Homework 2

Group 1

Contents

Prepared for:

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Group 1

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1 Data Source

The data is a set of actual classes and predicted classes as provided by Dr. Nathan Bastian for this exercise. We uploaded the data to our public GitHub repository for ease of access.

2 Data Explained and Confusion Matrix

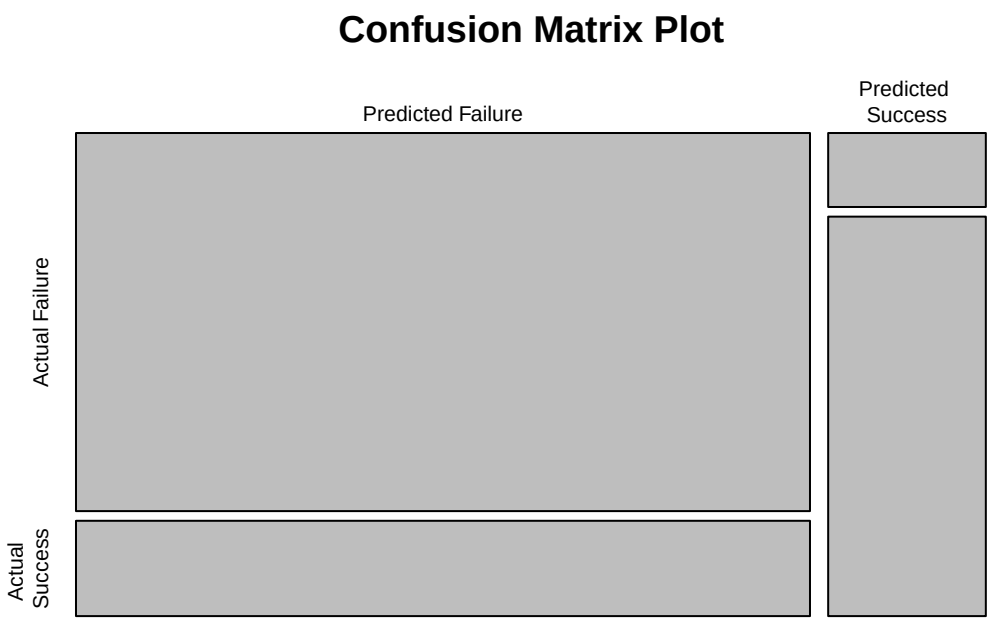
We will be using the following columns from the data source:

- class: the actual class for the observation
- scored.class: the predicted class for the observation (based on a threshold of 0.5)
- scored.probability: the predicted probability of success for the observation

The raw confusion matrix for our scored data set is represented the following table. The rows represent the actual classes and the columns represent the predicted classes.

	Predicted Failure	Predicted Success
Actual Failure	119	5
Actual Success	30	27

A visual representation of the confusion matrix is presented in the below figure.



3 Function for Accuracy of Predictions

We developed a function that takes the data set as a dataframe, with actual and predicted classifications identified, and returns the accuracy of the predictions.

Accuracy is determined by the below formula:

$$Accuracy = \frac{True\ Positives + True\ Negatives}{True\ Positives + False\ Positives + True\ Negatives + False\ Negatives}$$

4 Function for Classification Error Rate of Predictions

We developed a function that takes the data set as a dataframe, with actual and predicted classifications identified, and returns the classification error rate of the predictions. It also verifies that the accuracy and an error rate sums to one.

Classification of Error Rate is determined by the below formula:

$$Classification\ Error\ Rate = \frac{False\ Positives + False\ Negatives}{True\ Positives + False\ Positives + True\ Negatives + False\ Negatives}$$

5 Function for Precisions of Predictions

Write a function that takes the data set as a dataframe, with actual and predicted classifications identified, and returns the precision of the predictions.

Precision is determined by the below formula:

$$Precision = \frac{True\ Positives}{True\ Positives + False\ Positives}$$

6 Function for Sensitivity of Predictions

We developed a function that takes the data set as a dataframe, with actual and predicted classifications identified, and returns the sensitivity of the predictions. Sensitivity is also known as recall.

Sensitivity is determined by the below formula:

$$Sensitivity = \frac{True\ Positives}{True\ Positives + False\ Negatives}$$

7 Function for Specificity of Predictions

We developed a function that takes the data set as a dataframe, with actual and predicted classifications identified, and returns the specificity of the predictions.

Specificity is determined by the below formula:

$$Specificity = \frac{True\ Negative}{True\ Negatives + False\ Positives}$$

8 F1 Score of Predictions

We developed a function that takes the data set as a dataframe, with actual and predicted classifications identified, and returns the F1 score of the predictions.

The F1 score is determined by the below formula:

$$F1\ Score = \frac{2 * Precision * Sensitivity}{Precision + Sensitivity}$$

9 Bounds of F1 Score of Predictions

Before we move on, let's consider a question that was asked: What are the bounds on the F1 score? Show that the F1 score will always be between 0 and 1. (Hint: If 0 < ???? < 1 and 0 < ???? < 1 then ????????- Christophe

10 Function for ROC curve

We developed a function that generates an ROC curve from a data set with a true classification column (`class` from our data set) and a probability column (`scored.probability` from our data set). Our function returns a list that includes the plot of the ROC curve and a vector that contains the calculated area under the curve (AUC). As per Dr. Bastion's recommendation we used a sequence of thresholds ranging from 0 to 1 at 0.01 intervals.

11 R Functions created and classification output

11.1 Accuracy of Predictions

```
paste0("Accuracy of Predictions = ", percent(Accuracy(df = scores, actual = "class",
    prediction = "scored.class", positiveValue = 1, negativeValue = 0)))
```

[1] “Accuracy of Predictions = 80.7%”

11.2 Classification Error Rate of Predictions

```
paste0("Error Rate of Predictions = ", percent(ClassificationErrorRate(df = scores,
    actual = "class", prediction = "scored.class", positiveValue = 1, negativeValue = 0)))
```

[1] “Error Rate of Predictions = 19.3%”

11.3 Precisions of Predictions

```
paste0("Precision of Predictions = ", percent(Precision(df = scores, actual = "class",
    prediction = "scored.class", positiveValue = 1, negativeValue = 0)))
```

[1] “Precision of Predictions = 47.4%”

11.4 Sensitivity of Predictions

```
paste0("Sensitivity of Predictions = ", percent(Sensitivity(df = scores, actual = "class",
    prediction = "scored.class", positiveValue = 1, negativeValue = 0)))
```

[1] “Sensitivity of Predictions = 84.4%”

11.5 Specificity of Predictions

```
paste0("Specificity of Predictions = ", percent(Specificity(df = scores, actual = "class",
    prediction = "scored.class", positiveValue = 1, negativeValue = 0)))
```

[1] “Specificity of Predictions = 79.9%”

11.6 F1 Score of Predictions

```
paste0("The F1 Score = ", f1_score(df = scores, actual = "class", prediction = "scored.class",
    positiveValue = 1, negativeValue = 0))
```

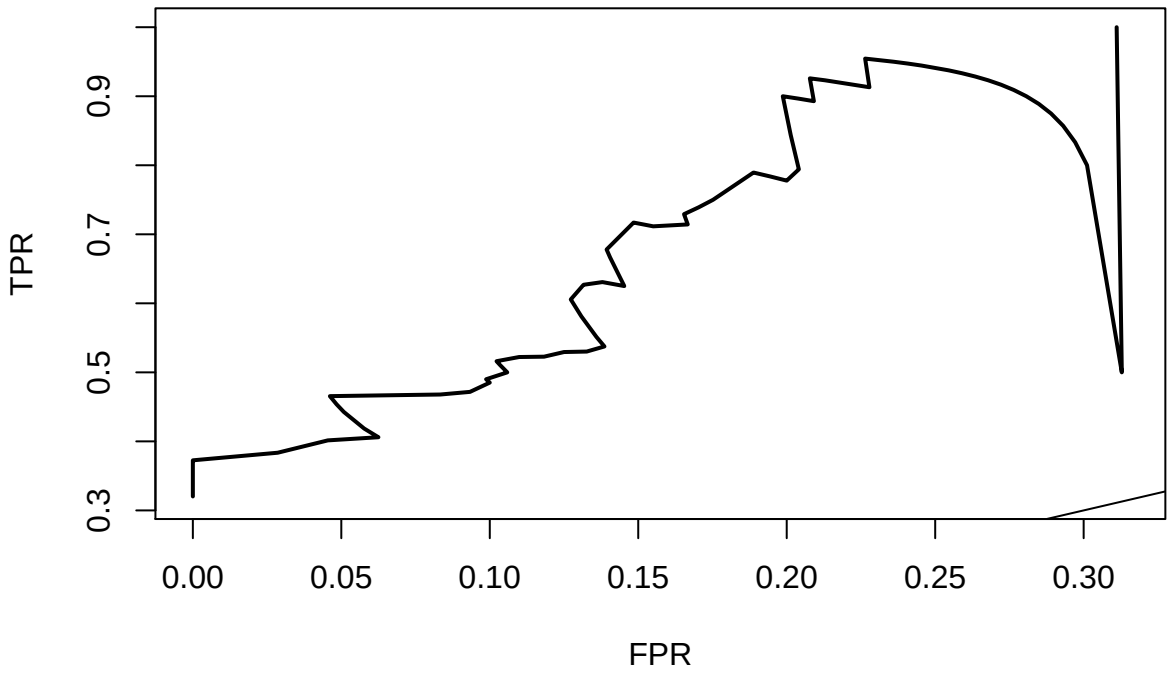
[1] “The F1 Score = 0.606741573033708”

11.7 ROC Function

We calculated best threshold value using two methods.
a) by calculating the distance of the point from (0,1).
b) by calculating AUC by making a curve for threshold{t} by joining points (0,0), (X{t},Y{t}), (1,1)

Two thresholds intervals were used:
1) .01
2) .001

1) As the cut-off interval was set threshold (0,1,0.01) the value returned is very close to the value that the R package `pROC` predicts

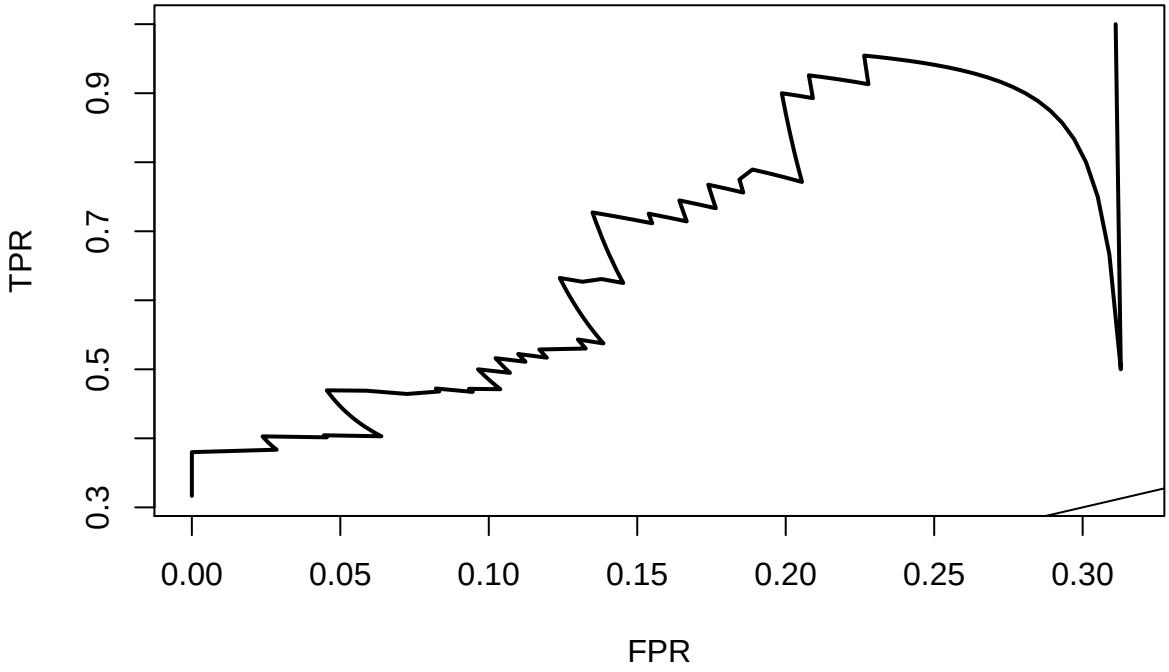


AUC using manual calculation is NaN.

Best Threshold value using method 1 is {Threshold = NA,fpr = NA,tpr = NA,auc = NA, dist = NA}

Best Threshold value using method 2 is {Threshold = NA,fpr = NA,tpr = NA,auc = NA, dist = NA}

- 2) when cut-off interval is threshold(0,1,0.001) -> value is exact to what pROC predicts



AUC using manual calculation is NaN.

Best Threshold value using method 1 is {Threshold = NA,fpr = NA,tpr = NA,auc = NA, dist = NA}

Best Threshold value using method 2 is {Threshold = NA,fpr = NA,tpr = NA,auc = NA, dist = NA}

12 Investigation of `caret` package.

In particular, consider the functions confusionMatrix, sensitivity, and specificity. Apply the functions to the data set. How do the results compare with your own functions?

```
0   1
```

0 119 5 1 30 27

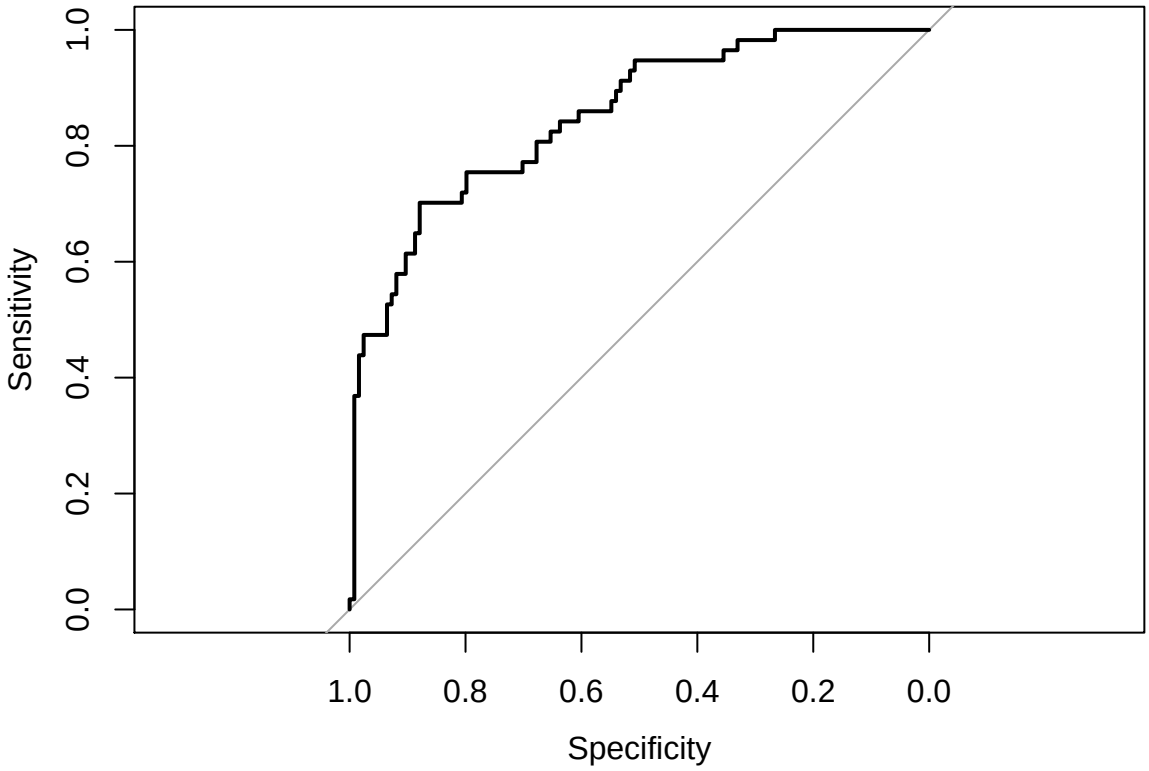
Here, the accuracy is rounded up to 4 decimal places. The confusion matrix has rows that represent the predicted classes and columns that represent the actual classes.

[1] 0.7986577

[1] 0.84375

13 Investigation of the pROC R package.

We used the pROC R package to generate an ROC curve for the data set.



Call: roc.default(response = scores$class, predictor = scores$scored.probability)

Data: scores$scored.probability in 124 controls (scores$class 0) < 57 cases (scores$class 1). Area under the curve: 0.8503

Best Threshold value using pROC package is {Threshold = 0.375117,fpr = 0.120968,tpr = 0.701754}

Our second method (using auc) predicts better than first method (using distance from (0,1))

14 Appendix A

14.1 Session Info

- R version 3.3.1 (2016-06-21), `x86_64-w64-mingw32`
- Locale: `LC_COLLATE=English_United States.1252`, `LC_CTYPE=English_United States.1252`, `LC_MONETARY=English_United States.1252`, `LC_NUMERIC=C`, `LC_TIME=English_United States.1252`
- Base packages: base, datasets, graphics, grDevices, methods, stats, utils
- Other packages: caret 6.0-71, dplyr 0.5.0, formatR 1.4, ggplot2 2.1.0, knitr 1.14, lattice 0.20-34, pacman 0.4.1, pander 0.6.0, pROC 1.8, purrr 0.2.2, readr 1.0.0, scales 0.4.0, tibble 1.2, tidyr 0.6.0, tidyverse 1.0.0, xtable 1.8-2
- Loaded via a namespace (and not attached): assertthat 0.1, car 2.1-3, class 7.3-14, codetools 0.2-15, colorspace 1.2-6, DBI 0.5-1, digest 0.6.10, e1071 1.6-7, evaluate 0.9, foreach 1.4.3, grid 3.3.1, gtable 0.2.0, htmltools 0.3.5, iterators 1.0.8, lazyeval 0.2.0, lme4 1.1-12, magrittr 1.5, MASS 7.3-45, Matrix 1.2-7.1, MatrixModels 0.4-1, mgcv 1.8-15, minqa 1.2.4, munsell 0.4.3, nlme 3.1-128, nloptr 1.0.4, nnet 7.3-12, parallel 3.3.1, pbkrtest 0.4-6, plyr 1.8.4, quantreg 5.29, R6 2.2.0, Rcpp 0.12.7, reshape2 1.4.1, rmarkdown 1.0, SparseM 1.72, splines 3.3.1, stats4 3.3.1, stringi 1.1.2, stringr 1.1.0, tools 3.3.1, yaml 2.1.13

14.2 Data Table

class	scored.class	scored.probability
0	0	0.3284523
0	0	0.2731904
1	0	0.1096604
0	0	0.0559984
0	0	0.1004907
0	0	0.0551546
0	0	0.1071154
0	0	0.4599474
0	0	0.1170237
0	0	0.3153632
0	0	0.1251892
0	0	0.2706248
0	0	0.2098096
0	0	0.0935859
1	1	0.8848457
1	0	0.3966522
0	1	0.8913949
1	1	0.5345490
1	1	0.9463342
0	0	0.1449162
0	0	0.2176380
0	0	0.0752136
0	0	0.0884325
0	0	0.3034682
1	1	0.7244800

class	scored.class	scored.probability
1	0	0.2749737
1	0	0.4248648
1	0	0.4309255
0	0	0.0232280
0	0	0.0459608
0	0	0.1279853
0	0	0.2993371
1	0	0.4590950
0	0	0.1047958
1	1	0.8630918
1	1	0.6399750
0	0	0.3581843
0	0	0.3721647
1	1	0.8111032
0	0	0.1681274
0	0	0.1512780
0	0	0.1070070
0	0	0.1879614
0	0	0.1371971
0	0	0.3004749
0	0	0.1368871
0	0	0.0978691
0	0	0.0629070
1	0	0.2694193
0	0	0.4885428
0	0	0.3717580
1	0	0.0994799
0	0	0.0865623
0	0	0.1752894
1	0	0.4693790
1	1	0.6165544
0	0	0.0998279
1	1	0.6891771
0	0	0.2552862
1	1	0.8505433
1	0	0.1688625
0	0	0.0972415
0	0	0.2483691
0	0	0.1815610
0	0	0.2399936
0	0	0.4045589
0	0	0.3583026
0	0	0.1506308
1	0	0.4865383
1	1	0.6150348
0	0	0.3544895
1	0	0.1731396
1	0	0.2596111
1	1	0.6989399
0	0	0.2986016
0	0	0.1042313
0	0	0.2110528

class	scored.class	scored.probability
0	0	0.0654278
0	0	0.0505143
0	0	0.1086797
0	0	0.0786895
1	1	0.6812876
1	0	0.3771203
0	0	0.1627077
0	0	0.3521508
1	0	0.4754964
0	0	0.1356581
0	0	0.1339198
0	1	0.5224711
0	0	0.2593819
0	0	0.0994674
0	0	0.1271923
1	0	0.3764462
0	1	0.5208823
1	1	0.7605921
1	0	0.2089265
1	0	0.2333521
0	0	0.2059407
0	0	0.1156596
0	0	0.0839931
1	0	0.1177312
1	1	0.7170364
0	0	0.1292900
0	0	0.4368037
0	0	0.2815537
1	1	0.5919838
1	1	0.8472932
0	0	0.3151556
0	0	0.1373101
0	0	0.1680963
0	0	0.0506711
0	0	0.4983591
1	0	0.4548143
0	0	0.4504421
1	0	0.1814974
0	0	0.2942037
1	0	0.4094483
1	0	0.3167683
0	0	0.1969549
0	0	0.0627996
1	1	0.8833591
0	0	0.0993645
1	0	0.4088370
0	0	0.3624922
0	0	0.0799184
1	1	0.6172762
0	0	0.2235817
0	0	0.3013863
0	0	0.0661091

class	scored.class	scored.probability
1	0	0.1670290
0	0	0.2970645
0	1	0.6276502
0	0	0.2036287
0	0	0.4574735
0	0	0.3722721
1	1	0.6357807
0	0	0.0837734
0	0	0.1519378
0	0	0.0532099
1	1	0.5486644
0	0	0.4946261
0	0	0.2353255
0	0	0.1831519
0	0	0.0641505
0	0	0.0859556
0	0	0.3737878
0	0	0.4128094
1	1	0.8304976
0	0	0.1314538
0	0	0.0661406
0	0	0.1009617
0	0	0.0286396
0	0	0.2696404
1	0	0.3281420
0	0	0.1493509
1	0	0.4555714
0	0	0.0809498
0	0	0.0347143
1	1	0.6614750
0	0	0.0659893
0	0	0.1397903
0	0	0.0474267
0	0	0.0266070
1	1	0.7825946
0	0	0.1418285
0	0	0.2850303
1	0	0.3388554
1	0	0.1626446
0	1	0.5649062
0	0	0.0562242
0	0	0.1891168
0	0	0.1707249
0	0	0.1608049
1	0	0.2457727
0	0	0.1099905
1	1	0.6764516
0	0	0.3114196
1	1	0.7072096
1	1	0.8882766
0	0	0.4224679
0	0	0.1199810

14.3 R source code

Please see Homework 2.rmd on GitHub for source code.

https://github.com/ChristopheHunt/DATA-621-Group-1/blob/master/Homework%202/Homework%202.Rmd.