**DATA 621 Homework 2**

**Classification Metrics**

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**Description**

In this homework assignment, you will work through various classification metrics. You will be asked to create functions in R to carry out the various calculations. You will also investigate some functions in packages that will let you obtain the equivalent results. Finally, you will create graphical output that also can be used to evaluate the output of classification models, such as binary logistic regression.

Question1: The Data set

| | pregnant | glucose | diastolic | skinfold | insulin | bmi | pedigree | age | class | scored.class | scored.probability |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 176 | 5 | 144 | 82 | 26 | 285 | 32.0 | 0.452 | 58 | 1 | 1 | 0.6764516 |
| 177 | 5 | 123 | 74 | 40 | 77 | 34.1 | 0.269 | 28 | 0 | 0 | 0.3114196 |
| 178 | 4 | 146 | 78 | 0 | 0 | 38.5 | 0.520 | 67 | 1 | 1 | 0.7072096 |
| 179 | 8 | 188 | 78 | 0 | 0 | 47.9 | 0.137 | 43 | 1 | 1 | 0.8882766 |
| 180 | 9 | 120 | 72 | 22 | 56 | 20.8 | 0.733 | 48 | 0 | 0 | 0.4224679 |
| 181 | 0 | 102 | 86 | 17 | 105 | 29.3 | 0.695 | 27 | 0 | 0 | 0.1199810 |

From the provided dataset, it appears that the dependent variable – class, was repressed against several variables. The scored.class variable is the predicted variable and the scored.probbility class gives the probability that the scored.class belongs to a class of 1.

Question 2: Raw confusion matrix

```
key_columns_df <- dplyr::select(data, scored.class, class)
table(key_columns_df)
```

```
##              class
## scored.class   0   1
##            0 119  30
##            1   5  27
```

The rows represent the predicted, the columns represent the actual classes.

Question 3: Accuracy of predictions

```
accuracy_fn <- function(df){
  TP <- sum(df$class == 1 & df$scored.class == 1)
  TN <- sum(df$class == 0 & df$scored.class == 0)
  accuracy <- (TP + TN)/nrow(df)
  return(accuracy)
}

# Run the function on the dataset
accuracy_fn(data)
```

```
## [1] 0.8066298
```

## Question 4: Classification error rate of the predictions

```
cf_err_rate_fn <- function(df){
  FP <- sum(df$class == 0 & df$scored.class == 1)
  FN <- sum(df$class == 1 & df$scored.class == 0)
  cf_err_rate <- (FP + FN)/nrow(df)
  return(cf_err_rate)
}

# run the function on the dataset
cf_err_rate_fn(data)
```

```
## [1] 0.1933702
```

The sum of Accuracy and Error rates:

```
print(paste0("The sum of Accuracy and Error Rates: ", (accuracy_fn(data) +  cf_err_rate_fn(data))))
```

```
## [1] "The sum of Accuracy and Error Rates: 1"
```

## Question 5: Precision of the predictions

```
precision_fn <- function(df){
  TP <- sum(df$class == 1 & df$scored.class == 1)
  FP <- sum(df$class == 0 & df$scored.class == 1)
  precision <- (TP)/(TP+FP)
  return(precision)
}

#Run it on the dataset
precision_fn(data)
```

```
## [1] 0.84375
```

## Question 6: Sensitivity of the predictions

```r
sensitivity_fn <- function(df){
  TP <- sum(df$class == 1 & df$scored.class == 1)
  FN <- sum(df$class == 1 & df$scored.class == 0)
  sensitivity <- (TP)/(TP+FN)
  return(sensitivity)
}

#Running it on the data
sensitivity_fn(data)
```

```
## [1] 0.4736842
```

## Question 7: Specificity of the predictions

```r
specificity_fn <- function(df){
  TN <- sum(df$class == 0 & df$scored.class == 0)
  FP <- sum(df$class == 0 & df$scored.class == 1)
  specificity <- (TN)/(TN+FP)
  return(specificity)
}

#Run it on the data
specificity_fn(data)
```

```
## [1] 0.9596774
```

## Question 8: F1 score of the predictions

```r
f1_score_fn <- function(df){
  f1_score <- (2*precision_fn(df)*sensitivity_fn(df))/(precision_fn(df)+sensitivity_fn(df))
   return(f1_score)
}

#Run it on the data
f1_score_fn(data)
```

```
## [1] 0.6067416
```

## Question 9: Bounds of F1 score

Precision values between from 0 to 1: $0 \geq p \geq 1$

Sensitivity values also range between 0 to 1: $0 \geq s \geq 1$

Using the relation: If $0 < a < 1$ and $0 < b < 1$ then a b < a, we have: $p*s \leq s$ and $p*s \leq p$

This implies that: $0 \leq p*s \leq p \leq 1$ and $0 \leq p*s \leq s \leq 1$

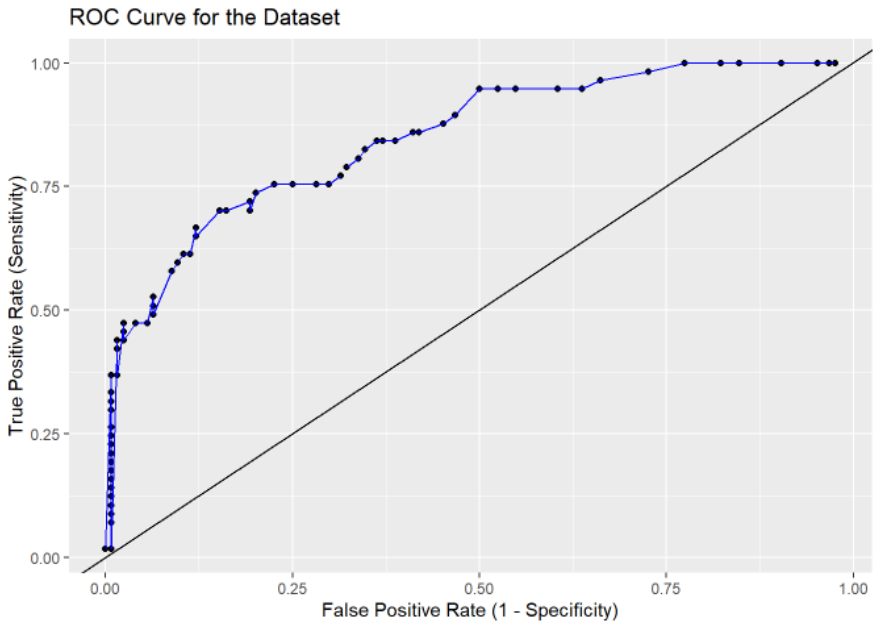
The numerator in the equation ranges from 0 to 1

The denominator ranges from 0 to 2 Hence the quotient will range from 0 to 1.

## Question 10: ROC Curve

```r
roc_curve_fn <- function(df){
  # sequence of thresholds ranging from 0 to 1 at 0.01 intervals.
  seq_int <- seq(0,1,by=0.01)
  TPR_vector <- c()
  FPR_vector <- c()

  for (i in 1:length(seq_int)){
    scored_class <- ifelse(df$scored.probability >= seq_int[i], 1, 0)
    rev_df <- data.frame(scored.class = scored_class, class = df$class)
    df_table <- with(rev_df, table(scored.class, class))
    TPR <- (df_table[4])/(df_table[4] + df_table[3])
    FPR <- (df_table[2]/(df_table[2] + df_table[1]))
    TPR_vector[i] <- TPR
    FPR_vector[i] <- FPR
  }

  plot_df <- data.frame(TRUE_POSITIVE = TPR_vector, FALSE_POSITIVE = FPR_vector)
  ROC_plot <- ggplot(plot_df, aes(x=FALSE_POSITIVE, y=TRUE_POSITIVE)) + geom_point() + geom_line(col="blue") + ge
om_abline(intercept = 0, slope = 1) + labs(title="ROC Curve for the Dataset", x = "False Positive Rate (1 - Speci
ficity)", y = "True Positive Rate (Sensitivity)")

  # Remove the NA values to calculate area under the curve
  auc_df <- plot_df[complete.cases(plot_df),]

  # Calculation AUC (Area under the curve)
  x <- abs(diff(auc_df$FALSE_POSITIVE))
  y <- auc_df$TRUE_POSITIVE

  area_under_curve <- sum(x*y)

  return(list(ROC_plot, area_under_curve))
}

ROC_list <- roc_curve_fn(data)
```






```r
print(paste0("Area Under the Curve: ", area_under_curve))
```

```
## [1] "Area Under the Curve: 0.829937747594793"
```



Question 11: All classification metrics

```
functions_df <- c(accuracy_fn(data),
         cf_err_rate_fn(data),
         precision_fn(data),
         sensitivity_fn(data),
         specificity_fn(data),
         f1_score_fn(data))
names(functions_df) <- c("Accuracy", "Classification Error", "Precision",
               "Sensitivity", "Specificity", "F1 Score")
functions_df<-as.data.frame(functions_df)
names(functions_df)[1]<-'Scores'
kbl(functions_df)%>%
   kable_classic("hover", full_width = F, html_font = "Helvetica")
```

| | Scores |
|---|---|
| Accuracy | 0.8066298 |
| Classification Error | 0.1933702 |
| Precision | 0.8437500 |
| Sensitivity | 0.4736842 |
| Specificity | 0.9596774 |
| F1 Score | 0.6067416 |

Question 12: Caret package

```
scored_df <- data %>%
  select(scored.class, class) %>%
  mutate(scored.class = as.factor(scored.class),
         class = as.factor(class))

c_matrix <- confusionMatrix(scored_df$scored.class, scored_df$class, positive = "1")

Caret_Package <- c(c_matrix$overall["Accuracy"], c_matrix$byClass["Sensitivity"], c_matrix$byClass["Specificity"
])
Written_Functions <- c(accuracy_fn(data), sensitivity_fn(data), specificity_fn(data))
d <- cbind(Caret_Package, Written_Functions)
kbl(d)%>%
   kable_classic("hover", full_width = F, html_font = "Garamond")
```

| | Caret_Package | Written_Functions |
|---|---|---|
| Accuracy | 0.8066298 | 0.8066298 |
| Sensitivity | 0.4736842 | 0.4736842 |
| Specificity | 0.9596774 | 0.9596774 |

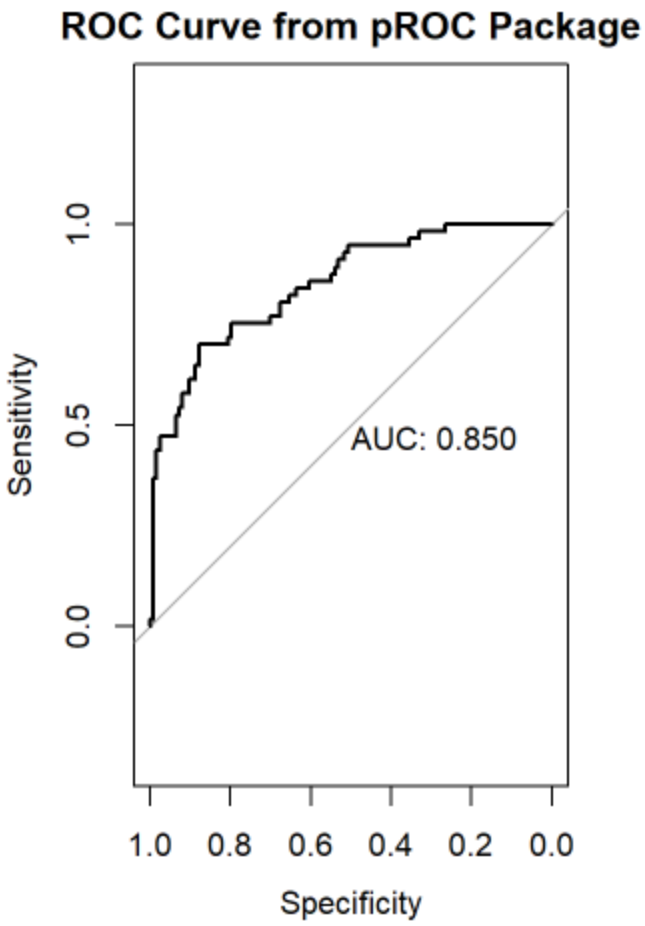
The results from the caret package and the functions Confusion matrix, sensitivity, and specificity are the same.

Question 13: pROC package

```
#The results are exactly the same
par(mfrow = c(1, 2))
plot(roc(data$class, data$scored.probability), print.auc = TRUE, main="ROC Curve from pROC Package")
```

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

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




This plot looks very similar to our manual plot, the only difference being the area under the curve.

**References**


- https://www.kaggle.com/kumargh/pimaindiansdiabetescsv
- https://en.wikipedia.org/wiki/Confusion_matrix
- https://rdrr.io/cran/caret/man/sensitivity.html
- https://developers.google.com/machine-learning/crash-course/classification/true-false-positive-negative


**Code**

GitHub: https://github.com/nathtrish334/Data-621/blob/main/Homework01.rmd

RPubs: https://rpubs.com/trishitanath/814750