80.0        110   2720         13.5   77      3
## 245 43.1         4         90.0         48   1985         21.5   78      2
## 246 36.1         4         98.0         66   1800         14.4   78      1
## 247 32.8         4         78.0         52   1985         19.4   78      3
## 248 39.4         4         85.0         70   2070         18.6   78      3
## 249 36.1         4         91.0         60   1800         16.4   78      3
## 250 19.9         8        260.0        110   3365         15.5   78      1
## 251 19.4         8        318.0        140   3735         13.2   78      1
## 252 20.2         8        302.0        139   3570         12.8   78      1
## 253 19.2         6        231.0        105   3535         19.2   78      1
## 254 20.5         6        200.0         95   3155         18.2   78      1
## 255 20.2         6        200.0         85   2965         15.8   78      1
```

```
## 256 25.1        4        140.0         88   2720         15.4   78      1
## 257 20.5        6        225.0        100   3430         17.2   78      1
## 258 19.4        6        232.0         90   3210         17.2   78      1
## 259 20.6        6        231.0        105   3380         15.8   78      1
## 260 20.8        6        200.0         85   3070         16.7   78      1
## 261 18.6        6        225.0        110   3620         18.7   78      1
## 262 18.1        6        258.0        120   3410         15.1   78      1
## 263 19.2        8        305.0        145   3425         13.2   78      1
## 264 17.7        6        231.0        165   3445         13.4   78      1
## 265 18.1        8        302.0        139   3205         11.2   78      1
## 266 17.5        8        318.0        140   4080         13.7   78      1
## 267 30.0        4         98.0         68   2155         16.5   78      1
## 268 27.5        4        134.0         95   2560         14.2   78      3
## 269 27.2        4        119.0         97   2300         14.7   78      3
## 270 30.9        4        105.0         75   2230         14.5   78      1
## 271 21.1        4        134.0         95   2515         14.8   78      3
## 272 23.2        4        156.0        105   2745         16.7   78      1
## 273 23.8        4        151.0         85   2855         17.6   78      1
## 274 23.9        4        119.0         97   2405         14.9   78      3
## 275 20.3        5        131.0        103   2830         15.9   78      2
## 276 17.0        6        163.0        125   3140         13.6   78      2
## 277 21.6        4        121.0        115   2795         15.7   78      2
## 278 16.2        6        163.0        133   3410         15.8   78      2
## 279 31.5        4         89.0         71   1990         14.9   78      2
## 280 29.5        4         98.0         68   2135         16.6   78      3
## 281 21.5        6        231.0        115   3245         15.4   79      1
## 282 19.8        6        200.0         85   2990         18.2   79      1
## 283 22.3        4        140.0         88   2890         17.3   79      1
## 284 20.2        6        232.0         90   3265         18.2   79      1
## 285 20.6        6        225.0        110   3360         16.6   79      1
## 286 17.0        8        305.0        130   3840         15.4   79      1
## 287 17.6        8        302.0        129   3725         13.4   79      1
## 288 16.5        8        351.0        138   3955         13.2   79      1
## 289 18.2        8        318.0        135   3830         15.2   79      1
## 290 16.9        8        350.0        155   4360         14.9   79      1
## 291 15.5        8        351.0        142   4054         14.3   79      1
## 292 19.2        8        267.0        125   3605         15.0   79      1
## 293 18.5        8        360.0        150   3940         13.0   79      1
## 294 31.9        4         89.0         71   1925         14.0   79      2
## 295 34.1        4         86.0         65   1975         15.2   79      3
## 296 35.7        4         98.0         80   1915         14.4   79      1
## 297 27.4        4        121.0         80   2670         15.0   79      1
## 298 25.4        5        183.0         77   3530         20.1   79      2
## 299 23.0        8        350.0        125   3900         17.4   79      1
## 300 27.2        4        141.0         71   3190         24.8   79      2
## 301 23.9        8        260.0         90   3420         22.2   79      1
## 302 34.2        4        105.0         70   2200         13.2   79      1
## 303 34.5        4        105.0         70   2150         14.9   79      1
## 304 31.8        4         85.0         65   2020         19.2   79      3
## 305 37.3        4         91.0         69   2130         14.7   79      2
## 306 28.4        4        151.0         90   2670         16.0   79      1
## 307 28.8        6        173.0        115   2595         11.3   79      1
## 308 26.8        6        173.0        115   2700         12.9   79      1
## 309 33.5        4        151.0         90   2556         13.2   79      1
```

```
## 310 41.5        4         98.0         76   2144         14.7   80      2
## 311 38.1        4         89.0         60   1968         18.8   80      3
## 312 32.1        4         98.0         70   2120         15.5   80      1
## 313 37.2        4         86.0         65   2019         16.4   80      3
## 314 28.0        4        151.0         90   2678         16.5   80      1
## 315 26.4        4        140.0         88   2870         18.1   80      1
## 316 24.3        4        151.0         90   3003         20.1   80      1
## 317 19.1        6        225.0         90   3381         18.7   80      1
## 318 34.3        4         97.0         78   2188         15.8   80      2
## 319 29.8        4        134.0         90   2711         15.5   80      3
## 320 31.3        4        120.0         75   2542         17.5   80      3
## 321 37.0        4        119.0         92   2434         15.0   80      3
## 322 32.2        4        108.0         75   2265         15.2   80      3
## 323 46.6        4         86.0         65   2110         17.9   80      3
## 324 27.9        4        156.0        105   2800         14.4   80      1
## 325 40.8        4         85.0         65   2110         19.2   80      3
## 326 44.3        4         90.0         48   2085         21.7   80      2
## 327 43.4        4         90.0         48   2335         23.7   80      2
## 328 36.4        5        121.0         67   2950         19.9   80      2
## 329 30.0        4        146.0         67   3250         21.8   80      2
## 330 44.6        4         91.0         67   1850         13.8   80      3
## 332 33.8        4         97.0         67   2145         18.0   80      3
## 333 29.8        4         89.0         62   1845         15.3   80      2
## 334 32.7        6        168.0        132   2910         11.4   80      3
## 335 23.7        3         70.0        100   2420         12.5   80      3
## 336 35.0        4        122.0         88   2500         15.1   80      2
## 338 32.4        4        107.0         72   2290         17.0   80      3
## 339 27.2        4        135.0         84   2490         15.7   81      1
## 340 26.6        4        151.0         84   2635         16.4   81      1
## 341 25.8        4        156.0         92   2620         14.4   81      1
## 342 23.5        6        173.0        110   2725         12.6   81      1
## 343 30.0        4        135.0         84   2385         12.9   81      1
## 344 39.1        4         79.0         58   1755         16.9   81      3
## 345 39.0        4         86.0         64   1875         16.4   81      1
## 346 35.1        4         81.0         60   1760         16.1   81      3
## 347 32.3        4         97.0         67   2065         17.8   81      3
## 348 37.0        4         85.0         65   1975         19.4   81      3
## 349 37.7        4         89.0         62   2050         17.3   81      3
## 350 34.1        4         91.0         68   1985         16.0   81      3
## 351 34.7        4        105.0         63   2215         14.9   81      1
## 352 34.4        4         98.0         65   2045         16.2   81      1
## 353 29.9        4         98.0         65   2380         20.7   81      1
## 354 33.0        4        105.0         74   2190         14.2   81      2
## 356 33.7        4        107.0         75   2210         14.4   81      3
## 357 32.4        4        108.0         75   2350         16.8   81      3
## 358 32.9        4        119.0        100   2615         14.8   81      3
## 359 31.6        4        120.0         74   2635         18.3   81      3
## 360 28.1        4        141.0         80   3230         20.4   81      2
## 361 30.7        6        145.0         76   3160         19.6   81      2
## 362 25.4        6        168.0        116   2900         12.6   81      3
## 363 24.2        6        146.0        120   2930         13.8   81      3
## 364 22.4        6        231.0        110   3415         15.8   81      1
## 365 26.6        8        350.0        105   3725         19.0   81      1
## 366 20.2        6        200.0         88   3060         17.1   81      1
```

```
## 367 17.6         6        225.0         85   3465         16.6   81      1
## 368 28.0         4        112.0         88   2605         19.6   82      1
## 369 27.0         4        112.0         88   2640         18.6   82      1
## 370 34.0         4        112.0         88   2395         18.0   82      1
## 371 31.0         4        112.0         85   2575         16.2   82      1
## 372 29.0         4        135.0         84   2525         16.0   82      1
## 373 27.0         4        151.0         90   2735         18.0   82      1
## 374 24.0         4        140.0         92   2865         16.4   82      1
## 375 36.0         4        105.0         74   1980         15.3   82      2
## 376 37.0         4         91.0         68   2025         18.2   82      3
## 377 31.0         4         91.0         68   1970         17.6   82      3
## 378 38.0         4        105.0         63   2125         14.7   82      1
## 379 36.0         4         98.0         70   2125         17.3   82      1
## 380 36.0         4        120.0         88   2160         14.5   82      3
## 381 36.0         4        107.0         75   2205         14.5   82      3
## 382 34.0         4        108.0         70   2245         16.9   82      3
## 383 38.0         4         91.0         67   1965         15.0   82      3
## 384 32.0         4         91.0         67   1965         15.7   82      3
## 385 38.0         4         91.0         67   1995         16.2   82      3
## 386 25.0         6        181.0        110   2945         16.4   82      1
## 387 38.0         6        262.0         85   3015         17.0   82      1
## 388 26.0         4        156.0         92   2585         14.5   82      1
## 389 22.0         6        232.0        112   2835         14.7   82      1
## 390 32.0         4        144.0         96   2665         13.9   82      3
## 391 36.0         4        135.0         84   2370         13.0   82      1
## 392 27.0         4        151.0         90   2950         17.3   82      1
## 393 27.0         4        140.0         86   2790         15.6   82      1
## 394 44.0         4         97.0         52   2130         24.6   82      2
## 395 32.0         4        135.0         84   2295         11.6   82      1
## 396 28.0         4        120.0         79   2625         18.6   82      1
## 397 31.0         4        119.0         82   2720         19.4   82      1
##                                     name mpg01
## 1              chevrolet chevelle malibu     0
## 2                      buick skylark 320     0
## 3                     plymouth satellite     0
## 4                          amc rebel sst     0
## 5                            ford torino     0
## 6                       ford galaxie 500     0
## 7                       chevrolet impala     0
## 8                      plymouth fury iii     0
## 9                       pontiac catalina     0
## 10                    amc ambassador dpl     0
## 11                   dodge challenger se     0
## 12                    plymouth 'cuda 340     0
## 13                 chevrolet monte carlo     0
## 14               buick estate wagon (sw)     0
## 15                 toyota corona mark ii     1
## 16                       plymouth duster     0
## 17                            amc hornet     0
## 18                         ford maverick     0
## 19                          datsun pl510     1
## 20          volkswagen 1131 deluxe sedan     1
## 21                            peugeot 504     1
## 22                            audi 100 ls     1
```

```
## 23                            saab 99e     1
## 24                            bmw 2002     1
## 25                          amc gremlin     0
## 26                            ford f250     0
## 27                            chevy c20     0
## 28                           dodge d200     0
## 29                             hi 1200d     0
## 30                          datsun pl510     1
## 31                  chevrolet vega 2300     1
## 32                        toyota corona     1
## 34                          amc gremlin     0
## 35             plymouth satellite custom     0
## 36             chevrolet chevelle malibu     0
## 37                       ford torino 500     0
## 38                           amc matador     0
## 39                     chevrolet impala     0
## 40             pontiac catalina brougham     0
## 41                       ford galaxie 500     0
## 42                      plymouth fury iii     0
## 43                      dodge monaco (sw)     0
## 44               ford country squire (sw)     0
## 45                    pontiac safari (sw)     0
## 46             amc hornet sportabout (sw)     0
## 47                    chevrolet vega (sw)     0
## 48                       pontiac firebird     0
## 49                           ford mustang     0
## 50                     mercury capri 2000     1
## 51                              opel 1900     1
## 52                            peugeot 304     1
## 53                              fiat 124b     1
## 54                  toyota corolla 1200     1
## 55                              datsun 1200     1
## 56                  volkswagen model 111     1
## 57                      plymouth cricket     1
## 58                  toyota corona hardtop     1
## 59                     dodge colt hardtop     1
## 60                     volkswagen type 3     1
## 61                         chevrolet vega     0
## 62                    ford pinto runabout     0
## 63                       chevrolet impala     0
## 64                       pontiac catalina     0
## 65                      plymouth fury iii     0
## 66                       ford galaxie 500     0
## 67                     amc ambassador sst     0
## 68                        mercury marquis     0
## 69                   buick lesabre custom     0
## 70              oldsmobile delta 88 royale     0
## 71                  chrysler newport royal     0
## 72                           mazda rx2 coupe     0
## 73                         amc matador (sw)     0
## 74      chevrolet chevelle concours (sw)     0
## 75                  ford gran torino (sw)     0
## 76         plymouth satellite custom (sw)     0
## 77                          volvo 145e (sw)     0
```

```
## 78                  volkswagen 411 (sw)     0
## 79                     peugeot 504 (sw)     0
## 80                      renault 12 (sw)     1
## 81                      ford pinto (sw)     0
## 82                      datsun 510 (sw)     1
## 83           toyouta corona mark ii (sw)    1
## 84                      dodge colt (sw)     1
## 85              toyota corolla 1600 (sw)    1
## 86                    buick century 350     0
## 87                         amc matador     0
## 88                    chevrolet malibu     0
## 89                    ford gran torino     0
## 90                dodge coronet custom     0
## 91              mercury marquis brougham    0
## 92             chevrolet caprice classic    0
## 93                           ford ltd     0
## 94              plymouth fury gran sedan    0
## 95          chrysler new yorker brougham    0
## 96              buick electra 225 custom    0
## 97               amc ambassador brougham    0
## 98                    plymouth valiant     0
## 99                 chevrolet nova custom    0
## 100                        amc hornet     0
## 101                     ford maverick     0
## 102                    plymouth duster     1
## 103              volkswagen super beetle    1
## 104                    chevrolet impala     0
## 105                       ford country     0
## 106              plymouth custom suburb     0
## 107             oldsmobile vista cruiser    0
## 108                        amc gremlin     0
## 109                     toyota carina     0
## 110                    chevrolet vega     0
## 111                        datsun 610     0
## 112                         maxda rx3     0
## 113                        ford pinto     0
## 114                    mercury capri v6     0
## 115                fiat 124 sport coupe     1
## 116             chevrolet monte carlo s     0
## 117                  pontiac grand prix     0
## 118                            fiat 128     1
## 119                         opel manta     1
## 120                         audi 100ls     0
## 121                        volvo 144ea     0
## 122                   dodge dart custom     0
## 123                           saab 99le     1
## 124                      toyota mark ii     0
## 125                    oldsmobile omega     0
## 126                     plymouth duster     0
## 128                          amc hornet     0
## 129                      chevrolet nova     0
## 130                         datsun b210     1
## 131                          ford pinto     1
## 132                 toyota corolla 1200     1
```

```
## 133                       chevrolet vega     1
## 134    chevrolet chevelle malibu classic     0
## 135                           amc matador     0
## 136           plymouth satellite sebring     0
## 137                     ford gran torino     0
## 138              buick century luxus (sw)     0
## 139             dodge coronet custom (sw)     0
## 140                 ford gran torino (sw)     0
## 141                       amc matador (sw)     0
## 142                               audi fox     1
## 143                     volkswagen dasher     1
## 144                             opel manta     1
## 145                         toyota corona     1
## 146                            datsun 710     1
## 147                            dodge colt     1
## 148                              fiat 128     1
## 149                           fiat 124 tc     1
## 150                           honda civic     1
## 151                                subaru     1
## 152                            fiat x1.9     1
## 153              plymouth valiant custom     0
## 154                       chevrolet nova     0
## 155                      mercury monarch     0
## 156                        ford maverick     0
## 157                     pontiac catalina     0
## 158                    chevrolet bel air     0
## 159                  plymouth grand fury     0
## 160                               ford ltd     0
## 161                         buick century     0
## 162            chevroelt chevelle malibu     0
## 163                           amc matador     0
## 164                          plymouth fury     0
## 165                          buick skyhawk     0
## 166                  chevrolet monza 2+2     0
## 167                      ford mustang ii     0
## 168                        toyota corolla     1
## 169                            ford pinto     1
## 170                           amc gremlin     0
## 171                         pontiac astro     1
## 172                         toyota corona     1
## 173                     volkswagen dasher     1
## 174                               datsun 710     1
## 175                               ford pinto     0
## 176                     volkswagen rabbit     1
## 177                               amc pacer     0
## 178                               audi 100ls     1
## 179                             peugeot 504     1
## 180                             volvo 244dl     0
## 181                               saab 99le     1
## 182                      honda civic cvcc     1
## 183                               fiat 131     1
## 184                               opel 1900     1
## 185                                capri ii     1
## 186                             dodge colt     1
```

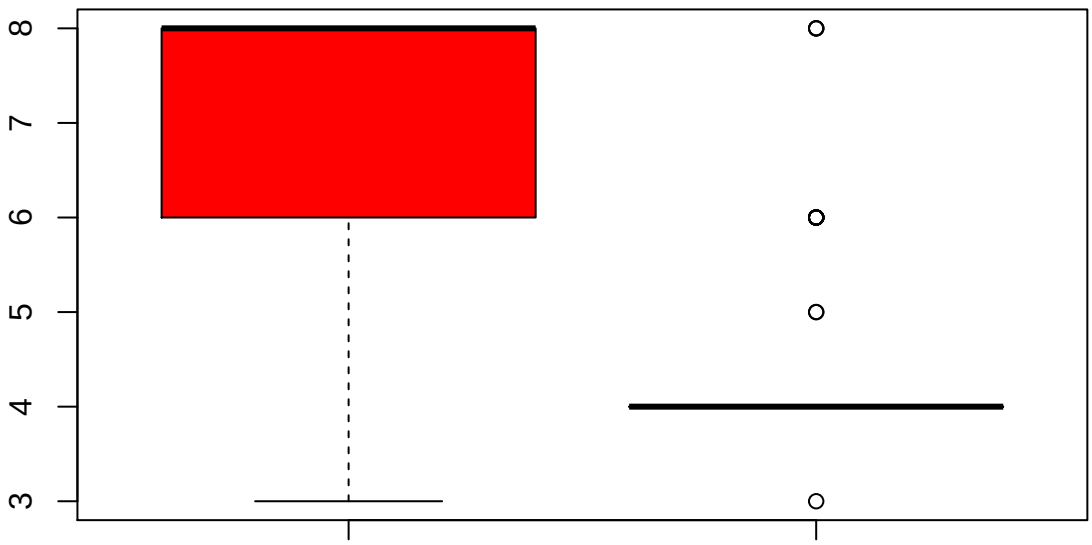
```
## 187                         renault 12tl     1
## 188    chevrolet chevelle malibu classic     0
## 189               dodge coronet brougham     0
## 190                           amc matador     0
## 191                      ford gran torino     0
## 192                      plymouth valiant     0
## 193                        chevrolet nova     0
## 194                        ford maverick     1
## 195                           amc hornet     0
## 196                    chevrolet chevette     1
## 197                       chevrolet woody     1
## 198                             vw rabbit     1
## 199                           honda civic     1
## 200                       dodge aspen se     0
## 201                     ford granada ghia     0
## 202                    pontiac ventura sj     0
## 203                         amc pacer d/l     0
## 204                     volkswagen rabbit     1
## 205                          datsun b-210     1
## 206                        toyota corolla     1
## 207                            ford pinto     1
## 208                             volvo 245     0
## 209          plymouth volare premier v8     0
## 210                           peugeot 504     0
## 211                        toyota mark ii     0
## 212                    mercedes-benz 280s     0
## 213                      cadillac seville     0
## 214                             chevy c10     0
## 215                             ford f108     0
## 216                            dodge d100     0
## 217                     honda accord cvcc     1
## 218               buick opel isuzu deluxe     1
## 219                          renault 5 gtl     1
## 220                     plymouth arrow gs     1
## 221                  datsun f-10 hatchback     1
## 222             chevrolet caprice classic     0
## 223           oldsmobile cutlass supreme     0
## 224                dodge monaco brougham     0
## 225               mercury cougar brougham     0
## 226                     chevrolet concours     0
## 227                          buick skylark     0
## 228                plymouth volare custom     0
## 229                            ford granada     0
## 230                  pontiac grand prix lj     0
## 231          chevrolet monte carlo landau     0
## 232                       chrysler cordoba     0
## 233                     ford thunderbird     0
## 234               volkswagen rabbit custom     1
## 235                  pontiac sunbird coupe     1
## 236                toyota corolla liftback     1
## 237                    ford mustang ii 2+2     1
## 238                     chevrolet chevette     1
## 239                         dodge colt m/m     1
## 240                              subaru dl     1
```

```
## 241                    volkswagen dasher     1
## 242                           datsun 810     0
## 243                             bmw 320i     0
## 244                           mazda rx-4     0
## 245     volkswagen rabbit custom diesel     1
## 246                           ford fiesta     1
## 247                     mazda glc deluxe     1
## 248                       datsun b210 gx     1
## 249                     honda civic cvcc     1
## 250   oldsmobile cutlass salon brougham     0
## 251                       dodge diplomat     0
## 252                  mercury monarch ghia     0
## 253                    pontiac phoenix lj     0
## 254                      chevrolet malibu     0
## 255                  ford fairmont (auto)     0
## 256                   ford fairmont (man)     1
## 257                       plymouth volare     0
## 258                           amc concord     0
## 259                 buick century special     0
## 260                        mercury zephyr     0
## 261                           dodge aspen     0
## 262                       amc concord d/l     0
## 263        chevrolet monte carlo landau     0
## 264     buick regal sport coupe (turbo)     0
## 265                           ford futura     0
## 266                       dodge magnum xe     0
## 267                    chevrolet chevette     1
## 268                          toyota corona     1
## 269                             datsun 510     1
## 270                             dodge omni     1
## 271           toyota celica gt liftback     0
## 272                     plymouth sapporo     1
## 273                oldsmobile starfire sx     1
## 274                           datsun 200-sx     1
## 275                               audi 5000     0
## 276                             volvo 264gl     0
## 277                              saab 99gle     0
## 278                            peugeot 604sl     0
## 279                  volkswagen scirocco     1
## 280                       honda accord lx     1
## 281                     pontiac lemans v6     0
## 282                      mercury zephyr 6     0
## 283                       ford fairmont 4     0
## 284                      amc concord dl 6     0
## 285                         dodge aspen 6     0
## 286           chevrolet caprice classic     0
## 287                       ford ltd landau     0
## 288                 mercury grand marquis     0
## 289                       dodge st. regis     0
## 290                buick estate wagon (sw)     0
## 291              ford country squire (sw)     0
## 292          chevrolet malibu classic (sw)     0
## 293 chrysler lebaron town @ country (sw)     0
## 294                       vw rabbit custom     1
```

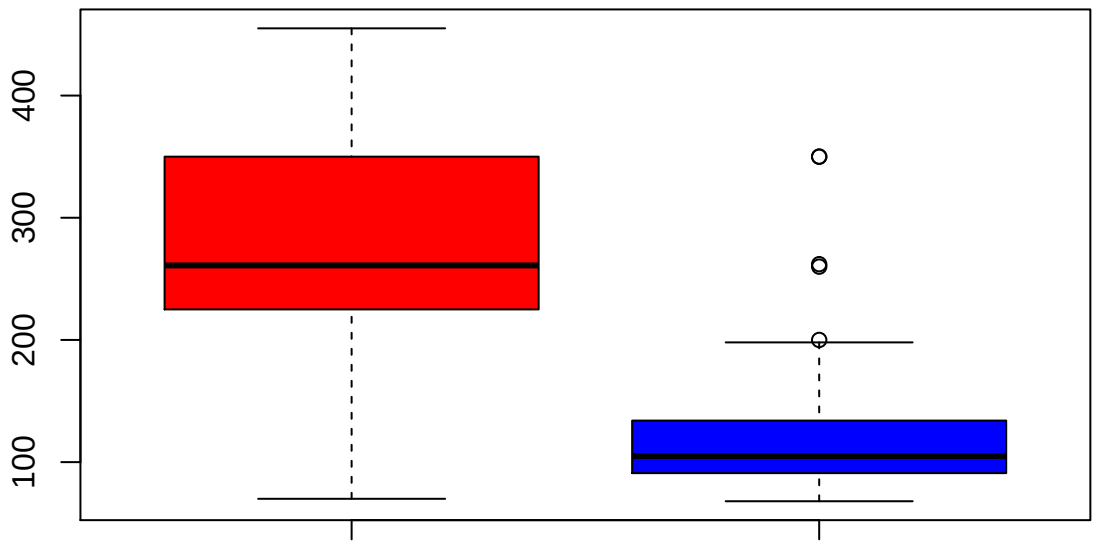
```
## 295                    maxda glc deluxe     1
## 296          dodge colt hatchback custom     1
## 297                       amc spirit dl     1
## 298                  mercedes benz 300d     1
## 299                   cadillac eldorado     1
## 300                        peugeot 504     1
## 301    oldsmobile cutlass salon brougham     1
## 302                     plymouth horizon     1
## 303                 plymouth horizon tc3     1
## 304                           datsun 210     1
## 305                  fiat strada custom     1
## 306                buick skylark limited     1
## 307                  chevrolet citation     1
## 308           oldsmobile omega brougham     1
## 309                     pontiac phoenix     1
## 310                           vw rabbit     1
## 311                toyota corolla tercel     1
## 312                   chevrolet chevette     1
## 313                           datsun 310     1
## 314                  chevrolet citation     1
## 315                       ford fairmont     1
## 316                         amc concord     1
## 317                         dodge aspen     0
## 318                           audi 4000     1
## 319               toyota corona liftback     1
## 320                         mazda 626     1
## 321                 datsun 510 hatchback     1
## 322                       toyota corolla     1
## 323                           mazda glc     1
## 324                         dodge colt     1
## 325                         datsun 210     1
## 326                 vw rabbit c (diesel)     1
## 327                   vw dasher (diesel)     1
## 328                  audi 5000s (diesel)     1
## 329                  mercedes-benz 240d     1
## 330                  honda civic 1500 gl     1
## 332                            subaru dl     1
## 333                    vokswagen rabbit     1
## 334                       datsun 280-zx     1
## 335                       mazda rx-7 gs     1
## 336                    triumph tr7 coupe     1
## 338                         honda accord     1
## 339                     plymouth reliant     1
## 340                       buick skylark     1
## 341               dodge aries wagon (sw)     1
## 342                   chevrolet citation     1
## 343                     plymouth reliant     1
## 344                       toyota starlet     1
## 345                       plymouth champ     1
## 346                     honda civic 1300     1
## 347                              subaru     1
## 348                       datsun 210 mpg     1
## 349                       toyota tercel     1
## 350                         mazda glc 4     1
```

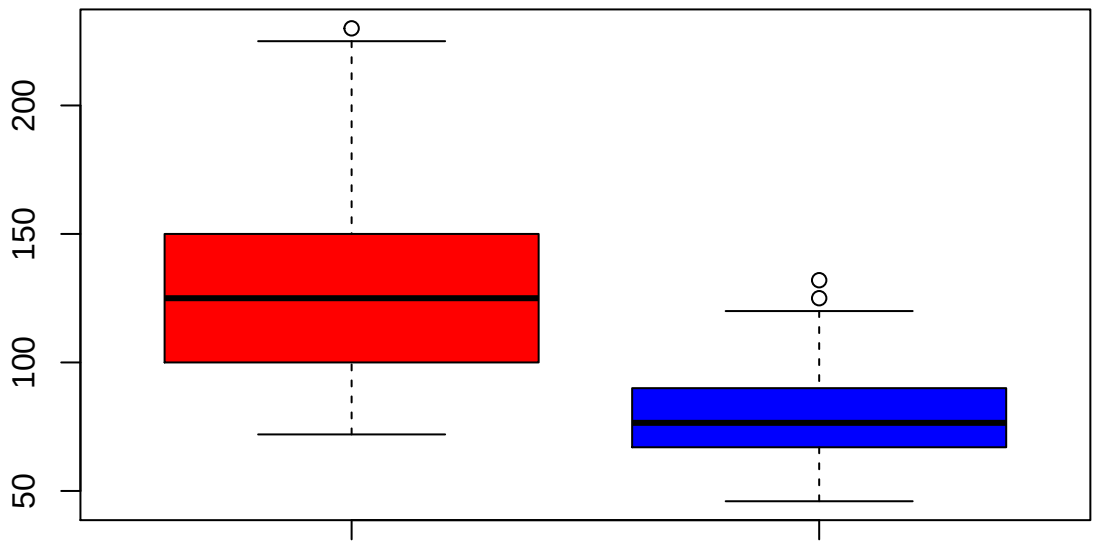
```
## 351                   plymouth horizon 4     1
## 352                       ford escort 4w     1
## 353                       ford escort 2h     1
## 354                     volkswagen jetta     1
## 356                        honda prelude     1
## 357                       toyota corolla     1
## 358                         datsun 200sx     1
## 359                            mazda 626     1
## 360            peugeot 505s turbo diesel     1
## 361                          volvo diesel     1
## 362                     toyota cressida     1
## 363                    datsun 810 maxima     1
## 364                        buick century     0
## 365                oldsmobile cutlass ls     1
## 366                      ford granada gl     0
## 367               chrysler lebaron salon     0
## 368                   chevrolet cavalier     1
## 369             chevrolet cavalier wagon     1
## 370            chevrolet cavalier 2-door     1
## 371          pontiac j2000 se hatchback     1
## 372                        dodge aries se     1
## 373                      pontiac phoenix     1
## 374                ford fairmont futura     1
## 375                 volkswagen rabbit l     1
## 376                 mazda glc custom l     1
## 377                   mazda glc custom     1
## 378               plymouth horizon miser     1
## 379                       mercury lynx l     1
## 380                     nissan stanza xe     1
## 381                         honda accord     1
## 382                       toyota corolla     1
## 383                          honda civic     1
## 384                   honda civic (auto)     1
## 385                        datsun 310 gx     1
## 386                buick century limited     1
## 387    oldsmobile cutlass ciera (diesel)     1
## 388           chrysler lebaron medallion     1
## 389                       ford granada l     0
## 390                     toyota celica gt     1
## 391                    dodge charger 2.2     1
## 392                     chevrolet camaro     1
## 393                      ford mustang gl     1
## 394                            vw pickup     1
## 395                       dodge rampage     1
## 396                         ford ranger     1
## 397                          chevy s-10     1
```

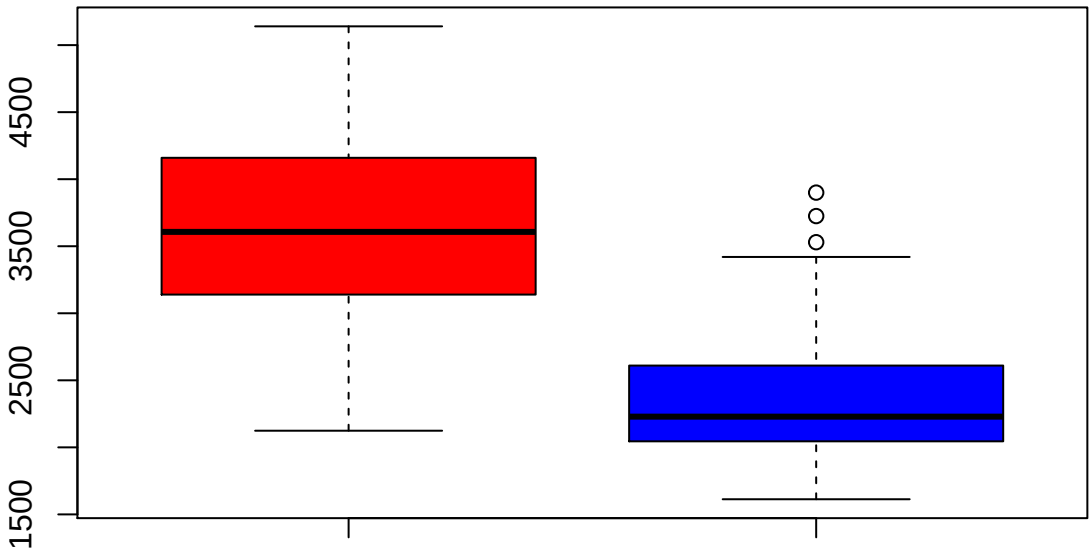
```
for (i in 2:8) {
  boxplot(Auto[Auto$mpg01==0,i], Auto[Auto$mpg01==1,i],col=c('red','blue'),xlab='mpg 0 mpg 1')
}
```

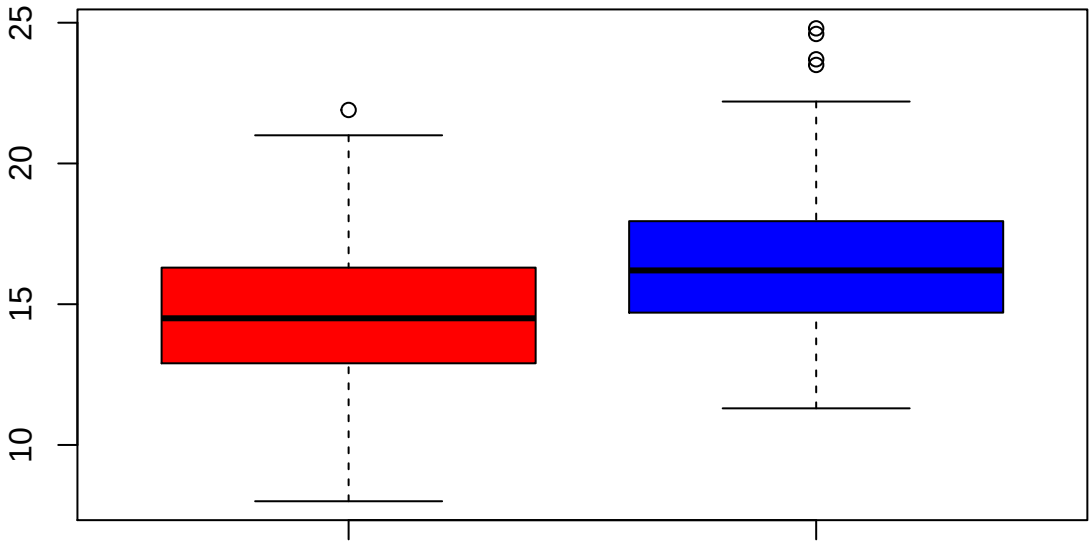


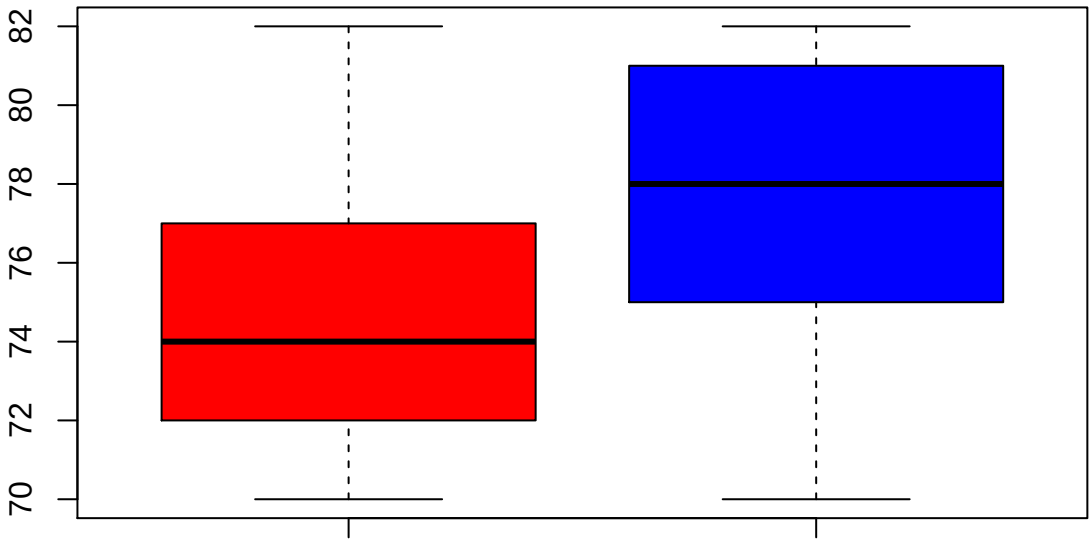
mpg 0 mpg 1

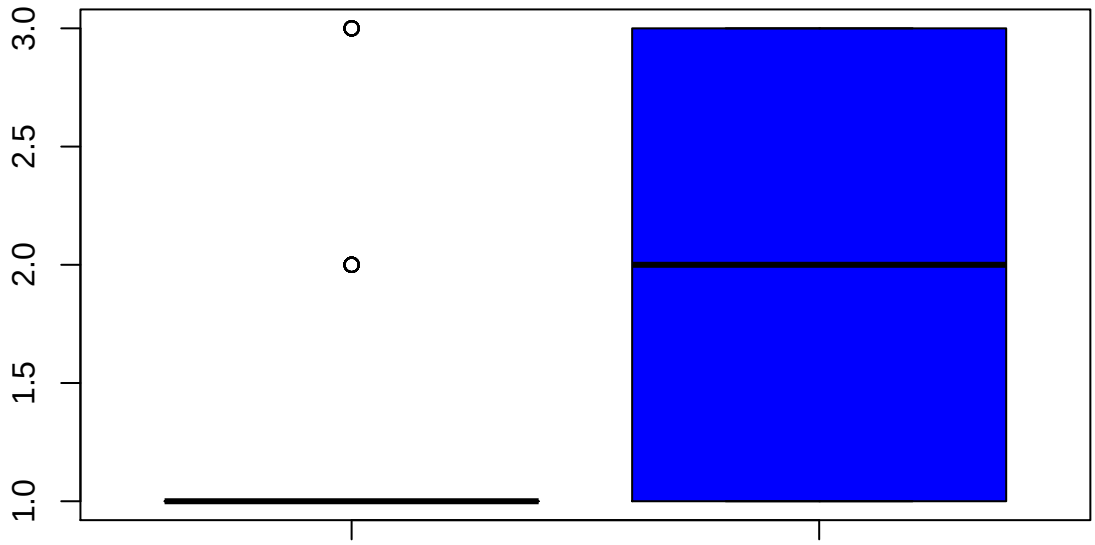

100
200
300
400
mpg 0 mpg 1


200
150
100
50
mpg 0 mpg 1

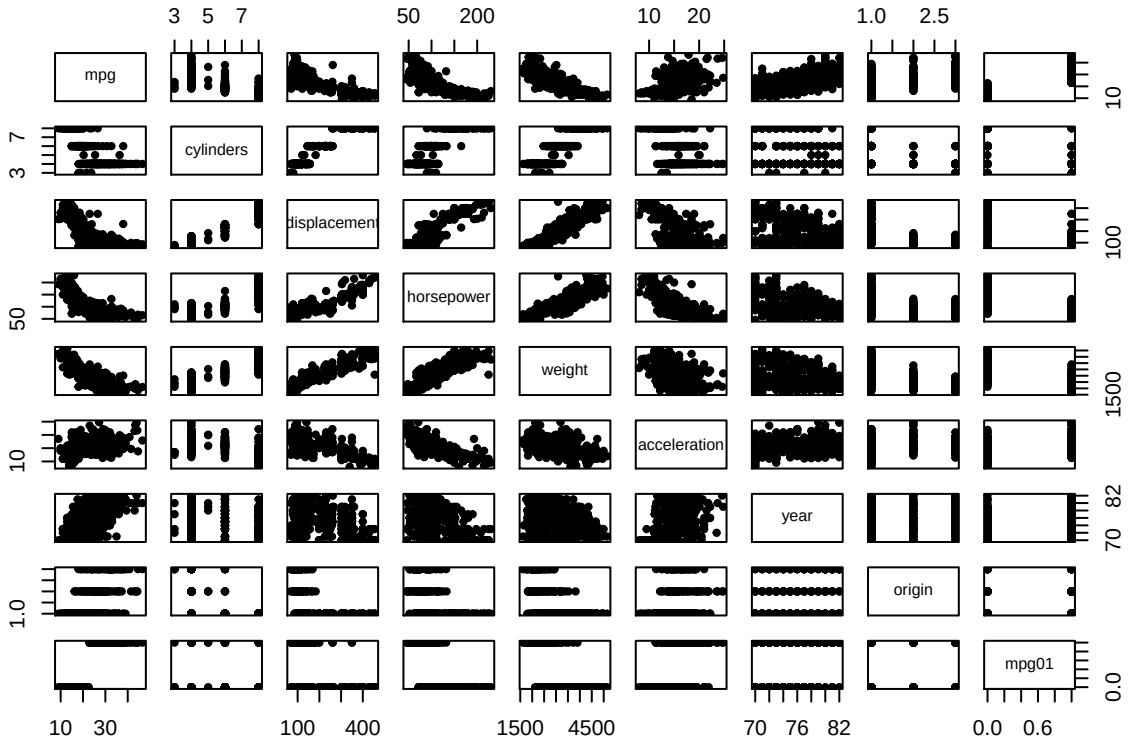

4500
3500
2500
1500
mpg 0 mpg 1


25
20
15
10
mpg 0 mpg 1


82
80
78
76
74
72
70
mpg 0 mpg 1




```
Auto_scat = as.matrix(Auto[,-9])
pairs(Auto_scat,pch = 20)
```



We determined that cylinders, displacement, horsepower, weight, and year would be the most useful in predicting mpg01. Acceleration was too similar to use and origin was not indicative at all.

```
train_size = 300
test_size = 92
n = dim(Auto)[1]
train_ind = sample(1:n, train_size, replace=FALSE)
test_ind = (1:n)[-train_ind]
Auto_train = Auto[train_ind,]
Auto_test = Auto[test_ind,]

mpg1_TR = Auto_train[Auto_train$mpg01 == "1",c(2,3,4,5,7)]
mpg0_TR = Auto_train[Auto_train$mpg01 == "0",c(2,3,4,5,7)]
n1_TR = dim(mpg1_TR)[1]
n0_TR = dim(mpg0_TR)[1]
N_TR = n1_TR + n0_TR
N_TR
```

```
## [1] 300
```

```
mpg1_p = n1_TR/N_TR
mpg0_p = n0_TR/N_TR
```

```
mpg1_mu = colMeans(mpg1_TR)
mpg0_mu = colMeans(mpg0_TR)
rbind(mpg1_mu,mpg0_mu)
```

```
##         cylinders displacement horsepower   weight     year
## mpg1_mu  4.149660     114.5748   78.58503 2320.755 77.53061
## mpg0_mu  6.816993     275.4052  131.20915 3635.314 74.43137
```

```
mpg1_S = cov(mpg1_TR)
mpg0_S = cov(mpg0_TR)
S_pool = ((n1_TR-1)*mpg1_S + (n0_TR-1)*mpg0_S)/(n1_TR + n0_TR - 1)
S_pool
```

```
##                cylinders displacement  horsepower       weight        year
## cylinders      1.1892418     66.78495    22.11701    453.68954  -0.1558362
## displacement  66.7849503   4736.87476  1604.89497  31710.09279 -19.6524476
## horsepower    22.1170082   1604.89497   831.52172  11718.48837 -20.0616608
## weight       453.6895387  31710.09279 11718.48837 304401.67935  21.0414587
## year          -0.1558362    -19.65245   -20.06166     21.04146  11.1576644
```

```
S_inv = solve(S_pool)
mpg1_alpha = -0.5*t(mpg1_mu) %*% S_inv %*% mpg1_mu + log(mpg1_p)
mpg0_alpha = -0.5*t(mpg0_mu) %*% S_inv %*% mpg0_mu + log(mpg0_p)
mpg01_alpha = c(mpg1_alpha,mpg0_alpha)
mpg01_alpha
```

```
## [1] -317.0845 -307.9987
```

```
mpg1_beta = S_inv %*% mpg1_mu
mpg0_beta = S_inv %*% mpg0_mu
mpg01_beta = cbind(mpg1_beta,mpg0_beta)
mpg01_beta
```

```
##                      [,1]         [,2]
## cylinders     7.610835856  9.231858269
## displacement -0.213587756 -0.215906733
## horsepower    0.511437650  0.481771086
## weight       -0.001683751  0.001624404
## year          7.601487939  7.282696475
```

```
prediction = c()
mpg1_dvec = c()
mpg0_dvec = c()
label = c("1","0")
for(i in 1:nrow(Auto_test)){
  x = t(Auto_test[i,c(2,3,4,5,7)])
  mpg1_d = mpg1_alpha + t(mpg1_beta) %*% x
  mpg0_d = mpg0_alpha + t(mpg0_beta) %*% x
  dvec = c(mpg1_d,mpg0_d)
  prediction = append(prediction, label[which.max(dvec)])
  mpg1_dvec = append(mpg1_dvec,mpg1_d)
  mpg0_dvec = append(mpg0_dvec,mpg0_d)
}

Auto_test$prediction = prediction
```

```
Auto_test
```

```
##      mpg cylinders displacement horsepower weight acceleration year origin
## 5   17.0         8          302        140   3449         10.5   70      1
## 7   14.0         8          454        220   4354          9.0   70      1
## 10  15.0         8          390        190   3850          8.5   70      1
## 16  22.0         6          198         95   2833         15.5   70      1
## 22  24.0         4          107         90   2430         14.5   70      2
## 37  19.0         6          250         88   3302         15.5   71      1
## 45  13.0         8          400        175   5140         12.0   71      1
## 46  18.0         6          258        110   2962         13.5   71      1
## 48  19.0         6          250        100   3282         15.0   71      1
## 52  30.0         4           79         70   2074         19.5   71      2
## 53  30.0         4           88         76   2065         14.5   71      2
## 55  35.0         4           72         69   1613         18.0   71      3
## 57  26.0         4           91         70   1955         20.5   71      1
## 61  20.0         4          140         90   2408         19.5   72      1
## 66  14.0         8          351        153   4129         13.0   72      1
## 67  17.0         8          304        150   3672         11.5   72      1
## 68  11.0         8          429        208   4633         11.0   72      1
## 72  19.0         3           70         97   2330         13.5   72      3
## 80  26.0         4           96         69   2189         18.0   72      2
## 81  22.0         4          122         86   2395         16.0   72      1
## 90  15.0         8          318        150   3777         12.5   73      1
## 91  12.0         8          429        198   4952         11.5   73      1
## 94  14.0         8          318        150   4237         14.5   73      1
## 106 13.0         8          360        170   4654         13.0   73      1
## 108 18.0         6          232        100   2789         15.0   73      1
## 111 22.0         4          108         94   2379         16.5   73      3
## 115 26.0         4           98         90   2265         15.5   73      2
## 116 15.0         8          350        145   4082         13.0   73      1
## 119 24.0         4          116         75   2158         15.5   73      2
## 122 15.0         8          318        150   3399         11.0   73      1
## 142 29.0         4           98         83   2219         16.5   74      2
## 147 28.0         4           90         75   2125         14.5   74      1
## 151 26.0         4          108         93   2391         15.5   74      3
## 152 31.0         4           79         67   2000         16.0   74      2
## 154 18.0         6          250        105   3459         16.0   75      1
## 155 15.0         6          250         72   3432         21.0   75      1
## 160 14.0         8          351        148   4657         13.5   75      1
## 161 17.0         6          231        110   3907         21.0   75      1
## 164 18.0         6          225         95   3785         19.0   75      1
## 165 21.0         6          231        110   3039         15.0   75      1
## 172 24.0         4          134         96   2702         13.5   75      3
## 177 19.0         6          232         90   3211         17.0   75      1
## 188 17.5         8          305        140   4215         13.0   76      1
## 192 22.0         6          225        100   3233         15.4   76      1
## 194 24.0         6          200         81   3012         17.6   76      1
## 213 16.5         8          350        180   4380         12.1   76      1
## 219 36.0         4           79         58   1825         18.6   77      2
## 220 25.5         4          122         96   2300         15.5   77      1
## 221 33.5         4           85         70   1945         16.8   77      3
## 223 17.0         8          260        110   4060         19.0   77      1
```

```
## 226 17.5         6          250        110   3520         16.4   77      1
## 228 19.0         6          225        100   3630         17.7   77      1
## 235 24.5         4          151         88   2740         16.0   77      1
## 237 25.5         4          140         89   2755         15.8   77      1
## 243 21.5         4          121        110   2600         12.8   77      2
## 245 43.1         4           90         48   1985         21.5   78      2
## 246 36.1         4           98         66   1800         14.4   78      1
## 247 32.8         4           78         52   1985         19.4   78      3
## 256 25.1         4          140         88   2720         15.4   78      1
## 260 20.8         6          200         85   3070         16.7   78      1
## 261 18.6         6          225        110   3620         18.7   78      1
## 268 27.5         4          134         95   2560         14.2   78      3
## 273 23.8         4          151         85   2855         17.6   78      1
## 278 16.2         6          163        133   3410         15.8   78      2
## 279 31.5         4           89         71   1990         14.9   78      2
## 280 29.5         4           98         68   2135         16.6   78      3
## 283 22.3         4          140         88   2890         17.3   79      1
## 289 18.2         8          318        135   3830         15.2   79      1
## 292 19.2         8          267        125   3605         15.0   79      1
## 297 27.4         4          121         80   2670         15.0   79      1
## 301 23.9         8          260         90   3420         22.2   79      1
## 308 26.8         6          173        115   2700         12.9   79      1
## 316 24.3         4          151         90   3003         20.1   80      1
## 320 31.3         4          120         75   2542         17.5   80      3
## 325 40.8         4           85         65   2110         19.2   80      3
## 326 44.3         4           90         48   2085         21.7   80      2
## 327 43.4         4           90         48   2335         23.7   80      2
## 334 32.7         6          168        132   2910         11.4   80      3
## 335 23.7         3           70        100   2420         12.5   80      3
## 339 27.2         4          135         84   2490         15.7   81      1
## 341 25.8         4          156         92   2620         14.4   81      1
## 354 33.0         4          105         74   2190         14.2   81      2
## 363 24.2         6          146        120   2930         13.8   81      3
## 369 27.0         4          112         88   2640         18.6   82      1
## 379 36.0         4           98         70   2125         17.3   82      1
## 384 32.0         4           91         67   1965         15.7   82      3
## 385 38.0         4           91         67   1995         16.2   82      3
## 387 38.0         6          262         85   3015         17.0   82      1
## 388 26.0         4          156         92   2585         14.5   82      1
## 389 22.0         6          232        112   2835         14.7   82      1
## 393 27.0         4          140         86   2790         15.6   82      1
## 394 44.0         4           97         52   2130         24.6   82      2
##                                    name mpg01 prediction
## 5                         ford torino     0          0
## 7                       chevrolet impala     0          0
## 10                    amc ambassador dpl     0          0
## 16                      plymouth duster     0          0
## 22                          audi 100 ls     1          1
## 37                       ford torino 500     0          0
## 45                   pontiac safari (sw)     0          0
## 46           amc hornet sportabout (sw)     0          0
## 48                     pontiac firebird     0          0
## 52                          peugeot 304     1          1
## 53                            fiat 124b     1          1
```

```
## 55                       datsun 1200     1          1
## 57                   plymouth cricket     1          1
## 61                     chevrolet vega     0          1
## 66                   ford galaxie 500     0          0
## 67                 amc ambassador sst     0          0
## 68                    mercury marquis     0          0
## 72                    mazda rx2 coupe     0          1
## 80                    renault 12 (sw)     1          1
## 81                    ford pinto (sw)     0          1
## 90               dodge coronet custom     0          0
## 91            mercury marquis brougham     0          0
## 94            plymouth fury gran sedan     0          0
## 106             plymouth custom suburb     0          0
## 108                        amc gremlin     0          0
## 111                        datsun 610     0          1
## 115               fiat 124 sport coupe     1          1
## 116            chevrolet monte carlo s     0          0
## 119                        opel manta     1          1
## 122                 dodge dart custom     0          0
## 142                          audi fox     1          1
## 147                        dodge colt     1          1
## 151                            subaru     1          1
## 152                         fiat x1.9     1          1
## 154                    chevrolet nova     0          0
## 155                   mercury monarch     0          0
## 160                          ford ltd     0          0
## 161                    buick century     0          0
## 164                    plymouth fury     0          0
## 165                    buick skyhawk     0          0
## 172                    toyota corona     1          1
## 177                        amc pacer     0          0
## 188 chevrolet chevelle malibu classic     0          0
## 192                  plymouth valiant     0          0
## 194                     ford maverick     1          0
## 213                  cadillac seville     0          0
## 219                     renault 5 gtl     1          1
## 220                 plymouth arrow gs     1          1
## 221              datsun f-10 hatchback     1          1
## 223        oldsmobile cutlass supreme     0          0
## 226                 chevrolet concours     0          0
## 228             plymouth volare custom     0          0
## 235              pontiac sunbird coupe     1          1
## 237                ford mustang ii 2+2     1          1
## 243                            bmw 320i     0          1
## 245   volkswagen rabbit custom diesel     1          1
## 246                        ford fiesta     1          1
## 247                   mazda glc deluxe     1          1
## 256                ford fairmont (man)     1          1
## 260                     mercury zephyr     0          0
## 261                        dodge aspen     0          0
## 268                    toyota corona     1          1
## 273             oldsmobile starfire sx     1          1
## 278                      peugeot 604sl     0          0
## 279                volkswagen scirocco     1          1
```

```
## 280                   honda accord lx     1          1
## 283                   ford fairmont 4     0          1
## 289                   dodge st. regis     0          0
## 292     chevrolet malibu classic (sw)     0          0
## 297                     amc spirit dl     1          1
## 301 oldsmobile cutlass salon brougham     1          0
## 308         oldsmobile omega brougham     1          1
## 316                       amc concord     1          1
## 320                         mazda 626     1          1
## 325                        datsun 210     1          1
## 326              vw rabbit c (diesel)     1          1
## 327                vw dasher (diesel)     1          1
## 334                     datsun 280-zx     1          1
## 335                     mazda rx-7 gs     1          1
## 339                  plymouth reliant     1          1
## 341            dodge aries wagon (sw)     1          1
## 354                  volkswagen jetta     1          1
## 363                 datsun 810 maxima     1          1
## 369          chevrolet cavalier wagon     1          1
## 379                    mercury lynx l     1          1
## 384                honda civic (auto)     1          1
## 385                     datsun 310 gx     1          1
## 387 oldsmobile cutlass ciera (diesel)     1          1
## 388        chrysler lebaron medallion     1          1
## 389                    ford granada l     0          1
## 393                   ford mustang gl     1          1
## 394                         vw pickup     1          1
```

```
Correct1 = 0
Incorrect1 = 0
Correct0 = 0
Incorrect0 = 0
for(i in 1:92){
  if(Auto_test[i,10] == 1){
    if(Auto_test[i,10]== Auto_test[i,11]){
      Correct1 = Correct1 + 1
    }
    if(Auto_test[i,10] != Auto_test[i,11]){
      Incorrect1 = Incorrect1 + 1
    }

  }
  if(Auto_test[i,10] == 0){
    if(Auto_test[i,10]== Auto_test[i,11]){
      Correct0 = Correct0 + 1
    }
    if(Auto_test[i,10] != Auto_test[i,11]){
      Incorrect0 = Incorrect0 + 1
    }

  }
}
```

```
Table1 = rbind(Correct1 + Incorrect1,Correct1,Incorrect1)
Table0 = rbind(Correct0 + Incorrect0,Correct0,Incorrect0)
Table_full = cbind(Table1,Table0)

colnames(Table_full) = c("mpg1","mpg0")
rownames(Table_full) = c("Number of Observations","Correct","Incorrect")
Table_full
```

```
##                         mpg1 mpg0
## Number of Observations   49   43
## Correct                  47   36
## Incorrect                 2    7
```

Results and Conclusions

We used horsepower, weight, number of cylinders, displacement, and acceleration to predict if the mpg for the automobile is higher or lower than the median. Using these variables we constructed linear discrimination functions used to predict the mpg01 of the automobile. Out of the 90 test samples, we correctly predicted 81 of the samples which is a 88.04% accuracy rate. 40 of the samples were correctly predicted to have a mpg greater than or equal to the median and 41 of the samples were correctly predicted to have a mpg less than the median. We incorrectly predicted 8 sample had lower mpg than the median when it actually had a higher mpg. We also incorrectly predicted 3 samples had higher mpg than the median when they actually had a lower mpg.