uOttawa

Assignment 2

Course: GNG5300 Machine Learning for Scientists and Engineers
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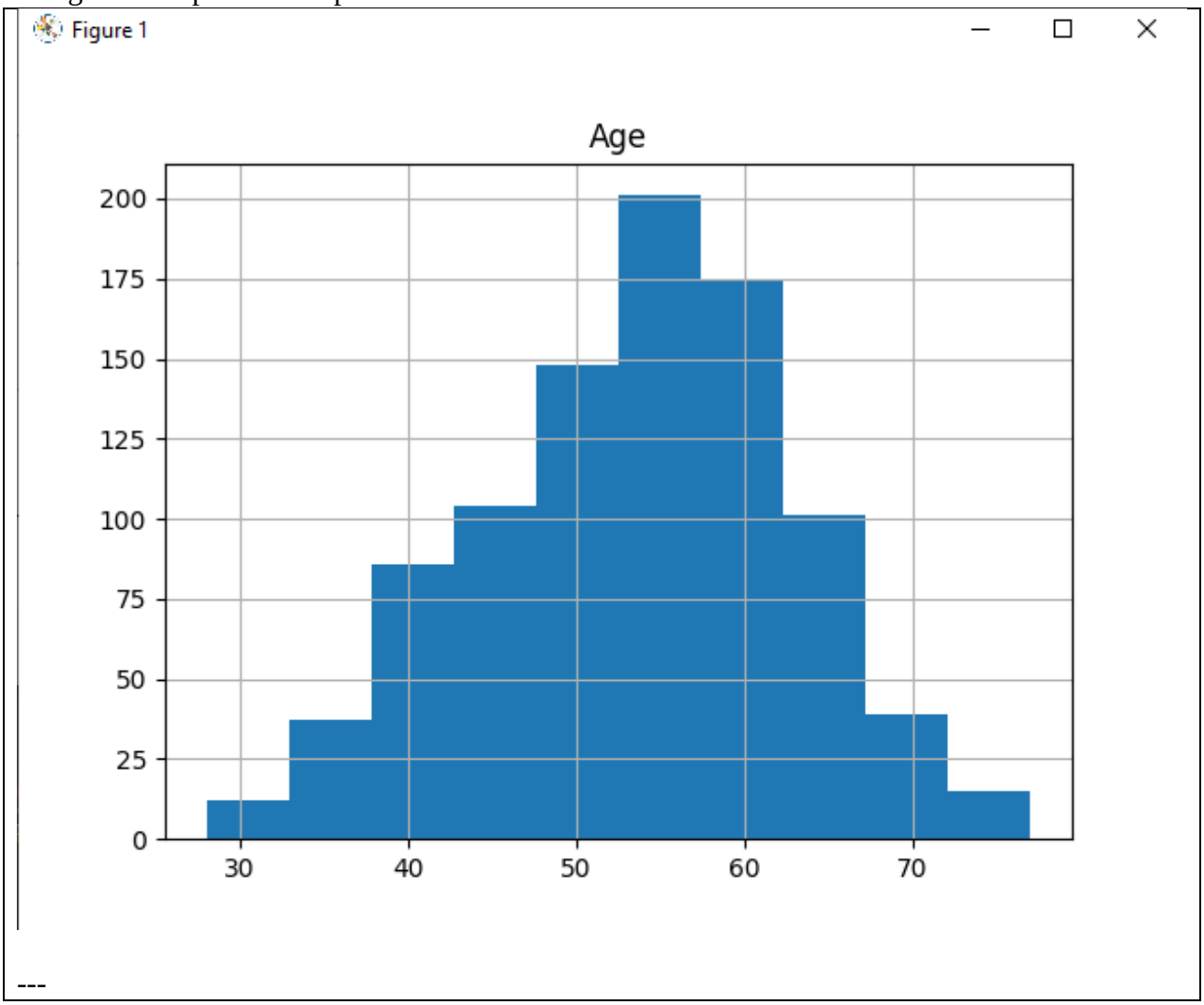
Part A: EDA

Step 1

- The excel sheet is imported into a data frame. Lines 8-9.
- Histograms are plotted and printed. Lines 61-69.



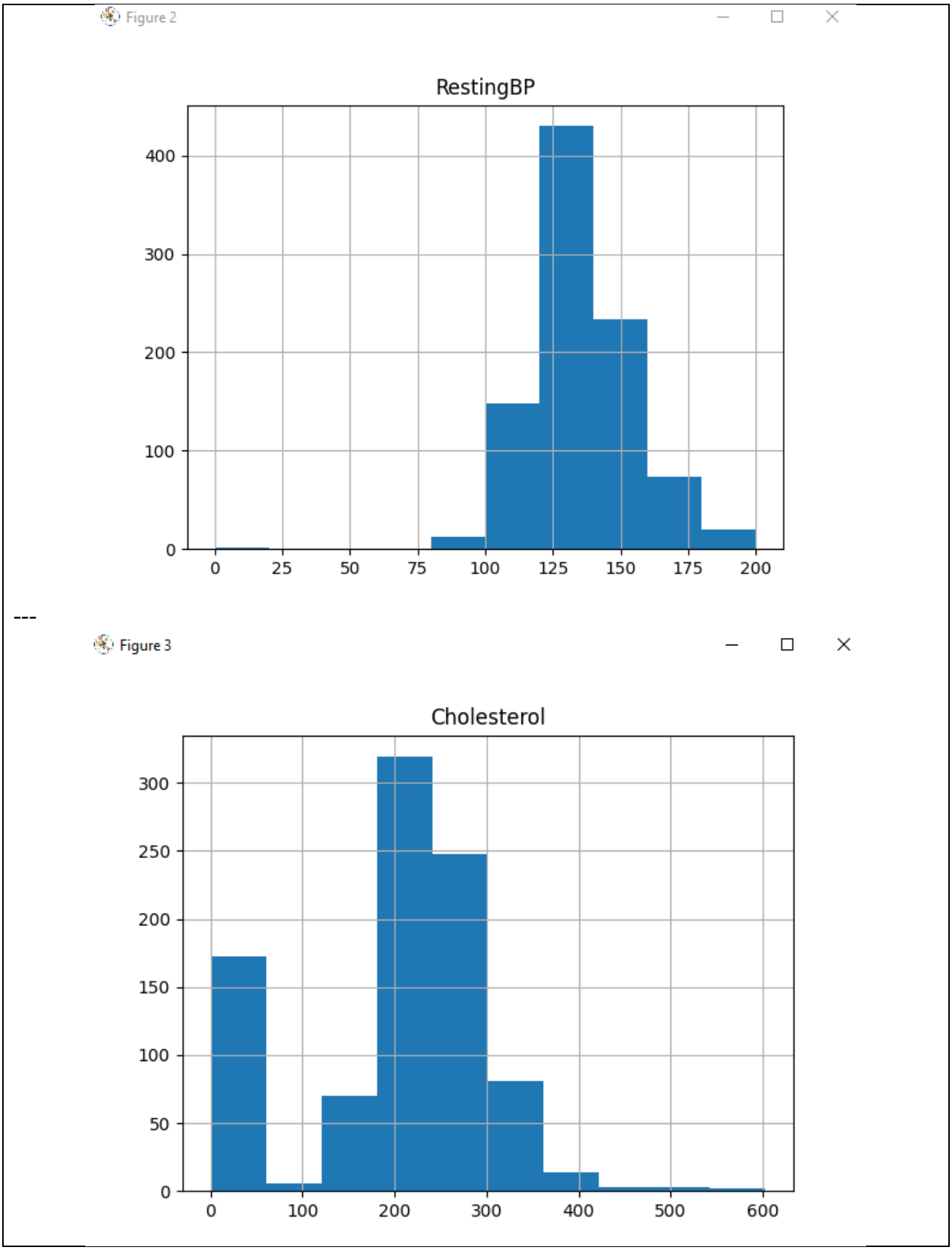


Figure 2
RestingBP
400
300
200
100
0
0
25
50
75
100
125
150
175
200

Figure 3
Cholesterol
300
250
200
150
100
50
0
0
100
200
300
400
500
600

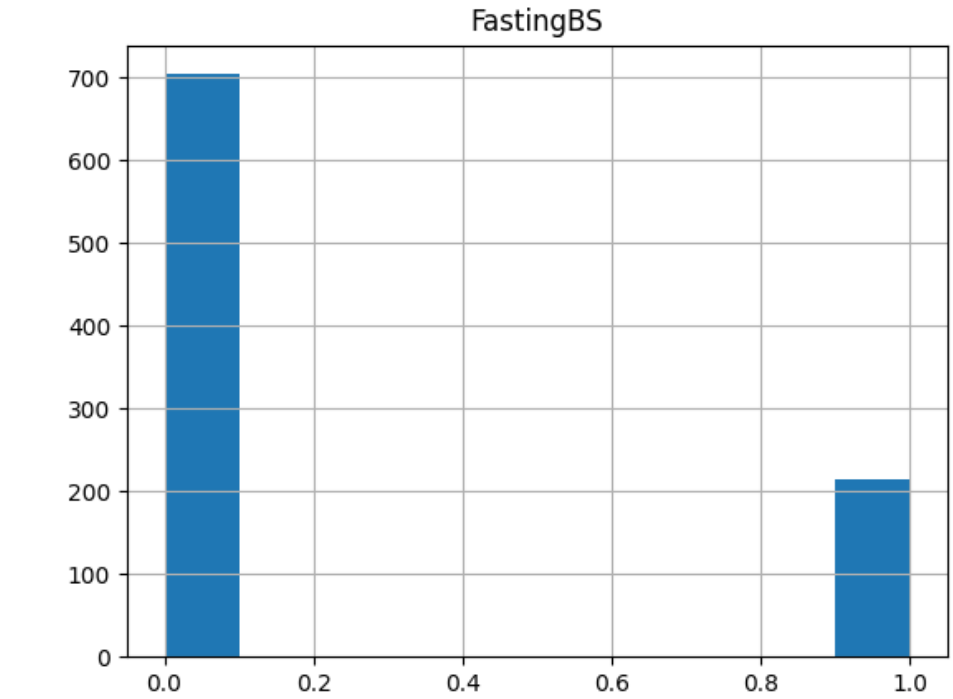


Figure 4
FastingBS
700
600
500
400
300
200
100
0
0.0
0.2
0.4
0.6
0.8
1.0

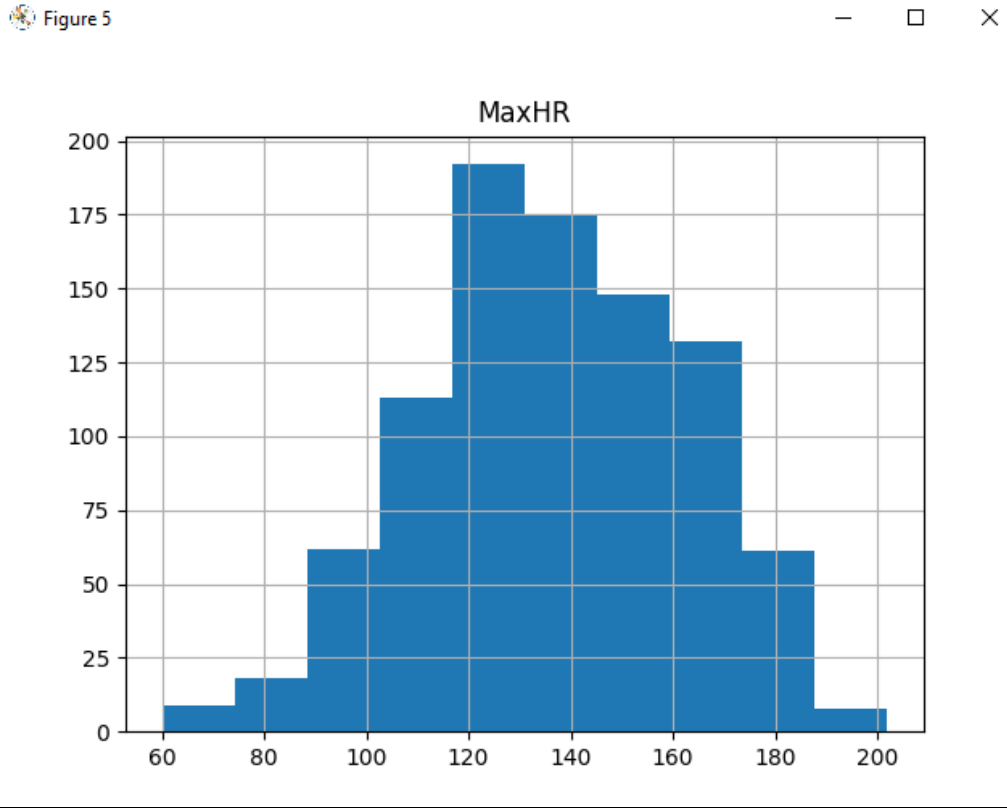


Figure 5
MaxHR
200
175
150
125
100
75
50
25
0
60
80
100
120
140
160
180
200

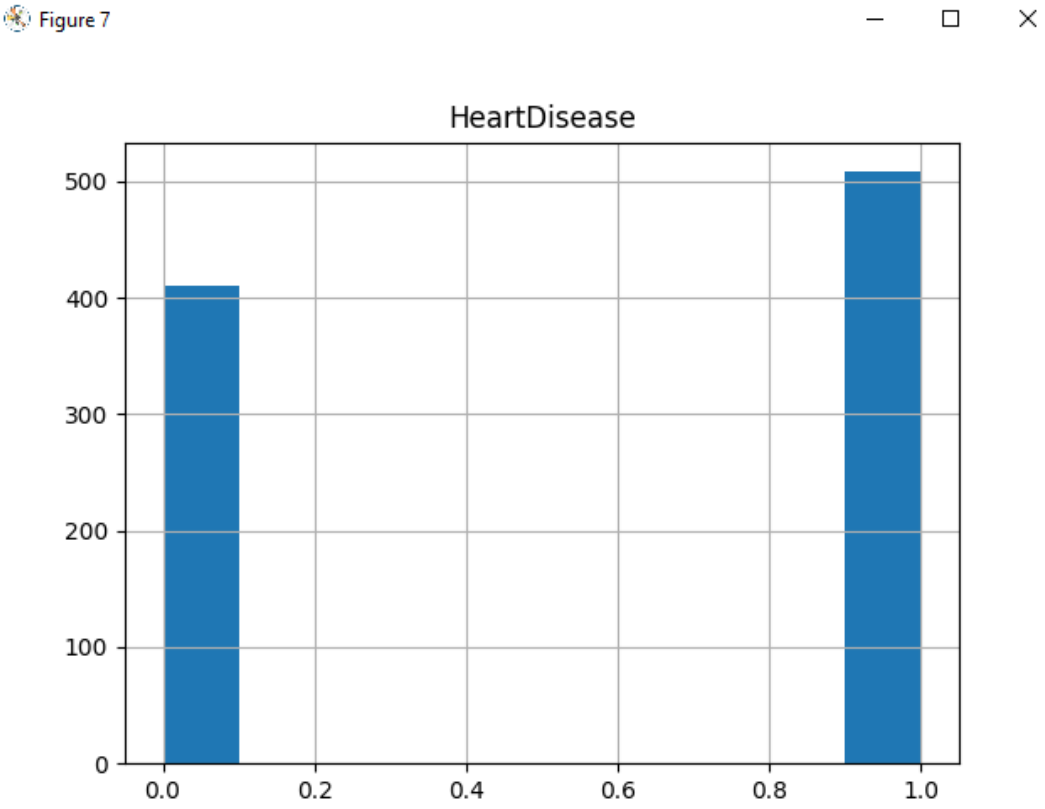


Figure 7
HeartDisease
500
400
300
200
100
0
0.0
0.2
0.4
0.6
0.8
1.0

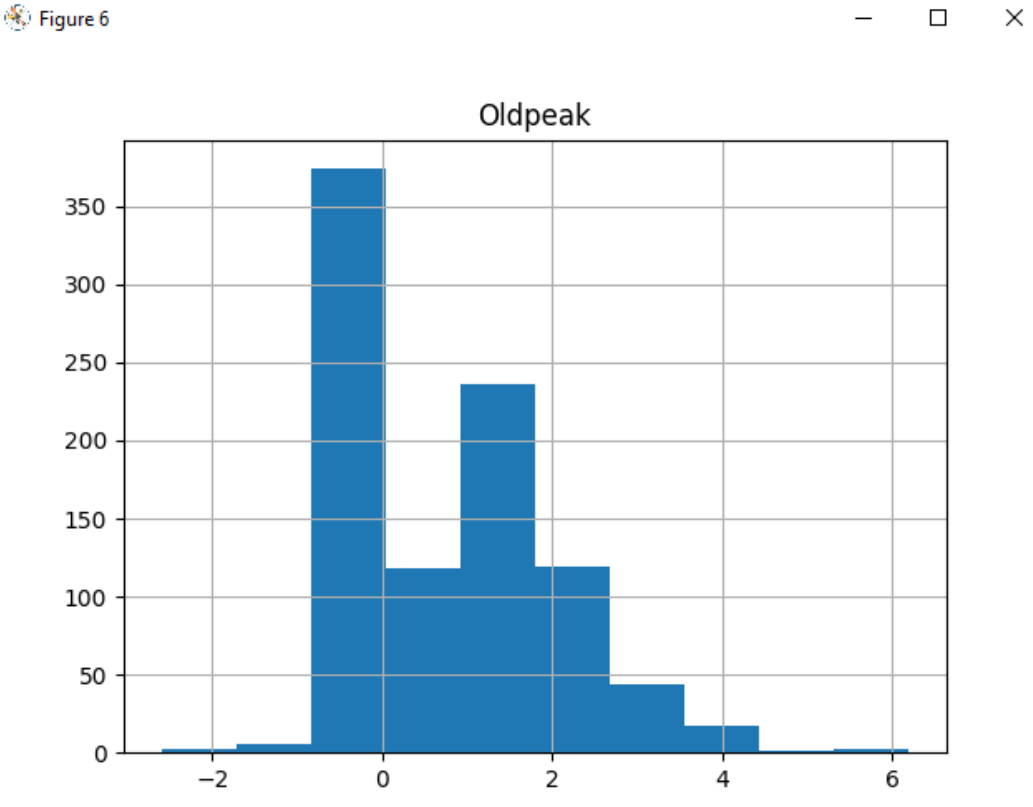
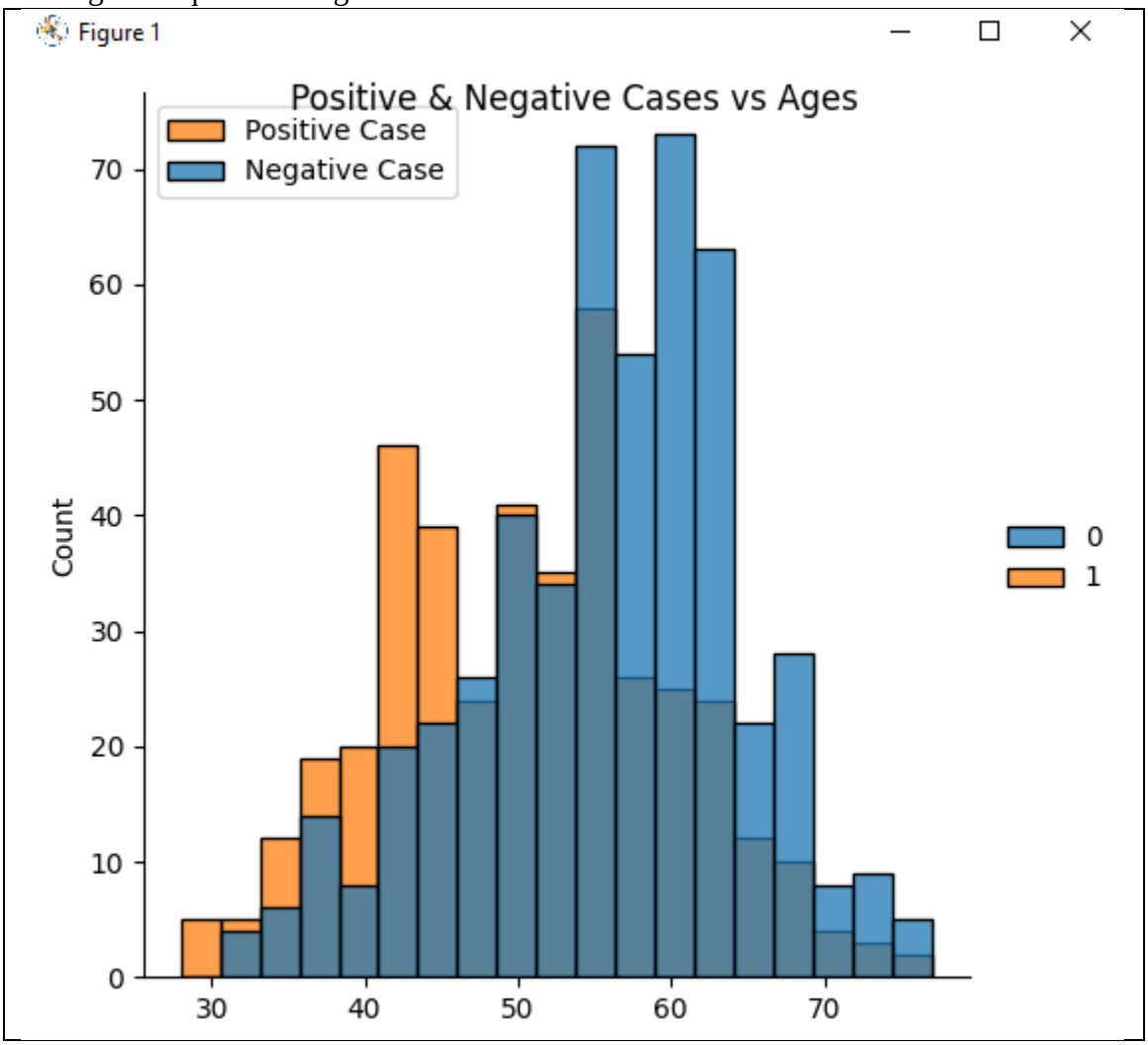


Figure 6
Oldpeak
350
300
250
200
150
100
50
0
−2
0
2
4
6

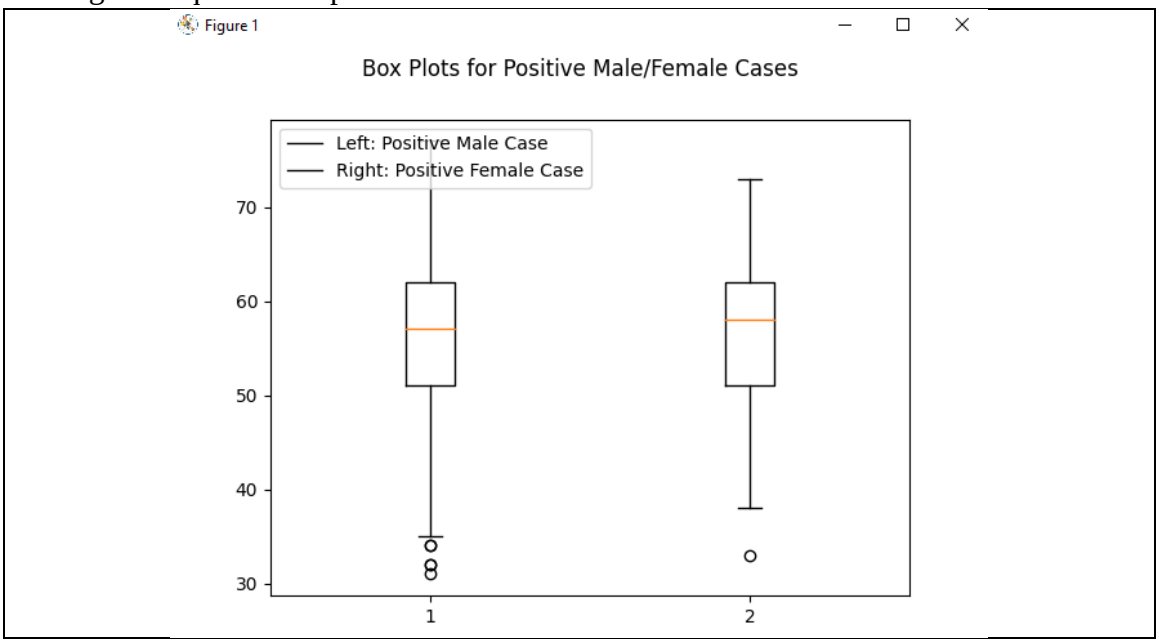
Step 2

- Getting a list with all the ages for positive and negative cases. Lines 75-79.
- Plotting the required histogram. Lines 81-85.



- Getting list of male/female ages for positive cases. Lines 87-94.

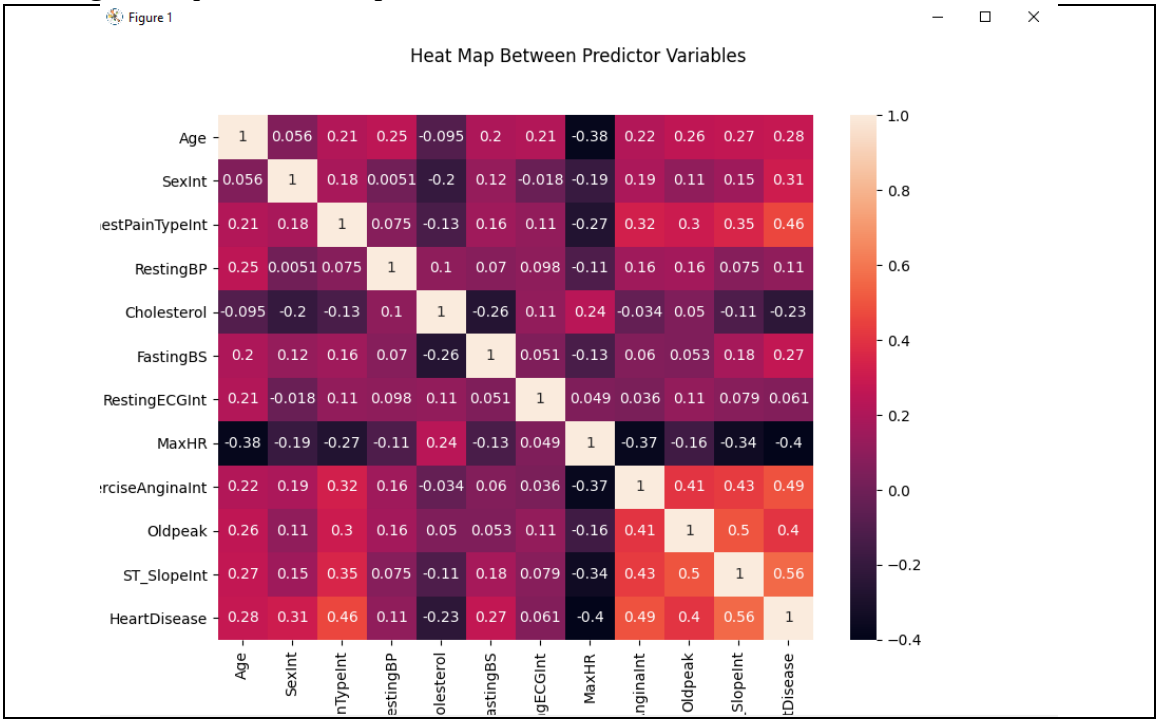
- Plotting the required box plot. Lines 96-104.



The median age for positive male cases is 57.0
The median age for positive female cases is 58.0
The median age for positive female cases is higher than that of males

Step 3

- Changing all string column to numerical values. Lines 11-57.
- Creating a new data frame with all the numerical values. Lines 110-122.
- Plotting the required heat map. Lines 124-127.



Part B: Feature Engineering

Step 1

- Checking for duplicate and missing data and then removing them. Lines 137-142.

Step 2

- Removing negative old peak and cholesterol values (also negative for cholesterol). Lines 148-156.

Step 3

- Converting categorical data to numeric values. Lines 11-57.

Step 4

- Using a standard scaler to scale the data. Lines 169-173.

Part C: Model Development I

Step 1

- Creating the KNN model and getting the model performance results. Lines 226-240.

```
The 5 fold cross validation score for KNeighborsClf is
: [0.85271318 0.85271318 0.8125     0.875      0.90625
]
KNeighborsClf: 0.86 accuracy with a standard deviation
of 0.03
KNeighborsClf: Classification report:
              precision    recall  f1-score   support

           0       0.85      0.89      0.87       123
           1       0.91      0.88      0.89       153

    accuracy                           0.88       276
   macro avg       0.88      0.88      0.88       276
weighted avg       0.88      0.88      0.88       276

243 correct predictions out of 276 for KNeighborsClf
The KNeighborsClf percentage of the correct predictions
is: 0.8804347826086957
Confusion matrix for KNeighborsClf:
[[109  14]
 [ 19 134]]
```

- Creating the SVM model and getting the model performance results. Lines 246-260.

```
The 5 fold cross validation score for SvmClf is : [0.84496124
0.8372093  0.859375   0.859375   0.8828125 ]
SvmClf: 0.86 accuracy with a standard deviation of 0.02
SvmClf: Classification report:
              precision    recall  f1-score   support

           0       0.85      0.85      0.85       123
           1       0.88      0.88      0.88       153

    accuracy                           0.86       276
   macro avg       0.86      0.86      0.86       276
weighted avg       0.86      0.86      0.86       276

238 correct predictions out of 276 for SvmClf
The SvmClf percentage of the correct predictions is:
0.8623188405797102
Confusion matrix for SvmClf:
[[104  19]
 [ 19 134]]
```

- Creating the DT model and getting the model performance results. Lines 266-289.

```
Optimal depth of the decision tree:  {'max_depth': 5}

The 5 fold cross validation score for
DecisionTreeClassifierClf is : [0.84496124 0.82945736
0.8515625  0.8359375  0.8671875 ]
DecisionTreeClassifierClf: 0.85 accuracy with a standard
deviation of 0.01
DecisionTreeClassifierClf: Classification report:
              precision    recall  f1-score   support

           0       0.81      0.83      0.82       123
           1       0.86      0.84      0.85       153

    accuracy                           0.84       276
   macro avg       0.83      0.84      0.84       276
weighted avg       0.84      0.84      0.84       276

231 correct predictions out of 276 for
DecisionTreeClassifierClf
The DecisionTreeClassifierClf percentage of the correct
predictions is: 0.8369565217391305
Confusion matrix for DecisionTreeClassifierClf:
[[102  21]
 [ 24 129]]
```

- Creating the XGboot model and getting the model performance results. Lines 295-309.

```
The 5 fold cross validation score for GradientBoostingClf is
: [0.80620155 0.88372093 0.8515625  0.890625   0.8828125 ]
GradientBoostingClf: 0.86 accuracy with a standard deviation
of 0.03
GradientBoostingClf: Classification report:
              precision    recall  f1-score   support

           0       0.84      0.85      0.84       123
           1       0.88      0.87      0.87       153

    accuracy                           0.86       276
   macro avg       0.86      0.86      0.86       276
weighted avg       0.86      0.86      0.86       276

237 correct predictions out of 276 for GradientBoostingClf
The GradientBoostingClf percentage of the correct predictions
is: 0.8586956521739131
Confusion matrix for GradientBoostingClf:
[[104  19]
 [ 20 133]]
```

Step 2

- Using the VotingClassifier to achieve the majority voting approach, first get the results for soft voting. Lines 315-317, 323-332.

```
The 5 fold cross validation score for MajorityVotingSoftClf
is : [0.86821705 0.86821705 0.859375   0.875      0.890625  ]
MajorityVotingSoftClf: 0.87 accuracy with a standard
deviation of 0.01
MajorityVotingSoftClf: Classification report:
              precision    recall  f1-score   support

           0       0.83      0.85      0.84       123
           1       0.88      0.86      0.87       153

    accuracy                           0.86       276
   macro avg       0.86      0.86      0.86       276
weighted avg       0.86      0.86      0.86       276

237 correct predictions out of 276 for
MajorityVotingSoftClfPredicted
The MajorityVotingSoftClfPredicted percentage of the correct
predictions is: 0.8586956521739131
Confusion matrix for MajorityVotingSoftClf:
[[105  18]
 [ 21 132]]
```

- Using the VotingClassifier to achieve the majority voting approach, then get the results for hard voting. Lines 319-321, 334-343.

```
The 5 fold cross validation score for MajorityVotingHardClf
is : [0.85271318 0.86046512 0.8515625  0.890625   0.8828125 ]
MajorityVotingHardClf: 0.87 accuracy with a standard
deviation of 0.02
MajorityVotingHardClf: Classification report:
              precision    recall  f1-score   support

           0       0.83      0.88      0.85       123
           1       0.90      0.86      0.88       153

    accuracy                           0.87       276
   macro avg       0.86      0.87      0.87       276
weighted avg       0.87      0.87      0.87       276

239 correct predictions out of 276 for MajorityVotingHardClf
The MajorityVotingHardClf percentage of the correct
predictions is: 0.8659420289855072
Confusion matrix for MajorityVotingHardClf:
[[108  15]
 [ 22 131]]
```

- We noticed that the hard voting method gave us slightly better results than the soft method.

Part D: Model Development II

Step 1

- Creating a deep neural network model using Keras with 3 dense layers. Two inner layers using ReLU, outer layer using Sigmoid. We then get the model performance results. Lines 356-360, 383-397.

```
Accuracy of kerasModelReLU: 93.46
kerasModelReLU: Classification report:
              precision    recall  f1-score   support

           0       0.83      0.90      0.86       123
           1       0.92      0.85      0.88       153

    accuracy                           0.87       276
   macro avg       0.87      0.88      0.87       276
weighted avg       0.88      0.87      0.87       276

241 correct predictions out of 276 for kerasModelReLU
The kerasModelReLU percentage of the correct predictions is:
0.8731884057971014
Confusion matrix for kerasModelReLU:
[[111  12]
 [ 23 130]]
```

- By changing the activation function, we created two new models and assessed them:
  - Two inner layers use Tanh, outer layer using Sigmoid. Lines 362-366, 399-413.

```
Accuracy of kerasModelTanh: 93.46
kerasModelTanh: Classification report:
              precision    recall  f1-score   support

           0       0.80      0.85      0.82       123
           1       0.88      0.82      0.85       153

    accuracy                           0.84       276
   macro avg       0.84      0.84      0.84       276
weighted avg       0.84      0.84      0.84       276

231 correct predictions out of 276 for
kerasModelTanh
The kerasModelTanh percentage of the correct
predictions is: 0.8369565217391305
Confusion matrix for kerasModelTanh:
[[105  18]
 [ 27 126]]
```

- All three layers using Sigmoid. Lines 368-372, 415-428.

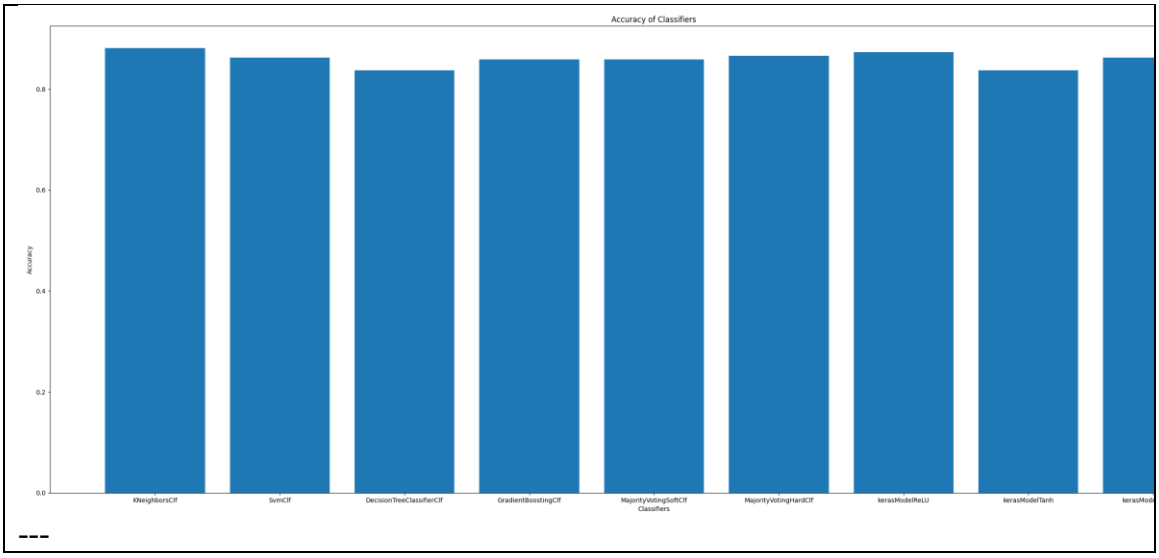
```
Accuracy of kerasModelSigmoid: 87.54
kerasModelSigmoid: Classification report:
              precision    recall  f1-score   support

           0       0.85      0.85      0.85       123
           1       0.88      0.88      0.88       153

    accuracy                           0.86       276
   macro avg       0.86      0.86      0.86       276
weighted avg       0.86      0.86      0.86       276

238 correct predictions out of 276 for
kerasModelSigmoid
The kerasModelSigmoid percentage of the correct
predictions is: 0.8623188405797102
Confusion matrix for kerasModelSigmoid:
[[104  19]
 [ 19 134]]
```

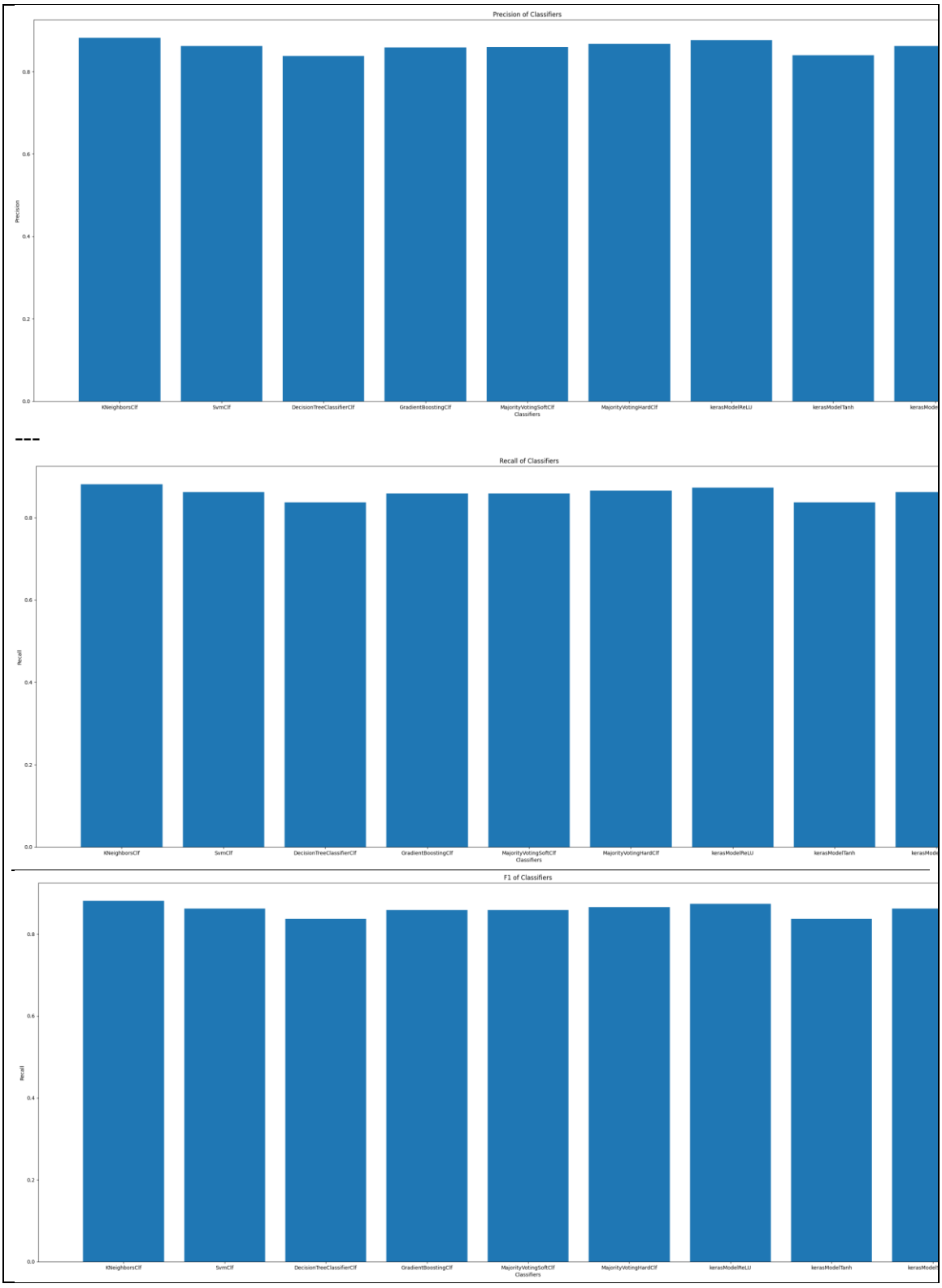
- The change of layer activation functions did change our results; however, our first model still had the better results.

Part E: Model Comparison

Step 1

- Getting precision, recall, accuracy and F-measure for all algorithms and then saving them in lists for plotting. Lines 454-470.
- Plotting bar graphs to display how algorithms compare for precision, recall, accuracy and F-measure.




Precision of Classifiers
Precision
0.0
0.2
0.4
0.6
0.8
KNeighborsClf
SvmClf
DecisionTreeClassifierClf
GradientBoostingClf
MajorityVotingSoftClf
MajorityVotingHardClf
kerasModelReLU
kerasModelTanh
Classifiers
Recall of Classifiers
Recall
0.0
0.2
0.4
0.6
0.8
KNeighborsClf
SvmClf
DecisionTreeClassifierClf
GradientBoostingClf
MajorityVotingSoftClf
MajorityVotingHardClf
kerasModelReLU
kerasModelTanh
Classifiers
F1 of Classifiers
Recall
0.0
0.2
0.4
0.6
0.8
KNeighborsClf
SvmClf
DecisionTreeClassifierClf
GradientBoostingClf
MajorityVotingSoftClf
MajorityVotingHardClf
kerasModelReLU
kerasModelTanh
Classifiers

Step 2

- Printing the models that performed best and worst according to each criterion.

```
KNeighborsClf has the highest accuracy
DecisionTreeClassifierClf has the lowest accuracy
KNeighborsClf has the highest precision
DecisionTreeClassifierClf has the lowest precision
KNeighborsClf has the highest recall
DecisionTreeClassifierClf has the lowest recall
KNeighborsClf has the highest F1
DecisionTreeClassifierClf has the lowest F1
```

- Between our ensemble and deep neural network classifier, we saw better results for the neural network classifier, however, between all the models the k-nearest neighbors' algorithm is the champion.