Laporan Praktikum 3 AMP

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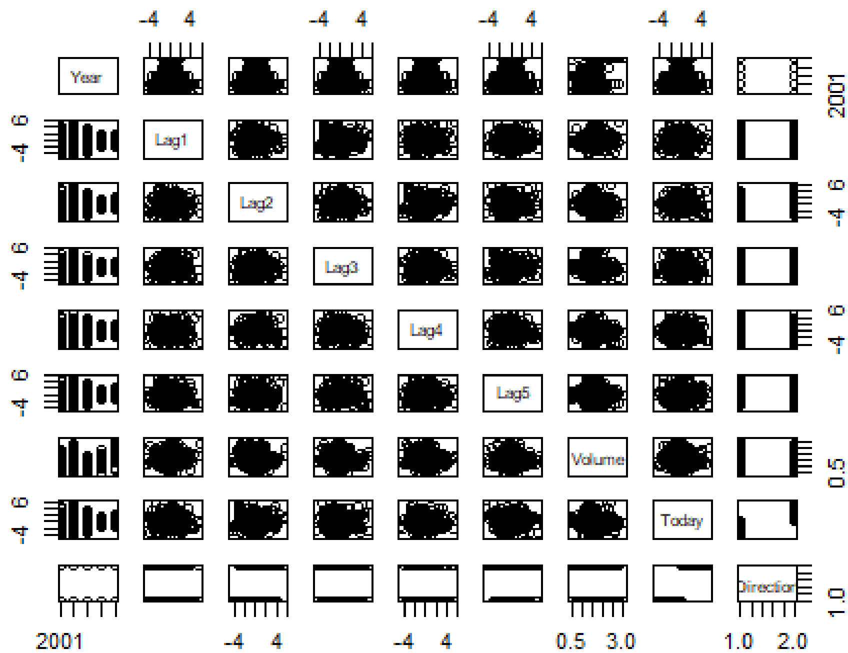
Classification Methods

The Stock Market Data

```
library(ISLR2)

## Warning: package 'ISLR2' was built under R version 4.3.3

names(Smarket)

## [1] "Year"      "Lag1"      "Lag2"      "Lag3"      "Lag4"      "Lag5"
## [7] "Volume"    "Today"     "Direction"

dim(Smarket)

## [1] 1250    9

summary(Smarket)

##       Year           Lag1                Lag2                Lag3          
##  Min.   :2001   Min.   :-4.922000   Min.   :-4.922000   Min.   :-4.922000  
##  1st Qu.:2002   1st Qu.:-0.639500   1st Qu.:-0.639500   1st Qu.:-0.640000  
##  Median :2003   Median : 0.039000   Median : 0.039000   Median : 0.038500  
##  Mean   :2003   Mean   : 0.003834   Mean   : 0.003919   Mean   : 0.001716  
##  3rd Qu.:2004   3rd Qu.: 0.596750   3rd Qu.: 0.596750   3rd Qu.: 0.596750  
##  Max.   :2005   Max.   : 5.733000   Max.   : 5.733000   Max.   : 5.733000  
##       Lag4                Lag5              Volume           Today          
##  Min.   :-4.922000   Min.   :-4.92200   Min.   :0.3561   Min.   :-4.922000  
##  1st Qu.:-0.640000   1st Qu.:-0.64000   1st Qu.:1.2574   1st Qu.:-0.639500  
##  Median : 0.038500   Median : 0.03850   Median :1.4229   Median : 0.038500  
##  Mean   : 0.001636   Mean   : 0.00561   Mean   :1.4783   Mean   : 0.003138  
##  3rd Qu.: 0.596750   3rd Qu.: 0.59700   3rd Qu.:1.6417   3rd Qu.: 0.596750  
##  Max.   : 5.733000   Max.   : 5.73300   Max.   :3.1525   Max.   : 5.733000  
##  Direction 
##  Down:602  
##  Up  :648  
##            
##            
##            
##            
```

```r
pairs(Smarket)
```



Keterangan :

Melakukan eksplorasi awal terhadap data untuk memahami struktur dan distribusinya.

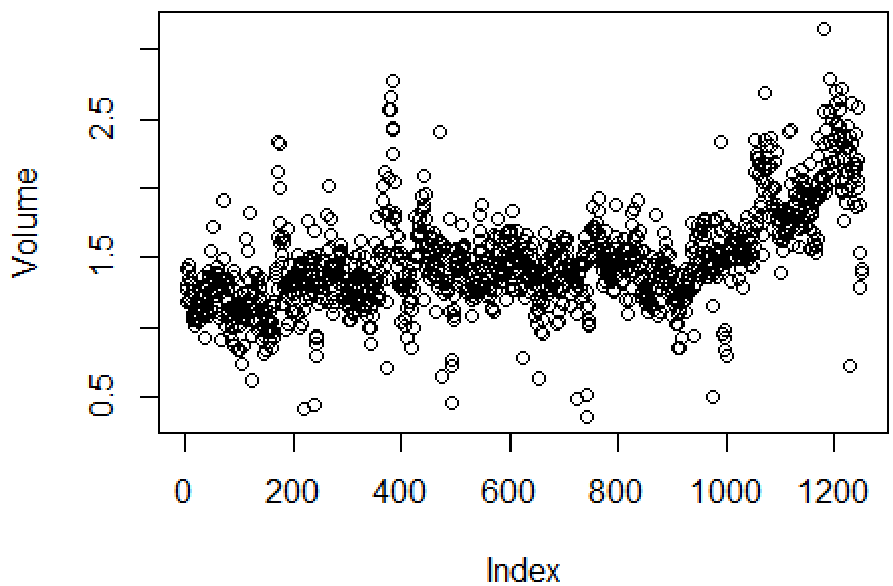
```r
#cor(Smarket)
cor(Smarket[, -9])
```

```
##              Year        Lag1         Lag2         Lag3         Lag4
## Year   1.00000000  0.029699649  0.030596422  0.033194581  0.035688718
## Lag1   0.02969965  1.000000000 -0.026294328 -0.010803402 -0.002985911
## Lag2   0.03059642 -0.026294328  1.000000000 -0.025896670 -0.010853533
## Lag3   0.03319458 -0.010803402 -0.025896670  1.000000000 -0.024051036
## Lag4   0.03568872 -0.002985911 -0.010853533 -0.024051036  1.000000000
## Lag5   0.02978799 -0.005674606 -0.003557949 -0.018808338 -0.027083641
## Volume 0.53900647  0.040909908 -0.043383215 -0.041823686 -0.048414246
## Today  0.03009523 -0.026155045 -0.010250033 -0.002447647 -0.006899527
##                Lag5      Volume        Today
## Year    0.029787995  0.53900647  0.030095229
## Lag1   -0.005674606  0.04090991 -0.026155045
## Lag2   -0.003557949 -0.04338321 -0.010250033
## Lag3   -0.018808338 -0.04182369 -0.002447647
## Lag4   -0.027083641 -0.04841425 -0.006899527
## Lag5    1.000000000 -0.02200231 -0.034860083
## Volume -0.022002315  1.00000000  0.014591823
## Today  -0.034860083  0.01459182  1.000000000
```

Keterangan :

Melihat hubungan linear antar variabel numerik untuk memahami mana yang mungkin berhubungan dengan `Direction`.

```
attach(Smarket)
plot(Volume)
```



Keterangan :

Melihat bagaimana tren Volume perdagangan berubah selama periode waktu yang ada dalam dataset.

Code Halaman 175

```
train <- (Year < 2005)
Smarket.2005 <- Smarket[!train, ]
dim(Smarket.2005)

## [1] 252   9

Direction.2005 <- Direction[!train]
```

Keterangan :

Pada baris awal kita mencoba memisahkan training set dengan test set. Data sebelum 2005 (training set), dan data dari 2005 ke atas (test set). Lalu dengan `Smarket[!train, ]`, kita memilih hanya data dengan `Year >= 2005`, sehingga `Smarket.2005` berisi hanya test set.

Fungsi `dim()` menampilkan jumlah baris dan kolom dari `Smarket.2005`, yaitu $252x9$. Selanjutnya, `Direction` adalah variabel respons yang menunjukkan apakah pasar saham naik ("Up") atau turun ("Down"). `Direction[!train]` mengambil hanya nilai `Direction` dari test set (2005 ke atas) dan menyimpannya di `Direction.2005`.

K-Nearest Neighbors

```
library(class)
train.X <- cbind(Lag1, Lag2)[train, ]
test.X <- cbind(Lag1, Lag2)[!train, ]
train.Direction <- Direction[train]
```

Keterangan :

Dataset dipecah menjadi training set dan test set, hanya menggunakan prediktor `Lag1` dan `Lag2` karena diduga memiliki hubungan dengan `Direction`. Sementara `train.Direction` berisi label kategori untuk data latih.

```
set.seed(1)
knn.pred <- knn(train.X, test.X, train.Direction, k = 1)
table(knn.pred, Direction.2005)

##           Direction.2005
## knn.pred Down Up
##     Down   43 58
##     Up     68 83

(83 + 43) / 252

## [1] 0.5
```

Keterangan :

Model KNN dengan $k = 1$ dibuat dan hasilnya dibandingkan dengan data aktual. Akurasi dihitung dengan $(83 + 43)/252 = 50$, yang menunjukkan model ini tidak jauh lebih baik dari tebakan acak.

```
knn.pred <- knn(train.X, test.X, train.Direction, k = 3)
table(knn.pred, Direction.2005)

##           Direction.2005
## knn.pred Down Up
##     Down   48 54
##     Up     63 87

mean(knn.pred == Direction.2005)

## [1] 0.5357143
```

Keterangan :

Model KNN dengan $k = 3$ diuji untuk melihat apakah lebih baik dari $k = 1$. Menggunakan `mean(knn.pred == Direction.2005)`, akurasi dihitung dan dibandingkan dengan model sebelumnya.

```
dim(Caravan)

## [1] 5822   86

attach(Caravan)
summary(Purchase)

##   No  Yes
## 5474  348

348 / 5822

## [1] 0.05977327
```

Keterangan :

Dataset `Caravan` memiliki 5.822 observasi dan target variabel `Purchase`. Hanya 348 orang yang membeli asuransi (sekitar 6), menunjukkan dataset sangat tidak seimbang.

```
standardized.X <- scale(Caravan[, -86])
var(Caravan[, 1])

## [1] 165.0378

var(Caravan[, 2])

## [1] 0.1647078

var(standardized.X[, 1])

## [1] 1

var(standardized.X[, 2])

## [1] 1
```

Keterangan :

Variabel prediktor distandarisasi menggunakan `scale()`, karena KNN sensitif terhadap skala variabel. Setelah standarisasi, semua variabel memiliki varians yang seragam.

```
test <- 1:1000
train.X <- standardized.X[-test, ]
test.X <- standardized.X[test, ]
train.Y <- Purchase[-test]
test.Y <- Purchase[test]
set.seed(1)
```

```
knn.pred <- knn(train.X, test.X, train.Y, k = 1)
mean(test.Y != knn.pred)

## [1] 0.118

mean(test.Y != "No")

## [1] 0.059
```

Keterangan :

1.000 observasi pertama digunakan sebagai test set, sisanya sebagai training set. Model KNN dengan $k = 1$ diuji dan error rate dihitung. Akurasi model tidak terlalu baik karena dataset tidak seimbang (`mean(test.Y != "No")` menunjukkan mayoritas prediksi adalah “No”).

```
table(knn.pred, test.Y)

##         test.Y
## knn.pred  No Yes
##      No  873  50
##      Yes  68   9

9 / (68 + 9)

## [1] 0.1168831
```

Keterangan :

Dari 77 prediksi “Yes”, hanya 9 yang benar. Rasio keberhasilan deteksi pembelian asuransi sangat kecil, sekitar 11.7. Model cenderung bias ke “No” karena mayoritas sampel memang “No”.

```
knn.pred <- knn(train.X, test.X, train.Y, k = 3)
table(knn.pred, test.Y)

##         test.Y
## knn.pred  No Yes
##      No  920  54
##      Yes  21   5

5 / 26

## [1] 0.1923077

knn.pred <- knn(train.X, test.X, train.Y, k = 5)
table(knn.pred, test.Y)

##         test.Y
## knn.pred  No Yes
##      No  930  55
##      Yes  11   4
```

```r
4 / 15
```

```
## [1] 0.2666667
```

Keterangan :

Dengan $k = 3$, hanya 5 dari 26 prediksi "Yes" yang benar, sekitar 19.2 akurasi pada kelas "Yes". Dengan $4k = 5$, hanya 4 dari 15 prediksi "Yes" yang benar, sekitar 26.7 akurasi pada kelas "Yes". Semakin besar k, semakin sedikit false positive, tetapi semakin banyak false negative.

```r
glm.fits <- glm(Purchase ~ ., data = Caravan,
    family = binomial, subset = -test)
```

```
## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
```

```r
glm.probs <- predict(glm.fits, Caravan[test, ],
    type = "response")
glm.pred <- rep("No", 1000)
glm.pred[glm.probs > .5] <- "Yes"
table(glm.pred, test.Y)
```

```
##         test.Y
## glm.pred  No Yes
##      No  934  59
##      Yes   7   0
```

```r
glm.pred <- rep("No", 1000)
glm.pred[glm.probs > .25] <- "Yes"
table(glm.pred, test.Y)
```

```
##         test.Y
## glm.pred  No Yes
##      No  919  48
##      Yes  22  11
```

```r
11 / (22 + 11)
```

```
## [1] 0.3333333
```

Keterangan :

Model regresi logistik dibuat dan dilatih hanya pada training test. Jika menggunakan ambang batas probabilitas 50, hampir semua prediksi adalah "No", karena dataset tidak seimbang. Jika ambang batas diturunkan ke 25, lebih banyak "Yes" yang terdeteksi. Akurasi untuk mendeteksi pembelian asuransi tetap rendah $(11/(22 + 11) = 33$ pada kategori "Yes").

Exercise

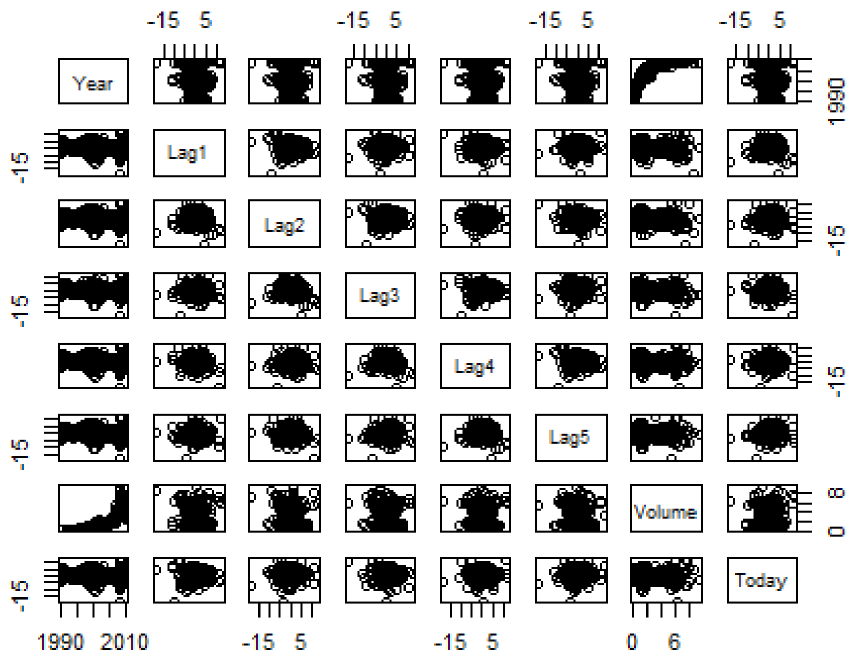
Nomor 13

This question should be answered using the `Weekly` data set, which is part of the `ISLR2` package. This data is similar in nature to the `Smarket` data from this chapter's lab, except that it contains 1,089 weekly returns for 21 years, from the beginning of 1990 to the end of 2010.

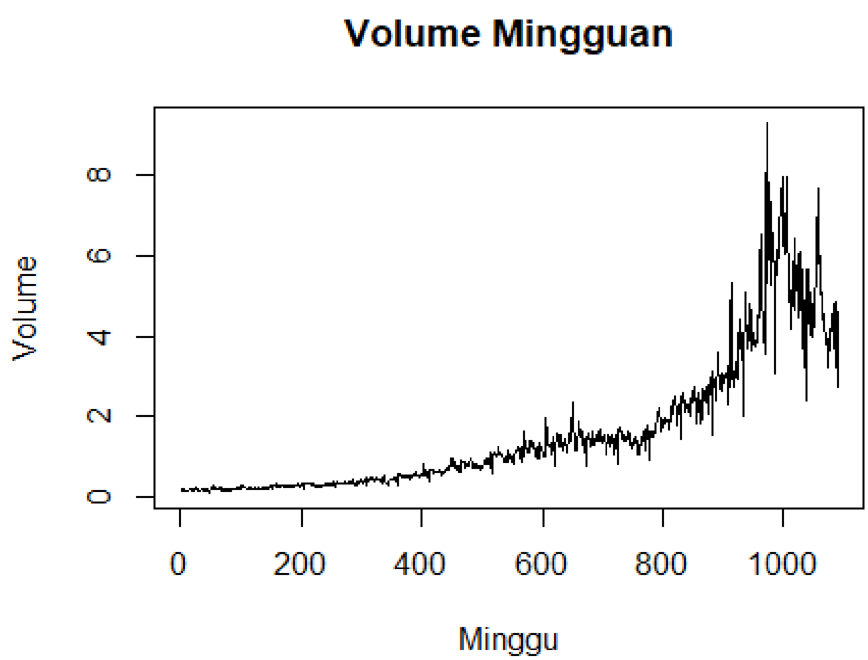
```
library(ISLR2)
library(class)
data(Weekly)
names(Weekly)

## [1] "Year"      "Lag1"      "Lag2"      "Lag3"      "Lag4"      "Lag5"
## [7] "Volume"    "Today"     "Direction"

dim(Weekly)

## [1] 1089    9
```

a. Produce some numerical and graphical summaries of the `Weekly` data. Do there appear to be any patterns?

```
summary(Weekly)

##       Year           Lag1               Lag2               Lag3
##  Min.   :1990   Min.   :-18.1950   Min.   :-18.1950   Min.   :-18.1950
##  1st Qu.:1995   1st Qu.: -1.1540   1st Qu.: -1.1540   1st Qu.: -1.1580
##  Median :2000   Median :  0.2410   Median :  0.2410   Median :  0.2410
##  Mean   :2000   Mean   :  0.1506   Mean   :  0.1511   Mean   :  0.1472
##  3rd Qu.:2005   3rd Qu.:  1.4050   3rd Qu.:  1.4090   3rd Qu.:  1.4090
##  Max.   :2010   Max.   : 12.0260   Max.   : 12.0260   Max.   : 12.0260
##       Lag4               Lag5              Volume            Today
##  Min.   :-18.1950   Min.   :-18.1950   Min.   :0.08747   Min.   :-18.1950
##  1st Qu.: -1.1580   1st Qu.: -1.1660   1st Qu.:0.33202   1st Qu.: -1.1540
##  Median :  0.2380   Median :  0.2340   Median :1.00268   Median :  0.2410
##  Mean   :  0.1458   Mean   :  0.1399   Mean   :1.57462   Mean   :  0.1499
##  3rd Qu.:  1.4090   3rd Qu.:  1.4050   3rd Qu.:2.05373   3rd Qu.:  1.4050
##  Max.   : 12.0260   Max.   : 12.0260   Max.   :9.32821   Max.   : 12.0260
##  Direction
##  Down:484
##  Up  :605
##
##
##
##

pairs(Weekly[, -9])
```




```r
plot(Weekly$Volume, type = "l", main = "Volume Mingguan", ylab = "Volume", xlab = "Minggu")
```



Year dan Volume tampaknya memiliki hubungan, trennya relatif positif.

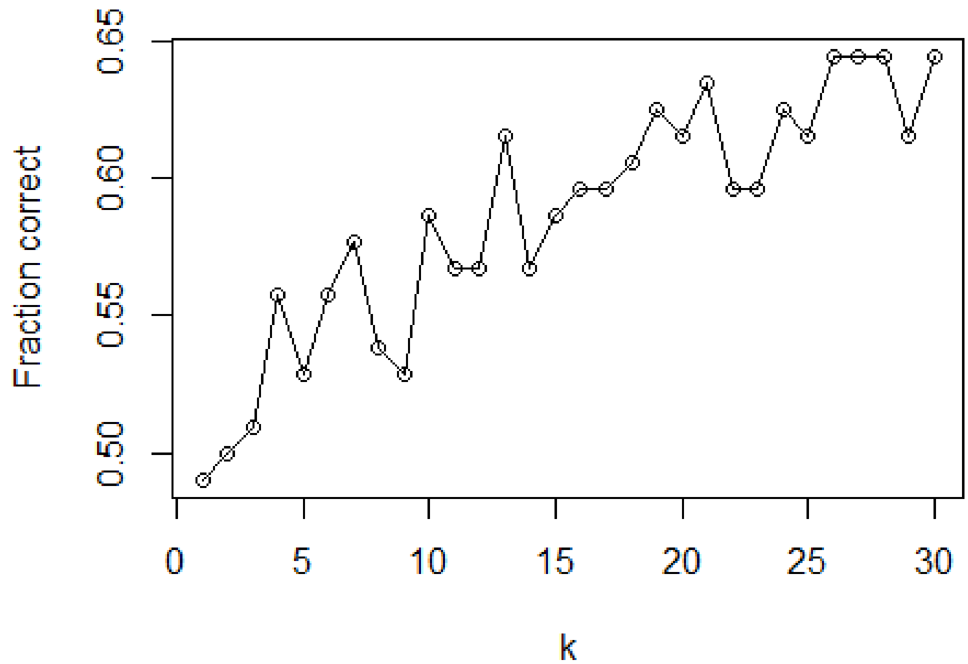
g. Repeat (d) using KNN with $K = 1$.

```
library(class)
train <- Weekly$Year < 2009
test <- Weekly$Year > 2008

knn_model <- knn(
  Weekly[train, "Lag2", drop = FALSE],
  Weekly[test, "Lag2", drop = FALSE],
  Weekly$Direction[train], k = 1
)
(confusion_matrix_knn <- table(Prediction = knn_model, Actual = Weekly[test,
]$Direction))

##             Actual
## Prediction Down Up
##       Down   21 29
##       Up     22 32

(akurasi_knn <- mean(knn_model == Weekly[test, ]$Direction))

## [1] 0.5096154

#sum(diag(confusion_matrix_knn)) / sum(confusion_matrix_knn)
```

Dengan model KNN pada $k = 1$, didapat akurasi 50

j. Experiment with different combinations of predictors, including possible transformations and interactions, for each of the methods. Report the variables, method, and associated confusion matrix that appears to provide the best results on the held out data. Note that you should also experiment with values for K in the KNN classifier.

```
set.seed(1)
res <- sapply(1:30, function(k) {
  fit <- knn(
    Weekly[train, 2:4, drop = FALSE],
    Weekly[test, 2:4, drop = FALSE],
    Weekly$Direction[train],
    k = k
  )
  mean(fit == Weekly[test, ]$Direction)
})
plot(1:30, res, type = "o", xlab = "k", ylab = "Fraction correct")
```




```r
(k <- which.max(res))

## [1] 26

fit <- knn(
  Weekly[train, 2:4, drop = FALSE],
  Weekly[test, 2:4, drop = FALSE],
  Weekly$Direction[train],
  k = k
)
table(Prediction = fit, Aktual = Weekly[test, ]$Direction)

##             Aktual
## Prediction Down Up
##       Down   23 18
##       Up     20 43

mean(fit == Weekly[test, ]$Direction)

## [1] 0.6346154
```

KNN menggunakan variabel 3 Lag pertama performa marginalnya lebih baik dari regresi logistik dengan `Lag2` jika kita setel k menjadi $k = 26$ dengan tingkat akurasi 63.46%

Nomor 14

In this problem, you will develop a model to predict whether a given car gets high or low gas mileage based on the `Auto` data set.

a. Create a binary variable, `mpg01`, that contains a 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. Note you may find it helpful to use the `data.frame()` function to create a single data set containing both `mpg01` and the other `Auto` variables.

```
library(ISLR2)
data(Auto)
mpg01 <- ifelse(Auto$mpg > median(Auto$mpg), 1, 0)
(data_auto <- data.frame(Auto[,-1], mpg01))
```

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

```
## 36          6          250.0         100   3329           15.5    71       1
## 37          6          250.0          88   3302           15.5    71       1
## 38          6          232.0         100   3288           15.5    71       1
## 39          8          350.0         165   4209           12.0    71       1
## 40          8          400.0         175   4464           11.5    71       1
## 41          8          351.0         153   4154           13.5    71       1
## 42          8          318.0         150   4096           13.0    71       1
## 43          8          383.0         180   4955           11.5    71       1
## 44          8          400.0         170   4746           12.0    71       1
## 45          8          400.0         175   5140           12.0    71       1
## 46          6          258.0         110   2962           13.5    71       1
## 47          4          140.0          72   2408           19.0    71       1
## 48          6          250.0         100   3282           15.0    71       1
## 49          6          250.0          88   3139           14.5    71       1
## 50          4          122.0          86   2220           14.0    71       1
## 51          4          116.0          90   2123           14.0    71       2
## 52          4           79.0          70   2074           19.5    71       2
## 53          4           88.0          76   2065           14.5    71       2
## 54          4           71.0          65   1773           19.0    71       3
## 55          4           72.0          69   1613           18.0    71       3
## 56          4           97.0          60   1834           19.0    71       2
## 57          4           91.0          70   1955           20.5    71       1
## 58          4          113.0          95   2278           15.5    72       3
## 59          4           97.5          80   2126           17.0    72       1
## 60          4           97.0          54   2254           23.5    72       2
## 61          4          140.0          90   2408           19.5    72       1
## 62          4          122.0          86   2226           16.5    72       1
## 63          8          350.0         165   4274           12.0    72       1
## 64          8          400.0         175   4385           12.0    72       1
## 65          8          318.0         150   4135           13.5    72       1
## 66          8          351.0         153   4129           13.0    72       1
## 67          8          304.0         150   3672           11.5    72       1
## 68          8          429.0         208   4633           11.0    72       1
## 69          8          350.0         155   4502           13.5    72       1
## 70          8          350.0         160   4456           13.5    72       1
## 71          8          400.0         190   4422           12.5    72       1
## 72          3           70.0          97   2330           13.5    72       3
## 73          8          304.0         150   3892           12.5    72       1
## 74          8          307.0         130   4098           14.0    72       1
## 75          8          302.0         140   4294           16.0    72       1
## 76          8          318.0         150   4077           14.0    72       1
## 77          4          121.0         112   2933           14.5    72       2
## 78          4          121.0          76   2511           18.0    72       2
## 79          4          120.0          87   2979           19.5    72       2
## 80          4           96.0          69   2189           18.0    72       2
## 81          4          122.0          86   2395           16.0    72       1
## 82          4           97.0          92   2288           17.0    72       3
## 83          4          120.0          97   2506           14.5    72       3
## 84          4           98.0          80   2164           15.0    72       1
## 85          4           97.0          88   2100           16.5    72       3
```

```
## 86          8    350.0    175  4100     13.0  73     1
## 87          8    304.0    150  3672     11.5  73     1
## 88          8    350.0    145  3988     13.0  73     1
## 89          8    302.0    137  4042     14.5  73     1
## 90          8    318.0    150  3777     12.5  73     1
## 91          8    429.0    198  4952     11.5  73     1
## 92          8    400.0    150  4464     12.0  73     1
## 93          8    351.0    158  4363     13.0  73     1
## 94          8    318.0    150  4237     14.5  73     1
## 95          8    440.0    215  4735     11.0  73     1
## 96          8    455.0    225  4951     11.0  73     1
## 97          8    360.0    175  3821     11.0  73     1
## 98          6    225.0    105  3121     16.5  73     1
## 99          6    250.0    100  3278     18.0  73     1
## 100         6    232.0    100  2945     16.0  73     1
## 101         6    250.0     88  3021     16.5  73     1
## 102         6    198.0     95  2904     16.0  73     1
## 103         4     97.0     46  1950     21.0  73     2
## 104         8    400.0    150  4997     14.0  73     1
## 105         8    400.0    167  4906     12.5  73     1
## 106         8    360.0    170  4654     13.0  73     1
## 107         8    350.0    180  4499     12.5  73     1
## 108         6    232.0    100  2789     15.0  73     1
## 109         4     97.0     88  2279     19.0  73     3
## 110         4    140.0     72  2401     19.5  73     1
## 111         4    108.0     94  2379     16.5  73     3
## 112         3     70.0     90  2124     13.5  73     3
## 113         4    122.0     85  2310     18.5  73     1
## 114         6    155.0    107  2472     14.0  73     1
## 115         4     98.0     90  2265     15.5  73     2
## 116         8    350.0    145  4082     13.0  73     1
## 117         8    400.0    230  4278      9.5  73     1
## 118         4     68.0     49  1867     19.5  73     2
## 119         4    116.0     75  2158     15.5  73     2
## 120         4    114.0     91  2582     14.0  73     2
## 121         4    121.0    112  2868     15.5  73     2
## 122         8    318.0    150  3399     11.0  73     1
## 123         4    121.0    110  2660     14.0  73     2
## 124         6    156.0    122  2807     13.5  73     3
## 125         8    350.0    180  3664     11.0  73     1
## 126         6    198.0     95  3102     16.5  74     1
## 128         6    232.0    100  2901     16.0  74     1
## 129         6    250.0    100  3336     17.0  74     1
## 130         4     79.0     67  1950     19.0  74     3
## 131         4    122.0     80  2451     16.5  74     1
## 132         4     71.0     65  1836     21.0  74     3
## 133         4    140.0     75  2542     17.0  74     1
## 134         6    250.0    100  3781     17.0  74     1
## 135         6    258.0    110  3632     18.0  74     1
## 136         6    225.0    105  3613     16.5  74     1
```

```
## 137         8       302.0       140   4141        14.0   74       1
## 138         8       350.0       150   4699        14.5   74       1
## 139         8       318.0       150   4457        13.5   74       1
## 140         8       302.0       140   4638        16.0   74       1
## 141         8       304.0       150   4257        15.5   74       1
## 142         4        98.0        83   2219        16.5   74       2
## 143         4        79.0        67   1963        15.5   74       2
## 144         4        97.0        78   2300        14.5   74       2
## 145         4        76.0        52   1649        16.5   74       3
## 146         4        83.0        61   2003        19.0   74       3
## 147         4        90.0        75   2125        14.5   74       1
## 148         4        90.0        75   2108        15.5   74       2
## 149         4       116.0        75   2246        14.0   74       2
## 150         4       120.0        97   2489        15.0   74       3
## 151         4       108.0        93   2391        15.5   74       3
## 152         4        79.0        67   2000        16.0   74       2
## 153         6       225.0        95   3264        16.0   75       1
## 154         6       250.0       105   3459        16.0   75       1
## 155         6       250.0        72   3432        21.0   75       1
## 156         6       250.0        72   3158        19.5   75       1
## 157         8       400.0       170   4668        11.5   75       1
## 158         8       350.0       145   4440        14.0   75       1
## 159         8       318.0       150   4498        14.5   75       1
## 160         8       351.0       148   4657        13.5   75       1
## 161         6       231.0       110   3907        21.0   75       1
## 162         6       250.0       105   3897        18.5   75       1
## 163         6       258.0       110   3730        19.0   75       1
## 164         6       225.0        95   3785        19.0   75       1
## 165         6       231.0       110   3039        15.0   75       1
## 166         8       262.0       110   3221        13.5   75       1
## 167         8       302.0       129   3169        12.0   75       1
## 168         4        97.0        75   2171        16.0   75       3
## 169         4       140.0        83   2639        17.0   75       1
## 170         6       232.0       100   2914        16.0   75       1
## 171         4       140.0        78   2592        18.5   75       1
## 172         4       134.0        96   2702        13.5   75       3
## 173         4        90.0        71   2223        16.5   75       2
## 174         4       119.0        97   2545        17.0   75       3
## 175         6       171.0        97   2984        14.5   75       1
## 176         4        90.0        70   1937        14.0   75       2
## 177         6       232.0        90   3211        17.0   75       1
## 178         4       115.0        95   2694        15.0   75       2
## 179         4       120.0        88   2957        17.0   75       2
## 180         4       121.0        98   2945        14.5   75       2
## 181         4       121.0       115   2671        13.5   75       2
## 182         4        91.0        53   1795        17.5   75       3
## 183         4       107.0        86   2464        15.5   76       2
## 184         4       116.0        81   2220        16.9   76       2
## 185         4       140.0        92   2572        14.9   76       1
## 186         4        98.0        79   2255        17.7   76       1
```

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## 187         4       101.0        83  2202          15.3   76       2
## 188         8       305.0       140  4215          13.0   76       1
## 189         8       318.0       150  4190          13.0   76       1
## 190         8       304.0       120  3962          13.9   76       1
## 191         8       351.0       152  4215          12.8   76       1
## 192         6       225.0       100  3233          15.4   76       1
## 193         6       250.0       105  3353          14.5   76       1
## 194         6       200.0        81  3012          17.6   76       1
## 195         6       232.0        90  3085          17.6   76       1
## 196         4        85.0        52  2035          22.2   76       1
## 197         4        98.0        60  2164          22.1   76       1
## 198         4        90.0        70  1937          14.2   76       2
## 199         4        91.0        53  1795          17.4   76       3
## 200         6       225.0       100  3651          17.7   76       1
## 201         6       250.0        78  3574          21.0   76       1
## 202         6       250.0       110  3645          16.2   76       1
## 203         6       258.0        95  3193          17.8   76       1
## 204         4        97.0        71  1825          12.2   76       2
## 205         4        85.0        70  1990          17.0   76       3
## 206         4        97.0        75  2155          16.4   76       3
## 207         4       140.0        72  2565          13.6   76       1
## 208         4       130.0       102  3150          15.7   76       2
## 209         8       318.0       150  3940          13.2   76       1
## 210         4       120.0        88  3270          21.9   76       2
## 211         6       156.0       108  2930          15.5   76       3
## 212         6       168.0       120  3820          16.7   76       2
## 213         8       350.0       180  4380          12.1   76       1
## 214         8       350.0       145  4055          12.0   76       1
## 215         8       302.0       130  3870          15.0   76       1
## 216         8       318.0       150  3755          14.0   76       1
## 217         4        98.0        68  2045          18.5   77       3
## 218         4       111.0        80  2155          14.8   77       1
## 219         4        79.0        58  1825          18.6   77       2
## 220         4       122.0        96  2300          15.5   77       1
## 221         4        85.0        70  1945          16.8   77       3
## 222         8       305.0       145  3880          12.5   77       1
## 223         8       260.0       110  4060          19.0   77       1
## 224         8       318.0       145  4140          13.7   77       1
## 225         8       302.0       130  4295          14.9   77       1
## 226         6       250.0       110  3520          16.4   77       1
## 227         6       231.0       105  3425          16.9   77       1
## 228         6       225.0       100  3630          17.7   77       1
## 229         6       250.0        98  3525          19.0   77       1
## 230         8       400.0       180  4220          11.1   77       1
## 231         8       350.0       170  4165          11.4   77       1
## 232         8       400.0       190  4325          12.2   77       1
## 233         8       351.0       149  4335          14.5   77       1
## 234         4        97.0        78  1940          14.5   77       2
## 235         4       151.0        88  2740          16.0   77       1
## 236         4        97.0        75  2265          18.2   77       3
```

```
## 237         4        140.0       89  2755         15.8   77       1
## 238         4         98.0       63  2051         17.0   77       1
## 239         4         98.0       83  2075         15.9   77       1
## 240         4         97.0       67  1985         16.4   77       3
## 241         4         97.0       78  2190         14.1   77       2
## 242         6        146.0       97  2815         14.5   77       3
## 243         4        121.0      110  2600         12.8   77       2
## 244         3         80.0      110  2720         13.5   77       3
## 245         4         90.0       48  1985         21.5   78       2
## 246         4         98.0       66  1800         14.4   78       1
## 247         4         78.0       52  1985         19.4   78       3
## 248         4         85.0       70  2070         18.6   78       3
## 249         4         91.0       60  1800         16.4   78       3
## 250         8        260.0      110  3365         15.5   78       1
## 251         8        318.0      140  3735         13.2   78       1
## 252         8        302.0      139  3570         12.8   78       1
## 253         6        231.0      105  3535         19.2   78       1
## 254         6        200.0       95  3155         18.2   78       1
## 255         6        200.0       85  2965         15.8   78       1
## 256         4        140.0       88  2720         15.4   78       1
## 257         6        225.0      100  3430         17.2   78       1
## 258         6        232.0       90  3210         17.2   78       1
## 259         6        231.0      105  3380         15.8   78       1
## 260         6        200.0       85  3070         16.7   78       1
## 261         6        225.0      110  3620         18.7   78       1
## 262         6        258.0      120  3410         15.1   78       1
## 263         8        305.0      145  3425         13.2   78       1
## 264         6        231.0      165  3445         13.4   78       1
## 265         8        302.0      139  3205         11.2   78       1
## 266         8        318.0      140  4080         13.7   78       1
## 267         4         98.0       68  2155         16.5   78       1
## 268         4        134.0       95  2560         14.2   78       3
## 269         4        119.0       97  2300         14.7   78       3
## 270         4        105.0       75  2230         14.5   78       1
## 271         4        134.0       95  2515         14.8   78       3
## 272         4        156.0      105  2745         16.7   78       1
## 273         4        151.0       85  2855         17.6   78       1
## 274         4        119.0       97  2405         14.9   78       3
## 275         5        131.0      103  2830         15.9   78       2
## 276         6        163.0      125  3140         13.6   78       2
## 277         4        121.0      115  2795         15.7   78       2
## 278         6        163.0      133  3410         15.8   78       2
## 279         4         89.0       71  1990         14.9   78       2
## 280         4         98.0       68  2135         16.6   78       3
## 281         6        231.0      115  3245         15.4   79       1
## 282         6        200.0       85  2990         18.2   79       1
## 283         4        140.0       88  2890         17.3   79       1
## 284         6        232.0       90  3265         18.2   79       1
## 285         6        225.0      110  3360         16.6   79       1
## 286         8        305.0      130  3840         15.4   79       1
```

```
## 287         8     302.0     129  3725      13.4  79     1
## 288         8     351.0     138  3955      13.2  79     1
## 289         8     318.0     135  3830      15.2  79     1
## 290         8     350.0     155  4360      14.9  79     1
## 291         8     351.0     142  4054      14.3  79     1
## 292         8     267.0     125  3605      15.0  79     1
## 293         8     360.0     150  3940      13.0  79     1
## 294         4      89.0      71  1925      14.0  79     2
## 295         4      86.0      65  1975      15.2  79     3
## 296         4      98.0      80  1915      14.4  79     1
## 297         4     121.0      80  2670      15.0  79     1
## 298         5     183.0      77  3530      20.1  79     2
## 299         8     350.0     125  3900      17.4  79     1
## 300         4     141.0      71  3190      24.8  79     2
## 301         8     260.0      90  3420      22.2  79     1
## 302         4     105.0      70  2200      13.2  79     1
## 303         4     105.0      70  2150      14.9  79     1
## 304         4      85.0      65  2020      19.2  79     3
## 305         4      91.0      69  2130      14.7  79     2
## 306         4     151.0      90  2670      16.0  79     1
## 307         6     173.0     115  2595      11.3  79     1
## 308         6     173.0     115  2700      12.9  79     1
## 309         4     151.0      90  2556      13.2  79     1
## 310         4      98.0      76  2144      14.7  80     2
## 311         4      89.0      60  1968      18.8  80     3
## 312         4      98.0      70  2120      15.5  80     1
## 313         4      86.0      65  2019      16.4  80     3
## 314         4     151.0      90  2678      16.5  80     1
## 315         4     140.0      88  2870      18.1  80     1
## 316         4     151.0      90  3003      20.1  80     1
## 317         6     225.0      90  3381      18.7  80     1
## 318         4      97.0      78  2188      15.8  80     2
## 319         4     134.0      90  2711      15.5  80     3
## 320         4     120.0      75  2542      17.5  80     3
## 321         4     119.0      92  2434      15.0  80     3
## 322         4     108.0      75  2265      15.2  80     3
## 323         4      86.0      65  2110      17.9  80     3
## 324         4     156.0     105  2800      14.4  80     1
## 325         4      85.0      65  2110      19.2  80     3
## 326         4      90.0      48  2085      21.7  80     2
## 327         4      90.0      48  2335      23.7  80     2
## 328         5     121.0      67  2950      19.9  80     2
## 329         4     146.0      67  3250      21.8  80     2
## 330         4      91.0      67  1850      13.8  80     3
## 332         4      97.0      67  2145      18.0  80     3
## 333         4      89.0      62  1845      15.3  80     2
## 334         6     168.0     132  2910      11.4  80     3
## 335         3      70.0     100  2420      12.5  80     3
## 336         4     122.0      88  2500      15.1  80     2
## 338         4     107.0      72  2290      17.0  80     3
```

```
## 339           4          135.0          84   2490          15.7    81        1
## 340           4          151.0          84   2635          16.4    81        1
## 341           4          156.0          92   2620          14.4    81        1
## 342           6          173.0         110   2725          12.6    81        1
## 343           4          135.0          84   2385          12.9    81        1
## 344           4           79.0          58   1755          16.9    81        3
## 345           4           86.0          64   1875          16.4    81        1
## 346           4           81.0          60   1760          16.1    81        3
## 347           4           97.0          67   2065          17.8    81        3
## 348           4           85.0          65   1975          19.4    81        3
## 349           4           89.0          62   2050          17.3    81        3
## 350           4           91.0          68   1985          16.0    81        3
## 351           4          105.0          63   2215          14.9    81        1
## 352           4           98.0          65   2045          16.2    81        1
## 353           4           98.0          65   2380          20.7    81        1
## 354           4          105.0          74   2190          14.2    81        2
## 356           4          107.0          75   2210          14.4    81        3
## 357           4          108.0          75   2350          16.8    81        3
## 358           4          119.0         100   2615          14.8    81        3
## 359           4          120.0          74   2635          18.3    81        3
## 360           4          141.0          80   3230          20.4    81        2
## 361           6          145.0          76   3160          19.6    81        2
## 362           6          168.0         116   2900          12.6    81        3
## 363           6          146.0         120   2930          13.8    81        3
## 364           6          231.0         110   3415          15.8    81        1
## 365           8          350.0         105   3725          19.0    81        1
## 366           6          200.0          88   3060          17.1    81        1
## 367           6          225.0          85   3465          16.6    81        1
## 368           4          112.0          88   2605          19.6    82        1
## 369           4          112.0          88   2640          18.6    82        1
## 370           4          112.0          88   2395          18.0    82        1
## 371           4          112.0          85   2575          16.2    82        1
## 372           4          135.0          84   2525          16.0    82        1
## 373           4          151.0          90   2735          18.0    82        1
## 374           4          140.0          92   2865          16.4    82        1
## 375           4          105.0          74   1980          15.3    82        2
## 376           4           91.0          68   2025          18.2    82        3
## 377           4           91.0          68   1970          17.6    82        3
## 378           4          105.0          63   2125          14.7    82        1
## 379           4           98.0          70   2125          17.3    82        1
## 380           4          120.0          88   2160          14.5    82        3
## 381           4          107.0          75   2205          14.5    82        3
## 382           4          108.0          70   2245          16.9    82        3
## 383           4           91.0          67   1965          15.0    82        3
## 384           4           91.0          67   1965          15.7    82        3
## 385           4           91.0          67   1995          16.2    82        3
## 386           6          181.0         110   2945          16.4    82        1
## 387           6          262.0          85   3015          17.0    82        1
## 388           4          156.0          92   2585          14.5    82        1
## 389           6          232.0         112   2835          14.7    82        1
```

```
## 390         4        144.0         96   2665          13.9   82       3
## 391         4        135.0         84   2370          13.0   82       1
## 392         4        151.0         90   2950          17.3   82       1
## 393         4        140.0         86   2790          15.6   82       1
## 394         4         97.0         52   2130          24.6   82       2
## 395         4        135.0         84   2295          11.6   82       1
## 396         4        120.0         79   2625          18.6   82       1
## 397         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
```

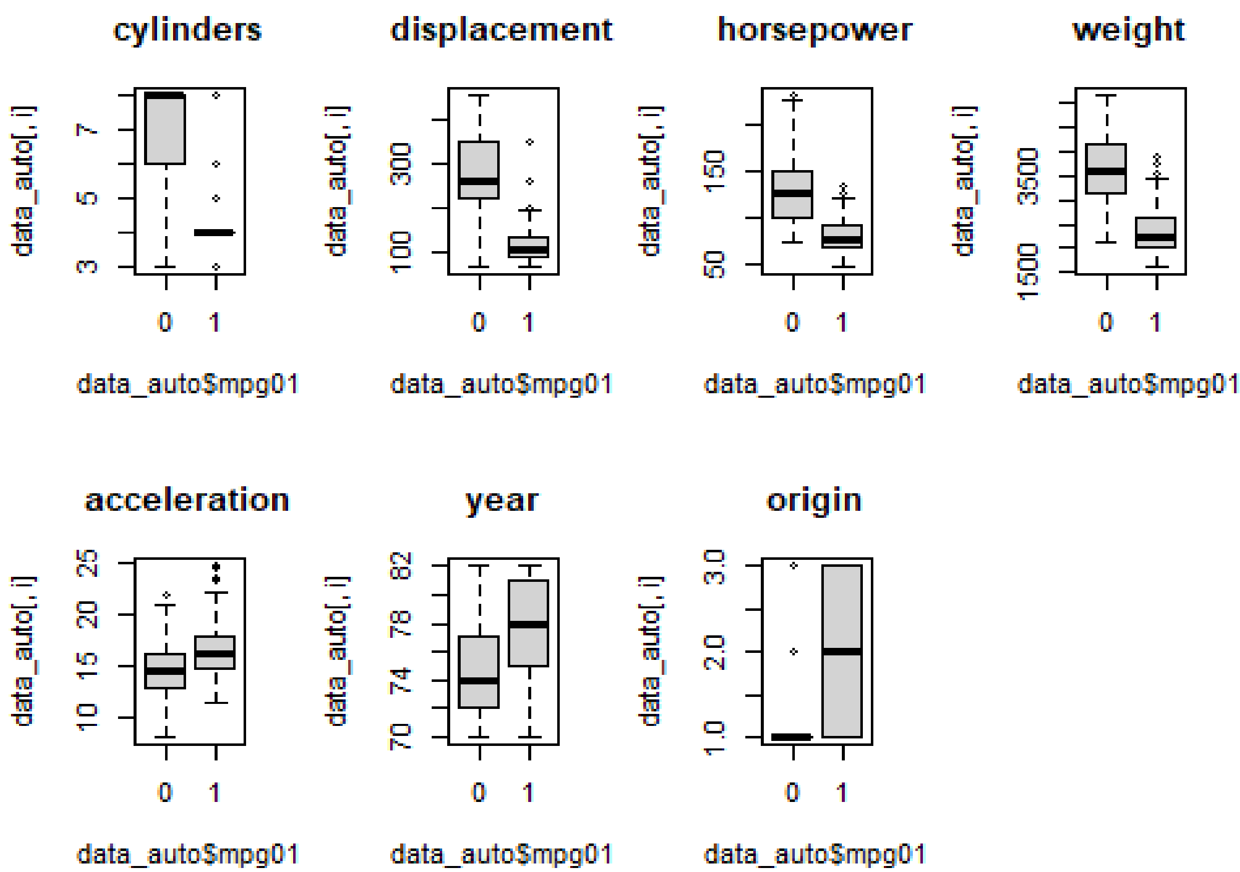
```
## 346                      honda civic 1300     1
## 347                                subaru     1
## 348                        datsun 210 mpg     1
## 349                         toyota tercel     1
## 350                           mazda glc 4     1
## 351                    plymouth horizon 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

#(data_auto <- data.frame(Auto, mpg01))
```

b. Explore the data graphically in order to investigate the association between `mpg01` and the other features. Which of the other features seem most likely to be useful in predicting `mpg01`? Scatterplots and boxplots may be useful tools to answer this question. Describe your findings.

```
par(mfrow = c(2, 4))
for (i in 1:7) boxplot(data_auto[, i] ~ data_auto$mpg01, main =
colnames(data_auto)[i])
```



1. `Cylinders` : Mobil dengan sedikit silinder (misalnya 4) cenderung hemat BBM.

2. `Displacement` : Mobil dengan displacement (kapasitas mesin) lebih kecil cenderung hemat BBM.

3. `Horsepower` : Mobil dengan horsepower lebih rendah cenderung hemat BBM.

4. `Weight` : Mobil yang lebih ringan cenderung lebih hemat BBM.

5. `Acceleration` : Tidak ada perbedaan yang cukup signifikan.

6. `Year` : Mobil yang lebih baru (year tinggi) tidak selalu lebih hemat BBM.

7. `Origin` : Mobil yang berasal dari tempat 1,2,dan 3 banyak yang hemat BBM, tapi ada juga yang tidak, hubungan tidak cukup signifikan.

Kesimpulan:

`Cylinders`, `Displacement`, `Horsepower`, dan `Weight` bisa dijadikan prediktor yang kuat. Sementara `Acceleration`, `Year`, dan `Origin`kurang memiliki hubungan yang signifikan dengan `mpg`.

c. Split the data into a training set and a test set.

```
set.seed(1)
train_index <- sample(1:nrow(data_auto), nrow(data_auto) * 2/3)
train_data <- data_auto[train_index, ]
test_data <- data_auto[-train_index, ]
```

h. Perform KNN on the training data, with several values of K, in order to predict `mpg01`. Use only the variables that seemed most associated with `mpg01` in (b). What test errors do you obtain? Which value of K seems to perform the best on this data set?

```
library(class)
train_X <- scale(train_data[, c("cylinders", "horsepower", "weight",
"displacement")])
test_X <- scale(test_data[, c("cylinders", "horsepower", "weight",
"displacement")])
train_Y <- train_data$mpg01

errors_knn <- c()
for (k in 1:10) {
  knn_predict <- knn(train_X, test_X, train_Y, k = k)
  error <- mean(knn_predict != test_data$mpg01)
  errors_knn <- c(errors_knn, error)
}
errors_knn

##  [1] 0.13740458 0.09923664 0.12977099 0.12977099 0.12213740 0.12213740
##  [7] 0.13740458 0.12977099 0.12977099 0.11450382

which.min(errors_knn)

## [1] 2
```

Untuk memprediksi `mpg` dengan prediktor `Cylinders`, `Displacement`, `Horsepower`, dan `Weight` menggunakan model K-Nearest Neighbors (KNN) nilai K yang paling bagus untuk data ini adalah $K = 2$ dengan error (potensi salah) sebesar 9.92%.

Nomor 16

> Using the Boston data set, fit classification models in order to predict whether a given census tract has a crime rate above or below the median. Explore logistic regression, LDA, naive Bayes and KNN models using various sub-sets of the predictors. Describe your findings.

```
library(ISLR2)
data(Boston)
crime01 <- ifelse(Boston$crim > median(Boston$crim), 1, 0)
data_boston <- data.frame(Boston, crime01)

# Membagi data
set.seed(123)
train_index2 <- sample(1:nrow(data_boston), nrow(data_boston) * 2/3)
train_data2 <- data_boston[train_index2, ]
test_data2 <- data_boston[-train_index2, ]

# KNN
library(class)
train2_X <- scale(train_data2[, c("lstat", "dis", "nox", "rm")])
test2_X <- scale(test_data2[, c("lstat", "dis", "nox", "rm")])
train2_Y <- train_data2$crime01

errors2_knn <- c()
for (k in 1:16) {
  knn_predict2 <- knn(train2_X, test2_X, train2_Y, k = k)
  error2 <- mean(knn_predict2 != test_data2$crime01)
  errors2_knn <- c(errors2_knn, error2)
}
errors2_knn

##  [1] 0.1834320 0.1952663 0.1538462 0.1834320 0.1656805 0.1715976 0.1538462
##  [8] 0.1656805 0.1656805 0.1715976 0.1715976 0.1715976 0.1715976 0.1715976
## [15] 0.1834320 0.1893491

which.min(errors2_knn)

## [1] 3
```

Untuk model K-Nearest Neighbors (KNN), nilai K yang paling bagus untuk data ini adalah $K = 3$ dengan error (potensi salah) sebesar 15.38%.