ALY 6015 Final Project Draft.R

```
# Intermediate Analytics
# ALY 6015
# Preliminary Analysis Group R Files
# 02/12/2021
# Team: Sunil Raj Thota, Nalini Macharla

# Get and set the working directories
getwd()

## [1] "G:/NEU/Coursework/2021 Q1 Winter/ALY 6015 IA/Discussions & Assignment
s"

setwd('G:/NEU/Coursework/2021 Q1 Winter/ALY 6015 IA/Discussions & Assignments
')
getwd()

## [1] "G:/NEU/Coursework/2021 Q1 Winter/ALY 6015 IA/Discussions & Assignment
s"

# Installed the above packages into the work space
install.packages("plyr")
install.packages("dplyr")
install.packages("tidyr")
install.packages("tidyverse")
install.packages("ggplot2")
install.packages("e1071")
install.packages("gmodels")
install.packages("caret")
install.packages("ROCR")
install.packages("kableExtra")
install.packages("rpart")
install.packages("rpart.plot")
install.packages("caTools")
install.packages("ncvreg")
install.packages("biglasso")
install.packages("bigmemory")
install.packages("glmnet")
install.packages("lars")
install.packages("randomForest")
install.packages("rattle")
install.packages("gridExtra")

# Loaded the below libraries into the work space
library(plyr)
library(dplyr)
library(tidyr)
```

```
library(tidyverse)
library(ggplot2)
require(e1071)
library(gmodels)
library(data.table)
library(caret)
library(ROCR)
library(kableExtra)
library(rpart)
library(rpart.plot)
library(caTools)
library(ncvreg)
library(biglasso)
library(bigmemory)
library(lars)
library(glmnet)
library(randomForest)
library(gridExtra)
library(rattle)
require(grDevices)

bankData <- read.csv("Bank Dataset.csv")

bankDataMain <- bankData

View(bankData) # To View the bank Data set
str(bankData) # To observe the structure of the Data set
## 'data.frame':    41188 obs. of  21 variables:
##  $ age           : int  56 57 37 40 56 45 59 41 24 25 ...
##  $ job           : chr  "housemaid" "services" "services" "admin." ...
##  $ marital       : chr  "married" "married" "married" "married" ...
##  $ education     : chr  "basic.4y" "high.school" "high.school" "basic.6y"
...
##  $ default       : chr  "no" "unknown" "no" "no" ...
##  $ housing       : chr  "no" "no" "yes" "no" ...
##  $ loan          : chr  "no" "no" "no" "no" ...
##  $ contact       : chr  "telephone" "telephone" "telephone" "telephone" ..
.
##  $ month         : chr  "may" "may" "may" "may" ...
##  $ day_of_week   : chr  "mon" "mon" "mon" "mon" ...
##  $ duration      : int  261 149 226 151 307 198 139 217 380 50 ...
##  $ campaign      : int  1 1 1 1 1 1 1 1 1 1 ...
##  $ pdays         : int  999 999 999 999 999 999 999 999 999 999 ...
##  $ previous      : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ poutcome      : chr  "nonexistent" "nonexistent" "nonexistent" "nonexis
tent" ...
##  $ emp.var.rate  : num  1.1 1.1 1.1 1.1 1.1 1.1 1.1 1.1 1.1 1.1 ...
##  $ cons.price.idx: num  94 94 94 94 94 ...
##  $ cons.conf.idx : num  -36.4 -36.4 -36.4 -36.4 -36.4 -36.4 -36.4 -36.4 -3
6.4 -36.4 ...
```

```
##  $ euribor3m     : num  4.86 4.86 4.86 4.86 4.86 ...
##  $ nr.employed   : num  5191 5191 5191 5191 5191 ...
##  $ y             : chr  "no" "no" "no" "no" ...

head(bankData) # It shows first few rows in the Data set

##   age       job marital   education default housing loan   contact month
## 1  56 housemaid married    basic.4y      no      no   no telephone   may
## 2  57  services married high.school unknown      no   no telephone   may
## 3  37  services married high.school      no     yes   no telephone   may
## 4  40    admin. married    basic.6y      no      no   no telephone   may
## 5  56  services married high.school      no      no  yes telephone   may
## 6  45  services married    basic.9y unknown      no   no telephone   may
##   day_of_week duration campaign pdays previous    poutcome emp.var.rate
## 1         mon      261        1   999        0 nonexistent          1.1
## 2         mon      149        1   999        0 nonexistent          1.1
## 3         mon      226        1   999        0 nonexistent          1.1
## 4         mon      151        1   999        0 nonexistent          1.1
## 5         mon      307        1   999        0 nonexistent          1.1
## 6         mon      198        1   999        0 nonexistent          1.1
##   cons.price.idx cons.conf.idx euribor3m nr.employed  y
## 1         93.994         -36.4     4.857        5191 no
## 2         93.994         -36.4     4.857        5191 no
## 3         93.994         -36.4     4.857        5191 no
## 4         93.994         -36.4     4.857        5191 no
## 5         93.994         -36.4     4.857        5191 no
## 6         93.994         -36.4     4.857        5191 no

tail(bankData) # It shows last few rows in the Data set

##       age         job marital           education default housing loan  co
ntact
## 41183  29  unemployed  single            basic.4y      no     yes   no cel
lular
## 41184  73     retired married professional.course      no     yes   no cel
lular
## 41185  46 blue-collar married professional.course      no      no   no cel
lular
## 41186  56     retired married   university.degree      no     yes   no cel
lular
## 41187  44  technician married professional.course      no      no   no cel
lular
## 41188  74     retired married professional.course      no     yes   no cel
lular
##       month day_of_week duration campaign pdays previous    poutcome
## 41183   nov         fri      112        1     9        1     success
## 41184   nov         fri      334        1   999        0 nonexistent
## 41185   nov         fri      383        1   999        0 nonexistent
## 41186   nov         fri      189        2   999        0 nonexistent
## 41187   nov         fri      442        1   999        0 nonexistent
## 41188   nov         fri      239        3   999        1     failure
```

```
##       emp.var.rate cons.price.idx cons.conf.idx euribor3m nr.employed   y
## 41183         -1.1         94.767         -50.8     1.028      4963.6  no
## 41184         -1.1         94.767         -50.8     1.028      4963.6 yes
## 41185         -1.1         94.767         -50.8     1.028      4963.6  no
## 41186         -1.1         94.767         -50.8     1.028      4963.6  no
## 41187         -1.1         94.767         -50.8     1.028      4963.6 yes
## 41188         -1.1         94.767         -50.8     1.028      4963.6  no
```

```
summary(bankData) # Provides the Descriptive Stats of the bank Data set
```

```
##       age            job              marital           education
##  Min.   :17.00   Length:41188       Length:41188       Length:41188
##  1st Qu.:32.00   Class :character   Class :character   Class :character
##  Median :38.00   Mode  :character   Mode  :character   Mode  :character
##  Mean   :40.02
##  3rd Qu.:47.00
##  Max.   :98.00
##    default            housing              loan             contact
##  Length:41188       Length:41188       Length:41188       Length:41188
##  Class :character   Class :character   Class :character   Class :character
##  Mode  :character   Mode  :character   Mode  :character   Mode  :character
##
##
##
##     month           day_of_week          duration         campaign
##  Length:41188       Length:41188       Min.   :   0.0   Min.   : 1.000
##  Class :character   Class :character   1st Qu.: 102.0   1st Qu.: 1.000
##  Mode  :character   Mode  :character   Median : 180.0   Median : 2.000
##                                        Mean   : 258.3   Mean   : 2.568
##                                        3rd Qu.: 319.0   3rd Qu.: 3.000
##                                        Max.   :4918.0   Max.   :56.000
##      pdays          previous       poutcome          emp.var.rate
##  Min.   :  0.0   Min.   :0.000   Length:41188       Min.   :-3.40000
##  1st Qu.:999.0   1st Qu.:0.000   Class :character   1st Qu.:-1.80000
##  Median :999.0   Median :0.000   Mode  :character   Median : 1.10000
##  Mean   :962.5   Mean   :0.173                      Mean   : 0.08189
##  3rd Qu.:999.0   3rd Qu.:0.000                      3rd Qu.: 1.40000
##  Max.   :999.0   Max.   :7.000                      Max.   : 1.40000
##  cons.price.idx  cons.conf.idx     euribor3m      nr.employed
##  Min.   :92.20   Min.   :-50.8   Min.   :0.634   Min.   :4964
##  1st Qu.:93.08   1st Qu.:-42.7   1st Qu.:1.344   1st Qu.:5099
##  Median :93.75   Median :-41.8   Median :4.857   Median :5191
##  Mean   :93.58   Mean   :-40.5   Mean   :3.621   Mean   :5167
##  3rd Qu.:93.99   3rd Qu.:-36.4   3rd Qu.:4.961   3rd Qu.:5228
##  Max.   :94.77   Max.   :-26.9   Max.   :5.045   Max.   :5228
##       y
##  Length:41188
##  Class :character
##  Mode  :character
```

```r
dim(bankData) # Shows the count of rows and columns in the dataset
```

```
## [1] 41188    21
```

```r
sum(duplicated(bankDataMain)) # Check for duplicate records
```

```
## [1] 12
```

```r
sum(!complete.cases(bankDataMain)) # Checking for Rows with missing Data
```

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

```r
all.empty <-
  rowSums(is.na(bankDataMain)) == ncol(bankDataMain) # How many rows are comp
letely went missing in all the cols
sum(all.empty)
```

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

```r
sapply(bankDataMain, function(x)
  sum(is.na(x))) # Missing values by variables
```

```
##            age            job        marital      education        default
##              0              0              0              0              0
##        housing           loan        contact          month    day_of_week
##              0              0              0              0              0
##       duration       campaign          pdays       previous       poutcome
##              0              0              0              0              0
##   emp.var.rate cons.price.idx  cons.conf.idx      euribor3m    nr.employed
##              0              0              0              0              0
##              y
##              0
```

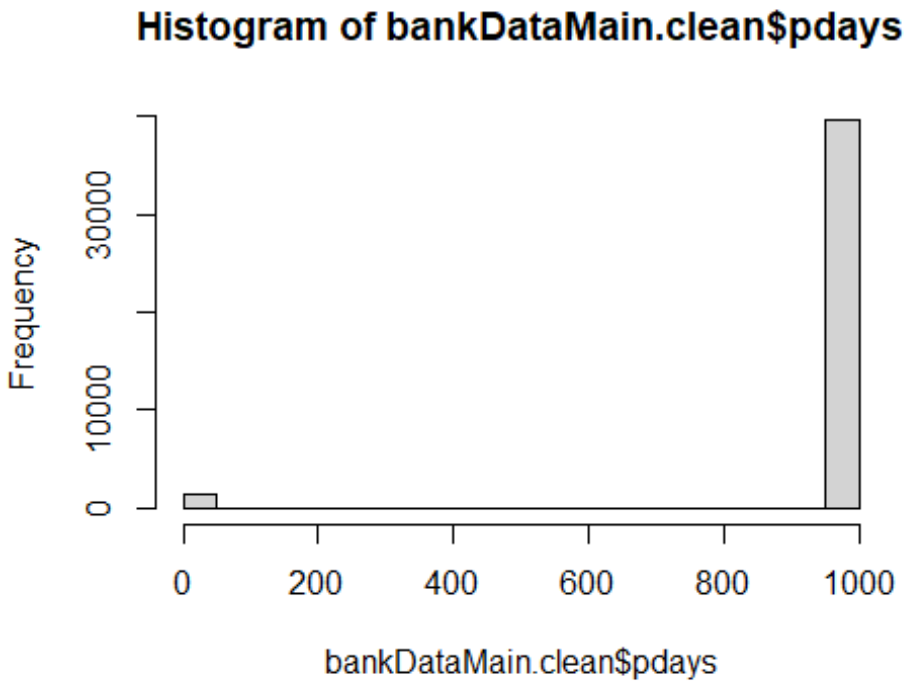
```r
bankDataMain.clean <- bankDataMain[!all.empty,]
bankDataMain.clean <- bankDataMain.clean %>% distinct
# Remove rows with clos that has missing values

nrow(bankDataMain.clean)
```

```
## [1] 41176
```

```r
# Impute Missing Values - replace with average
bankDataMain.clean$missing <- !complete.cases(bankDataMain.clean)

bankDataMain.clean$age[is.na(bankDataMain.clean$age)] <-
  mean(bankDataMain$age, na.rm = T)
bankDataMain.clean$day[is.na(bankDataMain.clean$day)] <-
  mean(bankDataMain$day, na.rm = T)
```

```
## Warning in mean.default(bankDataMain$day, na.rm = T): argument is not nume
ric or
## logical: returning NA
```

```
bankDataMain.clean$duration[is.na(bankDataMain.clean$duration)] <-
  mean(bankDataMain$duration, na.rm = T)
bankDataMain.clean$previous[is.na(bankDataMain.clean$previous)] <-
  mean(bankDataMain$previous, na.rm = T)
bankDataMain.clean$campaign[is.na(bankDataMain.clean$campaign)] <-
  mean(bankDataMain$campaign, na.rm = T)

# Plotted histogram of pdays
hist(bankDataMain.clean$pdays)
```




```
bankDataMain.clean$pdays[is.na(bankDataMain.clean$pdays)] <-
  as.numeric(names(sort(-table(bankDataMain$pdays)))[1])

bankDataMain.clean$balance[is.na(bankDataMain.clean$balance)] <-
  as.numeric(names(sort(-table(
    bankDataMain$balance
  )))[1])


bankDataMain.clean <- bankDataMain.clean %>% distinct
nrow(bankDataMain)

## [1] 41188

nrow(bankDataMain.clean)

## [1] 41176
```

```r
# Remove duplicated rows and verify for deduplication
sum(duplicated(bankDataMain.clean))
```

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

```r
sapply(bankDataMain.clean, function(x)
  sum(is.na(x)))
```

```
##            age            job        marital      education        default
##              0              0              0              0              0
##        housing           loan        contact          month    day_of_week
##              0              0              0              0              0
##       duration       campaign          pdays       previous       poutcome
##              0              0              0              0              0
##   emp.var.rate cons.price.idx  cons.conf.idx      euribor3m    nr.employed
##              0              0              0              0              0
##              y        missing            day
##              0              0              0
```

```r
levels(bankDataMain.clean$job)
```

```
## NULL
```

```r
levels(bankDataMain.clean$marital)
```

```
## NULL
```

```r
levels(bankDataMain.clean$education)
```

```
## NULL
```

```r
levels(bankDataMain.clean$default)
```

```
## NULL
```

```r
levels(bankDataMain.clean$loan)
```

```
## NULL
```

```r
levels(bankDataMain.clean$contact)
```

```
## NULL
```

```r
levels(bankDataMain.clean$poutcome)
```

```
## NULL
```

```r
levels(bankDataMain.clean$y)
```

```
## NULL
```

```r
levels(bankDataMain.clean$housing)
```

```
## NULL
```

```
levels(bankDataMain.clean$month)

## NULL

sum(bankDataMain.clean$missing)

## [1] 0

#Converting quantititative values to numeric class
bankDataMain$age <- as.numeric(bankDataMain$age)
bankDataMain$duration <- as.numeric(bankDataMain$duration)
bankDataMain$campaign <- as.numeric(bankDataMain$campaign)
bankDataMain$pdays <- as.numeric(bankDataMain$pdays)
bankDataMain$previous <- as.numeric(bankDataMain$previous)
bankDataMain$emp.var.rate <- as.numeric(bankDataMain$emp.var.rate)
bankDataMain$cons.price.idx <-
  as.numeric(bankDataMain$cons.price.idx)
bankDataMain$cons.conf.idx <- as.numeric(bankDataMain$cons.conf.idx)
bankDataMain$nr.employed <- as.numeric(bankDataMain$nr.employed)

#checking classes of attributes after transformation
sapply(bankDataMain, class)

##            age            job        marital      education        default
##      "numeric"    "character"    "character"    "character"    "character"
##        housing           loan        contact          month    day_of_week
##    "character"    "character"    "character"    "character"    "character"
##       duration       campaign          pdays       previous       poutcome
##      "numeric"      "numeric"      "numeric"      "numeric"    "character"
##   emp.var.rate cons.price.idx  cons.conf.idx      euribor3m    nr.employed
##      "numeric"      "numeric"      "numeric"      "numeric"      "numeric"
##              y
##    "character"

summary(bankDataMain.clean)

##       age            job              marital           education
##  Min.   :17.00   Length:41176       Length:41176       Length:41176
##  1st Qu.:32.00   Class :character   Class :character   Class :character
##  Median :38.00   Mode  :character   Mode  :character   Mode  :character
##  Mean   :40.02
##  3rd Qu.:47.00
##  Max.   :98.00
##    default            housing              loan             contact
##  Length:41176       Length:41176       Length:41176       Length:41176
##  Class :character   Class :character   Class :character   Class :character
##  Mode  :character   Mode  :character   Mode  :character   Mode  :character
##
##
##
##     month           day_of_week           duration         campaign
```

```
##  Length:41176       Length:41176       Min.   :   0.0   Min.   : 1.000
##  Class :character   Class :character   1st Qu.: 102.0   1st Qu.: 1.000
##  Mode  :character   Mode  :character   Median : 180.0   Median : 2.000
##                                        Mean   : 258.3   Mean   : 2.568
##                                        3rd Qu.: 319.0   3rd Qu.: 3.000
##                                        Max.   :4918.0   Max.   :56.000
##      pdays          previous       poutcome          emp.var.rate
##  Min.   :  0.0   Min.   :0.000   Length:41176       Min.   :-3.40000
##  1st Qu.:999.0   1st Qu.:0.000   Class :character   1st Qu.:-1.80000
##  Median :999.0   Median :0.000   Mode  :character   Median : 1.10000
##  Mean   :962.5   Mean   :0.173                      Mean   : 0.08192
##  3rd Qu.:999.0   3rd Qu.:0.000                      3rd Qu.: 1.40000
##  Max.   :999.0   Max.   :7.000                      Max.   : 1.40000
##  cons.price.idx  cons.conf.idx     euribor3m      nr.employed
##  Min.   :92.20   Min.   :-50.8   Min.   :0.634   Min.   :4964
##  1st Qu.:93.08   1st Qu.:-42.7   1st Qu.:1.344   1st Qu.:5099
##  Median :93.75   Median :-41.8   Median :4.857   Median :5191
##  Mean   :93.58   Mean   :-40.5   Mean   :3.621   Mean   :5167
##  3rd Qu.:93.99   3rd Qu.:-36.4   3rd Qu.:4.961   3rd Qu.:5228
##  Max.   :94.77   Max.   :-26.9   Max.   :5.045   Max.   :5228
##       y              missing            day
##  Length:41176       Mode :logical   Length:41176
##  Class :character   FALSE:41176     Class :character
##  Mode  :character                   Mode  :character
##
##
##
```

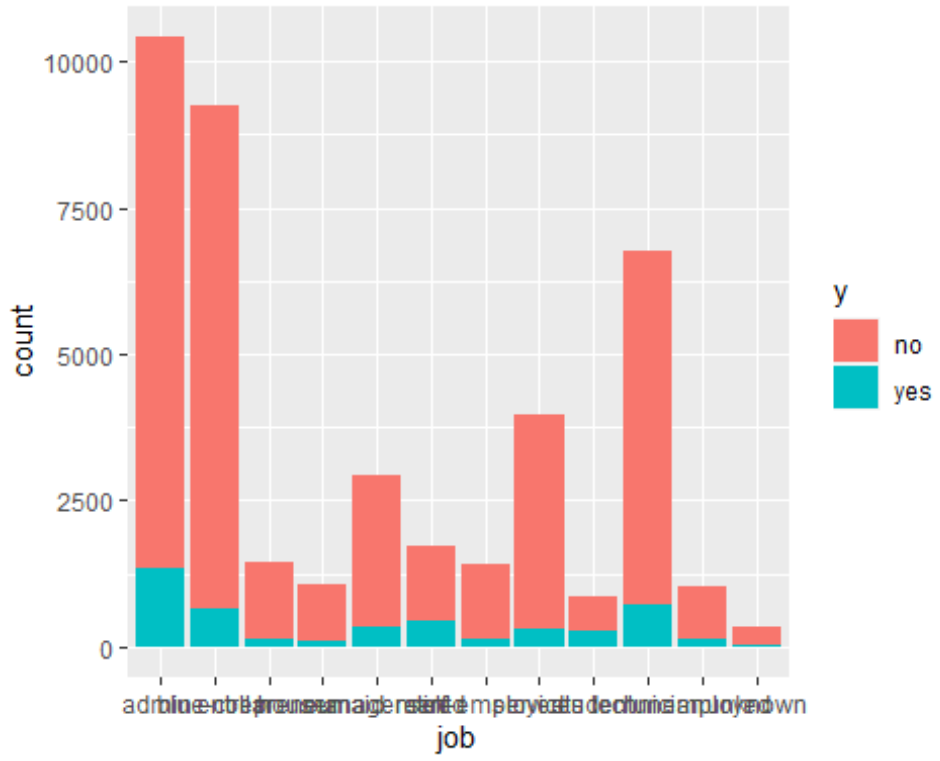
```
# Lets save the updated data in the below format
write.csv(bankDataMain.clean, file = "Banks Data Cleaned.csv")

bankDataCleaned <- bankDataMain.clean
bankDataCleaned

# Conditionally formatting all "y" to 0, and 1
bankDataCleaned$y <- ifelse(bankDataCleaned$y == "y", 1, 0)
bankDataCleaned

str(bankDataCleaned)
```

```
## 'data.frame':    41176 obs. of  23 variables:
##  $ age           : num  56 57 37 40 56 45 59 41 24 25 ...
##  $ job           : chr  "housemaid" "services" "services" "admin." ...
##  $ marital       : chr  "married" "married" "married" "married" ...
##  $ education     : chr  "basic.4y" "high.school" "high.school" "basic.6y"
...
##  $ default       : chr  "no" "unknown" "no" "no" ...
##  $ housing       : chr  "no" "no" "yes" "no" ...
##  $ loan          : chr  "no" "no" "no" "no" ...
##  $ contact       : chr  "telephone" "telephone" "telephone" "telephone" ..
.
```

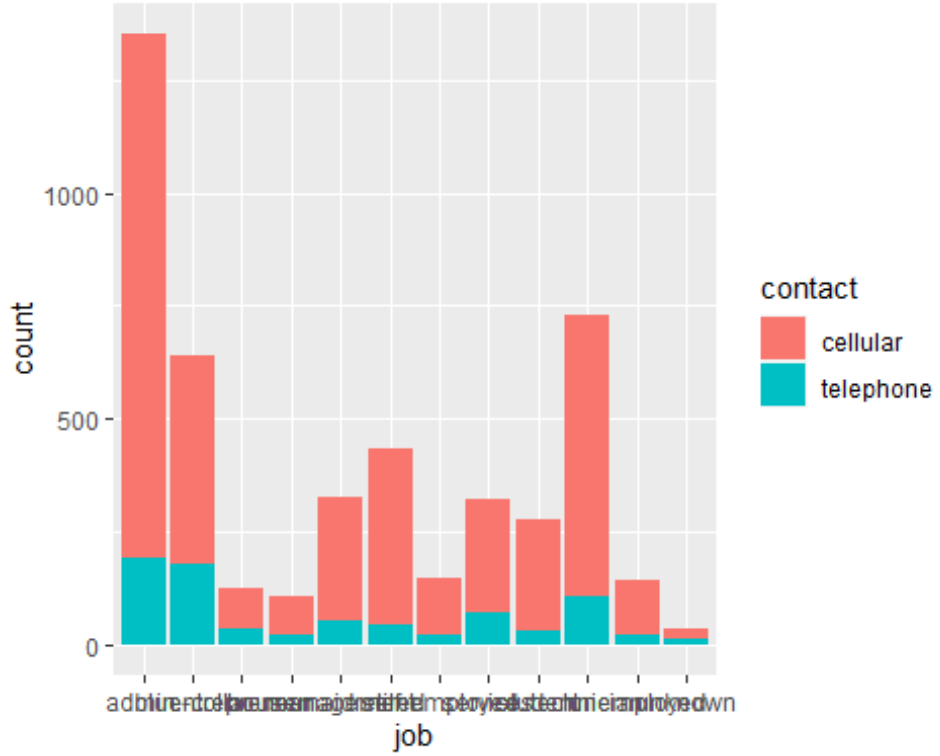
```
##  $ month         : chr  "may" "may" "may" "may" ...
##  $ day_of_week   : chr  "mon" "mon" "mon" "mon" ...
##  $ duration      : num  261 149 226 151 307 198 139 217 380 50 ...
##  $ campaign      : num  1 1 1 1 1 1 1 1 1 ...
##  $ pdays         : num  999 999 999 999 999 999 999 999 999 999 ...
##  $ previous      : num  0 0 0 0 0 0 0 0 0 ...
##  $ poutcome      : chr  "nonexistent" "nonexistent" "nonexistent" "nonexis
tent" ...
##  $ emp.var.rate  : num  1.1 1.1 1.1 1.1 1.1 1.1 1.1 1.1 1.1 1.1 ...
##  $ cons.price.idx: num  94 94 94 94 94 ...
##  $ cons.conf.idx : num  -36.4 -36.4 -36.4 -36.4 -36.4 -36.4 -36.4 -36.4 -3
6.4 -36.4 ...
##  $ euribor3m     : num  4.86 4.86 4.86 4.86 4.86 ...
##  $ nr.employed   : num  5191 5191 5191 5191 5191 ...
##  $ y             : num  0 0 0 0 0 0 0 0 0 ...
##  $ missing       : logi  FALSE FALSE FALSE FALSE FALSE FALSE ...
##  $ day           : chr  "mon" "mon" "mon" "mon" ...

nrow(bankDataCleaned)

## [1] 41176

ncol(bankDataCleaned)

## [1] 23

head(bankDataCleaned)

##   age       job marital   education default housing loan   contact month
## 1  56 housemaid married    basic.4y      no      no   no telephone   may
## 2  57  services married high.school unknown      no   no telephone   may
## 3  37  services married high.school      no     yes   no telephone   may
## 4  40    admin. married    basic.6y      no      no   no telephone   may
## 5  56  services married high.school      no      no  yes telephone   may
## 6  45  services married    basic.9y unknown      no   no telephone   may
##   day_of_week duration campaign pdays previous    poutcome emp.var.rate
## 1         mon      261        1   999        0 nonexistent          1.1
## 2         mon      149        1   999        0 nonexistent          1.1
## 3         mon      226        1   999        0 nonexistent          1.1
## 4         mon      151        1   999        0 nonexistent          1.1
## 5         mon      307        1   999        0 nonexistent          1.1
## 6         mon      198        1   999        0 nonexistent          1.1
##   cons.price.idx cons.conf.idx euribor3m nr.employed y missing day
## 1         93.994         -36.4     4.857        5191 0   FALSE mon
## 2         93.994         -36.4     4.857        5191 0   FALSE mon
## 3         93.994         -36.4     4.857        5191 0   FALSE mon
## 4         93.994         -36.4     4.857        5191 0   FALSE mon
## 5         93.994         -36.4     4.857        5191 0   FALSE mon
## 6         93.994         -36.4     4.857        5191 0   FALSE mon

summary(bankDataCleaned)
```

```
##       age            job              marital           education
##  Min.   :17.00   Length:41176       Length:41176       Length:41176
##  1st Qu.:32.00   Class :character   Class :character   Class :character
##  Median :38.00   Mode  :character   Mode  :character   Mode  :character
##  Mean   :40.02
##  3rd Qu.:47.00
##  Max.   :98.00
##    default            housing             loan             contact
##  Length:41176       Length:41176       Length:41176       Length:41176
##  Class :character   Class :character   Class :character   Class :character
##  Mode  :character   Mode  :character   Mode  :character   Mode  :character
##
##
##
##     month           day_of_week          duration         campaign
##  Length:41176       Length:41176       Min.   :   0.0   Min.   : 1.000
##  Class :character   Class :character   1st Qu.: 102.0   1st Qu.: 1.000
##  Mode  :character   Mode  :character   Median : 180.0   Median : 2.000
##                                        Mean   : 258.3   Mean   : 2.568
##                                        3rd Qu.: 319.0   3rd Qu.: 3.000
##                                        Max.   :4918.0   Max.   :56.000
##      pdays          previous       poutcome          emp.var.rate
##  Min.   :  0.0   Min.   :0.000   Length:41176       Min.   :-3.40000
##  1st Qu.:999.0   1st Qu.:0.000   Class :character   1st Qu.:-1.80000
##  Median :999.0   Median :0.000   Mode  :character   Median : 1.10000
##  Mean   :962.5   Mean   :0.173                      Mean   : 0.08192
##  3rd Qu.:999.0   3rd Qu.:0.000                      3rd Qu.: 1.40000
##  Max.   :999.0   Max.   :7.000                      Max.   : 1.40000
##  cons.price.idx  cons.conf.idx     euribor3m      nr.employed         y
##  Min.   :92.20   Min.   :-50.8   Min.   :0.634   Min.   :4964   Min.   :0
##  1st Qu.:93.08   1st Qu.:-42.7   1st Qu.:1.344   1st Qu.:5099   1st Qu.:0
##  Median :93.75   Median :-41.8   Median :4.857   Median :5191   Median :0
##  Mean   :93.58   Mean   :-40.5   Mean   :3.621   Mean   :5167   Mean   :0
##  3rd Qu.:93.99   3rd Qu.:-36.4   3rd Qu.:4.961   3rd Qu.:5228   3rd Qu.:0
##  Max.   :94.77   Max.   :-26.9   Max.   :5.045   Max.   :5228   Max.   :0
##   missing            day
##  Mode :logical   Length:41176
##  FALSE:41176     Class :character
##                  Mode  :character
##
##
##
```

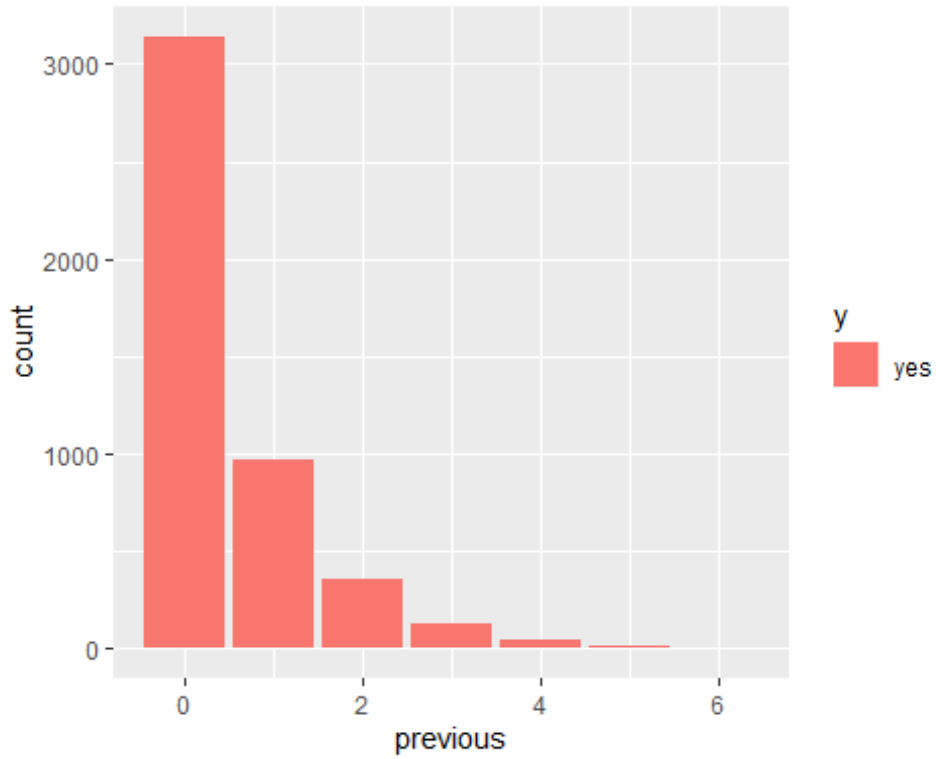
```
x <- filter(bankDataMain, y == "yes")

# Age Distribution and Analysis
ggplot(bankDataMain, aes(job)) + geom_bar(aes(fill = y))
```




```
# Job Distribution and Analysis
ggplot(x, aes(job)) + geom_bar(aes(fill = contact))
```



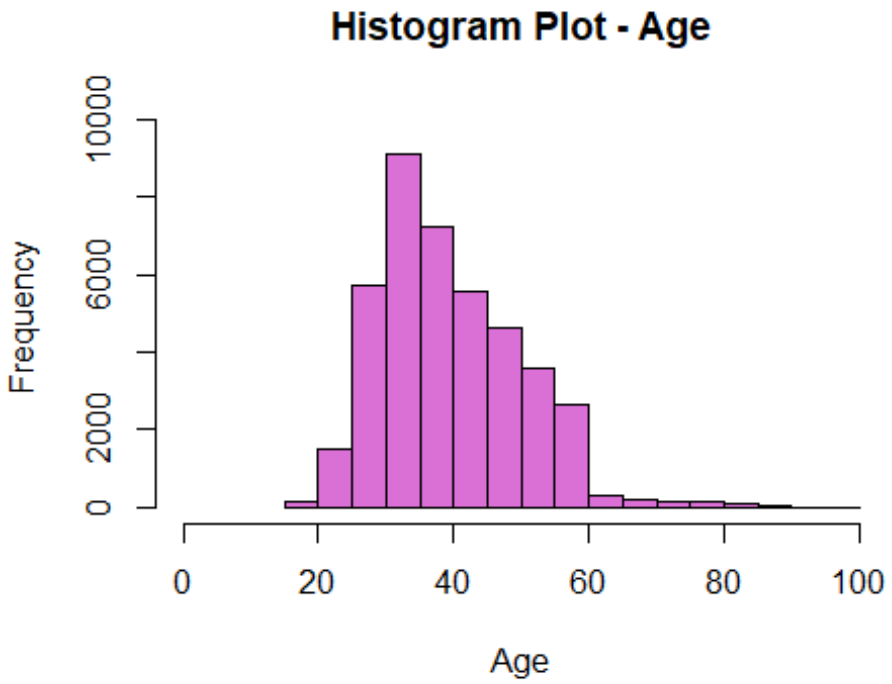
```
# previous Distribution and Analysis
ggplot(x, aes(previous)) + geom_bar(aes(fill = y))
```




```
table(bankDataMain$poutcome, bankDataMain$y)

##
##                    no   yes
##   failure        3647   605
##   nonexistent   32422  3141
##   success         479   894

table(bankDataMain$contact, bankDataMain$y)

##
##                  no   yes
##   cellular    22291  3853
##   telephone   14257   787

table(bankDataMain$education)

##
##            basic.4y            basic.6y            basic.9y         high.s
chool
##                4176                2292                6045
9515
##          illiterate professional.course   university.degree              un
known
```

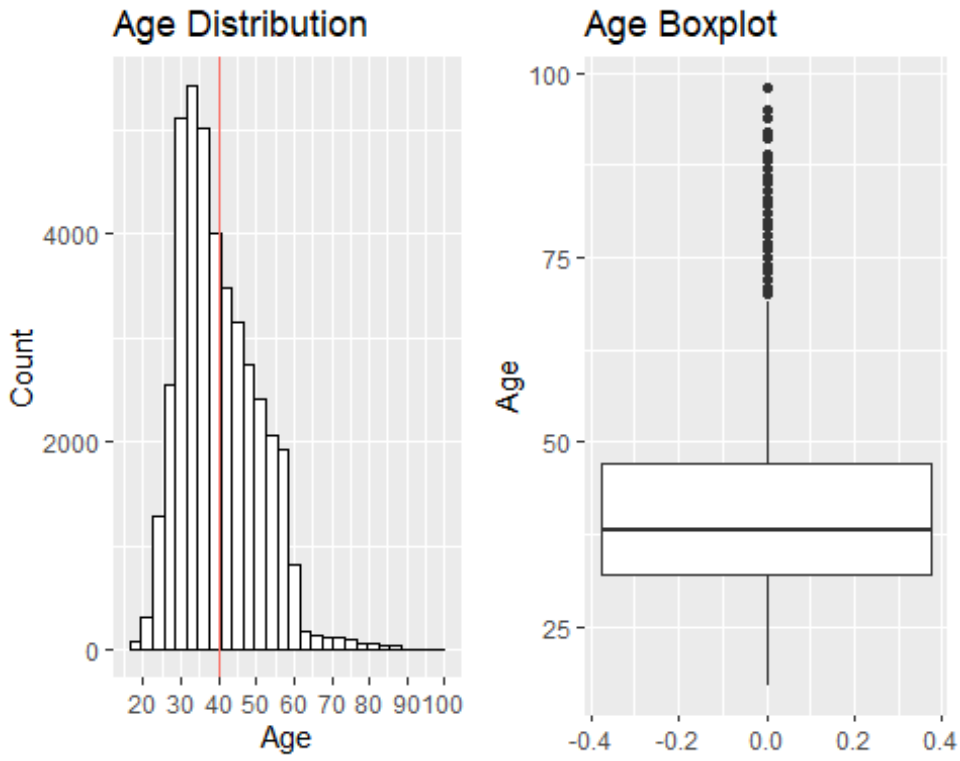
```
##                  18                5243                12168
1731

table(bankDataMain$default)

##
##      no unknown     yes
##   32588    8597       3

table(bankDataMain$housing)

##
##      no unknown     yes
##   18622     990   21576

table(bankDataMain$month)

##
##   apr   aug   dec   jul   jun   mar   may   nov   oct   sep
##  2632  6178   182  7174  5318   546 13769  4101   718   570
```

```r
# Age histogram
hist(
  bankDataMain$age,
  main = "Histogram Plot - Age",
  xlab = "Age",
  ylab = "Frequency ",
  border = "black",
  xlim = c(0, 100),
  ylim = c(0, 10000),
  col = "orchid"
)
```

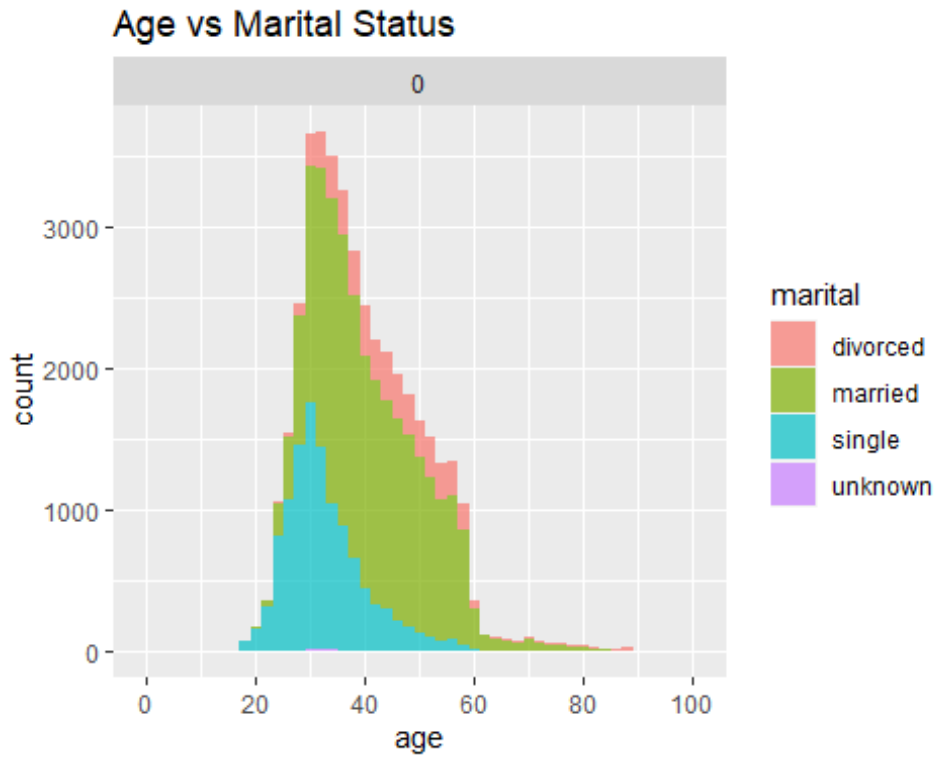



```r
# Age Density Plot
plot(
  density(bankDataMain$age),
  main = "Density Plot - Age",
  xlab = "Age",
  ylab = "Probability",
  col = "purple",
  lwd = 2.5,
)
```

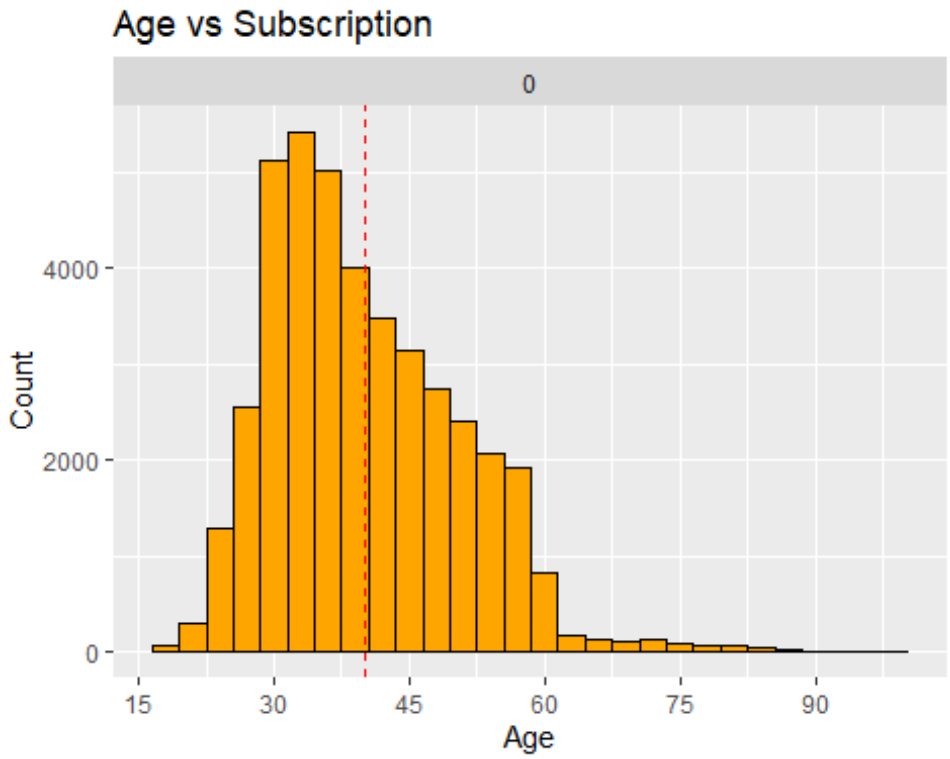

```
duration <- summary(bankDataMain$duration)
duration

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     0.0   102.0   180.0   258.3   319.0  4918.0

# Age ~ Marital Status Histogram
ggPlot <- ggplot (bankDataCleaned)
plot1 <- ggPlot + geom_histogram(aes(x = age),
                                 color = "black",
                                 fill = "white",
                                 binwidth = 3) +
  ggtitle('Age Distribution') +
  ylab('Count') +
  xlab('Age') +
  geom_vline(aes(xintercept = mean(age), color = "tomato")) +
  scale_x_continuous(breaks = seq(0, 100, 10)) +
  theme(legend.position = "none")

# Age ~ Marital Status Boxplot
plot2 <- ggPlot + geom_boxplot(aes(y = age)) +
  ggtitle('Age Boxplot') +
  ylab('Age')

grid.arrange(plot1, plot2, ncol = 2, nrow = 1)
```



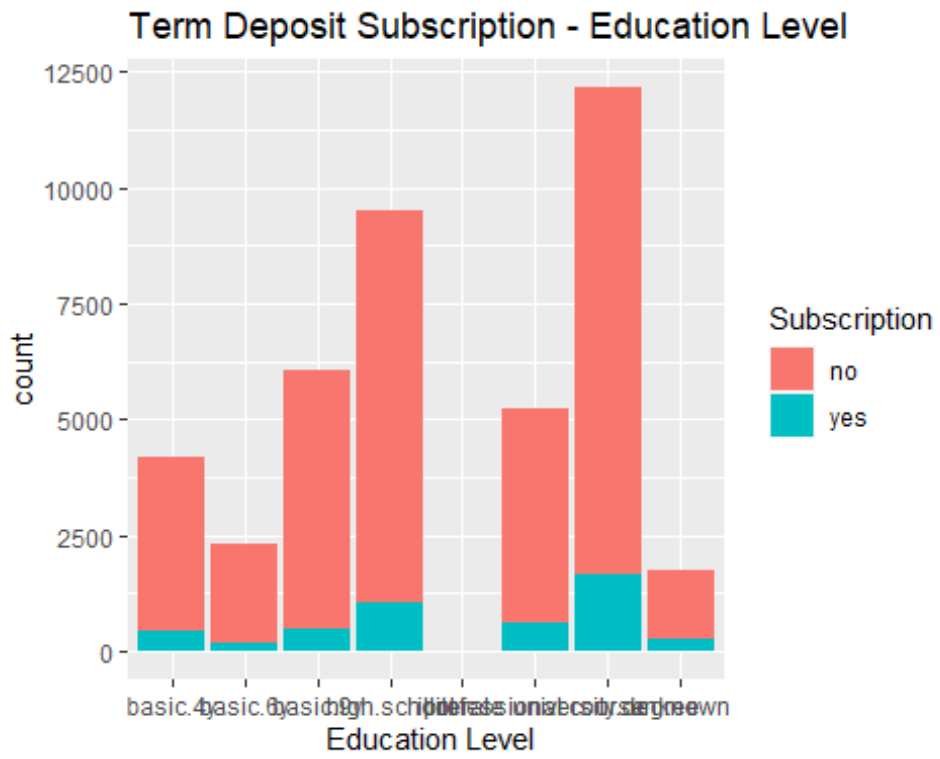

```r
p3 <- ggplot(bankDataCleaned, aes(x = age, fill = marital)) +
  geom_histogram(binwidth = 2, alpha = 0.7) +
  facet_grid(cols = vars(y)) +
  expand_limits(x = c(0, 100)) +
  scale_x_continuous(breaks = seq(0, 100, 20)) +
  ggtitle("Age vs Marital Status")

p3
```




```
meanAge <-
  bankDataCleaned %>% group_by(y) %>% summarize(grp.mean = mean(age))

# Age ~ Subscription Status Histogram
ggplot (bankDataCleaned, aes(x = age)) +
  geom_histogram(color = "black",
                 fill = "orange",
                 binwidth = 3) +
  facet_grid(cols = vars(y)) +
  ggtitle('Age vs Subscription') + ylab('Count') + xlab('Age') +
  scale_x_continuous(breaks = seq(0, 100, 15)) +
  geom_vline(
    data = meanAge,
    aes(xintercept = grp.mean),
    color = "red",
    linetype = "dashed"
  )
```




```r
# Education ~ Subscription Status Barplot
ggplot(data = bankDataMain.clean, aes(x = education, fill = y)) +
  geom_bar() +
  ggtitle("Term Deposit Subscription - Education Level") +
  xlab(" Education Level") +
  guides(fill = guide_legend(title = "Subscription"))
```



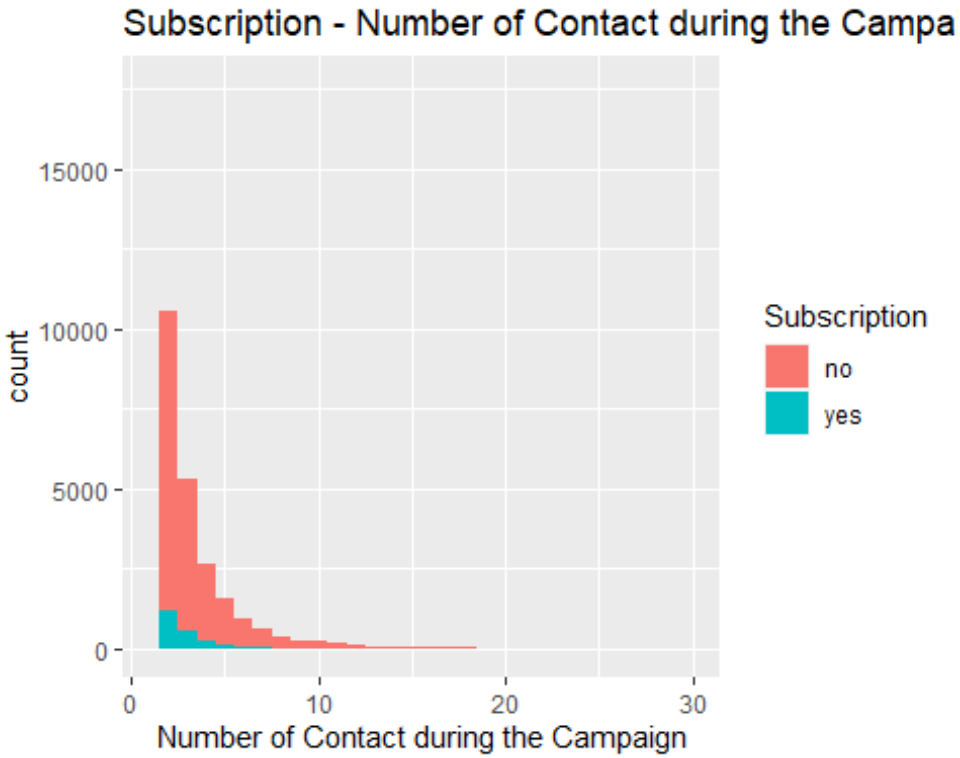

```
bankDataMain.clean %>%
  group_by(education) %>%
  summarize(pct.yes = mean(y == "yes") * 100) %>%
  arrange(desc(pct.yes))
```

```
## # A tibble: 8 x 2
##   education           pct.yes
##   <chr>                 <dbl>
## 1 illiterate            22.2
## 2 unknown               14.5
## 3 university.degree     13.7
## 4 professional.course   11.4
## 5 high.school           10.8
## 6 basic.4y              10.2
## 7 basic.6y               8.21
## 8 basic.9y               7.82
```

```
# Campaign ~ Subscription Status Histogram
ggplot(data = bankDataMain.clean, aes(x = campaign, fill = y)) +
  geom_histogram() +
  ggtitle("Subscription - Number of Contact during the Campaign") +
  xlab("Number of Contact during the Campaign") +
  xlim(c(min = 1, max = 30)) +
  guides(fill = guide_legend(title = "Subscription"))
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

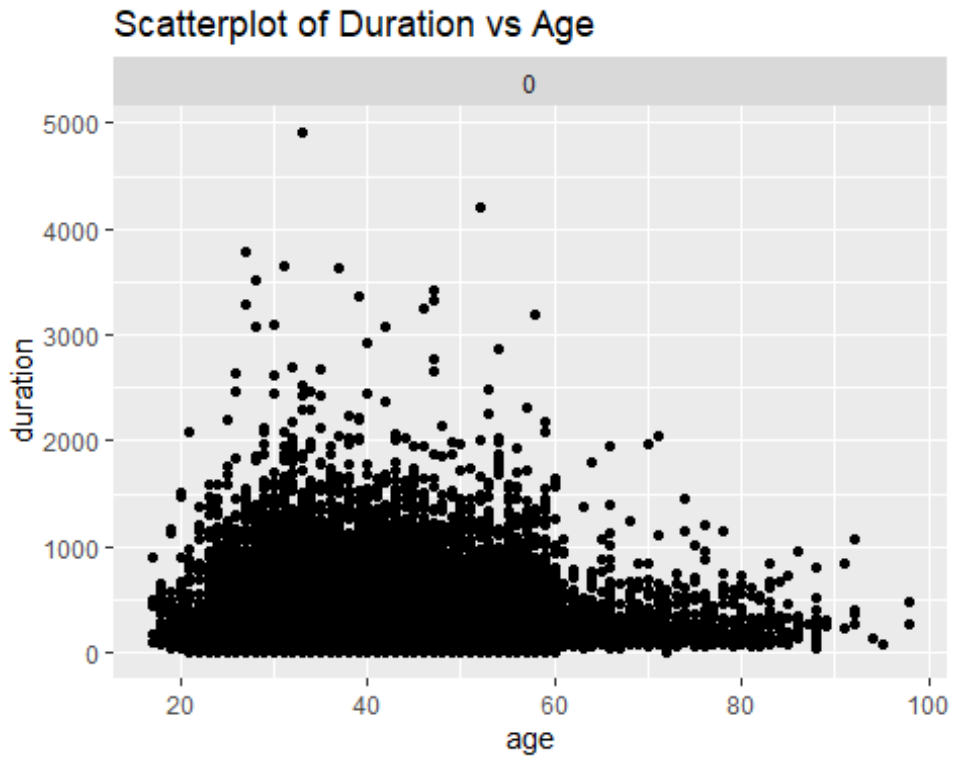
```
## Warning: Removed 33 rows containing non-finite values (stat_bin).

## Warning: Removed 4 rows containing missing values (geom_bar).
```



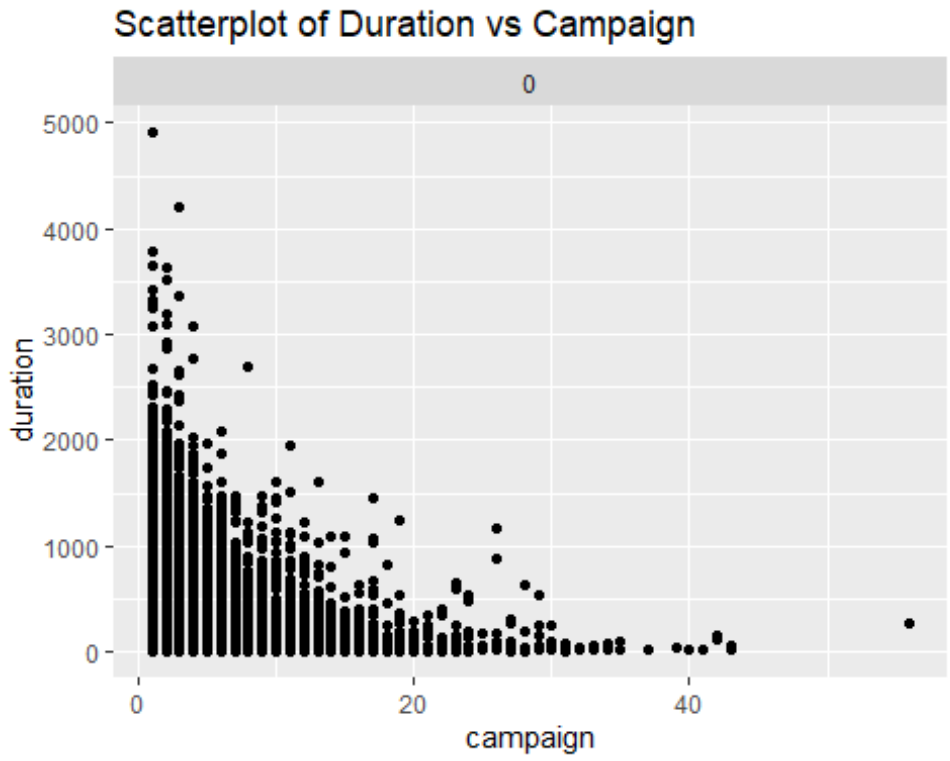

```
bankDataMain.clean %>%
  group_by(campaign) %>%
  summarize(contact.cnt = n(),
            pct.con.yes = mean(y == "yes") * 100) %>%
  arrange(desc(contact.cnt)) %>%
  head()

## # A tibble: 6 x 3
##   campaign contact.cnt pct.con.yes
##      <dbl>       <int>       <dbl>
## 1        1       17634       13.0
## 2        2       10568       11.5
## 3        3        5340       10.7
## 4        4        2650        9.40
## 5        5        1599        7.50
## 6        6         979        7.66

range(bankDataCleaned$duration)

## [1]    0 4918

summary(bankDataCleaned$duration)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     0.0   102.0   180.0   258.3   319.0  4918.0
```

```
# Age ~ Duration Status Scatterplot
ggplot(data = bankDataCleaned, aes(age, duration)) +
  geom_point() +
  facet_grid(cols = vars(y)) +
  scale_x_continuous(breaks = seq(0, 100, 20)) +
  ggtitle("Scatterplot of Duration vs Age")
```




```
# Campaign ~ Duration Status Scatterplot
bankDataCleaned %>% filter(campaign < 63) %>%
  ggplot(aes(campaign, duration)) +
  geom_point() +
  facet_grid(cols = vars(y)) +
  ggtitle("Scatterplot of Duration vs Campaign")
```




```
ageTermDeposit <-
  cor.test(as.numeric(as.factor(bankDataMain$y)),
           as.numeric(as.factor(bankDataMain$age)),
           method = "pearson")
ageTermDeposit

##
##  Pearson's product-moment correlation
##
## data:  as.numeric(as.factor(bankDataMain$y)) and as.numeric(as.factor(bank
DataMain$age))
## t = 6.16, df = 41186, p-value = 7.342e-10
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.02068781 0.03998505
## sample estimates:
##        cor
## 0.03033926

jobTermDeposit <-
  cor.test(as.numeric(as.factor(bankDataMain$y)),
           as.numeric(as.factor(bankDataMain$job)),
           method = "pearson")
jobTermDeposit

##
##  Pearson's product-moment correlation
```

```
##
## data:  as.numeric(as.factor(bankDataMain$y)) and as.numeric(as.factor(bank
DataMain$job))
## t = 5.1, df = 41186, p-value = 3.412e-07
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.01546842 0.03477124
## sample estimates:
##       cor
## 0.02512217

maritalTermDeposit <-
  cor.test(as.numeric(as.factor(bankDataMain$y)),
           as.numeric(as.factor(bankDataMain$marital)),
           method = "pearson")
maritalTermDeposit

##
##  Pearson's product-moment correlation
##
## data:  as.numeric(as.factor(bankDataMain$y)) and as.numeric(as.factor(bank
DataMain$marital))
## t = 9.3865, df = 41186, p-value < 2.2e-16
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.03656141 0.05583520
## sample estimates:
##       cor
## 0.04620261

eduTermDeposit <-
  cor.test(as.numeric(as.factor(bankDataMain$y)),
           as.numeric(as.factor(bankDataMain$education)),
           method = "pearson")
eduTermDeposit

##
##  Pearson's product-moment correlation
##
## data:  as.numeric(as.factor(bankDataMain$y)) and as.numeric(as.factor(bank
DataMain$education))
## t = 11.75, df = 41186, p-value < 2.2e-16
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.04816827 0.06741877
## sample estimates:
##       cor
## 0.05779889

housingTermDeposit <-
  cor.test(as.numeric(as.factor(bankDataMain$y)),
```

```
           as.numeric(as.factor(bankDataMain$housing)),
           method = "pearson")
housingTermDeposit

##
##  Pearson's product-moment correlation
##
## data:  as.numeric(as.factor(bankDataMain$y)) and as.numeric(as.factor(bank
DataMain$housing))
## t = 2.3445, df = 41186, p-value = 0.01906
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.00189439 0.02120683
## sample estimates:
##        cor
## 0.01155169

loanTermDeposit <-
  cor.test(as.numeric(as.factor(bankDataMain$y)),
           as.numeric(as.factor(bankDataMain$loan)),
           method = "pearson")
loanTermDeposit

##
##  Pearson's product-moment correlation
##
## data:  as.numeric(as.factor(bankDataMain$y)) and as.numeric(as.factor(bank
DataMain$loan))
## t = -0.99618, df = 41186, p-value = 0.3192
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.014565410  0.004749139
## sample estimates:
##          cor
## -0.004908593

housingLoanTermDeposit <-
  cor.test(as.numeric(as.factor(bankDataMain$y)),
           as.numeric(as.factor(bankDataMain$housing)) +
             as.numeric(as.factor(bankDataMain$loan)),
           method = "pearson")
housingLoanTermDeposit

##
##  Pearson's product-moment correlation
##
## data:  as.numeric(as.factor(bankDataMain$y)) and as.numeric(as.factor(bank
DataMain$housing)) + as.numeric(as.factor(bankDataMain$loan))
## t = 1.2733, df = 41186, p-value = 0.2029
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
```

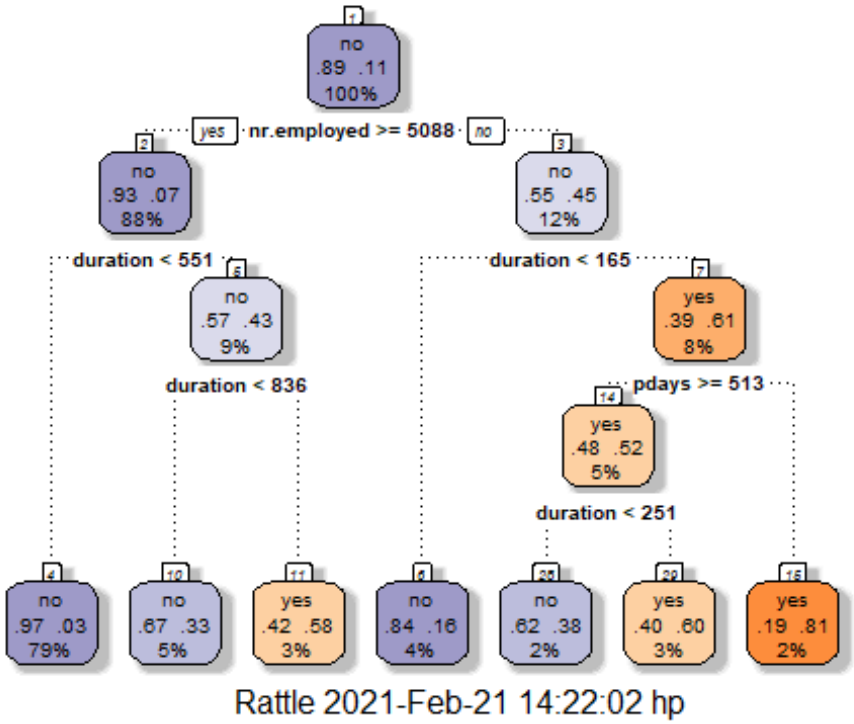
```
##  -0.003383843  0.015930411
## sample estimates:
##         cor
## 0.006273869
```

```
# Training and Testing the dataset
set.seed(12345)
sampleData <-
  sample(
    x = 1:nrow(bankDataMain),
    size = 0.8 * nrow(bankDataMain),
    replace = F
  )
sampleData
```

```
head(testData)
```

```
##    age         job marital           education default housing loan   cont
act
## 4   40      admin. married            basic.6y      no      no   no teleph
one
## 9   24  technician  single professional.course      no     yes   no teleph
one
## 10  25    services  single         high.school      no     yes   no teleph
one
## 11  41 blue-collar married             unknown unknown      no   no teleph
one
## 13  29 blue-collar  single         high.school      no      no  yes teleph
one
## 17  35 blue-collar married            basic.6y      no     yes   no teleph
one
##    month day_of_week duration campaign pdays previous    poutcome emp.var.
rate
## 4    may         mon      151        1   999        0 nonexistent
1.1
## 9    may         mon      380        1   999        0 nonexistent
1.1
## 10   may         mon       50        1   999        0 nonexistent
1.1
## 11   may         mon       55        1   999        0 nonexistent
1.1
## 13   may         mon      137        1   999        0 nonexistent
1.1
## 17   may         mon      312        1   999        0 nonexistent
1.1
##    cons.price.idx cons.conf.idx euribor3m nr.employed  y
## 4          93.994         -36.4     4.857        5191 no
```

```
## 9          93.994         -36.4     4.857        5191 no
## 10         93.994         -36.4     4.857        5191 no
## 11         93.994         -36.4     4.857        5191 no
## 13         93.994         -36.4     4.857        5191 no
## 17         93.994         -36.4     4.857        5191 no

sapply(bankDataMain, class)

##           age           job       marital     education       default
##     "numeric"   "character"   "character"   "character"   "character"
##       housing          loan       contact         month   day_of_week
##   "character"   "character"   "character"   "character"   "character"
##      duration      campaign         pdays      previous      poutcome
##     "numeric"     "numeric"     "numeric"     "numeric"   "character"
##   emp.var.rate cons.price.idx  cons.conf.idx     euribor3m   nr.employed
##     "numeric"     "numeric"     "numeric"     "numeric"     "numeric"
##             y
##   "character"

bankCART <- rpart(y ~ ., trainData , method = 'class')

par(mfrow = c(1, 1))
fancyRpartPlot(bankCART ,
               digits = 2 ,
               palettes = c("Purples", "Oranges"))
```



```r
cartPred <- predict(bankCART , testData , type = "class")
cartProb <- predict(bankCART , testData , type = "prob")

confusionMatrix(as.factor(testData$y), as.factor(cartPred))
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   no  yes
##        no  7020  295
##        yes  429  494
##
##                Accuracy : 0.9121
##                  95% CI : (0.9058, 0.9181)
##     No Information Rate : 0.9042
##     P-Value [Acc > NIR] : 0.00734
##
##                   Kappa : 0.5284
##
##  Mcnemar's Test P-Value : 7.697e-07
##
##             Sensitivity : 0.9424
##             Specificity : 0.6261
##          Pos Pred Value : 0.9597
##          Neg Pred Value : 0.5352
##              Prevalence : 0.9042
##          Detection Rate : 0.8521
##    Detection Prevalence : 0.8880
##       Balanced Accuracy : 0.7843
##
##        'Positive' Class : no
##
```

```r
CrossTable(
  testData$y,
  cartPred,
  prop.chisq = FALSE,
  prop.c = FALSE,
  prop.r = FALSE,
  dnn = c('actual default', 'predicted default')
)
```

```
##
##
##    Cell Contents
## |-------------------------|
## |                       N |
## |         N / Table Total |
## |-------------------------|
##
```

```
##
## Total Observations in Table:  8238
##
##
##                | predicted default
## actual default |        no |       yes | Row Total |
## ---------------|-----------|-----------|-----------|
##             no |      7020 |       295 |      7315 |
##                |     0.852 |     0.036 |           |
## ---------------|-----------|-----------|-----------|
##            yes |       429 |       494 |       923 |
##                |     0.052 |     0.060 |           |
## ---------------|-----------|-----------|-----------|
##   Column Total |      7449 |       789 |      8238 |
## ---------------|-----------|-----------|-----------|
##
##
```

```
bank.knn <- train(
  y ~ .,
  data = trainData,
  method = "knn",
  maximize = TRUE,
  trControl = trainControl(method = "cv", number = 10),
  preProcess = c("center", "scale")
)

predictedkNN <- predict(bank.knn , newdata = testData)
confusionMatrix(as.factor(predictedkNN) , as.factor(testData$y))
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   no  yes
##        no  7129  632
##        yes  186  291
##
##                Accuracy : 0.9007
##                  95% CI : (0.894, 0.9071)
##     No Information Rate : 0.888
##     P-Value [Acc > NIR] : 0.0001041
##
##                   Kappa : 0.3674
##
##  Mcnemar's Test P-Value : < 2.2e-16
##
##             Sensitivity : 0.9746
##             Specificity : 0.3153
##          Pos Pred Value : 0.9186
##          Neg Pred Value : 0.6101
```

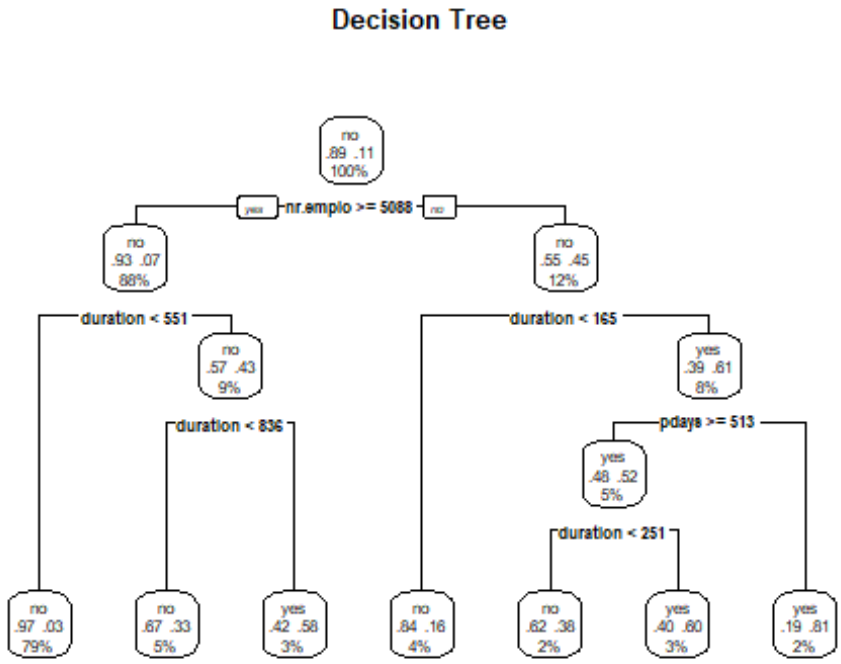
```
##              Prevalence : 0.8880
##          Detection Rate : 0.8654
##    Detection Prevalence : 0.9421
##       Balanced Accuracy : 0.6449
##
##        'Positive' Class : no
##
```

```
### Cross table validation for KNN
CrossTable(
  testData$y,
  predictedkNN,
  prop.chisq = FALSE,
  prop.c = FALSE,
  prop.r = FALSE,
  dnn = c('actual default', 'predicted default')
)
```

```
##
##
##    Cell Contents
## |-------------------------|
## |                       N |
## |         N / Table Total |
## |-------------------------|
##
##
## Total Observations in Table:  8238
##
##
##                | predicted default
## actual default |        no |       yes | Row Total |
## ---------------|-----------|-----------|-----------|
##             no |      7129 |       186 |      7315 |
##                |     0.865 |     0.023 |           |
## ---------------|-----------|-----------|-----------|
##            yes |       632 |       291 |       923 |
##                |     0.077 |     0.035 |           |
## ---------------|-----------|-----------|-----------|
##   Column Total |      7761 |       477 |      8238 |
## ---------------|-----------|-----------|-----------|
##
##
```

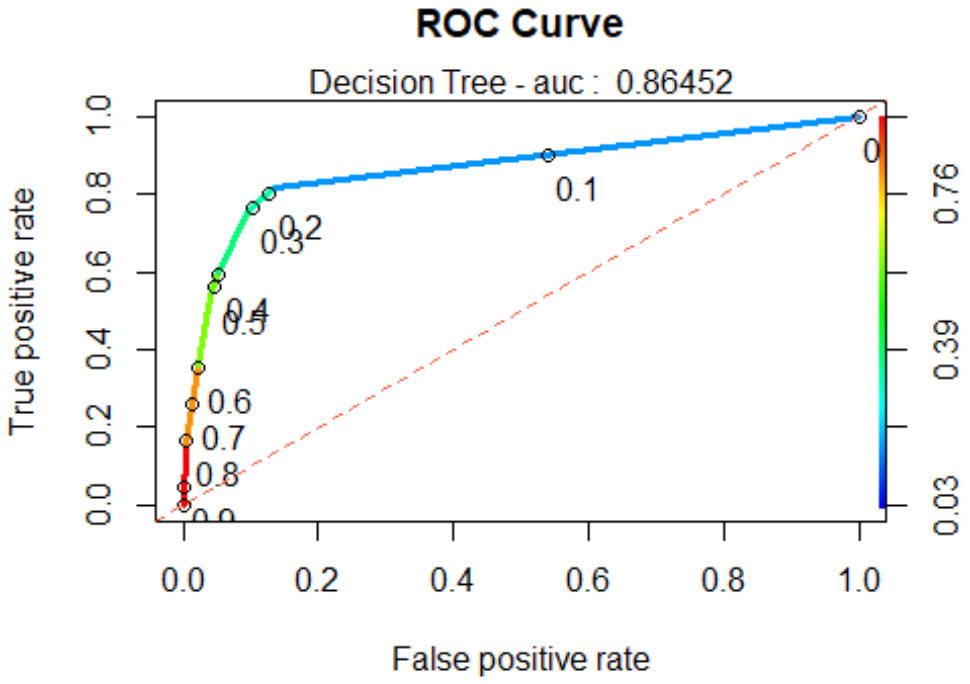
```
# fit the decision tree classification
decisionTree <-
  rpart(formula = y ~ .,
        data = trainData,
        method = "class")
```

```
# plot
prp(
  decisionTree,
  type = 2,
  extra = 104,
  fallen.leaves = TRUE,
  main = "Decision Tree"
)
```

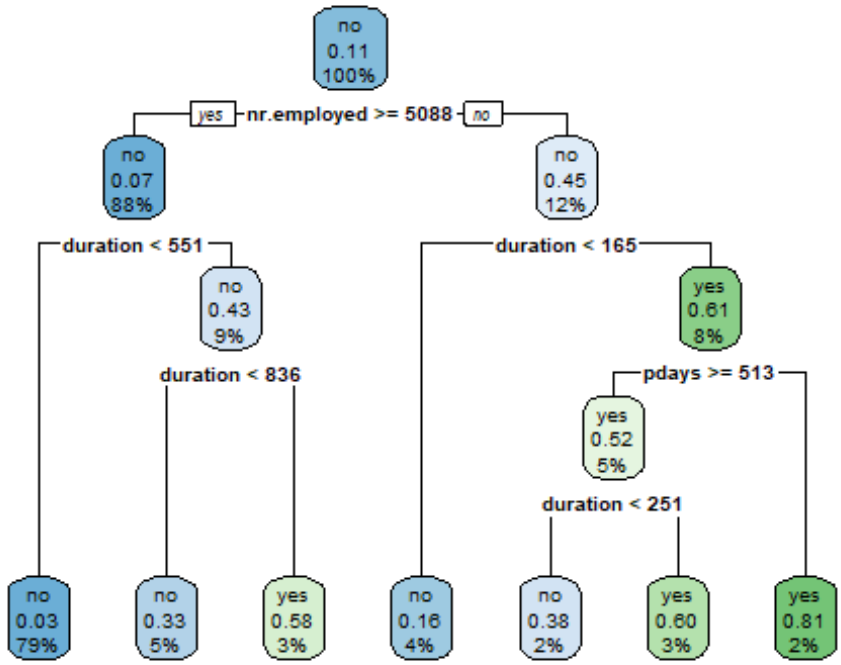



```
# predict test data by probability
pred.DT <-
  predict(decisionTree, newdata = testData[-21], type = 'prob')
pred.DT

rocr.pred <-
  prediction(predictions = pred.DT[, 2], labels = testData$y)
rocr.perf <-
  performance(rocr.pred, measure = "tpr", x.measure = "fpr")
rocr.auc <- as.numeric(performance(rocr.pred, "auc")@y.values)

# print ROC AUC
rocr.auc

## [1] 0.8645178

# plot ROC curve
plot(
```

```
  rocr.perf,
  lwd = 3,
  colorize = TRUE,
  print.cutoffs.at = seq(0, 1, by = 0.1),
  text.adj = c(-0.2, 1.7),
  main = 'ROC Curve'
)
mtext(paste('Decision Tree - auc : ', round(rocr.auc, 5)))
abline(0, 1, col = "tomato", lty = 2)
```




```
rpart.plot(decisionTree)
```




```
pred <- predict(decisionTree, testData[-21], type = "class")
confusionMatrix(as.factor(testData$y), as.factor(pred))
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   no  yes
##        no  7020  295
##        yes  429  494
##
##                Accuracy : 0.9121
##                  95% CI : (0.9058, 0.9181)
##     No Information Rate : 0.9042
##     P-Value [Acc > NIR] : 0.00734
##
##                   Kappa : 0.5284
##
##  Mcnemar's Test P-Value : 7.697e-07
##
##             Sensitivity : 0.9424
##             Specificity : 0.6261
##          Pos Pred Value : 0.9597
##          Neg Pred Value : 0.5352
##              Prevalence : 0.9042
##          Detection Rate : 0.8521
##    Detection Prevalence : 0.8880
##       Balanced Accuracy : 0.7843
```

```
##
##        'Positive' Class : no
##

# Logistic Regression Model
logRegModel <-
  glm(y ~ .,
      family = binomial(link = "logit"),
      data = bankDataCleaned)

## Warning: glm.fit: algorithm did not converge

logRegModel

##
## Call:  glm(formula = y ~ ., family = binomial(link = "logit"), data = bank
DataCleaned)
##
## Coefficients:
##                   (Intercept)                           age
##                     -2.657e+01                     4.538e-14
##                jobblue-collar                jobentrepreneur
##                     -7.872e-13                     -4.600e-13
##                   jobhousemaid                   jobmanagement
##                      1.148e-11                     -3.485e-13
##                    jobretired                jobself-employed
##                     -1.512e-12                     -2.903e-13
##                    jobservices                    jobstudent
##                     -1.037e-13                      6.082e-13
##                  jobtechnician                  jobunemployed
##                     -4.056e-14                     -1.822e-13
##                    jobunknown                  maritalmarried
##                     -6.349e-13                      7.420e-13
##                 maritalsingle                  maritalunknown
##                      8.705e-13                      1.739e-13
##             educationbasic.6y              educationbasic.9y
##                     -2.247e-12                     -2.141e-12
##          educationhigh.school            educationilliterate
##                     -2.519e-12                     -2.050e-12
## educationprofessional.course    educationuniversity.degree
##                     -2.395e-12                     -2.386e-12
##              educationunknown                defaultunknown
##                     -2.456e-12                     -1.202e-12
##                    defaultyes                housingunknown
##                      1.914e-13                     -8.029e-13
##                    housingyes                   loanunknown
##                     -6.502e-13                              NA
##                       loanyes              contacttelephone
##                     -3.491e-13                      1.622e-13
##                      monthaug                       monthdec
##                     -7.899e-13                     -1.486e-12
```

```
##                     monthjul                     monthjun
##                   -5.817e-13                   -5.461e-13
##                     monthmar                     monthmay
##                   -2.669e-13                    5.526e-13
##                     monthnov                     monthoct
##                   -9.521e-13                   -1.249e-12
##                     monthsep               day_of_weekmon
##                   -8.581e-13                    1.621e-12
##               day_of_weekthu               day_of_weektue
##                    1.083e-13                   -1.409e-13
##               day_of_weekwed                     duration
##                   -4.598e-14                    1.404e-17
##                     campaign                        pdays
##                   -7.415e-14                    7.324e-17
##                     previous          poutcomenonexistent
##                    3.624e-14                   -4.560e-15
##             poutcomesuccess                 emp.var.rate
##                   -3.429e-14                   -4.242e-13
##              cons.price.idx                cons.conf.idx
##                   -3.112e-13                   -1.384e-14
##                    euribor3m                  nr.employed
##                    1.190e-12                   -1.345e-14
##                  missingTRUE                       daymon
##                           NA                           NA
##                       daythu                       daytue
##                           NA                           NA
##                       daywed
##                           NA
##
## Degrees of Freedom: 41175 Total (i.e. Null);  41123 Residual
## Null Deviance:       0
## Residual Deviance: 2.389e-07     AIC: 106
```

```
summary(logRegModel)
```

```
##
## Call:
## glm(formula = y ~ ., family = binomial(link = "logit"), data = bankDataCle
aned)
##
## Deviance Residuals:
##        Min          1Q      Median          3Q         Max
## -2.409e-06  -2.409e-06  -2.409e-06  -2.409e-06  -2.409e-06
##
## Coefficients: (6 not defined because of singularities)
##                                Estimate Std. Error z value Pr(>|z|)
## (Intercept)                  -2.657e+01  4.306e+06       0        1
## age                           4.538e-14  2.189e+02       0        1
## jobblue-collar               -7.872e-13  6.539e+03       0        1
## jobentrepreneur              -4.600e-13  1.014e+04       0        1
```

```
## jobhousemaid                    1.148e-11  1.207e+04       0        1
## jobmanagement                  -3.485e-13  7.634e+03       0        1
## jobretired                     -1.512e-12  1.072e+04       0        1
## jobself-employed               -2.903e-13  1.018e+04       0        1
## jobservices                    -1.037e-13  7.107e+03       0        1
## jobstudent                      6.082e-13  1.331e+04       0        1
## jobtechnician                  -4.056e-14  6.297e+03       0        1
## jobunemployed                  -1.822e-13  1.188e+04       0        1
## jobunknown                     -6.349e-13  2.041e+04       0        1
## maritalmarried                  7.420e-13  5.784e+03       0        1
## maritalsingle                   8.705e-13  6.657e+03       0        1
## maritalunknown                  1.739e-13  4.027e+04       0        1
## educationbasic.6y              -2.247e-12  9.423e+03       0        1
## educationbasic.9y              -2.141e-12  7.452e+03       0        1
## educationhigh.school           -2.519e-12  7.710e+03       0        1
## educationilliterate            -2.050e-12  8.417e+04       0        1
## educationprofessional.course   -2.395e-12  8.669e+03       0        1
## educationuniversity.degree     -2.386e-12  7.868e+03       0        1
## educationunknown               -2.456e-12  1.059e+04       0        1
## defaultunknown                 -1.202e-12  4.641e+03       0        1
## defaultyes                      1.914e-13  2.057e+05       0        1
## housingunknown                 -8.029e-13  1.164e+04       0        1
## housingyes                     -6.502e-13  3.587e+03       0        1
## loanunknown                            NA         NA      NA       NA
## loanyes                        -3.491e-13  4.912e+03       0        1
## contacttelephone                1.622e-13  6.908e+03       0        1
## monthaug                       -7.899e-13  1.596e+04       0        1
## monthdec                       -1.486e-12  2.930e+04       0        1
## monthjul                       -5.817e-13  9.821e+03       0        1
## monthjun                       -5.461e-13  1.583e+04       0        1
## monthmar                       -2.669e-13  1.973e+04       0        1
## monthmay                        5.526e-13  9.260e+03       0        1
## monthnov                       -9.521e-13  1.195e+04       0        1
## monthoct                       -1.249e-12  1.848e+04       0        1
## monthsep                       -8.581e-13  2.257e+04       0        1
## day_of_weekmon                  1.621e-12  5.599e+03       0        1
## day_of_weekthu                  1.083e-13  5.586e+03       0        1
## day_of_weektue                 -1.409e-13  5.688e+03       0        1
## day_of_weekwed                 -4.598e-14  5.669e+03       0        1
## duration                        1.404e-17  6.826e+00       0        1
## campaign                       -7.415e-14  6.487e+02       0        1
## pdays                           7.324e-17  3.311e+01       0        1
## previous                        3.624e-14  8.646e+03       0        1
## poutcomenonexistent            -4.560e-15  1.157e+04       0        1
## poutcomesuccess                -3.429e-14  3.262e+04       0        1
## emp.var.rate                   -4.242e-13  1.725e+04       0        1
## cons.price.idx                 -3.112e-13  2.871e+04       0        1
## cons.conf.idx                  -1.384e-14  9.902e+02       0        1
## euribor3m                       1.190e-12  1.426e+04       0        1
## nr.employed                    -1.345e-14  3.435e+02       0        1
```

```
## missingTRUE                              NA         NA       NA       NA
## daymon                                   NA         NA       NA       NA
## daythu                                   NA         NA       NA       NA
## daytue                                   NA         NA       NA       NA
## daywed                                   NA         NA       NA       NA
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 0.0000e+00  on 41175  degrees of freedom
## Residual deviance: 2.3889e-07  on 41123  degrees of freedom
## AIC: 106
##
## Number of Fisher Scoring iterations: 25

# Probability
prob <-
  (exp(logRegModel$coefficients[1])) / (1 + exp(logRegModel$coefficients[1]))
prob

##  (Intercept)
## 2.900701e-12

# random forest
rfModel <- train(y ~ .,
                 data = trainData,
                 method = "rf",
                 ntree = 20)
# rpart.plot(rfModel)
refPred <- predict(rfModel, testData)
confusionMatrix(as.factor(testData$y), as.factor(refPred))

## Confusion Matrix and Statistics
##
##           Reference
## Prediction   no  yes
##        no  7006  309
##        yes  428  495
##
##                Accuracy : 0.9105
##                  95% CI : (0.9042, 0.9166)
##     No Information Rate : 0.9024
##     P-Value [Acc > NIR] : 0.006293
##
##                   Kappa : 0.5235
##
##  Mcnemar's Test P-Value : 1.383e-05
##
##             Sensitivity : 0.9424
##             Specificity : 0.6157
##          Pos Pred Value : 0.9578
##          Neg Pred Value : 0.5363
```

```
##              Prevalence : 0.9024
##          Detection Rate : 0.8504
##    Detection Prevalence : 0.8880
##       Balanced Accuracy : 0.7790
##
##        'Positive' Class : no
```