Logistic Regression

The Stock Market Data

- Smarket data : Consists of percentage returns for the S&P 500 stock index over 1,250 days, from the beginning of 2001 until the end of 2005
- For each date : -lagone through lagfive : percentage returns for each of the five previous trading days. -volume (the number of shares traded on the previous day, in billions) – Today (the percentage return on the date in question) and
  - direction (whether the market was Up or Down on this date)
- Target to predict whether shares will go upor down.

```
library(ISLR2)
library(tidyverse)
```

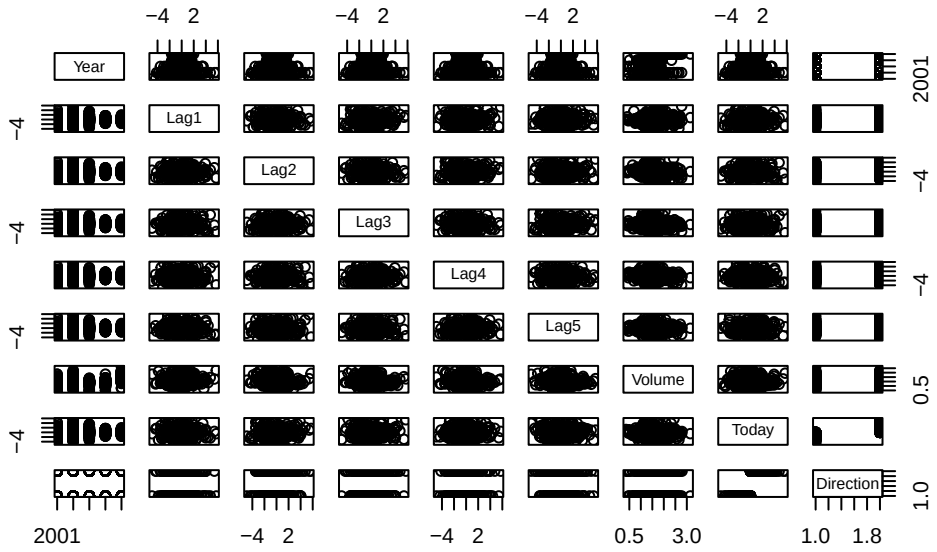
```
glimpse(Smarket)
```

```
Rows: 1,250
Columns: 9
$ Year      <dbl> 2001, 2001, 2001, 2001, 2001, 2001, 2001, 2001, 2001, 2001, ~
$ Lag1      <dbl> 0.381, 0.959, 1.032, -0.623, 0.614, 0.213, 1.392, -0.403, 0.~
$ Lag2      <dbl> -0.192, 0.381, 0.959, 1.032, -0.623, 0.614, 0.213, 1.392, -0~
$ Lag3      <dbl> -2.624, -0.192, 0.381, 0.959, 1.032, -0.623, 0.614, 0.213, 1~
$ Lag4      <dbl> -1.055, -2.624, -0.192, 0.381, 0.959, 1.032, -0.623, 0.614, ~
$ Lag5      <dbl> 5.010, -1.055, -2.624, -0.192, 0.381, 0.959, 1.032, -0.623, ~
$ Volume    <dbl> 1.1913, 1.2965, 1.4112, 1.2760, 1.2057, 1.3491, 1.4450, 1.40~
$ Today     <dbl> 0.959, 1.032, -0.623, 0.614, 0.213, 1.392, -0.403, 0.027, 1.~
$ Direction <fct> Up, Up, Down, Up, Up, Up, Down, Up, Up, Up, Down, Down, Up, ~
```

```
attach(Smarket)
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
```

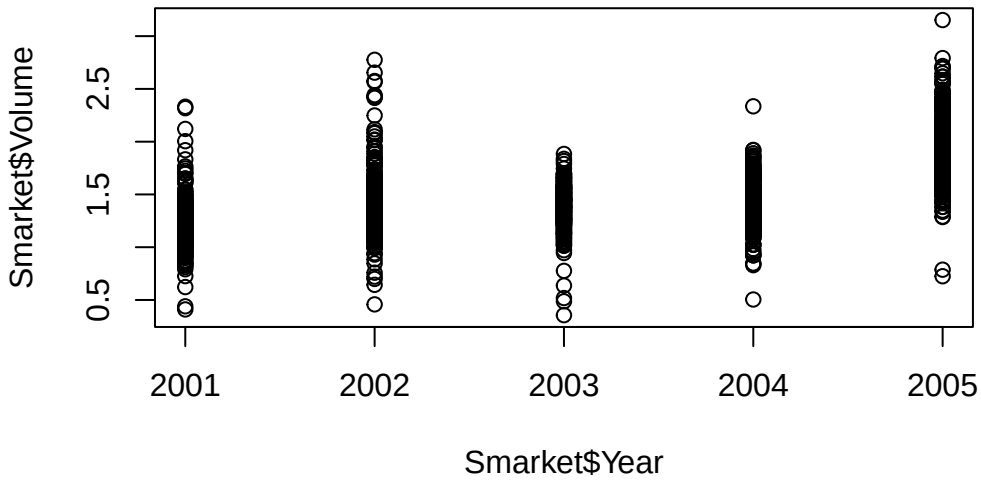
```
pairs(Smarket)
```



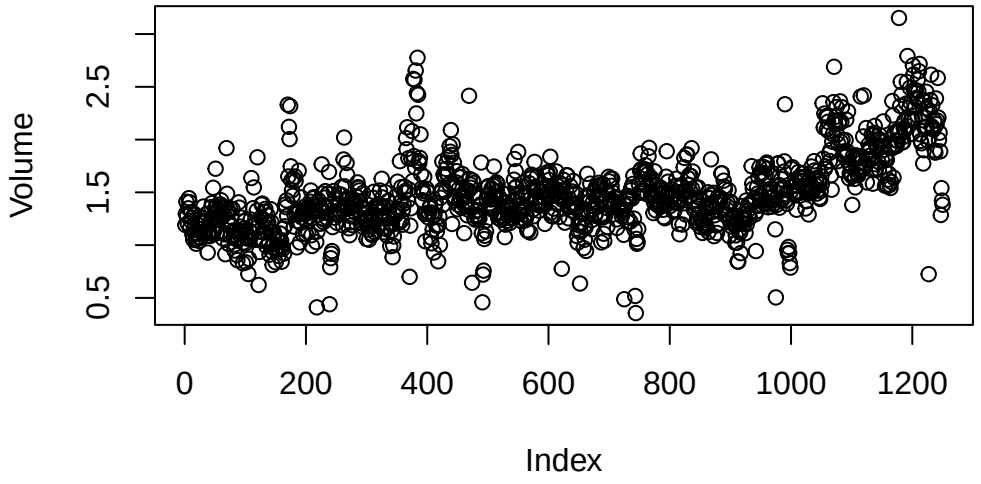

```
cor(Smarket[, 1:8])
```

```
             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
```

```
plot(Smarket$Year, Smarket$Volume)
```




```
plot(Volume)
```



- glm() : generalized linear model, binomial argument for logistic regression -p-value for all the predictors is more than 0.05. Therefore no significant realtionship.

```
glm.fits <- glm(
    Direction ~ Lag1 + Lag2 + Lag3 + Lag4 + Lag5 + Volume,
    data = Smarket, family = binomial
  )
summary(glm.fits)
```

```

Call:
glm(formula = Direction ~ Lag1 + Lag2 + Lag3 + Lag4 + Lag5 +
    Volume, family = binomial, data = Smarket)

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -0.126000   0.240736  -0.523    0.601
Lag1        -0.073074   0.050167  -1.457    0.145
Lag2        -0.042301   0.050086  -0.845    0.398
Lag3         0.011085   0.049939   0.222    0.824
Lag4         0.009359   0.049974   0.187    0.851
Lag5         0.010313   0.049511   0.208    0.835
Volume       0.135441   0.158360   0.855    0.392

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 1731.2  on 1249  degrees of freedom
Residual deviance: 1727.6  on 1243  degrees of freedom
AIC: 1741.6

Number of Fisher Scoring iterations: 3
```

```
coef(glm.fits)
```

```
 (Intercept)         Lag1         Lag2         Lag3         Lag4         Lag5
-0.126000257 -0.073073746 -0.042301344  0.011085108  0.009358938  0.010313068
      Volume
 0.135440659
```

```r
summary(glm.fits)$coef
```

```
               Estimate Std. Error    z value  Pr(>|z|)
(Intercept) -0.126000257 0.24073574 -0.5233966 0.6006983
Lag1        -0.073073746 0.05016739 -1.4565986 0.1452272
Lag2        -0.042301344 0.05008605 -0.8445733 0.3983491
Lag3         0.011085108 0.04993854  0.2219750 0.8243333
Lag4         0.009358938 0.04997413  0.1872757 0.8514445
Lag5         0.010313068 0.04951146  0.2082966 0.8349974
Volume       0.135440659 0.15835970  0.8552723 0.3924004
```

- **Prediction** : Probabilities and confusion matrix

```r
glm.probs <- predict(glm.fits, type = "response")
glm.probs[1:10]
```

```
        1         2         3         4         5         6         7         8
0.5070841 0.4814679 0.4811388 0.5152224 0.5107812 0.5069565 0.4926509 0.5092292
        9        10
0.5176135 0.4888378
```

```r
contrasts(Direction)
```

```
     Up
Down  0
Up    1
```

```r
glm.pred <- rep("Down", 1250)
glm.pred[glm.probs > 0.5] = "Up"
table(glm.pred, Direction)
```

```
        Direction
glm.pred Down  Up
    Down  145 141
    Up    457 507
```

```r
mean(glm.pred == Direction)
```

```
[1] 0.5216
```

- Diagonal : correct prediction
- The logistic regression model correctly predicted the movement of the market 52.2 % of the time.
- We trained and tested the model on same set : therfore 47.8% training error.

Split Data

```
training_data <- Smarket[Smarket$Year < 2005,]
testing_data <- Smarket[Smarket$Year == 2005, ]
dim(training_data)
```

```
[1] 998   9
```

```
dim(testing_data)
```

```
[1] 252   9
```

```
glm.fits <- glm(Direction~ Lag1 + Lag2 + Lag3 + Lag4 + Lag5 + Volume,
                data = training_data,
    family = binomial)
glm.probs <- predict(glm.fits, testing_data, type = "response")
```

```
glm.pred <- rep("Down", 252)
glm.pred[glm.probs > 0.5] <- "Up"
table(glm.pred, testing_data$Direction)
```

```
glm.pred Down Up
    Down   77 97
    Up     34 44
```

```
# test error score
mean(glm.pred != testing_data$Direction)
```

```
[1] 0.5198413
```

- **Test error score** -52% test error rate is worse than random guessing -logistic regression model had very underwhelming p-values associated with all of the predictors, -Let's try to remove predictors with high p-values

```r
# Keep predictors with low p-values
glm.fits <- glm(Direction ~ Lag1 + Lag2, data = training_data, family = binomial)
glm.probs <- predict(glm.fits, testing_data, type = "response")
glm.pred <- rep("Down", 252)
glm.pred[glm.probs > 0.5] <- "Up"
table(glm.pred, testing_data$Direction)
```

```
glm.pred Down  Up
    Down   35  35
    Up     76 106
```

```r
#testing error rate
mean(glm.pred != testing_data$Direction)
```

```
[1] 0.4404762
```

- predict the returns associated with particular values of lagone and lagtwo.

```r
predict(glm.fits, newdata = data.frame(Lag1 = c(1.5, 2.0),
                                       Lag2 = c(1.1, -0.5)),
        type = "response")
```

```
        1         2
0.4749834 0.4858084
```