R Notebook

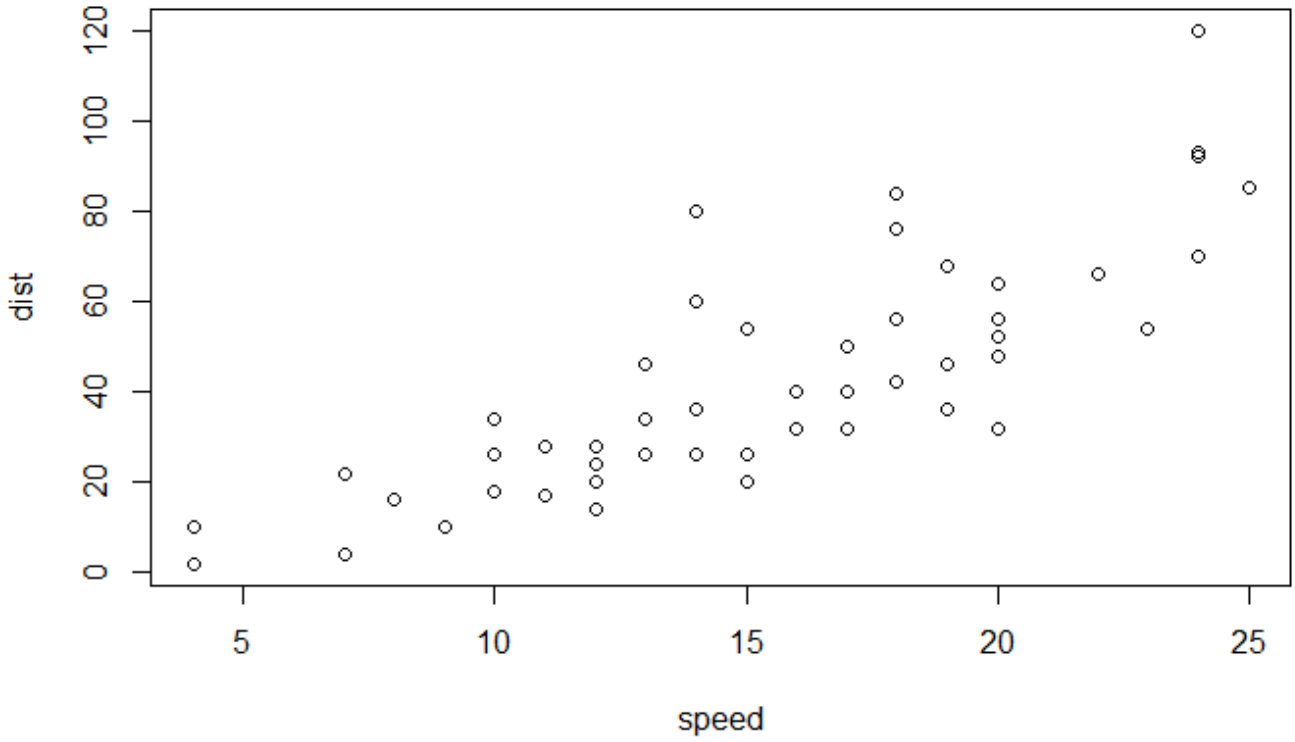
Code

This is an R Markdown Notebook. When you execute code within the notebook, the results appear beneath the code.

Try executing this chunk by clicking the *Run* button within the chunk or by placing your cursor inside it and pressing *Ctrl+Shift+Enter*.

Hide

```
plot(cars)
```



Add a new chunk by clicking the *Insert Chunk* button on the toolbar or by pressing *Ctrl+Alt+I*.

When you save the notebook, an HTML file containing the code and output will be saved alongside it (click the *Preview* button or press *Ctrl+Shift+K* to preview the HTML file).

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```
###I downloaded the CSV file from Kaggle "HR-Analytics". data contains the informat
ion about employees which are best and leaving the company. Company wants to find o
ut why good employees are leaving the company and whom should they retain.
HR<-read.csv(file="C:/Users/CK/Documents/Intro to Data Mining and Machine Learning/
Final Project/HR_comma_sep.csv", header = TRUE)
HR
```

Hide

```
head(HR)
```

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```
str(HR)
```

```
'data.frame':   14999 obs. of  10 variables:
 $ satisfaction_level   : num  0.38 0.8 0.11 0.72 0.37 0.41 0.1 0.92 0.89 0.42 ...
 $ last_evaluation      : num  0.53 0.86 0.88 0.87 0.52 0.5 0.77 0.85 1 0.53 ...
 $ number_project       : int  2 5 7 5 2 2 6 5 5 2 ...
 $ average_montly_hours : int  157 262 272 223 159 153 247 259 224 142 ...
 $ time_spend_company   : int  3 6 4 5 3 3 4 5 5 3 ...
 $ Work_accident        : int  0 0 0 0 0 0 0 0 0 0 ...
 $ left                 : int  1 1 1 1 1 1 1 1 1 1 ...
 $ promotion_last_5years: int  0 0 0 0 0 0 0 0 0 0 ...
 $ sales                : Factor w/ 10 levels "accounting","hr",..: 8 8 8 8 8 8 8
8 8 8 ...
 $ salary               : Factor w/ 3 levels "high","low","medium": 2 3 3 2 2 2 2
2 2 2 ...
```

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```
summary(HR)
```

```
 satisfaction_level last_evaluation  number_project  average_montly_hours time_spen
d_company Work_accident         left
 Min.   :0.0900     Min.   :0.3600   Min.   :2.000   Min.   : 96.0        Min.   :
2.000     Min.   :0.0000   Min.   :0.0000
 1st Qu.:0.4400     1st Qu.:0.5600   1st Qu.:3.000   1st Qu.:156.0        1st Qu.:
3.000     1st Qu.:0.0000   1st Qu.:0.0000
 Median :0.6400     Median :0.7200   Median :4.000   Median :200.0        Median :
3.000     Median :0.0000   Median :0.0000
 Mean   :0.6128     Mean   :0.7161   Mean   :3.803   Mean   :201.1        Mean   :
3.498     Mean   :0.1446   Mean   :0.2381
 3rd Qu.:0.8200     3rd Qu.:0.8700   3rd Qu.:5.000   3rd Qu.:245.0        3rd Qu.:
4.000     3rd Qu.:0.0000   3rd Qu.:0.0000
 Max.   :1.0000     Max.   :1.0000   Max.   :7.000   Max.   :310.0        Max.   :
10.000     Max.   :1.0000   Max.   :1.0000


 promotion_last_5years         sales         salary
 Min.   :0.00000       sales      :4140   high  :1237
 1st Qu.:0.00000       technical  :2720   low   :7316
 Median :0.00000       support    :2229   medium:6446
 Mean   :0.02127       IT         :1227
 3rd Qu.:0.00000       product_mng: 902
 Max.   :1.00000       marketing  : 858
                       (Other)    :2923
```

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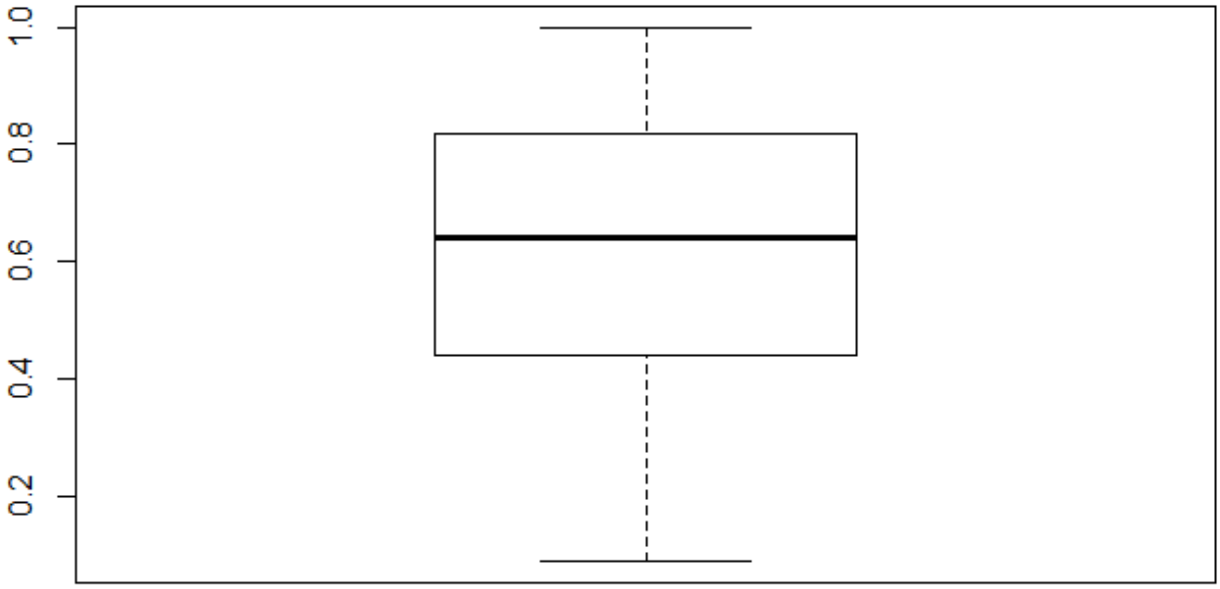
```
### through summary we can say that the satisfaction level around employees is arou
nd 62% and number of projects they are working is around 4, and evaluation of emplo
yees is at 71%
### corelation analysis
#install.packages("magrittr")
library(dplyr)
### with corrgram we can say that the blue color signifies the most corelated varia
ble and red color least significant variable
###
### Detection of outliers
boxplot(HR$satisfaction_level) # no outliers
```



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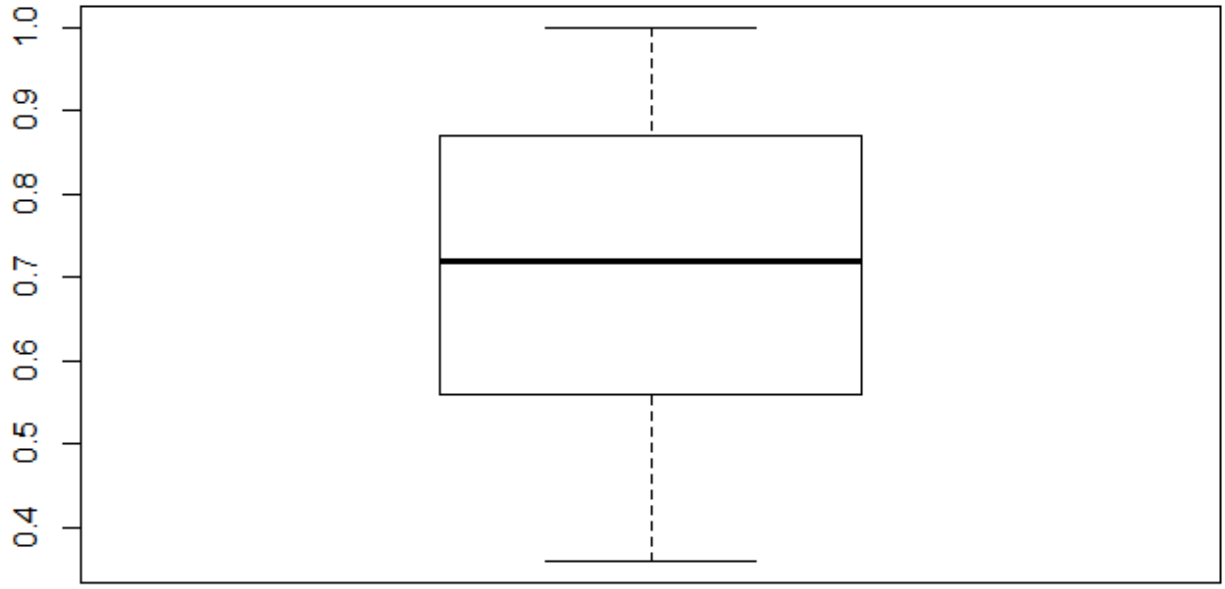
```
boxplot(HR$last_evaluation) # no outliers
```



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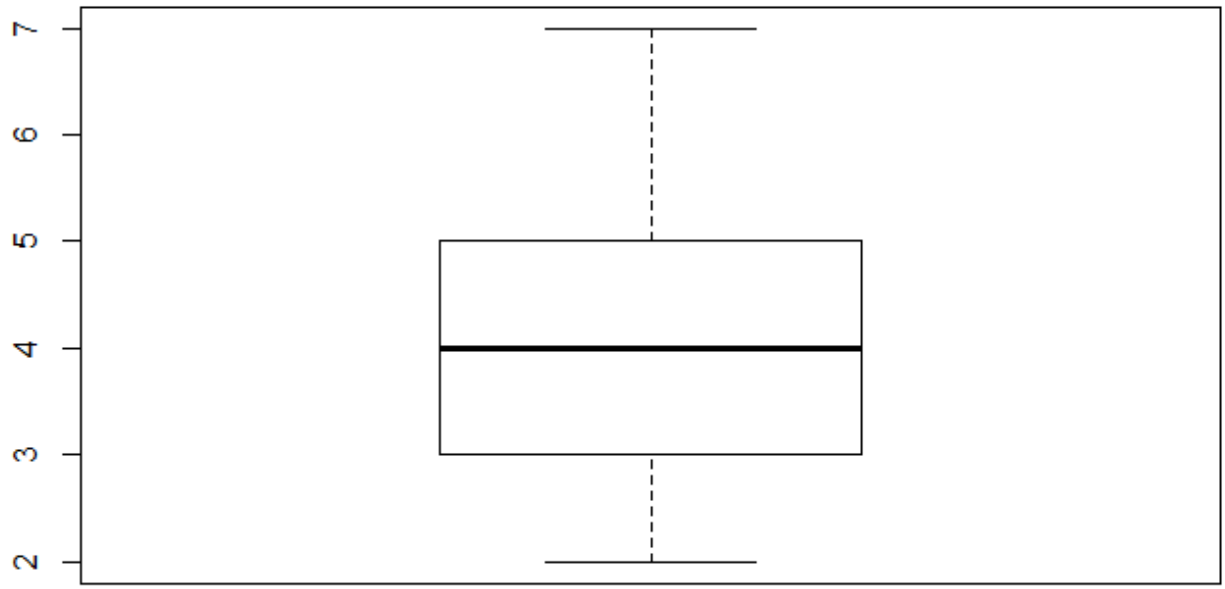
```
boxplot(HR$number_project) # no outliers
```



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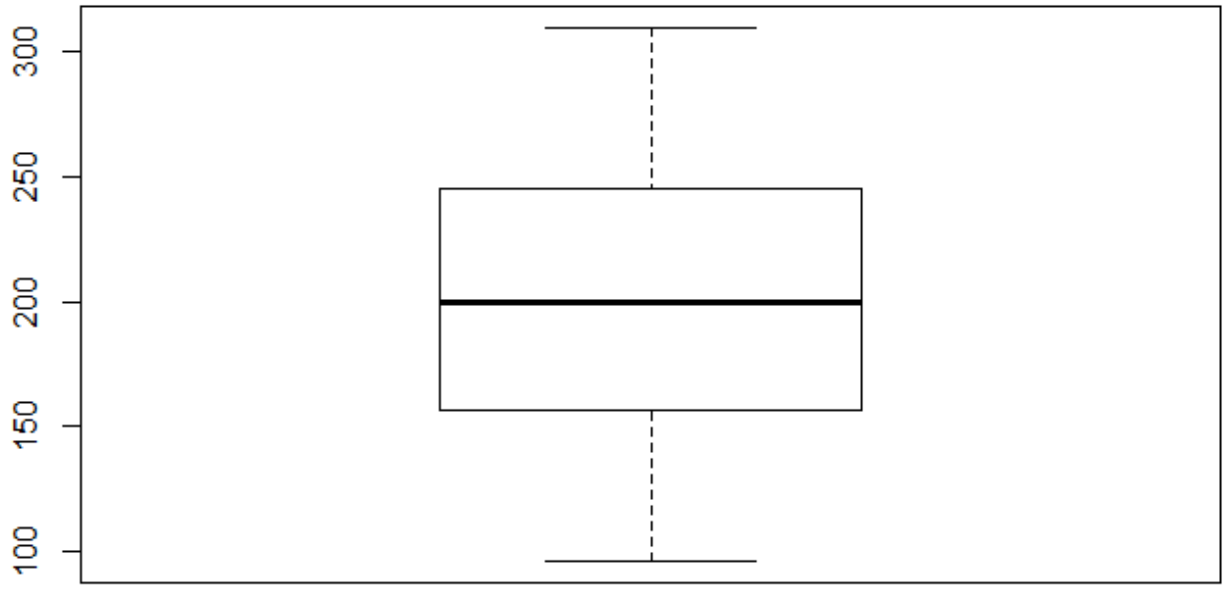
```
boxplot(HR$average_montly_hours) # no outliers
```



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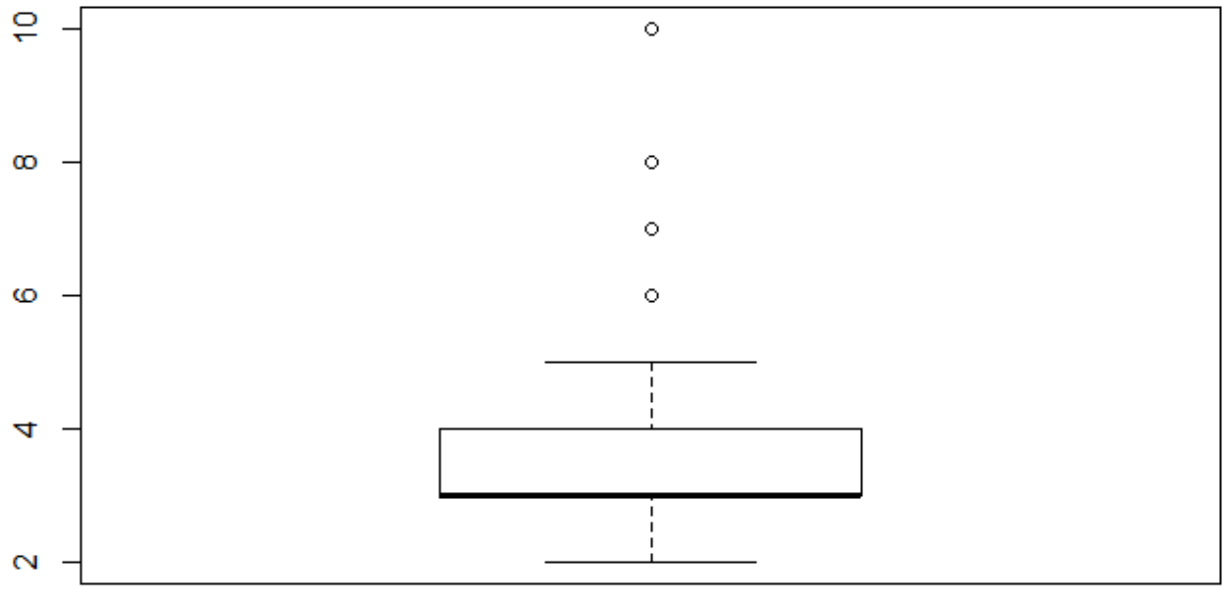
```
boxplot(HR$time_spend_company) # no outliers
```



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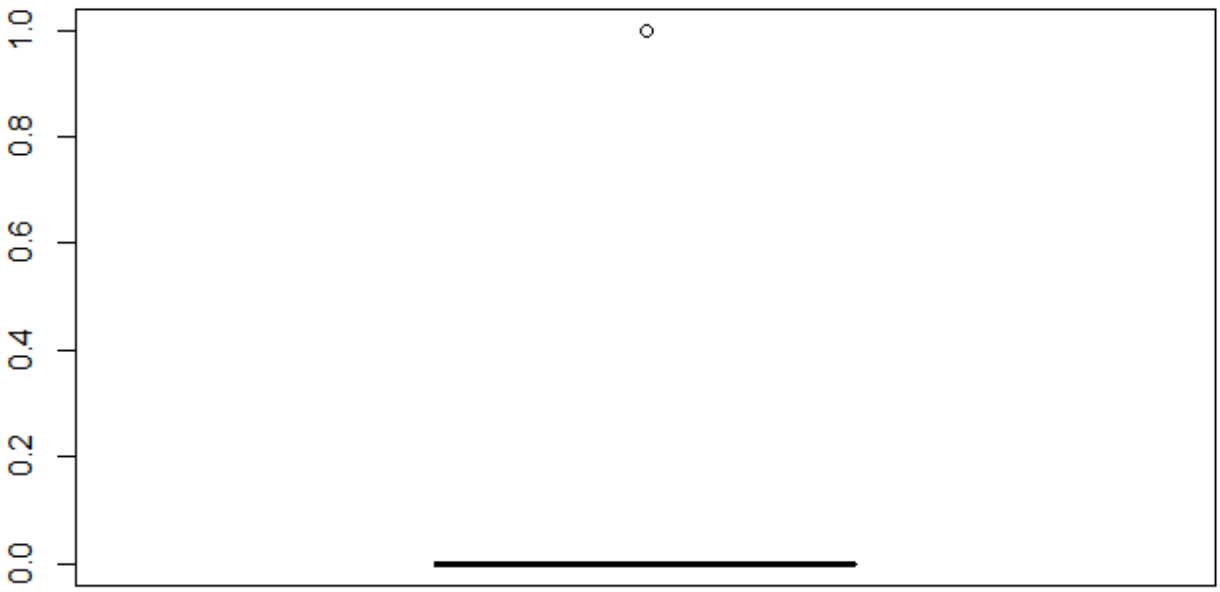
```
### here we can say that after looking at the boxplot outliers are present in time_
spend_company
boxplot(HR$Work_accident)
```



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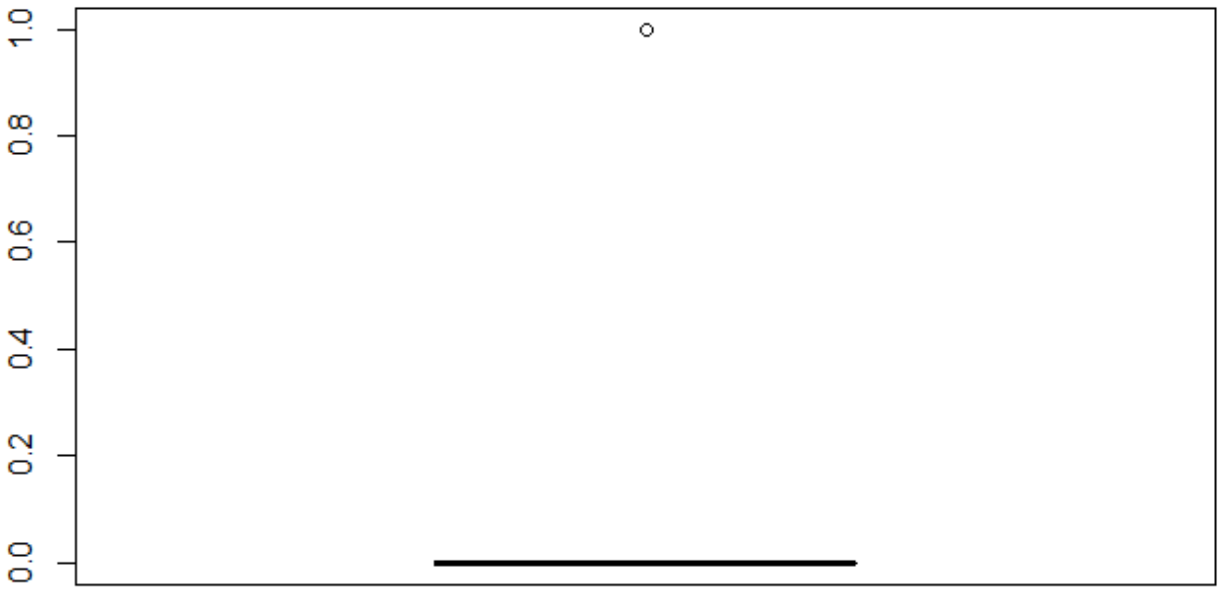
```
### here outliers are present in work_accident
boxplot(HR$left)
```



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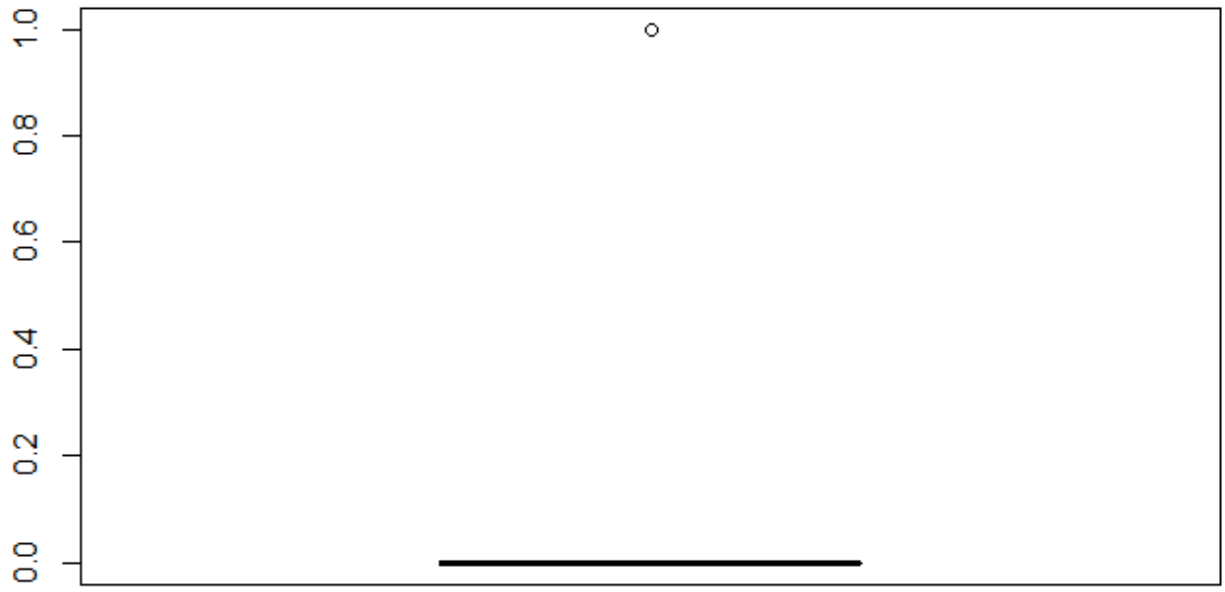
```
### outliers are present in the left column but as its important data we cannot eli
minate it
boxplot(HR$promotion_last_5years)
```



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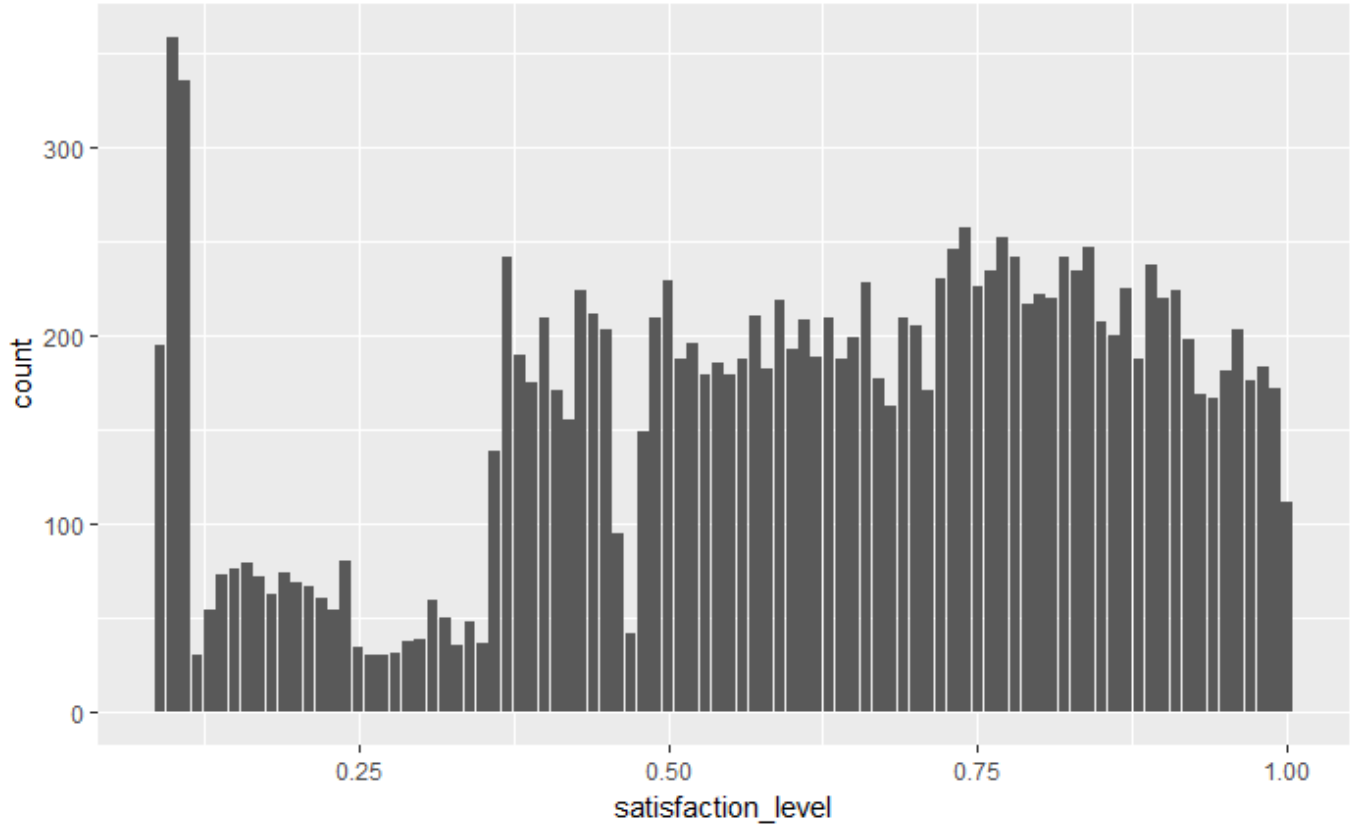
```
### above column contains outliers
#boxplot(HR$sales)
#boxplot(HR$salary)
### above two columns are character type so no outliers
### Exploratory data plots
library(ggplot2)
ggplot(HR)+ geom_bar(mapping = aes(x=satisfaction_level))
```



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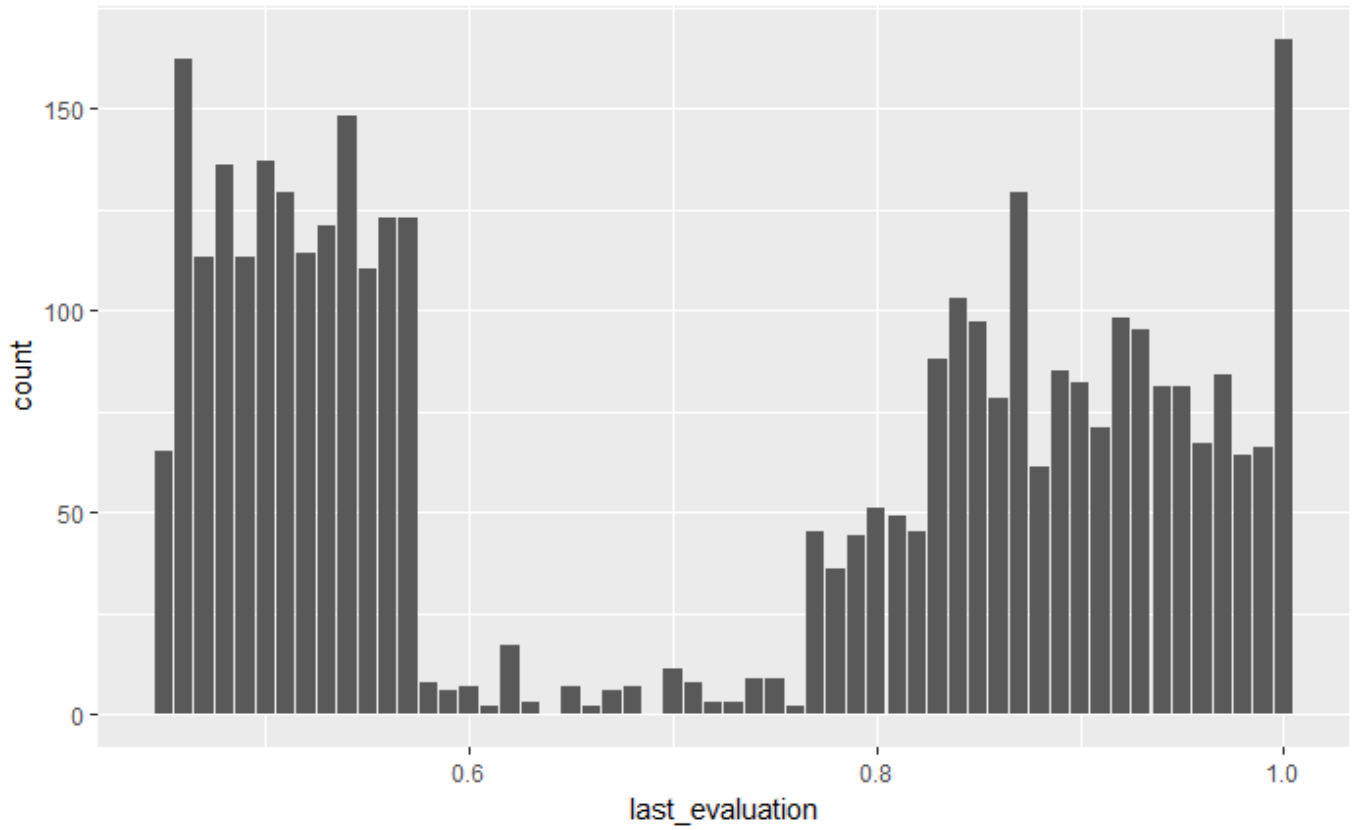
```
### creating a visualization with respect to the response variable
### for satisfaction level
HR_left <- HR%>% filter(left==1) ### selecting a dataframe containing employees tha
t have left the company to consider effect of response variable on different featur
es
ggplot(HR_left)+ geom_bar(mapping = aes(x=last_evaluation))
```



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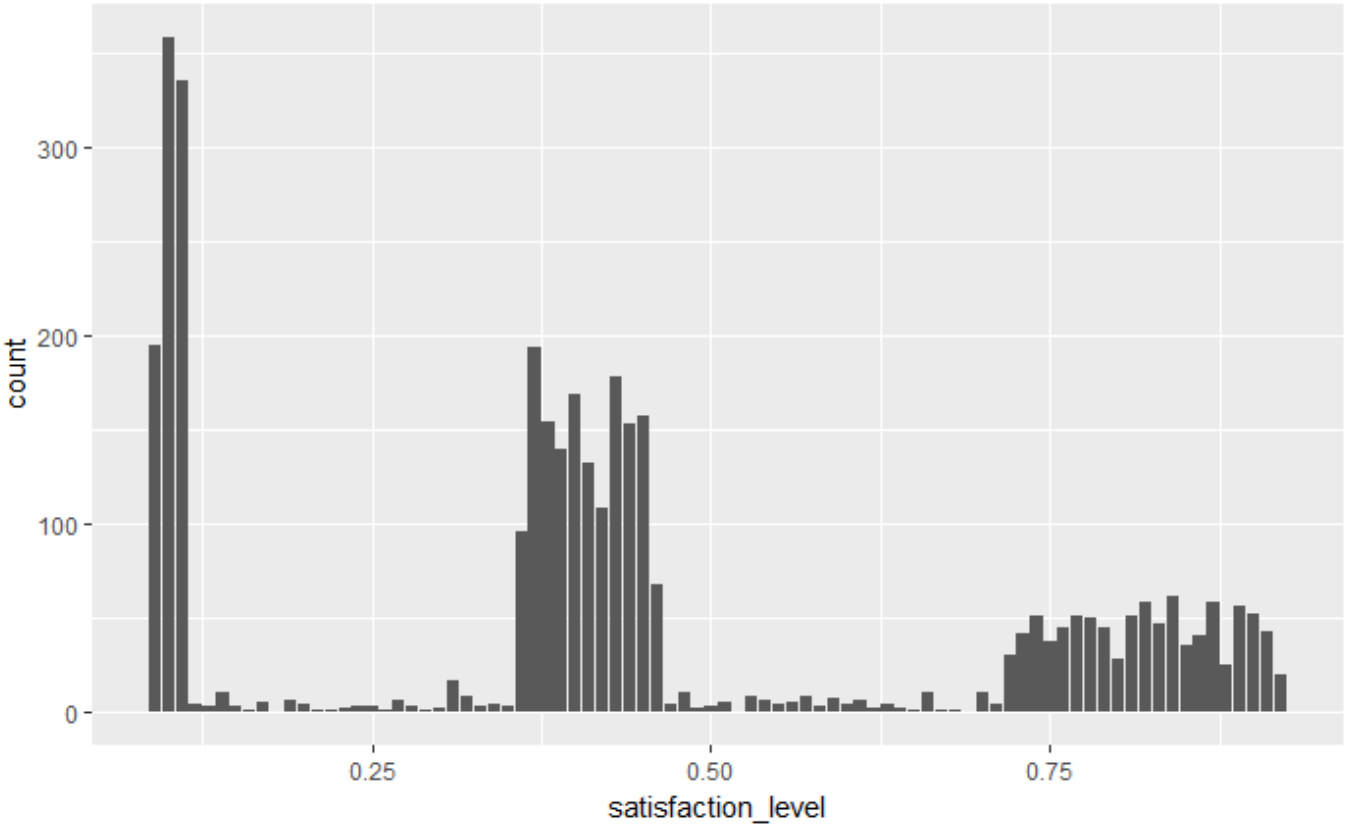
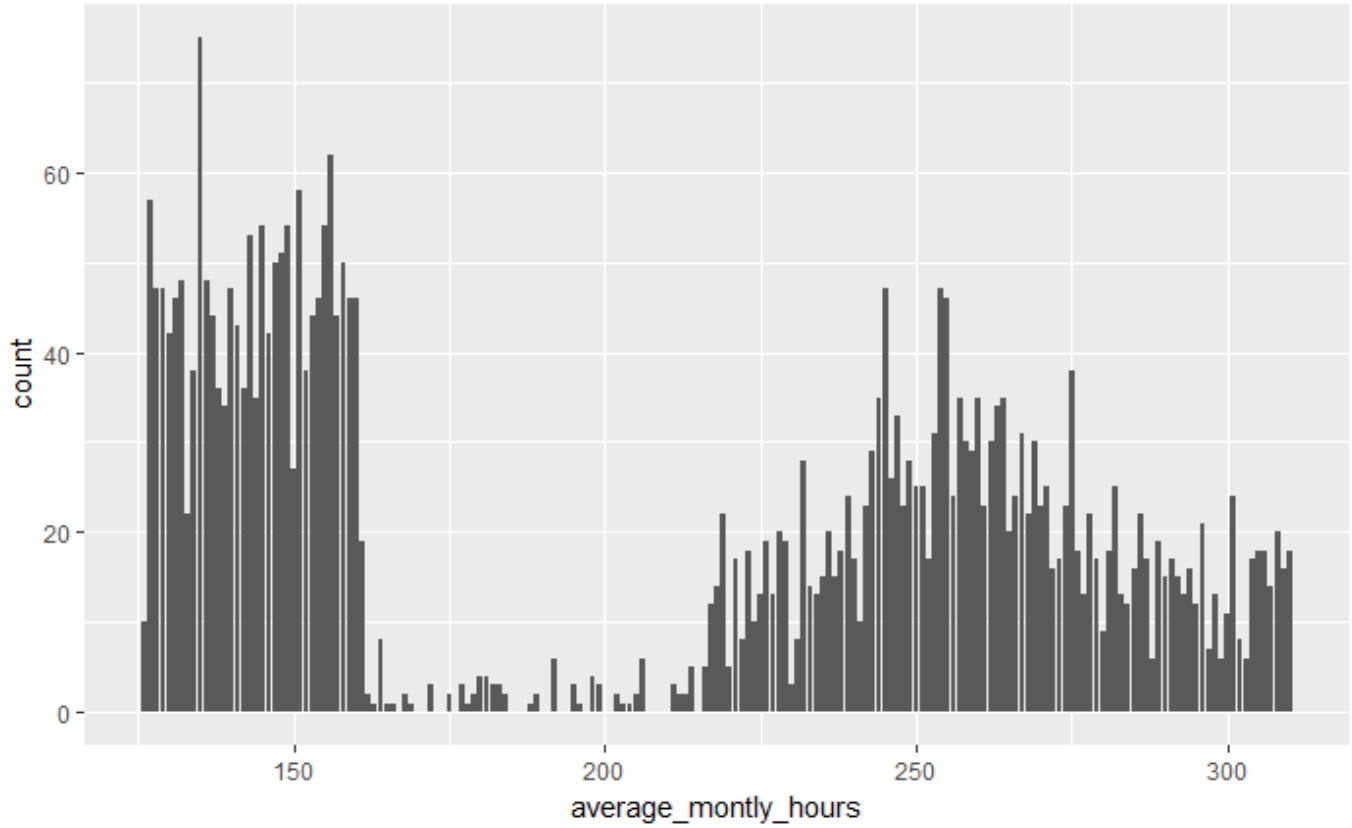
```
### Here from above plot we can see that employees with lower evaluation are leavin
g the company , but company also loosing the good employees too. So company should
retain those employees
ggplot(HR_left)+ geom_bar(mapping = aes(x=satisfaction_level))
```



Hide

```
### Here from above plot we can say that employees with lower satisfaction level ar
e tend to leave
ggplot(HR_left)+ geom_bar(mapping = aes(x=average_montly_hours))
```



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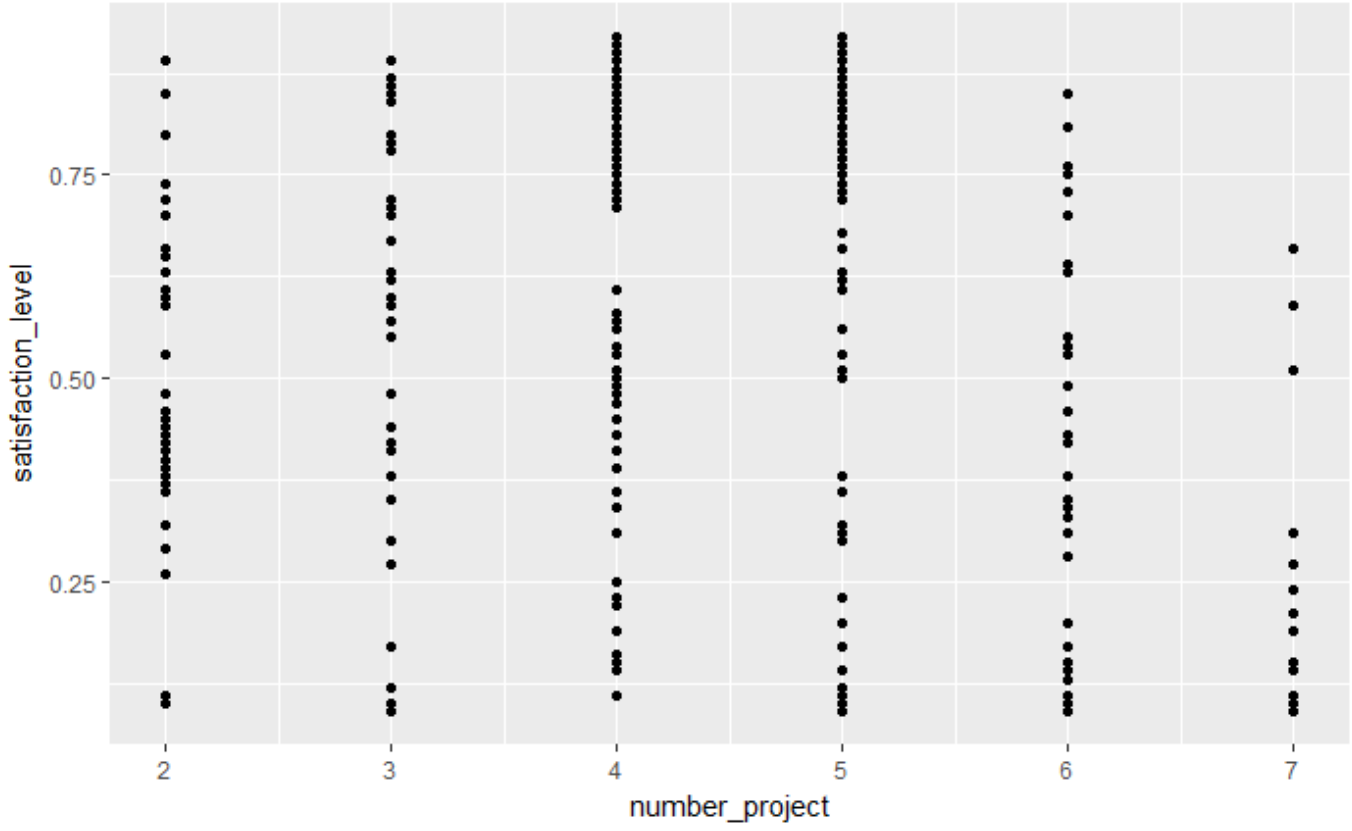
```
### employees with the less working hours and employees with more working hours are more likely to leave the company
ggplot(data = HR_left) +
  geom_point(mapping = aes(x = number_project, y = satisfaction_level))
```



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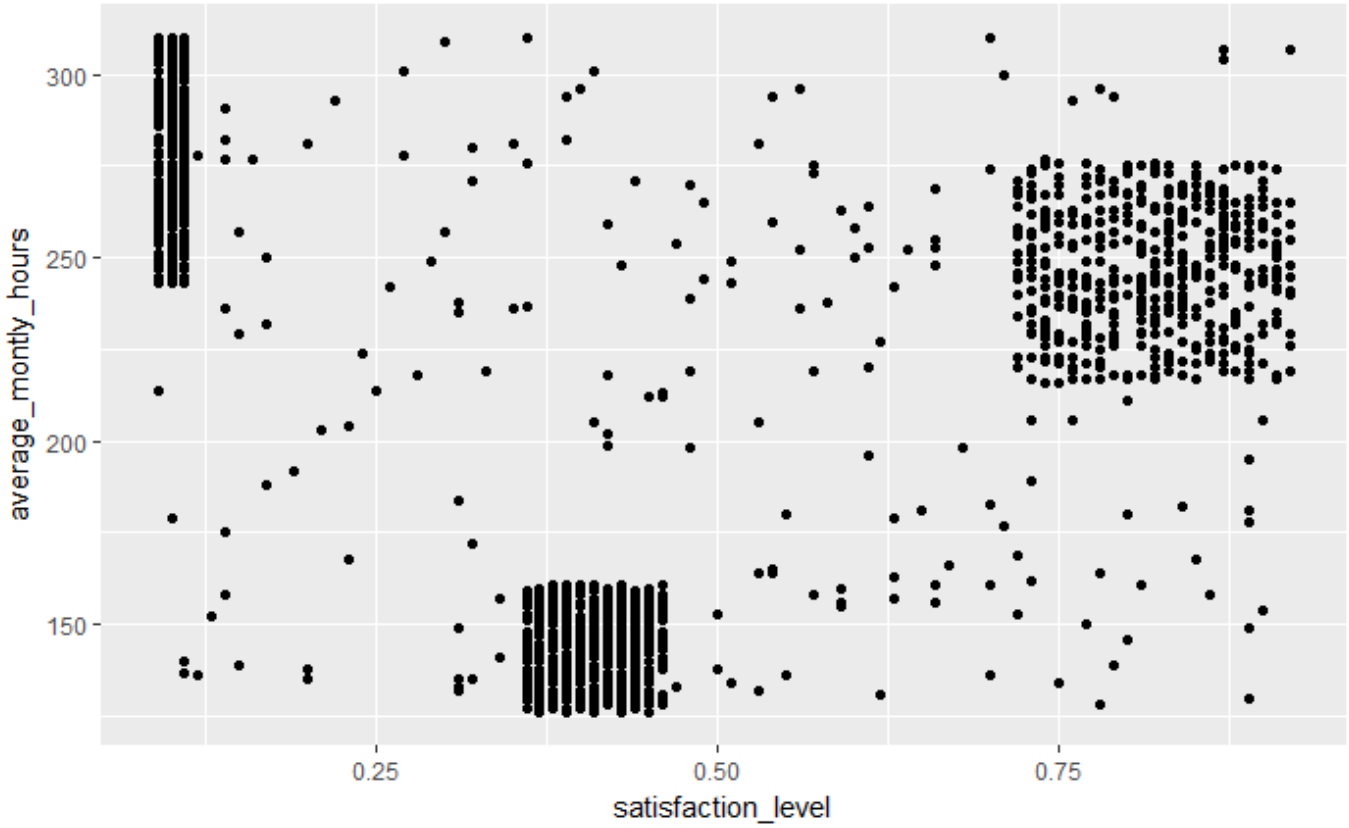
```
### from above plot we can say that the number of employees with the good valuation and higher satisfaction level are leaving the company more as compared to others
ggplot(data = HR_left) +
  geom_point(mapping = aes(x = satisfaction_level, y = average_montly_hours))
```



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```
### from above plot we can say that employees are leaving with the more working hours and more satisfaction level
### Data Cleaning and shaping
### Data Imputation
is.na(HR)
```

```
      satisfaction_level last_evaluation number_project average_montly_hours time_spend_company Work_accident  left promotion_last_5years
 [1,]              FALSE           FALSE          FALSE                 FALSE              FALSE         FALSE FALSE                FALSE
 [2,]              FALSE           FALSE          FALSE                 FALSE              FALSE         FALSE FALSE                FALSE
 [3,]              FALSE           FALSE          FALSE                 FALSE              FALSE         FALSE FALSE                FALSE
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 [100,] FALSE  FALSE
```

```
 [ reached getOption("max.print") -- omitted 14899 rows ]
```

Hide

```
## as there are no null values in dataset so, no data imputation
### Normalization and standardization
#install.packages("clusterSim")
library(clusterSim)
HR_norm <-data.Normalization (HR,type="n0",normalization="average_montly_hours")
```

```
Data not numeric, normalization not applicableData not numeric, normalization not a
pplicable
```

Hide

```
HR_No<-scale(HR_N) # to normalize whole df without categorical variables
summary(HR_norm) #### after comparing original data set and normalized on ewe can s
ee that the data is already normalized
```

```
 satisfaction_level last_evaluation  number_project  average_montly_hours time_spen
d_company Work_accident         left
 Min.   :0.0900     Min.   :0.3600   Min.   :2.000   Min.   : 96.0        Min.   :
2.000     Min.   :0.0000   Min.   :0.0000
 1st Qu.:0.4400     1st Qu.:0.5600   1st Qu.:3.000   1st Qu.:156.0        1st Qu.:
3.000     1st Qu.:0.0000   1st Qu.:0.0000
 Median :0.6400     Median :0.7200   Median :4.000   Median :200.0        Median :
3.000     Median :0.0000   Median :0.0000
 Mean   :0.6128     Mean   :0.7161   Mean   :3.803   Mean   :201.1        Mean   :
3.498     Mean   :0.1446   Mean   :0.2381
 3rd Qu.:0.8200     3rd Qu.:0.8700   3rd Qu.:5.000   3rd Qu.:245.0        3rd Qu.:
4.000     3rd Qu.:0.0000   3rd Qu.:0.0000
 Max.   :1.0000     Max.   :1.0000   Max.   :7.000   Max.   :310.0        Max.   :
10.000     Max.   :1.0000   Max.   :1.0000
 promotion_last_5years     sales            salary
 Min.   :0.00000       Min.   : 1.000   Min.   :1.000
 1st Qu.:0.00000       1st Qu.: 5.000   1st Qu.:2.000
 Median :0.00000       Median : 8.000   Median :2.000
 Mean   :0.02127       Mean   : 6.936   Mean   :2.347
 3rd Qu.:0.00000       3rd Qu.: 9.000   3rd Qu.:3.000
 Max.   :1.00000       Max.   :10.000   Max.   :3.000
```

Hide

```
summary(HR)
```

```
 satisfaction_level last_evaluation  number_project  average_montly_hours time_spend_company Work_accident         left
 Min.   :0.0900     Min.   :0.3600   Min.   :2.000   Min.   : 96.0        Min.   : 2.000     Min.   :0.0000   Min.   :0.0000
 1st Qu.:0.4400     1st Qu.:0.5600   1st Qu.:3.000   1st Qu.:156.0        1st Qu.: 3.000     1st Qu.:0.0000   1st Qu.:0.0000
 Median :0.6400     Median :0.7200   Median :4.000   Median :200.0        Median : 3.000     Median :0.0000   Median :0.0000
 Mean   :0.6128     Mean   :0.7161   Mean   :3.803   Mean   :201.1        Mean   : 3.498     Mean   :0.1446   Mean   :0.2381
 3rd Qu.:0.8200     3rd Qu.:0.8700   3rd Qu.:5.000   3rd Qu.:245.0        3rd Qu.: 4.000     3rd Qu.:0.0000   3rd Qu.:0.0000
 Max.   :1.0000     Max.   :1.0000   Max.   :7.000   Max.   :310.0        Max.   : 10.000     Max.   :1.0000   Max.   :1.0000


 promotion_last_5years         sales         salary
 Min.   :0.00000       sales      :4140   high  :1237
 1st Qu.:0.00000       technical  :2720   low   :7316
 Median :0.00000       support    :2229   medium:6446
 Mean   :0.02127       IT         :1227
 3rd Qu.:0.00000       product_mng: 902
 Max.   :1.00000       marketing  : 858
                       (Other)    :2923
```

Hide

```
### n0 is for normalization
HR_std<-data.Normalization (HR,type="n1",normalization="average_montly_hours")
```

```
Data not numeric, normalization not applicableData not numeric, normalization not applicable
```

Hide

```
summary(HR_std)
```

```
 satisfaction_level last_evaluation    number_project    average_montly_hours time_
spend_company Work_accident          left
 Min.   :-2.1029    Min.   :-2.08041   Min.   :-1.4628   Min.   :-2.10340     Min.
:-1.0261    Min.   :-0.4112   Min.   :-0.559
 1st Qu.:-0.6951    1st Qu.:-0.91197   1st Qu.:-0.6515   1st Qu.:-0.90203     1st
Qu.:-0.3412    1st Qu.:-0.4112   1st Qu.:-0.559
 Median : 0.1093    Median : 0.02277   Median : 0.1598   Median :-0.02103     Medi
an :-0.3412    Median :-0.4112   Median :-0.559
 Mean   : 0.0000    Mean   : 0.00000   Mean   : 0.0000   Mean   : 0.00000     Mean
: 0.0000    Mean   : 0.0000   Mean   : 0.000
 3rd Qu.: 0.8332    3rd Qu.: 0.89910   3rd Qu.: 0.9711   3rd Qu.: 0.87999     3rd Q
u.: 0.3436    3rd Qu.:-0.4112   3rd Qu.:-0.559
 Max.   : 1.5572    Max.   : 1.65858   Max.   : 2.5937   Max.   : 2.18148     Max.
: 4.4528    Max.   : 2.4320   Max.   : 1.789
 promotion_last_5years     sales            salary
 Min.   :-0.1474       Min.   : 1.000   Min.   :1.000
 1st Qu.:-0.1474       1st Qu.: 5.000   1st Qu.:2.000
 Median :-0.1474       Median : 8.000   Median :2.000
 Mean   : 0.0000       Mean   : 6.936   Mean   :2.347
 3rd Qu.:-0.1474       3rd Qu.: 9.000   3rd Qu.:3.000
 Max.   : 6.7835       Max.   :10.000   Max.   :3.000
```

Hide

```
### n1=standardization
### Dummy codes
library(forecast)
set.seed(1)
HR_Data <- data.frame(sex = sample(c("male","female"), 14999, replace = TRUE))
binary_dummy<-model.matrix( ~ sex - 1, data = HR_Data)
binary_dummy
```

```
      sexfemale sexmale
1             0       1
2             0       1
3             1       0
4             1       0
5             0       1
6             1       0
7             1       0
8             1       0
9             1       0
10            0       1
11            0       1
12            0       1
13            1       0
14            0       1
15            1       0
16            0       1
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19            0       1
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21            1       0
22            0       1
23            1       0
```

23	1	0
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31	0	1
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33	0	1
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39	1	0
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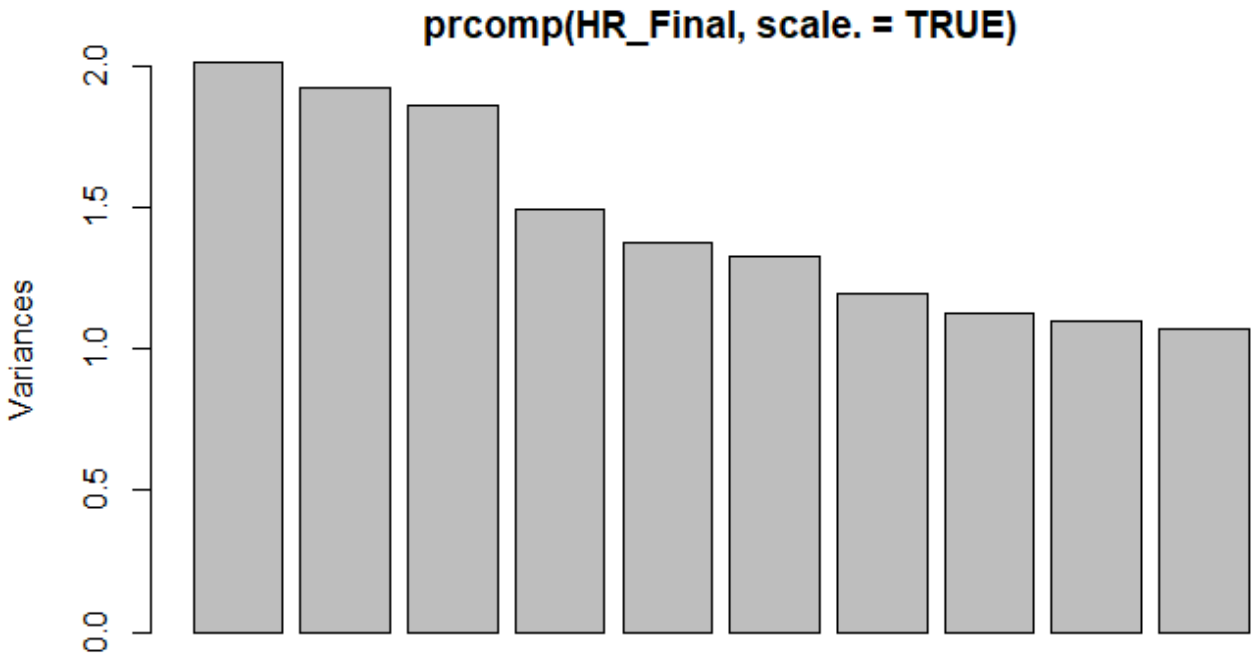
494           0       1
495           0       1
496           0       1
497           0       1
498           1       0
499           1       0
500           0       1
 [ reached getOption("max.print") -- omitted 14499 rows ]
attr(,"assign")
[1] 1 1
attr(,"contrasts")
attr(,"contrasts")$sex
[1] "contr.treatment"
```

Hide

```
#### I have created dummy variables male and female
### new derived features
library(forecast)
library(e1071)
library(ade4)
category <- HR[c("sales","salary")]
### as above variables as characte so , converting them to binary using following f
unction
one2n<- acm.disjonctif(category)
### creating a final data frame
HR_N<- HR[,-(9:10)]
### ommitting character variables from main df and selecting converted one
HR_Final<- data.frame(HR_N,one2n, binary_dummy)
### PCA
### to see the co relation between variables carrying out the PCA analysis
HR_pca<- prcomp(HR_Final, scale. = TRUE)
screeplot(prcomp(HR_Final, scale. = TRUE))
```



Hide

```
summary(HR_pca)
```

```
Importance of components%s:
                          PC1     PC2     PC3     PC4     PC5     PC6     PC7
PC8     PC9    PC10    PC11    PC12    PC13   PC14    PC15
Standard deviation     1.41872 1.38647 1.36281 1.22092 1.17292 1.15056 1.09430 1.06
030 1.04703 1.03608 1.03011 1.02626 1.02559 0.9934 0.96487
Proportion of Variance 0.08751 0.08358 0.08075 0.06481 0.05982 0.05756 0.05207 0.04
888 0.04766 0.04667 0.04614 0.04579 0.04573 0.0429 0.04048
Cumulative Proportion  0.08751 0.17109 0.25184 0.31665 0.37647 0.43402 0.48609 0.53
497 0.58263 0.62930 0.67544 0.72123 0.76696 0.8099 0.85034
                         PC16    PC17   PC18    PC19    PC20     PC21      PC22
PC23
Standard deviation     0.92434 0.89535 0.8293 0.79085 0.68768 6.43e-15 4.159e-15 2.
074e-16
Proportion of Variance 0.03715 0.03485 0.0299 0.02719 0.02056 0.00e+00 0.000e+00 0.
000e+00
Cumulative Proportion  0.88749 0.92235 0.9523 0.97944 1.00000 1.00e+00 1.000e+00 1.
000e+00
```

Hide

```
#### creation of training and test data
library(caret)
HR_sample <- sample(2,
                    nrow(HR),
                    replace = T,
                    prob = c(0.7,0.3)) ### splitting the dataset in training and
testing
HR_train <- HR[HR_sample==1,]
HR_test <- HR[HR_sample==2,]
summary(HR_test)
```

```
 satisfaction_level last_evaluation  number_project  average_montly_hours time_spen
d_company Work_accident         left
 Min.   :0.0900     Min.   :0.3600   Min.   :2.000   Min.   : 97.0        Min.   :
2.000     Min.   :0.0000   Min.   :0.0000
 1st Qu.:0.4400     1st Qu.:0.5600   1st Qu.:3.000   1st Qu.:156.0        1st Qu.:
3.000     1st Qu.:0.0000   1st Qu.:0.0000
 Median :0.6400     Median :0.7200   Median :4.000   Median :198.0        Median :
3.000     Median :0.0000   Median :0.0000
 Mean   :0.6118     Mean   :0.7141   Mean   :3.796   Mean   :200.0        Mean   :
3.487     Mean   :0.1478   Mean   :0.2365
 3rd Qu.:0.8200     3rd Qu.:0.8700   3rd Qu.:5.000   3rd Qu.:244.2        3rd Qu.:
4.000     3rd Qu.:0.0000   3rd Qu.:0.0000
 Max.   :1.0000     Max.   :1.0000   Max.   :7.000   Max.   :310.0        Max.   :
10.000     Max.   :1.0000   Max.   :1.0000


 promotion_last_5years         sales         salary
 Min.   :0.00000       sales      :1235   high  : 362
 1st Qu.:0.00000       technical  : 810   low   :2156
 Median :0.00000       support    : 671   medium:1914
 Mean   :0.02301       IT         : 370
 3rd Qu.:0.00000       marketing  : 263
 Max.   :1.00000       product_mng: 259
                       (Other)    : 824
```

Hide

```
summary(HR_train)
```

```
 satisfaction_level last_evaluation  number_project  average_montly_hours time_spen
d_company Work_accident         left
 Min.   :0.0900     Min.   :0.3600   Min.   :2.000   Min.   : 96.0        Min.   :
2.000     Min.   :0.0000   Min.   :0.0000
 1st Qu.:0.4400     1st Qu.:0.5600   1st Qu.:3.000   1st Qu.:156.0        1st Qu.:
3.000     1st Qu.:0.0000   1st Qu.:0.0000
 Median :0.6400     Median :0.7200   Median :4.000   Median :201.0        Median :
3.000     Median :0.0000   Median :0.0000
 Mean   :0.6133     Mean   :0.7169   Mean   :3.806   Mean   :201.5        Mean   :
3.503     Mean   :0.1433   Mean   :0.2388
 3rd Qu.:0.8200     3rd Qu.:0.8700   3rd Qu.:5.000   3rd Qu.:245.0        3rd Qu.:
4.000     3rd Qu.:0.0000   3rd Qu.:0.0000
 Max.   :1.0000     Max.   :1.0000   Max.   :7.000   Max.   :310.0        Max.   :
10.000     Max.   :1.0000   Max.   :1.0000


 promotion_last_5years         sales         salary
 Min.   :0.00000       sales      :2905   high  : 875
 1st Qu.:0.00000       technical  :1910   low   :5160
 Median :0.00000       support    :1558   medium:4532
 Mean   :0.02054       IT         : 857
 3rd Qu.:0.00000       product_mng: 643
 Max.   :1.00000       marketing  : 595
                       (Other)    :2099
```

Hide

```
# cross-validation
HR_train$left <- as.factor(HR_train$left) ### setting the variable as factor
train_control<- trainControl(method="cv", )
head(train_control)
```

```
$method
[1] "cv"

$number
[1] 10

$repeats
[1] NA

$search
[1] "grid"

$p
[1] 0.75

$initialWindow
NULL
```

Hide

```
### Building a tree model
library("rpart") ## loading the necessary libraries
```

```
package <U+393C><U+3E31>rpart<U+393C><U+3E32> was built under R version 3.4.2
```

Hide

```
library("rpart.plot")
```

```
package <U+393C><U+3E31>rpart.plot<U+393C><U+3E32> was built under R version 3.4.2
```

Hide

```
# training the rpart model
library(C50)
```

```
package <U+393C><U+3E31>C50<U+393C><U+3E32> was built under R version 3.4.4
```

Hide

```
HR_rpartmodel<- train(left ~ ., data=HR_train, trControl=train_control, method="rpa
rt", metric="Accuracy")
# making the predictions
predictions<- predict(HR_rpartmodel,HR_train)
HR_model_tree<- cbind(HR_train,predictions)
# summarize results
confusionMatrix<- confusionMatrix(HR_model_tree$predictions,HR_model_tree$left)
confusionMatrix
```

```
Confusion Matrix and Statistics

          Reference
Prediction    0    1
         0 7897  831
         1  147 1692

               Accuracy : 0.9074
                 95% CI : (0.9018, 0.9129)
    No Information Rate : 0.7612
    P-Value [Acc > NIR] : < 2.2e-16

                  Kappa : 0.7193
 Mcnemar's Test P-Value : < 2.2e-16

            Sensitivity : 0.9817
            Specificity : 0.6706
         Pos Pred Value : 0.9048
         Neg Pred Value : 0.9201
             Prevalence : 0.7612
         Detection Rate : 0.7473
   Detection Prevalence : 0.8260
      Balanced Accuracy : 0.8262

       'Positive' Class : 0
```

Hide

```
### Naive Bayes
library(e1071)
###install.packages("rminer")
library(rminer)
```

```
package <U+393C><U+3E31>rminer<U+393C><U+3E32> was built under R version 3.4.3
```

Hide

```
### training the Naive bayes model on the train data set
HR_nb <- train(left~., data=HR_train, trControl=train_control, method="nb")
```

```
Numerical 0 probability for all classes with observation 34Numerical 0 probability
for all classes with observation 105Numerical 0 probability for all classes with ob
servation 112Numerical 0 probability for all classes with observation 166Numerical
0 probability for all classes with observation 169Numerical 0 probability for all c
lasses with observation 241Numerical 0 probability for all classes with observation
261Numerical 0 probability for all classes with observation 303Numerical 0 probabil
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h observation 306Numerical 0 probability for all classes with observation 307Numeri
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tion 367Numerical 0 probability for all classes with observation 457Numerical 0 pro
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Hide

```
### predictions
predictions_nb <- predict(HR_nb, HR_train)
HR_nb_model <- cbind(HR_train, predictions_nb)
### summarize
confusionMatrix_nb <- confusionMatrix(HR_nb_model$predictions_nb, HR_nb_model$left)
confusionMatrix_nb
```

```
Confusion Matrix and Statistics

          Reference
Prediction    0    1
         0 7942  833
         1  102 1690

               Accuracy : 0.9115
                 95% CI : (0.9059, 0.9169)
    No Information Rate : 0.7612
    P-Value [Acc > NIR] : < 2.2e-16

                  Kappa : 0.7297
 Mcnemar's Test P-Value : < 2.2e-16

            Sensitivity : 0.9873
            Specificity : 0.6698
         Pos Pred Value : 0.9051
         Neg Pred Value : 0.9431
             Prevalence : 0.7612
         Detection Rate : 0.7516
   Detection Prevalence : 0.8304
      Balanced Accuracy : 0.8286

       'Positive' Class : 0
```

Hide

```
### logistic regression
### training the model on the train dataset
HR_lr <- train(left~., data=HR_train, trControl=train_control, method="LogitBoost")
# make predictions
predictions_lr<- predict(HR_lr,HR_train)
HR_lr_model <- cbind(HR_train,predictions_lr)
# summarize results
confusionMatrix_lr<- confusionMatrix(HR_lr_model$predictions, HR_lr_model$left)
confusionMatrix_lr
```

```
Confusion Matrix and Statistics

          Reference
Prediction    0    1
         0 7854  349
         1  190 2174

               Accuracy : 0.949
                 95% CI : (0.9446, 0.9531)
    No Information Rate : 0.7612
    P-Value [Acc > NIR] : < 2.2e-16

                  Kappa : 0.8566
 Mcnemar's Test P-Value : 1.007e-11

            Sensitivity : 0.9764
            Specificity : 0.8617
         Pos Pred Value : 0.9575
         Neg Pred Value : 0.9196
             Prevalence : 0.7612
         Detection Rate : 0.7433
   Detection Prevalence : 0.7763
      Balanced Accuracy : 0.9190

       'Positive' Class : 0
```

Hide

```
install.packages("Metrics")
```

```
Installing package into <U+393C><U+3E31>C:/Users/CK/Documents/R/win-library/3.4<U+3
93C><U+3E32>
(as <U+393C><U+3E31>lib<U+393C><U+3E32> is unspecified)
trying URL 'https://cran.rstudio.com/bin/windows/contrib/3.4/Metrics_0.1.3.zip'
Content type 'application/zip' length 65116 bytes (63 KB)
downloaded 63 KB
```

```
package  Metrics  successfully unpacked and MD5 sums checked

The downloaded binary packages are in
    C:\Users\CK\AppData\Local\Temp\RtmpUpqpWf\downloaded_packages
```

Hide

```
### buidlingn the KNN classification model
library(caret)
knn_fit <- train(left ~., data = HR_train, method = "knn",
 trControl= train_control,
 preProcess = c("center", "scale"),
 tuneLength = 10)
knn_fit
```

```
k-Nearest Neighbors

10567 samples
    9 predictor
    2 classes: '0', '1'

Pre-processing: centered (18), scaled (18)
Resampling: Cross-Validated (10 fold)
Summary of sample sizes: 9511, 9510, 9511, 9510, 9511, 9510, ...
Resampling results across tuning parameters:

  k   Accuracy   Kappa
   5  0.9394355  0.8370847
   7  0.9381087  0.8322196
   9  0.9360269  0.8266642
  11  0.9325258  0.8169862
  13  0.9287407  0.8066047
  15  0.9268478  0.8011237
  17  0.9245766  0.7944939
  19  0.9225896  0.7890570
  21  0.9222105  0.7874503
  23  0.9202235  0.7814156

Accuracy was used to select the optimal model using the largest value.
The final value used for the model was k = 5.
```

Hide

```
### tuning the model by tune length of the from 10 to 20
library(caret)
knn_fit_tune <- train(left ~., data = HR_train, method = "knn",
 trControl= train_control,
 preProcess = c("center", "scale"),
 tuneLength = 20)
knn_fit_tune
```

```
k-Nearest Neighbors

10567 samples
    9 predictor
    2 classes: '0', '1'

Pre-processing: centered (18), scaled (18)
Resampling: Cross-Validated (10 fold)
Summary of sample sizes: 9511, 9510, 9510, 9511, 9510, 9510, ...
Resampling results across tuning parameters:

  k   Accuracy   Kappa
   5  0.9394331  0.8366644
   7  0.9387715  0.8339517
   9  0.9343245  0.8218798
  11  0.9317690  0.8150993
  13  0.9303501  0.8106512
  15  0.9262809  0.7995495
  17  0.9258076  0.7979445
  19  0.9232523  0.7906805
  21  0.9221165  0.7871919
  23  0.9201291  0.7809981
  25  0.9173854  0.7727626
  27  0.9157763  0.7681618
  29  0.9131268  0.7602976
  31  0.9114227  0.7556736
  33  0.9110445  0.7542659
  35  0.9104771  0.7525085
  37  0.9083948  0.7462728
  39  0.9065967  0.7408794
  41  0.9036638  0.7313860
  43  0.9027182  0.7278233

Accuracy was used to select the optimal model using the largest value.
The final value used for the model was k = 5.
```

Hide

```
### after increasing the tune length from 10 to 20 accuracy increased from
###using random forest to see the most important variables with respect to the resp
onse variable
library(randomForest)
```

```
package <U+393C><U+3E31>randomForest<U+393C><U+3E32> was built under R version 3.4.
4randomForest 4.6-14
Type rfNews() to see new features/changes/bug fixes.

Attaching package: <U+393C><U+3E31>randomForest<U+393C><U+3E32>

The following object is masked from <U+393C><U+3E31>package:ggplot2<U+393C><U+3E32>
:

    margin

The following object is masked from <U+393C><U+3E31>package:dplyr<U+393C><U+3E32>:

    combine
```

Hide

```
randomforest<-randomForest(left ~ satisfaction_level+last_evaluation+number_project
+average_montly_hours+time_spend_company+Work_accident+promotion_last_5years+sales+
salary, HR_train, ntree=500, trcontrol=train_control)
randomforest
```

```
Call:
 randomForest(formula = left ~ satisfaction_level + last_evaluation +      number_p
roject + average_montly_hours + time_spend_company +      Work_accident + promotion
_last_5years + sales + salary, data = HR_train,      ntree = 500, trcontrol = trai
n_control)
               Type of random forest: classification
                     Number of trees: 500
No. of variables tried at each split: 3

        OOB estimate of  error rate: 0.92%
Confusion matrix:
     0    1 class.error
0 8030   14 0.001740428
1   83 2440 0.032897344
```

Hide

```
importance(randomforest) #### through this command we can lay out the mmost importa
nt variables with respect to response variable and they are; satisfaction level, la
st_evaluation, number_project, avergae_montly_hours and time_spend_company
```

```
                     MeanDecreaseGini
satisfaction_level         1302.973003
last_evaluation             445.435157
number_project              682.623900
average_montly_hours        543.174761
time_spend_company          727.081072
Work_accident                22.443770
promotion_last_5years         3.067834
sales                        61.541132
salary                       31.880204
```

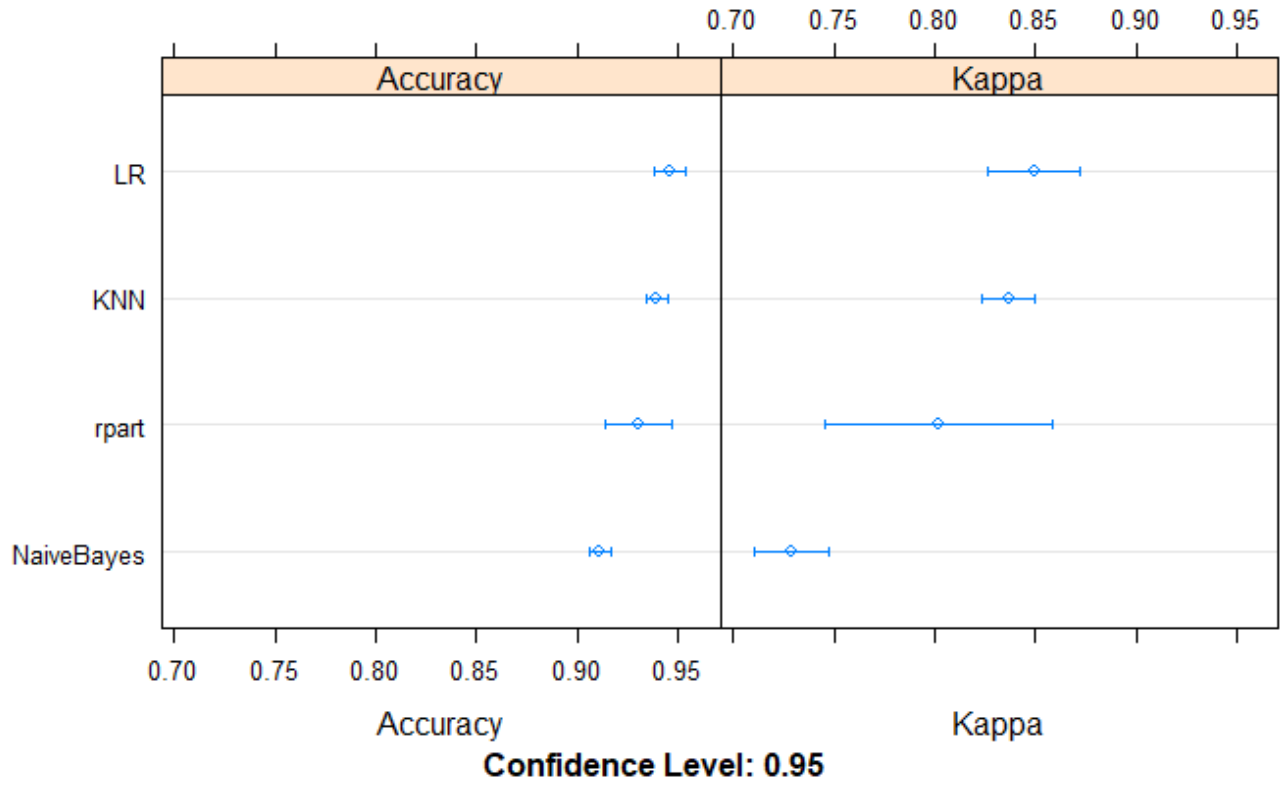
Hide

```
### comparision of model accuracy with dotplot
accuracy <- resamples(list(rpart=HR_rpartmodel, NaiveBayes= HR_nb, LR= HR_lr, KNN=k
nn_fit_tune))
### checking the accuracy for 4 different models
summary(accuracy)
```

```
Call:
summary.resamples(object = accuracy)

Models: rpart, NaiveBayes, LR, KNN
Number of resamples: 10

Accuracy
                Min.   1st Qu.    Median      Mean   3rd Qu.      Max. NA's
rpart      0.8939394 0.9122517 0.9398952 0.9303530 0.9436690 0.9526963    0
NaiveBayes 0.8968780 0.9086174 0.9128788 0.9113254 0.9162926 0.9205298    0
LR         0.9243141 0.9441288 0.9479668 0.9457758 0.9526963 0.9583333    0
KNN        0.9280303 0.9363163 0.9404251 0.9394331 0.9451277 0.9479659    0

Kappa
                Min.   1st Qu.    Median      Mean   3rd Qu.      Max. NA's
rpart      0.6724275 0.7391350 0.8398790 0.8016785 0.8492733 0.8721688    0
NaiveBayes 0.6788174 0.7230532 0.7325226 0.7288770 0.7461864 0.7566105    0
LR         0.7898619 0.8417775 0.8593908 0.8495374 0.8686941 0.8847070    0
KNN        0.8071956 0.8294605 0.8393826 0.8366644 0.8520999 0.8569066    0
```

Hide

```
dotplot(accuracy) ### plotting the accuracy for 4 different models
```



Hide

```
### Ensmebling the model
library(randomForest)
library(caret)
library(caretEnsemble)
```

```
package <U+393C><U+3E31>caretEnsemble<U+393C><U+3E32> was built under R version 3.4
.3
Attaching package: <U+393C><U+3E31>caretEnsemble<U+393C><U+3E32>

The following object is masked from <U+393C><U+3E31>package:ggplot2<U+393C><U+3E32>
:

    autoplot
```

Hide

```
Model_list <- c('rpart', 'nb', 'knn', 'LogitBoost')
set.seed(10)
models <- caretList(left~., data=HR_train, trControl=train_control, methodList=Mode
l_list)
```

```
trControl$savePredictions not 'all' or 'final'.  Setting to 'final' so we can ensem
ble the models.indexes not defined in trControl.  Attempting to set them ourselves,
so each model in the ensemble will have the same resampling indexes.Numerical 0 pro
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ll classes with observation 822Numerical 0 probability for all classes with observa
tion 825Numerical 0 probability for all classes with observation 830Numerical 0 pro
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h observation 981Numerical 0 probability for all classes with observation 1012Numer
ical 0 probability for all classes with observation 1021Numerical 0 probability for
all classes with observation 1046Numerical 0 probability for all classes with obser
vation 1054
```
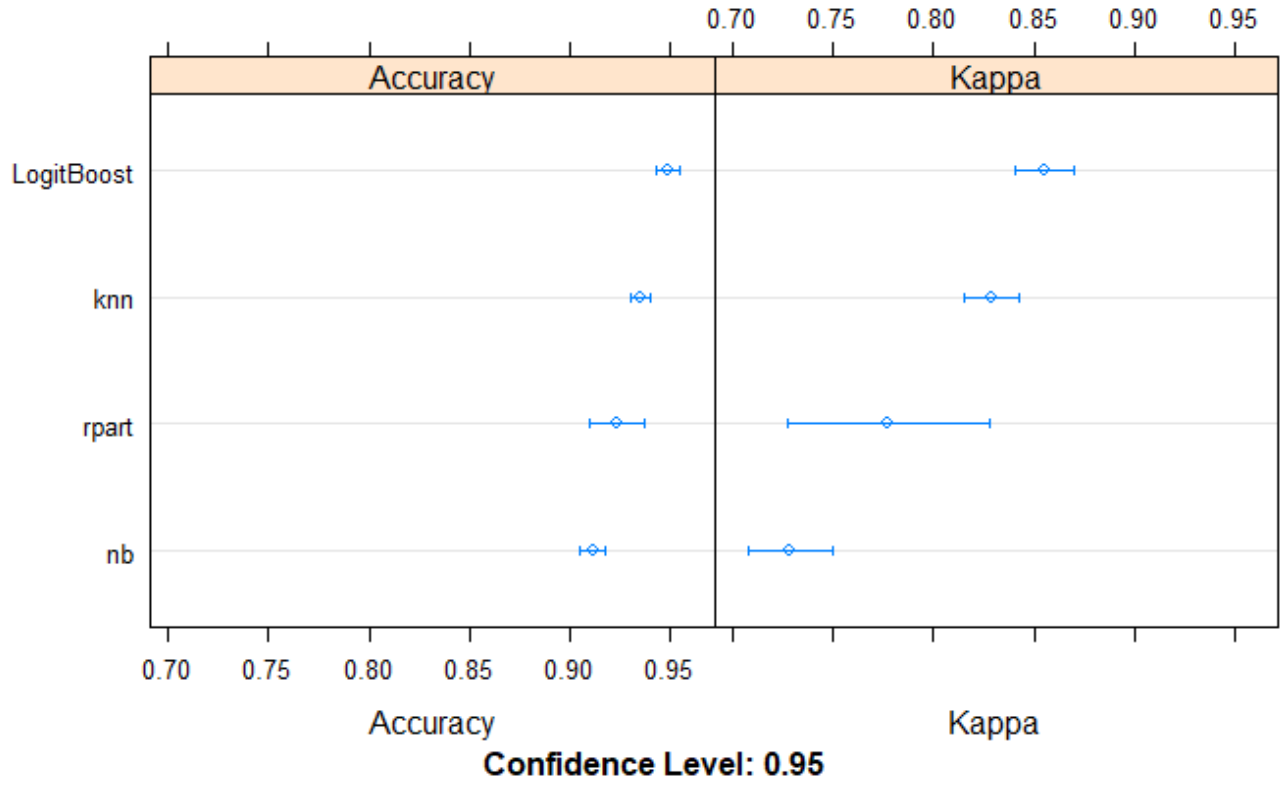

Hide

```
res_mod <- resamples(models)
summary(res_mod)
```

```
Call:
summary.resamples(object = res_mod)

Models: rpart, nb, knn, LogitBoost
Number of resamples: 10

Accuracy
                Min.   1st Qu.    Median      Mean   3rd Qu.      Max. NA's
rpart      0.8996212 0.9059334 0.9232955 0.9232479 0.9403409 0.9480151    0
nb         0.8996212 0.9041193 0.9110252 0.9112274 0.9155232 0.9291115    0
knn        0.9270833 0.9308712 0.9337757 0.9353635 0.9384470 0.9470699    0
LogitBoost 0.9346591 0.9460482 0.9512311 0.9485169 0.9539225 0.9583333    0

Kappa
                Min.   1st Qu.    Median      Mean   3rd Qu.      Max. NA's
rpart      0.6890252 0.7157091 0.7791268 0.7773943 0.8399521 0.8629024    0
nb         0.6899761 0.7075683 0.7279966 0.7287509 0.7424670 0.7876400    0
knn        0.8038784 0.8168684 0.8247881 0.8288628 0.8375766 0.8609522    0
LogitBoost 0.8204294 0.8455835 0.8605602 0.8552726 0.8699733 0.8821237    0
```

Hide

```
dotplot(res_mod)
```



Hide

```
### by looking at the accuaracy values we can see that logistic regression model is best among the all 4 models
### Using the test set for best fit model, after seeing the accuracy and checking the kappa of different models, I came to conclusion that logistic regression model is best with accuaracy of 95% and kappa of 84%
HR_lr_test = glm(left ~ ., family=binomial(logit), data=HR_train) ### glm is used to fit generilized linear moldels
EmployeemayLeave=predict(logreg,newdata=HR_test,type="response") ### to predict which employee may leave in order to retain them
Employeeattrition = data.frame(EmployeemayLeave) ### adding data of possible leaving employees to new data frame
Employeeattrition$performance=HR_test$last_evaluation ###  adding performance as a parameter in the Employeeattrition data frame
plot(Employeeattrition$EmployeemayLeave,Employeeattrition$performance)
```

Hide

```
#### Installing the package DT
library(DT)
```

```
package <U+393C><U+3E31>DT<U+393C><U+3E32> was built under R version 3.4.4
```

Hide

```
Employeeattrition$retain = Employeeattrition$performance*Employeeattrition$Employee
mayLeave
### assigning data obtained form above to new variable so, that the list of employe
es that we should retain should be in order
Employeeretainlist = Employeeattrition[order(Employeeattrition$retain ,decreasing =
TRUE),]
### ordering the list according to performance so, that top performed employee will
be on top of the list
Employeeretainlist <- head(Employeeretainlist, n=500) ### selecting a top 500 emplo
yees according to the performance
datatable(Employeeretainlist)
```

Hide

```
### Datatable function gives us the list of top 500 employees that company should r
etain
```