Untitled

Bhargav Rathod

2023-05-07

#Question 1

```
WAUS <- read.csv("Downloads/HumidPredict2023D.csv", stringsAsFactors = T)
L <- as.data.frame(c(1:49))
set.seed(32151446) # Your Student ID is the random seed
L <- L[sample(nrow(L), 10, replace = FALSE),] # sample 10 locations
WAUS <- WAUS[(WAUS$Location %in% L),]
WAUS <- WAUS[sample(nrow(WAUS), 2000, replace = FALSE),] # sample 2000 rows
```

Firstly, a sample data of 2k rows is taken

Further, using the MHT attribute values I divided the data frame to columns having it's entry value as 1 or 0, denoting whether it is more or less humid than the previous day.

Summary is used to get statistical information over each attributes

```
humid = WAUS[WAUS$MHT == 1,]
non_humid = WAUS[WAUS$MHT == 0,]

summary(humid)
```

```
##       Year         Location        MinTemp        MaxTemp     
##  Min.   :2008   Min.   : 2.00   Min.   :-6.3   Min.   : 8.30  
##  1st Qu.:2011   1st Qu.:13.00   1st Qu.: 6.7   1st Qu.:17.68  
##  Median :2013   Median :25.00   Median :10.5   Median :22.50  
##  Mean   :2014   Mean   :23.36   Mean   :11.0   Mean   :23.23  
##  3rd Qu.:2017   3rd Qu.:33.00   3rd Qu.:14.9   3rd Qu.:28.00  
##  Max.   :2019   Max.   :41.00   Max.   :27.9   Max.   :47.10  
##  NA's   :246    NA's   :237     NA's   :250    NA's   :246    
##     Rainfall        Evaporation        Sunshine       WindGustDir 
##  Min.   :  0.000   Min.   : 0.000   Min.   : 0.000   NW     : 70  
##  1st Qu.:  0.000   1st Qu.: 2.950   1st Qu.: 5.900   ENE    : 56  
##  Median :  0.000   Median : 5.400   Median : 9.100   E      : 54  
##  Mean   :  1.598   Mean   : 5.657   Mean   : 8.211   N      : 54  
##  3rd Qu.:  0.200   3rd Qu.: 8.000   3rd Qu.:11.000   W      : 54  
##  Max.   :240.000   Max.   :14.800   Max.   :13.600   (Other):422  
##  NA's   :251       NA's   :703      NA's   :739      NA's   :384  
##  WindGustSpeed     WindDir9am    WindDir3pm   WindSpeed9am    WindSpeed3pm  
##  Min.   : 9.00   NW     : 72   NW     : 99   Min.   : 0.00   Min.   : 0.00  
##  1st Qu.:31.00   N      : 59   NNW    : 69   1st Qu.: 5.00   1st Qu.:11.00  
##  Median :37.00   ENE    : 56   WNW    : 67   Median : 9.00   Median :17.00  
##  Mean   :38.94   NNW    : 55   WSW    : 65   Mean   :11.91   Mean   :17.78  
##  3rd Qu.:46.00   NE     : 54   ENE    : 64   3rd Qu.:17.00   3rd Qu.:24.00  
##  Max.   :91.00   (Other):464   (Other):469   Max.   :52.00   Max.   :56.00  
##  NA's   :380     NA's   :334   NA's   :261   NA's   :247     NA's   :248    
##   Pressure9am      Pressure3pm        Cloud9am        Cloud3pm    
##  Min.   : 991.2   Min.   : 990.1   Min.   :0.000   Min.   :0.000  
##  1st Qu.:1013.2   1st Qu.:1010.6   1st Qu.:1.000   1st Qu.:1.000  
##  Median :1017.8   Median :1015.3   Median :4.000   Median :4.000  
##  Mean   :1017.5   Mean   :1015.1   Mean   :3.918   Mean   :3.978  
##  3rd Qu.:1022.1   3rd Qu.:1020.0   3rd Qu.:7.000   3rd Qu.:7.000  
##  Max.   :1040.2   Max.   :1035.7   Max.   :8.000   Max.   :8.000  
##  NA's   :351      NA's   :356      NA's   :691     NA's   :725    
##     Temp9am          Temp3pm      RainToday     RISK_MM            MHT   
##  Min.   :-0.20   Min.   : 8.10   No  :694   Min.   : 0.000   Min.   :1  
##  1st Qu.:11.80   1st Qu.:16.57   Yes :155   1st Qu.: 0.000   1st Qu.:1  
##  Median :16.10   Median :21.25   NA's:245   Median : 0.000   Median :1  
##  Mean   :16.58   Mean   :21.90              Mean   : 1.652   Mean   :1  
##  3rd Qu.:21.30   3rd Qu.:26.50              3rd Qu.: 0.600   3rd Qu.:1  
##  Max.   :34.00   Max.   :45.20              Max.   :83.600   Max.   :1  
##  NA's   :244     NA's   :246                NA's   :245      NA's   :237
```

```
summary(non_humid)
```

```
##       Year         Location        MinTemp         MaxTemp     
##  Min.   :2008   Min.   : 2.00   Min.   :-4.60   Min.   : 7.00  
##  1st Qu.:2011   1st Qu.:13.00   1st Qu.: 6.60   1st Qu.:17.15  
##  Median :2014   Median :26.00   Median :10.80   Median :21.70  
##  Mean   :2014   Mean   :24.09   Mean   :10.92   Mean   :22.29  
##  3rd Qu.:2017   3rd Qu.:33.00   3rd Qu.:15.30   3rd Qu.:27.50  
##  Max.   :2019   Max.   :41.00   Max.   :26.40   Max.   :41.50  
##  NA's   :249    NA's   :237     NA's   :252     NA's   :248    
##     Rainfall         Evaporation         Sunshine       WindGustDir 
##  Min.   :  0.000   Min.   : 0.000   Min.   : 0.000   ENE    : 74  
##  1st Qu.:  0.000   1st Qu.: 2.250   1st Qu.: 3.800   NW     : 70  
##  Median :  0.000   Median : 4.400   Median : 7.850   SE     : 64  
##  Mean   :  2.171   Mean   : 5.005   Mean   : 7.274   W      : 63  
##  3rd Qu.:  0.800   3rd Qu.: 7.200   3rd Qu.:10.500   SW     : 61  
##  Max.   :174.600   Max.   :16.000   Max.   :14.100   (Other):452  
##  NA's   :246       NA's   :684      NA's   :719      NA's   :359  
##  WindGustSpeed    WindDir9am    WindDir3pm   WindSpeed9am    WindSpeed3pm  
##  Min.   : 6.0   N      : 69   NNW    : 89   Min.   : 0.00   Min.   : 0.00  
##  1st Qu.:31.0   ENE    : 64   NW     : 82   1st Qu.: 4.00   1st Qu.:13.00  
##  Median :37.0   NNW    : 60   WSW    : 71   Median :11.00   Median :19.00  
##  Mean   :38.3   SE     : 58   ENE    : 63   Mean   :11.51   Mean   :18.02  
##  3rd Qu.:44.0   E      : 54   SE     : 59   3rd Qu.:17.00   3rd Qu.:24.00  
##  Max.   :96.0   (Other):486   (Other):506   Max.   :46.00   Max.   :83.00  
##  NA's   :354    NA's   :352   NA's   :273   NA's   :255     NA's   :247    
##   Pressure9am    Pressure3pm        Cloud9am        Cloud3pm        Temp9am    
##  Min.   : 992   Min.   : 989.8   Min.   :0.000   Min.   :0.000   Min.   :-0.4  
##  1st Qu.:1014   1st Qu.:1011.6   1st Qu.:2.000   1st Qu.:1.500   1st Qu.:11.1  
##  Median :1018   Median :1015.8   Median :6.000   Median :5.000   Median :15.0  
##  Mean   :1018   Mean   :1015.8   Mean   :4.755   Mean   :4.396   Mean   :15.5  
##  3rd Qu.:1023   3rd Qu.:1020.5   3rd Qu.:7.000   3rd Qu.:7.000   3rd Qu.:19.9  
##  Max.   :1036   Max.   :1036.3   Max.   :8.000   Max.   :8.000   Max.   :31.6  
##  NA's   :345    NA's   :343      NA's   :694     NA's   :736     NA's   :242   
##     Temp3pm       RainToday     RISK_MM              MHT   
##  Min.   : 6.00   No  :685   Min.   :  0.000   Min.   :0  
##  1st Qu.:15.68   Yes :207   1st Qu.:  0.000   1st Qu.:0  
##  Median :20.30   NA's:251   Median :  0.000   Median :0  
##  Mean   :20.81              Mean   :  2.065   Mean   :0  
##  3rd Qu.:25.80              3rd Qu.:  0.400   3rd Qu.:0  
##  Max.   :40.90              Max.   :174.600   Max.   :0  
##  NA's   :247                NA's   :254       NA's   :237
```

observations:

1. Lower average mean value for max and min temperature, with higher rainfall average for cases predicted to have lower humidity(MHT=0) compared to higher humidity predictions (MHT=1)
2. Lower sunshine for cases having MHT=0 compared to MHT=1
3. rest of the attributes showing nearly the same characteristics
4. Quite significantly higher NANs for attributes like sunshine, cloud9am

#Question 2

Data Preprocessing

Pre Processing

Further trying to analyse how much percent of each attribute is NAN using apply function

```
#percent missing values per variable
apply(WAUS, 2, function(col)sum(is.na(col))/length(col)) * 100
```

```
##          Year      Location       MinTemp       MaxTemp      Rainfall
##          1.15          0.00          3.05          2.45          1.80
##   Evaporation      Sunshine   WindGustDir WindGustSpeed    WindDir9am
##         54.35         59.70         23.45         23.00         14.70
##    WindDir3pm  WindSpeed9am  WindSpeed3pm   Pressure9am   Pressure3pm
##         11.70          2.90          9.50         17.00         17.20
##      Cloud9am      Cloud3pm       Temp9am       Temp3pm     RainToday
##         48.95         59.55          2.00          9.30          1.80
##       RISK_MM           MHT
##          2.05         11.85
```

For getting rid of NANs I checked over which columns need ot be entirely removed in order to preserve mot of the data provided for analysis

Further I tried to find the right combination of columns which can improvise the model by trying to remove the columns with highest NANs till I received a match of 13 columns alongside MHT which preserved the need of having 10 unique locations

```
WAUS <- subset(WAUS, select = -c(Evaporation, Sunshine, Cloud9am, Cloud3pm, WindGustS
peed, WindGustDir, Pressure3pm, Pressure9am))
```

```
#percent missing values per variable
apply(WAUS, 2, function(col)sum(is.na(col))/length(col))
```

```
##         Year     Location      MinTemp      MaxTemp     Rainfall   WindDir9am
##       0.0115       0.0000       0.0305       0.0245       0.0180       0.1470
##   WindDir3pm WindSpeed9am WindSpeed3pm      Temp9am      Temp3pm    RainToday
##       0.1170       0.0290       0.0950       0.0200       0.0930       0.0180
##      RISK_MM          MHT
##       0.0205       0.1185
```

```
# to check the number of rows and cols
dim(WAUS)
```

```
## [1] 2000   14
```

Further removing NAN using na.omit

```
WAUS = na.omit(WAUS)

dim(WAUS)
```

```
## [1] 1353   14
```

checking the number of unique locations in the dataset

```
length(unique(WAUS$Location))
```

```
## [1] 10
```

Question 3

```
set.seed(32151446) #Student ID as random seed
train.row = sample(1:nrow(WAUS), 0.7*nrow(WAUS))
WAUS.train = WAUS[train.row,]
WAUS.test = WAUS[-train.row,]
```

training and testing data split

question 4, 5 and 6

(few of the methodologies adopted from
https://quantdev.ssri.psu.edu/sites/qdev/files/09_EnsembleMethods_2017_1127.html
(https://quantdev.ssri.psu.edu/sites/qdev/files/09_EnsembleMethods_2017_1127.html))

loading libraries

```
library(caret)
```

```
## Loading required package: ggplot2
```

```
## Loading required package: lattice
```

```
library(party)
```

```
## Loading required package: grid
```

```
## Loading required package: mvtnorm
```

```
## Loading required package: modeltools
```

```
## Loading required package: stats4
```

```
## Loading required package: strucchange
```

```
## Loading required package: zoo
```

```
##
## Attaching package: 'zoo'
```

```
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```
## Loading required package: sandwich
```

```r
library(ggplot2)
library(lattice)
library(zoo)
library(modeltools)
library(stats4)
library(strucchange)
library(mvtnorm)
library(sandwich)
library(pROC)
```

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

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

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

```r
library(randomForest)
```

```
## randomForest 4.7-1.1
```

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

```
##
## Attaching package: 'randomForest'
```

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

```r
library(grid)
```

The function trainControl generates parameters that further control how models are created, with possible values, which is denoted by cvcontrol variable here

It uses repeatedcv method with 10 k fold cross validation, allowing usage of parallel processing

```
#Setting the random seed for replication
set.seed(1234)

#setting up cross-validation
cvcontrol <- trainControl(method="repeatedcv", number = 10,
                          allowParallel=TRUE)
```

decision tree

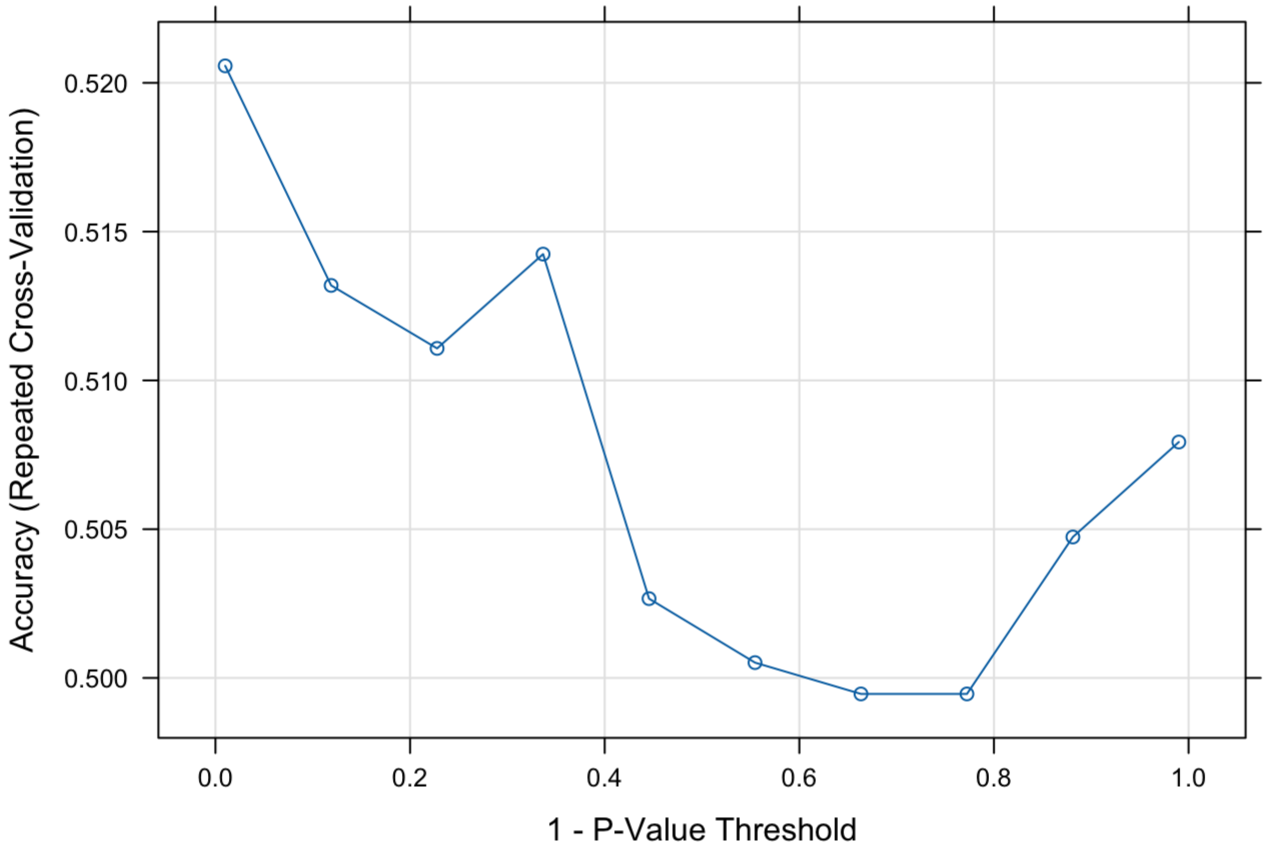
using the caret library's ctree method, based on cvcontrol having 10 k fold cross validation

```
train.tree <- train(as.factor(MHT) ~ .,
                    data=WAUS.train,
                    method="ctree",
                    trControl=cvcontrol,
                    tuneLength = 10)

train.tree
```

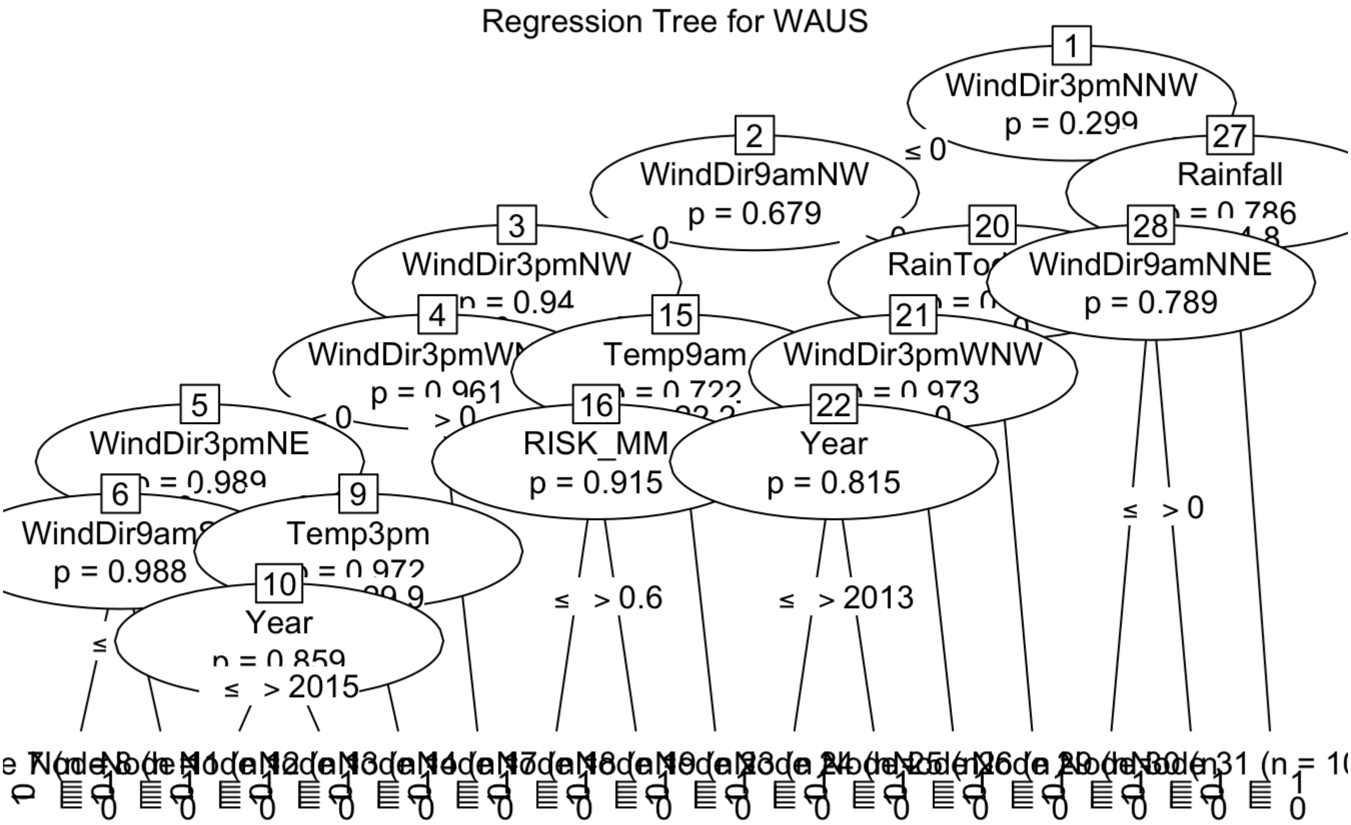
```
## Conditional Inference Tree
##
## 947 samples
##  13 predictor
##   2 classes: '0', '1'
##
## No pre-processing
## Resampling: Cross-Validated (10 fold, repeated 1 times)
## Summary of sample sizes: 852, 852, 851, 853, 852, 852, ...
## Resampling results across tuning parameters:
##
##   mincriterion  Accuracy   Kappa
##   0.0100000     0.5205716   0.035462822
##   0.1188889     0.5131920   0.017940453
##   0.2277778     0.5110755   0.016344945
##   0.3366667     0.5142441   0.024031626
##   0.4455556     0.5026652  -0.005231161
##   0.5544444     0.5005151  -0.005104550
##   0.6633333     0.4994625  -0.005172136
##   0.7722222     0.4994625  -0.008826325
##   0.8811111     0.5047371  -0.002674989
##   0.9900000     0.5079286   0.000000000
##
## Accuracy was used to select the optimal model using the largest value.
## The final value used for the model was mincriterion = 0.01.
```

making a plot over the p value to accuracy

```
plot(train.tree)
```




```
plot(train.tree$finalModel,
    main="Regression Tree for WAUS")
```



testing the model over test data using predict function

```
#obtaining class predictions
tree.classTest <-  predict(train.tree,
                         newdata = WAUS.test,
                          type="raw")
head(tree.classTest)
```

```
## [1] 0 0 0 0 0 1
## Levels: 0 1
```

evaluating the model performance using confusion matrix function of caret

```
#computing confusion matrix
confusionMatrix(as.factor(WAUS.test$MHT),tree.classTest)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 156  38
##          1 171  41
##
##                Accuracy : 0.4852
##                  95% CI : (0.4356, 0.535)
##     No Information Rate : 0.8054
##     P-Value [Acc > NIR] : 1
##
##                   Kappa : -0.0024
##
##  Mcnemar's Test P-Value : <2e-16
##
##             Sensitivity : 0.4771
##             Specificity : 0.5190
##          Pos Pred Value : 0.8041
##          Neg Pred Value : 0.1934
##              Prevalence : 0.8054
##          Detection Rate : 0.3842
##    Detection Prevalence : 0.4778
##       Balanced Accuracy : 0.4980
##
##        'Positive' Class : 0
##
```

we can observe it produced accuracy of 48.28%

obtaining probabilities of prediction

```
#Obtaining predicted probabilites for Test data
tree.probs=predict(train.tree,
                 newdata=WAUS.test,
                 type="prob")
head(tree.probs)
```

```
##           0         1
## 1 0.6153846 0.3846154
## 2 0.6338028 0.3661972
## 3 0.5268022 0.4731978
## 4 0.5268022 0.4731978
## 5 0.5268022 0.4731978
## 6 0.4035088 0.5964912
```

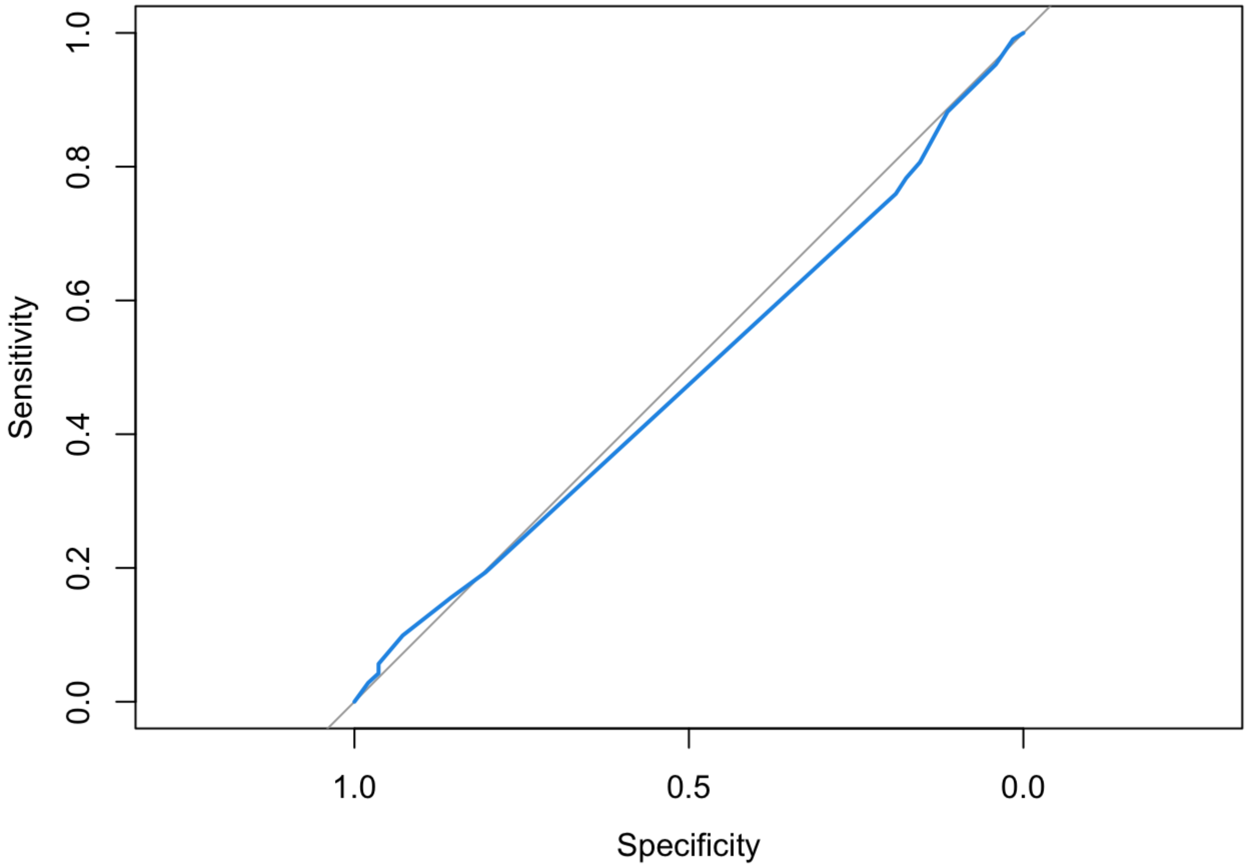
plotting the roc cure for the model

```
#Calculate ROC curve
rocCurve.tree <- roc(WAUS.test$MHT,tree.probs[,"1"])
```

```
## Setting levels: control = 0, case = 1
```

```
## Setting direction: controls < cases
```

```
#plot the ROC curve
plot(rocCurve.tree,col=c(4))
```



we can observe that the curve is downward area as the model performs bad compared to random guess

```
#getting auc area under the curve
auc(rocCurve.tree)
```

```
## Area under the curve: 0.4839
```

naive bayes

again using caret train function with nb method for naive bayes

```
library(klaR)
```

```
## Loading required package: MASS
```

```r
library(MASS)

model.knn <- train(as.factor(MHT) ~ .,
                   data=WAUS.train,
                   method="nb",
                   trControl=cvcontrol,
                   tuneLength = 10)
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 1
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 2
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 3
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 4
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 5
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 6
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 7
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 8
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 9
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 10
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 11
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 12
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 13
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 14
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 15
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 16
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 17
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 18
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 19
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 20
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 21
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 22
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 23
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 24
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 25
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 26
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 27
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 28
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 29
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 30
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 31
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 32
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 33
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 34
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 35
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 36
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 37
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 38
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 39
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 40
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 41
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 42
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 43
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 44
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 45
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 46
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 47
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 48
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 49
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 50
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 51
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 52
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 53
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 54
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 55
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 56
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 57
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 58
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 59
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 60
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 61
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 62
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 63
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 64
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 65
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 66
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 67
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 68
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 69
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 70
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 71
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 72
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 73
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 74
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 75
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 76
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 77
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 78
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 79
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 80
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 81
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 82
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 83
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 84
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 85
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 86
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 87
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 88
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 89
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 90
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 91
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 92
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 93
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 94
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 95
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 1
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 2
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 3
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 4
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 5
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 6
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 7
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 8
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 9
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 10
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 11
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 12
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 13
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 14
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 15
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 16
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 17
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 18
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 19
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 20
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 21
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 22
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 23
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 24
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 25
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 26
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 27
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 28
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 29
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 30
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 31
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 32
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 33
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 34
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 35
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 36
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 37
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 38
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 39
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 40
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 41
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 42
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 43
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 44
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 45
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 46
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 47
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 48
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 49
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 50
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 51
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 52
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 53
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 54
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 55
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 56
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 57
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 58
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 59
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 60
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 61
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 62
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 63
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 64
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 65
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 66
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 67
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 68
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 69
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 70
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 71
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 72
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 73
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 74
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 75
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 76
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 77
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 78
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 79
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 80
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 81
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 82
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 83
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 84
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 85
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 86
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 87
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 88
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 89
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 90
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 91
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 92
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 93
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 94
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 95
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 1
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 2
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 3
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 4
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 5
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 6
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 7
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 8
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 9
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 10
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 11
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 12
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 13
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 14
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 15
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 16
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 17
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 18
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 19
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 20
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 21
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 22
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 23
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 24
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 25
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 26
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 27
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 28
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 29
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 30
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 31
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 32
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 33
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 34
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 35
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 36
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 37
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 38
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 39
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 40
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 41
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 42
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 43
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 44
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 45
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 46
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 47
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 48
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 49
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 50
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 51
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 52
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 53
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 54
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 55
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 56
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 57
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 58
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 59
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 60
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 61
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 62
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 63
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 64
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 65
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 66
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 67
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 68
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 69
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 70
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 71
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 72
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 73
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 74
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 75
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 76
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 77
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 78
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 79
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 80
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 81
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 82
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 83
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 84
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 85
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 86
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 87
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 88
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 89
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 90
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 91
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 92
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 93
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 94
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 95
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 1
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 2
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 3
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 4
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 5
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 6
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 7
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 8
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 9
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 10
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 11
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 12
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 13
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 14
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 15
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 16
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 17
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 18
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 19
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 20
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 21
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 22
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 23
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 24
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 25
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 26
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 27
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 28
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 29
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 30
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 31
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 32
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 33
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 34
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 35
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 36
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 37
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 38
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 39
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 40
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 41
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 42
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 43
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 44
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 45
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 46
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 47
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 48
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 49
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 50
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 51
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 52
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 53
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 54
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 55
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 56
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 57
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 58
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 59
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 60
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 61
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 62
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 63
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 64
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 65
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 66
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 67
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 68
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 69
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 70
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 71
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 72
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 73
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 74
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 75
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 76
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 77
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 78
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 79
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 80
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 81
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 82
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 83
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 84
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 85
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 86
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 87
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 88
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 89
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 90
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 91
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 92
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 93
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 94
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 95
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 88
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 1
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 2
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 3
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 4
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 5
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 6
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 7
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 8
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 9
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 10
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 11
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 12
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 13
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 14
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 15
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 16
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 17
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 18
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 19
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 20
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 21
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 22
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 23
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 24
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 25
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 26
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 27
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 28
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 29
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 30
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 31
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 32
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 33
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 34
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 35
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 36
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 37
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 38
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 39
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 40
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 41
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 42
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 43
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 44
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 45
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 46
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 47
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 48
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 49
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 50
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 51
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 52
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 53
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 54
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 55
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 56
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 57
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 58
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 59
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 60
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 61
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 62
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 63
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 64
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 65
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 66
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 67
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 68
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 69
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 70
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 71
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 72
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 73
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 74
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 75
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 76
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 77
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 78
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 79
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 80
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 81
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 82
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 83
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 84
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 85
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 86
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 87
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 88
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 89
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 90
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 91
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 92
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 93
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 94
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 95
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 92
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 1
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 2
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 3
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 4
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 5
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 6
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 7
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 8
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 9
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 10
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 11
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 12
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 13
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 14
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 15
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 16
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 17
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 18
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 19
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 20
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 21
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 22
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 23
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 24
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 25
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 26
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 27
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 28
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 29
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 30
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 31
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 32
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 33
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 34
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 35
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 36
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 37
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 38
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 39
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 40
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 41
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 42
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 43
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 44
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 45
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 46
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 47
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 48
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 49
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 50
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 51
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 52
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 53
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 54
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 55
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 56
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 57
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 58
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 59
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 60
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 61
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 62
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 63
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 64
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 65
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 66
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 67
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 68
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 69
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 70
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 71
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 72
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 73
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 74
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 75
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 76
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 77
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 78
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 80
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 81
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 82
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 83
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 84
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 85
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 86
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 87
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 88
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 89
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 90
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 91
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 92
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 93
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 94
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 95
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 1
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 2
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 3
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 4
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 5
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 6
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 7
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 8
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 9
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 10
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 11
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 12
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 13
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 14
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 15
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 16
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 17
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 18
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 19
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 20
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 21
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 22
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 23
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 24
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 25
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 26
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 27
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 28
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 29
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 30
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 31
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 32
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 33
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 34
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 35
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 36
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 37
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 38
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 39
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 40
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 41
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 42
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 43
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 44
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 45
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 46
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 47
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 48
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 49
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 50
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 51
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 52
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 53
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 54
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 55
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 56
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 57
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 58
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 59
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 60
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 61
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 62
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 63
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 64
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 65
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 66
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 67
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 68
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 69
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 70
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 71
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 72
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 73
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 74
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 75
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 76
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 77
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 78
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 79
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 80
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 81
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 82
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 83
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 84
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 85
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 86
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 87
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 88
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 89
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 90
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 91
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 92
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 93
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 94
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 76
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 1
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 2
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 3
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 4
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 5
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 6
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 7
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 8
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 9
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 10
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 11
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 12
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 13
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 14
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 15
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 16
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 17
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 18
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 19
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 20
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 21
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 22
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 23
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 24
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 25
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 26
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 27
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 28
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 29
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 30
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 31
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 32
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 33
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 34
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 35
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 36
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 37
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 38
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 39
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 40
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 41
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 42
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 43
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 44
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 45
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 46
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 47
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 48
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 49
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 50
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 51
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 52
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 53
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 54
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 55
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 56
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 57
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 59
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 60
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 61
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 62
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 63
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 64
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 65
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 66
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 67
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 68
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 69
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 70
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 71
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 72
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 73
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 74
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 75
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 76
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 77
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 78
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 79
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 80
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 81
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 82
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 83
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 84
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 85
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 86
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 87
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 88
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 89
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 90
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 91
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 92
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 93
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 94
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 95
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 34
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 1
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 2
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 3
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 4
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 5
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 6
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 7
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 8
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 9
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 10
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 11
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 12
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 13
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 14
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 15
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 16
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 17
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 18
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 19
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 20
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 21
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 22
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 24
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 25
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 26
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 27
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 28
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 29
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 30
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 31
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 32
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 33
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 34
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 35
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 36
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 37
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 38
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 39
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 40
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 41
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 42
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 43
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 44
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 45
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 46
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 47
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 48
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 49
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 50
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 51
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 52
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 53
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 54
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 55
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 56
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 57
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 58
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 59
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 60
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 61
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 62
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 63
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 64
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 65
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 66
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 67
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 68
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 69
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 70
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 71
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 72
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 73
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 74
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 75
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 76
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 77
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 78
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 79
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 80
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 81
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 82
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 83
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 84
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 85
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 86
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 87
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 88
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 89
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 90
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 91
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 92
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 93
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 94
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 1
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 2
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 3
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 4
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 5
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 6
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 7
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 8
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 9
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 10
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 11
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 12
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 13
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 14
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 15
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 16
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 17
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 18
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 19
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 20
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 21
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 22
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 23
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 24
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 25
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 26
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 27
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 28
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 29
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 30
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 31
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 32
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 33
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 34
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 35
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 36
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 37
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 38
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 39
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 40
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 41
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 42
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 43
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 44
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 45
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 46
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 47
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 48
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 49
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 50
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 51
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 52
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 53
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 54
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 55
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 56
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 57
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 58
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 59
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 60
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 61
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 62
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 63
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 64
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 65
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 66
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 67
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 68
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 69
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 70
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 71
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 72
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 73
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 74
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 75
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 76
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 77
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 78
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 79
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 80
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 81
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 82
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 83
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 84
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 85
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 86
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 87
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 88
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 89
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 90
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 91
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 92
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 93
```

```
## Warning in FUN(X[[i]], ...): Numerical 0 probability for all classes with
## observation 94
```

```
model.knn
```

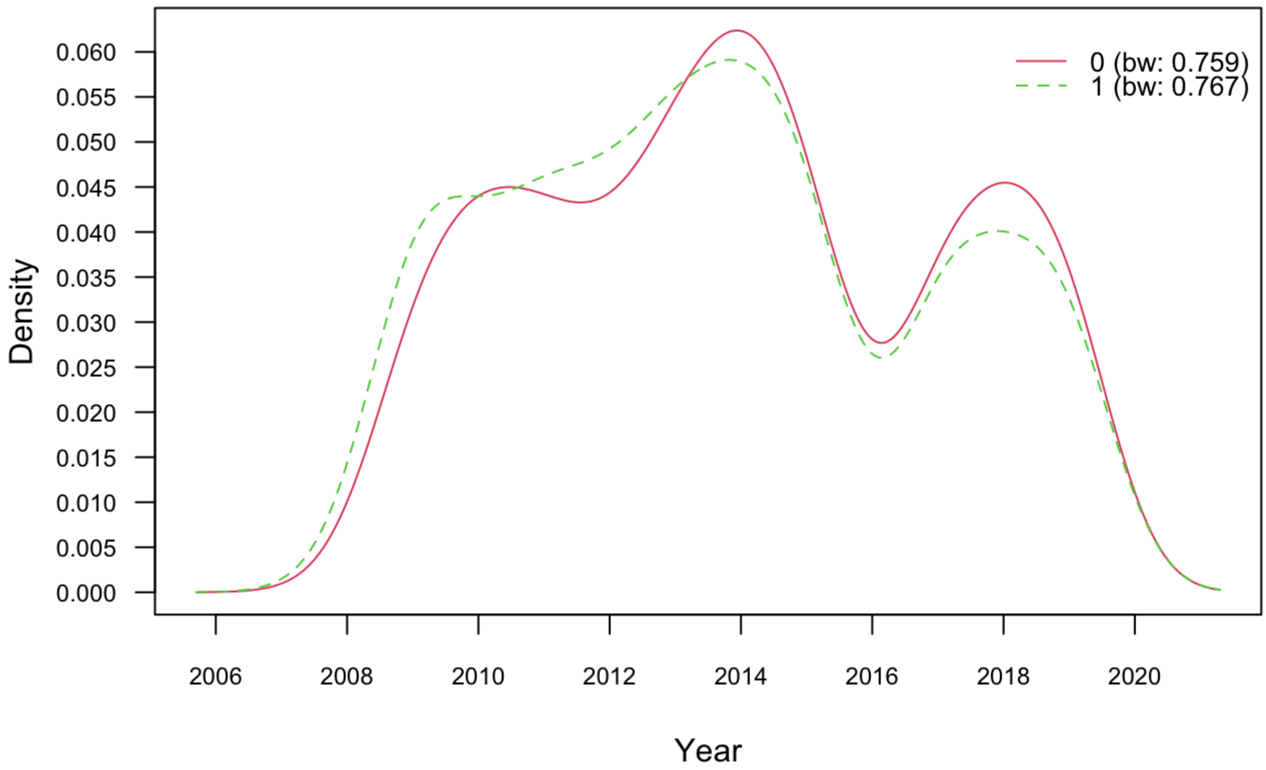
```
## Naive Bayes
##
## 947 samples
##  13 predictor
##   2 classes: '0', '1'
##
## No pre-processing
## Resampling: Cross-Validated (10 fold, repeated 1 times)
## Summary of sample sizes: 852, 852, 852, 852, 852, 852, ...
## Resampling results across tuning parameters:
##
##   usekernel  Accuracy   Kappa
##   FALSE      0.5227324  0.0479142
##    TRUE      0.5555095  0.1137682
##
## Tuning parameter 'fL' was held constant at a value of 0
## Tuning
##  parameter 'adjust' was held constant at a value of 1
## Accuracy was used to select the optimal model using the largest value.
## The final values used for the model were fL = 0, usekernel = TRUE and adjust
##  = 1.
```

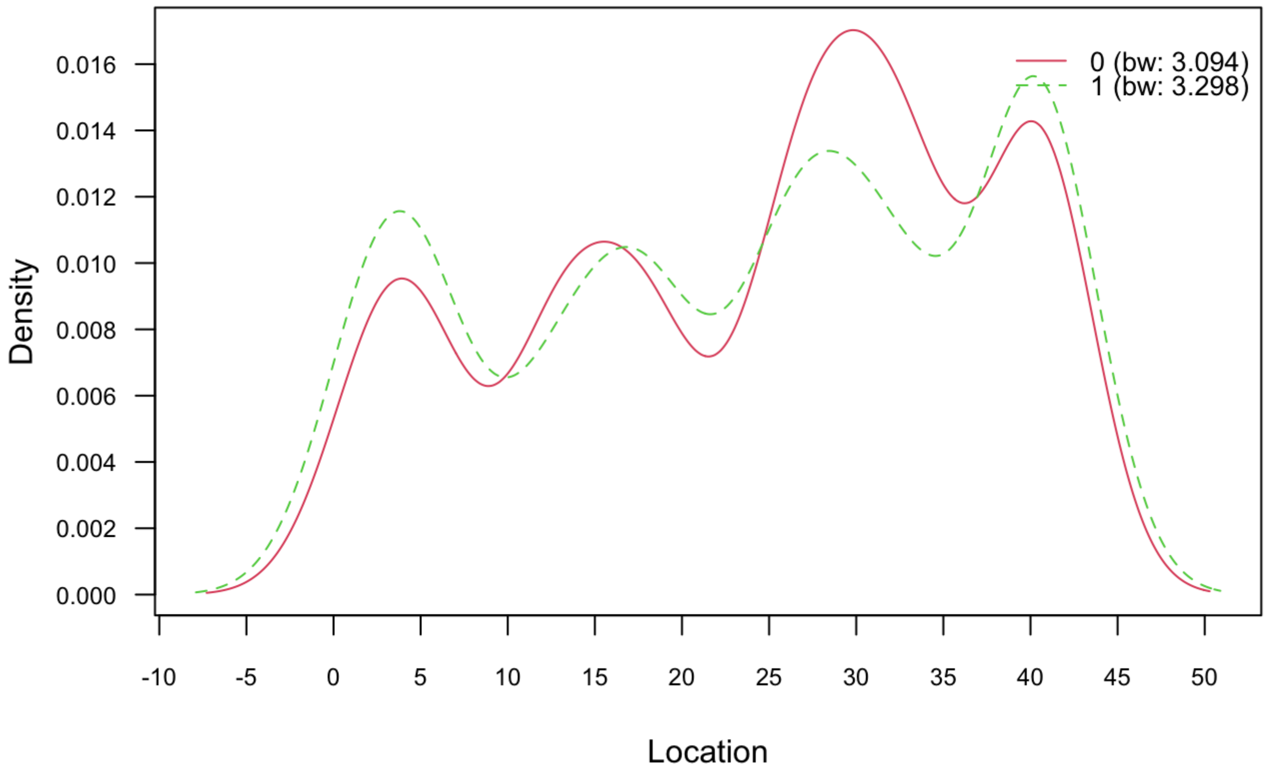
testing the model using class type using predict function

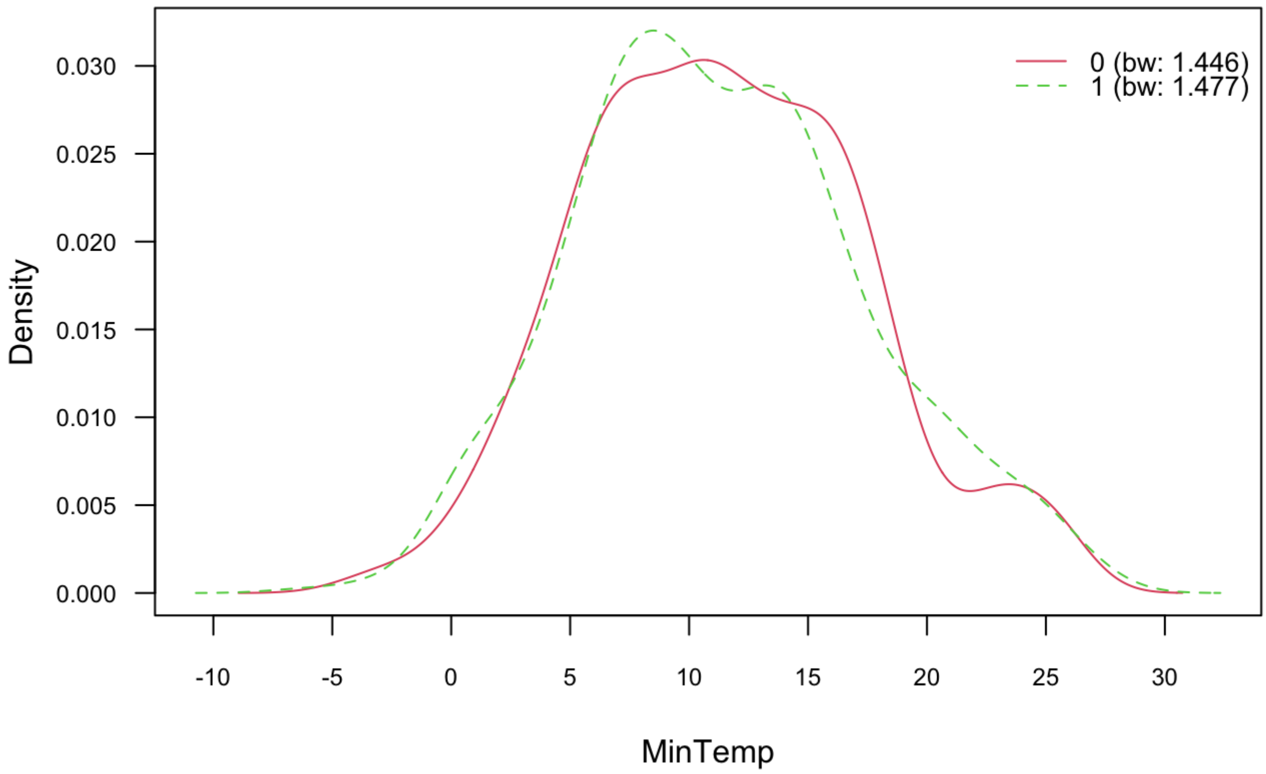
```
library(naivebayes)
```

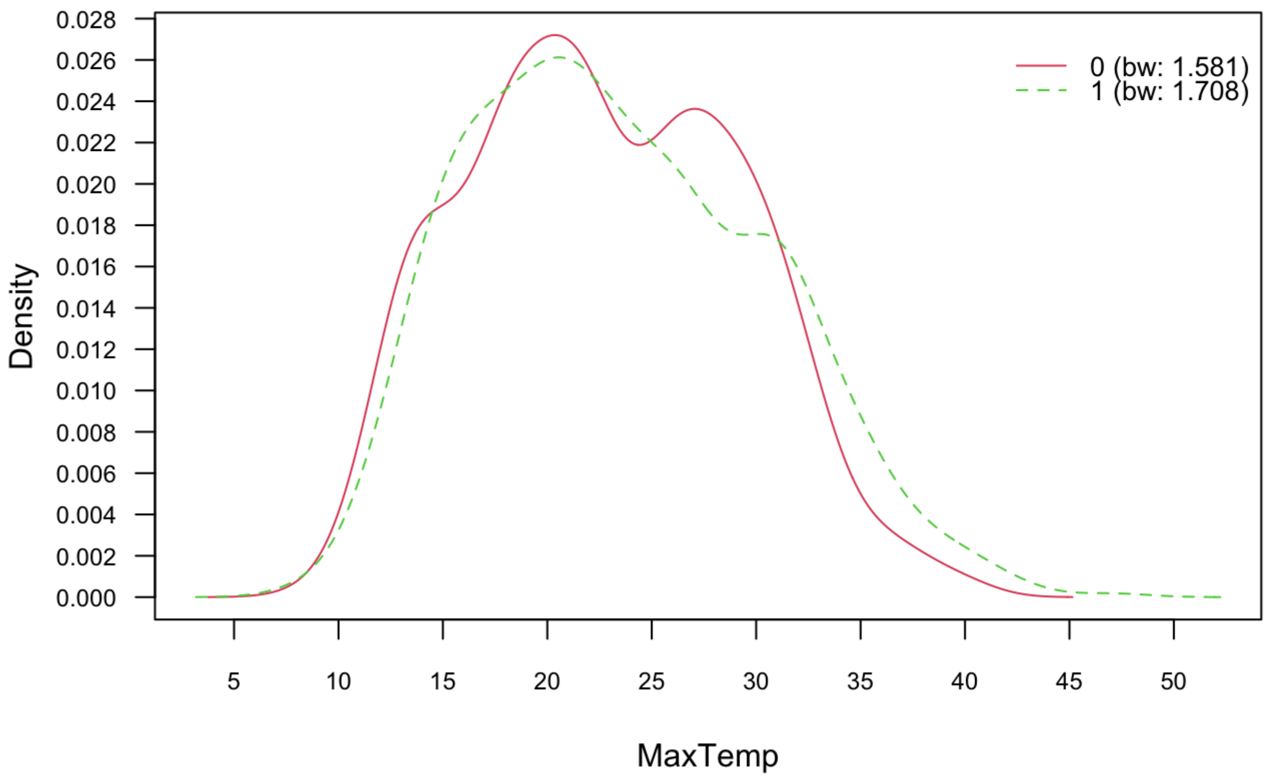
```
## naivebayes 0.9.7 loaded
```

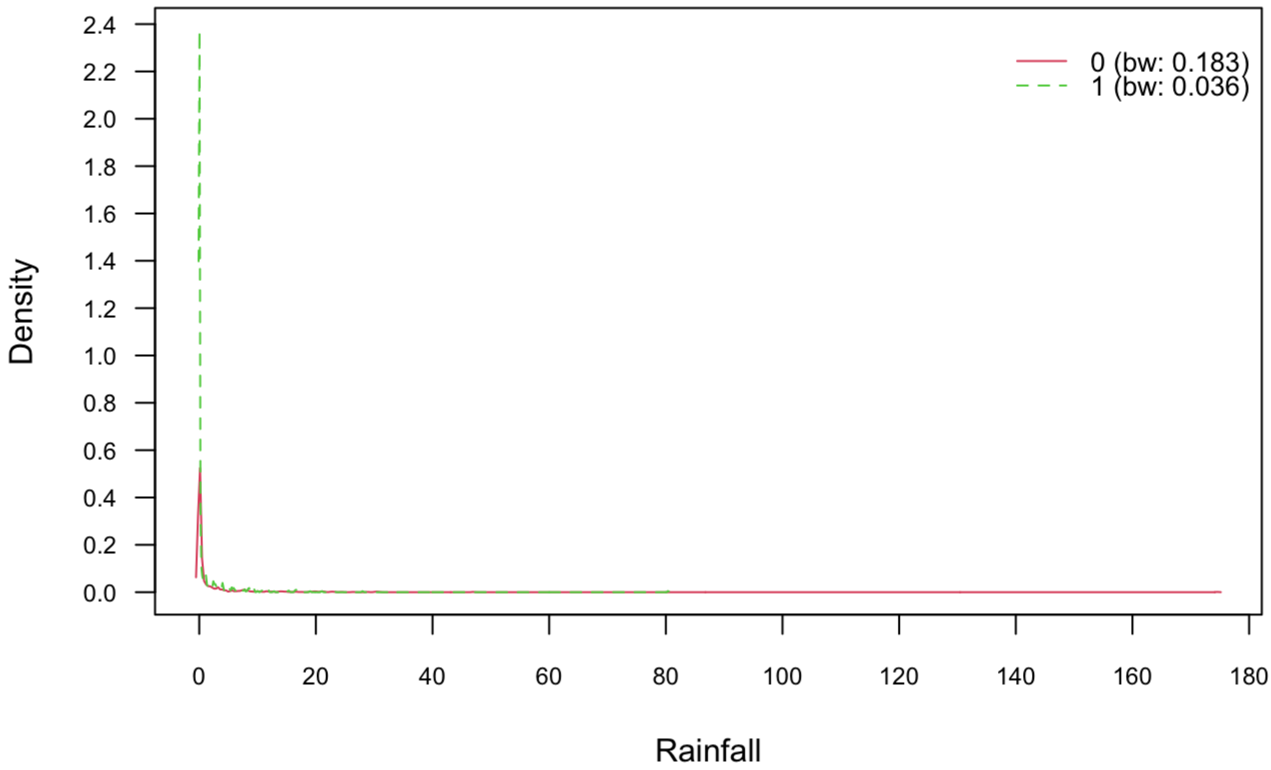
```
model.knn <- naive_bayes(as.factor(MHT) ~ ., data = WAUS, usekernel = T)
plot(model.knn)
```

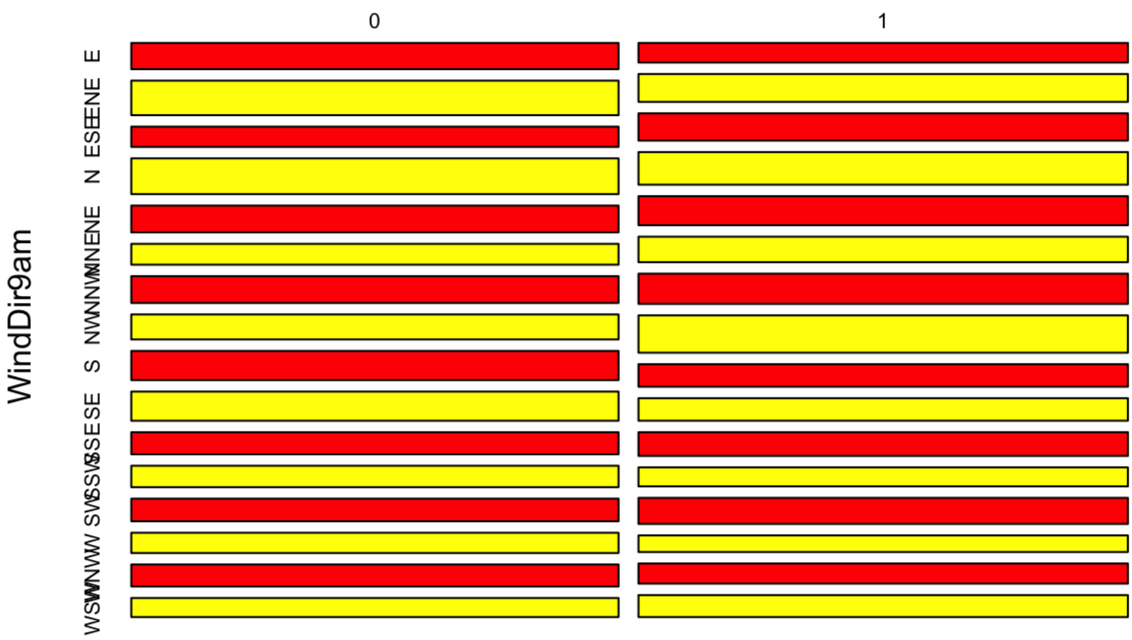

0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Density
2006
2008
2010
2012
2014
2016
2018
2020
Year
0 (bw: 0.759)
1 (bw: 0.767)

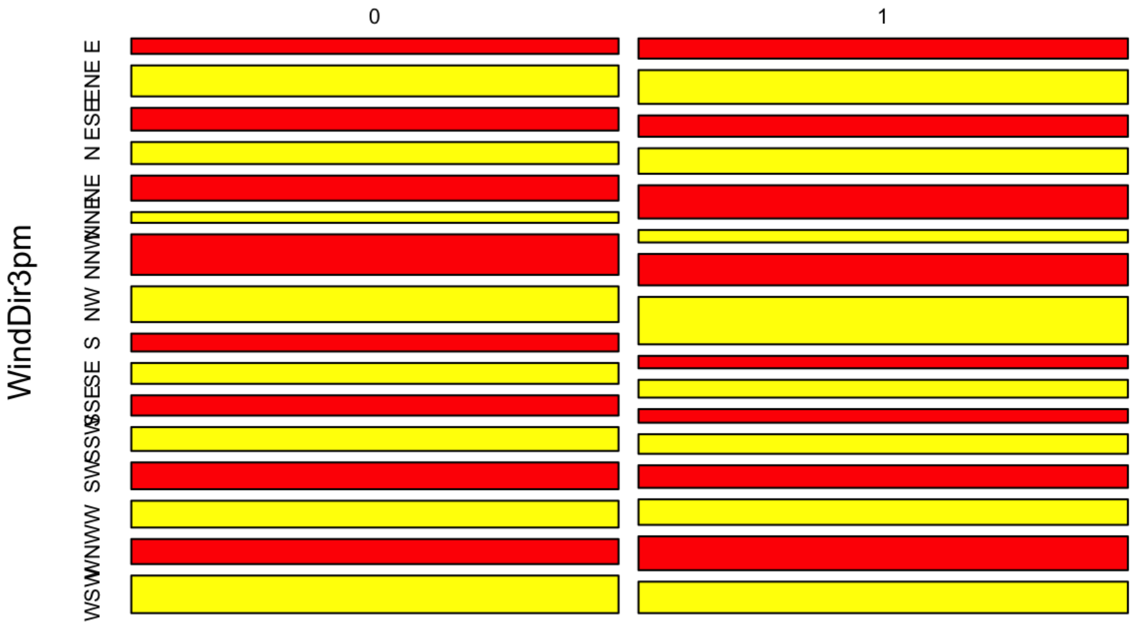

0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Density
-10
-5
0
5
10
15
20
25
30
35
40
45
50
Location
0 (bw: 3.094)
1 (bw: 3.298)

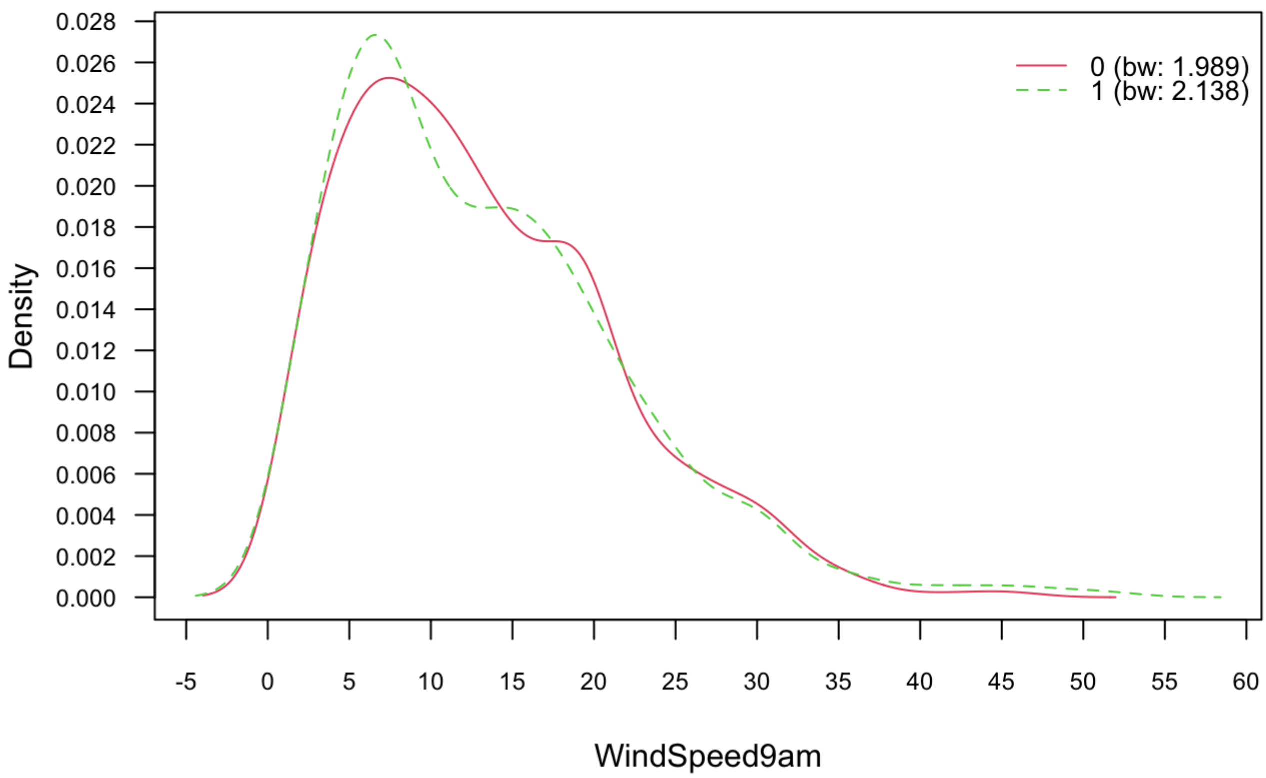

0 (bw: 1.446)
1 (bw: 1.477)
Density
0.030
0.025
0.020
0.015
0.010
0.005
0.000
-10
-5
0
5
10
15
20
25
30
MinTemp

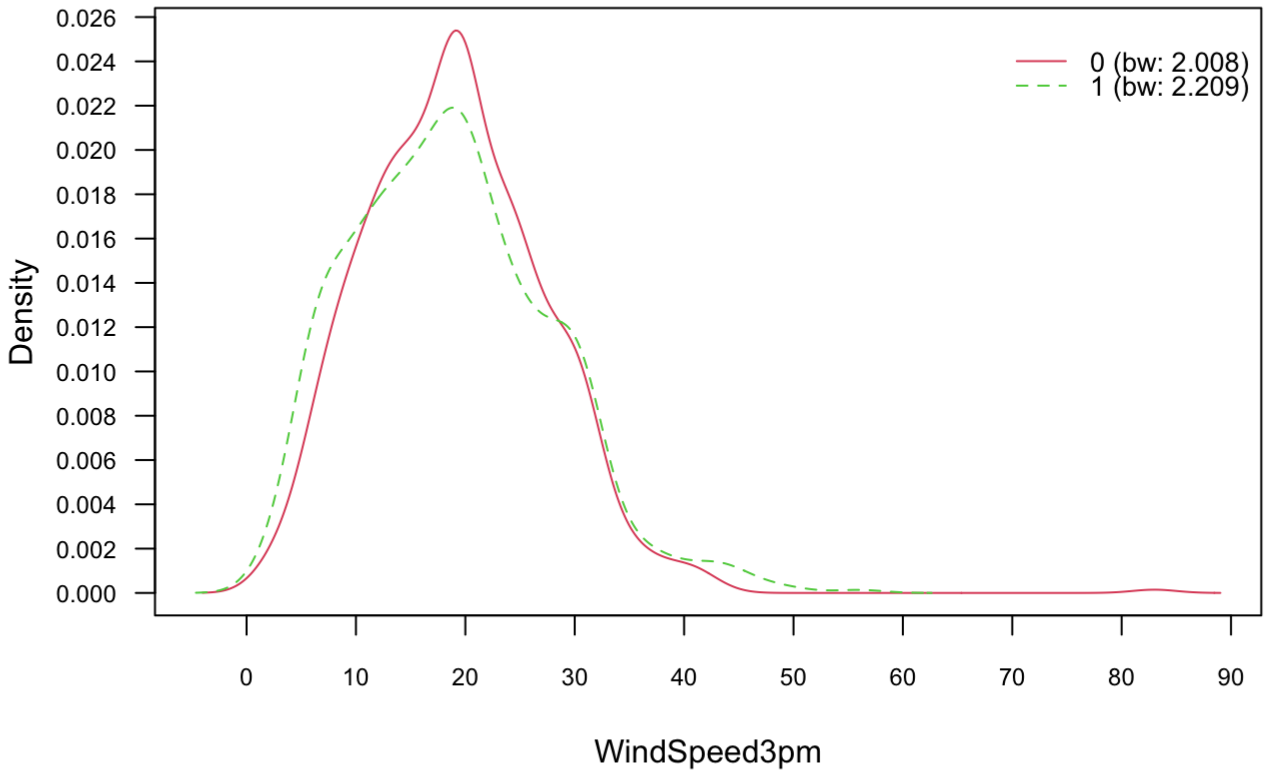

0 (bw: 1.581)
1 (bw: 1.708)
Density
0.028
0.026
0.024
0.022
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
5
10
15
20
25
30
35
40
45
50
MaxTemp

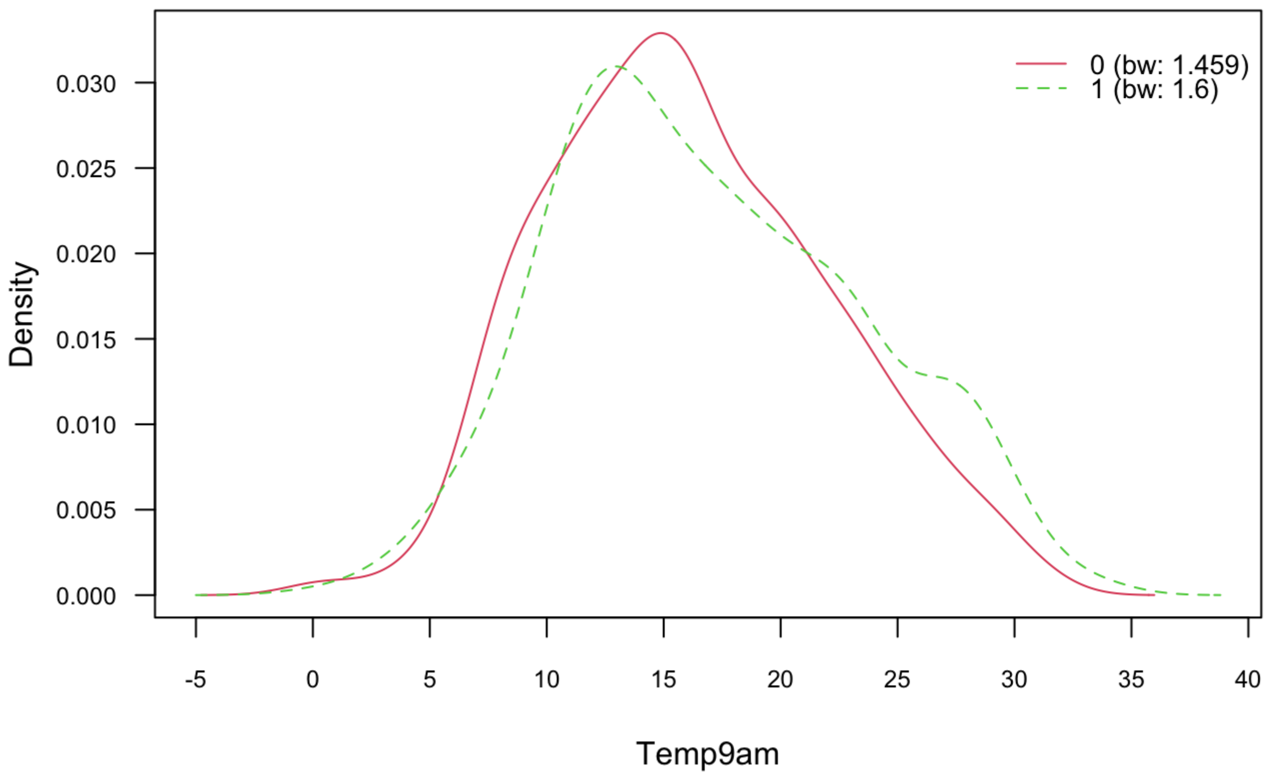

0 (bw: 0.183)
1 (bw: 0.036)
Density
Rainfall
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
120
140
160
180

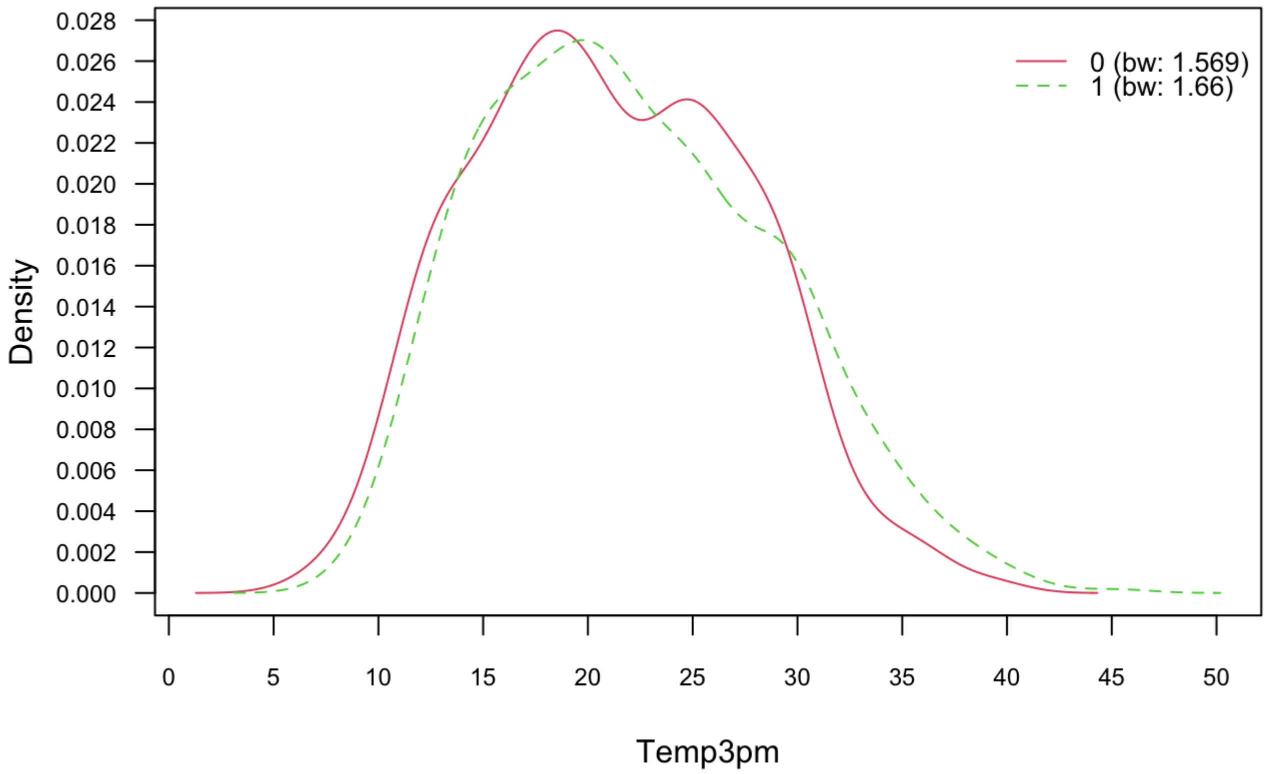

0
1
WindDir9am
E
ENE
ESE
N
NE
NNE
NNW
NW
S
SE
SSE
SSW
SW
W
WNW
WSW

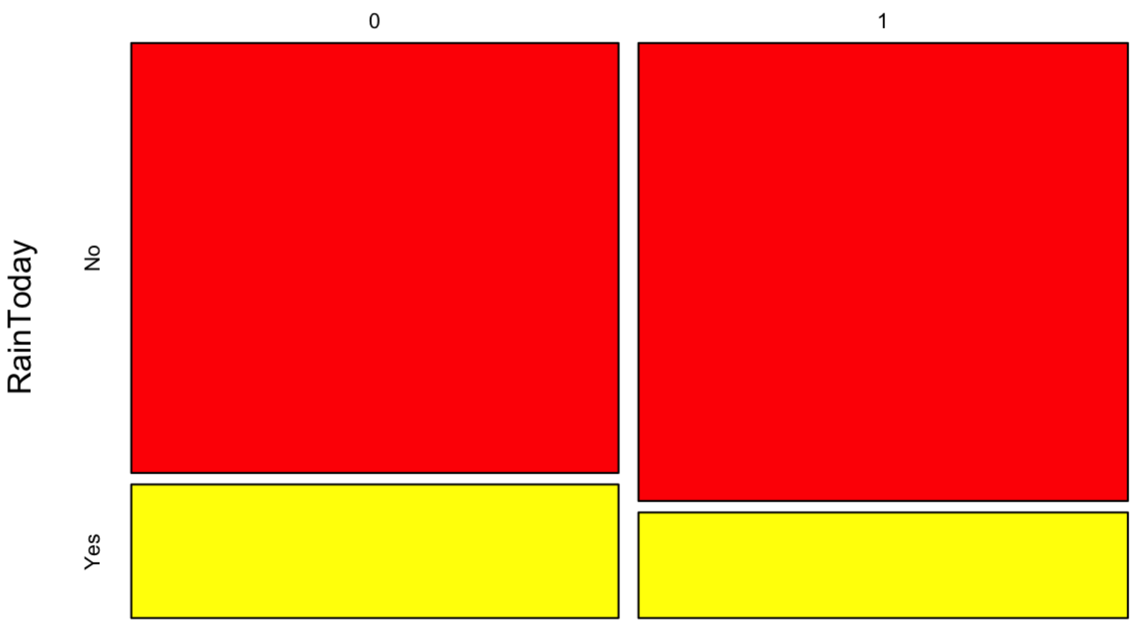

0
1
WindDir3pm
E
ENE
ESE
N
NE
NNE
NNW
NW
S
SE
SSE
SSW
SW
W
WNW
WSW

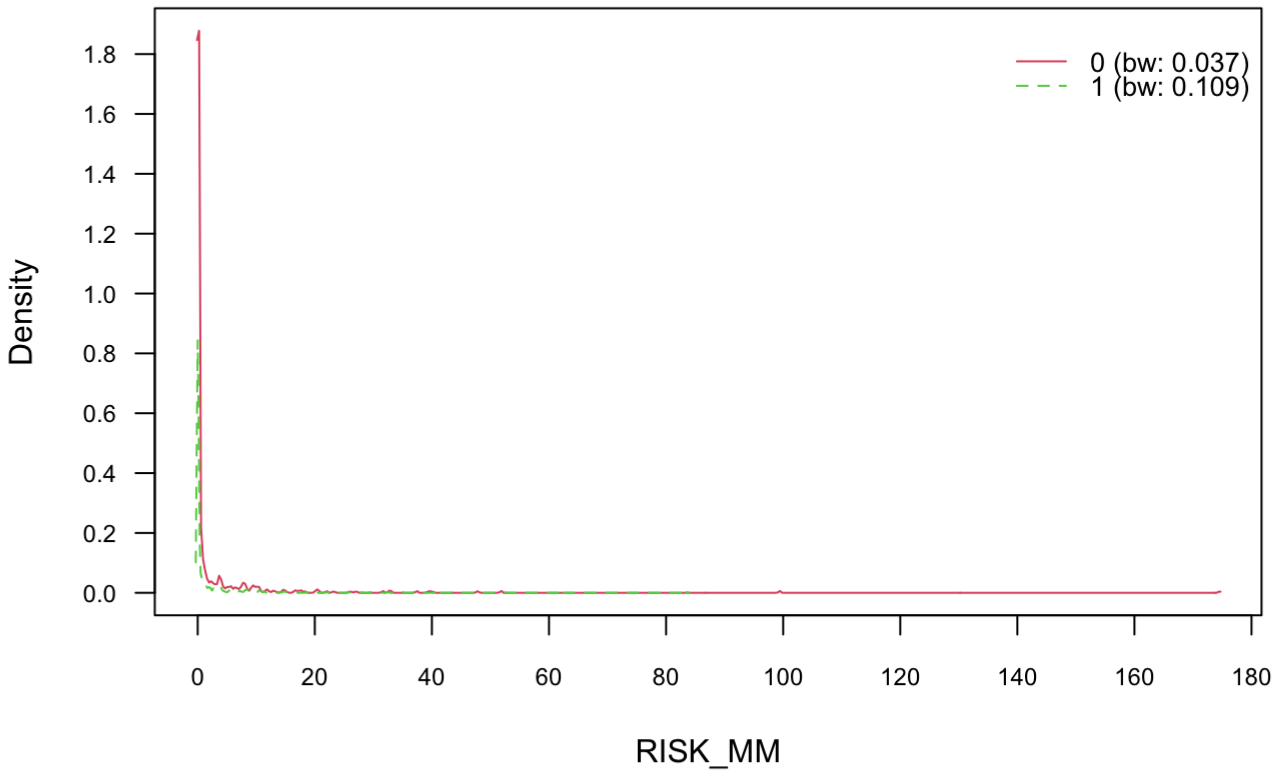

0 (bw: 1.989)
1 (bw: 2.138)
Density
WindSpeed9am
0.028
0.026
0.024
0.022
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
-5
0
5
10
15
20
25
30
35
40
45
50
55
60


0.026
0.024
0.022
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Density
0 (bw: 2.008)
1 (bw: 2.209)
0
10
20
30
40
50
60
70
80
90
WindSpeed3pm


0.030
0.025
0.020
0.015
0.010
0.005
0.000
Density
0 (bw: 1.459)
1 (bw: 1.6)
-5
0
5
10
15
20
25
30
35
40
Temp9am


0.028
0.026
0.024
0.022
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Density
0 (bw: 1.569)
1 (bw: 1.66)
0
5
10
15
20
25
30
35
40
45
50
Temp3pm


0
1
RainToday
No
Yes




```
#obtaining class predictions
knn.class.test <-  predict(model.knn,
                    newdata = WAUS.test, type="class")
```

```
## Warning: predict.naive_bayes(): more features in the newdata are provided as
## there are probability tables in the object. Calculation is performed based on
## features to be found in the tables.
```

```
head(knn.class.test)
```

```
## [1] 1 1 0 0 1 1
## Levels: 0 1
```

confusion matrix function is used

```
#computing confusion matrix
confusionMatrix(as.factor(WAUS.test$MHT),knn.class.test)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0  98  96
##          1  56 156
##
##                Accuracy : 0.6256
##                  95% CI : (0.5765, 0.6729)
##     No Information Rate : 0.6207
##     P-Value [Acc > NIR] : 0.44063
##
##                   Kappa : 0.2431
##
##  Mcnemar's Test P-Value : 0.00156
##
##             Sensitivity : 0.6364
##             Specificity : 0.6190
##          Pos Pred Value : 0.5052
##          Neg Pred Value : 0.7358
##              Prevalence : 0.3793
##          Detection Rate : 0.2414
##    Detection Prevalence : 0.4778
##       Balanced Accuracy : 0.6277
##
##        'Positive' Class : 0
##
```

we received accuracy of 62.56%

```
#Obtaining predicted probabilites for Test data
knn.probs=predict(model.knn,
                 newdata=WAUS.test,
                 type="prob")
```

```
## Warning: predict.naive_bayes(): more features in the newdata are provided as
## there are probability tables in the object. Calculation is performed based on
## features to be found in the tables.
```

```
head(knn.probs)
```

```
##              0         1
## [1,] 0.1586933 0.8413067
## [2,] 0.3554056 0.6445944
## [3,] 0.6084419 0.3915581
## [4,] 0.7514981 0.2485019
## [5,] 0.3845624 0.6154376
## [6,] 0.2383047 0.7616953
```

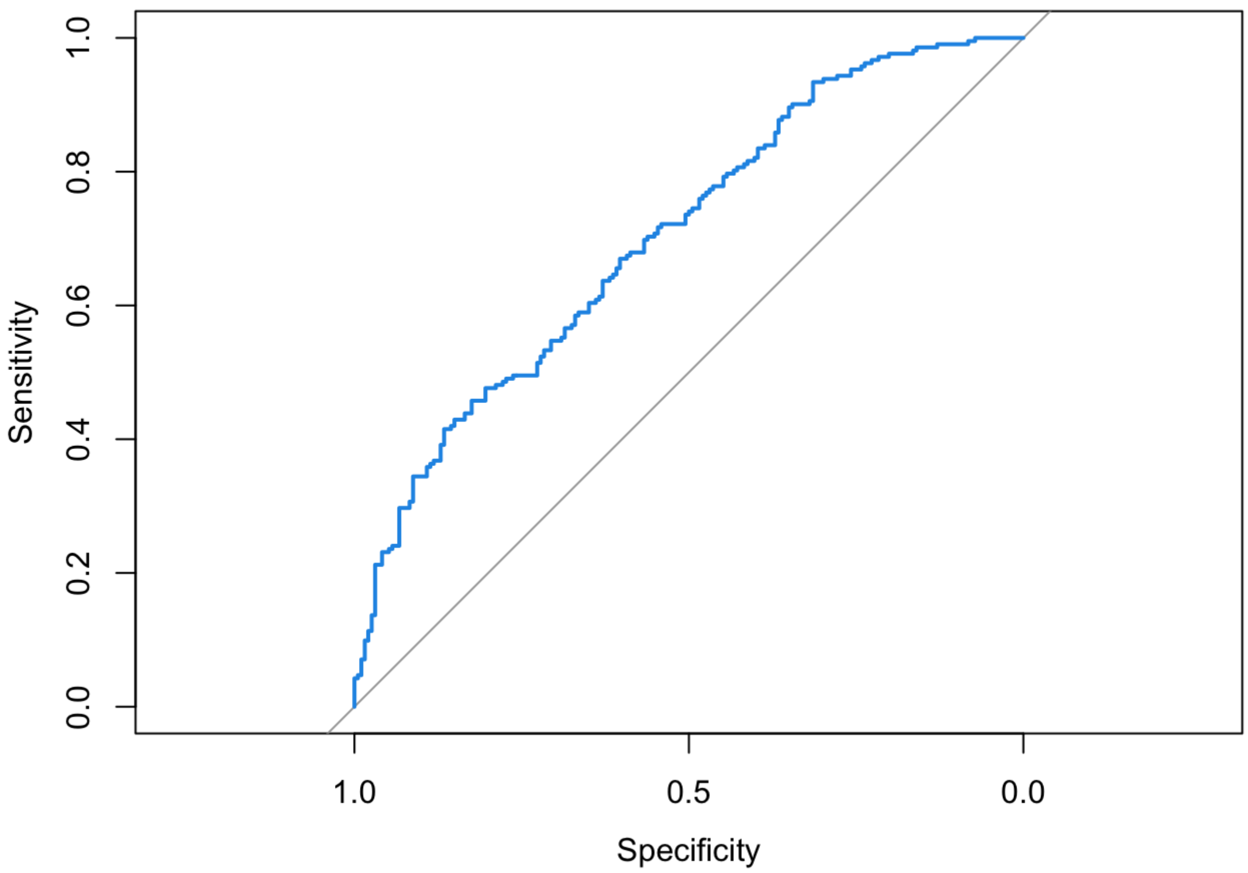
plotting the roc cure for the modelusing roc function of party package

```
#Calculate ROC curve
rocCurve.knn <- roc(WAUS.test$MHT,knn.probs[,"1"])
```

```
## Setting levels: control = 0, case = 1
```

```
## Setting direction: controls < cases
```

```
#plot the ROC curve
plot(rocCurve.knn,col=c(4))
```




```
#getting auc area under the curve
auc(rocCurve.knn)
```

```
## Area under the curve: 0.7031
```

we can observe the positive area under the curve accounting for increased model accuracy

bagging

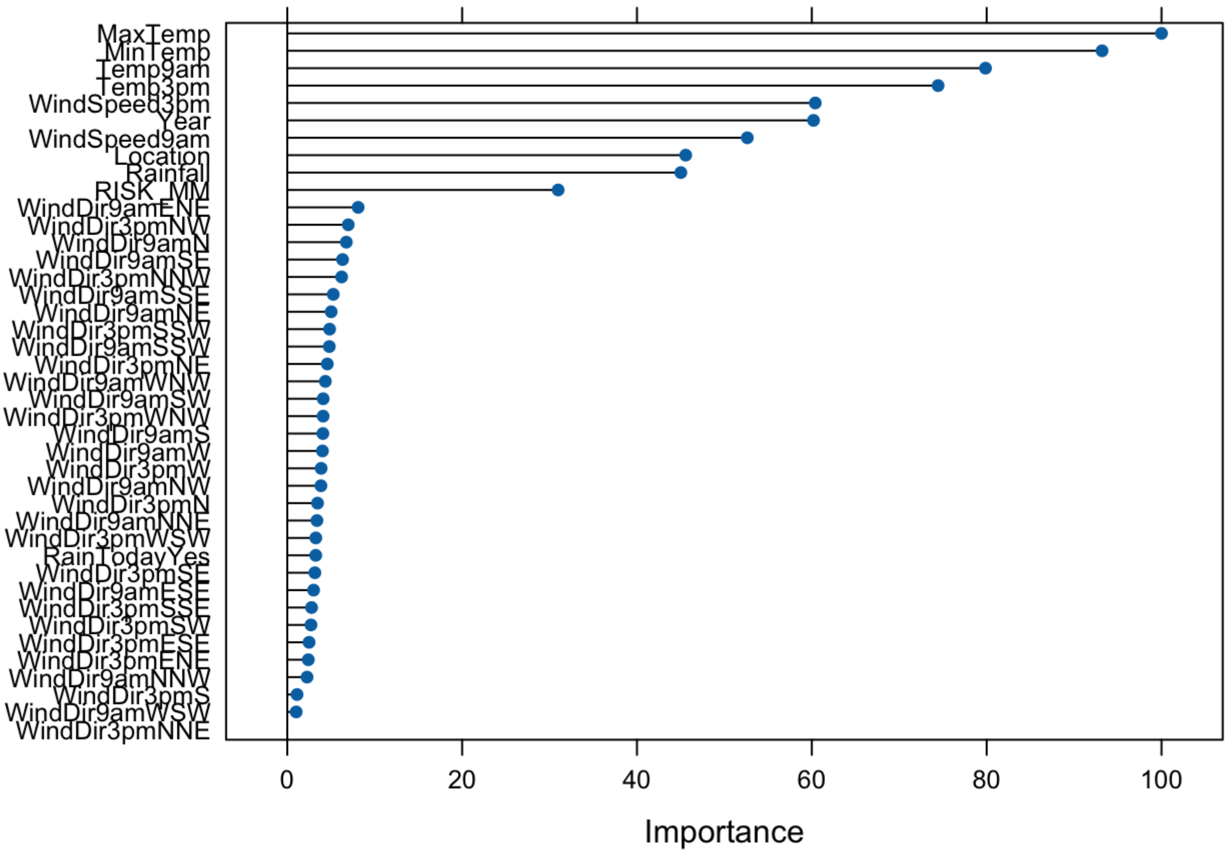
it is performed using treebag method of train function of caret

```
#Using treebag
train.bagg <- train(as.factor(MHT) ~ .,
                   data=WAUS.train,
                   method="treebag",
                   trControl=cvcontrol,
                   importance=TRUE)

train.bagg
```

```
## Bagged CART
##
## 947 samples
##  13 predictor
##   2 classes: '0', '1'
##
## No pre-processing
## Resampling: Cross-Validated (10 fold, repeated 1 times)
## Summary of sample sizes: 853, 852, 852, 852, 852, 852, ...
## Resampling results:
##
##   Accuracy   Kappa
##   0.5669455  0.1335776
```

plot of the model showing important factors

```
plot(varImp(train.bagg))
```



Further discussions regarding the attribute importnce in later stage of assignment

Testing the model using predict function of caret library

```
#obtaining class predictions
bagg.classTest <-  predict(train.bagg,
                         newdata = WAUS.test,
                          type="raw")
head(bagg.classTest)
```

```
## [1] 1 1 1 0 0 0
## Levels: 0 1
```

confusion matrix of the tree bagging model

```
confusionMatrix(as.factor(WAUS.test$MHT),bagg.classTest)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 110  84
##          1 101 111
##
##                Accuracy : 0.5443
##                  95% CI : (0.4945, 0.5935)
##     No Information Rate : 0.5197
##     P-Value [Acc > NIR] : 0.1727
##
##                   Kappa : 0.0903
##
##  Mcnemar's Test P-Value : 0.2395
##
##             Sensitivity : 0.5213
##             Specificity : 0.5692
##          Pos Pred Value : 0.5670
##          Neg Pred Value : 0.5236
##              Prevalence : 0.5197
##          Detection Rate : 0.2709
##    Detection Prevalence : 0.4778
##       Balanced Accuracy : 0.5453
##
##        'Positive' Class : 0
##
```

The model provided accuracy of 55.17%

getting probability values for different confidence level for roc plot

```
#Obtaining predicted probabilites for Test data
bagg.probs=predict(train.bagg,
                 newdata=WAUS.test,
                 type="prob")
head(bagg.probs)
```

```
##      0    1
## 1 0.36 0.64
## 2 0.24 0.76
## 3 0.32 0.68
## 4 0.56 0.44
## 5 0.68 0.32
## 6 0.56 0.44
```

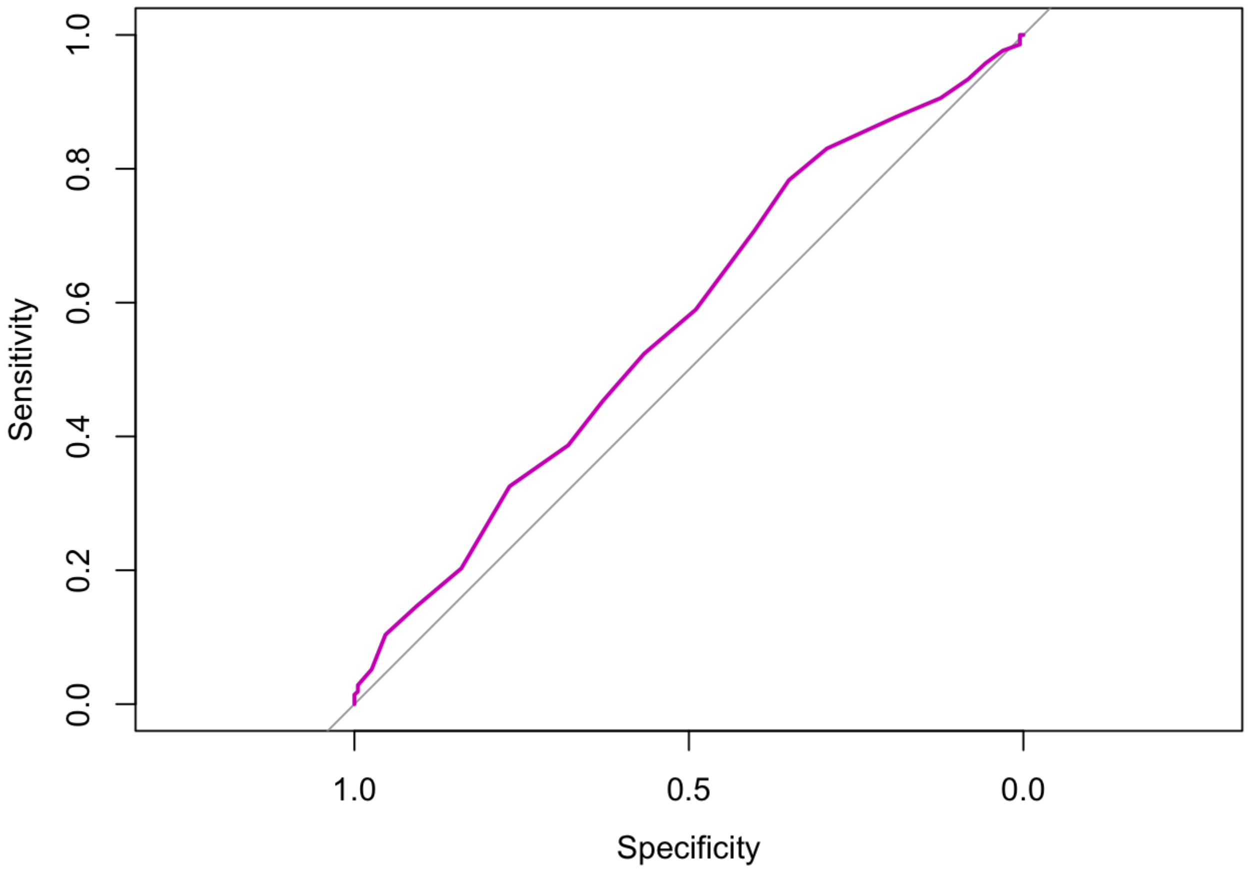
roc plot plotted using roc function of party library

```
#Calculate ROC curve
rocCurve.bagg <- roc(WAUS.test$MHT,bagg.probs[,"1"])
```

```
## Setting levels: control = 0, case = 1
```

```
## Setting direction: controls < cases
```

```
#plot the ROC curve
plot(rocCurve.bagg,col=c(6))
```




```
#getting auc area under the curve
auc(rocCurve.bagg)
```

```
## Area under the curve: 0.5716
```

area under curve calculated via auc function of caret

random forest model

random forest model uses rf method of train fucntion from caret

```
train.rf <- train(as.factor(MHT) ~ .,
                  data=WAUS.train,
                  method="rf",
                  trControl=cvcontrol,
                  #tuneLength = 3,
                  importance=TRUE)
train.rf
```

```
## Random Forest
##
## 947 samples
##  13 predictor
##   2 classes: '0', '1'
##
## No pre-processing
## Resampling: Cross-Validated (10 fold, repeated 1 times)
## Summary of sample sizes: 853, 852, 852, 853, 852, 851, ...
## Resampling results across tuning parameters:
##
##   mtry  Accuracy   Kappa
##    2    0.5606838  0.1194090
##   21    0.5795544  0.1582572
##   41    0.5838095  0.1665836
##
## Accuracy was used to select the optimal model using the largest value.
## The final value used for the model was mtry = 41.
```

testing the model over test data using predict function

```
#obtaining class predictions
rf.classTest <-  predict(train.rf,
                         newdata = WAUS.test,
                          type="raw")
head(rf.classTest)
```

```
## [1] 1 1 1 1 0 1
## Levels: 0 1
```

confusion matrix function used for getitng accuracy of the model

```
#computing confusion matrix
confusionMatrix(as.factor(WAUS.test$MHT),rf.classTest)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 108  86
##          1  94 118
##
##                Accuracy : 0.5567
##                  95% CI : (0.5068, 0.6056)
##     No Information Rate : 0.5025
##     P-Value [Acc > NIR] : 0.01634
##
##                   Kappa : 0.1131
##
##  Mcnemar's Test P-Value : 0.60184
##
##             Sensitivity : 0.5347
##             Specificity : 0.5784
##          Pos Pred Value : 0.5567
##          Neg Pred Value : 0.5566
##              Prevalence : 0.4975
##          Detection Rate : 0.2660
##    Detection Prevalence : 0.4778
##       Balanced Accuracy : 0.5565
##
##        'Positive' Class : 0
##
```

the model provided accuracy of 55.17%

```
#Obtaining predicted probabilites for Test data
rf.probs=predict(train.rf,
                 newdata=WAUS.test,
                 type="prob")
head(rf.probs)
```

```
##           0     1
## 74332 0.384 0.616
## 15835 0.444 0.556
## 72004 0.438 0.562
## 96879 0.390 0.610
## 35420 0.646 0.354
## 42966 0.436 0.564
```

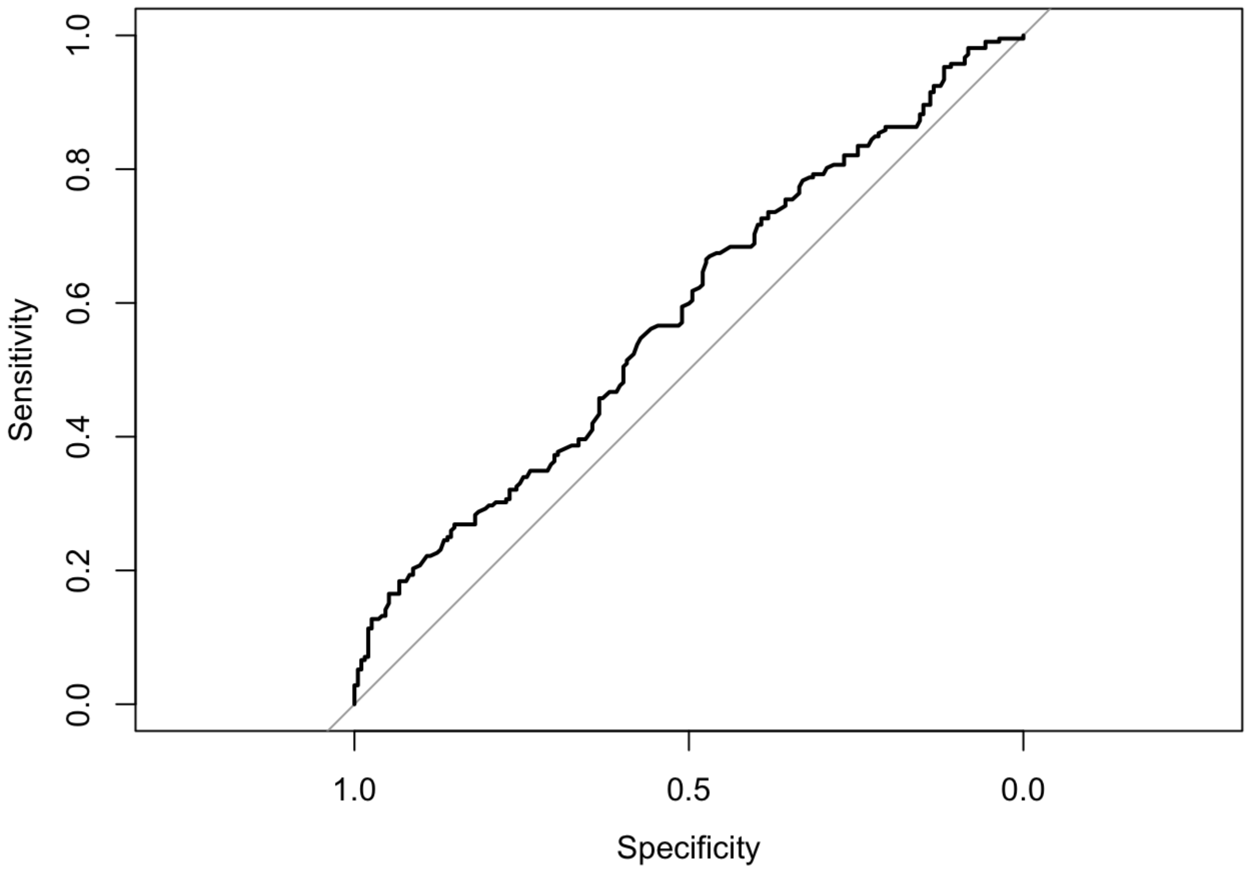
roc plot using roc function of caret library

```
#Calculate ROC curve
rocCurve.rf <- roc(WAUS.test$MHT,rf.probs[,"1"])
```

```
## Setting levels: control = 0, case = 1
```

```
## Setting direction: controls < cases
```

```
#plot the ROC curve
plot(rocCurve.rf,col=c(1))
```



area under curve using auc fucntion

```
#getting auc area under the curve
auc(rocCurve.bagg)
```

```
## Area under the curve: 0.5716
```

positive area denotes htat the random forest odel is a stable model performing better than random prediction

boosting

The model follows gradient boosting

the train function uses gbm method for gradient boosting

```
train.gbm <- train(as.factor(MHT) ~ .,
                   data=WAUS.train,
                   method="gbm",
                   verbose=F,
                   trControl=cvcontrol)
train.gbm
```

```
## Stochastic Gradient Boosting
##
## 947 samples
##  13 predictor
##   2 classes: '0', '1'
##
## No pre-processing
## Resampling: Cross-Validated (10 fold, repeated 1 times)
## Summary of sample sizes: 852, 853, 852, 852, 852, 853, ...
## Resampling results across tuning parameters:
##
##   interaction.depth  n.trees  Accuracy   Kappa
##   1                   50      0.5480403  0.09378481
##   1                  100      0.5691041  0.13640060
##   1                  150      0.5732027  0.14466158
##   2                   50      0.5394961  0.07646670
##   2                  100      0.5668981  0.13191600
##   2                  150      0.5785106  0.15571728
##   3                   50      0.5521501  0.10238522
##   3                  100      0.5679507  0.13464310
##   3                  150      0.5817021  0.16186515
##
## Tuning parameter 'shrinkage' was held constant at a value of 0.1
##
## Tuning parameter 'n.minobsinnode' was held constant at a value of 10
## Accuracy was used to select the optimal model using the largest value.
## The final values used for the model were n.trees = 150, interaction.depth =
##  3, shrinkage = 0.1 and n.minobsinnode = 10.
```

using predict function for testing model over test data

```
#obtaining class predictions
gbm.classTest <-  predict(train.gbm,
                         newdata = WAUS.test,
                          type="raw")

confusionMatrix(as.factor(WAUS.test$MHT), gbm.classTest)
```

```
## Confusion Matrix and Statistics
## 
##           Reference
## Prediction   0   1
##          0 111  83
##          1 108 104
##                                           
##                Accuracy : 0.5296          
##                  95% CI : (0.4797, 0.579) 
##     No Information Rate : 0.5394          
##     P-Value [Acc > NIR] : 0.67329         
##                                           
##                   Kappa : 0.0624          
##                                           
##  Mcnemar's Test P-Value : 0.08246         
##                                           
##             Sensitivity : 0.5068          
##             Specificity : 0.5561          
##          Pos Pred Value : 0.5722          
##          Neg Pred Value : 0.4906          
##              Prevalence : 0.5394          
##          Detection Rate : 0.2734          
##    Detection Prevalence : 0.4778          
##       Balanced Accuracy : 0.5315          
##                                           
##        'Positive' Class : 0               
## 
```

the model produces accuracy of 54.43%

```
#Obtaining predicted probabilites for Test data
rfboost.probs=predict(train.gbm,
                 newdata=WAUS.test,
                 type="prob")
head(rfboost.probs)
```

```
##           0         1
## 1 0.2444314 0.7555686
## 2 0.5428746 0.4571254
## 3 0.1557934 0.8442066
## 4 0.6036712 0.3963288
## 5 0.7795093 0.2204907
## 6 0.3998293 0.6001707
```

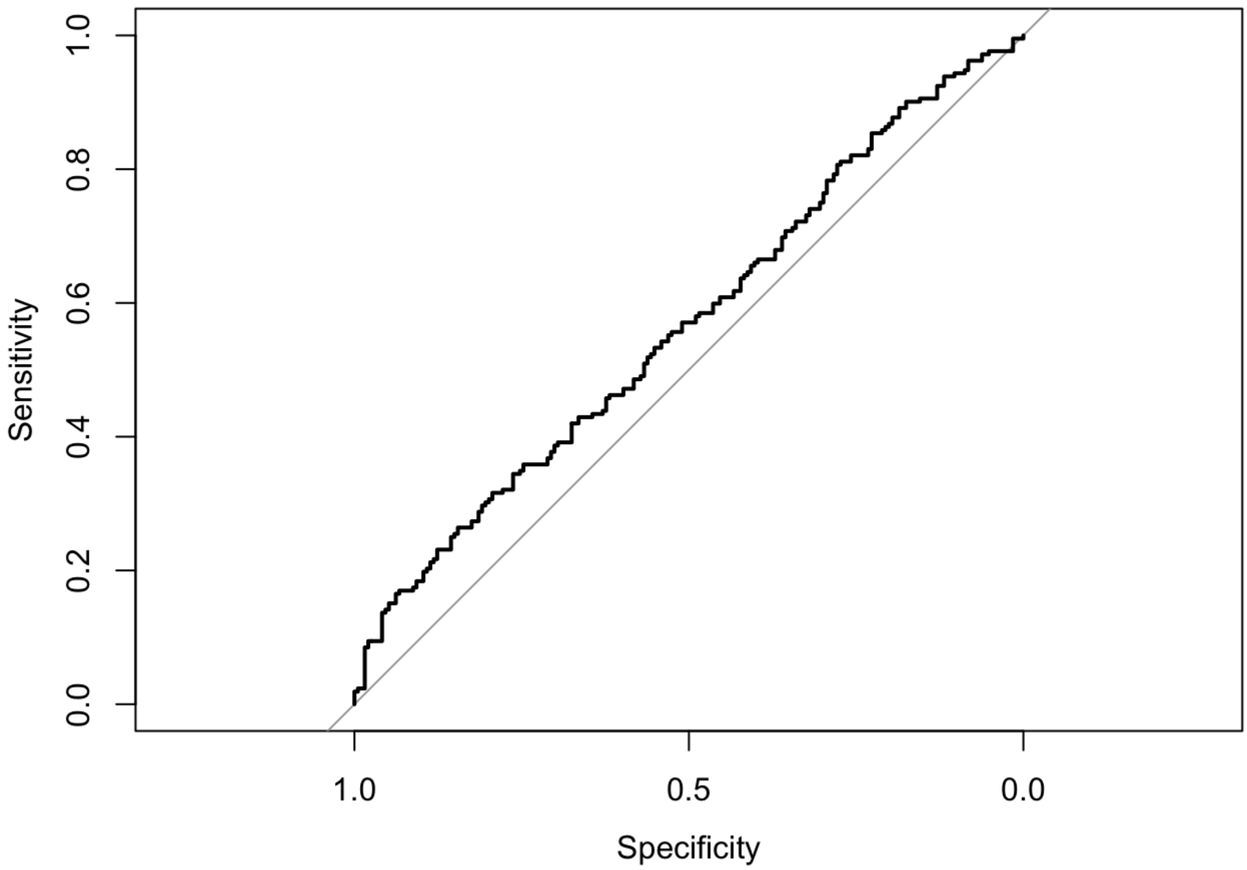
roc plot using roc function of caret library

```
#Calculate ROC curve
rocCurve.boost <- roc(WAUS.test$MHT,rfboost.probs[,"1"])
```

```
## Setting levels: control = 0, case = 1
```

```
## Setting direction: controls < cases
```

```
#plot the ROC curve
plot(rocCurve.boost,col=c(1))
```

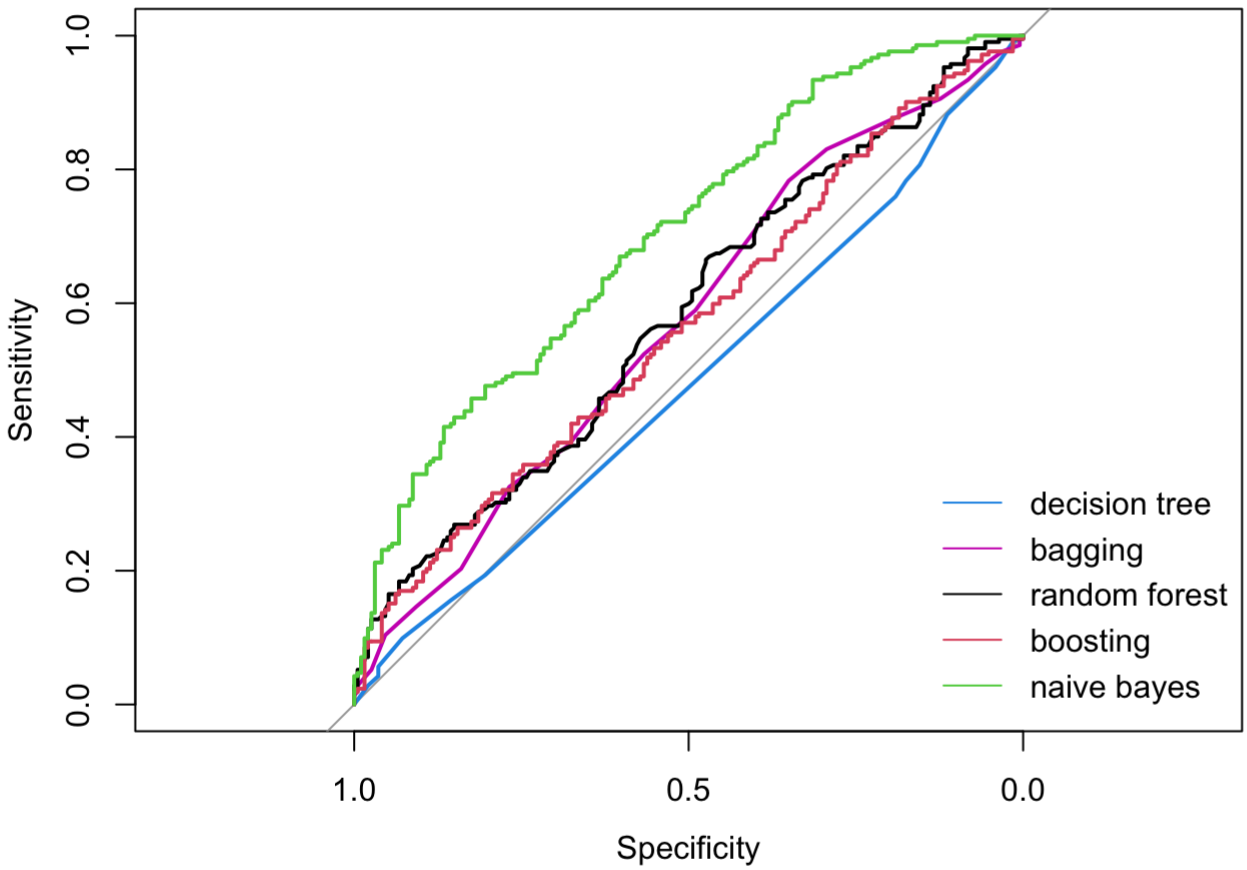



```
#getting auc area under the curve
auc(rocCurve.boost)
```

```
## Area under the curve: 0.5669
```

area under curve using aoc function

```
plot(rocCurve.tree,col=c(4))
plot(rocCurve.bagg,add=TRUE,col=c(6))
plot(rocCurve.rf,add=TRUE,col=c(1))
plot(rocCurve.boost,add=TRUE,col=c(2))
plot(rocCurve.knn,add=TRUE,col=c(3))

## Add Legend
legend("bottomright", c("decision tree", "bagging", "random forest", "boosting", "nai
ve bayes"), lty=1,
    col = c(4, 6, 1, 2, 3), bty="n")
```



question 7

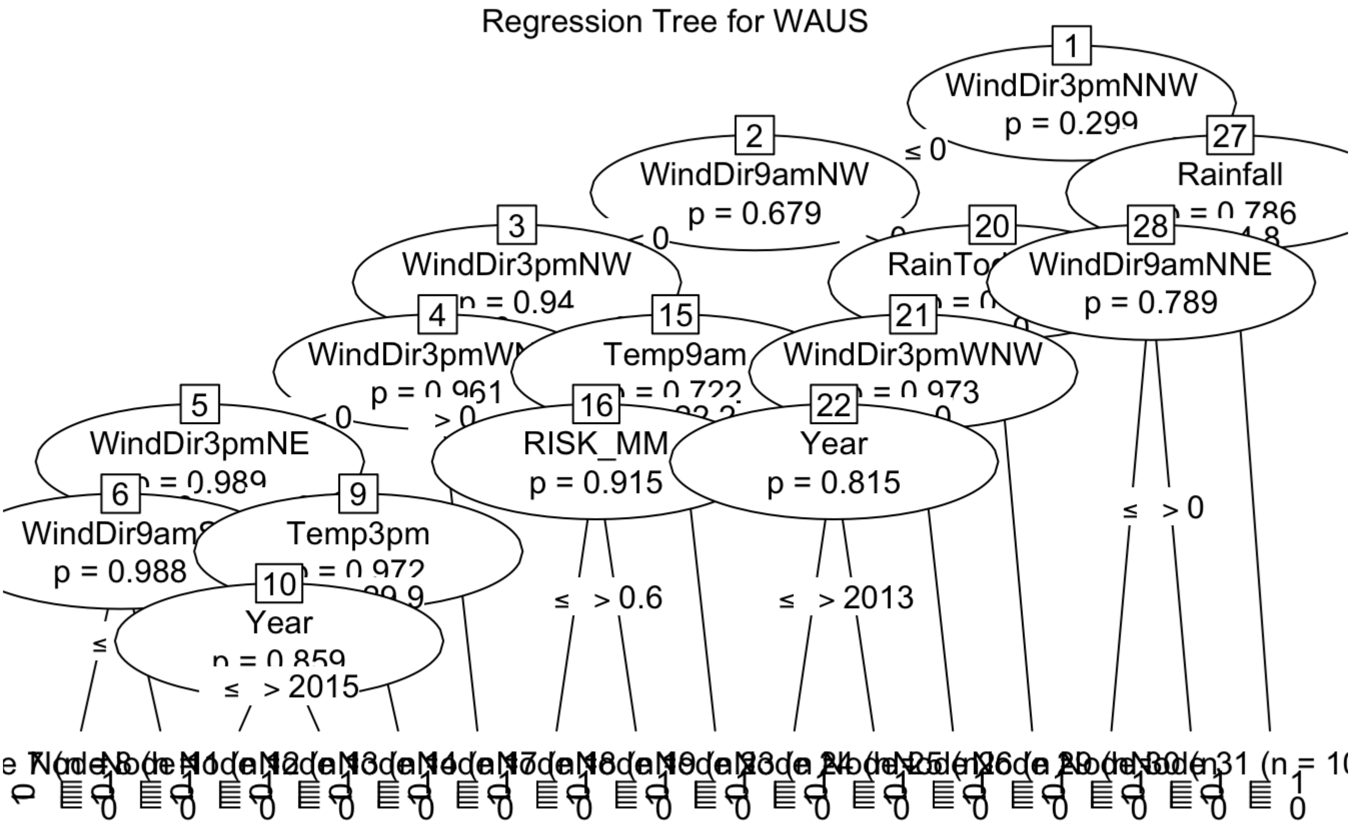
Model	Accuracy	sensitivity	specificity
decision tree	48.28%	47.93%	55.55%
Naive bayes	62.56%	63.64%	61.90%
bagging	55.17%	52.86%	57.65%
random forest	55.17%	52.88%	57.58%
Boosting	54.43%	52.17%	56.78%

based on the analysis we can see that naive bayes model produced the highest accuracy alongside highest sensitivity and specificity, indicating it seemingly predicting mostly 1 for it being the majority of MHT leading to higher accuracy, however random forest model gives the best overall output with lower average of sensitivity and specificity. Yet bagging, naive bayes, and random forest model performed nearly the same with similar accuracies

question 8

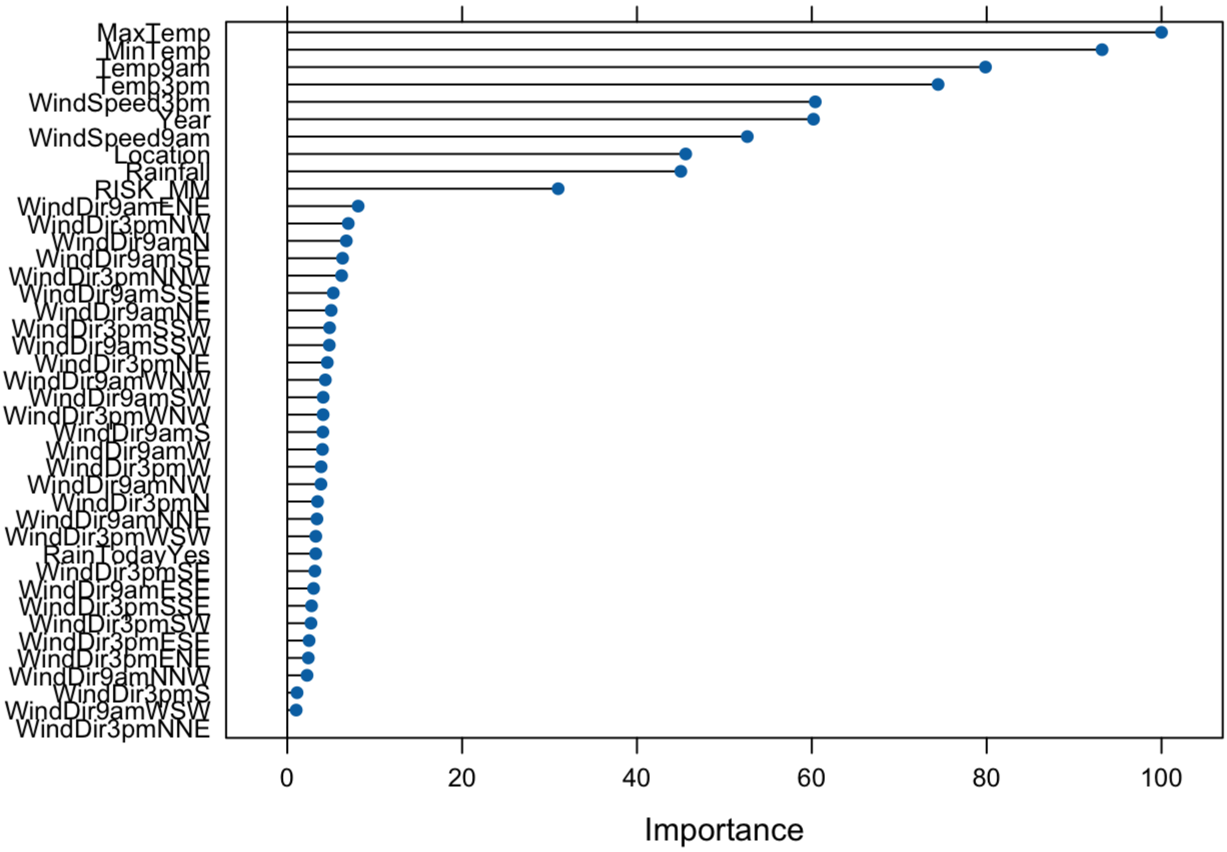
examining the decision tree plot

```
plot(train.tree$finalModel,
    main="Regression Tree for WAUS")
```



and bagging parameter contribution plot for each attribute

```
plot(varImp(train.bagg))
```



we can observe that rainfall is the biggest factor determining humidity, it's the child node to the root node of the decision tree, and also among top 4 in the bagging model distribution, additionally, we observed in the summary of Q1 itself, for rainfall having the most significant difference among the rest just by looking at it's mean value. This is closely followed by windDir3pmNNW, being the root node of decision tree, alongside it being close in the contribution plot but below rainfall.

Rest of significant attributes include WindDir9amNW, wind speed attributes and some of wind direction attributes, risk_mm being higher ranked ones in the attribution contribution plot, and decision tree.

Some of the least significant ones include those which are not part of decision tree itself and also on lower ranks in the importance plot from bagging including Rain Today, wind Dir NNE, wind dir in southern direction, year, location, etc.

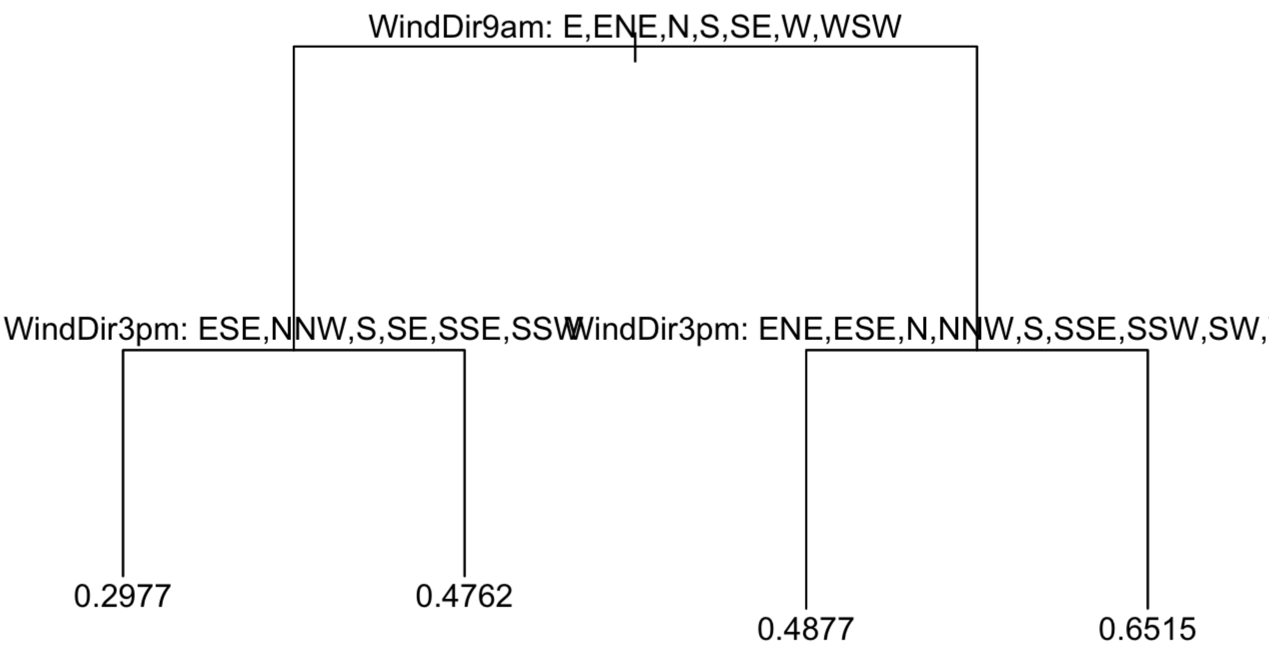
question 9

based on analysis above removing year, location, rain_today attributes from the data to check the decision tree form the decision tree model using tree library

```
colnames(WAUS.train)
```

```
##  [1] "Year"         "Location"     "MinTemp"      "MaxTemp"      "Rainfall"
##  [6] "WindDir9am"   "WindDir3pm"   "WindSpeed9am" "WindSpeed3pm" "Temp9am"
## [11] "Temp3pm"      "RainToday"    "RISK_MM"      "MHT"
```

```
library(tree)

ptfit = tree(MHT ~. , data = WAUS.train[, -c(1, 2, 13)])

plot(ptfit)
text(ptfit, pretty = 0)
```



The model starts with checking WindDir9am attribute value if it is E, ENE, N, S, SE, W, WSW then it moves on to check WindDir3pm to have values among ESE, NNW, S, SE, SSE, SSW if it is then there are 29.77% chances of the MHT to have value 1 and if not then it has 47.62% chances of MHT being 1. Similarly for case of not having the above mentioned values for WindDir9am the model checks WindDir3pm again if it has value among ENE, ESE, N, NNW, S, SSE, SSW, SW, W then it has 48.77% chances of having MHT values as 1 otherwsie 65.15% chances of MHT being 1 for other values of WindDir3pm.

Question 10

analysing if feature engineering can improvise model to test if removing attributes actually helps the model

```
# define the control using a random forest selection function
control <- rfeControl(functions = rfFuncs, # random forest
                      method = "repeatedcv", # repeated cv
                      repeats = 2, # number of repeats
                      number = 4, # number of folds
                      allowParallel = TRUE)
```

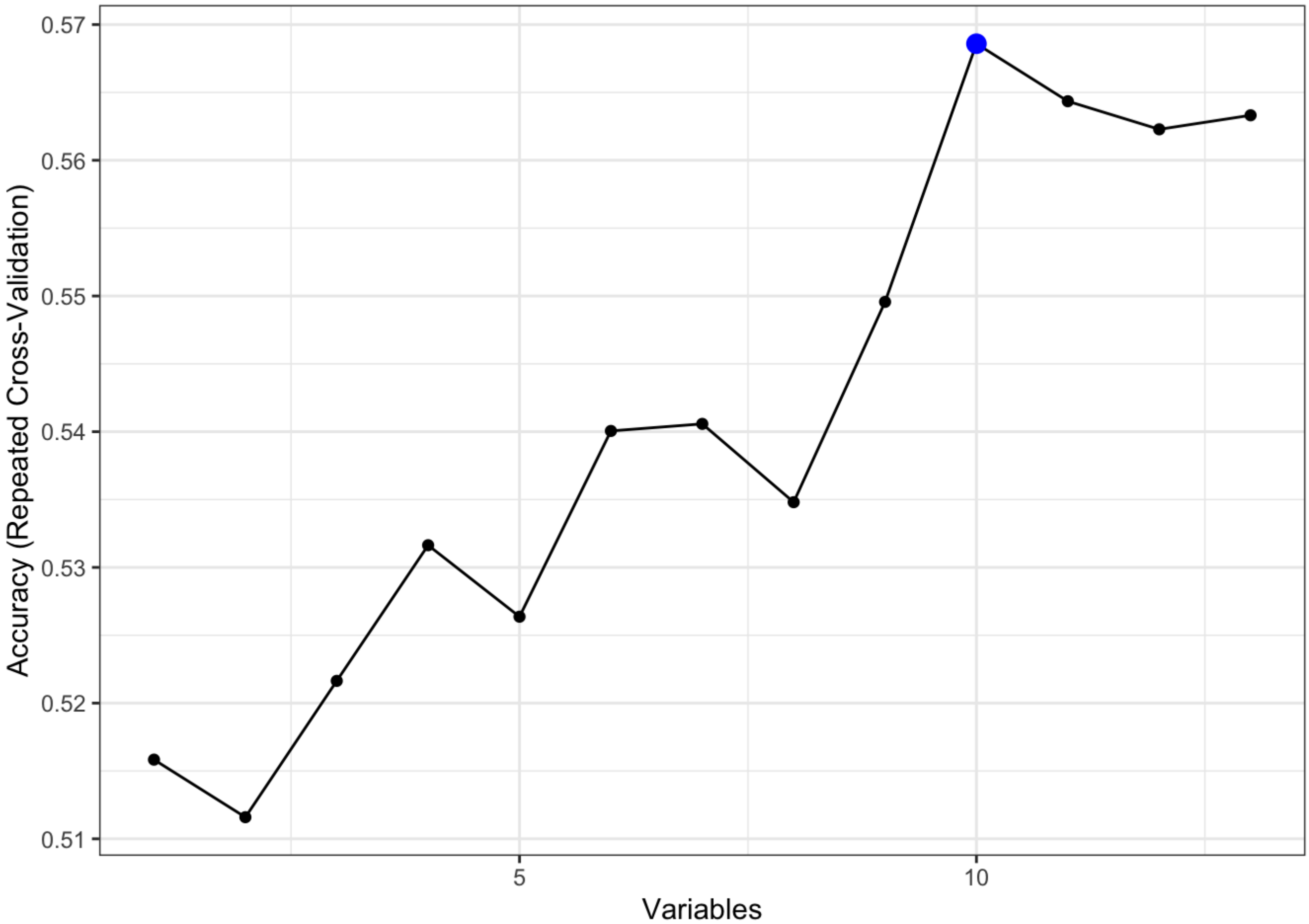
```
# Run RFE
result_rfe1 <- rfe(x = WAUS.train[,-14],
                   y = as.factor(WAUS.train$MHT),
                   sizes = c(1:13),
                   rfeControl = control)

# Print the results
result_rfe1
```

```
##
## Recursive feature selection
##
## Outer resampling method: Cross-Validated (4 fold, repeated 2 times)
##
## Resampling performance over subset size:
##
##  Variables Accuracy   Kappa AccuracySD KappaSD Selected
##          1   0.5158 0.03242    0.02824 0.05769
##          2   0.5116 0.02241    0.01414 0.02877
##          3   0.5216 0.04287    0.02679 0.05403
##          4   0.5316 0.06360    0.03164 0.06303
##          5   0.5264 0.05344    0.03508 0.06920
##          6   0.5401 0.08109    0.03968 0.07837
##          7   0.5406 0.08239    0.05023 0.09942
##          8   0.5348 0.07117    0.03306 0.06512
##          9   0.5496 0.10025    0.04066 0.08085
##         10   0.5686 0.13827    0.03286 0.06497        *
##         11   0.5644 0.13017    0.03644 0.07218
##         12   0.5623 0.12715    0.03893 0.07747
##         13   0.5633 0.12938    0.03128 0.06285
##
## The top 5 variables (out of 10):
##    Temp9am, MaxTemp, MinTemp, Rainfall, WindDir9am
```

```
# Print the selected features
predictors(result_rfe1)
```

```
##  [1] "Temp9am"      "MaxTemp"      "MinTemp"      "Rainfall"     "WindDir9am"
##  [6] "Location"     "WindSpeed3pm" "Temp3pm"      "RISK_MM"      "Year"
```

```
# Print the results visually
ggplot(data = result_rfe1, metric = "Accuracy") + theme_bw()
```



Since the model produced same results for 9 and 14 attributes, we can continue with finding ways to improvise model using some other approach, on testing over fewer attributes removing the ones I prviously removed for q9 produced average of 51% accuracy thus it was best to use all the attributes

For this question I tried developing over Random forest model built over k fold cross validation in q4 itself, as it provided good accuracy with lower sensitivity and specificity.

Improvising the model by setting the mtry value to 41 as in the output of random forest model as implemented in q4

```
repGrid <- expand.grid(.mtry=c(41))
train.rf.new <- train(as.factor(MHT) ~ .,
                  data=WAUS.train,
                  method="rf",
                  metric="Accuracy",
                  trControl=cvcontrol,
                  tuneLength = 3,
                  importance=TRUE,
                  tuneGrid = repGrid)
train.rf.new
```

```
## Random Forest
##
## 947 samples
##  13 predictor
##   2 classes: '0', '1'
##
## No pre-processing
## Resampling: Cross-Validated (10 fold, repeated 1 times)
## Summary of sample sizes: 853, 852, 852, 852, 852, 853, ...
## Resampling results:
##
##   Accuracy   Kappa
##   0.5828443  0.1651612
##
## Tuning parameter 'mtry' was held constant at a value of 41
```

```
#obtaining class predictions
rf.classTest.new <-  predict(train.rf.new,
                         newdata = WAUS.test,
                          type="raw")
head(rf.classTest.new)
```

```
## [1] 1 1 1 1 0 1
## Levels: 0 1
```

getting confusion matrix to check accuracy over test data

```
#computing confusion matrix
confusionMatrix(as.factor(WAUS.test$MHT),rf.classTest.new)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 109  85
##          1  99 113
##
##                Accuracy : 0.5468
##                  95% CI : (0.497, 0.596)
##     No Information Rate : 0.5123
##     P-Value [Acc > NIR] : 0.08997
##
##                   Kappa : 0.0946
##
##  Mcnemar's Test P-Value : 0.33787
##
##             Sensitivity : 0.5240
##             Specificity : 0.5707
##          Pos Pred Value : 0.5619
##          Neg Pred Value : 0.5330
##              Prevalence : 0.5123
##          Detection Rate : 0.2685
##    Detection Prevalence : 0.4778
##       Balanced Accuracy : 0.5474
##
##        'Positive' Class : 0
##
```

which produced accuracy of 55.67%, although the accuracy varry depending on randomness but based on implementation we managed to achieved goo average of 54.5% which normal random forest doesn't gaurantee

question 11

For applying ann we need numerical data, so I use unpack function from R to convert all the categorical variables to numericals, except location and MHT. Further scaling of data is also done in order to preserve accuracy

```
data_new <- sapply(WAUS.train[, -2], unclass)
data_new[, -13] <- scale(data_new[, -13])
summary(data_new)
```

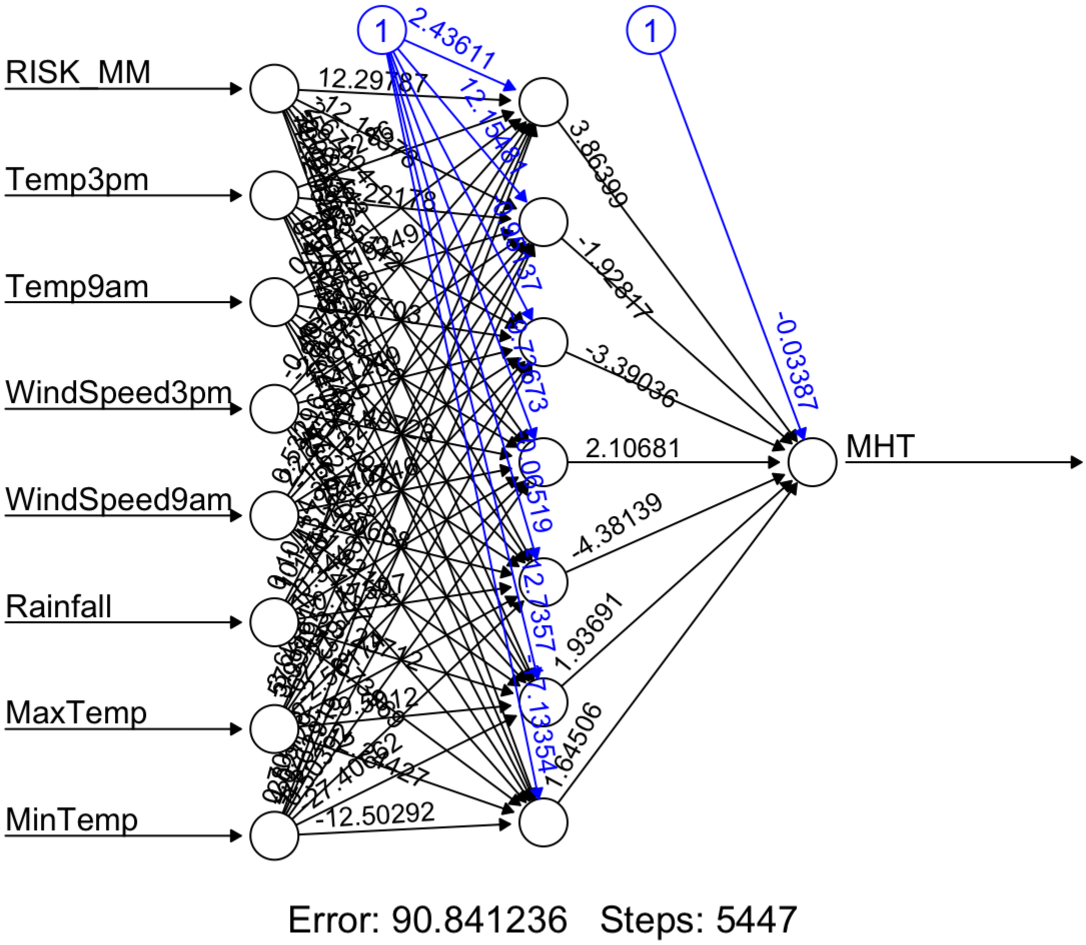
```
##       Year              MinTemp            MaxTemp            Rainfall
##  Min.   :-1.87788   Min.   :-2.93407   Min.   :-2.17122   Min.   :-0.2475
##  1st Qu.:-0.91296   1st Qu.:-0.72316   1st Qu.:-0.77568   1st Qu.:-0.2475
##  Median : 0.05197   Median :-0.05823   Median :-0.09994   Median :-0.2475
##  Mean   : 0.00000   Mean   : 0.00000   Mean   : 0.00000   Mean   : 0.0000
##  3rd Qu.: 1.01689   3rd Qu.: 0.70645   3rd Qu.: 0.73738   3rd Qu.:-0.1666
##  Max.   : 1.66017   Max.   : 2.66801   Max.   : 3.52846   Max.   :23.2814
##    WindDir9am          WindDir3pm        WindSpeed9am       WindSpeed3pm
##  Min.   :-1.5640149   Min.   :-1.6088   Min.   :-1.3025   Min.   :-1.947221
##  1st Qu.:-0.8940260   1st Qu.:-0.7695   1st Qu.:-0.8304   1st Qu.:-0.685138
##  Median :-0.0007075   Median :-0.1400   Median :-0.2402   Median : 0.003271
##  Mean   : 0.0000000   Mean   : 0.0000   Mean   : 0.0000   Mean   : 0.000000
##  3rd Qu.: 0.8926111   3rd Qu.: 0.9091   3rd Qu.: 0.7041   3rd Qu.: 0.576945
##  Max.   : 1.7859296   Max.   : 1.5385   Max.   : 4.5993   Max.   : 7.346299
##     Temp9am            Temp3pm           RainToday          RISK_MM
##  Min.   :-2.6551   Min.   :-2.34119   Min.   :-0.5204   Min.   :-0.2406
##  1st Qu.:-0.7199   1st Qu.:-0.78118   1st Qu.:-0.5204   1st Qu.:-0.2406
##  Median :-0.1068   Median :-0.09117   Median :-0.5204   Median :-0.2406
##  Mean   : 0.0000   Mean   : 0.00000   Mean   : 0.0000   Mean   : 0.0000
##  3rd Qu.: 0.7055   3rd Qu.: 0.71883   3rd Qu.:-0.5204   3rd Qu.:-0.1789
##  Max.   : 2.7919   Max.   : 3.53886   Max.   : 1.9194   Max.   :21.3156
##       MHT
##  Min.   :0.0000
##  1st Qu.:0.0000
##  Median :0.0000
##  Mean   :0.4921
##  3rd Qu.:1.0000
##  Max.   :1.0000
```

forming neural network with 7 hidden layers, stepmax is used to increase the execution speed, only attributes having numerical inputs are chosen over categorical ones as after scaling they would be converted to continuous variables and that can affect decision

```
library(neuralnet)
library(utils)




ann <- neuralnet(MHT ~ RISK_MM + Temp3pm + Temp9am + WindSpeed3pm + WindSpeed9am + Ra
infall + MaxTemp + MinTemp
                , data=data_new
                , hidden=c(7), linear.output = FALSE
                , likelihood = TRUE
                , stepmax=1e+05)
```

further using plot and result matrix to visualize and understand the model

```
plot(ann, rep = "best")
```




```
ann$result.matrix
```

```
##                                    [,1]
## error                     9.084124e+01
## reached.threshold         9.987663e-03
## steps                     5.447000e+03
## aic                       3.236825e+02
## bic                       6.682667e+02
## Intercept.to.1layhid1     2.436113e+00
## RISK_MM.to.1layhid1       1.229787e+01
## Temp3pm.to.1layhid1       1.352859e+00
## Temp9am.to.1layhid1       1.528159e-01
## WindSpeed3pm.to.1layhid1 -4.677968e-01
## WindSpeed9am.to.1layhid1  5.329644e-01
## Rainfall.to.1layhid1      1.074434e-01
## MaxTemp.to.1layhid1      -3.626074e+00
## MinTemp.to.1layhid1       7.033336e-01
## Intercept.to.1layhid2     1.215481e+01
## RISK_MM.to.1layhid2      -1.214378e+01
## Temp3pm.to.1layhid2      -5.622178e+01
## Temp9am.to.1layhid2      -2.219249e+01
## WindSpeed3pm.to.1layhid2 -2.067515e+00
## WindSpeed9am.to.1layhid2  2.227723e+01
## Rainfall.to.1layhid2      1.014373e+02
## MaxTemp.to.1layhid2       5.748814e+01
## MinTemp.to.1layhid2      -2.857120e+01
## Intercept.to.1layhid3    -9.513674e-01
## RISK_MM.to.1layhid3       2.671040e+00
## Temp3pm.to.1layhid3      -4.851419e+00
## Temp9am.to.1layhid3      -4.577026e+00
## WindSpeed3pm.to.1layhid3  1.412487e+00
## WindSpeed9am.to.1layhid3 -1.613242e+00
## Rainfall.to.1layhid3      1.170137e+00
## MaxTemp.to.1layhid3       3.994948e+00
## MinTemp.to.1layhid3       4.027289e+00
## Intercept.to.1layhid4    -9.736734e+00
## RISK_MM.to.1layhid4      -5.931442e+01
## Temp3pm.to.1layhid4      -1.144879e+00
## Temp9am.to.1layhid4       1.755456e+01
## WindSpeed3pm.to.1layhid4 -4.449723e+01
## WindSpeed9am.to.1layhid4  3.040746e+01
## Rainfall.to.1layhid4      3.443715e-01
## MaxTemp.to.1layhid4      -6.227970e+01
## MinTemp.to.1layhid4      -2.562915e+01
## Intercept.to.1layhid5    -6.519011e-02
## RISK_MM.to.1layhid5      -3.364935e-03
## Temp3pm.to.1layhid5       5.776212e-01
## Temp9am.to.1layhid5       3.911937e-01
## WindSpeed3pm.to.1layhid5 -1.790629e-01
## WindSpeed9am.to.1layhid5  1.306680e+00
## Rainfall.to.1layhid5      1.750672e-01
## MaxTemp.to.1layhid5      -2.561737e+00
## MinTemp.to.1layhid5       5.039210e-01
## Intercept.to.1layhid6    -1.273570e+01
## RISK_MM.to.1layhid6       7.992899e+01
## Temp3pm.to.1layhid6      -1.832876e+01
## Temp9am.to.1layhid6       6.322473e+00
```

```
## WindSpeed3pm.to.1layhid6  4.727592e+01
## WindSpeed9am.to.1layhid6  3.192124e+01
## Rainfall.to.1layhid6      2.323712e+01
## MaxTemp.to.1layhid6      -2.950120e+01
## MinTemp.to.1layhid6      -2.740662e+01
## Intercept.to.1layhid7    -1.713354e+01
## RISK_MM.to.1layhid7      -4.220649e+01
## Temp3pm.to.1layhid7       8.478449e+00
## Temp9am.to.1layhid7       4.604014e+01
## WindSpeed3pm.to.1layhid7  4.564801e+01
## WindSpeed9am.to.1layhid7 -9.142372e+00
## Rainfall.to.1layhid7      1.387397e+02
## MaxTemp.to.1layhid7      -1.224427e+01
## MinTemp.to.1layhid7      -1.250292e+01
## Intercept.to.MHT         -3.387384e-02
## 1layhid1.to.MHT           3.863990e+00
## 1layhid2.to.MHT          -1.928170e+00
## 1layhid3.to.MHT          -3.390362e+00
## 1layhid4.to.MHT           2.106809e+00
## 1layhid5.to.MHT          -4.381385e+00
## 1layhid6.to.MHT           1.936912e+00
## 1layhid7.to.MHT           1.645062e+00
```

further using compute function to make predictions over test data, rounding the responses to 0 and 1 and storing it as data frame

```
ann.pred = compute(ann, WAUS.test[, c('RISK_MM', 'Temp3pm', 'Temp9am', 'WindSpeed3p
m', 'WindSpeed9am', 'Rainfall', 'MaxTemp', 'MinTemp')])

ann.predr = round(ann.pred$net.result, 0)
ann.predrdf = as.data.frame(as.table(ann.predr))
```

table function used to produce confusion matrix of the model, giving accuracy of 53.69%

```
table(observed = WAUS.test$MHT, predicted = ann.predrdf$Freq)
```

```
##         predicted
## observed   0   1
##        0  31 163
##        1  23 189
```

The classifier performed comparablly equivalet to the tree based classification algorithms, most models are not able to perform better than 50% due to lack of diversity large testing data and entries with response 1 being in quite larger than those with response 0 which leads to nearly same accuracy of 50 to 55% for nearly every model

Question 12

For the question I would be implementing xgboost algorithm, as it outperforms neural networks and every tree based algorithm, specifically made for tabular classification. (https://neptune.ai/blog/tabular-data-binary-classification-tips-and-tricks-from-5-kaggle-competitions (https://neptune.ai/blog/tabular-data-binary-classification-tips-and-tricks-from-5-kaggle-competitions)) and (https://www.kaggle.com/code/rtatman/machine-learning-with-xgboost-in-r (https://www.kaggle.com/code/rtatman/machine-learning-with-xgboost-in-r))

for the same libraries imported

```
library(xgboost)
library(readr)
library(stringr)
```

```
##
## Attaching package: 'stringr'
```

```
## The following object is masked from 'package:strucchange':
##
##     boundary
```

```
library(caret)
library(car)
```

```
## Loading required package: carData
```

```
##
## Attaching package: 'car'
```

```
## The following object is masked from 'package:modeltools':
##
##     Predict
```

converting data_new being the numerical data of WAUS.train in order to access MHT easily and segmenting cases having MHT = 0 and 1

```
data_new_df = as.data.frame(data_new)
negative_cases = nrow(data_new_df[data_new_df$MHT == 0,])
positive_cases = nrow(data_new_df[data_new_df$MHT == 1,])
```

further using xgboost function I created a model which trains itself over 10 boosting rounds with 3 repetitions and for non improvements it stops after 3 itserations, it uses binary logistic function as it’s objective function.

```r
library(xgboost)
# train a model using our training data

model_xgb <- xgboost(data = as.matrix(data_new), # the data
                 label = as.matrix(getElement(as.data.frame(data_new), 'MHT')),
                 max.depth = 3, # the maximum depth of each decision tree
                 nround = 10, # number of boosting rounds
                 early_stopping_rounds = 3, # if we dont see an improvement in this m
any rounds, stop
                 objective = "binary:logistic", # the objective function
                 scale_pos_weight = negative_cases/positive_cases, # control for imba
lanced classes
                 gamma = 1) # add a regularization term
```

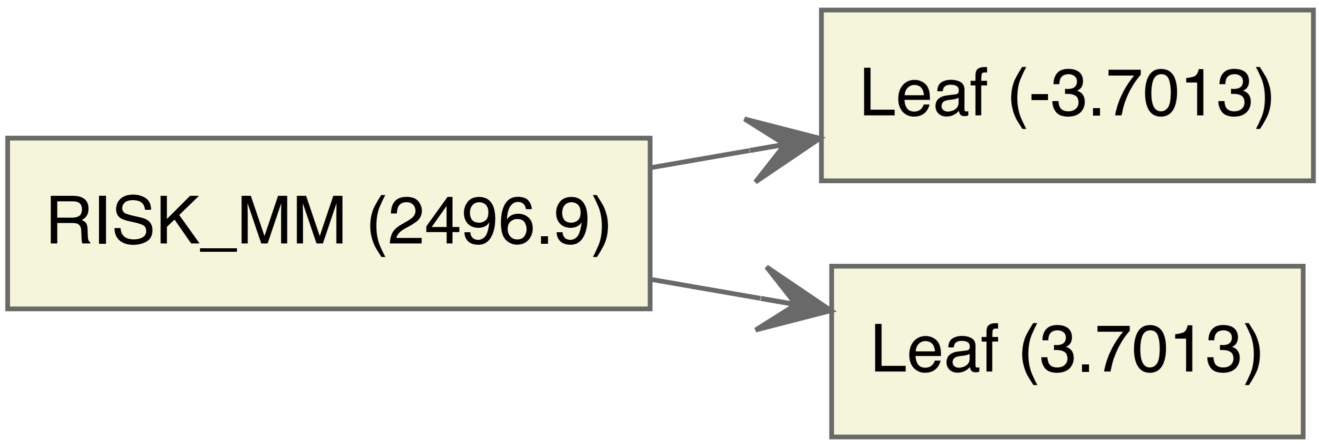
```
## [1]  train-logloss:0.439244
## Will train until train_logloss hasn't improved in 3 rounds.
##
## [2]  train-logloss:0.298422
## [3]  train-logloss:0.209529
## [4]  train-logloss:0.149986
## [5]  train-logloss:0.108745
## [6]  train-logloss:0.079576
## [7]  train-logloss:0.058658
## [8]  train-logloss:0.043515
## [9]  train-logloss:0.032476
## [10] train-logloss:0.024390
```

we can see from the model itself that the loss log is so low suggesting better accuracy of the model

further using diagrammeR library for plotting xgboost

```r
library(DiagrammeR)
xgb.plot.multi.trees(feature_names = names(WAUS),
                     model = model_xgb)
```

```
## Column 2 ['No'] of item 2 is missing in item 1. Use fill=TRUE to fill with NA (NUL
L for list columns), or use.names=FALSE to ignore column names. use.names='check' (de
fault from v1.12.2) emits this message and proceeds as if use.names=FALSE for  backwa
rds compatibility. See news item 5 in v1.12.2 for options to control this message.
```



The plot shows direct reliance over risk_mm for prediction, which accounts for no complexity in model, which might be result of scaling which might have resulted in higher correlation between the 2 variables, however we can test it over test data to verify it

scaling test data after using unclass over it

```
data_new_test <- sapply(WAUS.test[, -2], unclass)
data_new_test[, -13] <- scale(data_new_test[, -13])
```

testing the model over test data using xgb.DMatrix function and getting ocnfusion matrix via caret library function

```
library(caret)
library(ggplot2)
library(lattice)

dtest = xgb.DMatrix(data = as.matrix(data_new_test), label= as.matrix(getElement(as.d
ata.frame(data_new_test), 'MHT')))
# generate predictions for our held-out testing data
pred = predict(model_xgb, dtest)

pred[pred>0.5] = "1"
pred[pred<=0.5]= "0"


confusionMatrix(as.factor(WAUS.test$MHT), as.factor(pred))
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 194   0
##          1   0 212
##
##                Accuracy : 1
##                  95% CI : (0.991, 1)
##     No Information Rate : 0.5222
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 1
##
##  Mcnemar's Test P-Value : NA
##
##             Sensitivity : 1.0000
##             Specificity : 1.0000
##          Pos Pred Value : 1.0000
##          Neg Pred Value : 1.0000
##              Prevalence : 0.4778
##          Detection Rate : 0.4778
##    Detection Prevalence : 0.4778
##       Balanced Accuracy : 1.0000
##
##        'Positive' Class : 0
##
```

The model produced accuracy of 100% which could be result of over fitting alongside lack of larger test dataset which would be diverse than training data set, for the given training data and testing data this model correctly measured output og MHT for every entry suffesting direct correlation between RISK_MM and MHT. However, it could be further improvised and worked over for provision of larger datasets. It didn't include the rest of factors are they are direct contrast to the predictor.

Methodologies tried to reduce the overfitting, removal of 1 to 3 more parameters resulted in model with single root node directly predicting the the output node.