HEC MONTRÉAL

Projet MATH60603

Prévisions de perte de clientèle

David Garson, 11262368
Jean Guirguis, num-matricule

Projet présenté à

.Professeure Aurélie Labbé

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Note :

baggin + svm + regression linéaire

équilibrer VS non équilibré (3 méthode)

1. Introduction : présentation des objectifs de l'étude

L'objectif de cette étude est de faire une prédiction sur le désbonnemennt d'un client pour un service de télécommunication. Cette simulation a été fait à partir d'une base de données présent sur kaggle à l'adresse suivante : https://www.kaggle.com/mnassrib/telecom-churn-datasets?select=churn-bigml-80.csv. L'analyse a été effectué sur les client d'Orange Telecom aux États-Unis et plusieurs variables on été analysés tels que lieu géographique, le type de plan que le client possède, le nombre de minutes utilisé pour des appels durant le jour et le soir, etc.

Ce rapport contient en premier lieu, une présentation détaillés de notre méthode d'analyse. Cette section contiendra d'abord une exploration détaillés des données possédés, un traitement et un nettoyage préparatoire des données. Puis, plusieurs méthode et stratégie de prédiction seront testés afin de déterminer le modèle le mieux adapté à notre échantillion d'utilisateurs.

Une fois le modèle choisi, la deuxième section du rapport présentera les résultats du modèle de prédiction.

... ...

2. Méthode : présentation du design de l'étude et des différents scénarios utilisés. Présentation de la méthode d'analyse en général.

2.1. Exploration des données

2.1.1 Présentation des varaibles

2.1.2 Traitement et nettoyage préparatoire des données

3. Exploration des données

```
# Importation des données

train0=read.csv("data/churn-bigml-80.csv")
nb_ligne_train = nrow(train0)
test0=read.csv("data/churn-bigml-20.csv")
mydata = rbind(train0,test0)
id.train=c(1:nrow(train0))
id.test=c((nrow(train0)+1):(nrow(mydata)))



train= mydata[id.train,]
test = mydata[id.test,]
attributes(test)$row.names = attributes(test0)$row.names
identical(train,train0)
```

```
## [1] TRUE
```

```
identical(test,test0)
```

```
## [1] TRUE
```

```
all.equal(train,train0)
```

```
## [1] TRUE
```

```
all.equal(test,test0)
```

```
## [1] TRUE
```

```
summary(train)
```

```
##     State           Account.length    Area.code     International.plan
##  Length:2666        Min.   :  1.0   Min.   :408.0   Length:2666
##  Class :character   1st Qu.: 73.0   1st Qu.:408.0   Class :character
##  Mode  :character   Median :100.0   Median :415.0   Mode  :character
##                     Mean   :100.6   Mean   :437.4
##                     3rd Qu.:127.0   3rd Qu.:510.0
##                     Max.   :243.0   Max.   :510.0
##  Voice.mail.plan    Number.vmail.messages Total.day.minutes Total.day.calls
##  Length:2666        Min.   : 0.000        Min.   :  0.0     Min.   :  0.0
##  Class :character   1st Qu.: 0.000        1st Qu.:143.4     1st Qu.: 87.0
##  Mode  :character   Median : 0.000        Median :179.9     Median :101.0
##                     Mean   : 8.022        Mean   :179.5     Mean   :100.3
##                     3rd Qu.:19.000        3rd Qu.:215.9     3rd Qu.:114.0
##                     Max.   :50.000        Max.   :350.8     Max.   :160.0
##  Total.day.charge Total.eve.minutes Total.eve.calls Total.eve.charge
##  Min.   : 0.00    Min.   :  0.0     Min.   :  0     Min.   : 0.00
##  1st Qu.:24.38    1st Qu.:165.3     1st Qu.: 87     1st Qu.:14.05
##  Median :30.59    Median :200.9     Median :100     Median :17.08
##  Mean   :30.51    Mean   :200.4     Mean   :100     Mean   :17.03
##  3rd Qu.:36.70    3rd Qu.:235.1     3rd Qu.:114     3rd Qu.:19.98
##  Max.   :59.64    Max.   :363.7     Max.   :170     Max.   :30.91
##  Total.night.minutes Total.night.calls Total.night.charge Total.intl.minutes
##  Min.   : 43.7       Min.   : 33.0     Min.   : 1.970     Min.   : 0.00
##  1st Qu.:166.9       1st Qu.: 87.0     1st Qu.: 7.513     1st Qu.: 8.50
##  Median :201.2       Median :100.0     Median : 9.050     Median :10.20
##  Mean   :201.2       Mean   :100.1     Mean   : 9.053     Mean   :10.24
##  3rd Qu.:236.5       3rd Qu.:113.0     3rd Qu.:10.640     3rd Qu.:12.10
##  Max.   :395.0       Max.   :166.0     Max.   :17.770     Max.   :20.00
##  Total.intl.calls Total.intl.charge Customer.service.calls    Churn
##  Min.   : 0.000   Min.   :0.000     Min.   :0.000          Length:2666
##  1st Qu.: 3.000   1st Qu.:2.300     1st Qu.:1.000          Class :character
##  Median : 4.000   Median :2.750     Median :1.000          Mode  :character
##  Mean   : 4.467   Mean   :2.764     Mean   :1.563
##  3rd Qu.: 6.000   3rd Qu.:3.270     3rd Qu.:2.000
##  Max.   :20.000   Max.   :5.400     Max.   :9.000
```

3.1. Réencodage des variables “State”, “International.plan” et “Voice.mail.plan” en facteur. La variable d’intérêt est réencodée en variable logique, à savoir que les valeurs “vrai” sont codées “1” et les valeurs “faux” sont codées en 0

```
#transformation des variables "character" en "facteur"

mydata$State=as.factor(mydata$State)
mydata$International.plan=as.factor(mydata$International.plan)
mydata$Voice.mail.plan=as.factor(mydata$Voice.mail.plan)

#transformation variable d'intérêt en variable logique
mydata$Churn=as.logical(mydata$Churn)


train= mydata[id.train,]
test = mydata[id.test,]
attributes(test)$row.names = attributes(test0)$row.names
```

3.2. Étude descriptive des données

```
# fonction
analyse_table = function (nom,variable,nb_donne)
{
  table_temporaire= table(variable)
  table_temporaire = as.data.frame(table_temporaire)
  table_temporaire = data.frame(table_temporaire,pourcentage=round(table_temporaire[2]/nb_donne
  names(table_temporaire)[3] = "% Freq"
  names(table_temporaire)[1] = nom
  #table_temporaire = head(table_temporaire[order(-table_temporaire[3]),],3)
  table_temporaire = table_temporaire[order(-table_temporaire[3]),]
  return(table_temporaire)
}

analyse_table('State',train$State,nrow(train))
```

```
##    State Freq % Freq
## 50    WV   88   3.30
## 24    MN   70   2.63
## 35    NY   68   2.55
## 46    VA   67   2.51
## 2     AL   66   2.48
## 36    OH   66   2.48
## 51    WY   66   2.48
## 38    OR   62   2.33
## 34    NV   61   2.29
## 49    WI   61   2.29
## 21    MD   60   2.25
## 45    UT   60   2.25
## 6     CO   59   2.21
## 7     CT   59   2.21
## 23    MI   58   2.18
## 47    VT   57   2.14
```

```
## 14    ID   56   2.10
## 28    NC   56   2.10
## 44    TX   55   2.06
## 10    FL   54   2.03
## 16    IN   54   2.03
## 27    MT   53   1.99
## 17    KS   52   1.95
## 20    MA   52   1.95
## 37    OK   52   1.95
## 9     DE   51   1.91
## 25    MO   51   1.91
## 32    NJ   50   1.88
## 11    GA   49   1.84
## 22    ME   49   1.84
## 41    SC   49   1.84
## 42    SD   49   1.84
## 26    MS   48   1.80
## 40    RI   48   1.80
## 48    WA   48   1.80
## 3     AR   47   1.76
## 4     AZ   45   1.69
## 8     DC   45   1.69
## 15    IL   45   1.69
## 30    NE   45   1.69
## 12    HI   44   1.65
## 29    ND   44   1.65
## 33    NM   44   1.65
## 1     AK   43   1.61
## 18    KY   43   1.61
## 31    NH   43   1.61
## 43    TN   41   1.54
## 13    IA   38   1.43
## 39    PA   36   1.35
## 19    LA   35   1.31
## 5     CA   24   0.90
```

```
analyse_table('International.plan',train$International.plan,nrow(train))
```

```
##   International.plan Freq % Freq
## 1                 No 2396  89.87
## 2                Yes  270  10.13
```

```
analyse_table('Voice.mail.plan',train$Voice.mail.plan,nrow(train))
```

```
##   Voice.mail.plan Freq % Freq
## 1              No 1933  72.51
## 2             Yes  733  27.49
```

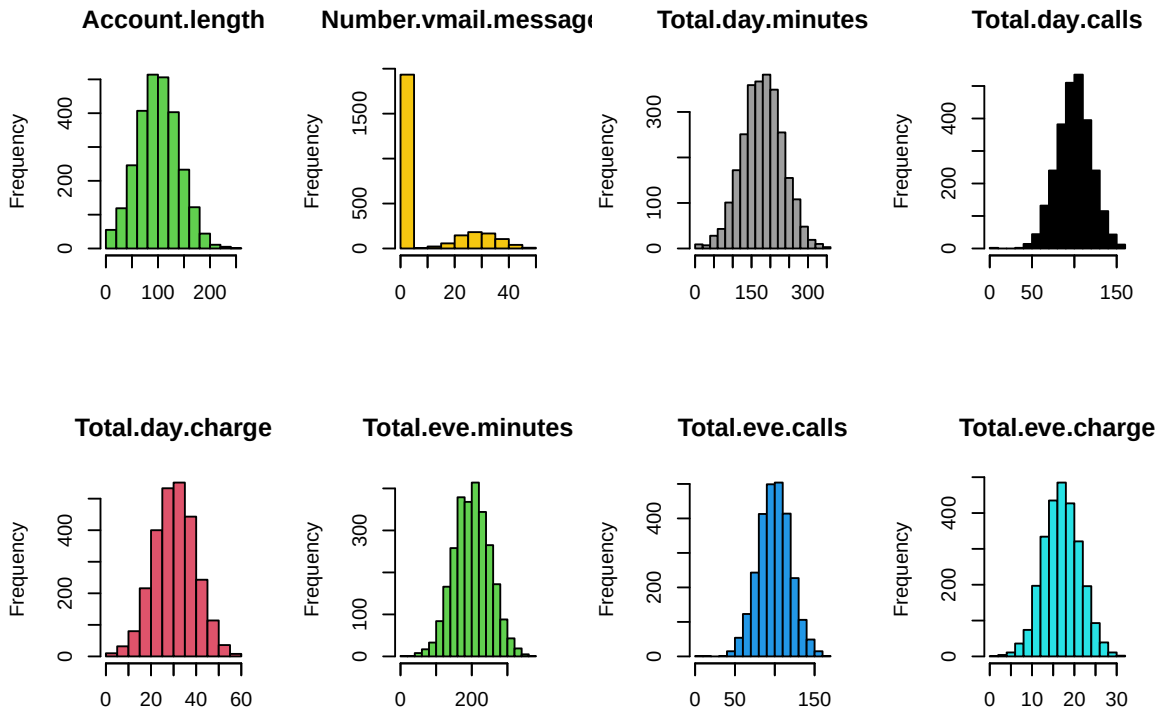
```
analyse_table('Churn',train$Churn,nrow(train))
```

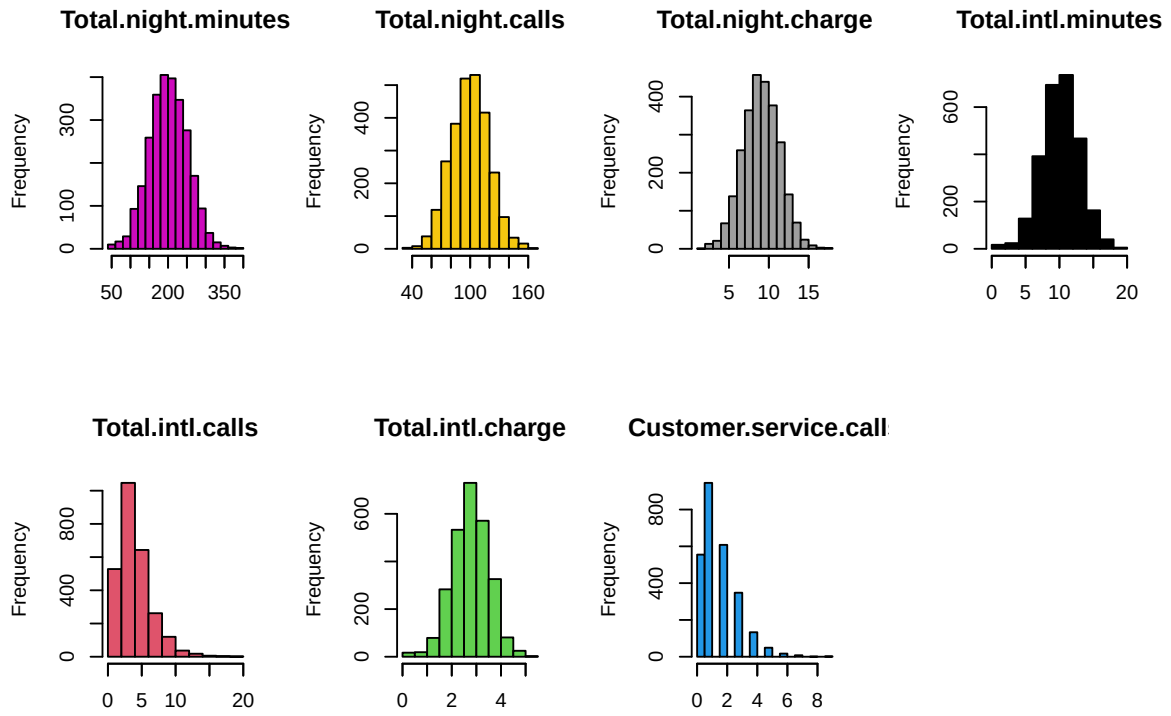
```
##   Churn Freq % Freq
## 1 FALSE 2278  85.45
## 2  TRUE  388  14.55
```

```
analyse_table('Area.code',train$Area.code,nrow(train))
```

```
##   Area.code Freq % Freq
## 2       415 1318  49.44
## 3       510  679  25.47
## 1       408  669  25.09
```

```
par(mfrow=c(2,4))
for (i in 1:length(colnames(train)))
{
  if (i != 1 & i !=3  & i != 4 & i != 5 & i !=length(colnames(train)))
  {
    hist(train[,i], main = (colnames(train)[i] ),xlab = element_blank(),col = i+1)
    Axis(side=1, labels=FALSE)
    #plot(train[,i], main = (colnames(train)[i] ))
  }
}
```





REMARQUE : Si on conserve les varialbes Customer.service.calls et total.intl,calls en variables numériques, il faudra surement prendre le log de ces variables car elles sont asymetriques à droite.!!

3.3. Analyse descriptive des données

```
summary(train)
```

```
##      State      Account.length    Area.code     International.plan
##  WV     :  88   Min.   :  1.0   Min.   :408.0   No :2396
##  MN     :  70   1st Qu.: 73.0   1st Qu.:408.0   Yes: 270
##  NY     :  68   Median :100.0   Median :415.0
##  VA     :  67   Mean   :100.6   Mean   :437.4
##  AL     :  66   3rd Qu.:127.0   3rd Qu.:510.0
##  OH     :  66   Max.   :243.0   Max.   :510.0
##  (Other):2241
##  Voice.mail.plan Number.vmail.messages Total.day.minutes Total.day.calls
##  No :1933        Min.   : 0.000        Min.   :  0.0     Min.   :  0.0
##  Yes: 733        1st Qu.: 0.000        1st Qu.:143.4     1st Qu.: 87.0
##                  Median : 0.000        Median :179.9     Median :101.0
##                  Mean   : 8.022        Mean   :179.5     Mean   :100.3
##                  3rd Qu.:19.000        3rd Qu.:215.9     3rd Qu.:114.0
##                  Max.   :50.000        Max.   :350.8     Max.   :160.0
##
##  Total.day.charge Total.eve.minutes Total.eve.calls Total.eve.charge
##  Min.   : 0.00    Min.   :  0.0     Min.   :  0     Min.   : 0.00
##  1st Qu.:24.38    1st Qu.:165.3     1st Qu.: 87     1st Qu.:14.05
##  Median :30.59    Median :200.9     Median :100     Median :17.08
```

```
##  Mean   :30.51    Mean   :200.4     Mean   :100     Mean   :17.03
##  3rd Qu.:36.70    3rd Qu.:235.1     3rd Qu.:114     3rd Qu.:19.98
##  Max.   :59.64    Max.   :363.7     Max.   :170     Max.   :30.91
##
##  Total.night.minutes Total.night.calls Total.night.charge Total.intl.minutes
##  Min.   : 43.7       Min.   : 33.0     Min.   : 1.970     Min.   : 0.00
##  1st Qu.:166.9       1st Qu.: 87.0     1st Qu.: 7.513     1st Qu.: 8.50
##  Median :201.2       Median :100.0     Median : 9.050     Median :10.20
##  Mean   :201.2       Mean   :100.1     Mean   : 9.053     Mean   :10.24
##  3rd Qu.:236.5       3rd Qu.:113.0     3rd Qu.:10.640     3rd Qu.:12.10
##  Max.   :395.0       Max.   :166.0     Max.   :17.770     Max.   :20.00
##
##  Total.intl.calls Total.intl.charge Customer.service.calls   Churn
##  Min.   : 0.000   Min.   :0.000     Min.   :0.000           Mode :logical
##  1st Qu.: 3.000   1st Qu.:2.300     1st Qu.:1.000           FALSE:2278
##  Median : 4.000   Median :2.750     Median :1.000           TRUE :388
##  Mean   : 4.467   Mean   :2.764     Mean   :1.563
##  3rd Qu.: 6.000   3rd Qu.:3.270     3rd Qu.:2.000
##  Max.   :20.000   Max.   :5.400     Max.   :9.000
##
```

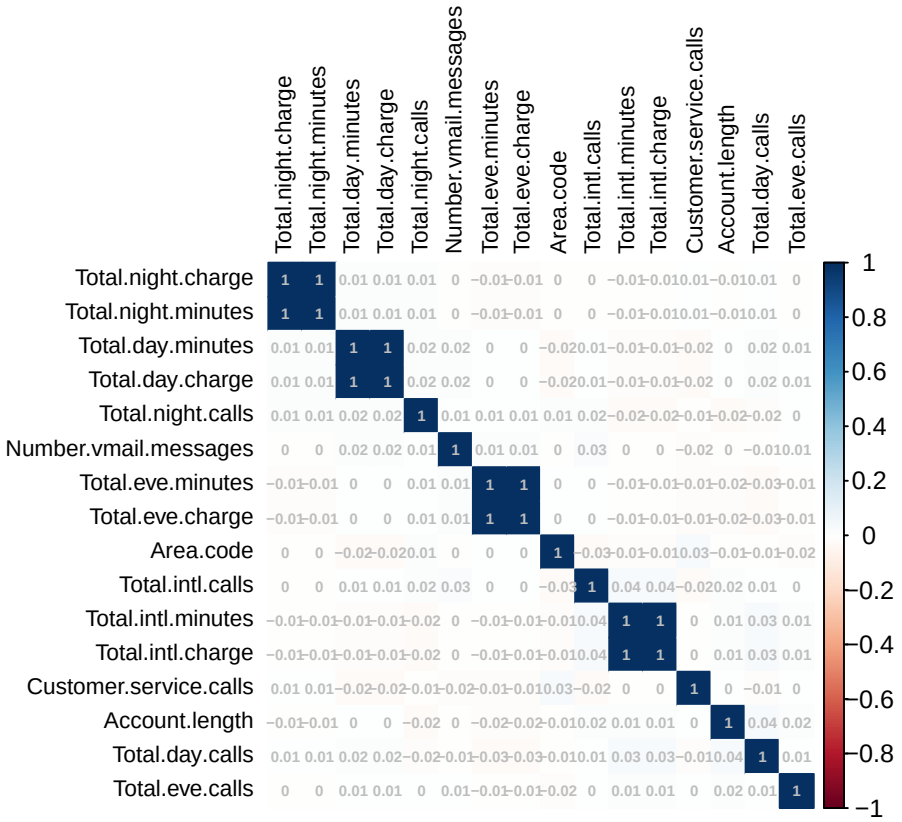
Le dataset d'entraînement ne contient aucune valeur manquante. il y a 15 variables continues, 3 variables catégorielles, et une variables binaires. (a faire avec cours chapitre 9 .... is na ....)

```
round(mean(train$Churn),digits=2)
```

```
## [1] 0.15
```

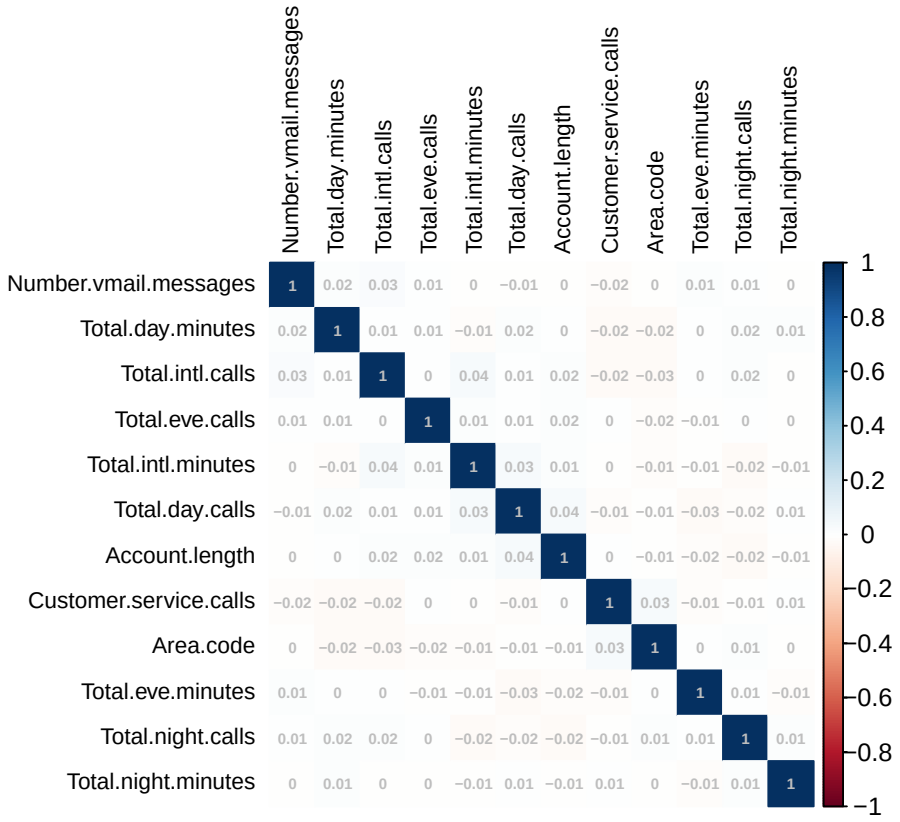
Le pourcentage de clients ayant quittés la compagnie est de 15%.

```
corrplot(cor(train[,c(2,3,6:19)]), method = "color", addCoef.col="grey", order = "AOE",tl.cex=0
```

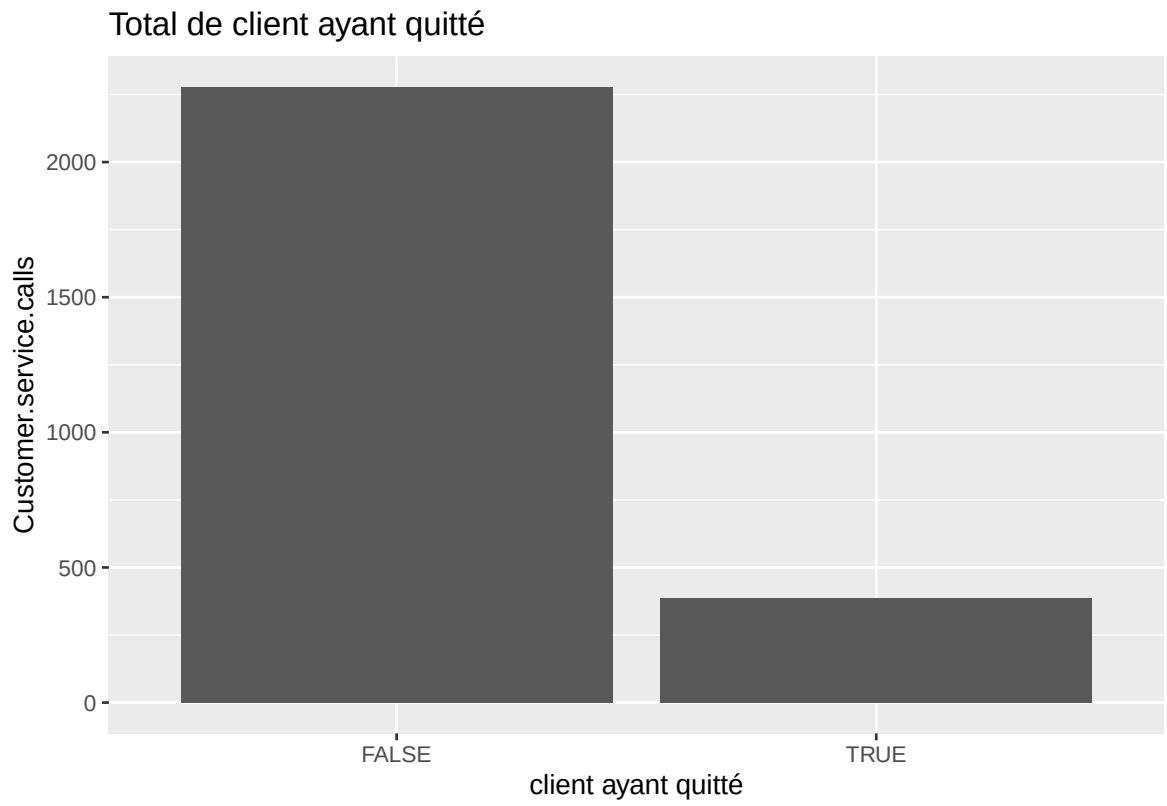


Les varaibles du dataset sont faiblement corrélées à l'exception des variables indiquant le nombre de muinutes consommés et les frais chargés associés, comme les varaibles : "Total.night charge" et "Total.night.minutes". Comme ces variables ont une corrélation parfaites, nous décidons de supprimer du dataset les variables "charge". Ce qui revient à supprimer 4 variables du dataset.

```
mydata = subset(mydata, select = -c(Total.day.charge,Total.night.charge,Total.eve.charge,Total.

train= mydata[id.train,]
test = mydata[id.test,]
attributes(test)$row.names = attributes(test0)$row.names

corrplot(cor(train[,c(2,3,6:(length(names(mydata))-1))]), method = "color", addCoef.col="grey",
```




```
library(ggplot2)
ggplot(train, aes(x = Churn, fill=Customer.service.calls)) +
  geom_bar( ) +
  xlab("client ayant quitté") + ylab("Customer.service.calls") +
  ggtitle("Total de client ayant quitté")
```




```
library(dplyr)
```

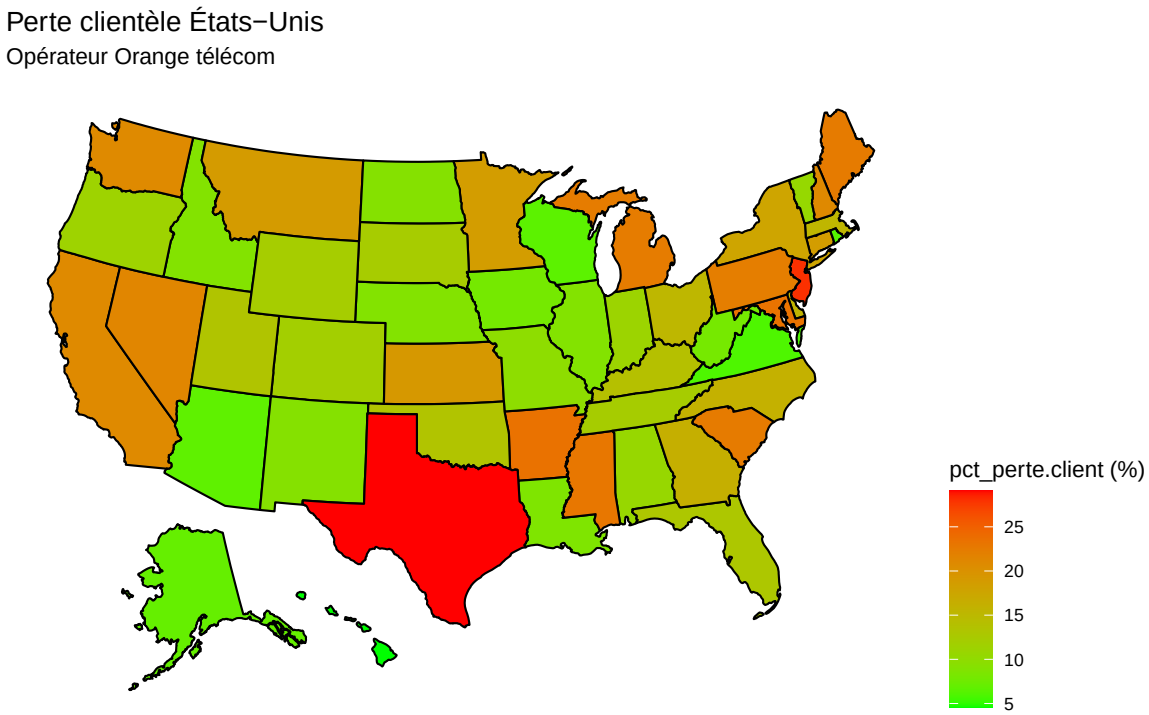
```
## Warning: package 'dplyr' was built under R version 4.0.3
```

```
library(usmap)
```

```
## Warning: package 'usmap' was built under R version 4.0.3
```

```
us.map=train
names(us.map)[names(us.map)=="State"]="state"
us.map = data.frame(us.map)

state.churn=us.map %>%
  group_by(state) %>%
  summarise(pct_perte.client = mean(Churn)*100)
```

```
us.map = data.frame(us.map)

plot_usmap(regions="state", data=state.churn, values = "pct_perte.client", color="black")+
  scale_fill_continuous(low = "green", high = "red", name = "pct_perte.client (%)")+
  labs(title = "Perte clientèle États-Unis", subtitle = "Opérateur Orange télécom")+
  theme(legend.position = "right")
```



On constate que les états du Texas et New Jersey sont les états ayant perdus le plus de clientèle, avec un pourcentage de perte supérieur à 25%.

3.4. Régression logistique (validation croisé) — a corriger la courbe roc .....

```
train = train0
test = train0

set.seed(1234)

train$Churn[train$Churn == "False"] = 0
train$Churn[train$Churn == "True"] = 1
train$Churn = as.numeric(train$Churn)

test$Churn[test$Churn == "False"] = 0
test$Churn[test$Churn == "True"] = 1
test$Churn = as.numeric(test$Churn)


model1=glm(Churn~ ., family="binomial",data=train)
summary(model1)
```

```
##
## Call:
## glm(formula = Churn ~ ., family = "binomial", data = train)
```

```
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.9878  -0.4968  -0.3075  -0.1580   3.1228
##
## Coefficients:
##                         Estimate Std. Error z value Pr(>|z|)
## (Intercept)           -8.920e+00  1.260e+00  -7.079 1.45e-12 ***
## StateAL                2.075e-01  7.925e-01   0.262  0.79346
## StateAR                8.758e-01  7.711e-01   1.136  0.25607
## StateAZ                1.406e-01  9.246e-01   0.152  0.87916
## StateCA                1.309e+00  8.860e-01   1.477  0.13969
## StateCO                3.176e-01  7.994e-01   0.397  0.69114
## StateCT                1.150e+00  7.500e-01   1.533  0.12524
## StateDC                7.592e-01  8.254e-01   0.920  0.35770
## StateDE                6.462e-01  7.753e-01   0.833  0.40463
## StateFL                5.189e-01  7.931e-01   0.654  0.51291
## StateGA                7.058e-01  7.902e-01   0.893  0.37175
## StateHI               -7.328e-01  1.002e+00  -0.731  0.46457
## StateIA                3.493e-01  9.146e-01   0.382  0.70252
## StateID                3.175e-01  8.344e-01   0.381  0.70355
## StateIL               -4.100e-01  8.949e-01  -0.458  0.64683
## StateIN                2.688e-01  8.043e-01   0.334  0.73824
## StateKS                9.024e-01  7.661e-01   1.178  0.23883
## StateKY                5.636e-01  8.182e-01   0.689  0.49096
## StateLA                5.682e-01  9.068e-01   0.627  0.53091
## StateMA                1.069e+00  7.853e-01   1.361  0.17346
## StateMD                9.575e-01  7.461e-01   1.283  0.19937
## StateME                1.375e+00  7.587e-01   1.813  0.06987 .
## StateMI                1.285e+00  7.462e-01   1.722  0.08506 .
## StateMN                1.175e+00  7.426e-01   1.583  0.11353
## StateMO                3.961e-01  8.306e-01   0.477  0.63344
## StateMS                1.505e+00  7.654e-01   1.967  0.04920 *
## StateMT                1.645e+00  7.562e-01   2.176  0.02957 *
## StateNC                2.904e-01  7.996e-01   0.363  0.71650
## StateND                2.940e-03  8.741e-01   0.003  0.99732
## StateNE                2.949e-01  8.536e-01   0.345  0.72973
## StateNH                1.305e+00  7.888e-01   1.654  0.09811 .
## StateNJ                1.398e+00  7.471e-01   1.871  0.06134 .
## StateNM                3.212e-01  8.655e-01   0.371  0.71052
## StateNV                1.040e+00  7.450e-01   1.395  0.16289
## StateNY                1.111e+00  7.467e-01   1.488  0.13671
## StateOH                7.216e-01  7.650e-01   0.943  0.34559
## StateOK                5.418e-01  7.982e-01   0.679  0.49728
## StateOR                3.802e-01  7.912e-01   0.481  0.63080
## StatePA                1.244e+00  8.055e-01   1.544  0.12260
## StateRI               -9.942e-01  9.569e-01  -1.039  0.29882
## StateSC                1.726e+00  7.675e-01   2.249  0.02451 *
## StateSD                4.039e-01  8.078e-01   0.500  0.61703
## StateTN                3.497e-01  8.477e-01   0.412  0.67998
## StateTX                1.809e+00  7.353e-01   2.461  0.01386 *
## StateUT                9.522e-01  7.754e-01   1.228  0.21945
## StateVA               -6.646e-01  8.765e-01  -0.758  0.44833
## StateVT               -2.364e-01  8.448e-01  -0.280  0.77962
## StateWA                1.326e+00  7.692e-01   1.724  0.08473 .
```

```
## StateWI                -1.862e-01  8.740e-01  -0.213  0.83128
## StateWV                 2.495e-01  7.771e-01   0.321  0.74819
## StateWY                 2.085e-01  7.812e-01   0.267  0.78952
## Account.length          1.482e-03  1.630e-03   0.909  0.36343
## Area.code              -3.446e-04  1.532e-03  -0.225  0.82202
## International.planYes   2.278e+00  1.704e-01  13.373  < 2e-16 ***
## Voice.mail.planYes     -2.159e+00  6.811e-01  -3.170  0.00152 **
## Number.vmail.messages   4.076e-02  2.143e-02   1.902  0.05721 .
## Total.day.minutes      -3.491e-01  3.826e+00  -0.091  0.92729
## Total.day.calls         3.608e-03  3.246e-03   1.111  0.26643
## Total.day.charge        2.132e+00  2.251e+01   0.095  0.92455
## Total.eve.minutes       1.419e+00  1.921e+00   0.738  0.46029
## Total.eve.calls        -1.615e-03  3.220e-03  -0.501  0.61609
## Total.eve.charge       -1.662e+01  2.260e+01  -0.735  0.46223
## Total.night.minutes     4.749e-04  1.023e+00   0.000  0.99963
## Total.night.calls       1.735e-03  3.294e-03   0.527  0.59839
## Total.night.charge      5.718e-02  2.272e+01   0.003  0.99799
## Total.intl.minutes     -2.985e+00  6.178e+00  -0.483  0.62895
## Total.intl.calls       -1.228e-01  3.005e-02  -4.086 4.38e-05 ***
## Total.intl.charge       1.141e+01  2.288e+01   0.499  0.61795
## Customer.service.calls  5.463e-01  4.662e-02  11.718  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 2212.2  on 2665  degrees of freedom
## Residual deviance: 1641.2  on 2597  degrees of freedom
## AIC: 1779.2
##
## Number of Fisher Scoring iterations: 6
```

```
#BIC
round(BIC(model1), digit = 2)
```

```
## [1] 2185.52
```

```
#AIC
round(model1$aic, digit = 2)
```

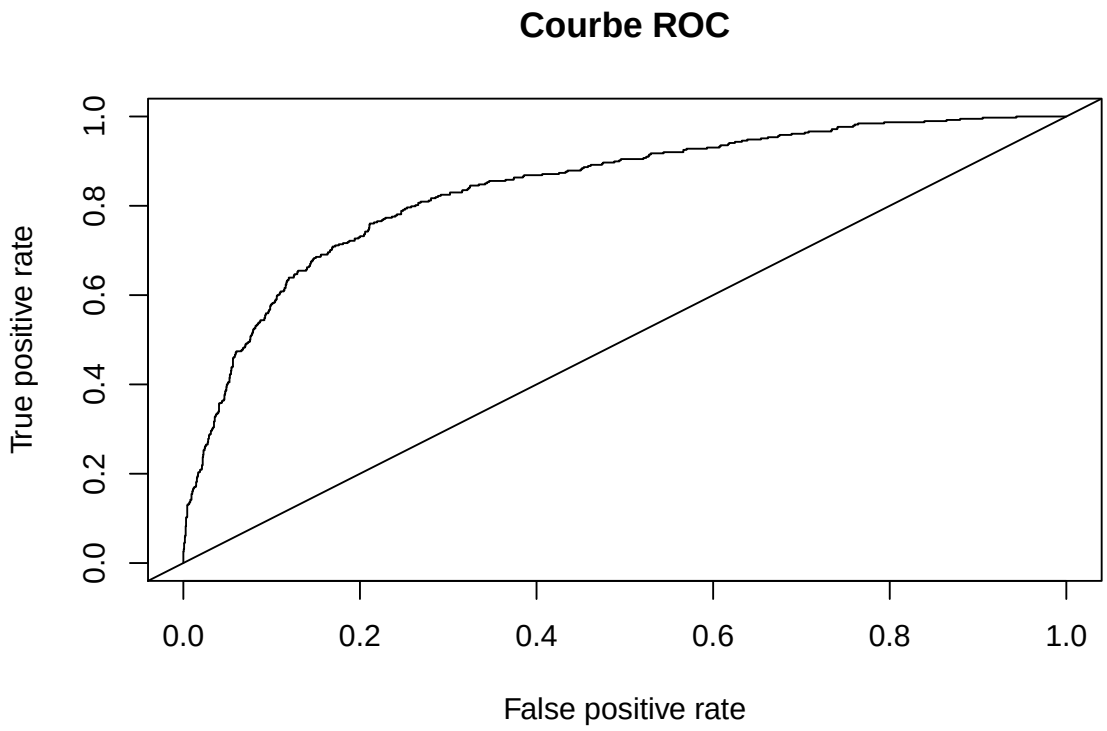
```
## [1] 1779.22
```

```
library(ROCR)
prob.predict=predict.glm(model1,test,type="response")
cutoff=0.5
test.pred = rep(0, nrow(test))
test.pred[prob.predict > cutoff] = 1
M=table(test.pred, test$Churn,dnn=c("Prediction","Observation"))

a=M[1,1]
b=M[1,2]
c=M[2,1]
d=M[2,2]
```

```r
# Sensibilité
Sensibilité = d/(b+d)

# Specificité
Specificité = a/(a+c)

# Taux d'erreures de classification (%)
((b+c)/(a+b+c+d))*100
```

```
## [1] 12.90323
```

```r
pred=prediction(prob.predict,test$Churn)
perf=performance(pred,measure="tpr",x.measure="fpr")
auc.perf = performance(pred, measure = "auc")

plot(perf, main = "Courbe ROC")
abline(a=0,b=1)
```



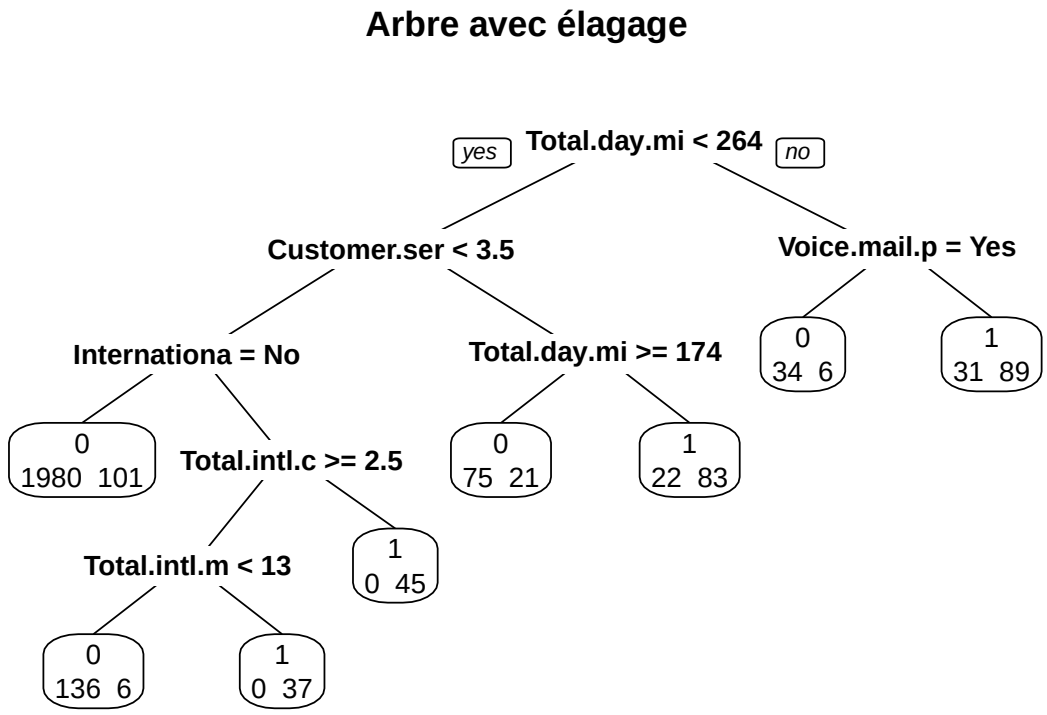
3.5. Arbre de classification élagé

```r
train = train0
test = train0

train$Churn[train$Churn == "False"] = 0
train$Churn[train$Churn == "True"] = 1
```

```
train$Churn = as.numeric(train$Churn)

test$Churn[test$Churn == "False"] = 0
test$Churn[test$Churn == "True"] = 1
test$Churn = as.numeric(test$Churn)

set.seed(400)

# Création de l'arbre :
library(rpart.plot)
```

```
## Loading required package: rpart
```

```
mytree = rpart(Churn~., data=train , method = "class")
cp_optimal=mytree$cptable[which.min(mytree$cptable[,4]),1]
mytree_optimal = prune(mytree,cp=cp_optimal)
prp(mytree_optimal,extra=1,roundint=FALSE, main = "Arbre avec élagage")
```




```
mytable=table(test$Churn, predict(mytree_optimal,test, type="class"))
names(dimnames(mytable))= c("Observed", "Predicted")
M = mytable

a=M[1,1]
b=M[1,2]
c=M[2,1]
d=M[2,2]
```

```
# Taux de mauvaises classifications
((b+c)/(a+b+c+d))*100
```

```
## [1] 7.014254
```

```
# Taux de faux positifs
round(((b+c)/(a+b+c+d))*100, digit = 2)
```

```
## [1] 7.01
```

```
# Taux faux négatif
round((1-(d/(b+d)))*100, digit = 2)
```

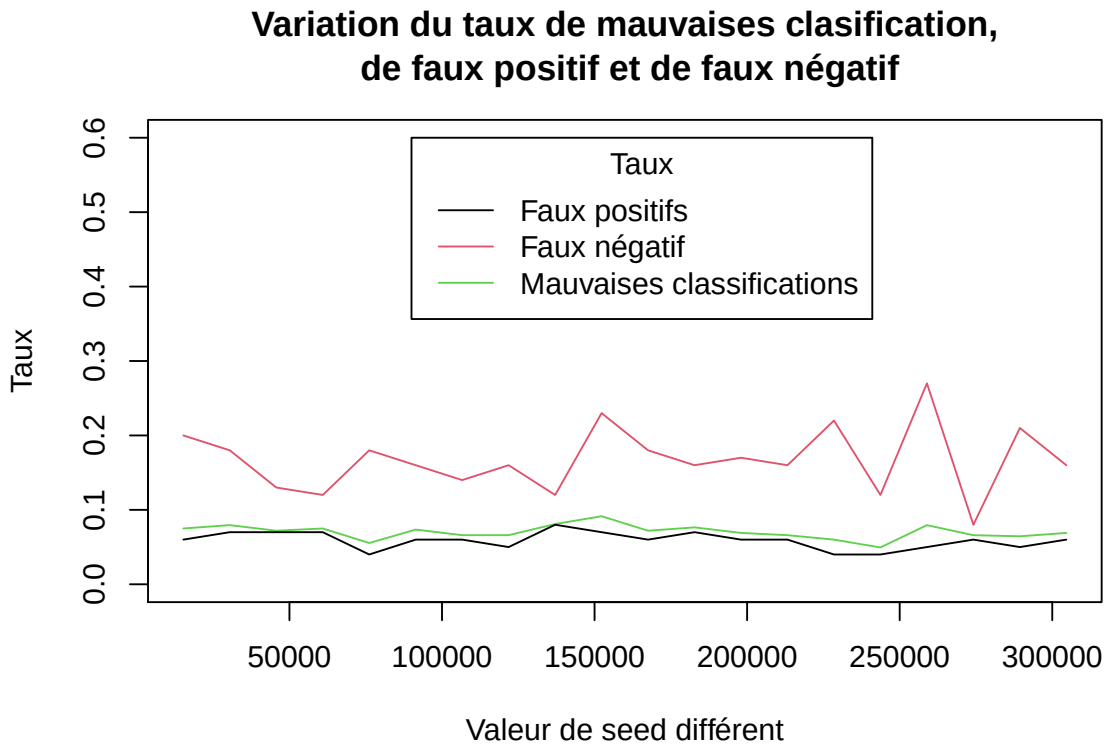
```
## [1] 17.26
```

```
# Paramètre de complexité maximale
cp_optimal
```

```
## [1] 0.02835052
```

```
# Boucle for

nb_boucle = 20

Taux_mauvaise_classificaiton=matrix(0,nb_boucle,1)
Taux_faux_positifs=matrix(0,nb_boucle,1)
Taux_faux_negatif=matrix(0,nb_boucle,1)
valeur_seed = matrix(0,nb_boucle,1)

par(mfrow=c(4,3))

for (i in 1:nb_boucle)
{
n=nrow(mydata)
set.seed(i*15231)
id.train=sample(1:n,size=nrow(train))
id.test=setdiff(1:n,id.train)

mydata.train= mydata[id.train,]
mydata.test = mydata[id.test,]

library(rpart.plot)
set.seed(i*15231)
valeur_seed[i]=i*15231

mytree = rpart(Churn~., data=mydata.train, method = "class")

cp_optimal=mytree$cptable[which.min(mytree$cptable[,4]),1]
mytree_optimal = prune(mytree,cp=cp_optimal)

#prp(mytree_optimal,extra=1,roundint=FALSE)
```

```
mytable=table(mydata.test$Churn, predict(mytree_optimal,mydata.test, type="class"))
names(dimnames(mytable))= c("Observed", "Predicted")
M = mytable

a=M[1,1]
b=M[1,2]
c=M[2,1]
d=M[2,2]

# Taux de mauvaises classificaitons
Taux_mauvaise_classificaiton[i]= ((b+c)/(a+b+c+d))
# Taux faux positifs
Taux_faux_positifs[i]= round((1-(a/(a+c))), digit = 2 )
# Taux faux négatif
Taux_faux_negatif[i] = round((1-(d/(b+d))), digit = 2)


}

par(mfrow=c(1,1))

plot(valeur_seed,Taux_mauvaise_classificaiton, type = "l", ylim= c(0,0.6), col = 3, ylab = "Taux
lines(valeur_seed,Taux_faux_positifs,col=1)
lines(valeur_seed,Taux_faux_negatif,col=2)
legend(90000, 0.6, legend=c("Faux positifs","Faux négatif","Mauvaises classifications"), col=1:3
```



```
# Taux de faux positif
## Maximum
round(max(Taux_faux_positifs), digit =2)
```

```
## [1] 0.08
```

```
## Minimum
round(min(Taux_faux_positifs), digit =2)
```

```
## [1] 0.04
```

```
# Taux de mauvaises classifications
## Maximum
round(max(Taux_mauvaise_classificaiton), digit =2 )
```

```
## [1] 0.09
```

```
## Minimum
round(min(Taux_mauvaise_classificaiton) , digit = 2)
```

```
## [1] 0.05
```

```
# Taux faux négatif
## Maximum
round(max(Taux_faux_negatif), digit = 2)
```

```
## [1] 0.27
```

```
## Minimum
round(min(Taux_faux_negatif), digit = 2)
```

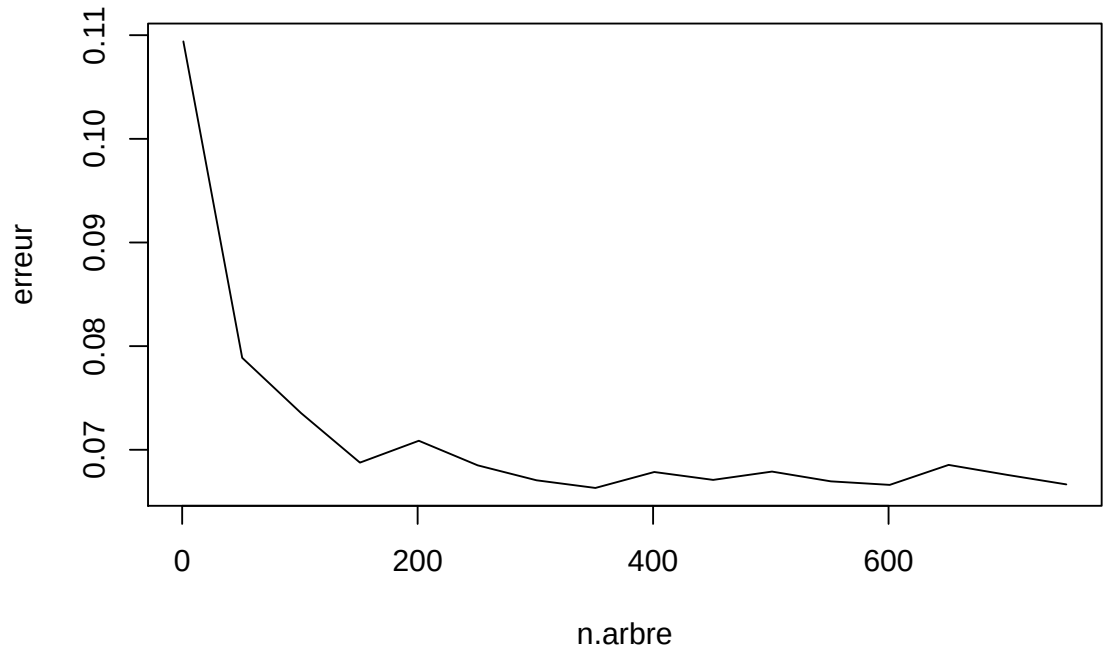
```
## [1] 0.08
```

3.6. forêt aléatoire approche bagging

```
train = train0
test = train0

train$Churn[train$Churn == "False"] = 0
train$Churn[train$Churn == "True"] = 1
train$Churn = as.numeric(train$Churn)

test$Churn[test$Churn == "False"] = 0
test$Churn[test$Churn == "True"] = 1
test$Churn = as.numeric(test$Churn)


library(randomForest)
```

```
## randomForest 4.6-14

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

##
## Attaching package: 'randomForest'

## The following object is masked from 'package:dplyr':
##
##     combine

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

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

```
mydata$Churn <- as.factor(mydata$Churn)

set.seed(1234)
n.arbre=seq(1,800,by=50)
erreur=NULL
for (i in n.arbre)
{
  rf=randomForest(Churn~.,data=mydata,ntree=i,mtry=length(colnames(mydata))-1)
  erreur=c(erreur,sum(rf$err.rate[,1])/rf$ntree)
}
plot(n.arbre, erreur,type="l")
```




```
rf=randomForest(Churn~.,data=mydata,ntree=600,mtry=length(colnames(mydata))-1)
rf
```

```
##
## Call:
##  randomForest(formula = Churn ~ ., data = mydata, ntree = 600,      mtry = length(colnames(my
##                Type of random forest: classification
##                      Number of trees: 600
## No. of variables tried at each split: 15
##
##         OOB estimate of  error rate: 6.78%
## Confusion matrix:
##       FALSE TRUE class.error
## FALSE  2759   91  0.03192982
## TRUE    135  348  0.27950311
```

```
importance(rf,type=1)
```

```
##
## State
## Account.length
## Area.code
## International.plan
## Voice.mail.plan
## Number.vmail.messages
## Total.day.minutes
## Total.day.calls
## Total.eve.minutes
```

```
## Total.eve.calls
## Total.night.minutes
## Total.night.calls
## Total.intl.minutes
## Total.intl.calls
## Customer.service.calls
```

3.7. Boosting

```
library(randomForest)
library(adabag)
```

```
## Warning: package 'adabag' was built under R version 4.0.3
```

```
## Loading required package: caret
```

```
## Loading required package: foreach
```

```
## Warning: package 'foreach' was built under R version 4.0.3
```

```
## Loading required package: doParallel
```

```
## Loading required package: iterators
```

```
## Warning: package 'iterators' was built under R version 4.0.3
```

```
## Loading required package: parallel
```

```
train = train0
test = train0

train$Churn[train$Churn == "False"] = 0
train$Churn[train$Churn == "True"] = 1
train$Churn = as.numeric(train$Churn)

test$Churn[test$Churn == "False"] = 0
test$Churn[test$Churn == "True"] = 1
test$Churn = as.numeric(test$Churn)

train$Churn=as.factor(train$Churn)
test$Churn=as.factor(test$Churn)

set.seed(1234)

# boosting with trees of depth 10
myboost=boosting(Churn~., data=train, mfinal = 100, coeflearn = 'Freund', control=rpart.control
myboost$importance
```

```
##         Account.length              Area.code Customer.service.calls
##              4.3438994              0.7133557              5.0969783
##     International.plan  Number.vmail.messages                  State
##              3.1865928              1.3572300             37.1238850
##        Total.day.calls       Total.day.charge      Total.day.minutes
##              3.6866111              0.0000000             11.8285429
##        Total.eve.calls       Total.eve.charge      Total.eve.minutes
##              3.6300543              0.0000000              7.1423496
##       Total.intl.calls      Total.intl.charge     Total.intl.minutes
##              3.8396138              0.0000000              6.2613481
##      Total.night.calls     Total.night.charge    Total.night.minutes
##              4.4219756              0.0000000              5.5826679
##        Voice.mail.plan
##              1.7848953
```

```
pred=predict(myboost, newdata=test)

pred$error
```

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

```
M=pred$confusion


#mytable=table(myboost$class,mydata$Churn)
# names(dimnames(mytable))= c("Predicted", "Observed")
# M = mytable
# M
# a=M[1,1]
# b=M[1,2]
# c=M[2,1]
# d=M[2,2]

# Taux de faux positifs
M[2,1]/(M[2,1]+M[1,1])
```

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

```
# Taux de faux négatifs
M[1,2]/(M[2,2]+M[1,2])
```

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

3.8. SVM

4. Résultats : présentation des résultats sous forme de tableaux et figures (ne mettez pas de sortie R)

5. Conclusion/discussion : conclusion générale, limites de votre étude, qu'avez vous appris ?