STAT 4198 Final Project

STAT 4198 Data Mining

Final Project

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Dataset input

```
data <- read.csv(file = "D:/file/STAT4198 Final/fordTrain.csv",stringsAsFactors=TRUE)
indexes <- read.csv(file = "D:/file/STAT4198 Final/indexes.csv",header=FALSE, stringsAsFactors=TRUE)
# G49803308
last.two.digits<- 08
k<-last.two.digits+1

newdata<-data.frame(data[data[,1]%in%indexes[k,], ])
summary(newdata)
```

```
##     TrialID          ObsNum          IsAlert            P1
##  Min.   :  0.0   Min.   :   0.0   Min.   :0.000   Min.   : 22.35
##  1st Qu.: 99.0   1st Qu.: 302.0   1st Qu.:0.000   1st Qu.: 31.59
##  Median :274.0   Median : 604.0   Median :1.000   Median : 34.13
##  Mean   :245.3   Mean   : 603.9   Mean   :0.575   Mean   : 35.22
##  3rd Qu.:357.0   3rd Qu.: 906.0   3rd Qu.:1.000   3rd Qu.: 37.14
##  Max.   :505.0   Max.   :1210.0   Max.   :1.000   Max.   :100.15
##        P2                P3              P4                P5
##  Min.   :-23.239   Min.   : 504   Min.   : 24.83   Min.   : 0.04800
##  1st Qu.:  9.988   1st Qu.: 788   1st Qu.: 50.00   1st Qu.: 0.09081
##  Median : 11.479   Median :1000   Median : 60.00   Median : 0.10379
##  Mean   : 12.035   Mean   :1017   Mean   : 64.45   Mean   : 0.21511
##  3rd Qu.: 13.694   3rd Qu.:1200   3rd Qu.: 76.14   3rd Qu.: 0.14011
##  Max.   : 29.082   Max.   :2416   Max.   :119.05   Max.   :27.20220
##        P6               P7               P8          E1
##  Min.   : 140.0   Min.   : 22.42   Min.   :0   Min.   : 0.00
##  1st Qu.: 648.0   1st Qu.: 68.49   1st Qu.:0   1st Qu.: 0.00
##  Median : 768.0   Median : 78.12   Median :0   Median : 0.00
##  Mean   : 789.3   Mean   : 80.59   Mean   :0   Mean   :10.95
##  3rd Qu.: 876.0   3rd Qu.: 92.59   3rd Qu.:0   3rd Qu.:28.63
##  Max.   :2676.0   Max.   :428.57   Max.   :0   Max.   :38.62
##        E2               E3              E4                 E5
##  Min.   :  0.00   Min.   :0.000   Min.   :-250.000   Min.   :0.00800
##  1st Qu.:  0.00   1st Qu.:0.000   1st Qu.:  -8.000   1st Qu.:0.01562
##  Median :  0.00   Median :0.000   Median :   0.000   Median :0.01600
```

```
##  Mean   : 95.91   Mean   :0.336   Mean   :  -2.336   Mean   :0.01629
##  3rd Qu.:196.63   3rd Qu.:0.000   3rd Qu.:   6.000   3rd Qu.:0.01688
##  Max.   :359.82   Max.   :4.000   Max.   : 250.000   Max.   :0.02394
##        E6               E7               E8               E9
##  Min.   :260.0   Min.   : 0.000   Min.   :0.000   Min.   :0.0000
##  1st Qu.:350.0   1st Qu.: 0.000   1st Qu.:0.000   1st Qu.:1.0000
##  Median :366.0   Median : 1.000   Median :1.000   Median :1.0000
##  Mean   :359.1   Mean   : 1.503   Mean   :1.252   Mean   :0.8941
##  3rd Qu.:367.0   3rd Qu.: 2.000   3rd Qu.:2.000   3rd Qu.:1.0000
##  Max.   :513.0   Max.   :20.000   Max.   :9.000   Max.   :1.0000
##       E10              E11               V1               V2
##  Min.   :  0.00   Min.   : 0.000   Min.   :  0.00   Min.   :-4.20000
##  1st Qu.: 44.00   1st Qu.: 0.000   1st Qu.: 23.64   1st Qu.:-0.07000
##  Median : 65.00   Median : 0.000   Median : 99.88   Median : 0.00000
##  Mean   : 60.16   Mean   : 1.293   Mean   : 75.73   Mean   :-0.02632
##  3rd Qu.: 72.00   3rd Qu.: 0.000   3rd Qu.:108.13   3rd Qu.: 0.07000
##  Max.   :117.00   Max.   :32.800   Max.   :123.88   Max.   : 2.83500
##        V3              V4               V5               V6
##  Min.   : 240   Min.   :  0.000   Min.   :0.0000   Min.   : 531
##  1st Qu.: 255   1st Qu.:  1.488   1st Qu.:0.0000   1st Qu.:1068
##  Median : 497   Median :  3.019   Median :0.0000   Median :1982
##  Mean   : 568   Mean   : 34.079   Mean   :0.1247   Mean   :1708
##  3rd Qu.: 767   3rd Qu.:  9.012   3rd Qu.:0.0000   3rd Qu.:2137
##  Max.   :1023   Max.   :479.981   Max.   :1.0000   Max.   :3466
##        V7           V8               V9          V10             V11
##  Min.   :0   Min.   : 0.00   Min.   :0   Min.   :1.000   Min.   : 3.506
##  1st Qu.:0   1st Qu.: 0.00   1st Qu.:0   1st Qu.:2.000   1st Qu.: 7.498
##  Median :0   Median :12.10   Median :0   Median :4.000   Median :10.796
##  Mean   :0   Mean   :12.18   Mean   :0   Mean   :3.276   Mean   :11.179
##  3rd Qu.:0   3rd Qu.:21.00   3rd Qu.:0   3rd Qu.:4.000   3rd Qu.:15.232
##  Max.   :0   Max.   :62.10   Max.   :0   Max.   :7.000   Max.   :19.711
```

```
sum(is.na(newdata))
```

```
## [1] 0
```

The entire data has no missing value

Exploratory Data Analysis

1.Remove features which do not change their values

delete: P8, V7, V9

```
drops <- c("P8","V7","V9")
newdata<-newdata[ , !(names(newdata) %in% drops)]
```

2.For each feature

Due to the lack of dataset decription, I can only determine whether a variable is continuous of categorical by checking how many levels the variable has. For example, if a variable is

continuous, then it could have as many levels as the sample size. Otherwise, if a variable is categorical, then it could have much fewer numbers of levels compared to the sample size.

TrialID: From the dataset description, variable "TrialID" is a code for a subject, which means such variable is categorical. And the specific levels for vairable "TrialID" are listing as following:

```
TrialID <- as.factor(newdata$TrialID)
levels(TrialID)
```

```
##  [1] "0"   "8"   "17"  "29"  "35"  "36"  "44"  "60"  "63"  "78"  "83"
## [12] "91"  "99"  "100" "146" "155" "170" "180" "208" "225" "235" "244"
## [23] "256" "258" "268" "274" "290" "291" "296" "308" "315" "320" "322"
## [34] "324" "325" "338" "352" "357" "359" "392" "395" "405" "411" "416"
## [45] "422" "425" "438" "450" "452" "505"
```

ObsNum: Based on the dataset description, variable "ObsNum" is the number of new sample. Therefore, this variable has no influence on the analysis. Range from 0 to 1211.

IsAlert: Based in the dataset description, this variable is the response variable. This variable only concludes two levels – 1 for having alert, and 0 for not having alert

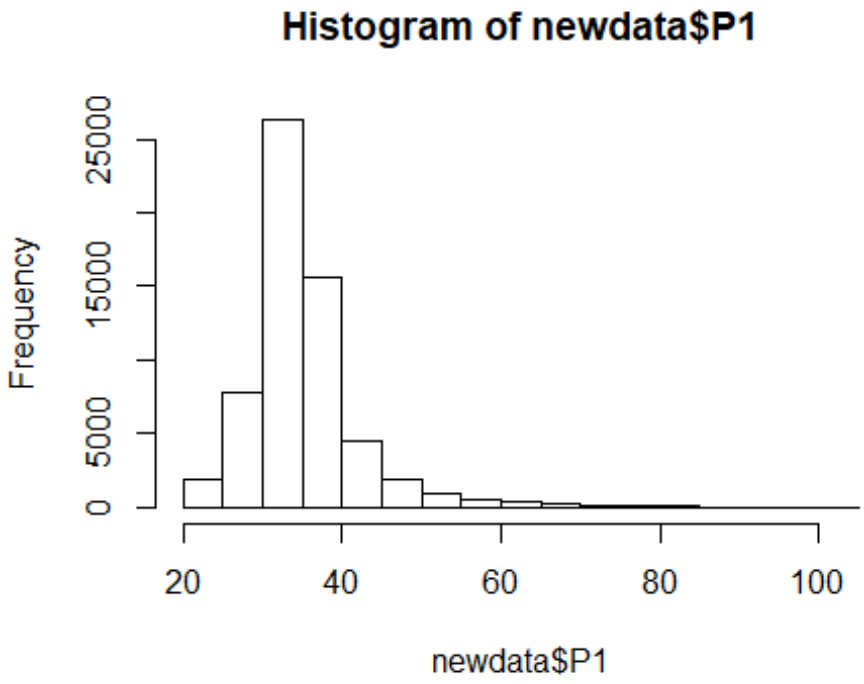
```
table(newdata$IsAlert)
```

```
##
##     0     1
## 25686 34756
```

There are 25686 observations have no alert, and 34756 onservations have alert.

Physical data: P1: Variable "P1" is continuous, and has symmetry distribution.

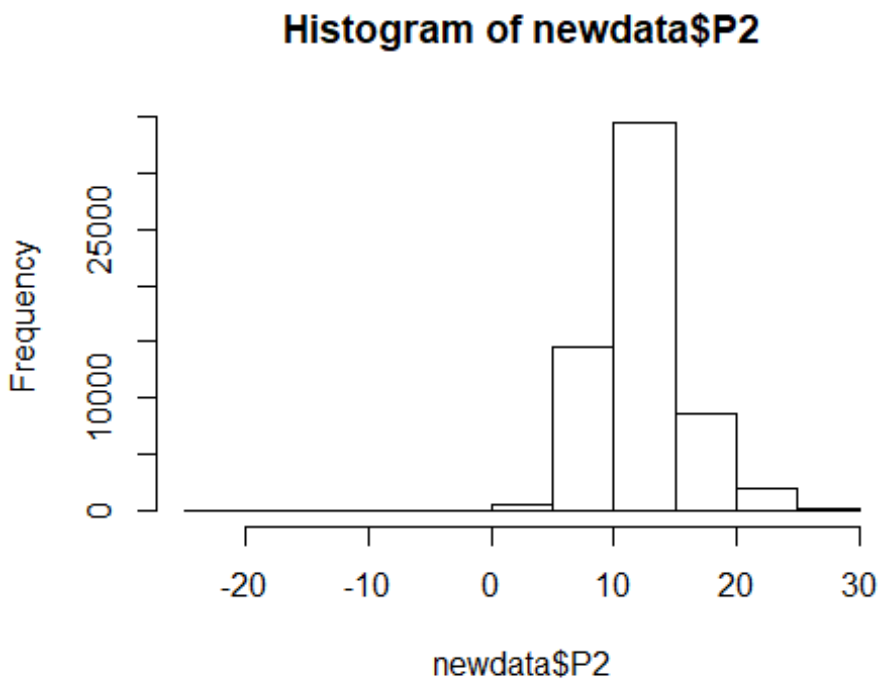
```
#P1 <- as.factor(newdata$P1)
#levels(P1)
hist(newdata$P1)
```




```
summary(newdata$P1)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   22.35   31.59   34.13   35.22   37.14  100.15
```

P2: Variable “P2” is continuous, and has symmetry distribution.

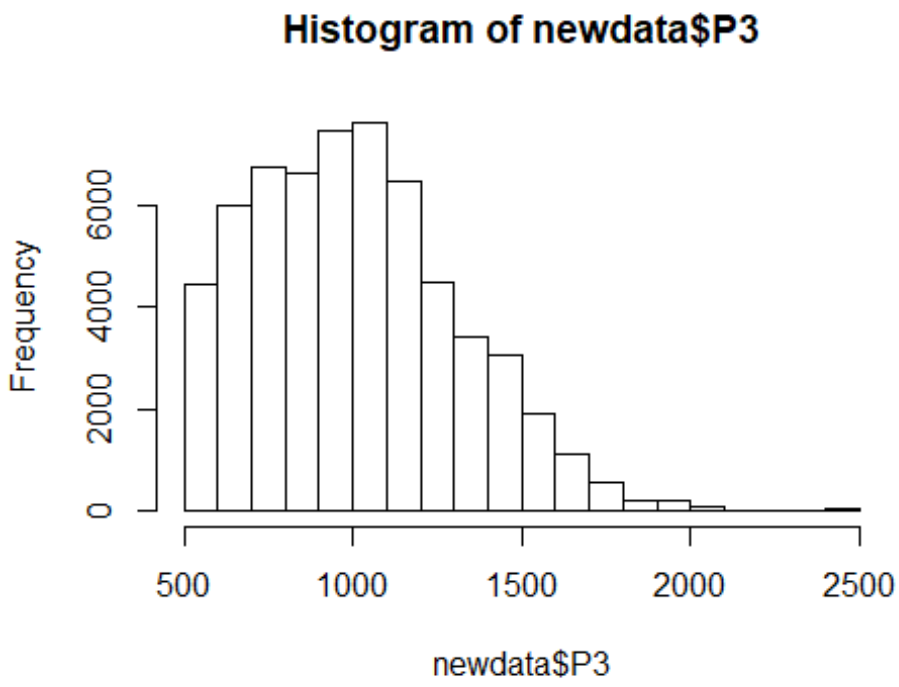
```
#P2 <- as.factor(newdata$P2)
#levels(P2)
hist(newdata$P2)
```




```
summary(newdata$P2)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## -23.239   9.988  11.479  12.035  13.694  29.082
```

P3: Variable “P3” is continuous, and has symmetry distribution.

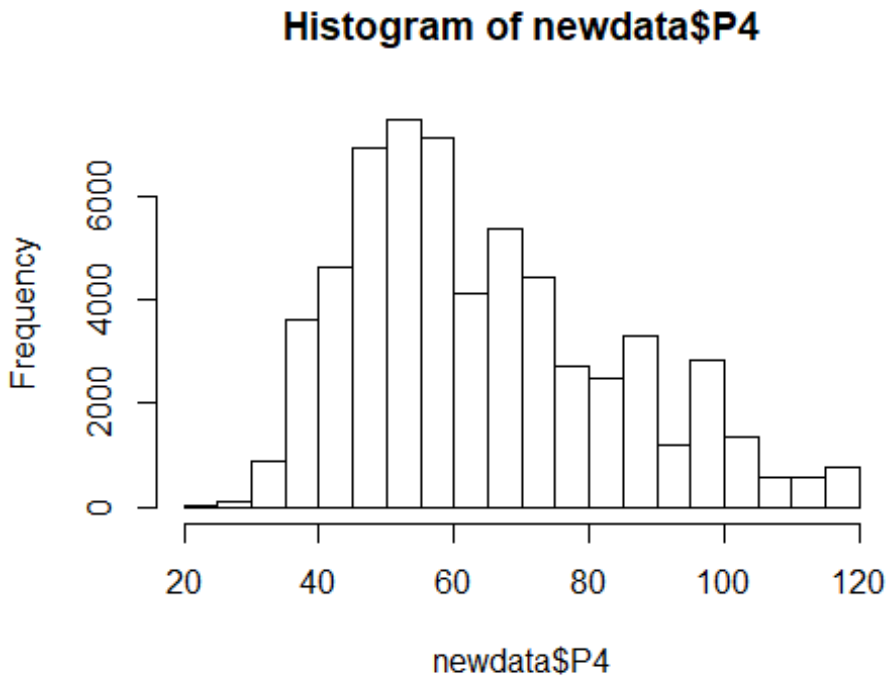
```
#P3 <- as.factor(newdata$P3)
#levels(P3)
hist(newdata$P3)
```




```
#barplot(table(newdata$P3),xlab= 'P3')
summary(newdata$P3)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     504     788    1000    1017    1200    2416
```

P4: Variable “P4” is continuous, and has symmetry distribution.

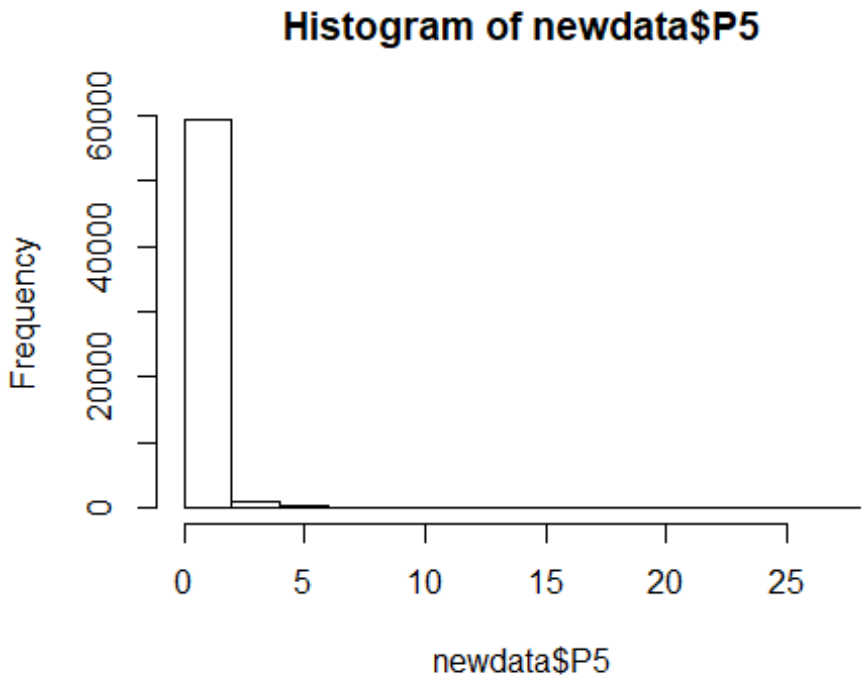
```
#P4 <- as.factor(newdata$P4)
#levels(P4)
hist(newdata$P4)
```




```
#barplot(table(newdata$P4),xlab= 'P4')
summary(newdata$P4)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   24.83   50.00   60.00   64.45   76.14  119.05
```

P5: Variable "P5" is continuous, and has right-skewed distribution.

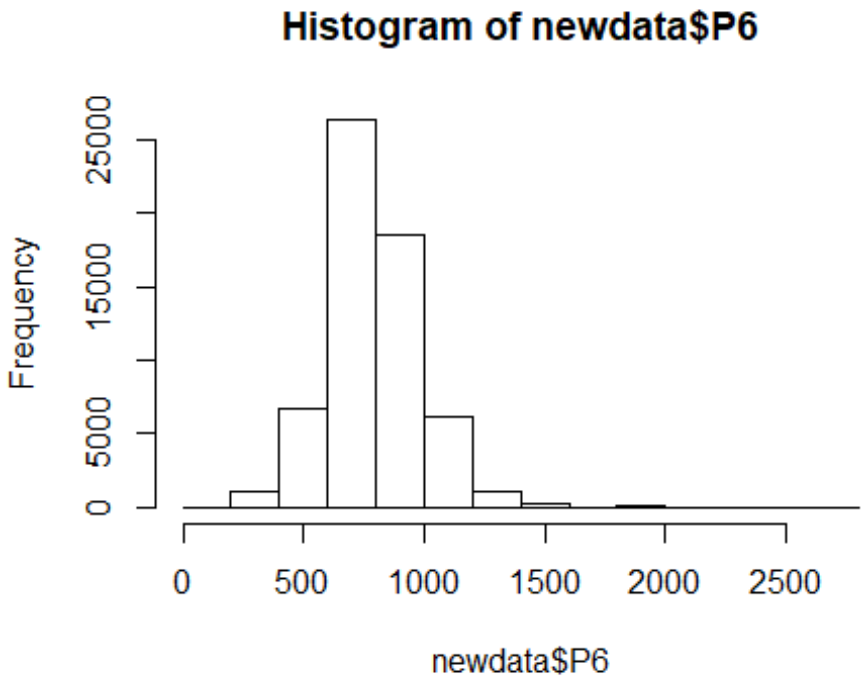
```
#P5 <- as.factor(newdata$P5)
#levels(P5)
hist(newdata$P5)
```




```
#barplot(table(newdata$P5),xlab= 'P5')
summary(newdata$P5)

##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
##  0.04800  0.09081  0.10379  0.21511  0.14011 27.20220
```

P6: Variable “P6” is continuous, and has symmetry distribution.

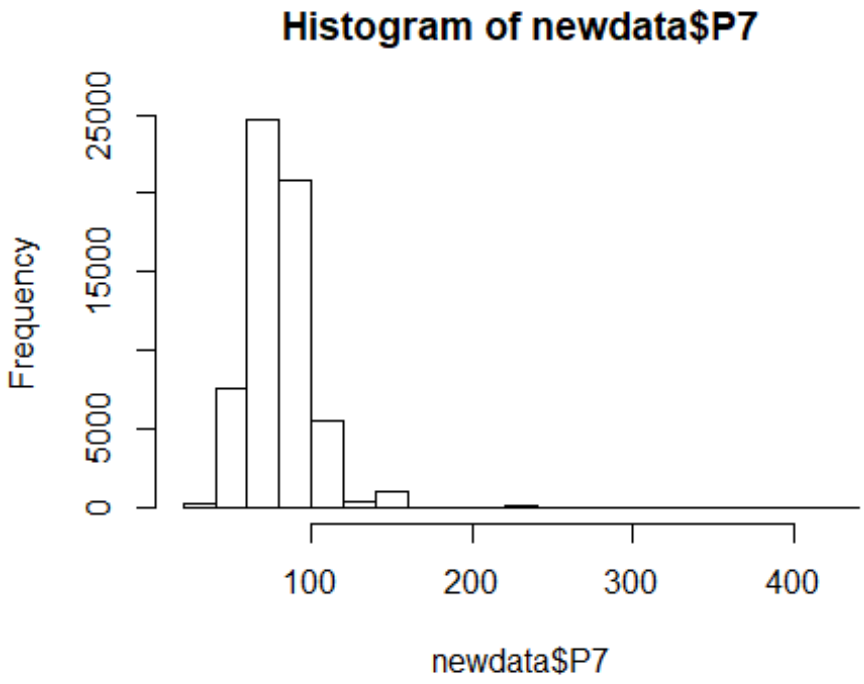
```
#P6 <- as.factor(newdata$P6)
#levels(P6)
hist(newdata$P6)
```




```
#barplot(table(newdata$P6),xlab= 'P6')
summary(newdata$P6)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   140.0   648.0   768.0   789.3   876.0  2676.0
```

P7: Variable “P7” is continuous, and has symmetry distribution.

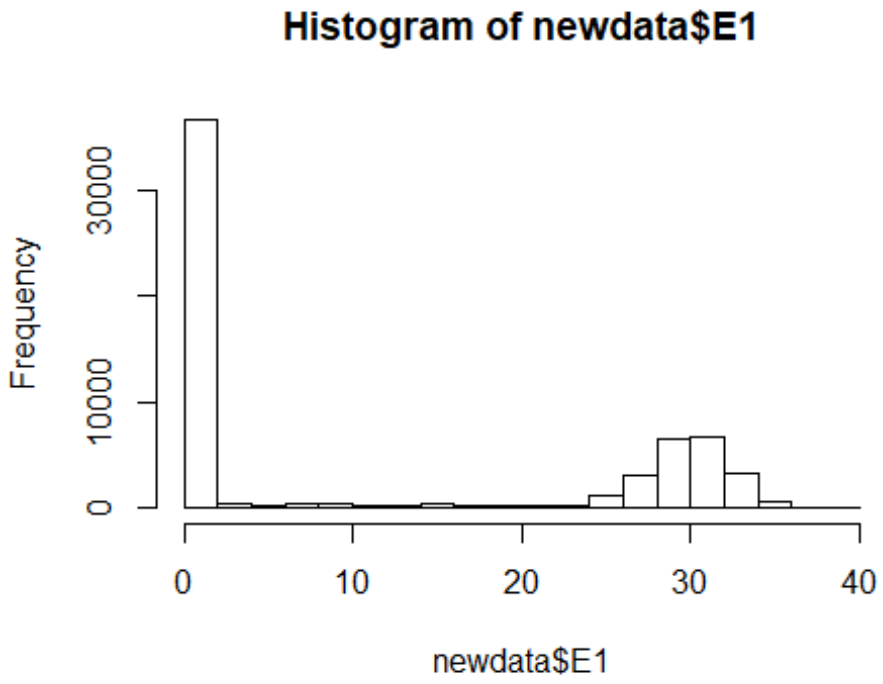
```
#P7 <- as.factor(newdata$P7)
#levels(P7)
hist(newdata$P7)
```




```
#barplot(table(newdata$P7),xlab= 'P7')
summary(newdata$P7)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   22.42   68.49   78.12   80.59   92.59  428.57
```

E1: Variable “E1” is continuous, and has multimodality distribution.

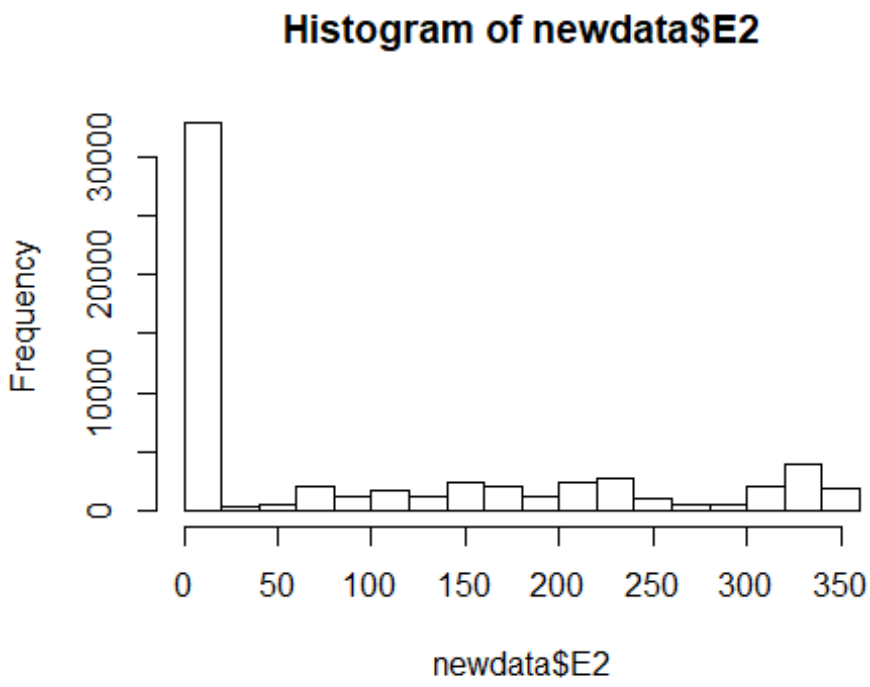
```
#E1 <- as.factor(newdata$E1)
#levels(E1)
hist(newdata$E1)
```




```
#barplot(table(newdata$E1),xlab= 'E1')
summary(newdata$E1)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    0.00    0.00    0.00   10.95   28.63   38.62
```

E2: Variable “E2” is continuous, and has multimodality distribution.

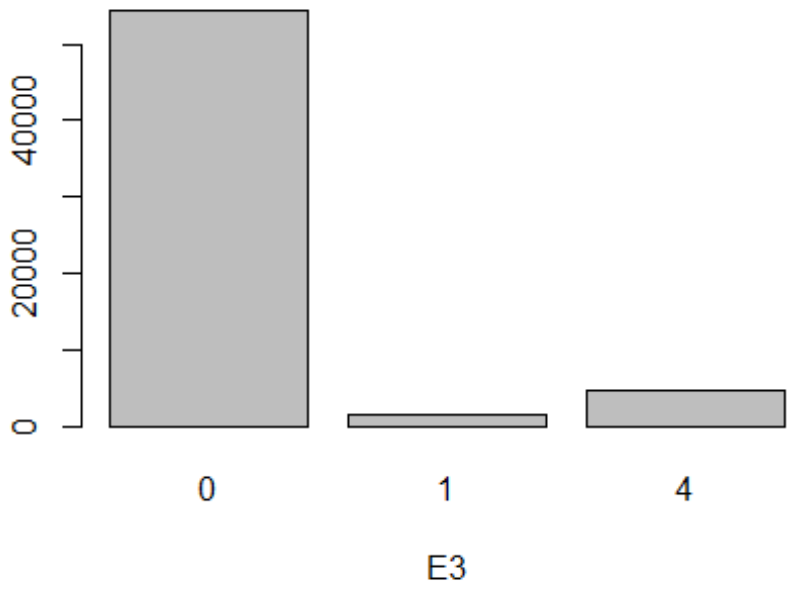
```
#E2 <- as.factor(newdata$E2)
#levels(E2)
hist(newdata$E2)
```




```
#barplot(table(newdata$E2),xlab= 'E2')
summary(newdata$E2)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    0.00    0.00    0.00   95.91  196.63  359.82
```

E3: Variable "E3" is categorical, with 3 levels.

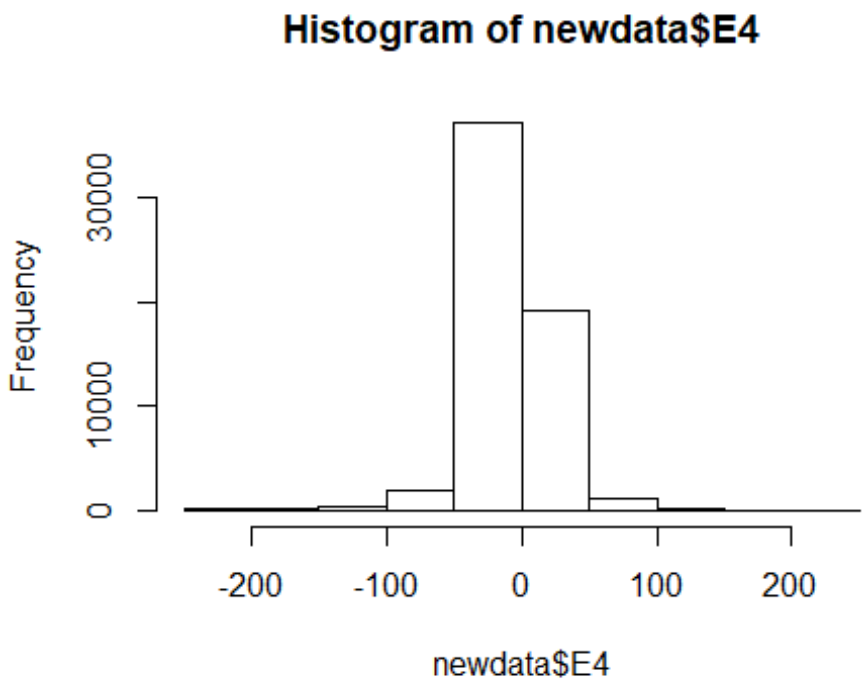
```
E3 <- as.factor(newdata$E3)
levels(E3)

## [1] "0" "1" "4"

#hist(newdata$E3)
barplot(table(newdata$E3),xlab= 'E3')
```




```
#summary(newdata$E3)
```

E4: Variable “E4” is continuous, and has symmetry distribution.

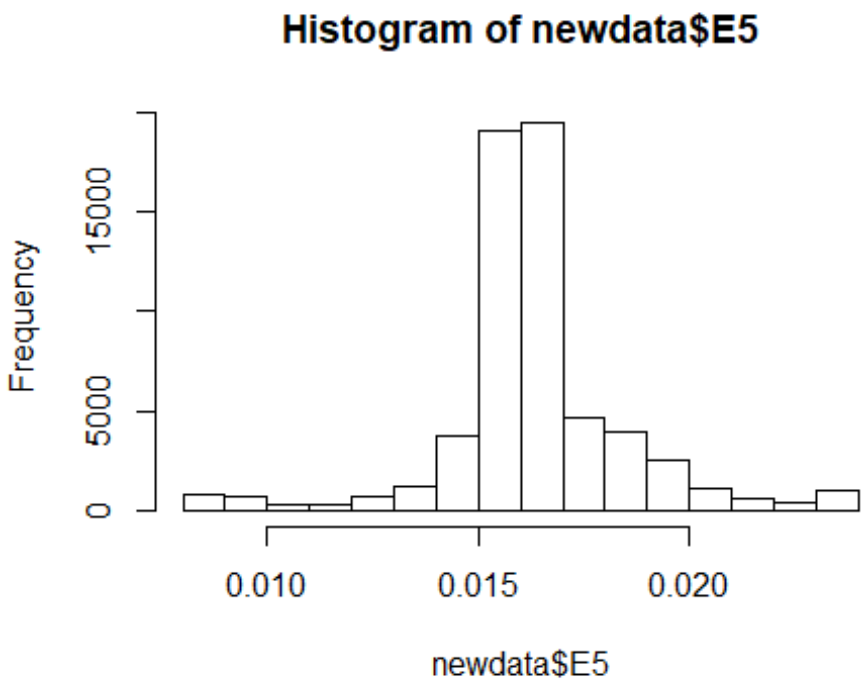
```
#E4 <- as.factor(newdata$E4)
#levels(E4)
hist(newdata$E4)
```




```
#barplot(table(newdata$E4),xlab= 'E4')
summary(newdata$E4)

##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
## -250.000   -8.000    0.000   -2.336    6.000  250.000
```

E5: Variable “E5” is continuous, and has symmetry distribution.

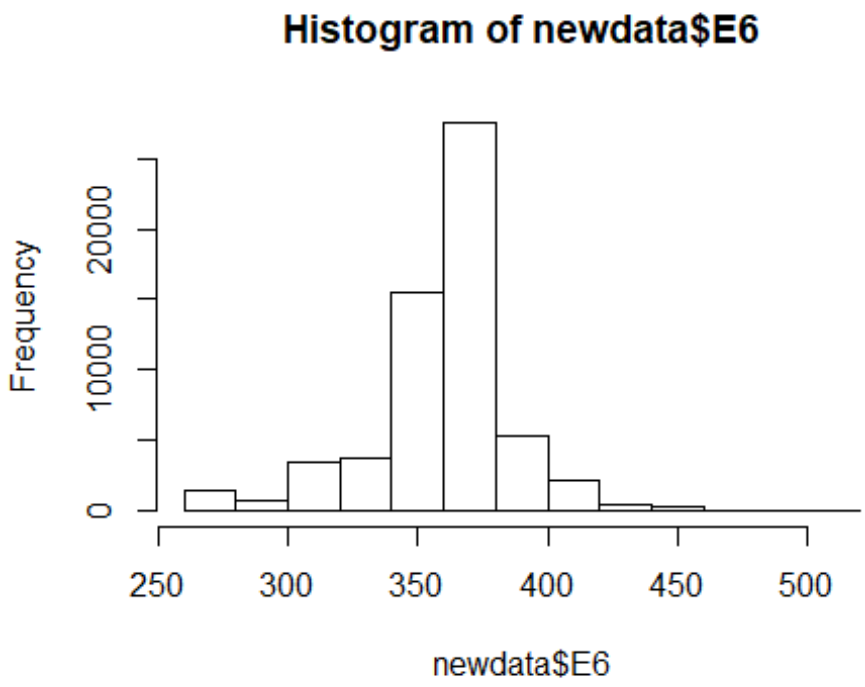
```
#E5 <- as.factor(newdata$E5)
#levels(E5)
hist(newdata$E5)
```




```
#barplot(table(newdata$E5),xlab= 'E5')
summary(newdata$E5)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## 0.00800 0.01562 0.01600 0.01629 0.01688 0.02394
```

E6: Variable "E6" is continuous, and has symmetry distribution.

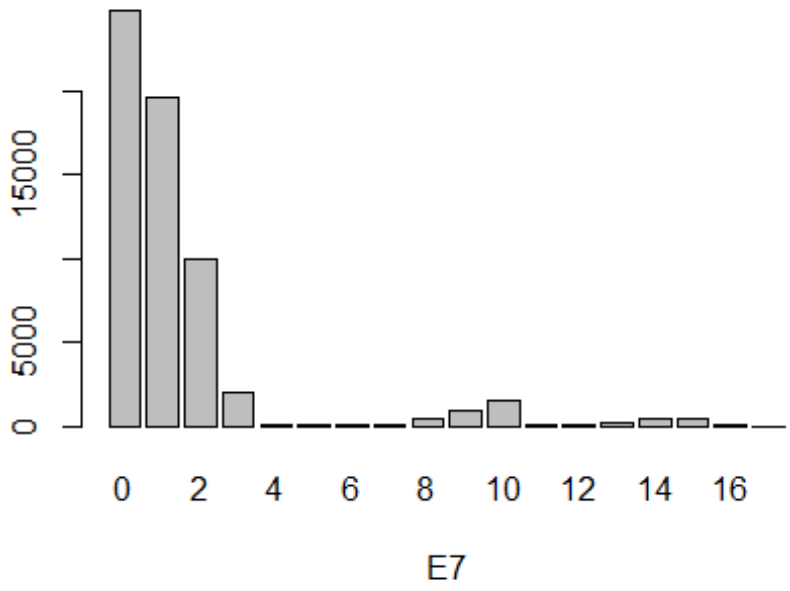
```
#E6 <- as.factor(newdata$E6)
#levels(E6)
hist(newdata$E6)
```




```
#barplot(table(newdata$E6),xlab= 'E6')
summary(newdata$E6)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   260.0   350.0   366.0   359.1   367.0   513.0
```

E7: Variable "E7" is categorial, with 18 levels. because all values of E7 are integers, and the values follow an order from 1 to 16 and the last one is 20.

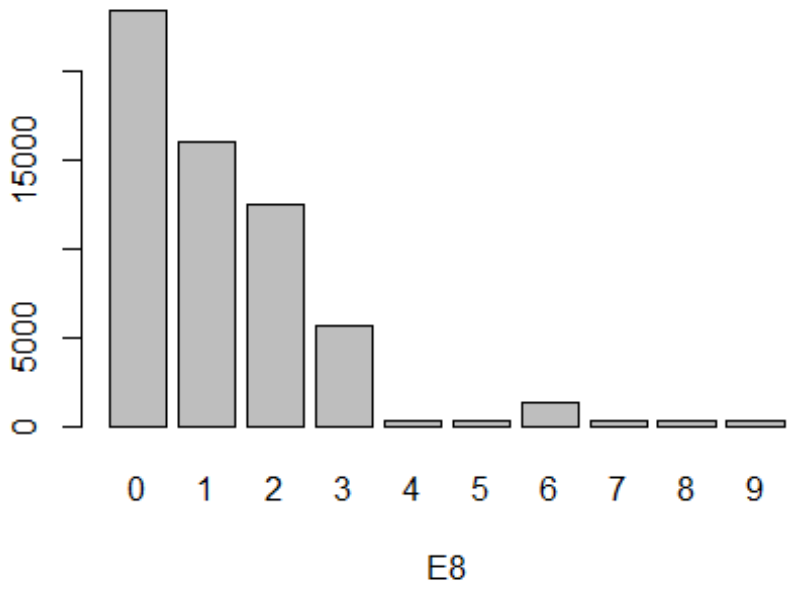
```
E7 <- as.factor(newdata$E7)
levels(E7)

##  [1] "0"  "1"  "2"  "3"  "4"  "5"  "6"  "7"  "8"  "9"  "10" "11" "12" "13"
## [15] "14" "15" "16" "20"

#hist(newdata$E7)
barplot(table(newdata$E7),xlab= 'E7')
```




```
#summary(newdata$E7)
```

E8: Variable “E8” is categorial, with 10 levels.

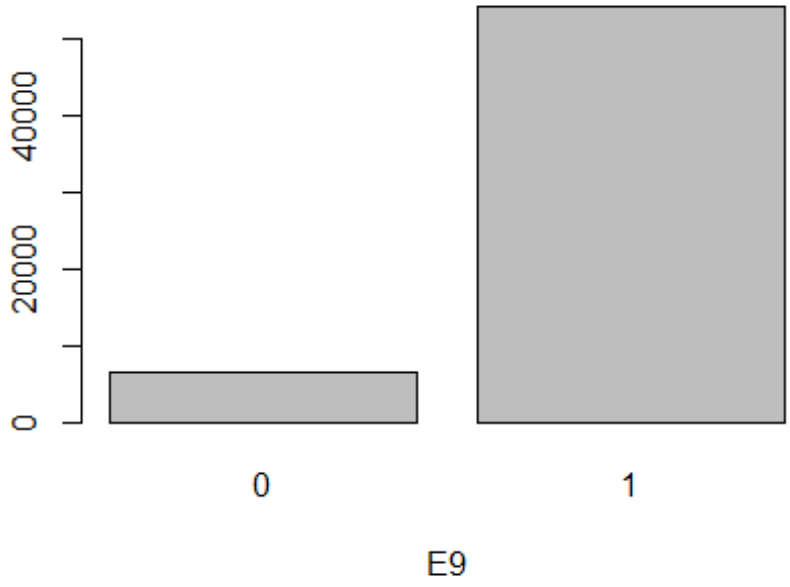
```
E8 <- as.factor(newdata$E8)
levels(E8)

##  [1] "0" "1" "2" "3" "4" "5" "6" "7" "8" "9"

#hist(newdata$E8)
barplot(table(newdata$E8),xlab= 'E8')
```




```
#summary(newdata$E8)
```

E9: Variable “E9” is categorial, with 2 levels.

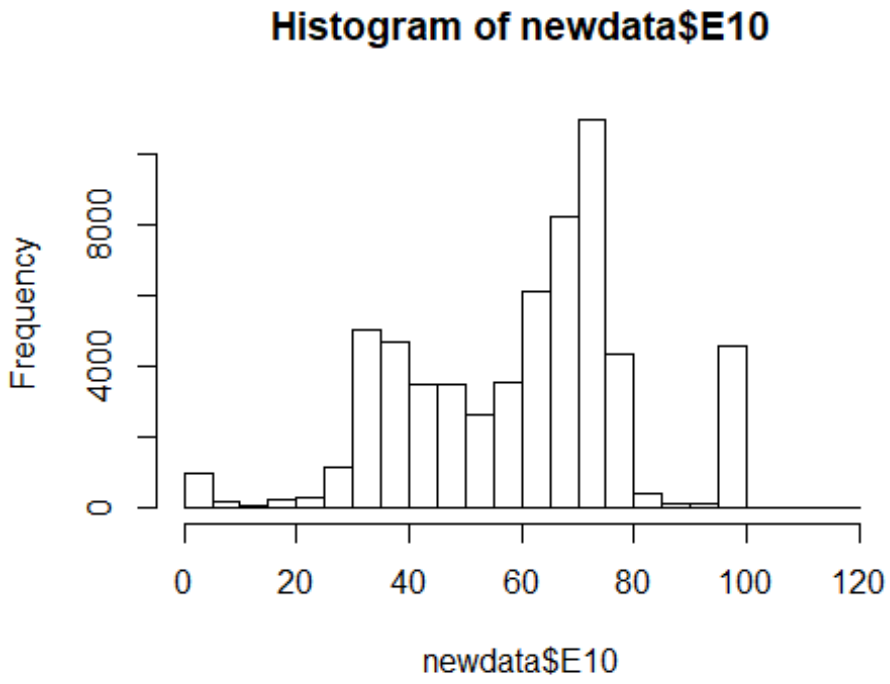
```
E9 <- as.factor(newdata$E9)
levels(E9)

## [1] "0" "1"

#hist(newdata$E9)
barplot(table(newdata$E9),xlab= 'E9')
```




```
#summary(newdata$E9)
```

E10: Variable “E10” is continuous, and has multimodality distribution.

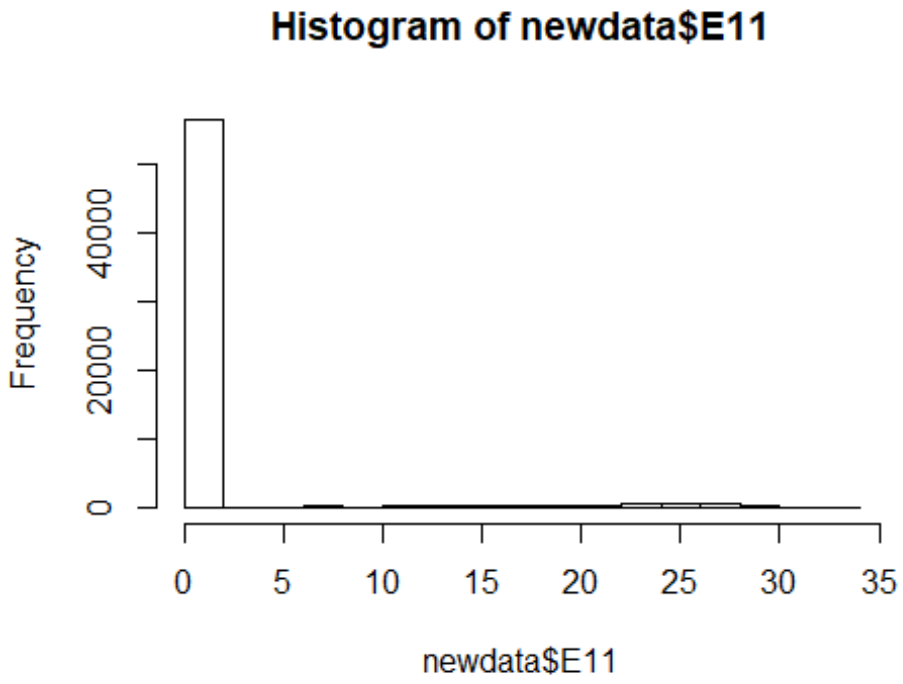
```
#E10 <- as.factor(newdata$E10)
#levels(E10)
hist(newdata$E10)
```




```
#barplot(table(newdata$E10),xlab= 'E10')
summary(newdata$E10)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    0.00   44.00   65.00   60.16   72.00  117.00
```

E11: Variable "E11" is continuous, and has right-skewed distribution.

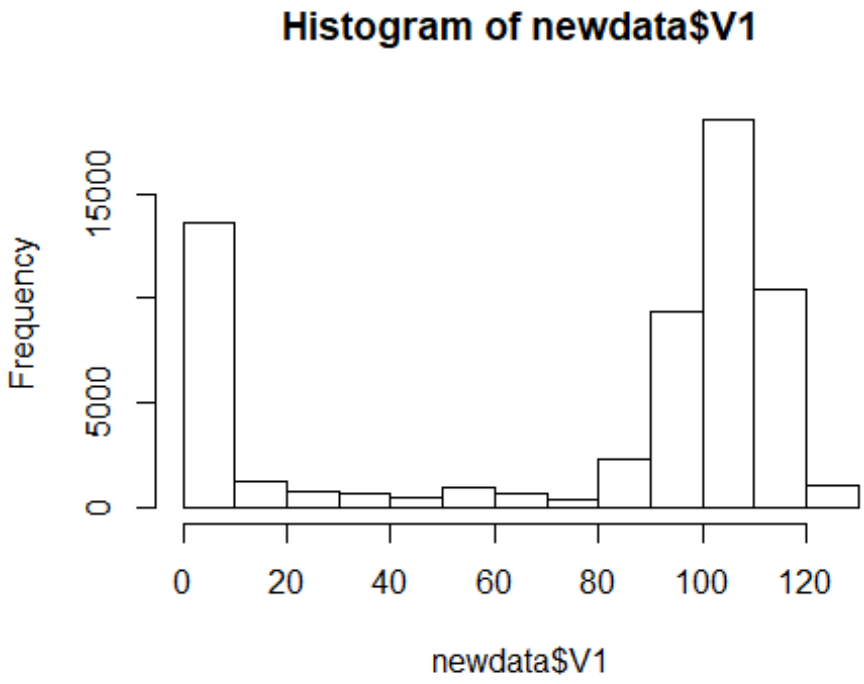
```
#E11 <- as.factor(newdata$E11)
#levels(E11)
hist(newdata$E11)
```




```
#barplot(table(newdata$E11),xlab= 'E11')
summary(newdata$E11)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.000   0.000   0.000   1.293   0.000  32.800
```

V1: Variable “V1” is continuous, and has multimodality distribution.

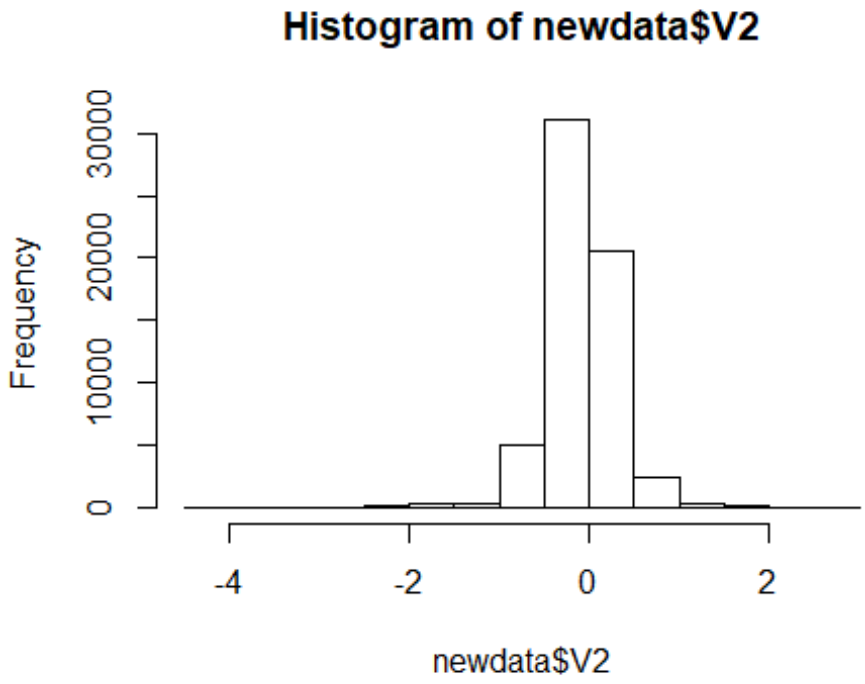
```
#V1 <- as.factor(newdata$V1)
#levels(V1)
hist(newdata$V1)
```




```
#barplot(table(newdata$V1),xlab= 'V1')
summary(newdata$V1)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    0.00   23.64   99.88   75.73  108.13  123.88
```

V2: Variable "V2" is continuous, and has symmetry distribution.

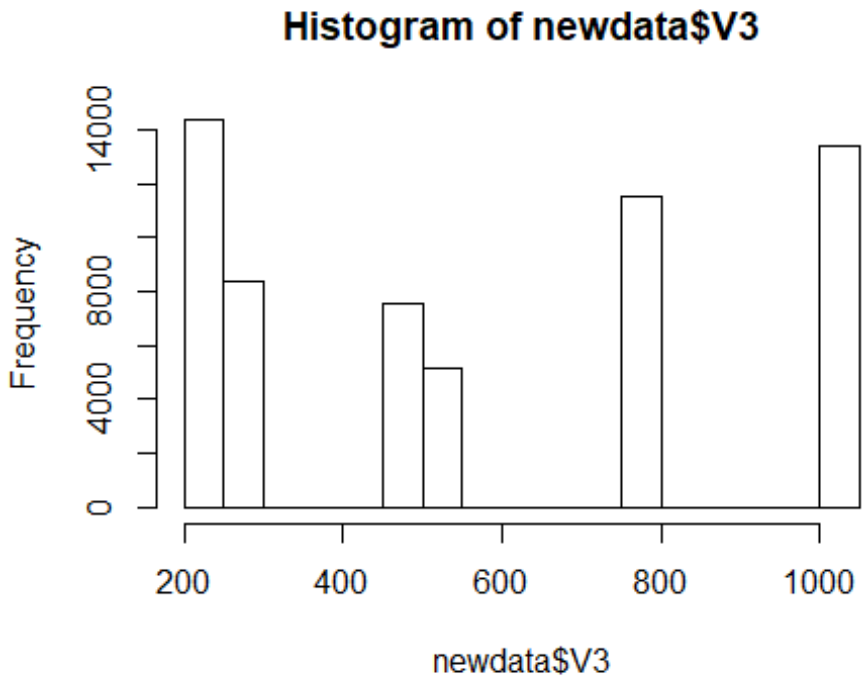
```
#V2 <- as.factor(newdata$V2)
#levels(V2)
hist(newdata$V2)
```




```
#barplot(table(newdata$V2),xlab= 'V2')
summary(newdata$V2)

##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
## -4.20000 -0.07000  0.00000 -0.02632  0.07000  2.83500
```

V3: Variable "V3" is continuous, and has multimodality distribution.

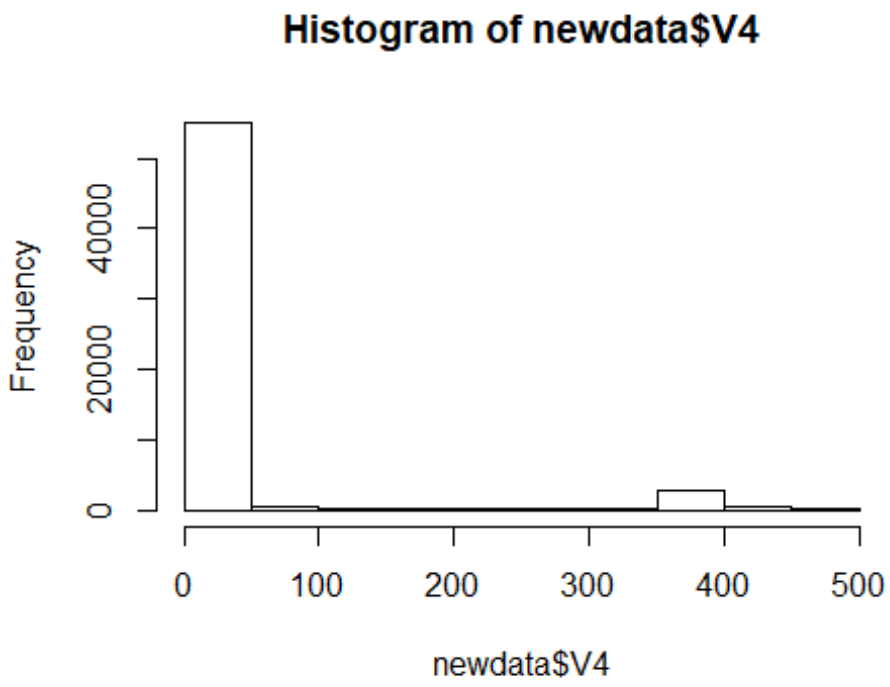
```
#V3 <- as.factor(newdata$V3)
#levels(V3)
hist(newdata$V3)
```




```
#barplot(table(newdata$V3),xlab= 'V3')
summary(newdata$V3)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     240     255     497     568     767    1023
```

V4: Variable "V4" is continuous, and has right-skewed distribution.

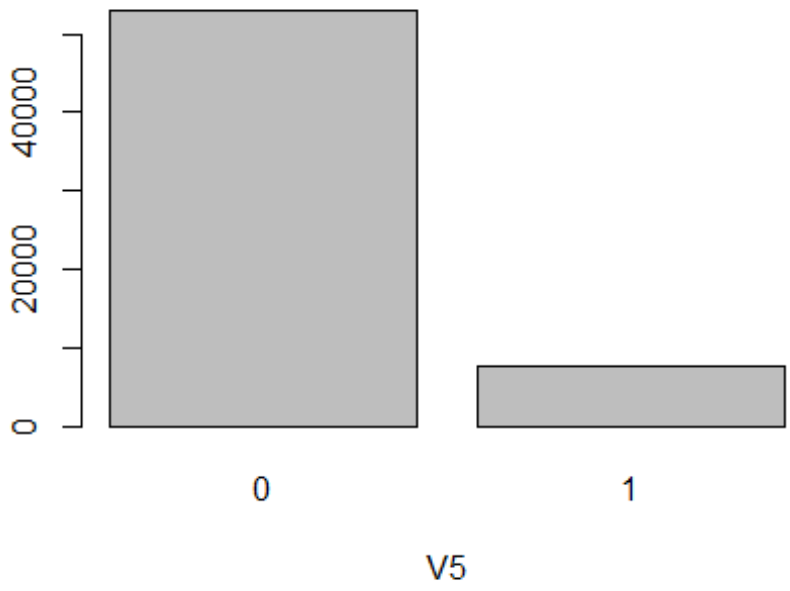
```
#V4 <- as.factor(newdata$V4)
#levels(V4)
hist(newdata$V4)
```




```
#barplot(table(newdata$V4),xlab= 'V4')
summary(newdata$V4)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.000   1.488   3.019  34.079   9.012 479.981
```

V5: Variable "V5" is categorial, with 2 levels.

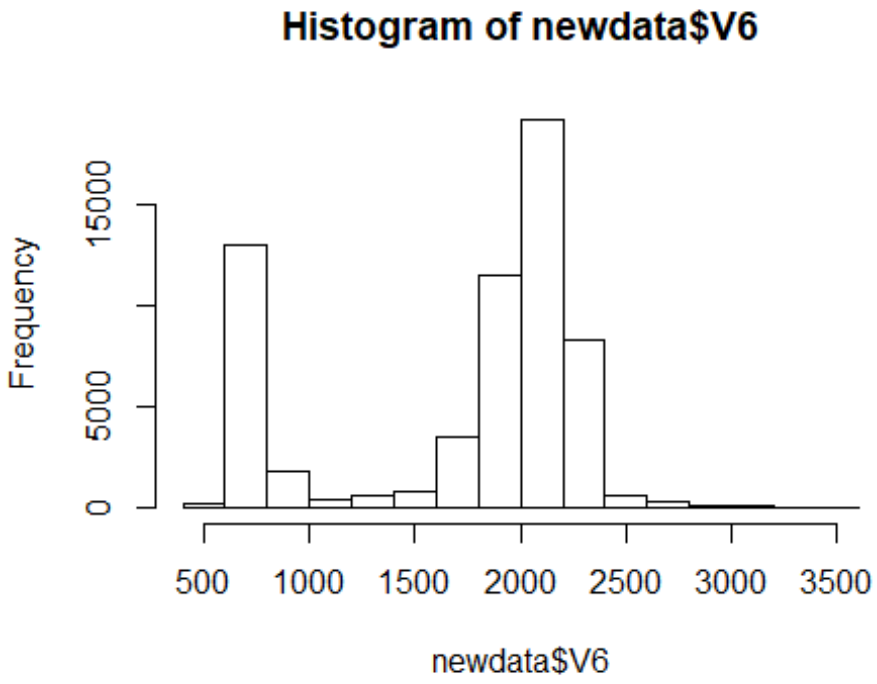
```
V5 <- as.factor(newdata$V5)
levels(V5)

## [1] "0" "1"

#hist(newdata$V5)
barplot(table(newdata$V5),xlab= 'V5')
```




```
#summary(newdata$V5)
```

V6: Variable “V6” is continuous, and has multimodality distribution.

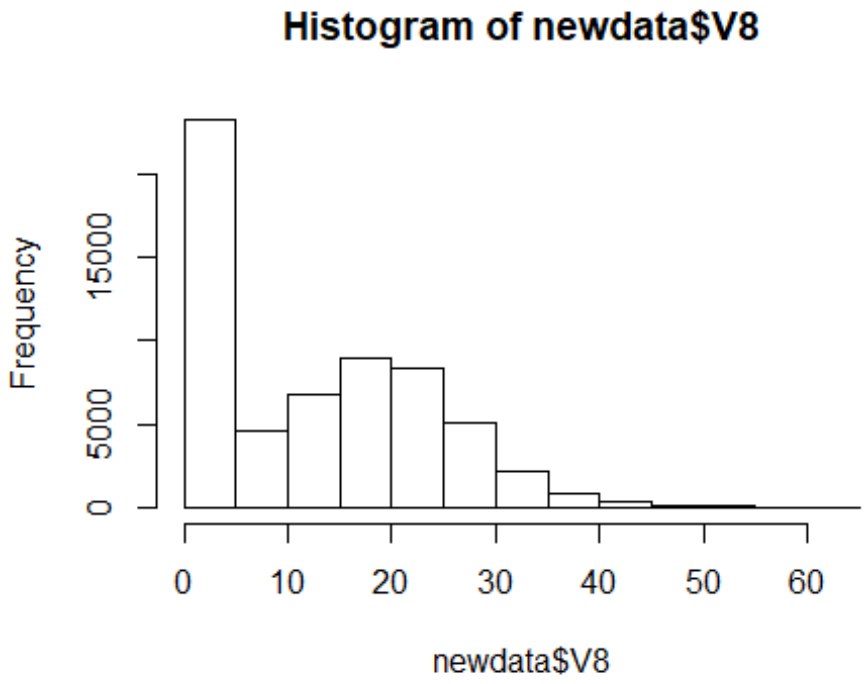
```
#V6 <- as.factor(newdata$V6)
#levels(V6)
hist(newdata$V6)
```




```
#barplot(table(newdata$V6),xlab= 'V6')
summary(newdata$V6)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     531    1068    1982    1708    2137    3466
```

V8: Variable "V8" is continuous, and has right-skewed distribution.

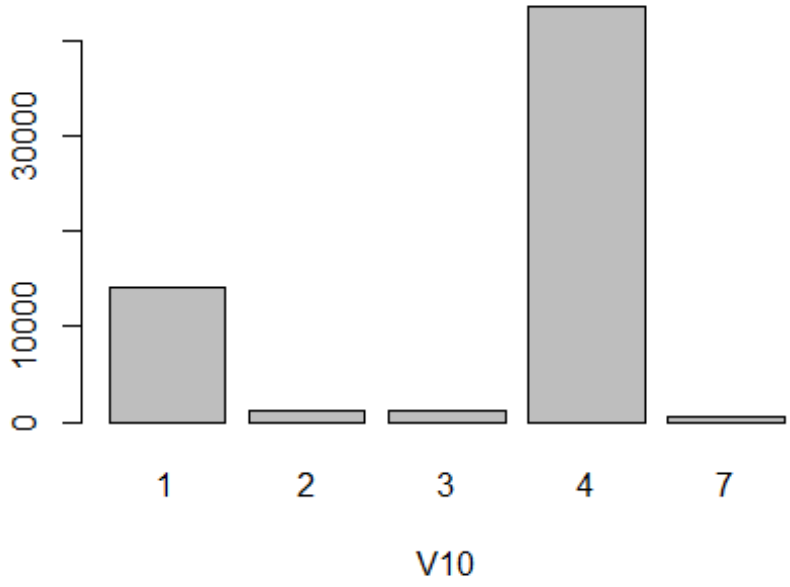
```
#V8 <- as.factor(newdata$V8)
#levels(V8)
hist(newdata$V8)
```




```
#barplot(table(newdata$V8),xlab= 'V8')
summary(newdata$V8)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    0.00    0.00   12.10   12.18   21.00   62.10
```

V10: Variable "V10" is categorial, with 5 levels.

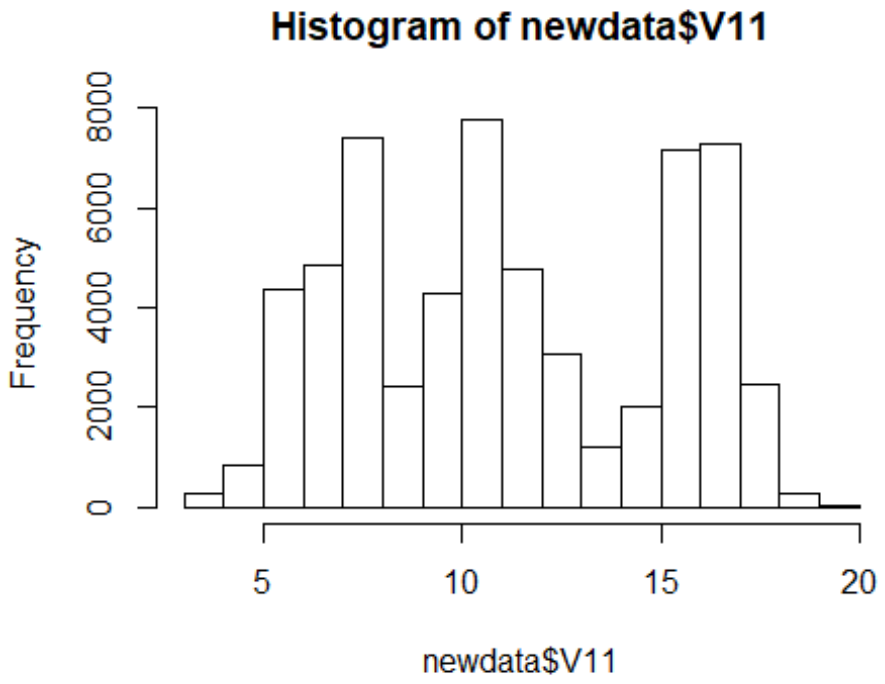
```
V10 <- as.factor(newdata$V10)
levels(V10)

## [1] "1" "2" "3" "4" "7"

#hist(newdata$V10)
barplot(table(newdata$V10),xlab= 'V10')
```




```
#summary(newdata$V10)
```

V11: Variable “V11” is continuous, and has multimodality distribution.

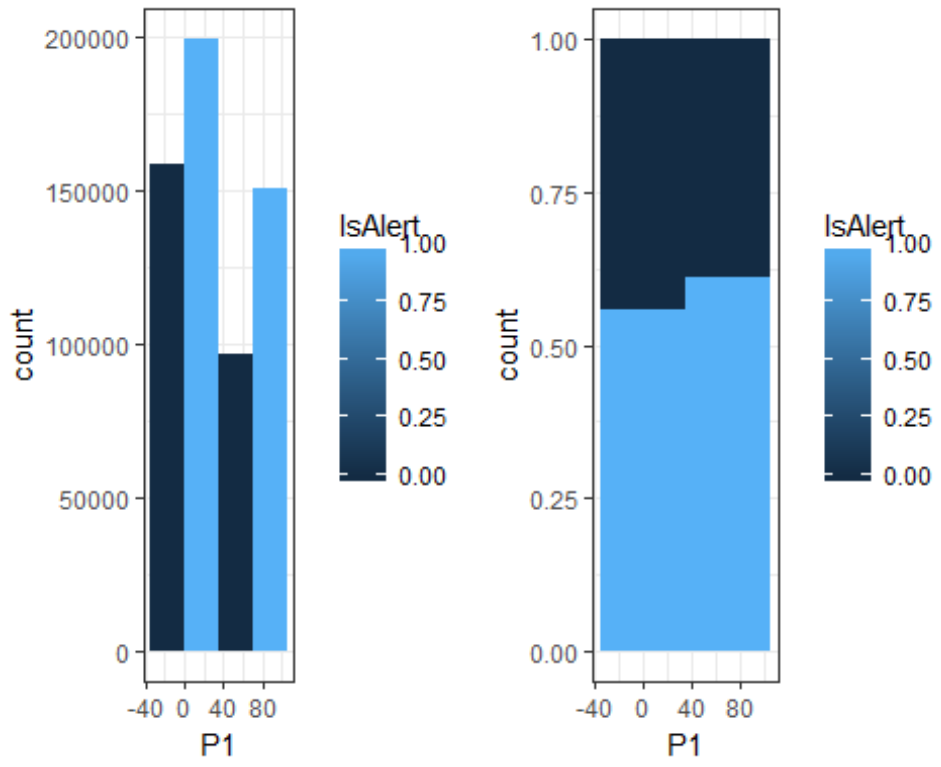
```
#V11 <- as.factor(newdata$V11)
#levels(V11)
hist(newdata$V11)
```



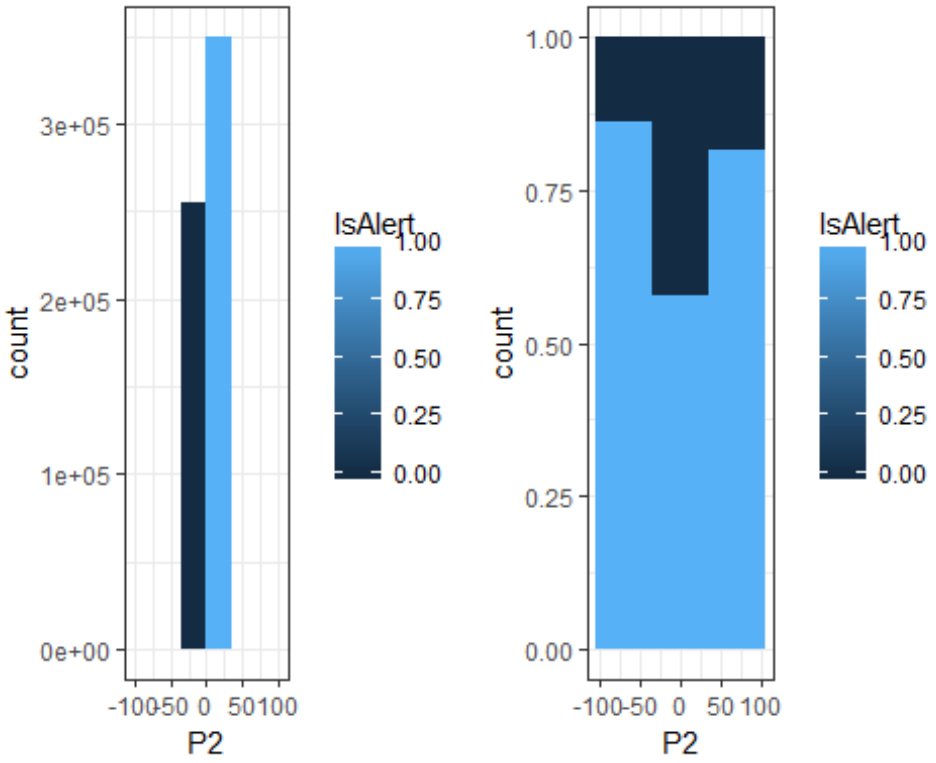

```
#barplot(table(newdata$V11),xlab= 'V11')
summary(newdata$V11)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   3.506   7.498  10.796  11.179  15.232  19.711
```

3.Graphical investigation to whether the feature has a relationship with the response

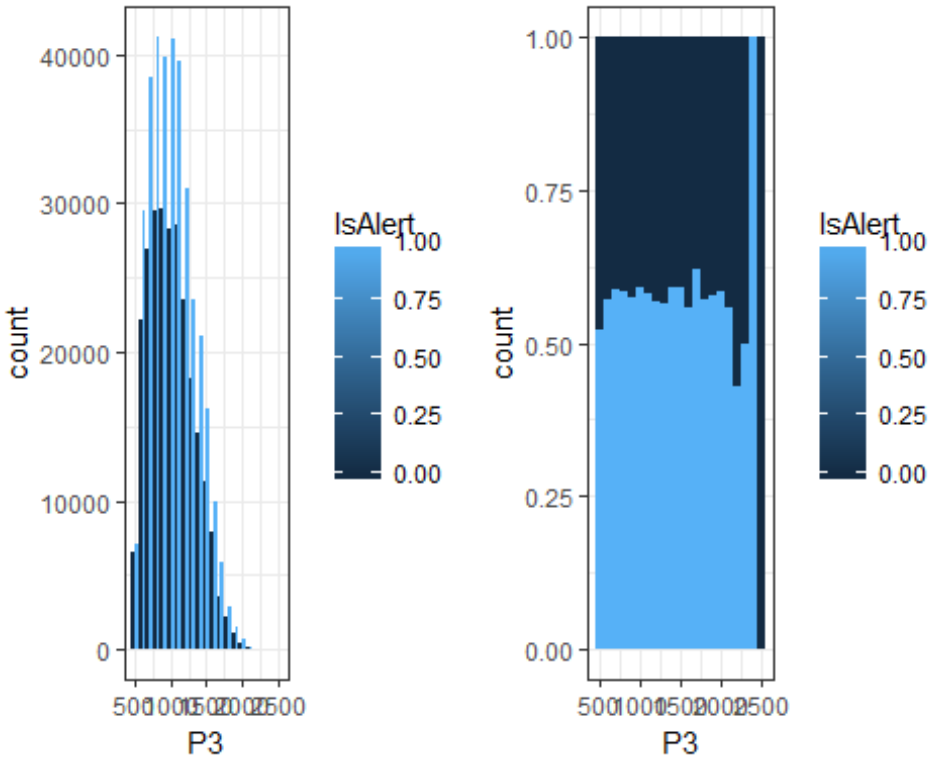
```
library(gridExtra)
library(ggplot2)
#P1
p1_1<-ggplot(data,aes(x=P1,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=70)+theme_bw()
p1_2<-ggplot(data,aes(x=P1,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=70)+theme_bw()
grid.arrange(p1_1, p1_2, ncol=2)
```



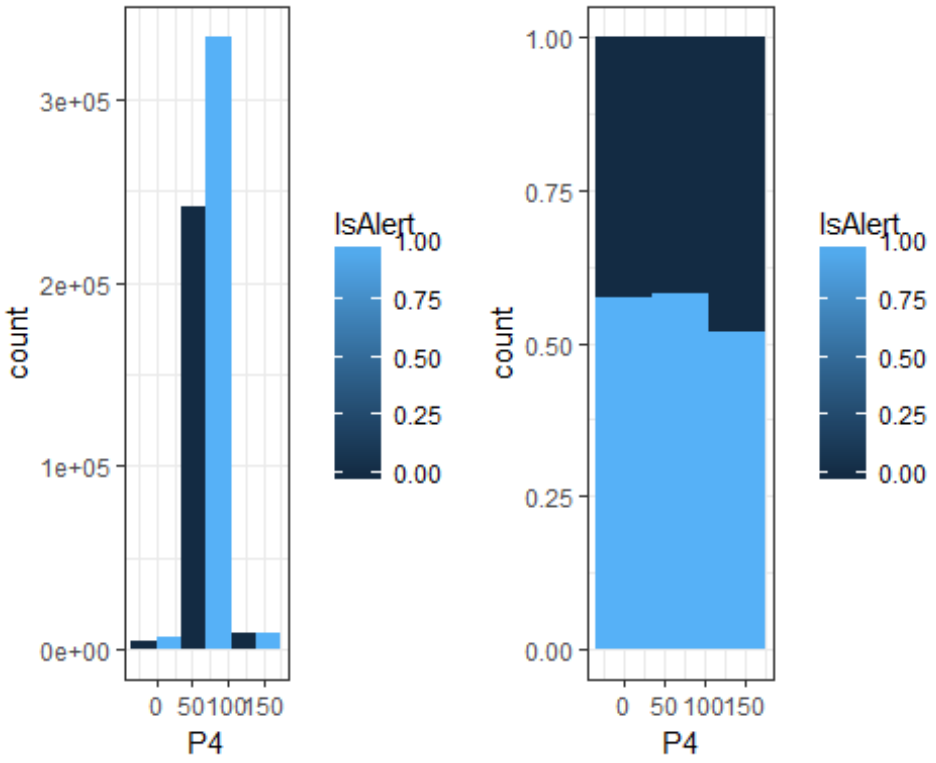

```r
#P2
p2_1<-ggplot(data,aes(x=P2,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=70)+theme_bw()
p2_2<-ggplot(data,aes(x=P2,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=70)+theme_bw()
grid.arrange(p2_1, p2_2, ncol=2)
```



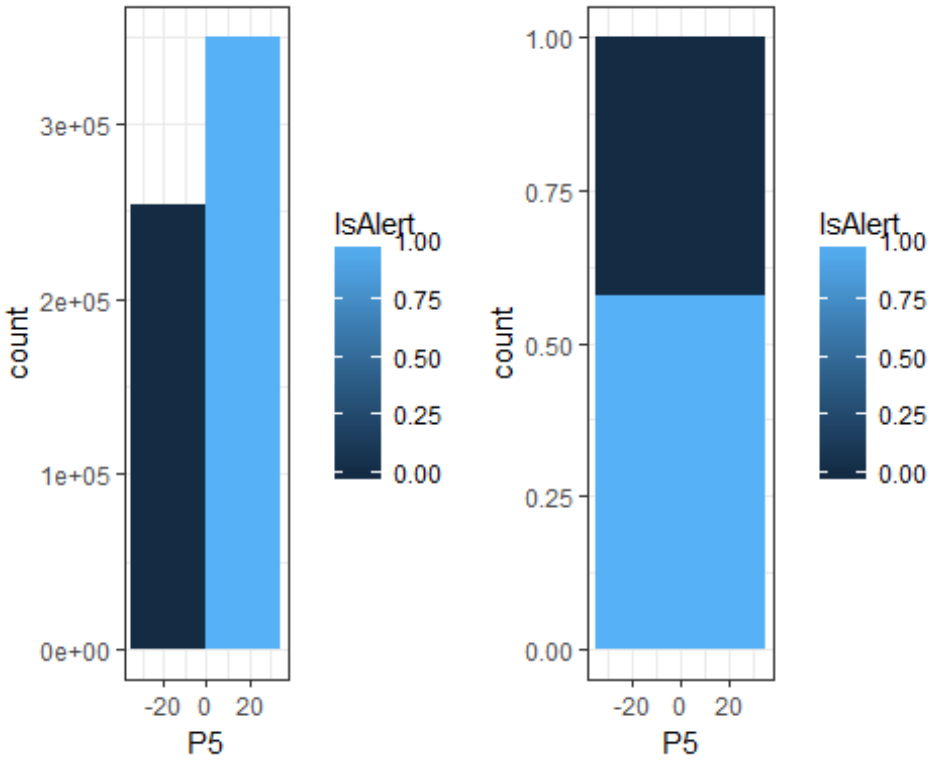

```
#P3
p3_1<-ggplot(data,aes(x=P3,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=100)+theme_bw()
p3_2<-ggplot(data,aes(x=P3,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=100)+theme_bw()
grid.arrange(p3_1, p3_2, ncol=2)
```



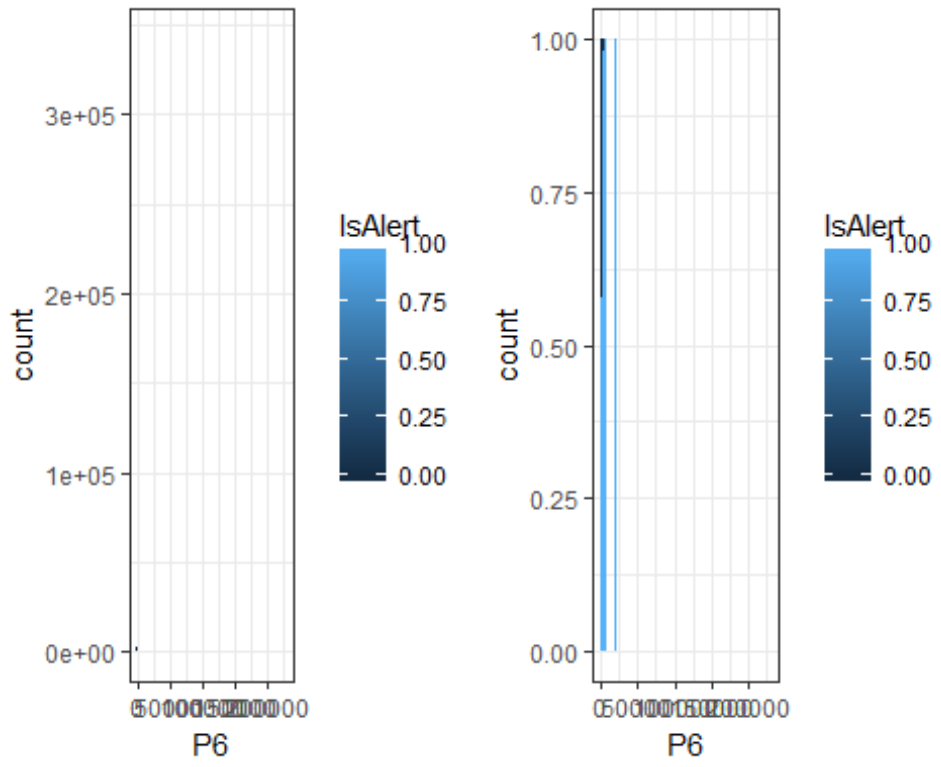

```r
#P4
p4_1<-ggplot(data,aes(x=P4,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=70)+theme_bw()
p4_2<-ggplot(data,aes(x=P4,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=70)+theme_bw()
grid.arrange(p4_1, p4_2, ncol=2)
```



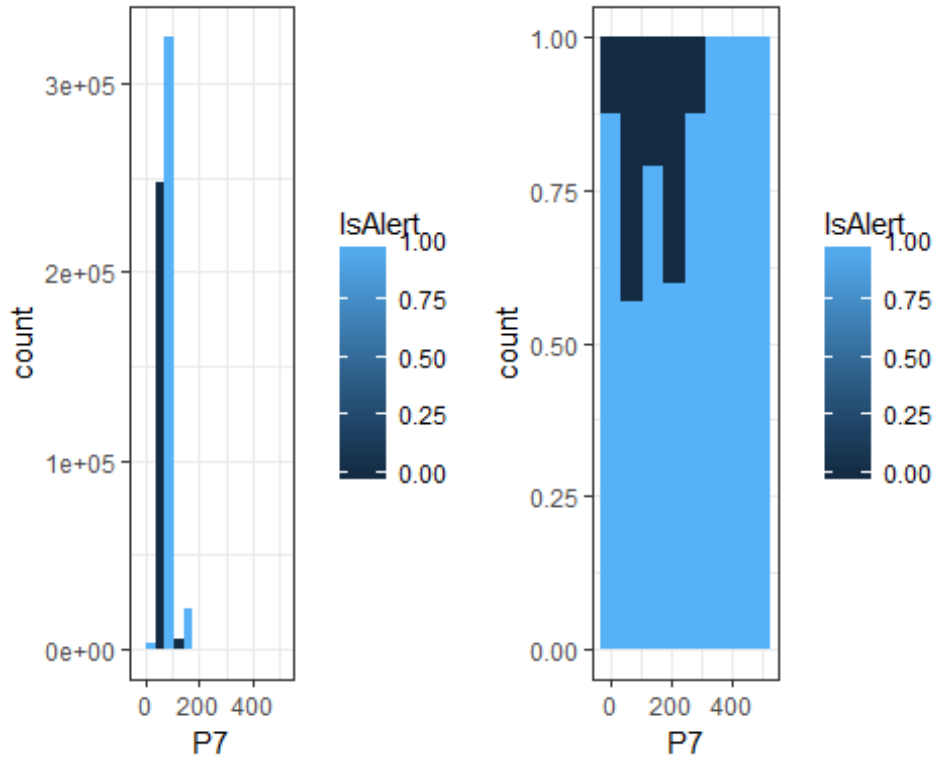

```
#P5
p5_1<-ggplot(data,aes(x=P5,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=70)+theme_bw()
p5_2<-ggplot(data,aes(x=P5,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=70)+theme_bw()
grid.arrange(p5_1, p5_2, ncol=2)
```




```
#P6
p6_1<-ggplot(data,aes(x=P6,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=1000)+theme_bw()
p6_2<-ggplot(data,aes(x=P6,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=1000)+theme_bw()
grid.arrange(p6_1, p6_2, ncol=2)

## Warning: Removed 440 rows containing missing values (geom_bar).
```

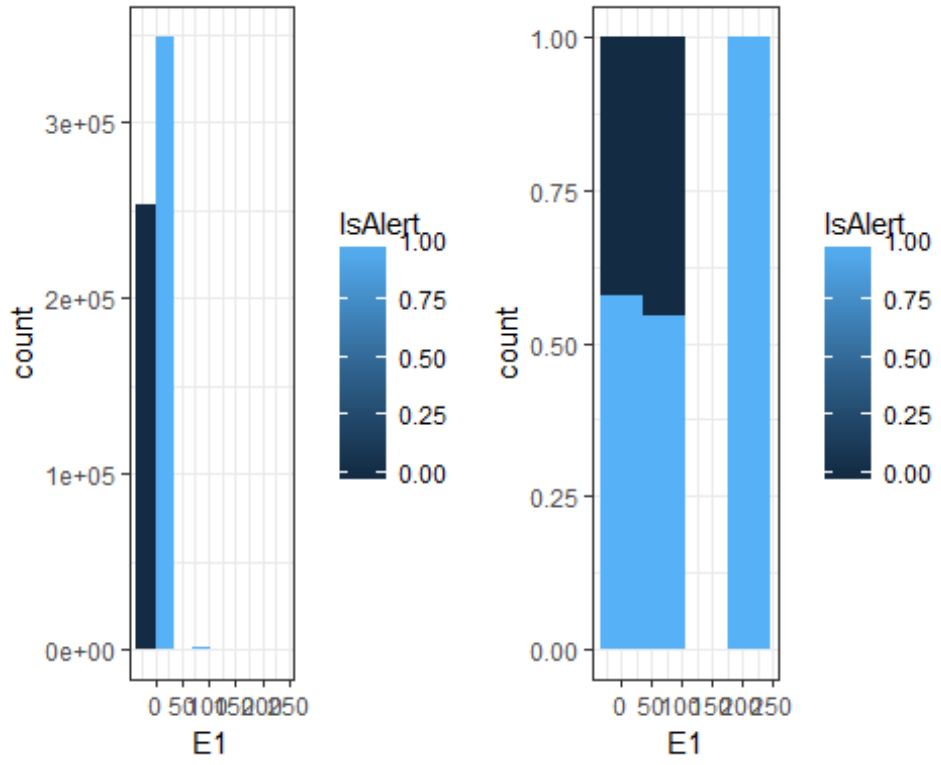



```
#P7
p7_1<-ggplot(data,aes(x=P7,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=70)+theme_bw()
p7_2<-ggplot(data,aes(x=P7,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=70)+theme_bw()
grid.arrange(p7_1, p7_2, ncol=2)
```

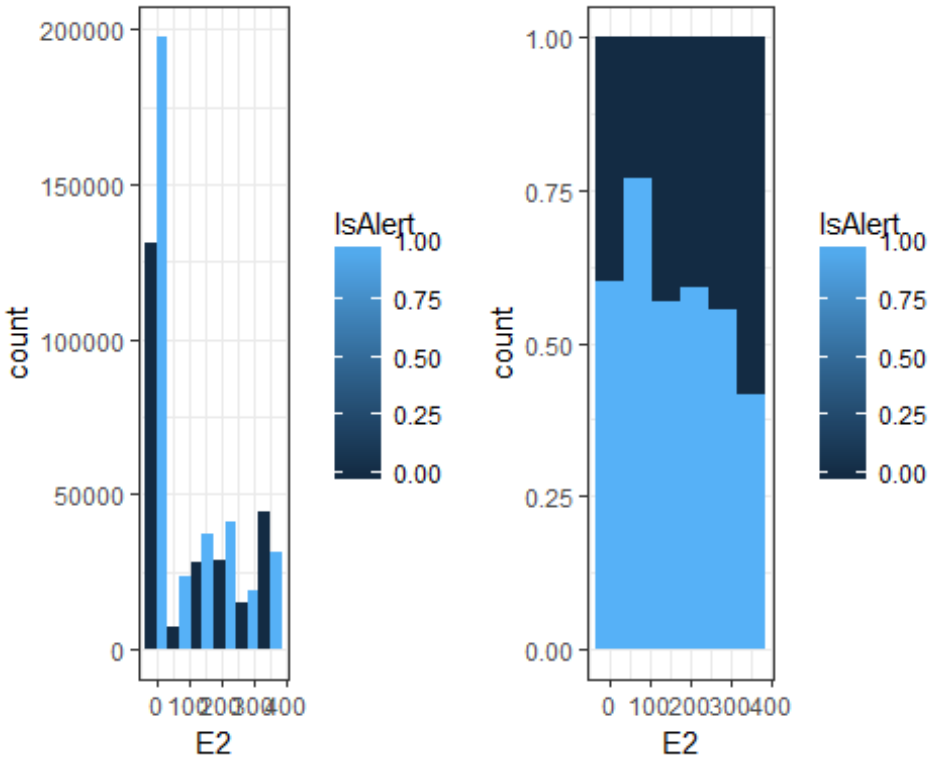


Among all Physical data, the chang of P5 has no effect on the change of response variable, which indicates that P5 has no relationship with response variable

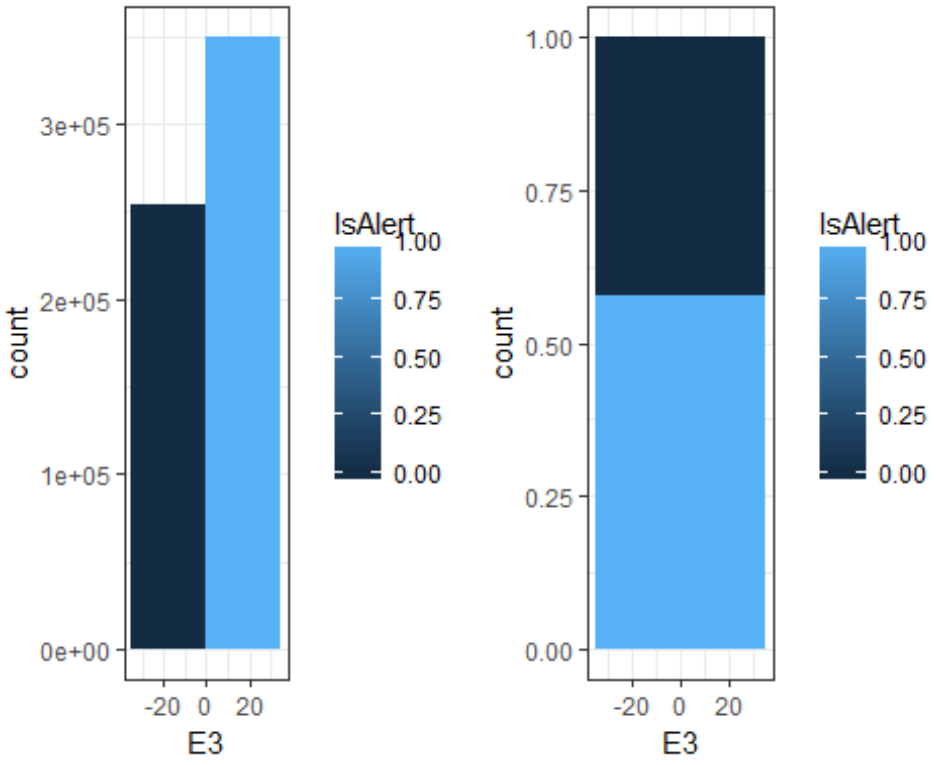
```
#E1
e1_1<-ggplot(data,aes(x=E1,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=70)+theme_bw()
e1_2<-ggplot(data,aes(x=E1,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=70)+theme_bw()
grid.arrange(e1_1, e1_2, ncol=2)

## Warning: Removed 2 rows containing missing values (geom_bar).
```



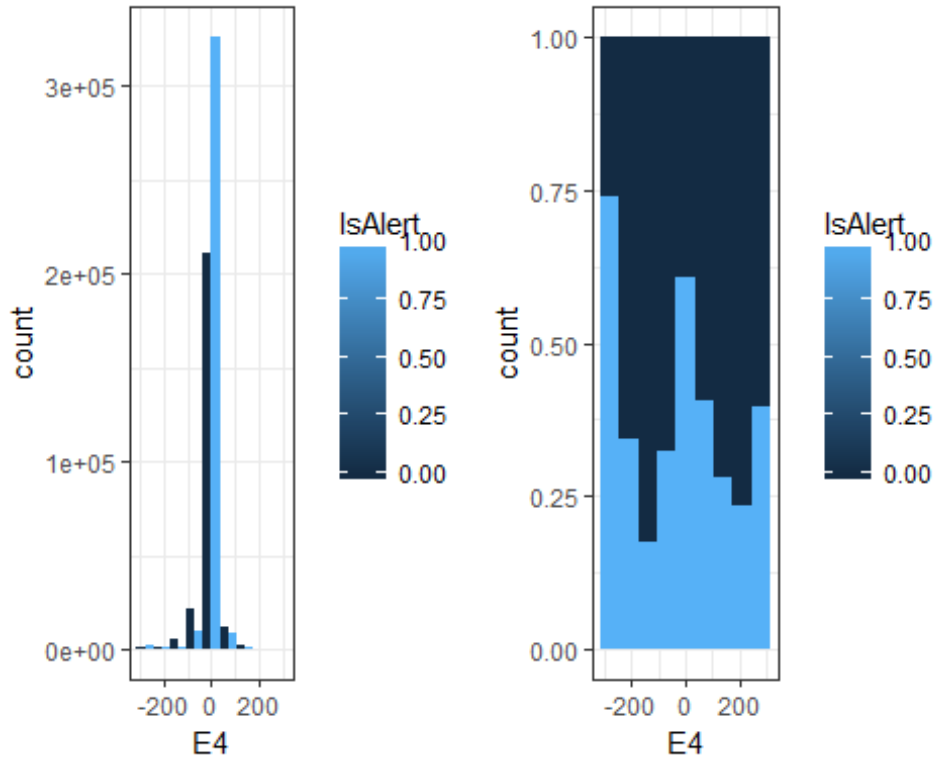

```
#E2
e2_1<-ggplot(data,aes(x=E2,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=70)+theme_bw()
e2_2<-ggplot(data,aes(x=E2,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=70)+theme_bw()
grid.arrange(e2_1, e2_2, ncol=2)
```



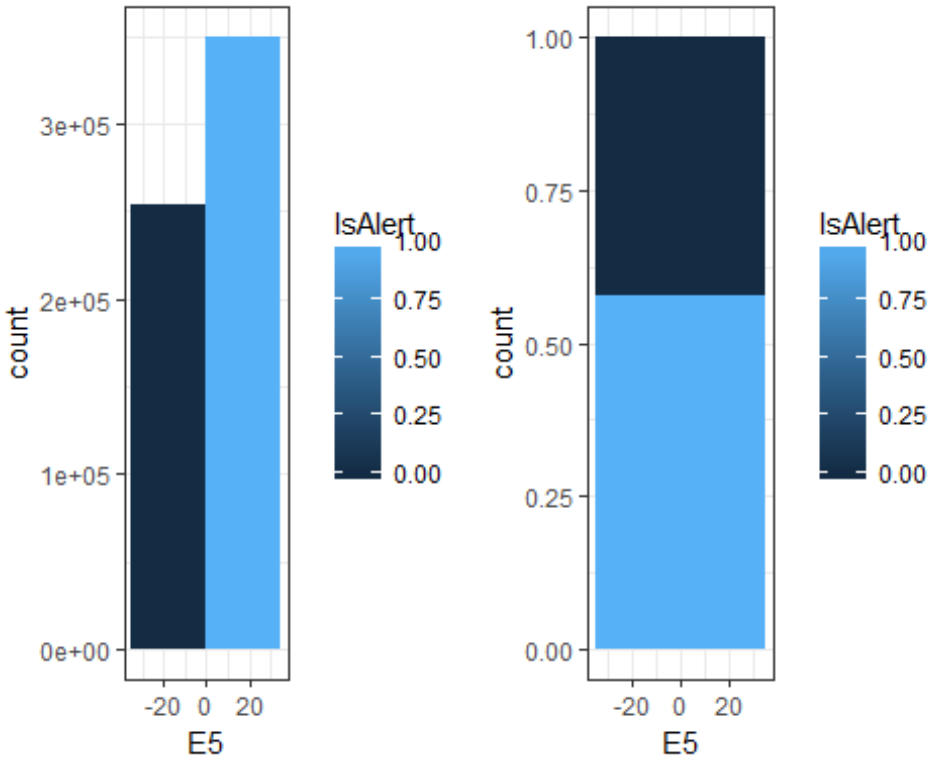

```
#E3
e3_1<-ggplot(data,aes(x=E3,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=70)+theme_bw()
e3_2<-ggplot(data,aes(x=E3,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=70)+theme_bw()
grid.arrange(e3_1, e3_2, ncol=2)
```



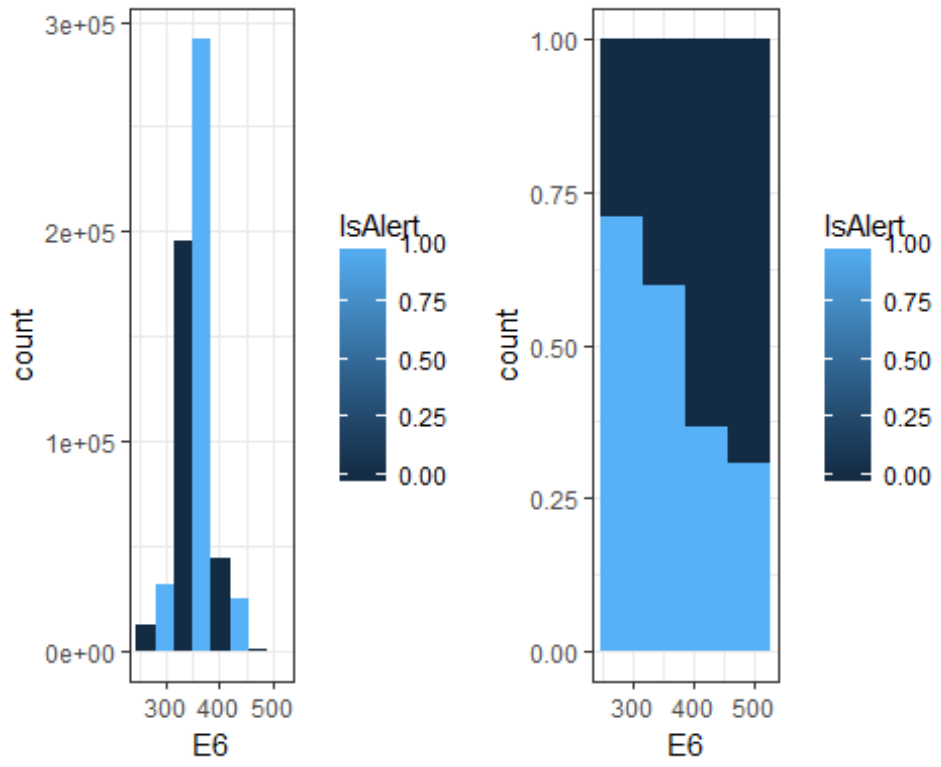

```
#E4
e4_1<-ggplot(data,aes(x=E4,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=70)+theme_bw()
e4_2<-ggplot(data,aes(x=E4,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=70)+theme_bw()
grid.arrange(e4_1, e4_2, ncol=2)
```



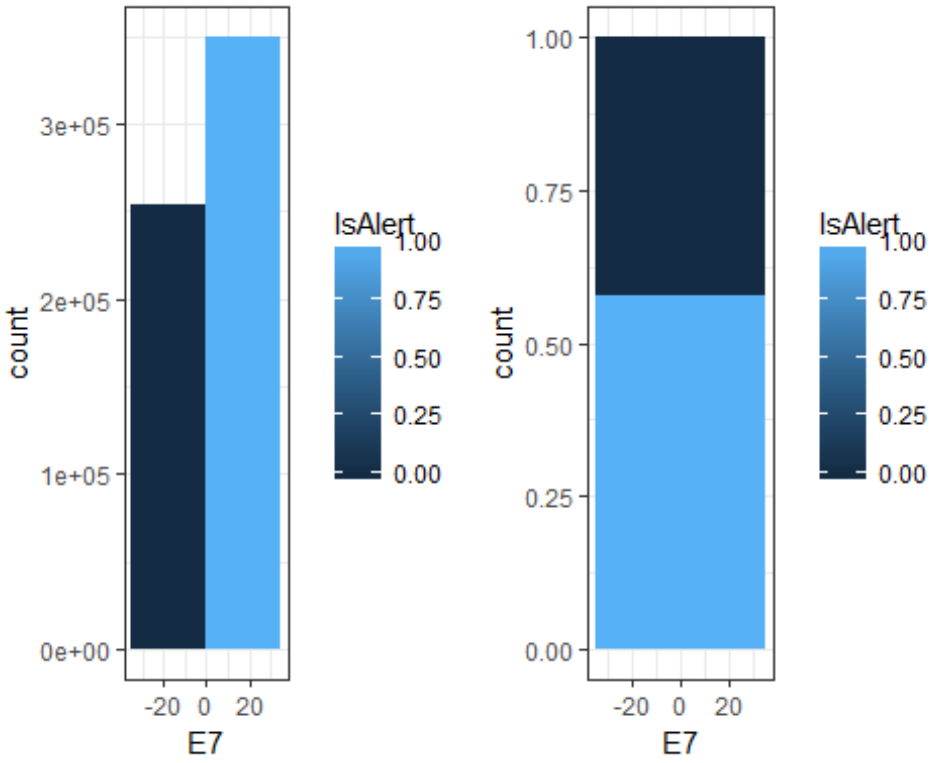

```
#E5
e5_1<-ggplot(data,aes(x=E5,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=70)+theme_bw()
e5_2<-ggplot(data,aes(x=E5,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=70)+theme_bw()
grid.arrange(e5_1, e5_2, ncol=2)
```



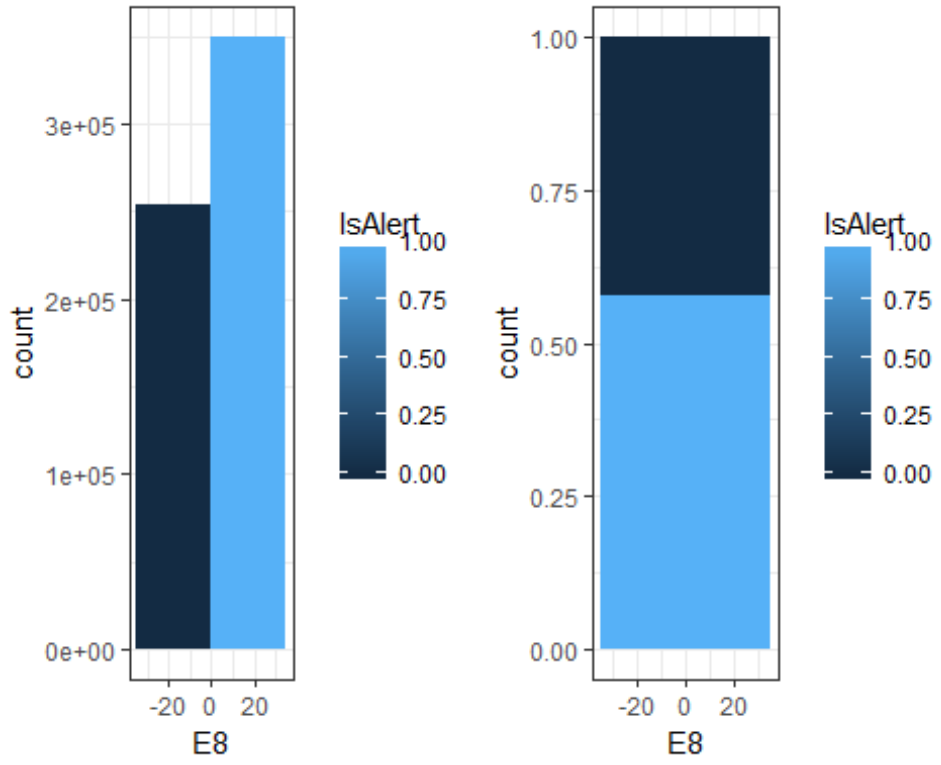

```
#E6
e6_1<-ggplot(data,aes(x=E6,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=70)+theme_bw()
e6_2<-ggplot(data,aes(x=E6,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=70)+theme_bw()
grid.arrange(e6_1, e6_2, ncol=2)
```



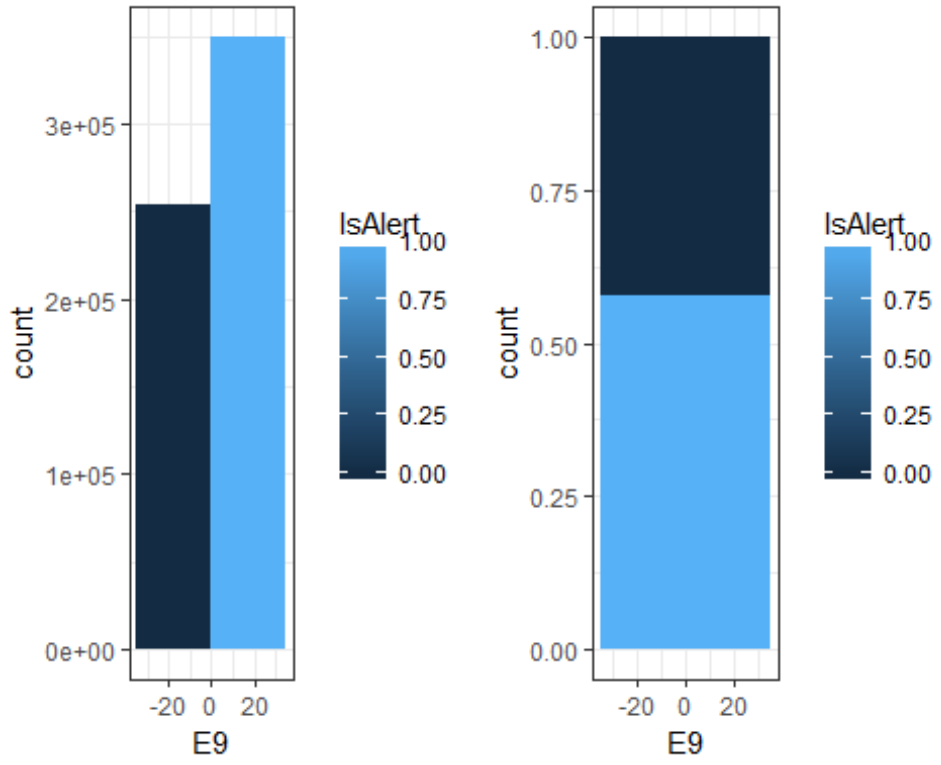

```
#E7
e7_1<-ggplot(data,aes(x=E7,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=70)+theme_bw()
e7_2<-ggplot(data,aes(x=E7,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=70)+theme_bw()
grid.arrange(e7_1, e7_2, ncol=2)
```



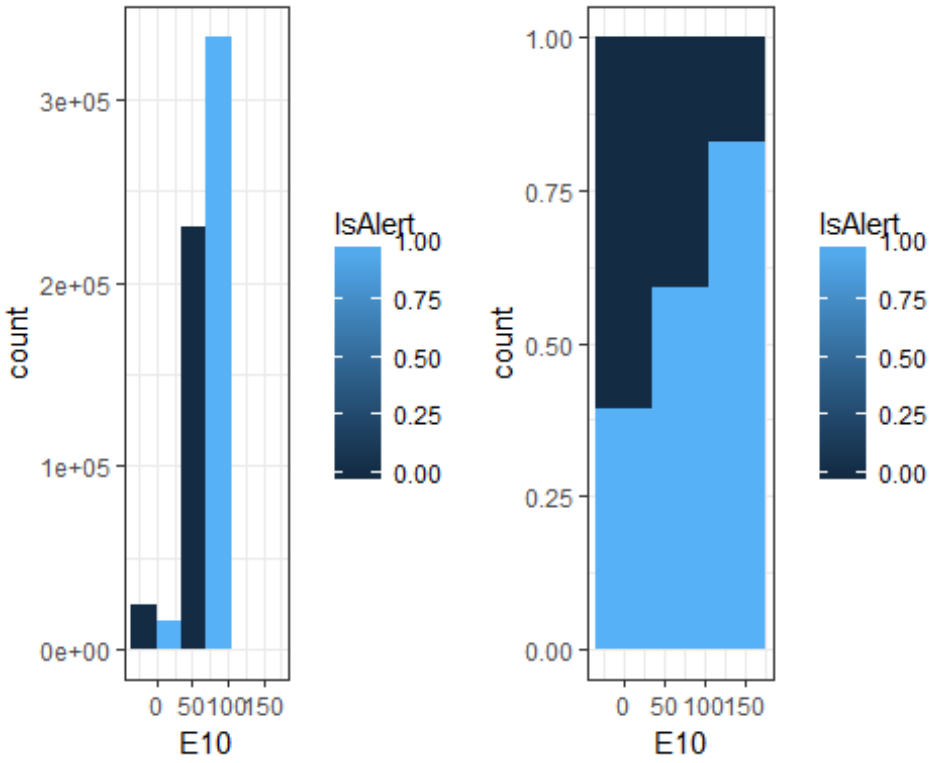

```
#E8
e8_1<-ggplot(data,aes(x=E8,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=70)+theme_bw()
e8_2<-ggplot(data,aes(x=E8,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=70)+theme_bw()
grid.arrange(e8_1, e8_2, ncol=2)
```



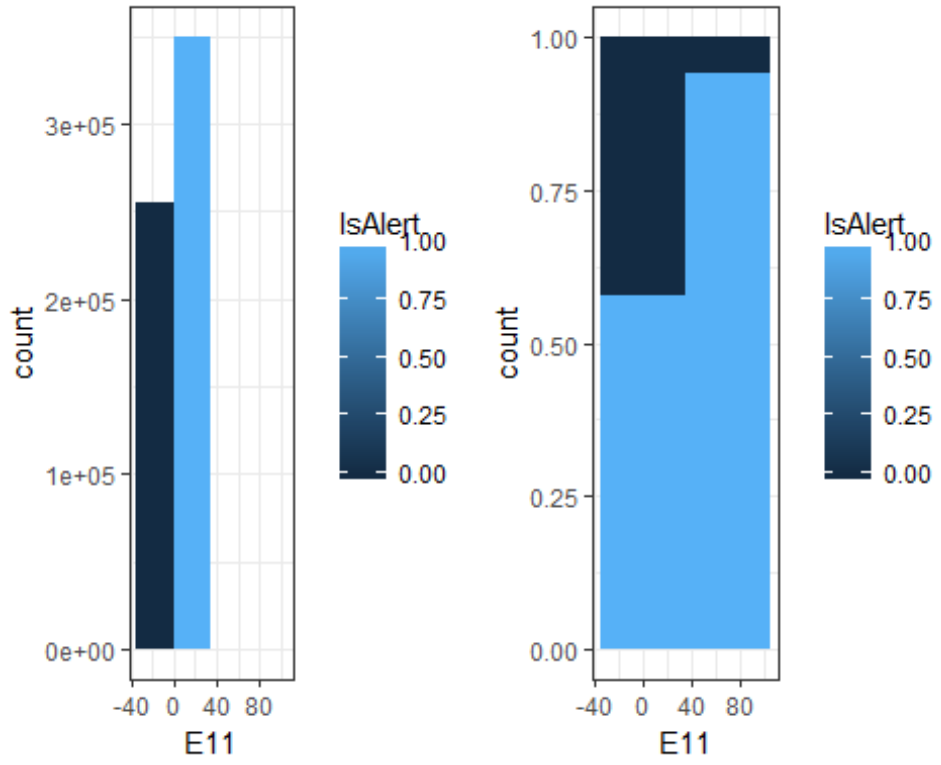

```
#E9
e9_1<-ggplot(data,aes(x=E9,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=70)+theme_bw()
e9_2<-ggplot(data,aes(x=E9,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=70)+theme_bw()
grid.arrange(e9_1, e9_2, ncol=2)
```




```
#E10
e10_1<-ggplot(data,aes(x=E10,group=IsAlert,fill=IsAlert))+  geom_histogram(po
sition="dodge",binwidth=70)+theme_bw()
e10_2<-ggplot(data,aes(x=E10,group=IsAlert,fill=IsAlert))+  geom_histogram(po
sition="fill",binwidth=70)+theme_bw()
grid.arrange(e10_1, e10_2, ncol=2)
```

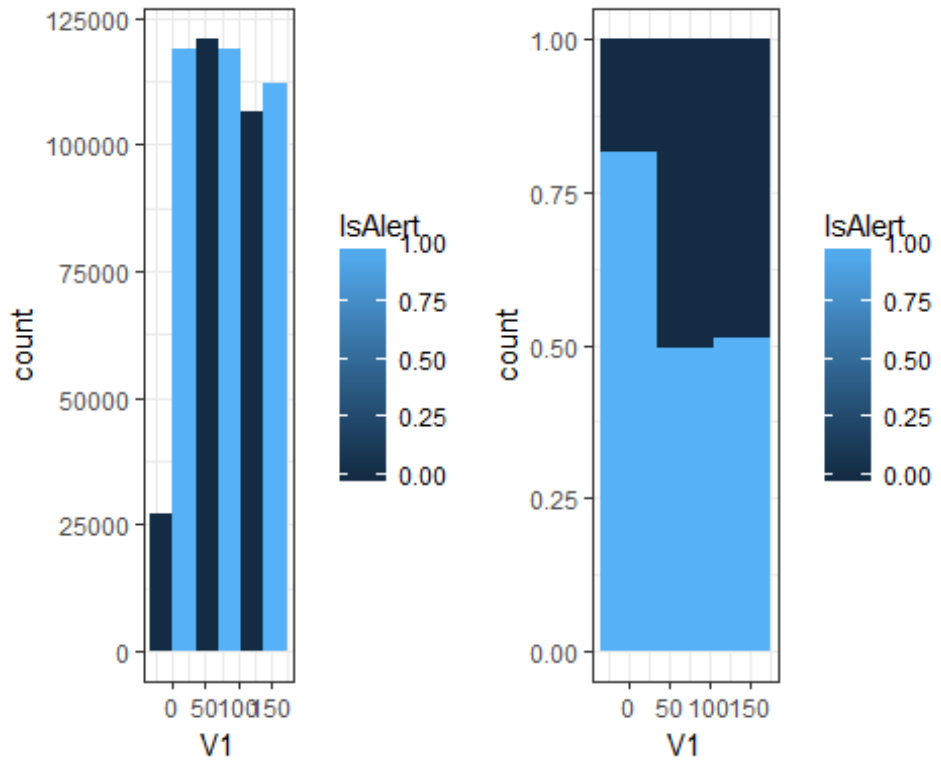



```
#E11
e11_1<-ggplot(data,aes(x=E11,group=IsAlert,fill=IsAlert))+  geom_histogram(po
sition="dodge",binwidth=70)+theme_bw()
e11_2<-ggplot(data,aes(x=E11,group=IsAlert,fill=IsAlert))+  geom_histogram(po
sition="fill",binwidth=70)+theme_bw()
grid.arrange(e11_1, e11_2, ncol=2)
```

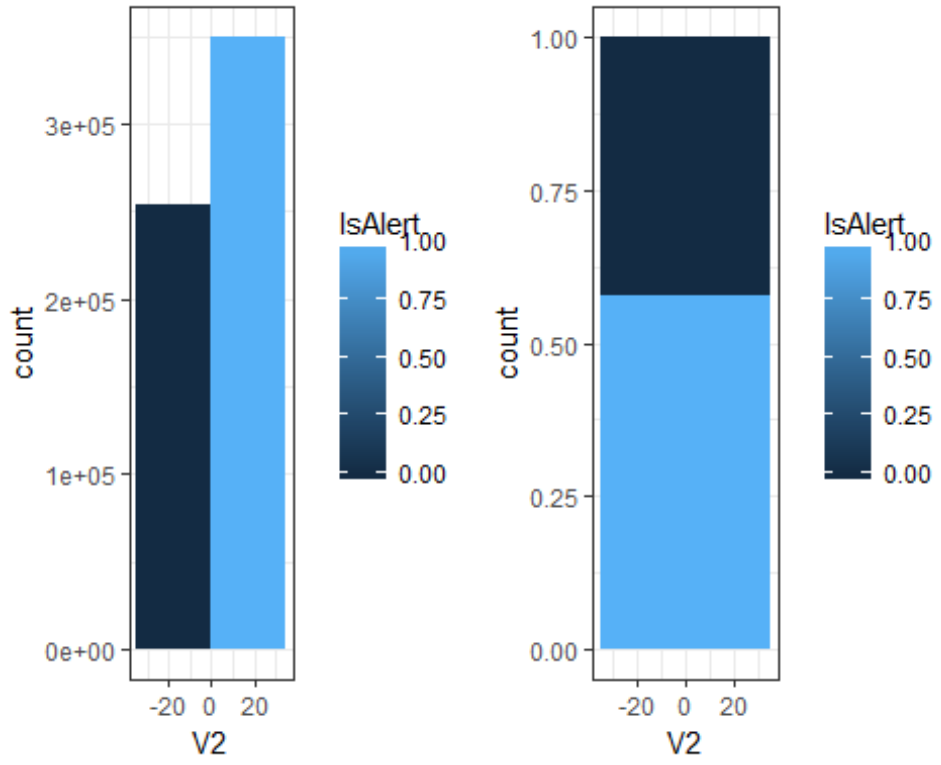


E3, E5, E7, E8, E9 have no relationship with response variable. However, considered some of them are categorial variables, we cannot simply delete them from dataset.

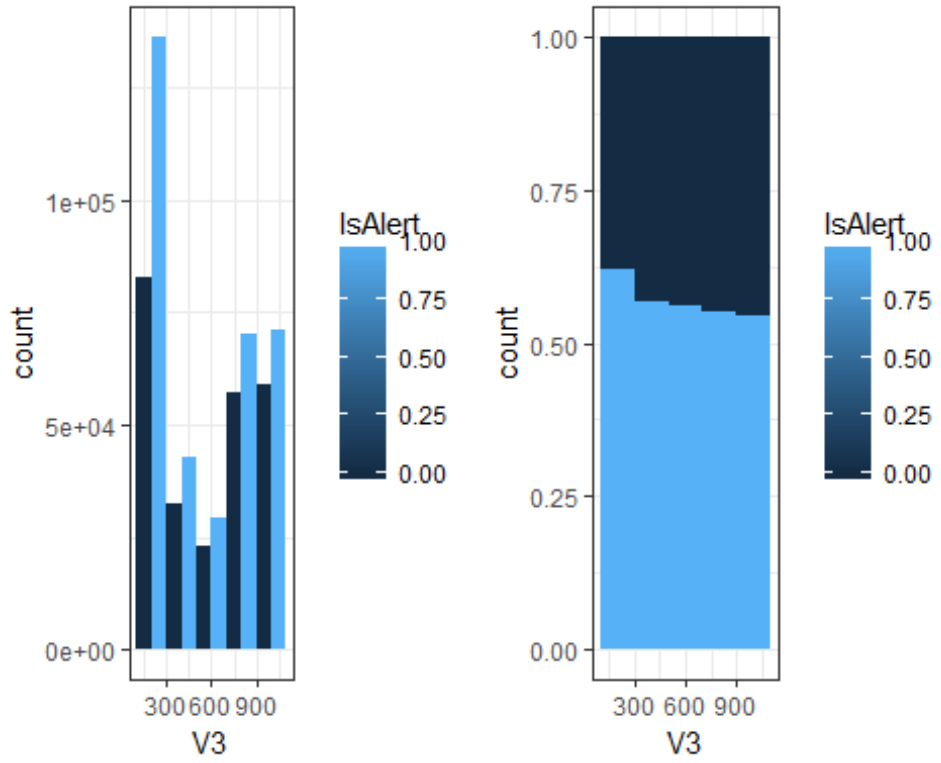
```
#V1
v1_1<-ggplot(data,aes(x=V1,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=70)+theme_bw()
v1_2<-ggplot(data,aes(x=V1,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=70)+theme_bw()
grid.arrange(v1_1, v1_2, ncol=2)
```



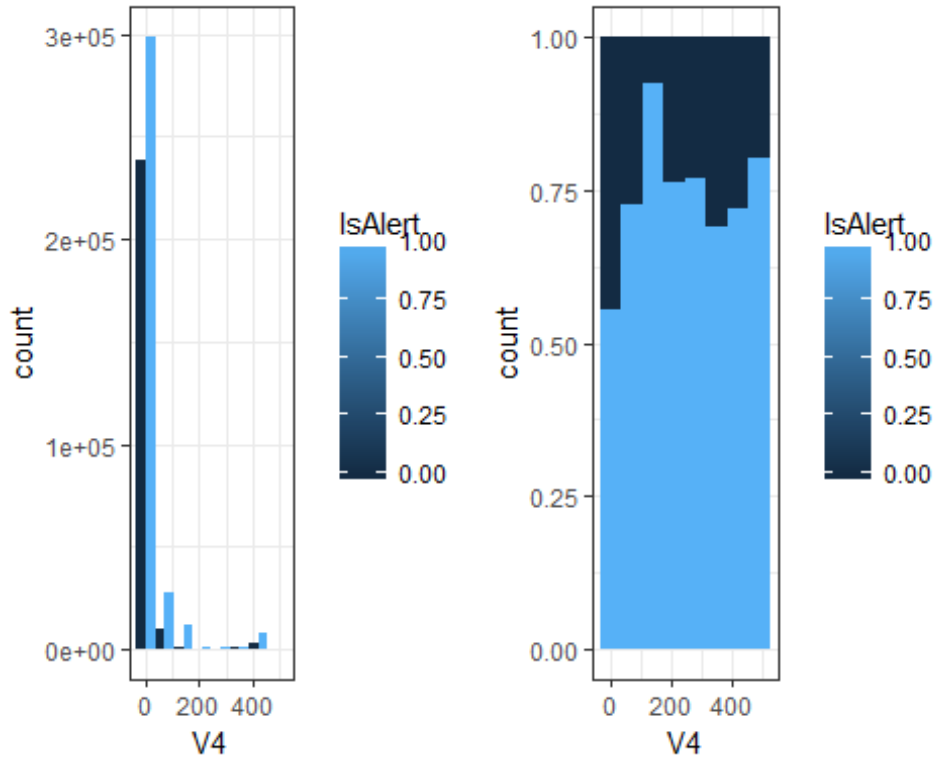

```r
#V2
v2_1<-ggplot(data,aes(x=V2,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=70)+theme_bw()
v2_2<-ggplot(data,aes(x=V2,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=70)+theme_bw()
grid.arrange(v2_1, v2_2, ncol=2)
```



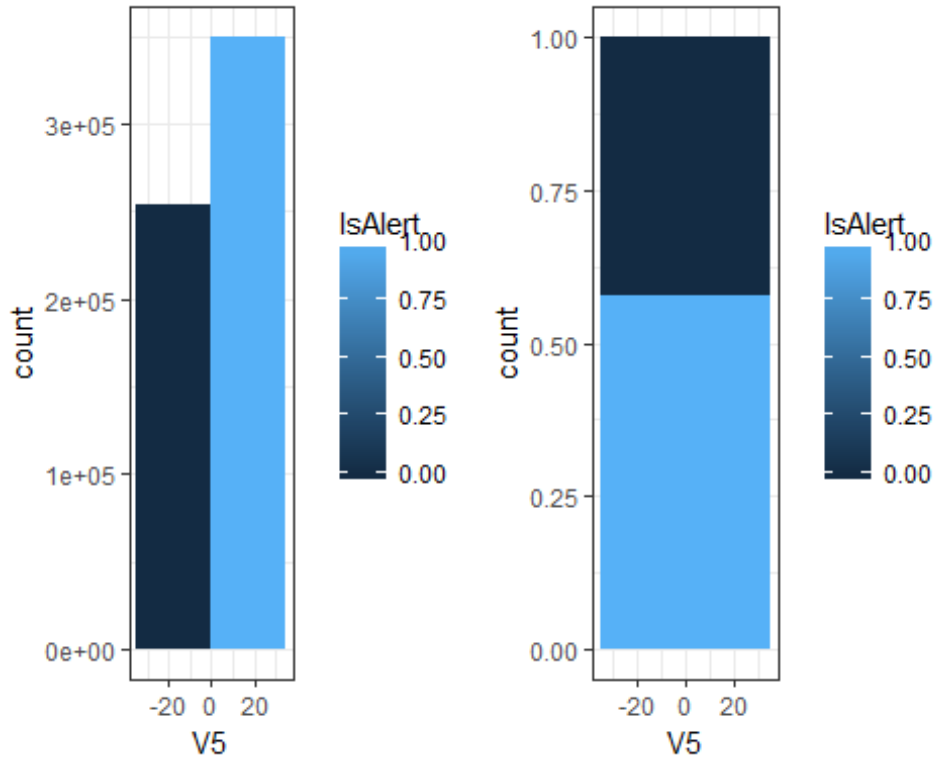

```
#V3
v3_1<-ggplot(data,aes(x=V3,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=200)+theme_bw()
v3_2<-ggplot(data,aes(x=V3,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=200)+theme_bw()
grid.arrange(v3_1, v3_2, ncol=2)
```



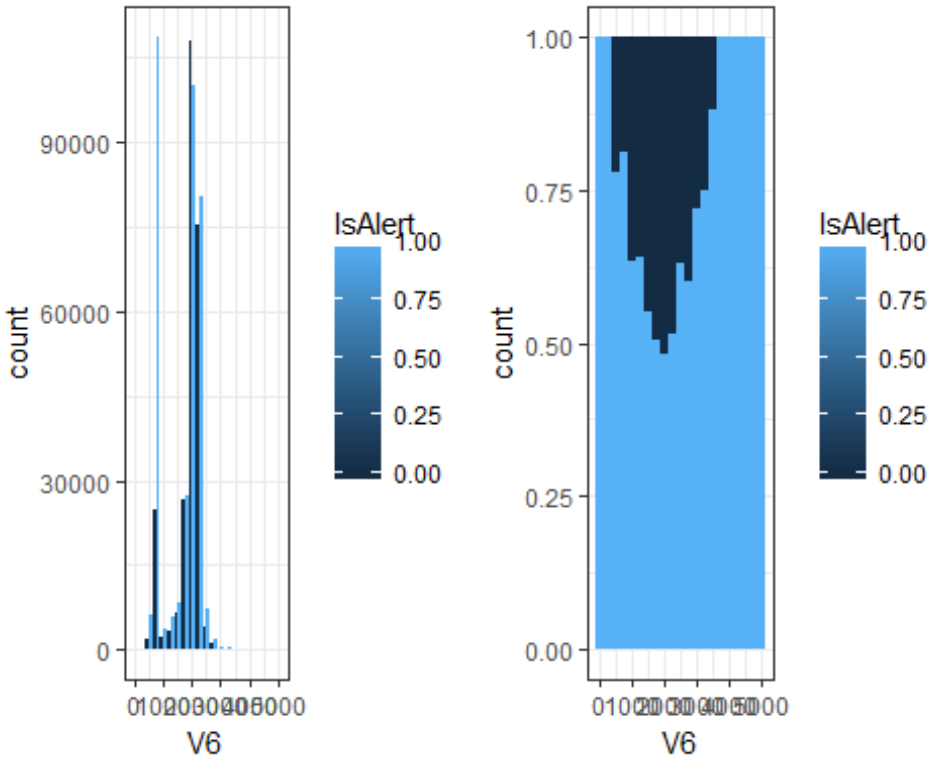

```
#V4
v4_1<-ggplot(data,aes(x=V4,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=70)+theme_bw()
v4_2<-ggplot(data,aes(x=V4,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=70)+theme_bw()
grid.arrange(v4_1, v4_2, ncol=2)
```



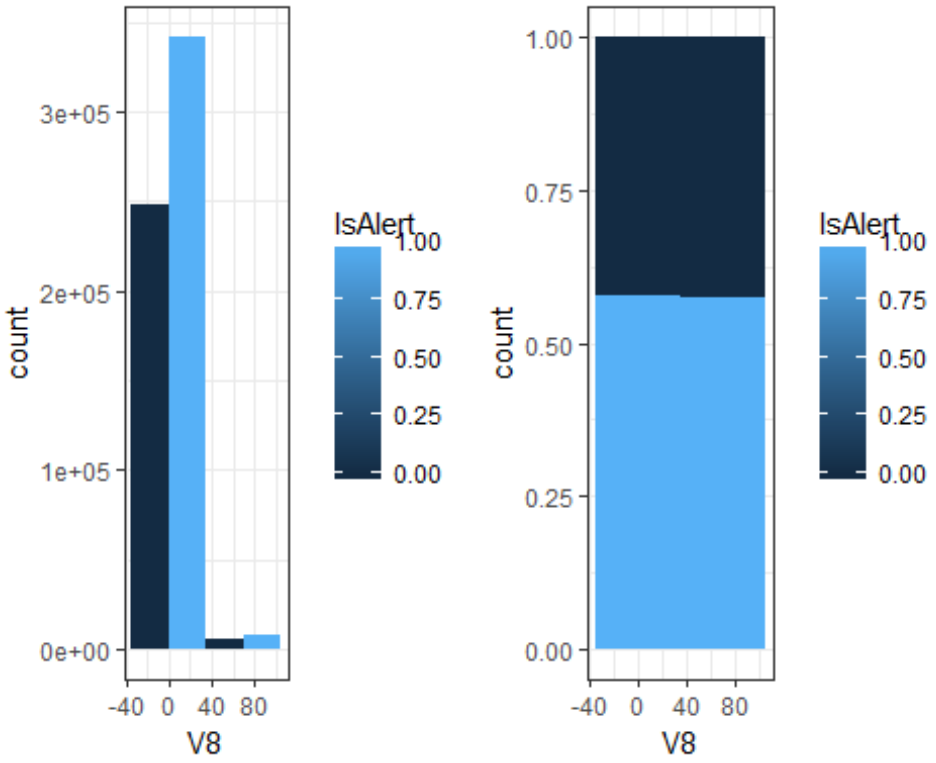

```
#V5
v5_1<-ggplot(data,aes(x=V5,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=70)+theme_bw()
v5_2<-ggplot(data,aes(x=V5,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=70)+theme_bw()
grid.arrange(v5_1, v5_2, ncol=2)
```



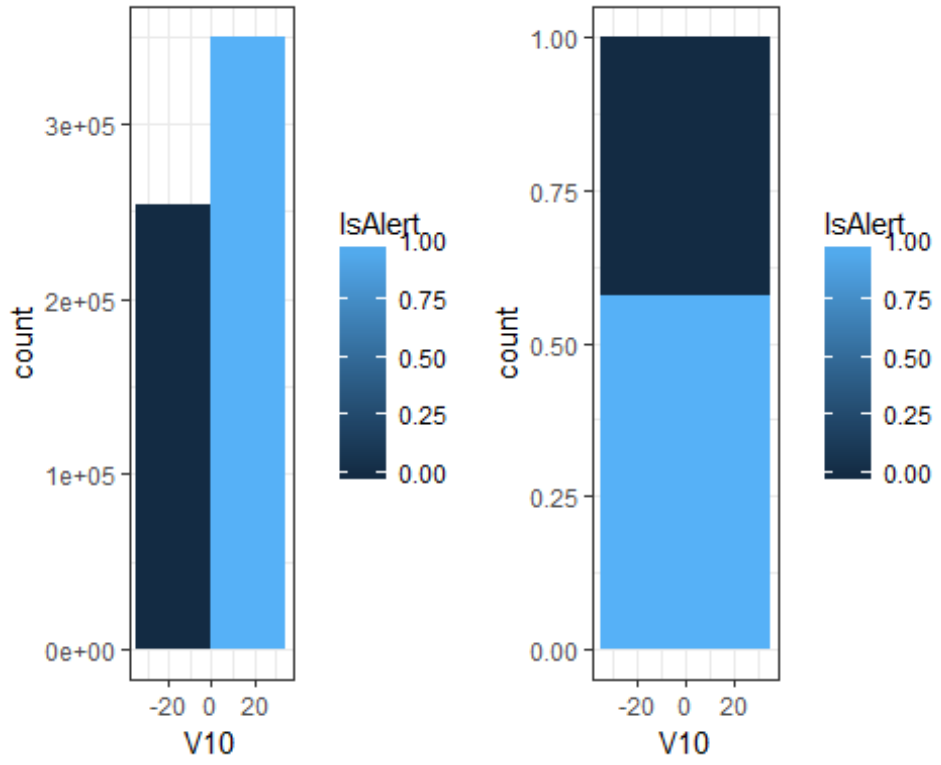

```
#V6
v6_1<-ggplot(data,aes(x=V6,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=250)+theme_bw()
v6_2<-ggplot(data,aes(x=V6,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=250)+theme_bw()
grid.arrange(v6_1, v6_2, ncol=2)
```



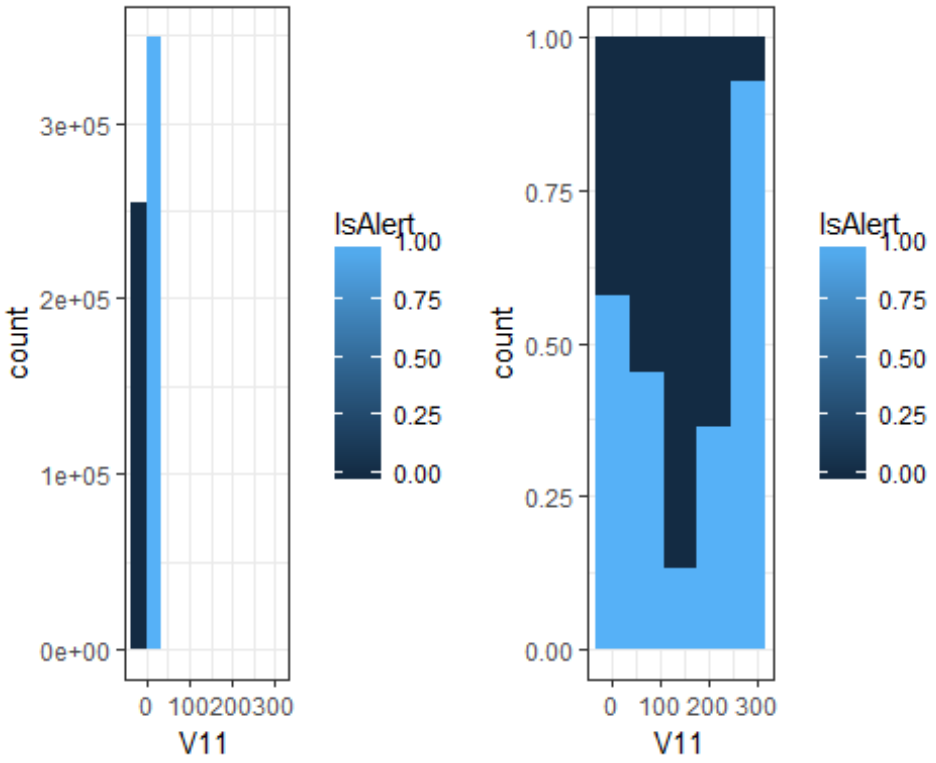

```
#V8
v8_1<-ggplot(data,aes(x=V8,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="dodge",binwidth=70)+theme_bw()
v8_2<-ggplot(data,aes(x=V8,group=IsAlert,fill=IsAlert))+  geom_histogram(posi
tion="fill",binwidth=70)+theme_bw()
grid.arrange(v8_1, v8_2, ncol=2)
```




```
#V10
v10_1<-ggplot(data,aes(x=V10,group=IsAlert,fill=IsAlert))+  geom_histogram(po
sition="dodge",binwidth=70)+theme_bw()
v10_2<-ggplot(data,aes(x=V10,group=IsAlert,fill=IsAlert))+  geom_histogram(po
sition="fill",binwidth=70)+theme_bw()
grid.arrange(v10_1, v10_2, ncol=2)
```



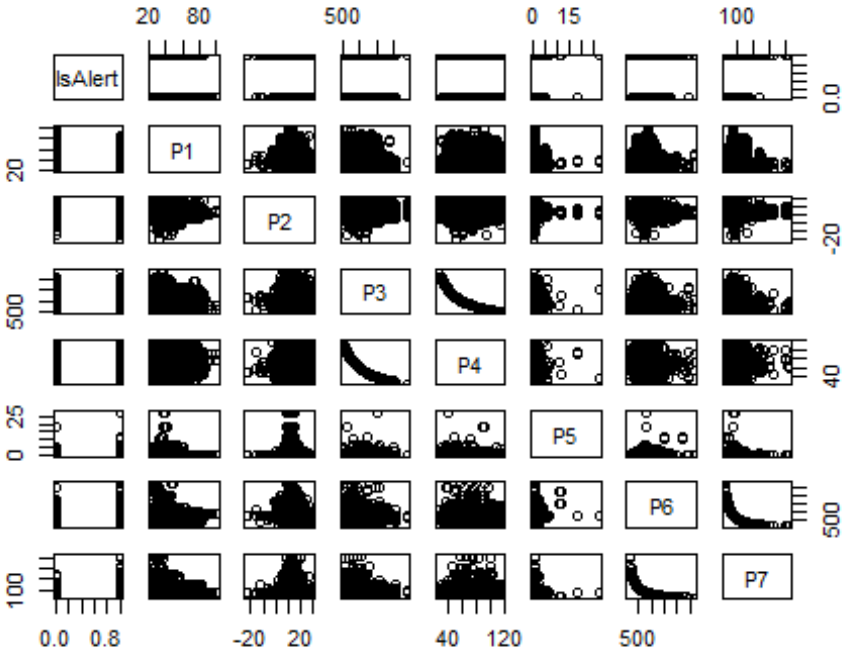

```
#V11
v11_1<-ggplot(data,aes(x=V11,group=IsAlert,fill=IsAlert))+  geom_histogram(po
sition="dodge",binwidth=70)+theme_bw()
v11_2<-ggplot(data,aes(x=V11,group=IsAlert,fill=IsAlert))+  geom_histogram(po
sition="fill",binwidth=70)+theme_bw()
grid.arrange(v11_1, v11_2, ncol=2)
```



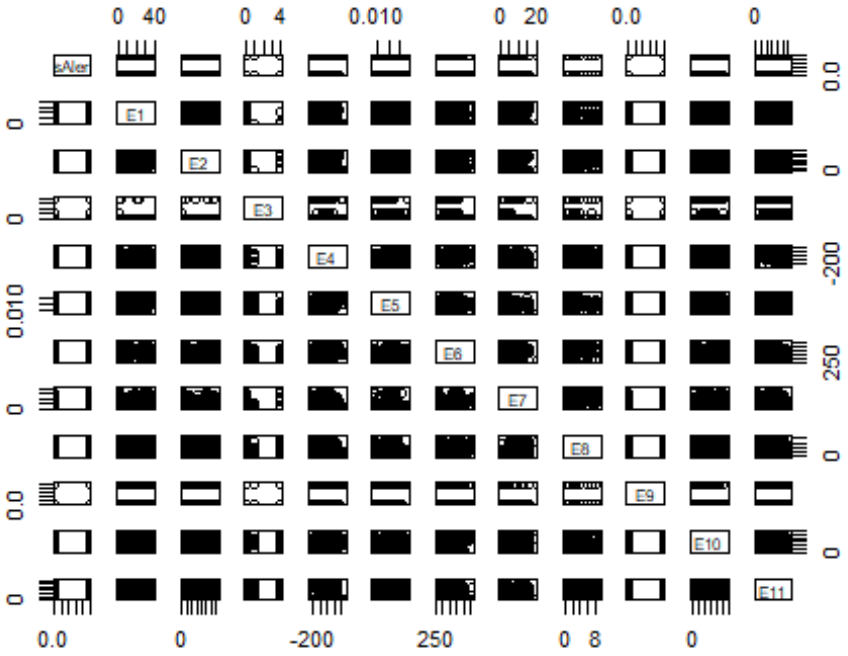
V2, V5, V8, V10 have no relationship with response wariable. Similarly, we have to consider the categorial data.

4.Identify pairs of features which are related to each other

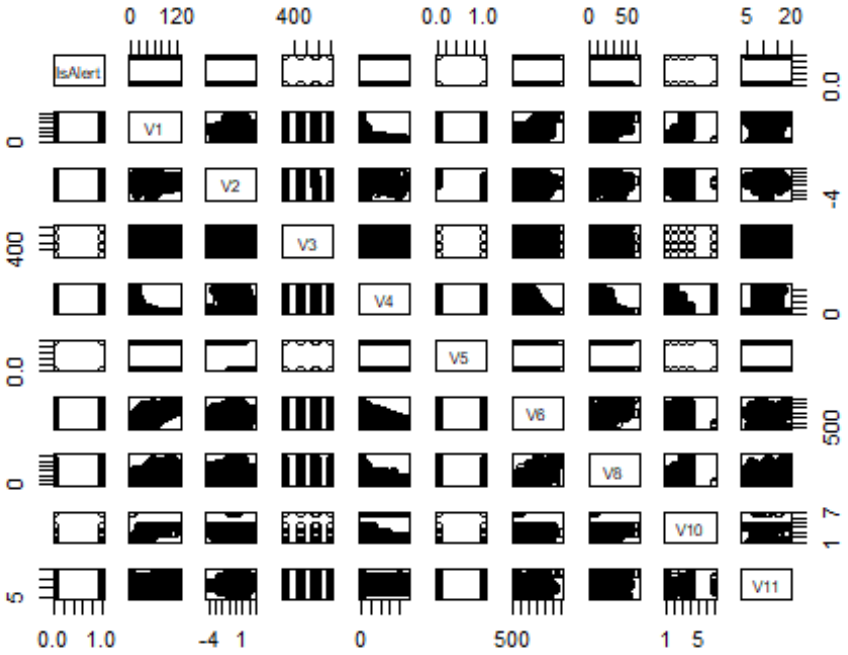
```
#P~
pairs(newdata[,c(3,4,5,6,7,8,9,10)])
```




```r
#E~
pairs(newdata[,c(3,11, 12,13,14,15,16,17,18,19,20,21)])
```



```
#V~
pairs(newdata[,c(3,22, 23,24,25,26,27,28, 29, 30)])
```



5. Dimension reduction

1). Remove the features which have no relationship with the response Becasue variables E1 to E11 are environmental data, which is reasonable to consider that certain environmental features could have no relationship with response variable. And to determine the specific variables which have no relationship with response variable, we need to check scatter plot matrix. And for those who have no relationship with response variable, the distribution of dots for "1" and "0" would be same. Therefore, I decide to delete the following variables: E1 E2 E5 E10 E11

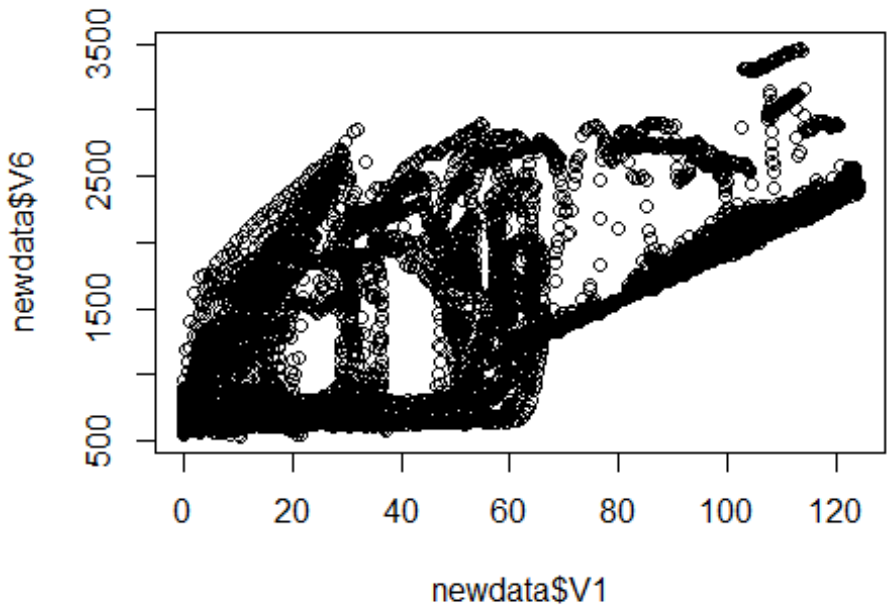
```
drops <- c("E1","E2","E5","E10","E11")
newdata<-newdata[ , !(names(newdata) %in% drops)]
```

2). Remove a feature(s) that has a perfect relationship to another one P3 - P4, drop P4 P6 - P7, drop P7

```
drops <- c("P4","P7")
newdata<-newdata[ , !(names(newdata) %in% drops)]
```

3)Reduce the number of features which are significantly related to each other in some non-linear way V1 - V6, drop V6

```
plot(newdata$V1, newdata$V6)
```




```
drops <- c("V6")
newdata<-newdata[ , !(names(newdata) %in% drops)]
```

4)Transform a set of highly correlated features into a smaller set, by using wrapper method

```
#install.packages("caret", repos = "http://cran.r-project.org",  dependencies
= c("Depends", "Imports", "Suggests"))
#install.packages("ggplot2", dependencies = TRUE)
#install.packages("Rcpp", dependencies = TRUE)
library(ggplot2)
library(caret)

library(randomForest)

## randomForest 4.6-14

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

##
## Attaching package: 'randomForest'

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

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

```
temp_train <- newdata[1:100,]
temp_train$IsAlert <- as.factor(temp_train$IsAlert)
#Feature selection using rfe in caret
control <- rfeControl(functions = rfFuncs,method = "repeatedcv",repeats = 3,
verbose = FALSE)
outcomeName<-'IsAlert'
predictors<-names(temp_train)[!names(temp_train) %in% outcomeName]
result <- rfe(temp_train[,predictors], temp_train[,outcomeName],rfeControl =
control)
result
```

```
##
## Recursive feature selection
##
## Outer resampling method: Cross-Validated (10 fold, repeated 3 times)
##
## Resampling performance over subset size:
##
##  Variables Accuracy  Kappa AccuracySD KappaSD Selected
##          4   0.9926 0.9667    0.04057  0.1826        *
##          8   0.9796 0.9237    0.05089  0.2081
##         16   0.9661 0.8806    0.05705  0.2228
##         21   0.9661 0.8806    0.05705  0.2228
##
## The top 4 variables (out of 4):
##    E4, ObsNum, V1, E6
```

Now we have four variables which might have significant influence on response variable. they are E3, ObsNum, V1, and E6. However, F=four variables are insufficient to make analysis, So I will still keep as 22 variables.

Until now, we have 22 variables as following: P1:continuous P2:continuous P3:continuous P5:continuous P6:continuous E3:categorial, with 3 levels E4:continuous E6:continuous E7:categorial, with 18 levels E8:categorial, with 10 levels E9:categorial, with 2 levels V1:continuous V2:continuous V3:continuous V4:continuous V5:categorial, with 2 levels V8:continuous V10:categorial, with 5 levels V11:continuous

Basic Model building

```
#Check indicator variables
unique(newdata$E3)
```

```
## [1] 1 0 4
```

```
unique(newdata$E7)
```

```
##  [1]  1  0  6  5  3 13 14 15 16 12 11  2 10  9  8  7  4 20
```

```
unique(newdata$E8)
```

```
##  [1] 1 0 4 7 2 3 5 8 6 9
```

```r
unique(newdata$E9)
```

```
## [1] 1 0
```

```r
unique(newdata$V5)
```

```
## [1] 0 1
```

```r
unique(newdata$V10)
```

```
## [1] 4 3 7 1 2
```

```r
#Create indicator variable
newdata$E3_1 = c(rep(0, length(newdata$IsAlert)))
newdata$E3_0 = newdata$E3_4 = newdata$E7_low = newdata$E7_high = newdata$E8_l
ow = newdata$E8_high = newdata$E9_0 = newdata$E9_1 = newdata$V5_0 =  newdata$
V5_1 = newdata$V10_low = newdata$V10_high = newdata$E3_1

for (i in 1:length(newdata$IsAlert)) {
#E3
if(newdata$E3[i] == 1) newdata$E3_1[i] <- 1
if(newdata$E3[i] == 0) newdata$E3_0[i] <- 1
if(newdata$E3[i] == 4) newdata$E3_4[i] <- 1

#E7
if(newdata$E7[i] <= 10) newdata$E7_low[i] <- 1
if(newdata$E7[i] > 10) newdata$E7_high[i] <- 1

#E8
if(newdata$E8[i] <= 4) newdata$E7_low[i] <- 1
if(newdata$E8[i] > 4) newdata$E7_high[i] <- 1

#E9
if(newdata$E9[i] == 1) newdata$E9_1[i] <- 1
if(newdata$E9[i] == 0) newdata$E9_0[i] <- 1

#V5
if(newdata$V5[i] == 1) newdata$V5_1[i] <- 1
if(newdata$V5[i] == 0) newdata$V5_0[i] <- 1

#V10
if(newdata$E8[i] <= 3) newdata$V10_low[i] <- 1
if(newdata$E8[i] > 3) newdata$V10_high[i]<- 1
}

# Minimax transform the continuous variables
#P1
newdata$P1_mm <- (newdata$P1 - min(newdata$P1)) / (max(newdata$P1) - min(newd
ata$P1))
#P2
newdata$P2_mm <- (newdata$P2 - min(newdata$P2)) / (max(newdata$P2) - min(newd
```

```
ata$P2))
#P3
newdata$P3_mm <- (newdata$P3 - min(newdata$P3)) / (max(newdata$P3) - min(newd
ata$P3))
#P5
newdata$P5_mm <- (newdata$P5 - min(newdata$P5)) / (max(newdata$P5) - min(newd
ata$P5))
#P6
newdata$P6_mm <- (newdata$P6 - min(newdata$P6)) / (max(newdata$P6) - min(newd
ata$P6))
#E4
newdata$E4_mm <- (newdata$E4 - min(newdata$E4)) / (max(newdata$E4) - min(newd
ata$E4))
#E6
newdata$E6_mm <- (newdata$E6 - min(newdata$E6)) / (max(newdata$E6) - min(newd
ata$E6))
#V1
newdata$V1_mm <- (newdata$V1 - min(newdata$V1)) / (max(newdata$V1) - min(newd
ata$V1))
#V2
newdata$V2_mm <- (newdata$V2 - min(newdata$V2)) / (max(newdata$V2) - min(newd
ata$V2))
#V3
newdata$V3_mm <- (newdata$V3 - min(newdata$V3)) / (max(newdata$V3) - min(newd
ata$V3))
#V4
newdata$V4_mm <- (newdata$V4 - min(newdata$V4)) / (max(newdata$V4) - min(newd
ata$V4))
#V8
newdata$V8_mm <- (newdata$V8 - min(newdata$V8)) / (max(newdata$V8) - min(newd
ata$V8))
#V11
newdata$V11_mm <- (newdata$V11 - min(newdata$V11)) / (max(newdata$V11) - min(
newdata$V11))

#new dataset
mydata_nn <- newdata[ , -c(4:22)]
mydata_nn <- mydata_nn[, -c(1, 2)]
mydata_nn <- mydata_nn[1:10000,]
#training data
training <- mydata_nn[1:7000, ]
#testing data
testing <- mydata_nn[7001:10000,]
```

Neural Network

1) Constructing and comparing model

```
library(nnet) # Requires package nnet
set.seed(2018)
myNewFrame <- data.frame(node = integer(0),maxit = integer(0), decay = intege
r(0) ,misscls.train = integer(0), misscls.test = integer(0))
```

```r
for (m in c(10, 100, 10000)) {
  for (d in c(0, 0.1, 0.2)) {
    for (s in c(5, 10, 15)) {
       net.dat <- nnet(IsAlert~., data = training, size = s, decay = d, maxit
= m)
       #table(round(net.dat$fitted.values, 1))

       estimated_isAlert=as.numeric(net.dat$fitted.values>0.5)

       T = table(estimated_isAlert,training$IsAlert)

       misscls.train<-sum((estimated_isAlert - training$IsAlert)^2)/length(tr
aining$IsAlert)
       misscls.train
       presdicted.testing<-as.numeric(predict(net.dat,testing )>0.5)
       Ttest = table(presdicted.testing, testing$IsAlert)
       misscls.test<-sum((presdicted.testing - testing$IsAlert)^2)/length(tes
ting$IsAlert)
       misscls.test

       df <- data.frame(s, m, d, misscls.train, misscls.test)
       names(df)<-c("node", "maxit", "decay", "misscls.train", "misscls.test"
)
       myNewFrame <- rbind(myNewFrame, df)

    }
  }
}
```

```
## # weights:  141
## initial  value 1306.799428
## final  value 396.000000
## converged
## # weights:  281
## initial  value 2012.521226
## final  value 1744.000000
## converged
## # weights:  421
## initial  value 2549.624964
## final  value 1744.000000
## converged
## # weights:  141
## initial  value 2029.279725
## iter  10 value 1281.854021
## final  value 1281.854021
## stopped after 10 iterations
## # weights:  281
## initial  value 2391.598699
```

```
## iter  10 value 1495.701339
## final  value 1495.701339
## stopped after 10 iterations
## # weights:  421
## initial  value 1465.568100
## iter  10 value 421.075809
## final  value 421.075809
## stopped after 10 iterations
## # weights:  141
## initial  value 2107.655542
## iter  10 value 1503.434091
## final  value 1503.434091
## stopped after 10 iterations
## # weights:  281
## initial  value 3246.847111
## iter  10 value 1527.330158
## final  value 1527.330158
## stopped after 10 iterations
## # weights:  421
## initial  value 2786.487949
## iter  10 value 1678.682384
## final  value 1678.682384
## stopped after 10 iterations
## # weights:  141
## initial  value 1410.739557
## final  value 396.000000
## converged
## # weights:  281
## initial  value 1257.845833
## final  value 396.000000
## converged
## # weights:  421
## initial  value 1381.157690
## iter  10 value 361.583794
## iter  20 value 351.994633
## iter  30 value 345.572434
## iter  40 value 334.199224
## iter  50 value 317.929717
## iter  60 value 305.379378
## iter  70 value 292.090277
## iter  80 value 272.128459
## iter  90 value 258.600778
## iter 100 value 249.058926
## final  value 249.058926
## stopped after 100 iterations
## # weights:  141
## initial  value 1406.774649
## iter  10 value 509.934431
## iter  20 value 376.834567
## iter  30 value 364.277056
```

```
## iter  40 value 363.897512
## iter  50 value 363.637781
## iter  60 value 363.539481
## iter  70 value 363.338802
## iter  80 value 363.243296
## iter  90 value 363.059820
## iter 100 value 363.007993
## final  value 363.007993
## stopped after 100 iterations
## # weights:  281
## initial  value 1941.192597
## iter  10 value 1576.397392
## iter  20 value 430.834136
## iter  30 value 380.908419
## iter  40 value 365.992123
## iter  50 value 364.144361
## iter  60 value 363.447173
## iter  70 value 363.247153
## iter  80 value 363.168043
## iter  90 value 363.029031
## iter 100 value 362.885454
## final  value 362.885454
## stopped after 100 iterations
## # weights:  421
## initial  value 1343.584185
## iter  10 value 420.587566
## iter  20 value 366.720145
## iter  30 value 363.656050
## iter  40 value 363.260930
## iter  50 value 363.146127
## iter  60 value 362.951359
## iter  70 value 362.762791
## iter  80 value 362.564508
## iter  90 value 362.474733
## iter 100 value 362.442954
## final  value 362.442954
## stopped after 100 iterations
## # weights:  141
## initial  value 1390.434380
## iter  10 value 428.396901
## iter  20 value 374.731388
## iter  30 value 369.920856
## iter  40 value 369.261492
## iter  50 value 368.834084
## iter  60 value 368.635723
## iter  70 value 368.576908
## iter  80 value 368.574660
## iter  90 value 368.574445
## iter 100 value 368.574282
## final  value 368.574282
```

```
## stopped after 100 iterations
## # weights:  281
## initial  value 2328.470687
## iter  10 value 1412.431944
## iter  20 value 473.096669
## iter  30 value 389.573877
## iter  40 value 375.330528
## iter  50 value 370.561815
## iter  60 value 369.156849
## iter  70 value 368.813227
## iter  80 value 368.611964
## iter  90 value 368.491813
## iter 100 value 368.387404
## final  value 368.387404
## stopped after 100 iterations
## # weights:  421
## initial  value 2547.952114
## iter  10 value 1679.176969
## iter  20 value 466.734073
## iter  30 value 374.596332
## iter  40 value 368.846596
## iter  50 value 368.383504
## iter  60 value 368.255936
## iter  70 value 368.223781
## iter  80 value 368.218594
## iter  90 value 368.212747
## iter 100 value 368.206357
## final  value 368.206357
## stopped after 100 iterations
## # weights:  141
## initial  value 2850.854771
## final  value 1744.000000
## converged
## # weights:  281
## initial  value 2009.172362
## final  value 1744.000000
## converged
## # weights:  421
## initial  value 2526.940767
## final  value 1744.000000
## converged
## # weights:  141
## initial  value 3591.169029
## iter  10 value 1572.849814
## iter  20 value 415.484227
## iter  30 value 369.150964
## iter  40 value 364.322632
## iter  50 value 364.124594
## iter  60 value 363.844907
## iter  70 value 363.673686
```

```
## iter  80 value 363.564042
## iter  90 value 363.423684
## iter 100 value 363.213267
## iter 110 value 362.876440
## iter 120 value 362.771216
## iter 130 value 362.539276
## iter 140 value 362.469943
## iter 150 value 362.455320
## iter 160 value 362.446853
## iter 170 value 362.443819
## iter 180 value 362.438245
## iter 190 value 362.436594
## iter 200 value 362.436126
## iter 210 value 362.432247
## iter 220 value 362.430566
## iter 230 value 362.429535
## iter 240 value 362.428531
## iter 250 value 362.428054
## final  value 362.428020
## converged
## # weights:  281
## initial  value 1292.209168
## iter  10 value 663.247708
## iter  20 value 387.227913
## iter  30 value 366.227343
## iter  40 value 364.219362
## iter  50 value 363.657815
## iter  60 value 363.264071
## iter  70 value 363.023963
## iter  80 value 362.916812
## iter  90 value 362.815893
## iter 100 value 362.717704
## iter 110 value 362.601341
## iter 120 value 362.550526
## iter 130 value 362.518659
## iter 140 value 362.490773
## iter 150 value 362.462390
## iter 160 value 362.447005
## iter 170 value 362.436124
## iter 180 value 362.429136
## iter 190 value 362.423164
## iter 200 value 362.417193
## iter 210 value 362.412477
## iter 220 value 362.408908
## iter 230 value 362.406278
## iter 240 value 362.405085
## iter 250 value 362.404442
## iter 260 value 362.403808
## iter 270 value 362.403495
## iter 280 value 362.401943
```

```
## iter 290 value 362.401233
## iter 300 value 362.400974
## iter 310 value 362.400838
## final  value 362.400138
## converged
## # weights:  421
## initial  value 1401.399696
## iter  10 value 408.648049
## iter  20 value 373.341776
## iter  30 value 365.027901
## iter  40 value 363.788715
## iter  50 value 363.333385
## iter  60 value 363.180033
## iter  70 value 363.060518
## iter  80 value 362.752318
## iter  90 value 362.519441
## iter 100 value 362.463256
## iter 110 value 362.450330
## iter 120 value 362.444239
## iter 130 value 362.441093
## iter 140 value 362.436359
## iter 150 value 362.427218
## iter 160 value 362.422082
## iter 170 value 362.418903
## iter 180 value 362.416198
## iter 190 value 362.414841
## iter 200 value 362.413345
## iter 210 value 362.412703
## iter 220 value 362.412166
## iter 230 value 362.411581
## iter 240 value 362.411267
## iter 250 value 362.411077
## iter 260 value 362.410935
## iter 270 value 362.410794
## iter 280 value 362.410598
## iter 290 value 362.410253
## iter 300 value 362.409644
## iter 310 value 362.409345
## iter 320 value 362.409148
## iter 330 value 362.408767
## iter 340 value 362.408669
## iter 350 value 362.408514
## final  value 362.408506
## converged
## # weights:  141
## initial  value 1324.431307
## iter  10 value 413.369813
## iter  20 value 371.472711
## iter  30 value 368.742135
## iter  40 value 368.586511
```

```
## iter  50 value 368.575998
## iter  60 value 368.575654
## iter  70 value 368.574568
## final  value 368.573533
## converged
## # weights:  281
## initial  value 2848.781381
## iter  10 value 1602.822447
## iter  20 value 976.212020
## iter  30 value 459.292679
## iter  40 value 417.234153
## iter  50 value 372.060190
## iter  60 value 369.043194
## iter  70 value 368.574584
## iter  80 value 368.387506
## iter  90 value 368.341836
## iter 100 value 368.314161
## iter 110 value 368.294447
## iter 120 value 368.283180
## iter 130 value 368.278502
## iter 140 value 368.276798
## iter 150 value 368.276392
## iter 160 value 368.276280
## iter 170 value 368.276145
## final  value 368.276009
## converged
## # weights:  421
## initial  value 1591.958396
## iter  10 value 413.185743
## iter  20 value 389.890075
## iter  30 value 373.016553
## iter  40 value 369.645385
## iter  50 value 368.702181
## iter  60 value 368.433782
## iter  70 value 368.321278
## iter  80 value 368.274693
## iter  90 value 368.246836
## iter 100 value 368.234059
## iter 110 value 368.226857
## iter 120 value 368.219032
## iter 130 value 368.213343
## iter 140 value 368.208683
## iter 150 value 368.205179
## iter 160 value 368.202874
## iter 170 value 368.201806
## iter 180 value 368.200935
## iter 190 value 368.200451
## iter 200 value 368.199774
## iter 210 value 368.199313
## iter 220 value 368.198918
```

```
## iter 230 value 368.198663
## final  value 368.198511
## converged
```

```
  myNewFrame
```

```
##    node maxit decay misscls.train misscls.test
## 1     5    10   0.0    0.05657143    0.1033333
## 2    10    10   0.0    0.24914286    0.1190000
## 3    15    10   0.0    0.24914286    0.1190000
## 4     5    10   0.1    0.24914286    0.1190000
## 5    10    10   0.1    0.24914286    0.1190000
## 6    15    10   0.1    0.05657143    0.1033333
## 7     5    10   0.2    0.24914286    0.1190000
## 8    10    10   0.2    0.24914286    0.1190000
## 9    15    10   0.2    0.24914286    0.1190000
## 10    5   100   0.0    0.05657143    0.1033333
## 11   10   100   0.0    0.05657143    0.1033333
## 12   15   100   0.0    0.04000000    0.1143333
## 13    5   100   0.1    0.05657143    0.1033333
## 14   10   100   0.1    0.05657143    0.1033333
## 15   15   100   0.1    0.05657143    0.1033333
## 16    5   100   0.2    0.05657143    0.1033333
## 17   10   100   0.2    0.05657143    0.1033333
## 18   15   100   0.2    0.05657143    0.1033333
## 19    5 10000   0.0    0.24914286    0.1190000
## 20   10 10000   0.0    0.24914286    0.1190000
## 21   15 10000   0.0    0.24914286    0.1190000
## 22    5 10000   0.1    0.05657143    0.1033333
## 23   10 10000   0.1    0.05657143    0.1033333
## 24   15 10000   0.1    0.05657143    0.1033333
## 25    5 10000   0.2    0.05657143    0.1033333
## 26   10 10000   0.2    0.05657143    0.1033333
## 27   15 10000   0.2    0.05657143    0.1033333
```

Based on the output, I would choose the best model with 5 nodes, maxit as 100, and decay as 0.

```
best_nn <- nnet(IsAlert~., data = newdata, size = 5, decay = 0, maxit = 100)
```

```
## # weights:  246
## initial  value 17630.923600
## iter  10 value 14460.156899
## iter  20 value 14199.861982
## iter  30 value 13520.782083
## iter  40 value 13451.497230
## iter  50 value 13400.787369
## iter  60 value 12849.881837
## iter  70 value 12392.392073
## iter  80 value 12073.870893
## iter  90 value 11418.815823
```

```
## iter 100 value 10581.357555
## final  value 10581.357555
## stopped after 100 iterations

misscls.train<-sum((estimated_isAlert - training$IsAlert)^2)/length(training$
IsAlert)
misscls.train

## [1] 0.05657143

presdicted.testing<-as.numeric(predict(net.dat,testing )>0.5)
Ttest = table(presdicted.testing, testing$IsAlert)
misscls.test<-sum((presdicted.testing - testing$IsAlert)^2)/length(testing$Is
Alert)
misscls.test

## [1] 0.1033333

presdicted.testing.all<-as.numeric(predict(net.dat, newdata )>0.5)
Ttest = table(presdicted.testing.all, newdata$IsAlert)
misscls.test.all<-sum((presdicted.testing.all - newdata$IsAlert)^2)/length(ne
wdata$IsAlert)
misscls.test.all

## [1] 0.3264452
```

the best Neural Network model has 5 nodes, decay = 0, maxit = 100, the missclasification rate for training data : 0.05657143 the missclasification rate for testing data : 0.1033333 the missclasification rate for entire data : 0.3264452

Logistic Regression

```
#new data set
drops <- c("E3", "E7", "E8", "E9" , "V5","V10")
mydata_lm<-newdata[ , !(names(newdata) %in% drops)]
mydata_lm <- mydata_lm[ , -c(30:42)]

mydata_lm <- mydata_lm[1:1000,]
#training data
training <- mydata_lm[1:700, ]
#testing data
testing <- mydata_lm[701:1000,]

summary(training)

##     TrialID      ObsNum         IsAlert             P1
##  Min.   :0   Min.   :  0.0   Min.   :0.0000   Min.   :25.38
##  1st Qu.:0   1st Qu.:174.8   1st Qu.:1.0000   1st Qu.:34.15
##  Median :0   Median :349.5   Median :1.0000   Median :35.24
##  Mean   :0   Mean   :349.5   Mean   :0.8457   Mean   :35.89
##  3rd Qu.:0   3rd Qu.:524.2   3rd Qu.:1.0000   3rd Qu.:37.35
##  Max.   :0   Max.   :699.0   Max.   :1.0000   Max.   :44.82
```

```
##        P2               P3              P5               P6
##  Min.   : 6.137   Min.   : 516   Min.   :0.2335   Min.   :556.0
##  1st Qu.:10.936   1st Qu.: 816   1st Qu.:0.2672   1st Qu.:592.0
##  Median :12.783   Median :1084   Median :0.2789   Median :612.0
##  Mean   :12.844   Mean   :1081   Mean   :0.2782   Mean   :617.3
##  3rd Qu.:14.753   3rd Qu.:1400   3rd Qu.:0.2919   3rd Qu.:632.0
##  Max.   :18.524   Max.   :1816   Max.   :0.3140   Max.   :732.0
##        E4                E6              V1               V2
##  Min.   :-20.0000   Min.   :260.0   Min.   : 93.36   Min.   :-0.6650
##  1st Qu.: -6.0000   1st Qu.:317.0   1st Qu.: 97.01   1st Qu.: 0.0000
##  Median :  0.0000   Median :320.0   Median : 99.61   Median : 0.0000
##  Mean   :  0.6857   Mean   :319.9   Mean   : 99.47   Mean   : 0.0568
##  3rd Qu.:  8.0000   3rd Qu.:324.0   3rd Qu.:102.30   3rd Qu.: 0.0700
##  Max.   : 36.0000   Max.   :332.0   Max.   :104.97   Max.   : 0.8750
##        V3               V4               V8              V11
##  Min.   : 240.0   Min.   : 0.000   Min.   : 0.00   Min.   :14.08
##  1st Qu.: 240.0   1st Qu.: 3.019   1st Qu.: 7.95   1st Qu.:14.83
##  Median : 496.0   Median : 4.506   Median :14.70   Median :14.94
##  Mean   : 536.8   Mean   : 3.952   Mean   :13.70   Mean   :14.95
##  3rd Qu.: 767.0   3rd Qu.: 4.506   3rd Qu.:20.60   3rd Qu.:15.05
##  Max.   :1023.0   Max.   :10.500   Max.   :28.60   Max.   :15.60
##       E3_1           V10_high    V10_low       V5_1
##  Min.   :0.0000   Min.   :0   Min.   :1   Min.   :0.000000
##  1st Qu.:1.0000   1st Qu.:0   1st Qu.:1   1st Qu.:0.000000
##  Median :1.0000   Median :0   Median :1   Median :0.000000
##  Mean   :0.9857   Mean   :0   Mean   :1   Mean   :0.005714
##  3rd Qu.:1.0000   3rd Qu.:0   3rd Qu.:1   3rd Qu.:0.000000
##  Max.   :1.0000   Max.   :0   Max.   :1   Max.   :1.000000
##       V5_0             E9_1             E9_0            E8_high
##  Min.   :0.0000   Min.   :0.0000   Min.   :0.00000   Min.   :0
##  1st Qu.:1.0000   1st Qu.:1.0000   1st Qu.:0.00000   1st Qu.:0
##  Median :1.0000   Median :1.0000   Median :0.00000   Median :0
##  Mean   :0.9943   Mean   :0.9886   Mean   :0.01143   Mean   :0
##  3rd Qu.:1.0000   3rd Qu.:1.0000   3rd Qu.:0.00000   3rd Qu.:0
##  Max.   :1.0000   Max.   :1.0000   Max.   :1.00000   Max.   :0
##      E8_low     E7_high      E7_low       E3_4        E3_0
##  Min.   :0   Min.   :0   Min.   :1   Min.   :0   Min.   :0.00000
##  1st Qu.:0   1st Qu.:0   1st Qu.:1   1st Qu.:0   1st Qu.:0.00000
##  Median :0   Median :0   Median :1   Median :0   Median :0.00000
##  Mean   :0   Mean   :0   Mean   :1   Mean   :0   Mean   :0.01429
##  3rd Qu.:0   3rd Qu.:0   3rd Qu.:1   3rd Qu.:0   3rd Qu.:0.00000
##  Max.   :0   Max.   :0   Max.   :1   Max.   :0   Max.   :1.00000
```

```
logistic.model <- glm(IsAlert~., data = training, family = binomial(link="log
it"))
summary(logistic.model)
```

```
##
## Call:
## glm(formula = IsAlert ~ ., family = binomial(link = "logit"),
```

```
##     data = training)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -2.9021   0.1444   0.3130   0.5397   1.5659
##
## Coefficients: (11 not defined because of singularities)
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept)  3.733e+01  1.686e+03   0.022 0.982335
## TrialID             NA         NA      NA       NA
## ObsNum       8.934e-04  1.137e-03   0.786 0.432118
## P1           7.744e-02  1.345e-01   0.576 0.564902
## P2           2.972e-02  4.806e-02   0.618 0.536281
## P3          -1.408e-03  4.476e-04  -3.145 0.001659 **
## P5          -4.477e+01  8.113e+00  -5.519 3.42e-08 ***
## P6           2.204e-03  5.182e-03   0.425 0.670534
## E4           2.433e-02  1.371e-02   1.774 0.076050 .
## E6           5.952e-02  1.755e-02   3.392 0.000693 ***
## V1           1.121e-01  5.888e-02   1.904 0.056877 .
## V2           3.510e+00  1.104e+00   3.181 0.001467 **
## V3          -1.404e-03  4.887e-04  -2.873 0.004070 **
## V4          -6.796e-01  1.737e-01  -3.912 9.15e-05 ***
## V8           2.384e-02  1.801e-02   1.323 0.185720
## V11         -1.561e+00  1.743e+00  -0.896 0.370507
## E3_1        -1.559e+01  1.150e+03  -0.014 0.989190
## V10_high            NA         NA      NA       NA
## V10_low             NA         NA      NA       NA
## V5_1         1.474e+01  1.944e+03   0.008 0.993948
## V5_0                NA         NA      NA       NA
## E9_1        -1.427e+01  1.232e+03  -0.012 0.990763
## E9_0                NA         NA      NA       NA
## E8_high             NA         NA      NA       NA
## E8_low              NA         NA      NA       NA
## E7_high             NA         NA      NA       NA
## E7_low              NA         NA      NA       NA
## E3_4                NA         NA      NA       NA
## E3_0                NA         NA      NA       NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 602.10  on 699  degrees of freedom
## Residual deviance: 452.36  on 682  degrees of freedom
## AIC: 488.36
##
## Number of Fisher Scoring iterations: 16
```

To preserve only the significant variables: P3, P6, E4, E6, V1, V2, V3, V4, E9_1

```r
logistic.model.cur <- glm(IsAlert~P3 + P6 + E4 + E6 + V1 +V2 + V3 + V4 + E9_1
, data = training, family = binomial(link="logit"))
summary(logistic.model.cur)
```

```
##
## Call:
## glm(formula = IsAlert ~ P3 + P6 + E4 + E6 + V1 + V2 + V3 + V4 +
##     E9_1, family = binomial(link = "logit"), data = training)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -2.7354   0.2117   0.3612   0.6086   1.5315
##
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept) -1.755e+01  7.935e+02  -0.022 0.982356
## P3          -1.734e-03  3.923e-04  -4.419 9.90e-06 ***
## P6           3.365e-03  4.706e-03   0.715 0.474574
## E4           3.596e-02  1.300e-02   2.767 0.005653 **
## E6           6.314e-02  1.528e-02   4.132 3.60e-05 ***
## V1           1.599e-01  4.734e-02   3.377 0.000733 ***
## V2           3.201e+00  1.025e+00   3.124 0.001786 **
## V3          -6.224e-04  4.015e-04  -1.550 0.121054
## V4          -5.903e-01  1.251e-01  -4.720 2.36e-06 ***
## E9_1        -1.416e+01  7.935e+02  -0.018 0.985759
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 602.10  on 699  degrees of freedom
## Residual deviance: 499.65  on 690  degrees of freedom
## AIC: 519.65
##
## Number of Fisher Scoring iterations: 15
```

```r
library(MASS)
set.seed(10)
birthwt.step <- stepAIC(logistic.model.cur, trace = 1, direction="both")
```

```
## Start:  AIC=519.65
## IsAlert ~ P3 + P6 + E4 + E6 + V1 + V2 + V3 + V4 + E9_1
##
##        Df Deviance    AIC
## - P6    1   500.18 518.18
## - E9_1  1   501.11 519.11
## <none>      499.65 519.65
## - V3    1   502.05 520.05
## - E4    1   507.70 525.70
## - V2    1   509.74 527.74
```

```
## - V1    1   512.03 530.03
## - E6    1   518.91 536.91
## - P3    1   520.11 538.11
## - V4    1   523.50 541.50
##
## Step:  AIC=518.18
## IsAlert ~ P3 + E4 + E6 + V1 + V2 + V3 + V4 + E9_1
##
##        Df Deviance    AIC
## - E9_1  1   501.67 517.67
## <none>      500.18 518.18
## - V3    1   502.81 518.81
## + P6    1   499.65 519.65
## - E4    1   509.05 525.05
## - V2    1   510.52 526.52
## - V1    1   512.04 528.04
## - E6    1   524.16 540.16
## - V4    1   524.31 540.31
## - P3    1   525.01 541.01
##
## Step:  AIC=517.67
## IsAlert ~ P3 + E4 + E6 + V1 + V2 + V3 + V4
##
##        Df Deviance    AIC
## <none>      501.67 517.67
## + E9_1  1   500.18 518.18
## - V3    1   504.60 518.60
## + P6    1   501.11 519.11
## - E4    1   510.48 524.48
## - V1    1   513.18 527.18
## - V2    1   513.32 527.32
## - E6    1   525.59 539.59
## - V4    1   526.80 540.80
## - P3    1   527.33 541.33
```

```
birthwt.step$anova
```

```
## Stepwise Model Path
## Analysis of Deviance Table
##
## Initial Model:
## IsAlert ~ P3 + P6 + E4 + E6 + V1 + V2 + V3 + V4 + E9_1
##
## Final Model:
## IsAlert ~ P3 + E4 + E6 + V1 + V2 + V3 + V4
##
##
##     Step Df  Deviance Resid. Df Resid. Dev      AIC
## 1                           690   499.6475 519.6475
```

```
## 2   - P6  1 0.5342874       691   500.1818 518.1818
## 3 - E9_1  1 1.4860335       692   501.6679 517.6679
```

the best Logistic Regression model has variables as following P3 + E4 + E6 + V1 + V2 + V3 + V4

```
logistic.model.best <- glm(IsAlert~P3 + E4 + E6 + V1 +V2 + V3 + V4, data = tr
aining, family = binomial(link="logit"))
estimated_isAlert<- predict(logistic.model.best, training, type = "response")
misscls.train<-sum((estimated_isAlert-training$IsAlert)^2)/ length(training$I
sAlert)
misscls.train

## [1] 0.1102006

presdicted.testing <- predict(logistic.model.best, testing, type = "response"
)
misscls.test<-sum((presdicted.testing - testing$IsAlert)^2)/length(testing$Is
Alert)
misscls.test

## [1] 0.1379455

presdicted.testing.all <- predict(logistic.model.best, mydata_lm, type = "res
ponse")
misscls.test.all<-sum((presdicted.testing.all - mydata_lm$IsAlert)^2)/length(
mydata_lm$IsAlert)
misscls.test.all

## [1] 0.1185241
```

the missclasification rate for training data : 0.1102006 the missclasification rate for testing data : 0.1379455 the missclasification rate for entire data : 0.1185241

Decision Tree

```
#new data set
mydata_tree <- newdata[ , 3:22]
mydata_tree <- mydata_tree[1:1000,]
#training data
training <- mydata_tree[1:700, ]
#testing data
testing <- mydata_tree[701:1000,]

summary(training)

##     IsAlert             P1              P2              P3
##  Min.   :0.0000   Min.   :25.38   Min.   : 6.137   Min.   : 516
##  1st Qu.:1.0000   1st Qu.:34.15   1st Qu.:10.936   1st Qu.: 816
##  Median :1.0000   Median :35.24   Median :12.783   Median :1084
##  Mean   :0.8457   Mean   :35.89   Mean   :12.844   Mean   :1081
##  3rd Qu.:1.0000   3rd Qu.:37.35   3rd Qu.:14.753   3rd Qu.:1400
```

```
##  Max.   :1.0000   Max.   :44.82   Max.   :18.524   Max.   :1816
##        P5               P6              E3               E4
##  Min.   :0.2335   Min.   :556.0   Min.   :0.0000   Min.   :-20.0000
##  1st Qu.:0.2672   1st Qu.:592.0   1st Qu.:1.0000   1st Qu.: -6.0000
##  Median :0.2789   Median :612.0   Median :1.0000   Median :  0.0000
##  Mean   :0.2782   Mean   :617.3   Mean   :0.9857   Mean   :  0.6857
##  3rd Qu.:0.2919   3rd Qu.:632.0   3rd Qu.:1.0000   3rd Qu.:  8.0000
##  Max.   :0.3140   Max.   :732.0   Max.   :1.0000   Max.   : 36.0000
##        E6              E7               E8               E9
##  Min.   :260.0   Min.   :0.0000   Min.   :0.0000   Min.   :0.0000
##  1st Qu.:317.0   1st Qu.:1.0000   1st Qu.:1.0000   1st Qu.:1.0000
##  Median :320.0   Median :1.0000   Median :1.0000   Median :1.0000
##  Mean   :319.9   Mean   :0.9914   Mean   :0.9914   Mean   :0.9886
##  3rd Qu.:324.0   3rd Qu.:1.0000   3rd Qu.:1.0000   3rd Qu.:1.0000
##  Max.   :332.0   Max.   :1.0000   Max.   :1.0000   Max.   :1.0000
##        V1               V2                V3               V4
##  Min.   : 93.36   Min.   :-0.6650   Min.   : 240.0   Min.   : 0.000
##  1st Qu.: 97.01   1st Qu.: 0.0000   1st Qu.: 240.0   1st Qu.: 3.019
##  Median : 99.61   Median : 0.0000   Median : 496.0   Median : 4.506
##  Mean   : 99.47   Mean   : 0.0568   Mean   : 536.8   Mean   : 3.952
##  3rd Qu.:102.30   3rd Qu.: 0.0700   3rd Qu.: 767.0   3rd Qu.: 4.506
##  Max.   :104.97   Max.   : 0.8750   Max.   :1023.0   Max.   :10.500
##        V5                V8             V10         V11
##  Min.   :0.000000   Min.   : 0.00   Min.   :4   Min.   :14.08
##  1st Qu.:0.000000   1st Qu.: 7.95   1st Qu.:4   1st Qu.:14.83
##  Median :0.000000   Median :14.70   Median :4   Median :14.94
##  Mean   :0.005714   Mean   :13.70   Mean   :4   Mean   :14.95
##  3rd Qu.:0.000000   3rd Qu.:20.60   3rd Qu.:4   3rd Qu.:15.05
##  Max.   :1.000000   Max.   :28.60   Max.   :4   Max.   :15.60
```

```
IsAlert=ifelse(mydata_tree$IsAlert == 1," yes"," No ")
mydata_tree <-  data.frame(mydata_tree[,-1],IsAlert)
summary(mydata_tree)
```

```
##        P1              P2              P3             P5
##  Min.   :25.38   Min.   : 6.137   Min.   : 516   Min.   :0.2335
##  1st Qu.:34.46   1st Qu.:10.873   1st Qu.: 800   1st Qu.:0.2672
##  Median :35.81   Median :12.840   Median :1000   Median :0.2763
##  Mean   :36.22   Mean   :12.838   Mean   :1048   Mean   :0.2768
##  3rd Qu.:37.59   3rd Qu.:14.629   3rd Qu.:1232   3rd Qu.:0.2896
##  Max.   :44.82   Max.   :20.608   Max.   :1816   Max.   :0.3321
##        P6            E3              E4               E6
##  Min.   :556   Min.   :0.00   Min.   :-24.000   Min.   :260
##  1st Qu.:600   1st Qu.:1.00   1st Qu.: -6.000   1st Qu.:317
##  Median :616   Median :1.00   Median :  0.000   Median :320
##  Mean   :625   Mean   :0.99   Mean   :  1.072   Mean   :321
##  3rd Qu.:632   3rd Qu.:1.00   3rd Qu.:  8.000   3rd Qu.:324
##  Max.   :892   Max.   :1.00   Max.   : 36.000   Max.   :393
##        E7              E8              E9              V1
##  Min.   :0.00   Min.   :0.000   Min.   :0.000   Min.   : 93.36
```

```
##  1st Qu.:1.00   1st Qu.:1.000   1st Qu.:1.000   1st Qu.: 97.51
##  Median :1.00   Median :1.000   Median :1.000   Median :101.09
##  Mean   :1.04   Mean   :1.036   Mean   :0.976   Mean   :100.26
##  3rd Qu.:1.00   3rd Qu.:1.000   3rd Qu.:1.000   3rd Qu.:102.86
##  Max.   :6.00   Max.   :7.000   Max.   :1.000   Max.   :106.11
##        V2                  V3               V4               V5
##  Min.   :-0.665000   Min.   : 240.0   Min.   : 0.000   Min.   :0.000
##  1st Qu.:-0.070000   1st Qu.: 255.0   1st Qu.: 1.488   1st Qu.:0.000
##  Median : 0.000000   Median : 752.0   Median : 3.019   Median :0.000
##  Mean   : 0.005565   Mean   : 595.7   Mean   : 3.209   Mean   :0.006
##  3rd Qu.: 0.070000   3rd Qu.: 767.0   3rd Qu.: 4.506   3rd Qu.:0.000
##  Max.   : 0.875000   Max.   :1023.0   Max.   :10.500   Max.   :1.000
##        V8              V10         V11         IsAlert
##  Min.   : 0.00   Min.   :4   Min.   :14.08    No :150
##  1st Qu.: 8.40   1st Qu.:4   1st Qu.:14.87    yes:850
##  Median :15.20   Median :4   Median :15.02
##  Mean   :14.01   Mean   :4   Mean   :15.01
##  3rd Qu.:19.50   3rd Qu.:4   3rd Qu.:15.14
##  Max.   :28.60   Max.   :4   Max.   :15.60
```

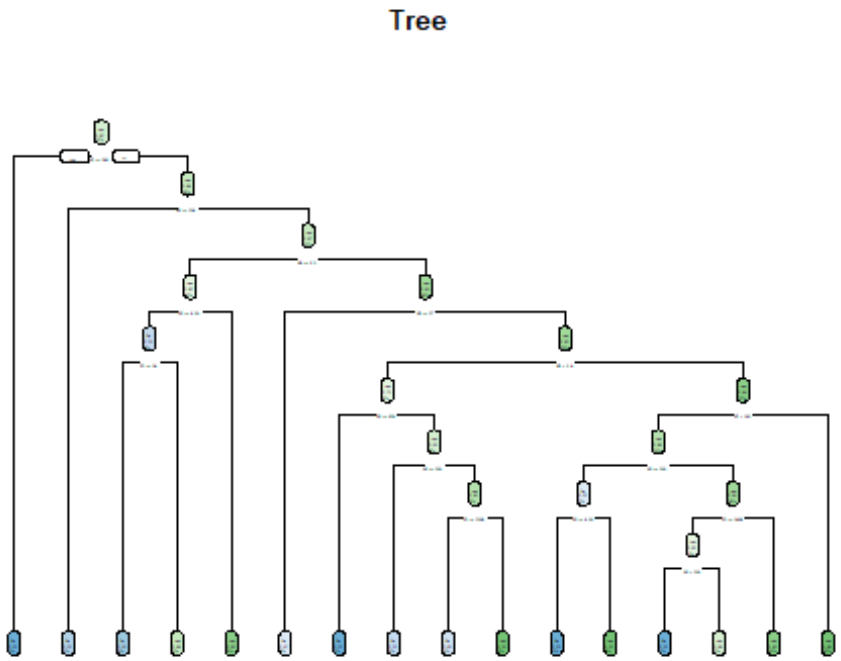
```
library(tree)
```

```
tree.mydata_tree =tree(IsAlert~.,data=mydata_tree )
summary (tree.mydata_tree )
```

```
##
## Classification tree:
## tree(formula = IsAlert ~ ., data = mydata_tree)
## Variables actually used in tree construction:
## [1] "V1" "E6" "V4" "E4" "P1" "P6" "V8" "V2" "P5"
## Number of terminal nodes:  25
## Residual mean deviance:  0.098 = 95.55 / 975
## Misclassification error rate: 0.023 = 23 / 1000
```

```
#plot(tree.mydata_tree)
#text(tree.mydata_tree ,pretty =0)
library(rpart.plot)
```

```
rpart.plot::rpart.plot(rpart(IsAlert~ .,data = mydata_tree),main = "Tree")
```

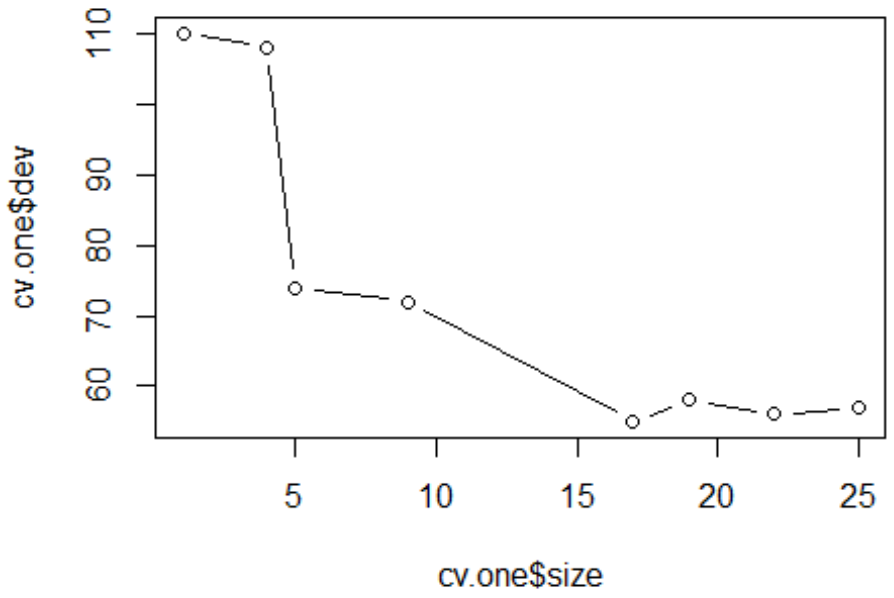



```
ntrain=700
set.seed(2020)
train=sample(1: nrow(mydata_tree ),ntrain )
training = mydata_tree[train,]
testing=mydata_tree[-train ,]
tree.one =tree(IsAlert~.,data=training )
summary (tree.one )

##
## Classification tree:
## tree(formula = IsAlert ~ ., data = training)
## Variables actually used in tree construction:
##  [1] "V4" "V1" "E6" "E4" "P2" "V8" "P3" "P6" "V2" "P5" "P1"
## Number of terminal nodes:  25
## Residual mean deviance:  0.1242 = 83.81 / 675
## Misclassification error rate: 0.02857 = 20 / 700

IsAlert.test=IsAlert[-train ]
tree.pred=predict(tree.one, testing,type="class")
table(tree.pred ,IsAlert.test)

##          IsAlert.test
## tree.pred  No   yes
##       No    29   12
##       yes   11  248
```

the missclasification rate for testing data :

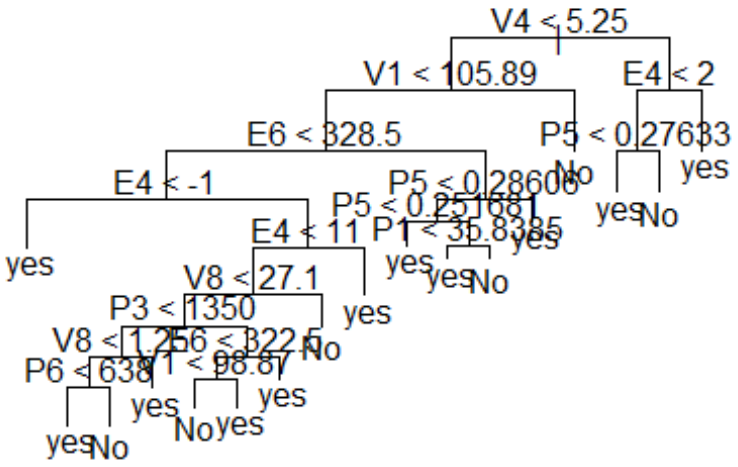
$$\frac{12+11}{29+12+11+248} = 0.076667$$

```
set.seed (2021)
cv.one =cv.tree(tree.one ,FUN=prune.misclass )
names(cv.one )

## [1] "size"   "dev"    "k"      "method"

cv.one

## $size
## [1] 25 22 19 17  9  5  4  1
##
## $dev
## [1]  57  56  58  55  72  74 108 110
##
## $k
## [1]       -Inf  0.0000000  0.6666667  2.0000000  3.6250000  4.0000000
## [7]  9.0000000 10.0000000
##
## $method
## [1] "misclass"
##
## attr(,"class")
## [1] "prune"         "tree.sequence"

plot(cv.one$size ,cv.one$dev ,type="b")
```



The best node size is 17.

```
mybest = 17
prune.one = prune.misclass (tree.one ,best = mybest)
plot(prune.one)
text(prune.one ,pretty =0)
```




```
summary(prune.one)
```

```
##
## Classification tree:
## snip.tree(tree = tree.one, nodes = c(7L, 16L, 75L, 273L, 12L,
## 549L))
## Variables actually used in tree construction:
## [1] "V4" "V1" "E6" "E4" "V8" "P3" "P6" "P5" "P1"
## Number of terminal nodes:  17
## Residual mean deviance:  0.243 = 166 / 683
## Misclassification error rate: 0.03714 = 26 / 700
```

```
IsAlert.train=IsAlert[train ]
tree.pred=predict(prune.one, training,type="class")
table(tree.pred ,IsAlert.train)
```

```
##          IsAlert.train
## tree.pred  No   yes
##       No    89    5
##       yes   21  585
```

```
IsAlert.test=IsAlert[-train ]
tree.pred=predict(prune.one, testing,type="class")
table(tree.pred ,IsAlert.test)
```

```
##          IsAlert.test
## tree.pred  No   yes
```

```
##        No    26    5
##        yes   14  255
```

After we reduce the size of nodes,

the missclasification rate for training data:

$$\frac{21+5}{89+21+5+585} = 0.037143$$

the missclasification rate for testing data:

$$\frac{14+5}{26+14+5+255} = 0.063333$$

After reducing the size of nodes, the missclasification has reduced.

Random Forest Boost

```
library(randomForest)
bag.one =randomForest(IsAlert~.,data=mydata_tree,subset =train , mtry=4, ntre
e =200,importance=TRUE)
IsAlert.test=IsAlert[-train]
tree.pred = predict ( bag.one ,newdata =mydata_tree[-train ,],type="class")
table(tree.pred , IsAlert.test)
```

```
##           IsAlert.test
## tree.pred  No   yes
##        No    33    0
##        yes    7  260
```

the missclasification rate for testing data:

$$\frac{7+0}{33+7+0+260} = 0.02333333$$

Esemble

```
library("mlbench")
```

```
## Warning: package 'mlbench' was built under R version 3.4.4
```

```
library("pROC")
```

```
## Warning: package 'pROC' was built under R version 3.4.4
```

```
## Type 'citation("pROC")' for a citation.
```

```
##
## Attaching package: 'pROC'
```

```
## The following objects are masked from 'package:stats':
##
##     cov, smooth, var
```

```r
library(caret)
#names(getModelInfo())

set.seed(2022)
mydata_last <- newdata[1:10000, ]
mydata_last$IsAlert <- as.factor(ifelse(mydata_last$IsAlert == 0, "No", "Yes"
))

inTrain <- createDataPartition(y = mydata_last$IsAlert, p = .75, list = FALSE
)
trainSet <- mydata_last[ inTrain,]
testSet <- mydata_last[-inTrain,]

#Defining the training controls for multiple models
fitControl <- trainControl(
  method = "cv",
  number = 5,
savePredictions = 'final',
classProbs = T)

#Defining the predictors and outcome
#based on the result from logistic regression
predictors<-c("P3", "E4", "E6", "V1", "V2", "V3", "V4")
outcomeName<-'IsAlert'


#Training the random forest model
model_rf<-train(trainSet[,predictors],trainSet[,outcomeName],method = 'rf')

#Predicting using random forest model
testSet$pred_rf<-predict(object = model_rf,testSet[,predictors],na.action = n
a.pass)


#Checking the accuracy of the random forest model
confusionMatrix(testSet$IsAlert,testSet$pred_rf)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   No  Yes
##        No   504   21
##        Yes    1 1973
##
##                Accuracy : 0.9912
##                  95% CI : (0.9867, 0.9945)
##     No Information Rate : 0.7979
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.9731
```

```
##  Mcnemar's Test P-Value : 5.104e-05
##
##             Sensitivity : 0.9980
##             Specificity : 0.9895
##          Pos Pred Value : 0.9600
##          Neg Pred Value : 0.9995
##              Prevalence : 0.2021
##          Detection Rate : 0.2017
##    Detection Prevalence : 0.2101
##       Balanced Accuracy : 0.9937
##
##        'Positive' Class : No
##
```

```
#Training the knn model
model_knn<-train(trainSet[,predictors],trainSet[,outcomeName],method='knn')

#Predicting using knn model
testSet$pred_knn<-predict(object = model_knn,testSet[,predictors])

#Checking the accuracy of the random forest model
confusionMatrix(testSet$IsAlert,testSet$pred_knn)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   No  Yes
##        No   377  148
##        Yes   71 1903
##
##                Accuracy : 0.9124
##                  95% CI : (0.9006, 0.9232)
##     No Information Rate : 0.8207
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.7209
##  Mcnemar's Test P-Value : 2.812e-07
##
##             Sensitivity : 0.8415
##             Specificity : 0.9278
##          Pos Pred Value : 0.7181
##          Neg Pred Value : 0.9640
##              Prevalence : 0.1793
##          Detection Rate : 0.1509
##    Detection Prevalence : 0.2101
##       Balanced Accuracy : 0.8847
##
##        'Positive' Class : No
##
```

```r
#Training the Logistic regression model
model_lr<-train(trainSet[,predictors],trainSet[,outcomeName],method='glm')

#Predicting using Logistic regression model
testSet$pred_lr<-predict(object = model_lr,testSet[,predictors])

#Checking the accuracy of the random forest model
confusionMatrix(testSet$IsAlert,testSet$pred_lr)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   No  Yes
##        No   271  254
##        Yes   29 1945
##
##                Accuracy : 0.8868
##                  95% CI : (0.8737, 0.8989)
##     No Information Rate : 0.88
##     P-Value [Acc > NIR] : 0.1548
##
##                   Kappa : 0.5951
##  Mcnemar's Test P-Value : <2e-16
##
##             Sensitivity : 0.9033
##             Specificity : 0.8845
##          Pos Pred Value : 0.5162
##          Neg Pred Value : 0.9853
##              Prevalence : 0.1200
##          Detection Rate : 0.1084
##    Detection Prevalence : 0.2101
##       Balanced Accuracy : 0.8939
##
##        'Positive' Class : No
##
```

Random forst model has accuracy as 0.9912; knn model has accuracy as 0.9124; Logistic regression model has accuracy as 0.8868.

```r
#Defining the training control
fitControl <- trainControl(
method = "cv",
number = 10,
savePredictions = 'final', # To save out of fold predictions for best paramet
er combinantions
classProbs = T # To save the class probabilities of the out of fold predictio
ns
)
```

```r
#Training the random forest model
model_rf<-train(trainSet[,predictors],trainSet[,outcomeName],method='rf',trCo
ntrol=fitControl,tuneLength=3)

#Training the knn model
model_knn<-train(trainSet[,predictors],trainSet[,outcomeName],method='knn',tr
Control=fitControl,tuneLength=3)

#Training the logistic regression model
model_lr<-train(trainSet[,predictors],trainSet[,outcomeName],method='glm',trC
ontrol=fitControl,tuneLength=3)

#Predicting the out of fold prediction probabilities for training data
trainSet$OOF_pred_rf<-model_rf$pred$Y[order(model_rf$pred$rowIndex)]
trainSet$OOF_pred_knn<-model_knn$pred$Y[order(model_knn$pred$rowIndex)]
trainSet$OOF_pred_lr<-model_lr$pred$Y[order(model_lr$pred$rowIndex)]

#Predicting probabilities for the test data
testSet$OOF_pred_rf<-predict(model_rf,testSet[predictors],type='prob')$Y
testSet$OOF_pred_knn<-predict(model_knn,testSet[predictors],type='prob')$Y
testSet$OOF_pred_lr<-predict(model_lr,testSet[predictors],type='prob')$Y

#Predictors for top layer models
predictors_top<-c('OOF_pred_rf','OOF_pred_knn','OOF_pred_lr')

#GBM as top layer model
model_gbm<-
train(trainSet[,predictors_top],trainSet[,outcomeName],method='gbm')
```

```
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8380             nan     0.1000    0.0892
##      2        0.7189             nan     0.1000    0.0599
##      3        0.6286             nan     0.1000    0.0448
##      4        0.5579             nan     0.1000    0.0355
##      5        0.4975             nan     0.1000    0.0304
##      6        0.4466             nan     0.1000    0.0254
##      7        0.4043             nan     0.1000    0.0206
##      8        0.3673             nan     0.1000    0.0190
##      9        0.3345             nan     0.1000    0.0165
##     10        0.3058             nan     0.1000    0.0141
##     20        0.1507             nan     0.1000    0.0044
##     40        0.0839             nan     0.1000    0.0005
##     60        0.0738             nan     0.1000    0.0001
##     80        0.0710             nan     0.1000   -0.0000
##    100        0.0695             nan     0.1000   -0.0000
##    120        0.0679             nan     0.1000    0.0001
##    140        0.0665             nan     0.1000   -0.0001
##    150        0.0660             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
```

```
##      1        0.8388             nan     0.1000    0.0872
##      2        0.7190             nan     0.1000    0.0609
##      3        0.6279             nan     0.1000    0.0449
##      4        0.5544             nan     0.1000    0.0359
##      5        0.4942             nan     0.1000    0.0304
##      6        0.4429             nan     0.1000    0.0259
##      7        0.3989             nan     0.1000    0.0218
##      8        0.3619             nan     0.1000    0.0186
##      9        0.3291             nan     0.1000    0.0166
##     10        0.3009             nan     0.1000    0.0141
##     20        0.1467             nan     0.1000    0.0042
##     40        0.0802             nan     0.1000    0.0003
##     60        0.0661             nan     0.1000   -0.0000
##     80        0.0619             nan     0.1000   -0.0001
##    100        0.0583             nan     0.1000   -0.0001
##    120        0.0538             nan     0.1000    0.0001
##    140        0.0499             nan     0.1000    0.0000
##    150        0.0491             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8368             nan     0.1000    0.0905
##      2        0.7163             nan     0.1000    0.0606
##      3        0.6251             nan     0.1000    0.0453
##      4        0.5517             nan     0.1000    0.0364
##      5        0.4910             nan     0.1000    0.0296
##      6        0.4401             nan     0.1000    0.0250
##      7        0.3969             nan     0.1000    0.0221
##      8        0.3595             nan     0.1000    0.0190
##      9        0.3272             nan     0.1000    0.0160
##     10        0.2978             nan     0.1000    0.0142
##     20        0.1429             nan     0.1000    0.0044
##     40        0.0740             nan     0.1000    0.0007
##     60        0.0590             nan     0.1000   -0.0001
##     80        0.0545             nan     0.1000   -0.0001
##    100        0.0494             nan     0.1000    0.0001
##    120        0.0457             nan     0.1000   -0.0000
##    140        0.0421             nan     0.1000   -0.0000
##    150        0.0403             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8754             nan     0.1000    0.0867
##      2        0.7536             nan     0.1000    0.0602
##      3        0.6598             nan     0.1000    0.0466
##      4        0.5831             nan     0.1000    0.0377
##      5        0.5209             nan     0.1000    0.0317
##      6        0.4671             nan     0.1000    0.0265
##      7        0.4228             nan     0.1000    0.0220
##      8        0.3843             nan     0.1000    0.0193
##      9        0.3497             nan     0.1000    0.0171
##     10        0.3207             nan     0.1000    0.0142
```

```
##     20        0.1595             nan     0.1000    0.0041
##     40        0.0878             nan     0.1000    0.0005
##     60        0.0771             nan     0.1000    0.0000
##     80        0.0736             nan     0.1000   -0.0000
##    100        0.0717             nan     0.1000   -0.0001
##    120        0.0702             nan     0.1000    0.0000
##    140        0.0689             nan     0.1000   -0.0001
##    150        0.0683             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8732             nan     0.1000    0.0882
##      2        0.7499             nan     0.1000    0.0607
##      3        0.6549             nan     0.1000    0.0463
##      4        0.5789             nan     0.1000    0.0377
##      5        0.5155             nan     0.1000    0.0309
##      6        0.4623             nan     0.1000    0.0267
##      7        0.4170             nan     0.1000    0.0226
##      8        0.3779             nan     0.1000    0.0194
##      9        0.3434             nan     0.1000    0.0172
##     10        0.3137             nan     0.1000    0.0146
##     20        0.1527             nan     0.1000    0.0041
##     40        0.0835             nan     0.1000    0.0005
##     60        0.0707             nan     0.1000    0.0001
##     80        0.0661             nan     0.1000   -0.0001
##    100        0.0602             nan     0.1000   -0.0000
##    120        0.0570             nan     0.1000    0.0000
##    140        0.0544             nan     0.1000   -0.0001
##    150        0.0533             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8722             nan     0.1000    0.0899
##      2        0.7481             nan     0.1000    0.0605
##      3        0.6528             nan     0.1000    0.0479
##      4        0.5762             nan     0.1000    0.0382
##      5        0.5128             nan     0.1000    0.0312
##      6        0.4595             nan     0.1000    0.0265
##      7        0.4139             nan     0.1000    0.0229
##      8        0.3743             nan     0.1000    0.0198
##      9        0.3399             nan     0.1000    0.0173
##     10        0.3104             nan     0.1000    0.0145
##     20        0.1477             nan     0.1000    0.0044
##     40        0.0764             nan     0.1000    0.0004
##     60        0.0619             nan     0.1000   -0.0000
##     80        0.0555             nan     0.1000   -0.0001
##    100        0.0497             nan     0.1000    0.0000
##    120        0.0465             nan     0.1000    0.0000
##    140        0.0405             nan     0.1000   -0.0000
##    150        0.0391             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
```

```
##      1        0.8325             nan     0.1000    0.0872
##      2        0.7131             nan     0.1000    0.0593
##      3        0.6243             nan     0.1000    0.0449
##      4        0.5512             nan     0.1000    0.0371
##      5        0.4911             nan     0.1000    0.0302
##      6        0.4412             nan     0.1000    0.0246
##      7        0.3975             nan     0.1000    0.0217
##      8        0.3600             nan     0.1000    0.0186
##      9        0.3284             nan     0.1000    0.0158
##     10        0.3005             nan     0.1000    0.0139
##     20        0.1454             nan     0.1000    0.0039
##     40        0.0770             nan     0.1000    0.0006
##     60        0.0655             nan     0.1000   -0.0000
##     80        0.0624             nan     0.1000    0.0000
##    100        0.0605             nan     0.1000   -0.0001
##    120        0.0591             nan     0.1000   -0.0000
##    140        0.0584             nan     0.1000   -0.0000
##    150        0.0581             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8305             nan     0.1000    0.0919
##      2        0.7105             nan     0.1000    0.0601
##      3        0.6192             nan     0.1000    0.0450
##      4        0.5464             nan     0.1000    0.0370
##      5        0.4863             nan     0.1000    0.0298
##      6        0.4357             nan     0.1000    0.0256
##      7        0.3918             nan     0.1000    0.0218
##      8        0.3544             nan     0.1000    0.0186
##      9        0.3218             nan     0.1000    0.0164
##     10        0.2934             nan     0.1000    0.0139
##     20        0.1411             nan     0.1000    0.0037
##     40        0.0731             nan     0.1000    0.0002
##     60        0.0597             nan     0.1000    0.0001
##     80        0.0545             nan     0.1000    0.0001
##    100        0.0496             nan     0.1000   -0.0001
##    120        0.0482             nan     0.1000    0.0001
##    140        0.0438             nan     0.1000   -0.0001
##    150        0.0427             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8303             nan     0.1000    0.0872
##      2        0.7098             nan     0.1000    0.0606
##      3        0.6176             nan     0.1000    0.0456
##      4        0.5448             nan     0.1000    0.0367
##      5        0.4840             nan     0.1000    0.0299
##      6        0.4331             nan     0.1000    0.0253
##      7        0.3895             nan     0.1000    0.0217
##      8        0.3518             nan     0.1000    0.0186
##      9        0.3196             nan     0.1000    0.0164
##     10        0.2910             nan     0.1000    0.0142
```

```
##     20        0.1357             nan     0.1000    0.0043
##     40        0.0656             nan     0.1000    0.0004
##     60        0.0507             nan     0.1000    0.0001
##     80        0.0437             nan     0.1000   -0.0001
##    100        0.0379             nan     0.1000   -0.0000
##    120        0.0353             nan     0.1000   -0.0001
##    140        0.0330             nan     0.1000    0.0000
##    150        0.0511             nan     0.1000    0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8413             nan     0.1000    0.0894
##      2        0.7208             nan     0.1000    0.0593
##      3        0.6284             nan     0.1000    0.0455
##      4        0.5561             nan     0.1000    0.0362
##      5        0.4953             nan     0.1000    0.0303
##      6        0.4442             nan     0.1000    0.0259
##      7        0.4018             nan     0.1000    0.0208
##      8        0.3627             nan     0.1000    0.0192
##      9        0.3299             nan     0.1000    0.0162
##     10        0.3013             nan     0.1000    0.0143
##     20        0.1442             nan     0.1000    0.0041
##     40        0.0750             nan     0.1000    0.0005
##     60        0.0662             nan     0.1000    0.0001
##     80        0.0643             nan     0.1000   -0.0000
##    100        0.0623             nan     0.1000   -0.0000
##    120        0.0609             nan     0.1000   -0.0000
##    140        0.0599             nan     0.1000   -0.0001
##    150        0.0592             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8396             nan     0.1000    0.0899
##      2        0.7188             nan     0.1000    0.0608
##      3        0.6258             nan     0.1000    0.0460
##      4        0.5519             nan     0.1000    0.0373
##      5        0.4905             nan     0.1000    0.0304
##      6        0.4383             nan     0.1000    0.0259
##      7        0.3940             nan     0.1000    0.0221
##      8        0.3563             nan     0.1000    0.0189
##      9        0.3231             nan     0.1000    0.0166
##     10        0.2942             nan     0.1000    0.0142
##     20        0.1403             nan     0.1000    0.0039
##     40        0.0733             nan     0.1000    0.0007
##     60        0.0618             nan     0.1000    0.0001
##     80        0.0569             nan     0.1000   -0.0001
##    100        0.0480             nan     0.1000   -0.0002
##    120        0.0439             nan     0.1000   -0.0000
##    140        0.0414             nan     0.1000   -0.0002
##    150        0.0407             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
```

```
##      1        0.8389             nan     0.1000    0.0924
##      2        0.7172             nan     0.1000    0.0610
##      3        0.6249             nan     0.1000    0.0461
##      4        0.5507             nan     0.1000    0.0366
##      5        0.4891             nan     0.1000    0.0302
##      6        0.4371             nan     0.1000    0.0258
##      7        0.3929             nan     0.1000    0.0222
##      8        0.3547             nan     0.1000    0.0191
##      9        0.3214             nan     0.1000    0.0163
##     10        0.2923             nan     0.1000    0.0145
##     20        0.1349             nan     0.1000    0.0045
##     40        0.0659             nan     0.1000    0.0004
##     60        0.0525             nan     0.1000   -0.0016
##     80        0.0445             nan     0.1000   -0.0000
##    100        0.0405             nan     0.1000   -0.0001
##    120        0.0361             nan     0.1000    0.0000
##    140        0.0336             nan     0.1000   -0.0001
##    150        0.0371             nan     0.1000    0.0002
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8513             nan     0.1000    0.0880
##      2        0.7322             nan     0.1000    0.0586
##      3        0.6403             nan     0.1000    0.0465
##      4        0.5668             nan     0.1000    0.0358
##      5        0.5055             nan     0.1000    0.0292
##      6        0.4543             nan     0.1000    0.0259
##      7        0.4112             nan     0.1000    0.0216
##      8        0.3731             nan     0.1000    0.0189
##      9        0.3412             nan     0.1000    0.0160
##     10        0.3119             nan     0.1000    0.0143
##     20        0.1544             nan     0.1000    0.0045
##     40        0.0857             nan     0.1000    0.0006
##     60        0.0752             nan     0.1000   -0.0000
##     80        0.0713             nan     0.1000    0.0000
##    100        0.0694             nan     0.1000   -0.0000
##    120        0.0677             nan     0.1000   -0.0001
##    140        0.0662             nan     0.1000   -0.0000
##    150        0.0659             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8521             nan     0.1000    0.0896
##      2        0.7301             nan     0.1000    0.0595
##      3        0.6378             nan     0.1000    0.0452
##      4        0.5638             nan     0.1000    0.0362
##      5        0.5020             nan     0.1000    0.0308
##      6        0.4507             nan     0.1000    0.0263
##      7        0.4071             nan     0.1000    0.0216
##      8        0.3684             nan     0.1000    0.0190
##      9        0.3348             nan     0.1000    0.0166
##     10        0.3056             nan     0.1000    0.0146
```

```
##     20        0.1513             nan     0.1000    0.0040
##     40        0.0827             nan     0.1000    0.0004
##     60        0.0703             nan     0.1000    0.0001
##     80        0.0635             nan     0.1000   -0.0001
##    100        0.0585             nan     0.1000   -0.0001
##    120        0.0546             nan     0.1000   -0.0000
##    140        0.0520             nan     0.1000   -0.0001
##    150        0.0502             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8501             nan     0.1000    0.0874
##      2        0.7278             nan     0.1000    0.0616
##      3        0.6354             nan     0.1000    0.0455
##      4        0.5606             nan     0.1000    0.0371
##      5        0.4993             nan     0.1000    0.0302
##      6        0.4472             nan     0.1000    0.0260
##      7        0.4029             nan     0.1000    0.0218
##      8        0.3650             nan     0.1000    0.0188
##      9        0.3315             nan     0.1000    0.0167
##     10        0.3024             nan     0.1000    0.0144
##     20        0.1443             nan     0.1000    0.0046
##     40        0.0754             nan     0.1000    0.0004
##     60        0.0622             nan     0.1000    0.0001
##     80        0.0550             nan     0.1000    0.0000
##    100        0.0459             nan     0.1000    0.0000
##    120        0.0425             nan     0.1000   -0.0001
##    140        0.0409             nan     0.1000    0.0001
##    150        0.0391             nan     0.1000    0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8357             nan     0.1000    0.0877
##      2        0.7160             nan     0.1000    0.0603
##      3        0.6243             nan     0.1000    0.0451
##      4        0.5515             nan     0.1000    0.0366
##      5        0.4908             nan     0.1000    0.0295
##      6        0.4404             nan     0.1000    0.0255
##      7        0.3964             nan     0.1000    0.0216
##      8        0.3581             nan     0.1000    0.0190
##      9        0.3258             nan     0.1000    0.0156
##     10        0.2971             nan     0.1000    0.0139
##     20        0.1411             nan     0.1000    0.0046
##     40        0.0723             nan     0.1000    0.0004
##     60        0.0629             nan     0.1000    0.0000
##     80        0.0607             nan     0.1000    0.0000
##    100        0.0592             nan     0.1000   -0.0001
##    120        0.0580             nan     0.1000   -0.0001
##    140        0.0571             nan     0.1000   -0.0001
##    150        0.0567             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
```

```
##      1        0.8338             nan     0.1000    0.0902
##      2        0.7128             nan     0.1000    0.0600
##      3        0.6209             nan     0.1000    0.0465
##      4        0.5476             nan     0.1000    0.0367
##      5        0.4865             nan     0.1000    0.0312
##      6        0.4352             nan     0.1000    0.0252
##      7        0.3912             nan     0.1000    0.0217
##      8        0.3537             nan     0.1000    0.0185
##      9        0.3207             nan     0.1000    0.0164
##     10        0.2918             nan     0.1000    0.0143
##     20        0.1367             nan     0.1000    0.0044
##     40        0.0696             nan     0.1000    0.0003
##     60        0.0582             nan     0.1000    0.0001
##     80        0.0520             nan     0.1000   -0.0001
##    100        0.0495             nan     0.1000   -0.0002
##    120        0.0471             nan     0.1000   -0.0001
##    140        0.0458             nan     0.1000   -0.0001
##    150        0.0449             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8340             nan     0.1000    0.0892
##      2        0.7131             nan     0.1000    0.0611
##      3        0.6207             nan     0.1000    0.0452
##      4        0.5465             nan     0.1000    0.0366
##      5        0.4852             nan     0.1000    0.0307
##      6        0.4339             nan     0.1000    0.0248
##      7        0.3896             nan     0.1000    0.0223
##      8        0.3514             nan     0.1000    0.0192
##      9        0.3182             nan     0.1000    0.0164
##     10        0.2891             nan     0.1000    0.0143
##     20        0.1341             nan     0.1000    0.0042
##     40        0.0642             nan     0.1000    0.0005
##     60        0.0513             nan     0.1000    0.0000
##     80        0.0468             nan     0.1000    0.0000
##    100        0.0434             nan     0.1000    0.0000
##    120        0.0398             nan     0.1000   -0.0000
##    140        0.0373             nan     0.1000   -0.0002
##    150        0.0363             nan     0.1000   -0.0002
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8584             nan     0.1000    0.0904
##      2        0.7349             nan     0.1000    0.0608
##      3        0.6413             nan     0.1000    0.0488
##      4        0.5653             nan     0.1000    0.0380
##      5        0.5037             nan     0.1000    0.0305
##      6        0.4510             nan     0.1000    0.0262
##      7        0.4058             nan     0.1000    0.0224
##      8        0.3667             nan     0.1000    0.0195
##      9        0.3321             nan     0.1000    0.0172
##     10        0.3032             nan     0.1000    0.0142
```

```
##     20        0.1423             nan     0.1000    0.0043
##     40        0.0709             nan     0.1000    0.0005
##     60        0.0616             nan     0.1000    0.0000
##     80        0.0590             nan     0.1000   -0.0002
##    100        0.0573             nan     0.1000   -0.0001
##    120        0.0556             nan     0.1000   -0.0000
##    140        0.0549             nan     0.1000   -0.0000
##    150        0.0545             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8567             nan     0.1000    0.0906
##      2        0.7330             nan     0.1000    0.0606
##      3        0.6384             nan     0.1000    0.0475
##      4        0.5617             nan     0.1000    0.0369
##      5        0.4988             nan     0.1000    0.0313
##      6        0.4464             nan     0.1000    0.0262
##      7        0.4010             nan     0.1000    0.0226
##      8        0.3620             nan     0.1000    0.0190
##      9        0.3280             nan     0.1000    0.0168
##     10        0.2980             nan     0.1000    0.0145
##     20        0.1368             nan     0.1000    0.0047
##     40        0.0676             nan     0.1000    0.0004
##     60        0.0554             nan     0.1000    0.0000
##     80        0.0479             nan     0.1000   -0.0001
##    100        0.0453             nan     0.1000   -0.0000
##    120        0.0431             nan     0.1000   -0.0001
##    140        0.0402             nan     0.1000   -0.0000
##    150        0.0392             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8566             nan     0.1000    0.0915
##      2        0.7327             nan     0.1000    0.0621
##      3        0.6381             nan     0.1000    0.0468
##      4        0.5614             nan     0.1000    0.0382
##      5        0.4984             nan     0.1000    0.0318
##      6        0.4450             nan     0.1000    0.0267
##      7        0.3989             nan     0.1000    0.0229
##      8        0.3597             nan     0.1000    0.0196
##      9        0.3252             nan     0.1000    0.0170
##     10        0.2952             nan     0.1000    0.0150
##     20        0.1330             nan     0.1000    0.0040
##     40        0.0621             nan     0.1000    0.0002
##     60        0.0481             nan     0.1000   -0.0003
##     80        0.0412             nan     0.1000   -0.0001
##    100        0.0380             nan     0.1000   -0.0001
##    120        0.0352             nan     0.1000   -0.0001
##    140        0.0323             nan     0.1000   -0.0000
##    150        0.0315             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
```

```
##      1        0.8451             nan     0.1000    0.0880
##      2        0.7241             nan     0.1000    0.0602
##      3        0.6312             nan     0.1000    0.0466
##      4        0.5564             nan     0.1000    0.0358
##      5        0.4956             nan     0.1000    0.0293
##      6        0.4446             nan     0.1000    0.0250
##      7        0.4021             nan     0.1000    0.0216
##      8        0.3635             nan     0.1000    0.0189
##      9        0.3307             nan     0.1000    0.0163
##     10        0.3031             nan     0.1000    0.0139
##     20        0.1460             nan     0.1000    0.0049
##     40        0.0743             nan     0.1000    0.0004
##     60        0.0633             nan     0.1000    0.0001
##     80        0.0611             nan     0.1000   -0.0000
##    100        0.0593             nan     0.1000   -0.0000
##    120        0.0582             nan     0.1000   -0.0000
##    140        0.0571             nan     0.1000   -0.0001
##    150        0.0568             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8426             nan     0.1000    0.0865
##      2        0.7222             nan     0.1000    0.0596
##      3        0.6295             nan     0.1000    0.0458
##      4        0.5554             nan     0.1000    0.0368
##      5        0.4941             nan     0.1000    0.0307
##      6        0.4423             nan     0.1000    0.0255
##      7        0.3976             nan     0.1000    0.0224
##      8        0.3593             nan     0.1000    0.0191
##      9        0.3261             nan     0.1000    0.0164
##     10        0.2967             nan     0.1000    0.0146
##     20        0.1405             nan     0.1000    0.0040
##     40        0.0697             nan     0.1000    0.0006
##     60        0.0573             nan     0.1000    0.0001
##     80        0.0535             nan     0.1000    0.0001
##    100        0.0502             nan     0.1000   -0.0000
##    120        0.0485             nan     0.1000   -0.0000
##    140        0.0462             nan     0.1000    0.0000
##    150        0.0454             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8426             nan     0.1000    0.0910
##      2        0.7205             nan     0.1000    0.0619
##      3        0.6274             nan     0.1000    0.0468
##      4        0.5528             nan     0.1000    0.0371
##      5        0.4912             nan     0.1000    0.0305
##      6        0.4390             nan     0.1000    0.0264
##      7        0.3943             nan     0.1000    0.0221
##      8        0.3562             nan     0.1000    0.0187
##      9        0.3227             nan     0.1000    0.0168
##     10        0.2933             nan     0.1000    0.0142
```

```
##     20        0.1358             nan     0.1000    0.0042
##     40        0.0647             nan     0.1000    0.0005
##     60        0.0521             nan     0.1000   -0.0000
##     80        0.0453             nan     0.1000   -0.0001
##    100        0.0395             nan     0.1000   -0.0001
##    120        0.0350             nan     0.1000   -0.0000
##    140        0.0323             nan     0.1000   -0.0000
##    150        0.1469             nan     0.1000    0.0002
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8549             nan     0.1000    0.0901
##      2        0.7345             nan     0.1000    0.0600
##      3        0.6420             nan     0.1000    0.0456
##      4        0.5674             nan     0.1000    0.0368
##      5        0.5069             nan     0.1000    0.0302
##      6        0.4553             nan     0.1000    0.0255
##      7        0.4124             nan     0.1000    0.0211
##      8        0.3734             nan     0.1000    0.0190
##      9        0.3394             nan     0.1000    0.0169
##     10        0.3099             nan     0.1000    0.0146
##     20        0.1546             nan     0.1000    0.0044
##     40        0.0849             nan     0.1000    0.0005
##     60        0.0739             nan     0.1000    0.0001
##     80        0.0714             nan     0.1000    0.0001
##    100        0.0702             nan     0.1000   -0.0001
##    120        0.0693             nan     0.1000   -0.0000
##    140        0.0682             nan     0.1000   -0.0000
##    150        0.0677             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8540             nan     0.1000    0.0899
##      2        0.7317             nan     0.1000    0.0608
##      3        0.6383             nan     0.1000    0.0456
##      4        0.5642             nan     0.1000    0.0366
##      5        0.5027             nan     0.1000    0.0302
##      6        0.4504             nan     0.1000    0.0261
##      7        0.4065             nan     0.1000    0.0225
##      8        0.3679             nan     0.1000    0.0197
##      9        0.3342             nan     0.1000    0.0166
##     10        0.3049             nan     0.1000    0.0144
##     20        0.1500             nan     0.1000    0.0042
##     40        0.0815             nan     0.1000    0.0003
##     60        0.0661             nan     0.1000    0.0001
##     80        0.0616             nan     0.1000   -0.0002
##    100        0.0568             nan     0.1000   -0.0001
##    120        0.0543             nan     0.1000   -0.0001
##    140        0.0514             nan     0.1000   -0.0001
##    150        0.0501             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
```

```
##      1        0.8531             nan     0.1000    0.0899
##      2        0.7308             nan     0.1000    0.0601
##      3        0.6375             nan     0.1000    0.0468
##      4        0.5634             nan     0.1000    0.0373
##      5        0.5012             nan     0.1000    0.0312
##      6        0.4486             nan     0.1000    0.0263
##      7        0.4039             nan     0.1000    0.0221
##      8        0.3647             nan     0.1000    0.0190
##      9        0.3318             nan     0.1000    0.0161
##     10        0.3030             nan     0.1000    0.0145
##     20        0.1448             nan     0.1000    0.0042
##     40        0.0739             nan     0.1000    0.0006
##     60        0.0577             nan     0.1000    0.0000
##     80        0.0513             nan     0.1000   -0.0002
##    100        0.0482             nan     0.1000   -0.0001
##    120        0.0455             nan     0.1000    0.0000
##    140        0.0426             nan     0.1000    0.0001
##    150        0.0407             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8526             nan     0.1000    0.0897
##      2        0.7339             nan     0.1000    0.0601
##      3        0.6417             nan     0.1000    0.0459
##      4        0.5685             nan     0.1000    0.0367
##      5        0.5065             nan     0.1000    0.0305
##      6        0.4557             nan     0.1000    0.0254
##      7        0.4115             nan     0.1000    0.0223
##      8        0.3733             nan     0.1000    0.0187
##      9        0.3402             nan     0.1000    0.0164
##     10        0.3122             nan     0.1000    0.0138
##     20        0.1524             nan     0.1000    0.0041
##     40        0.0833             nan     0.1000    0.0005
##     60        0.0726             nan     0.1000    0.0000
##     80        0.0695             nan     0.1000   -0.0000
##    100        0.0675             nan     0.1000   -0.0000
##    120        0.0657             nan     0.1000   -0.0000
##    140        0.0646             nan     0.1000   -0.0001
##    150        0.0640             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8512             nan     0.1000    0.0886
##      2        0.7304             nan     0.1000    0.0597
##      3        0.6382             nan     0.1000    0.0462
##      4        0.5635             nan     0.1000    0.0374
##      5        0.5017             nan     0.1000    0.0300
##      6        0.4493             nan     0.1000    0.0262
##      7        0.4050             nan     0.1000    0.0224
##      8        0.3670             nan     0.1000    0.0190
##      9        0.3333             nan     0.1000    0.0168
##     10        0.3040             nan     0.1000    0.0145
```

```
##     20        0.1478             nan     0.1000    0.0039
##     40        0.0805             nan     0.1000    0.0006
##     60        0.0643             nan     0.1000    0.0003
##     80        0.0584             nan     0.1000   -0.0001
##    100        0.0543             nan     0.1000   -0.0001
##    120        0.0503             nan     0.1000   -0.0001
##    140        0.0478             nan     0.1000   -0.0000
##    150        0.0464             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8512             nan     0.1000    0.0910
##      2        0.7293             nan     0.1000    0.0606
##      3        0.6363             nan     0.1000    0.0466
##      4        0.5615             nan     0.1000    0.0385
##      5        0.4997             nan     0.1000    0.0302
##      6        0.4476             nan     0.1000    0.0260
##      7        0.4039             nan     0.1000    0.0217
##      8        0.3656             nan     0.1000    0.0189
##      9        0.3316             nan     0.1000    0.0166
##     10        0.3022             nan     0.1000    0.0144
##     20        0.1436             nan     0.1000    0.0041
##     40        0.0739             nan     0.1000    0.0002
##     60        0.0596             nan     0.1000   -0.0001
##     80        0.0622             nan     0.1000   -0.0000
##    100  2701721.6555             nan     0.1000    0.0003
##    120           inf             nan     0.1000       nan
##    140           inf             nan     0.1000       nan
##    150           inf             nan     0.1000       nan
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8284             nan     0.1000    0.0878
##      2        0.7109             nan     0.1000    0.0587
##      3        0.6217             nan     0.1000    0.0439
##      4        0.5493             nan     0.1000    0.0368
##      5        0.4905             nan     0.1000    0.0295
##      6        0.4409             nan     0.1000    0.0247
##      7        0.3987             nan     0.1000    0.0213
##      8        0.3621             nan     0.1000    0.0181
##      9        0.3315             nan     0.1000    0.0154
##     10        0.3036             nan     0.1000    0.0139
##     20        0.1551             nan     0.1000    0.0044
##     40        0.0903             nan     0.1000    0.0004
##     60        0.0802             nan     0.1000   -0.0001
##     80        0.0778             nan     0.1000    0.0000
##    100        0.0759             nan     0.1000   -0.0001
##    120        0.0746             nan     0.1000    0.0000
##    140        0.0735             nan     0.1000   -0.0001
##    150        0.0731             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
```

```
##      1        0.8282             nan     0.1000    0.0885
##      2        0.7089             nan     0.1000    0.0601
##      3        0.6185             nan     0.1000    0.0451
##      4        0.5465             nan     0.1000    0.0362
##      5        0.4876             nan     0.1000    0.0292
##      6        0.4381             nan     0.1000    0.0251
##      7        0.3960             nan     0.1000    0.0209
##      8        0.3594             nan     0.1000    0.0184
##      9        0.3272             nan     0.1000    0.0162
##     10        0.2993             nan     0.1000    0.0141
##     20        0.1507             nan     0.1000    0.0038
##     40        0.0861             nan     0.1000    0.0004
##     60        0.0736             nan     0.1000    0.0001
##     80        0.0679             nan     0.1000   -0.0001
##    100        0.0636             nan     0.1000   -0.0000
##    120        0.0585             nan     0.1000   -0.0000
##    140        0.0561             nan     0.1000   -0.0001
##    150        0.0547             nan     0.1000    0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8273             nan     0.1000    0.0915
##      2        0.7082             nan     0.1000    0.0598
##      3        0.6182             nan     0.1000    0.0450
##      4        0.5463             nan     0.1000    0.0364
##      5        0.4871             nan     0.1000    0.0301
##      6        0.4367             nan     0.1000    0.0252
##      7        0.3936             nan     0.1000    0.0211
##      8        0.3563             nan     0.1000    0.0187
##      9        0.3243             nan     0.1000    0.0157
##     10        0.2966             nan     0.1000    0.0139
##     20        0.1463             nan     0.1000    0.0039
##     40        0.0805             nan     0.1000    0.0005
##     60        0.0643             nan     0.1000   -0.0001
##     80        0.0582             nan     0.1000    0.0002
##    100        0.0540             nan     0.1000   -0.0001
##    120        0.0516             nan     0.1000   -0.0000
##    140        0.0476             nan     0.1000    0.0001
##    150        0.0453             nan     0.1000    0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8434             nan     0.1000    0.0908
##      2        0.7211             nan     0.1000    0.0608
##      3        0.6279             nan     0.1000    0.0475
##      4        0.5537             nan     0.1000    0.0380
##      5        0.4920             nan     0.1000    0.0304
##      6        0.4405             nan     0.1000    0.0258
##      7        0.3965             nan     0.1000    0.0225
##      8        0.3590             nan     0.1000    0.0189
##      9        0.3252             nan     0.1000    0.0166
##     10        0.2965             nan     0.1000    0.0146
```

```
##     20        0.1374             nan     0.1000    0.0043
##     40        0.0672             nan     0.1000    0.0006
##     60        0.0562             nan     0.1000    0.0001
##     80        0.0537             nan     0.1000   -0.0000
##    100        0.0521             nan     0.1000   -0.0000
##    120        0.0509             nan     0.1000   -0.0000
##    140        0.0498             nan     0.1000   -0.0001
##    150        0.0492             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8433             nan     0.1000    0.0941
##      2        0.7209             nan     0.1000    0.0611
##      3        0.6273             nan     0.1000    0.0470
##      4        0.5527             nan     0.1000    0.0368
##      5        0.4902             nan     0.1000    0.0312
##      6        0.4384             nan     0.1000    0.0256
##      7        0.3936             nan     0.1000    0.0226
##      8        0.3553             nan     0.1000    0.0188
##      9        0.3215             nan     0.1000    0.0169
##     10        0.2924             nan     0.1000    0.0143
##     20        0.1357             nan     0.1000    0.0042
##     40        0.0628             nan     0.1000    0.0004
##     60        0.0490             nan     0.1000    0.0003
##     80        0.0450             nan     0.1000   -0.0000
##    100        0.0420             nan     0.1000   -0.0000
##    120        0.0397             nan     0.1000    0.0000
##    140        0.0381             nan     0.1000   -0.0000
##    150        0.0372             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8417             nan     0.1000    0.0892
##      2        0.7183             nan     0.1000    0.0616
##      3        0.6247             nan     0.1000    0.0465
##      4        0.5496             nan     0.1000    0.0374
##      5        0.4871             nan     0.1000    0.0300
##      6        0.4350             nan     0.1000    0.0256
##      7        0.3901             nan     0.1000    0.0218
##      8        0.3516             nan     0.1000    0.0192
##      9        0.3178             nan     0.1000    0.0163
##     10        0.2888             nan     0.1000    0.0142
##     20        0.1291             nan     0.1000    0.0043
##     40        0.0563             nan     0.1000    0.0004
##     60        0.0432             nan     0.1000    0.0000
##     80        0.0391             nan     0.1000   -0.0001
##    100        0.0362             nan     0.1000   -0.0001
##    120        0.0336             nan     0.1000   -0.0001
##    140        0.0316             nan     0.1000    0.0000
##    150        0.0300             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
```

```
##      1        0.8462             nan     0.1000    0.0869
##      2        0.7257             nan     0.1000    0.0592
##      3        0.6346             nan     0.1000    0.0447
##      4        0.5607             nan     0.1000    0.0365
##      5        0.4996             nan     0.1000    0.0302
##      6        0.4493             nan     0.1000    0.0256
##      7        0.4064             nan     0.1000    0.0212
##      8        0.3667             nan     0.1000    0.0193
##      9        0.3345             nan     0.1000    0.0157
##     10        0.3052             nan     0.1000    0.0149
##     20        0.1470             nan     0.1000    0.0044
##     40        0.0791             nan     0.1000    0.0006
##     60        0.0685             nan     0.1000    0.0001
##     80        0.0663             nan     0.1000   -0.0001
##    100        0.0643             nan     0.1000   -0.0000
##    120        0.0627             nan     0.1000   -0.0000
##    140        0.0614             nan     0.1000   -0.0000
##    150        0.0608             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8442             nan     0.1000    0.0886
##      2        0.7230             nan     0.1000    0.0599
##      3        0.6308             nan     0.1000    0.0458
##      4        0.5568             nan     0.1000    0.0360
##      5        0.4961             nan     0.1000    0.0297
##      6        0.4435             nan     0.1000    0.0261
##      7        0.3991             nan     0.1000    0.0221
##      8        0.3616             nan     0.1000    0.0187
##      9        0.3282             nan     0.1000    0.0164
##     10        0.2992             nan     0.1000    0.0146
##     20        0.1439             nan     0.1000    0.0040
##     40        0.0754             nan     0.1000    0.0005
##     60        0.0607             nan     0.1000    0.0001
##     80        0.0560             nan     0.1000    0.0001
##    100        0.0532             nan     0.1000   -0.0001
##    120        0.0503             nan     0.1000    0.0000
##    140        0.0478             nan     0.1000    0.0000
##    150        0.0470             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8441             nan     0.1000    0.0898
##      2        0.7222             nan     0.1000    0.0612
##      3        0.6294             nan     0.1000    0.0456
##      4        0.5547             nan     0.1000    0.0361
##      5        0.4931             nan     0.1000    0.0311
##      6        0.4414             nan     0.1000    0.0258
##      7        0.3972             nan     0.1000    0.0220
##      8        0.3585             nan     0.1000    0.0191
##      9        0.3251             nan     0.1000    0.0165
##     10        0.2958             nan     0.1000    0.0145
```

```
##     20        0.1366             nan     0.1000    0.0042
##     40        0.0684             nan     0.1000    0.0007
##     60        0.0540             nan     0.1000    0.0001
##     80        0.0484             nan     0.1000   -0.0000
##    100        0.0449             nan     0.1000   -0.0001
##    120        0.0402             nan     0.1000   -0.0001
##    140        0.0382             nan     0.1000    0.0000
##    150        0.0370             nan     0.1000    0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8525             nan     0.1000    0.0882
##      2        0.7313             nan     0.1000    0.0604
##      3        0.6381             nan     0.1000    0.0464
##      4        0.5636             nan     0.1000    0.0371
##      5        0.5024             nan     0.1000    0.0306
##      6        0.4507             nan     0.1000    0.0260
##      7        0.4066             nan     0.1000    0.0220
##      8        0.3679             nan     0.1000    0.0192
##      9        0.3356             nan     0.1000    0.0160
##     10        0.3064             nan     0.1000    0.0147
##     20        0.1478             nan     0.1000    0.0041
##     40        0.0805             nan     0.1000    0.0005
##     60        0.0707             nan     0.1000   -0.0000
##     80        0.0680             nan     0.1000   -0.0000
##    100        0.0658             nan     0.1000   -0.0001
##    120        0.0642             nan     0.1000   -0.0000
##    140        0.0628             nan     0.1000   -0.0000
##    150        0.0623             nan     0.1000    0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8511             nan     0.1000    0.0886
##      2        0.7289             nan     0.1000    0.0617
##      3        0.6362             nan     0.1000    0.0476
##      4        0.5614             nan     0.1000    0.0375
##      5        0.4997             nan     0.1000    0.0310
##      6        0.4475             nan     0.1000    0.0262
##      7        0.4026             nan     0.1000    0.0222
##      8        0.3646             nan     0.1000    0.0190
##      9        0.3309             nan     0.1000    0.0168
##     10        0.3027             nan     0.1000    0.0143
##     20        0.1449             nan     0.1000    0.0040
##     40        0.0747             nan     0.1000    0.0006
##     60        0.0604             nan     0.1000   -0.0004
##     80        0.0556             nan     0.1000   -0.0001
##    100        0.0515             nan     0.1000   -0.0003
##    120        0.0462             nan     0.1000   -0.0001
##    140        0.0444             nan     0.1000   -0.0001
##    150        0.0432             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
```

```
##      1        0.8495             nan     0.1000    0.0902
##      2        0.7275             nan     0.1000    0.0611
##      3        0.6340             nan     0.1000    0.0458
##      4        0.5590             nan     0.1000    0.0367
##      5        0.4973             nan     0.1000    0.0315
##      6        0.4453             nan     0.1000    0.0263
##      7        0.4009             nan     0.1000    0.0220
##      8        0.3620             nan     0.1000    0.0192
##      9        0.3277             nan     0.1000    0.0169
##     10        0.2974             nan     0.1000    0.0147
##     20        0.1405             nan     0.1000    0.0041
##     40        0.0694             nan     0.1000    0.0005
##     60        0.0548             nan     0.1000    0.0000
##     80        0.0475             nan     0.1000   -0.0000
##    100        0.0427             nan     0.1000   -0.0000
##    120        0.0387             nan     0.1000   -0.0001
##    140        0.0361             nan     0.1000   -0.0001
##    150        0.0345             nan     0.1000   -0.0004
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8408             nan     0.1000    0.0879
##      2        0.7230             nan     0.1000    0.0598
##      3        0.6311             nan     0.1000    0.0458
##      4        0.5573             nan     0.1000    0.0372
##      5        0.4957             nan     0.1000    0.0304
##      6        0.4451             nan     0.1000    0.0255
##      7        0.4015             nan     0.1000    0.0222
##      8        0.3637             nan     0.1000    0.0187
##      9        0.3306             nan     0.1000    0.0160
##     10        0.3028             nan     0.1000    0.0134
##     20        0.1483             nan     0.1000    0.0043
##     40        0.0822             nan     0.1000    0.0004
##     60        0.0725             nan     0.1000   -0.0000
##     80        0.0698             nan     0.1000   -0.0001
##    100        0.0679             nan     0.1000   -0.0000
##    120        0.0664             nan     0.1000   -0.0000
##    140        0.0654             nan     0.1000   -0.0001
##    150        0.0648             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8397             nan     0.1000    0.0895
##      2        0.7193             nan     0.1000    0.0603
##      3        0.6276             nan     0.1000    0.0465
##      4        0.5541             nan     0.1000    0.0364
##      5        0.4936             nan     0.1000    0.0307
##      6        0.4417             nan     0.1000    0.0254
##      7        0.3980             nan     0.1000    0.0222
##      8        0.3604             nan     0.1000    0.0186
##      9        0.3277             nan     0.1000    0.0162
##     10        0.2990             nan     0.1000    0.0141
```

```
##     20        0.1463             nan     0.1000    0.0037
##     40        0.0772             nan     0.1000    0.0006
##     60        0.0640             nan     0.1000    0.0002
##     80        0.0602             nan     0.1000   -0.0001
##    100        0.0547             nan     0.1000   -0.0000
##    120        0.0519             nan     0.1000   -0.0001
##    140        0.0492             nan     0.1000   -0.0000
##    150        0.0516             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8388             nan     0.1000    0.0899
##      2        0.7179             nan     0.1000    0.0594
##      3        0.6266             nan     0.1000    0.0463
##      4        0.5531             nan     0.1000    0.0373
##      5        0.4922             nan     0.1000    0.0291
##      6        0.4401             nan     0.1000    0.0259
##      7        0.3962             nan     0.1000    0.0217
##      8        0.3584             nan     0.1000    0.0184
##      9        0.3254             nan     0.1000    0.0164
##     10        0.2970             nan     0.1000    0.0139
##     20        0.1428             nan     0.1000    0.0045
##     40        0.0739             nan     0.1000    0.0005
##     60        0.0590             nan     0.1000    0.0001
##     80        0.0527             nan     0.1000    0.0000
##    100        0.0487             nan     0.1000    0.0000
##    120        0.0457             nan     0.1000   -0.0001
##    140        0.0430             nan     0.1000   -0.0000
##    150        0.0423             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8637             nan     0.1000    0.0902
##      2        0.7420             nan     0.1000    0.0595
##      3        0.6493             nan     0.1000    0.0477
##      4        0.5752             nan     0.1000    0.0365
##      5        0.5153             nan     0.1000    0.0293
##      6        0.4624             nan     0.1000    0.0266
##      7        0.4174             nan     0.1000    0.0224
##      8        0.3790             nan     0.1000    0.0192
##      9        0.3450             nan     0.1000    0.0169
##     10        0.3166             nan     0.1000    0.0138
##     20        0.1528             nan     0.1000    0.0044
##     40        0.0826             nan     0.1000    0.0006
##     60        0.0729             nan     0.1000    0.0000
##     80        0.0701             nan     0.1000   -0.0001
##    100        0.0683             nan     0.1000    0.0000
##    120        0.0670             nan     0.1000   -0.0001
##    140        0.0656             nan     0.1000   -0.0001
##    150        0.0650             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
```

```
##      1        0.8615             nan     0.1000    0.0894
##      2        0.7396             nan     0.1000    0.0619
##      3        0.6459             nan     0.1000    0.0463
##      4        0.5703             nan     0.1000    0.0367
##      5        0.5079             nan     0.1000    0.0317
##      6        0.4557             nan     0.1000    0.0259
##      7        0.4106             nan     0.1000    0.0226
##      8        0.3717             nan     0.1000    0.0192
##      9        0.3375             nan     0.1000    0.0170
##     10        0.3082             nan     0.1000    0.0148
##     20        0.1503             nan     0.1000    0.0040
##     40        0.0795             nan     0.1000    0.0003
##     60        0.0670             nan     0.1000    0.0000
##     80        0.0621             nan     0.1000    0.0000
##    100        0.0578             nan     0.1000   -0.0001
##    120        0.0558             nan     0.1000   -0.0001
##    140        0.0539             nan     0.1000   -0.0000
##    150        0.0519             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8610             nan     0.1000    0.0878
##      2        0.7389             nan     0.1000    0.0602
##      3        0.6449             nan     0.1000    0.0461
##      4        0.5693             nan     0.1000    0.0377
##      5        0.5065             nan     0.1000    0.0312
##      6        0.4538             nan     0.1000    0.0262
##      7        0.4087             nan     0.1000    0.0224
##      8        0.3695             nan     0.1000    0.0196
##      9        0.3359             nan     0.1000    0.0170
##     10        0.3056             nan     0.1000    0.0152
##     20        0.1455             nan     0.1000    0.0041
##     40        0.0721             nan     0.1000    0.0005
##     60        0.0586             nan     0.1000   -0.0001
##     80        0.0527             nan     0.1000    0.0001
##    100        0.0489             nan     0.1000   -0.0001
##    120        0.0527             nan     0.1000   -0.0025
##    140        0.0410             nan     0.1000    0.0000
##    150        0.0395             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8499             nan     0.1000    0.0880
##      2        0.7294             nan     0.1000    0.0618
##      3        0.6371             nan     0.1000    0.0459
##      4        0.5631             nan     0.1000    0.0365
##      5        0.5009             nan     0.1000    0.0306
##      6        0.4497             nan     0.1000    0.0261
##      7        0.4052             nan     0.1000    0.0223
##      8        0.3674             nan     0.1000    0.0189
##      9        0.3347             nan     0.1000    0.0165
##     10        0.3057             nan     0.1000    0.0144
```

```
##     20        0.1503             nan     0.1000    0.0046
##     40        0.0829             nan     0.1000    0.0005
##     60        0.0735             nan     0.1000   -0.0001
##     80        0.0704             nan     0.1000   -0.0001
##    100        0.0688             nan     0.1000   -0.0000
##    120        0.0676             nan     0.1000   -0.0001
##    140        0.0663             nan     0.1000    0.0000
##    150        0.0659             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8480             nan     0.1000    0.0899
##      2        0.7269             nan     0.1000    0.0615
##      3        0.6338             nan     0.1000    0.0464
##      4        0.5594             nan     0.1000    0.0374
##      5        0.4972             nan     0.1000    0.0305
##      6        0.4455             nan     0.1000    0.0262
##      7        0.4013             nan     0.1000    0.0220
##      8        0.3635             nan     0.1000    0.0186
##      9        0.3305             nan     0.1000    0.0165
##     10        0.3019             nan     0.1000    0.0146
##     20        0.1463             nan     0.1000    0.0042
##     40        0.0781             nan     0.1000    0.0006
##     60        0.0650             nan     0.1000    0.0001
##     80        0.0572             nan     0.1000   -0.0000
##    100        0.0520             nan     0.1000   -0.0002
##    120        0.0490             nan     0.1000    0.0000
##    140        0.0458             nan     0.1000   -0.0001
##    150        0.0450             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8483             nan     0.1000    0.0885
##      2        0.7256             nan     0.1000    0.0608
##      3        0.6329             nan     0.1000    0.0473
##      4        0.5587             nan     0.1000    0.0379
##      5        0.4970             nan     0.1000    0.0312
##      6        0.4445             nan     0.1000    0.0265
##      7        0.4004             nan     0.1000    0.0217
##      8        0.3621             nan     0.1000    0.0194
##      9        0.3287             nan     0.1000    0.0166
##     10        0.2996             nan     0.1000    0.0144
##     20        0.1429             nan     0.1000    0.0042
##     40        0.0737             nan     0.1000    0.0005
##     60        0.0526             nan     0.1000    0.0004
##     80        0.0458             nan     0.1000    0.0000
##    100        0.0410             nan     0.1000   -0.0000
##    120        0.0379             nan     0.1000   -0.0000
##    140        0.0351             nan     0.1000   -0.0000
##    150        0.0340             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
```

```
##      1        0.8527             nan     0.1000    0.0895
##      2        0.7293             nan     0.1000    0.0613
##      3        0.6355             nan     0.1000    0.0466
##      4        0.5605             nan     0.1000    0.0370
##      5        0.4980             nan     0.1000    0.0312
##      6        0.4464             nan     0.1000    0.0257
##      7        0.4028             nan     0.1000    0.0218
##      8        0.3644             nan     0.1000    0.0191
##      9        0.3302             nan     0.1000    0.0170
##     10        0.3011             nan     0.1000    0.0147
##     20        0.1383             nan     0.1000    0.0049
##     40        0.0662             nan     0.1000    0.0005
##     60        0.0561             nan     0.1000   -0.0001
##     80        0.0531             nan     0.1000    0.0000
##    100        0.0507             nan     0.1000   -0.0001
##    120        0.0499             nan     0.1000   -0.0001
##    140        0.0485             nan     0.1000   -0.0000
##    150        0.0480             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8513             nan     0.1000    0.0880
##      2        0.7277             nan     0.1000    0.0620
##      3        0.6338             nan     0.1000    0.0468
##      4        0.5581             nan     0.1000    0.0383
##      5        0.4957             nan     0.1000    0.0308
##      6        0.4433             nan     0.1000    0.0265
##      7        0.3989             nan     0.1000    0.0220
##      8        0.3595             nan     0.1000    0.0195
##      9        0.3254             nan     0.1000    0.0173
##     10        0.2955             nan     0.1000    0.0147
##     20        0.1348             nan     0.1000    0.0041
##     40        0.0644             nan     0.1000    0.0003
##     60        0.0519             nan     0.1000   -0.0000
##     80        0.0474             nan     0.1000    0.0000
##    100        0.0439             nan     0.1000   -0.0000
##    120        0.0427             nan     0.1000   -0.0001
##    140        0.0412             nan     0.1000   -0.0001
##    150        0.0397             nan     0.1000   -0.0002
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8503             nan     0.1000    0.0897
##      2        0.7264             nan     0.1000    0.0620
##      3        0.6325             nan     0.1000    0.0480
##      4        0.5570             nan     0.1000    0.0373
##      5        0.4937             nan     0.1000    0.0314
##      6        0.4408             nan     0.1000    0.0261
##      7        0.3953             nan     0.1000    0.0222
##      8        0.3559             nan     0.1000    0.0193
##      9        0.3213             nan     0.1000    0.0170
##     10        0.2912             nan     0.1000    0.0149
```

```
##     20        0.1286             nan     0.1000    0.0043
##     40        0.0557             nan     0.1000    0.0004
##     60        0.0428             nan     0.1000   -0.0000
##     80        0.0385             nan     0.1000    0.0000
##    100        0.0379             nan     0.1000    0.0002
##    120        0.0345             nan     0.1000   -0.0000
##    140        0.0315             nan     0.1000   -0.0001
##    150        0.0301             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8660             nan     0.1000    0.0868
##      2        0.7432             nan     0.1000    0.0605
##      3        0.6502             nan     0.1000    0.0459
##      4        0.5742             nan     0.1000    0.0383
##      5        0.5118             nan     0.1000    0.0313
##      6        0.4596             nan     0.1000    0.0261
##      7        0.4145             nan     0.1000    0.0223
##      8        0.3763             nan     0.1000    0.0192
##      9        0.3432             nan     0.1000    0.0162
##     10        0.3131             nan     0.1000    0.0148
##     20        0.1504             nan     0.1000    0.0042
##     40        0.0782             nan     0.1000    0.0006
##     60        0.0681             nan     0.1000    0.0001
##     80        0.0648             nan     0.1000    0.0000
##    100        0.0625             nan     0.1000    0.0001
##    120        0.0611             nan     0.1000   -0.0000
##    140        0.0599             nan     0.1000   -0.0000
##    150        0.0594             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8644             nan     0.1000    0.0891
##      2        0.7417             nan     0.1000    0.0627
##      3        0.6480             nan     0.1000    0.0464
##      4        0.5723             nan     0.1000    0.0375
##      5        0.5088             nan     0.1000    0.0314
##      6        0.4551             nan     0.1000    0.0270
##      7        0.4094             nan     0.1000    0.0225
##      8        0.3693             nan     0.1000    0.0195
##      9        0.3354             nan     0.1000    0.0167
##     10        0.3058             nan     0.1000    0.0150
##     20        0.1450             nan     0.1000    0.0043
##     40        0.0745             nan     0.1000    0.0006
##     60        0.0622             nan     0.1000    0.0000
##     80        0.0580             nan     0.1000    0.0002
##    100        0.0523             nan     0.1000   -0.0000
##    120        0.0499             nan     0.1000    0.0000
##    140        0.0463             nan     0.1000   -0.0002
##    150        0.0452             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
```

```
##      1        0.8630             nan     0.1000    0.0890
##      2        0.7396             nan     0.1000    0.0618
##      3        0.6445             nan     0.1000    0.0473
##      4        0.5685             nan     0.1000    0.0379
##      5        0.5048             nan     0.1000    0.0313
##      6        0.4518             nan     0.1000    0.0264
##      7        0.4059             nan     0.1000    0.0228
##      8        0.3665             nan     0.1000    0.0199
##      9        0.3325             nan     0.1000    0.0167
##     10        0.3024             nan     0.1000    0.0150
##     20        0.1404             nan     0.1000    0.0042
##     40        0.0680             nan     0.1000    0.0004
##     60        0.0551             nan     0.1000    0.0001
##     80        0.0748             nan     0.1000    0.0001
##    100        0.0712             nan     0.1000    0.0002
##    120           inf             nan     0.1000       nan
##    140           inf             nan     0.1000       nan
##    150           inf             nan     0.1000       nan
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8414             nan     0.1000    0.0860
##      2        0.7227             nan     0.1000    0.0582
##      3        0.6315             nan     0.1000    0.0448
##      4        0.5588             nan     0.1000    0.0363
##      5        0.4996             nan     0.1000    0.0296
##      6        0.4486             nan     0.1000    0.0256
##      7        0.4061             nan     0.1000    0.0216
##      8        0.3678             nan     0.1000    0.0189
##      9        0.3360             nan     0.1000    0.0156
##     10        0.3068             nan     0.1000    0.0145
##     20        0.1501             nan     0.1000    0.0040
##     40        0.0821             nan     0.1000    0.0005
##     60        0.0717             nan     0.1000    0.0001
##     80        0.0693             nan     0.1000   -0.0001
##    100        0.0676             nan     0.1000   -0.0001
##    120        0.0664             nan     0.1000   -0.0000
##    140        0.0653             nan     0.1000   -0.0000
##    150        0.0647             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8412             nan     0.1000    0.0908
##      2        0.7208             nan     0.1000    0.0607
##      3        0.6290             nan     0.1000    0.0464
##      4        0.5549             nan     0.1000    0.0363
##      5        0.4938             nan     0.1000    0.0307
##      6        0.4424             nan     0.1000    0.0251
##      7        0.3988             nan     0.1000    0.0217
##      8        0.3614             nan     0.1000    0.0186
##      9        0.3287             nan     0.1000    0.0163
##     10        0.3000             nan     0.1000    0.0141
```

```
##     20        0.1463             nan     0.1000    0.0039
##     40        0.0781             nan     0.1000    0.0005
##     60        0.0656             nan     0.1000    0.0002
##     80        0.0636             nan     0.1000   -0.0042
##    100        0.0533             nan     0.1000    0.0001
##    120        0.0498             nan     0.1000   -0.0001
##    140        0.0458             nan     0.1000   -0.0001
##    150        0.0471             nan     0.1000   -0.0023
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8400             nan     0.1000    0.0897
##      2        0.7197             nan     0.1000    0.0597
##      3        0.6272             nan     0.1000    0.0456
##      4        0.5530             nan     0.1000    0.0369
##      5        0.4919             nan     0.1000    0.0311
##      6        0.4408             nan     0.1000    0.0253
##      7        0.3969             nan     0.1000    0.0220
##      8        0.3595             nan     0.1000    0.0186
##      9        0.3263             nan     0.1000    0.0161
##     10        0.2969             nan     0.1000    0.0143
##     20        0.1411             nan     0.1000    0.0039
##     40        0.0707             nan     0.1000    0.0003
##     60        0.0586             nan     0.1000    0.0000
##     80        0.0508             nan     0.1000   -0.0004
##    100        0.0448             nan     0.1000    0.0000
##    120        0.0413             nan     0.1000    0.0000
##    140        0.0380             nan     0.1000   -0.0001
##    150        0.0369             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8523             nan     0.1000    0.0882
##      2        0.7309             nan     0.1000    0.0604
##      3        0.6367             nan     0.1000    0.0461
##      4        0.5618             nan     0.1000    0.0365
##      5        0.4997             nan     0.1000    0.0310
##      6        0.4472             nan     0.1000    0.0264
##      7        0.4020             nan     0.1000    0.0225
##      8        0.3640             nan     0.1000    0.0191
##      9        0.3295             nan     0.1000    0.0174
##     10        0.2993             nan     0.1000    0.0146
##     20        0.1392             nan     0.1000    0.0046
##     40        0.0681             nan     0.1000    0.0005
##     60        0.0580             nan     0.1000    0.0000
##     80        0.0557             nan     0.1000   -0.0000
##    100        0.0543             nan     0.1000   -0.0000
##    120        0.0531             nan     0.1000   -0.0001
##    140        0.0519             nan     0.1000   -0.0000
##    150        0.0517             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
```

```
##      1        0.8496             nan     0.1000    0.0888
##      2        0.7267             nan     0.1000    0.0614
##      3        0.6327             nan     0.1000    0.0466
##      4        0.5573             nan     0.1000    0.0372
##      5        0.4951             nan     0.1000    0.0311
##      6        0.4426             nan     0.1000    0.0261
##      7        0.3977             nan     0.1000    0.0224
##      8        0.3589             nan     0.1000    0.0192
##      9        0.3252             nan     0.1000    0.0165
##     10        0.2954             nan     0.1000    0.0150
##     20        0.1360             nan     0.1000    0.0044
##     40        0.0661             nan     0.1000    0.0007
##     60        0.0535             nan     0.1000   -0.0001
##     80        0.0495             nan     0.1000   -0.0000
##    100        0.0470             nan     0.1000   -0.0000
##    120        0.0452             nan     0.1000   -0.0000
##    140        0.0431             nan     0.1000    0.0000
##    150        0.0422             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8491             nan     0.1000    0.0913
##      2        0.7259             nan     0.1000    0.0619
##      3        0.6313             nan     0.1000    0.0477
##      4        0.5560             nan     0.1000    0.0377
##      5        0.4934             nan     0.1000    0.0297
##      6        0.4405             nan     0.1000    0.0269
##      7        0.3951             nan     0.1000    0.0227
##      8        0.3563             nan     0.1000    0.0192
##      9        0.3223             nan     0.1000    0.0167
##     10        0.2925             nan     0.1000    0.0148
##     20        0.1323             nan     0.1000    0.0042
##     40        0.0598             nan     0.1000    0.0003
##     60        0.0490             nan     0.1000    0.0001
##     80        0.0430             nan     0.1000   -0.0001
##    100        0.0393             nan     0.1000   -0.0000
##    120        0.0371             nan     0.1000   -0.0000
##    140        0.0345             nan     0.1000   -0.0000
##    150        0.0336             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8476             nan     0.1000    0.0867
##      2        0.7282             nan     0.1000    0.0586
##      3        0.6375             nan     0.1000    0.0449
##      4        0.5651             nan     0.1000    0.0363
##      5        0.5058             nan     0.1000    0.0299
##      6        0.4555             nan     0.1000    0.0245
##      7        0.4119             nan     0.1000    0.0217
##      8        0.3742             nan     0.1000    0.0187
##      9        0.3408             nan     0.1000    0.0166
##     10        0.3114             nan     0.1000    0.0147
```

```
##     20        0.1561             nan     0.1000    0.0046
##     40        0.0868             nan     0.1000    0.0005
##     60        0.0770             nan     0.1000   -0.0001
##     80        0.0739             nan     0.1000   -0.0001
##    100        0.0715             nan     0.1000   -0.0000
##    120        0.0701             nan     0.1000   -0.0000
##    140        0.0689             nan     0.1000   -0.0001
##    150        0.0685             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8472             nan     0.1000    0.0873
##      2        0.7267             nan     0.1000    0.0594
##      3        0.6347             nan     0.1000    0.0456
##      4        0.5612             nan     0.1000    0.0363
##      5        0.4999             nan     0.1000    0.0302
##      6        0.4480             nan     0.1000    0.0257
##      7        0.4048             nan     0.1000    0.0212
##      8        0.3664             nan     0.1000    0.0190
##      9        0.3330             nan     0.1000    0.0163
##     10        0.3043             nan     0.1000    0.0143
##     20        0.1494             nan     0.1000    0.0044
##     40        0.0823             nan     0.1000    0.0006
##     60        0.0697             nan     0.1000    0.0000
##     80        0.0648             nan     0.1000   -0.0000
##    100        0.0587             nan     0.1000   -0.0001
##    120        0.0557             nan     0.1000    0.0000
##    140        0.0524             nan     0.1000    0.0000
##    150        0.0514             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8471             nan     0.1000    0.0883
##      2        0.7258             nan     0.1000    0.0612
##      3        0.6340             nan     0.1000    0.0453
##      4        0.5594             nan     0.1000    0.0366
##      5        0.4979             nan     0.1000    0.0308
##      6        0.4460             nan     0.1000    0.0258
##      7        0.4025             nan     0.1000    0.0219
##      8        0.3645             nan     0.1000    0.0185
##      9        0.3309             nan     0.1000    0.0164
##     10        0.3021             nan     0.1000    0.0143
##     20        0.1457             nan     0.1000    0.0038
##     40        0.0756             nan     0.1000    0.0005
##     60        0.0628             nan     0.1000   -0.0001
##     80        0.0564             nan     0.1000   -0.0001
##    100        0.0494             nan     0.1000    0.0000
##    120        0.0462             nan     0.1000   -0.0001
##    140        0.0438             nan     0.1000   -0.0000
##    150        0.0442             nan     0.1000    0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
```

```
##      1        0.8513             nan     0.1000    0.0886
##      2        0.7304             nan     0.1000    0.0616
##      3        0.6375             nan     0.1000    0.0458
##      4        0.5641             nan     0.1000    0.0362
##      5        0.5028             nan     0.1000    0.0312
##      6        0.4514             nan     0.1000    0.0256
##      7        0.4082             nan     0.1000    0.0215
##      8        0.3690             nan     0.1000    0.0190
##      9        0.3354             nan     0.1000    0.0166
##     10        0.3065             nan     0.1000    0.0143
##     20        0.1499             nan     0.1000    0.0041
##     40        0.0832             nan     0.1000    0.0006
##     60        0.0738             nan     0.1000    0.0000
##     80        0.0711             nan     0.1000   -0.0000
##    100        0.0691             nan     0.1000    0.0000
##    120        0.0676             nan     0.1000    0.0000
##    140        0.0668             nan     0.1000   -0.0001
##    150        0.0662             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8506             nan     0.1000    0.0894
##      2        0.7283             nan     0.1000    0.0613
##      3        0.6354             nan     0.1000    0.0462
##      4        0.5617             nan     0.1000    0.0366
##      5        0.5001             nan     0.1000    0.0314
##      6        0.4486             nan     0.1000    0.0257
##      7        0.4046             nan     0.1000    0.0220
##      8        0.3659             nan     0.1000    0.0192
##      9        0.3321             nan     0.1000    0.0167
##     10        0.3027             nan     0.1000    0.0146
##     20        0.1468             nan     0.1000    0.0039
##     40        0.0795             nan     0.1000    0.0007
##     60        0.0662             nan     0.1000   -0.0001
##     80        0.0608             nan     0.1000   -0.0001
##    100        0.0560             nan     0.1000   -0.0001
##    120        0.0520             nan     0.1000   -0.0001
##    140        0.0480             nan     0.1000   -0.0000
##    150        0.0468             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8509             nan     0.1000    0.0884
##      2        0.7285             nan     0.1000    0.0613
##      3        0.6355             nan     0.1000    0.0465
##      4        0.5604             nan     0.1000    0.0378
##      5        0.4983             nan     0.1000    0.0309
##      6        0.4461             nan     0.1000    0.0262
##      7        0.4013             nan     0.1000    0.0222
##      8        0.3628             nan     0.1000    0.0194
##      9        0.3297             nan     0.1000    0.0166
##     10        0.3001             nan     0.1000    0.0144
```

```
##     20        0.1429             nan     0.1000    0.0045
##     40        0.0738             nan     0.1000    0.0004
##     60        0.0619             nan     0.1000   -0.0000
##     80        0.0541             nan     0.1000    0.0003
##    100        0.0499             nan     0.1000    0.0002
##    120        0.0438             nan     0.1000   -0.0000
##    140        0.0393             nan     0.1000   -0.0001
##    150        0.0377             nan     0.1000    0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8615             nan     0.1000    0.0901
##      2        0.7393             nan     0.1000    0.0613
##      3        0.6452             nan     0.1000    0.0469
##      4        0.5702             nan     0.1000    0.0365
##      5        0.5076             nan     0.1000    0.0313
##      6        0.4557             nan     0.1000    0.0260
##      7        0.4103             nan     0.1000    0.0225
##      8        0.3716             nan     0.1000    0.0194
##      9        0.3378             nan     0.1000    0.0168
##     10        0.3077             nan     0.1000    0.0147
##     20        0.1481             nan     0.1000    0.0047
##     40        0.0784             nan     0.1000    0.0004
##     60        0.0679             nan     0.1000    0.0000
##     80        0.0660             nan     0.1000   -0.0001
##    100        0.0643             nan     0.1000   -0.0000
##    120        0.0634             nan     0.1000   -0.0001
##    140        0.0623             nan     0.1000   -0.0000
##    150        0.0617             nan     0.1000    0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8604             nan     0.1000    0.0876
##      2        0.7375             nan     0.1000    0.0612
##      3        0.6433             nan     0.1000    0.0471
##      4        0.5673             nan     0.1000    0.0376
##      5        0.5041             nan     0.1000    0.0311
##      6        0.4510             nan     0.1000    0.0261
##      7        0.4056             nan     0.1000    0.0225
##      8        0.3665             nan     0.1000    0.0196
##      9        0.3326             nan     0.1000    0.0167
##     10        0.3027             nan     0.1000    0.0148
##     20        0.1427             nan     0.1000    0.0041
##     40        0.0748             nan     0.1000    0.0004
##     60        0.0625             nan     0.1000    0.0001
##     80        0.0552             nan     0.1000    0.0000
##    100        0.0515             nan     0.1000   -0.0002
##    120        0.0464             nan     0.1000   -0.0000
##    140        0.0441             nan     0.1000   -0.0001
##    150        0.0428             nan     0.1000   -0.0000
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
```

```
##      1        0.8593             nan     0.1000    0.0893
##      2        0.7361             nan     0.1000    0.0629
##      3        0.6418             nan     0.1000    0.0476
##      4        0.5657             nan     0.1000    0.0381
##      5        0.5026             nan     0.1000    0.0310
##      6        0.4494             nan     0.1000    0.0266
##      7        0.4037             nan     0.1000    0.0221
##      8        0.3642             nan     0.1000    0.0196
##      9        0.3302             nan     0.1000    0.0171
##     10        0.3007             nan     0.1000    0.0147
##     20        0.1406             nan     0.1000    0.0044
##     40        0.0696             nan     0.1000    0.0002
##     60        0.0549             nan     0.1000   -0.0001
##     80        0.0448             nan     0.1000   -0.0000
##    100        0.0381             nan     0.1000    0.0001
##    120        0.0352             nan     0.1000   -0.0000
##    140        0.0319             nan     0.1000   -0.0001
##    150        0.0310             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8618             nan     0.1000    0.0913
##      2        0.7393             nan     0.1000    0.0609
##      3        0.6449             nan     0.1000    0.0474
##      4        0.5700             nan     0.1000    0.0371
##      5        0.5066             nan     0.1000    0.0318
##      6        0.4536             nan     0.1000    0.0261
##      7        0.4085             nan     0.1000    0.0223
##      8        0.3702             nan     0.1000    0.0192
##      9        0.3360             nan     0.1000    0.0172
##     10        0.3070             nan     0.1000    0.0145
##     20        0.1475             nan     0.1000    0.0042
##     40        0.0783             nan     0.1000    0.0006
##     60        0.0679             nan     0.1000    0.0000
##     80        0.0657             nan     0.1000   -0.0001
##    100        0.0638             nan     0.1000    0.0000
##    120        0.0632             nan     0.1000   -0.0001
##    140        0.0623             nan     0.1000    0.0001
##    150        0.0623             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8611             nan     0.1000    0.0885
##      2        0.7371             nan     0.1000    0.0629
##      3        0.6431             nan     0.1000    0.0463
##      4        0.5669             nan     0.1000    0.0379
##      5        0.5033             nan     0.1000    0.0314
##      6        0.4503             nan     0.1000    0.0265
##      7        0.4052             nan     0.1000    0.0223
##      8        0.3658             nan     0.1000    0.0198
##      9        0.3319             nan     0.1000    0.0165
##     10        0.3021             nan     0.1000    0.0150
```

```
##     20        0.1435             nan     0.1000    0.0044
##     40        0.0738             nan     0.1000    0.0005
##     60        0.0603             nan     0.1000   -0.0001
##     80        0.0561             nan     0.1000   -0.0000
##    100        0.0534             nan     0.1000    0.0000
##    120        0.0474             nan     0.1000   -0.0000
##    140        0.0443             nan     0.1000   -0.0000
##    150        0.0427             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8615             nan     0.1000    0.0875
##      2        0.7375             nan     0.1000    0.0617
##      3        0.6431             nan     0.1000    0.0480
##      4        0.5660             nan     0.1000    0.0388
##      5        0.5027             nan     0.1000    0.0320
##      6        0.4495             nan     0.1000    0.0269
##      7        0.4038             nan     0.1000    0.0226
##      8        0.3645             nan     0.1000    0.0197
##      9        0.3303             nan     0.1000    0.0169
##     10        0.3005             nan     0.1000    0.0147
##     20        0.1401             nan     0.1000    0.0042
##     40        0.0693             nan     0.1000    0.0004
##     60        0.0571             nan     0.1000   -0.0000
##     80        0.0482             nan     0.1000   -0.0000
##    100        0.0444             nan     0.1000   -0.0003
##    120        0.0408             nan     0.1000    0.0000
##    140        0.0391             nan     0.1000   -0.0001
##    150        0.0376             nan     0.1000   -0.0001
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.8509             nan     0.1000    0.0896
##      2        0.7297             nan     0.1000    0.0608
##      3        0.6374             nan     0.1000    0.0467
##      4        0.5633             nan     0.1000    0.0360
##      5        0.5027             nan     0.1000    0.0301
##      6        0.4518             nan     0.1000    0.0253
##      7        0.4090             nan     0.1000    0.0219
##      8        0.3704             nan     0.1000    0.0194
##      9        0.3378             nan     0.1000    0.0161
##     10        0.3084             nan     0.1000    0.0147
##     20        0.1516             nan     0.1000    0.0047
##     40        0.0812             nan     0.1000    0.0005
##     50        0.0741             nan     0.1000    0.0002

#Logistic regression as top layer model
model_glm<-
train(trainSet[,predictors_top],trainSet[,outcomeName],method='glm')

#predict using GBM top layer model
testSet$gbm_stacked<-predict(model_gbm,testSet[,predictors_top])
```

```r
#predict using logictic regression top layer model
testSet$glm_stacked<-predict(model_glm,testSet[,predictors_top])

confusionMatrix(testSet$IsAlert,testSet$gbm_stacked)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   No  Yes
##        No   515   10
##        Yes    9 1965
##
##                Accuracy : 0.9924
##                  95% CI : (0.9882, 0.9954)
##     No Information Rate : 0.7903
##     P-Value [Acc > NIR] : <2e-16
##
##                   Kappa : 0.9771
##  Mcnemar's Test P-Value : 1
##
##             Sensitivity : 0.9828
##             Specificity : 0.9949
##          Pos Pred Value : 0.9810
##          Neg Pred Value : 0.9954
##              Prevalence : 0.2097
##          Detection Rate : 0.2061
##    Detection Prevalence : 0.2101
##       Balanced Accuracy : 0.9889
##
##        'Positive' Class : No
##
```

```r
confusionMatrix(testSet$IsAlert,testSet$glm_stacked)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   No  Yes
##        No   514   11
##        Yes    3 1971
##
##                Accuracy : 0.9944
##                  95% CI : (0.9906, 0.9969)
##     No Information Rate : 0.7931
##     P-Value [Acc > NIR] : < 2e-16
##
##                   Kappa : 0.983
##  Mcnemar's Test P-Value : 0.06137
##
##             Sensitivity : 0.9942
```

```
##             Specificity : 0.9945
##          Pos Pred Value : 0.9790
##          Neg Pred Value : 0.9985
##              Prevalence : 0.2069
##          Detection Rate : 0.2057
##    Detection Prevalence : 0.2101
##       Balanced Accuracy : 0.9943
##
##        'Positive' Class : No
##
```

When GBM model at top layer, the ensemable mdoel has accuracy as 0.9924. When logistic model at top layer, the ensemable model has accuracy as 0.9944. they both are good, but I prefer using logistic model as top layer model.