Assignment 4

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Datasets Used

- Iris Dataset
- Wine Dataset
- Seeds Dataset
- Breast Cancer Wisconsin Dataset
- Haberman's Survival Dataset
- Pima Indian Diabetes Dataset
- BankNote Authentication Dataset

All the datasets are taken from the well-known UCI Machine Learning repository.

Task 1 - Cluster Analysis

DBSCAN and Infomap don't work too well with the Seeds Dataset and thus we use the Wine Dataset in its place for those 2 algorithms. The Iris Dataset and the Breast Cancer Wisconsin Dataset has been used for all clustering algorithms.

K-Means Algorithm

- **Iris Dataset**

  Cluster 1 -> Length = 50
  Cluster 2 -> Length = 53
  Cluster 3 -> Length = 47

  Cluster validation Indices (rounded to 4 decimal places):
  Silhouette Index = 0.5059
  Davies Bouldin Index = 0.8354
  Dunne Index = 0.5303

- **Breast Cancer Wisconsin Dataset**

  Cluster 1 -> Length = 230
  Cluster 2 -> Length = 453

  Cluster validation Indices (rounded to 4 decimal places):
  Silhouette Index = 0.5939
  Davies Bouldin Index = 0.8200
  Dunne Index = 0.6417

- **Seeds Dataset**

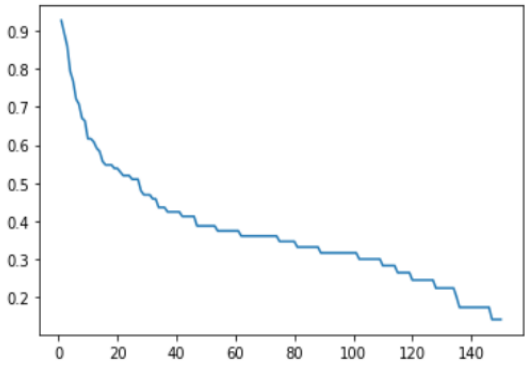
  Cluster 1 -> Length = 67
  Cluster 2 -> Length = 71
  Cluster 3 -> Length = 72

  Cluster validation Indices (rounded to 4 decimal places):
  Silhouette Index = 0.4506

Davies Bouldin Index = 0.9279
Dunne Index = 0.5000

DBSCAN Algorithm

Graph for determining optimum epsilon value using grid search.



- **Iris Dataset**

  Cluster 1 -> Length = 5
  Cluster 2 -> Length = 50
  Cluster 3 -> Length = 95

  Cluster validation Indices (rounded to 4 decimal places):
  Silhouette Index = 0.5336
  Davies Bouldin Index = 0.5262
  Dunne Index = 0.5813

- **Breast Cancer Wisconsin Dataset**

  Cluster 1 -> Length = 183
  Cluster 2 -> Length = 35
  Cluster 3 -> Length = 351

  Cluster validation Indices (rounded to 4 decimal places):
  Silhouette Index = 0.2712
  Davies Bouldin Index = 2.5451
  Dunne Index = 0.0556

- **Wine Dataset**

  Cluster 1 -> Length = 23
  Cluster 2 -> Length = 104
  Cluster 3 -> Length = 51

  Cluster validation Indices (rounded to 4 decimal places):
  Silhouette Index = - 0.0554
  Davies Bouldin Index = 3.0640
  Dunne Index = 0.0148

Infomap Algorithm

Infomap is a graph-based clustering algorithm where each data point can be treated as a node with edges connecting pairs of them. The weight of an edge corresponds to the euclidean distance between them.

For the implementation, an average value of edge weights is determined and all edges with weights less than that are dropped. The final set of edges (in a .gml file) is given as input to igraph's community_infomap.

- **Iris Dataset**

  Cluster 1 -> Length = 52
  Cluster 2 -> Length = 97
  Cluster 3 -> Length = 1

  Cluster validation Indices (rounded to 4 decimal places): Silhouette Index = 0.4218
  Davies Bouldin Index = 0.4220
  Dunne Index = 0.4664

- **Breast Cancer Wisconsin Dataset**

  Cluster 1 -> Length = 460
  Cluster 2 -> Length = 216
  Cluster 3 -> Length = 6
  Cluster 4 -> Length = 1

  Cluster validation Indices (rounded to 4 decimal places):
  Silhouette Index = 0.3982
  Davies Bouldin Index = 1.0675
  Dunne Index = 0.4026

- **Wine Dataset**

  Cluster 1 -> Length = 47
  Cluster 2 -> Length = 131

  Cluster validation Indices (rounded to 4 decimal places):
  Silhouette Index = 0.6572
  Davies Bouldin Index = 0.4565
  Dunne Index = 0.8579

Clustering Algorithm developed in Assignment-1

- **Iris Dataset**

  Cluster 1 -> Length = 86
  Cluster 2 -> Length = 50
  Cluster 3 -> Length = 14

  Cluster validation Indices (rounded to 4 decimal places):
  Silhouette Index = 0.0309
  Davies Bouldin Index = 2.2610
  Dunne Index = 0.1293

- **Breast Cancer Wisconsin Dataset**

  Only the first 200 data points are used to reduce the extensive computation time needed by this algorithm.

  Cluster 1 -> Length = 135
  Cluster 2 -> Length = 63

Cluster validation Indices (rounded to 4 decimal places):
Silhouette Index = 0.4415
Davies Bouldin Index = 1.0738
Dunne Index = 0.4662

- **Seeds Dataset**

  Cluster 1 -> Length = 39
  Cluster 2 -> Length = 58
  Cluster 3 -> Length = 113

  Cluster validation Indices (rounded to 4 decimal places):
  Silhouette Index = 0.3599
  Davies Bouldin Index = 1.1377
  Dunne Index = 0.3642

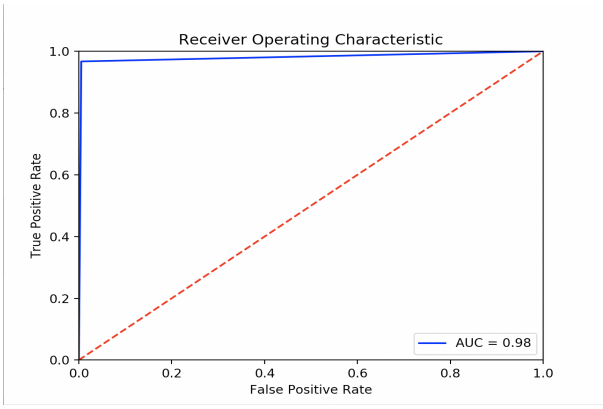
Task-2 : Classification Analysis

10 fold cross validation is done for all cases. The intermediate results are not presented here for brevity, only the final results are given for each case.

Decision Tree

- **BankNote Authentication Dataset**

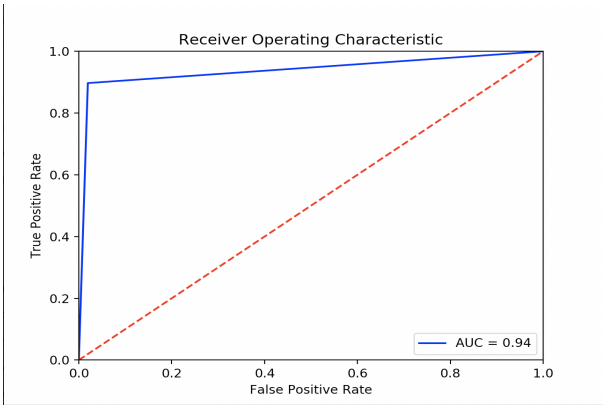
  Accuracy: 0.982497619803237
  Specificity: 0.9828352222510384
  Sensitivity: 0.9820866935483871
  Precision: 0.9789299717514691
  F-measure: 0.9803762035555337
  Prediction: 760 612
  Actual Class label: 762 610



- **Breast Cancer Wisconsin Dataset**

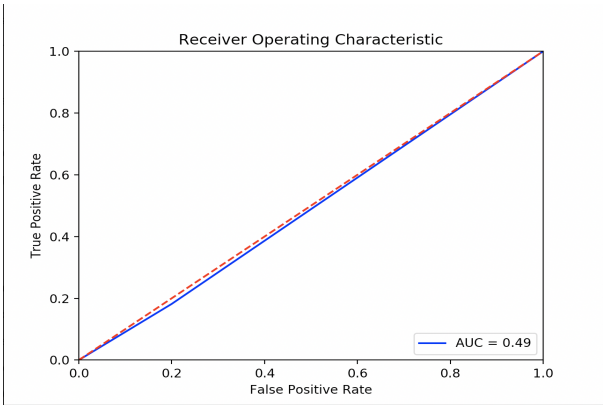
  Accuracy: 0.9501705029838023
  Specificity: 0.9614337520630845
  Sensitivity: 0.930331616853356
  Precision: 0.9305259595476987
  F-measure: 0.9290235519235841

Prediction: 444 239
Actual Class label: 444 239



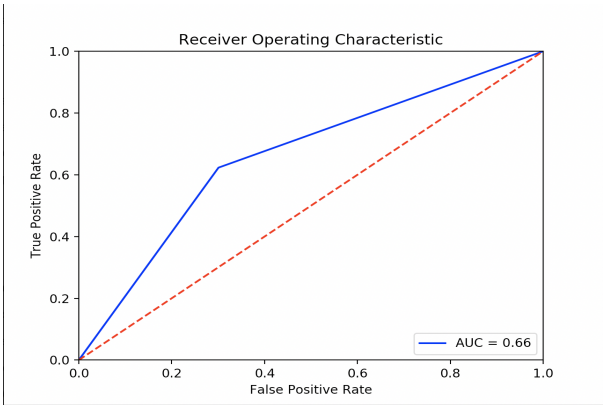
- **Haberman's Survival Dataset**

  Accuracy: 0.666236559139785
  Specificity: 0.7749470217044588
  Sensitivity: 0.4202633477633477
  Precision: 0.37238095238095237
  F-measure: 0.3753861369109047
  Prediction: 225 81
  Actual Class label: 225 81



- **Pima Indian Diabetes Dataset**

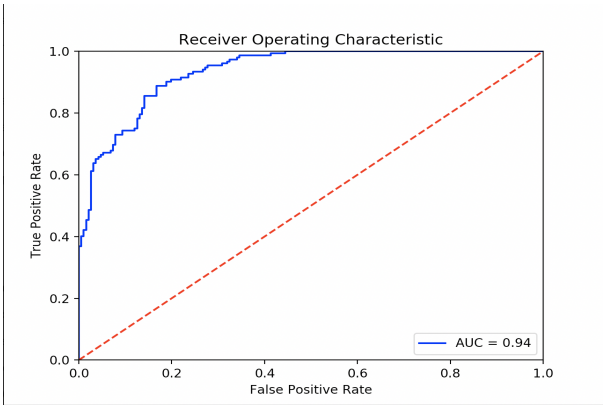
  Accuracy: 0.7031100478468899
  Specificity: 0.7805294970986459
  Sensitivity: 0.5661191805715133
  Precision: 0.5792382641253608
  F-measure: 0.5662043283931991
  Prediction: 508 260
  Actual Class label: 500 268



Naïve Bayes

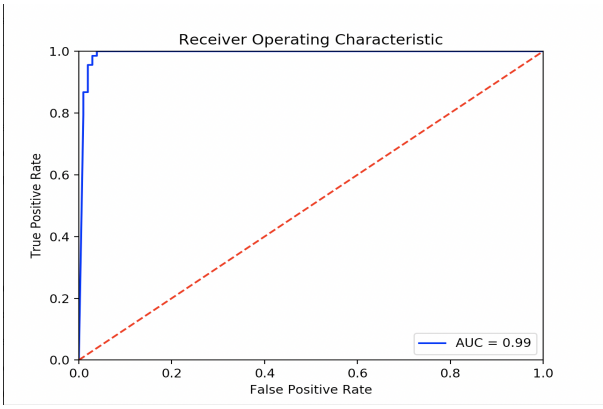
- **BankNote Authentication Dataset**

  Accuracy: 0.8389664656722733
  Specificity: 0.8787525628364371
  Sensitivity: 0.7926724168785175
  Precision: 0.8386117247270881
  F-measure: 0.8132050044960154
  Prediction: 797 575
  Actual Class label: 762 610



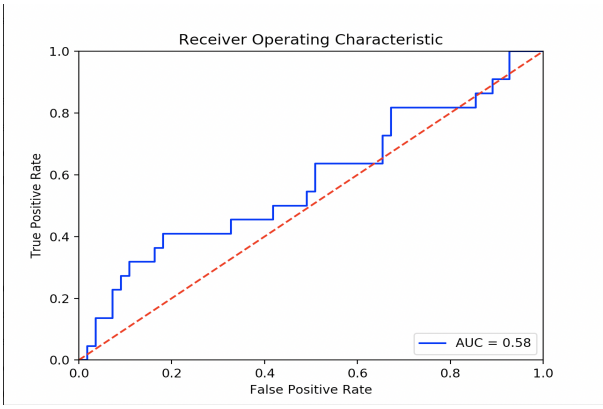
- **Breast Cancer Wisconsin Dataset**

  Accuracy: 0.9633205456095482
  Specificity: 0.9558769143796896
  Sensitivity: 0.9802900137232973
  Precision: 0.9233205240813935
  F-measure: 0.9488355568988098
  Prediction: 429 254
  Actual Class label: 444 239



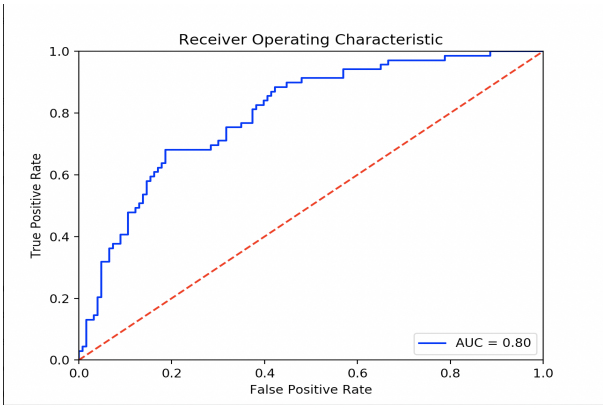
- **Haberman's Survival Dataset**

  Accuracy: 0.7450537634408602
  Specificity: 0.9385720873329569
  Sensitivity: 0.211019536019536
  Precision: 0.5511904761904762
  F-measure: 0.28564102564102567
  Prediction: 275 31
  Actual Class label: 225 81



- **Pima Indian Diabetes Dataset**

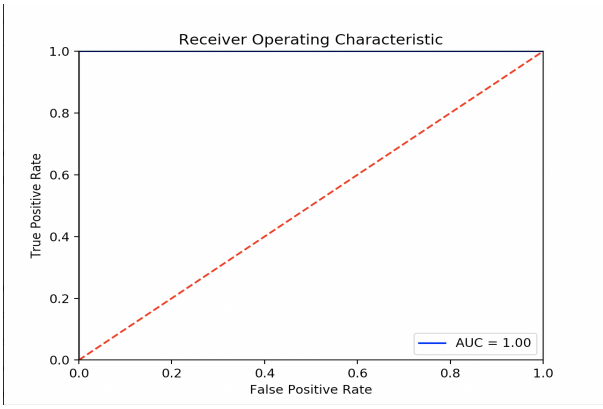
  Accuracy: 0.7592105263157896
  Specificity: 0.8425872995663299
  Sensitivity: 0.6082767775518201
  Precision: 0.6692941963084392
  F-measure: 0.6330167235470293
  Prediction: 527 241
  Actual Class label: 500 268



KNN

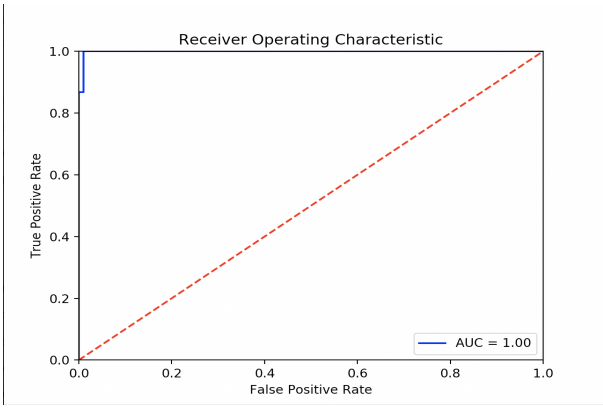
- **BankNote Authentication Dataset**

  Accuracy: 0.9956310166084841
  Specificity: 0.9921013090555345
  Sensitivity: 1.0
  Precision: 0.9904764638346727
  F-measure: 0.9951569442389516
  Prediction: 756 616
  Actual Class label: 762 610



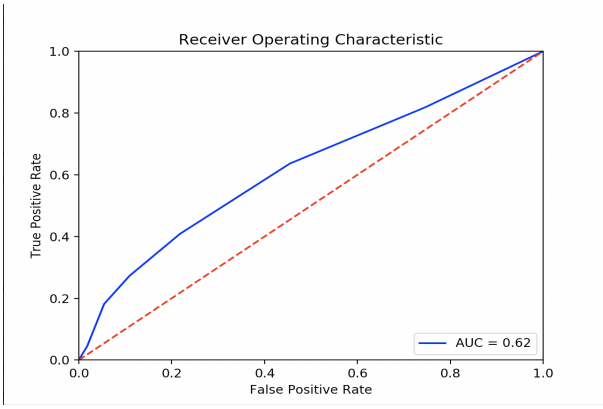
- **Breast Cancer Wisconsin Dataset**

  Accuracy: 0.9663682864450127
  Specificity: 0.9748283800563758
  Sensitivity: 0.9536729797979799
  Precision: 0.956188961900169
  F-measure: 0.9538943469414246
  Prediction: 445 238
  Actual Class label: 444 239



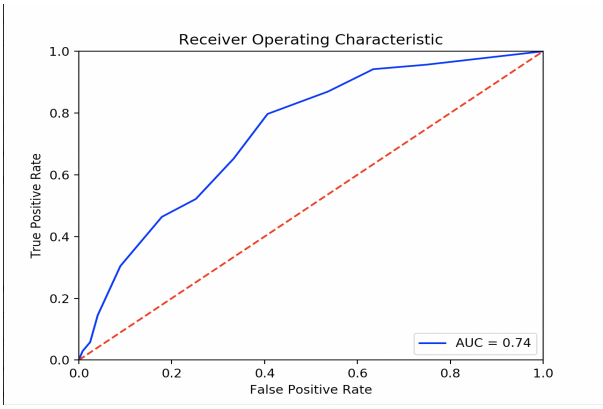
- **Haberman's Survival Dataset**

  Accuracy: 0.725268817204301
  Specificity: 0.9324858886346302
  Sensitivity: 0.16428571428571428
  Precision: 0.44000000000000006
  F-measure: 0.22576923076923078
  Prediction: 279 27
  Actual Class label: 225 81



- **Pima Indian Diabetes Dataset**

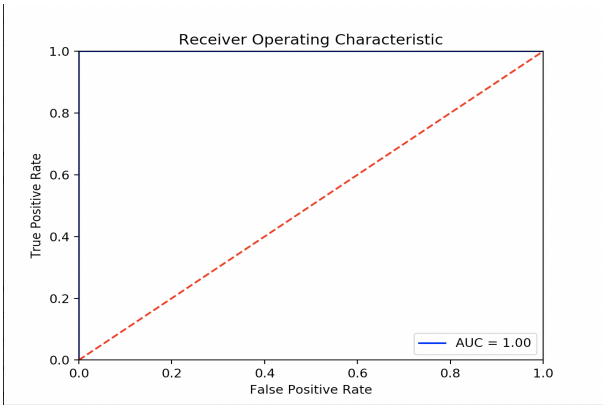
  Accuracy: 0.7345181134654819
  Specificity: 0.8537733948309499
  Sensitivity: 0.505056462056462
  Precision: 0.654110233778426
  F-measure: 0.5661286781167465
  Prediction: 560 208
  Actual Class label: 500 268



SVM

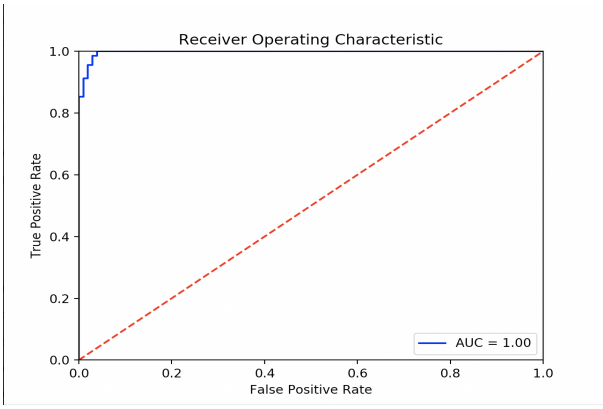
- **BankNote Authentication Dataset**

  Accuracy: 1.0
  Specificity: 1.0
  Sensitivity: 1.0
  Precision: 1.0
  F-measure: 1.0
  Prediction: 762 610
  Actual Class label: 762 610



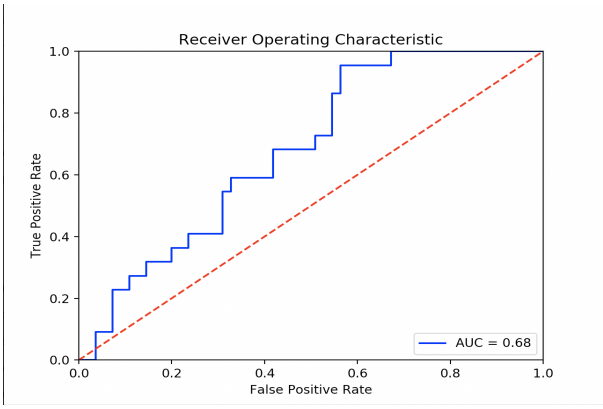
- **Breast Cancer Wisconsin Dataset**

  Accuracy: 0.9706947996589939
  Specificity: 0.9674638205531718
  Sensitivity: 0.9758705647176411
  Precision: 0.94581223893066
  F-measure: 0.9598474346492758
  Prediction: 436 247
  Actual Class label: 444 239



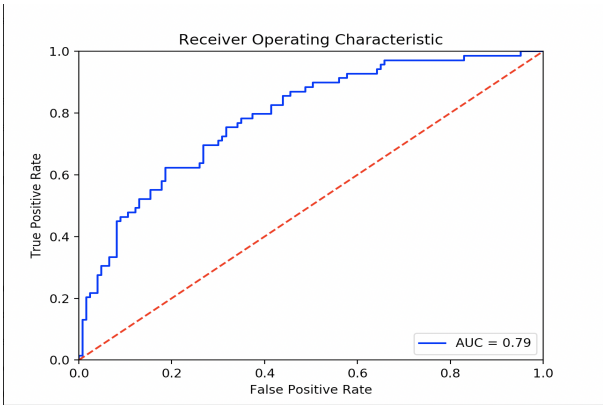
- **Haberman's Survival Dataset**

  Accuracy: 0.738279569892473
  Specificity: 0.9280952380952382
  Sensitivity: 0.21119047619047623
  Precision: 0.5516666666666665
  F-measure: 0.293005883005883
  Prediction: 273 33
  Actual Class label: 225 81



- **Pima Indian Diabetes Dataset**

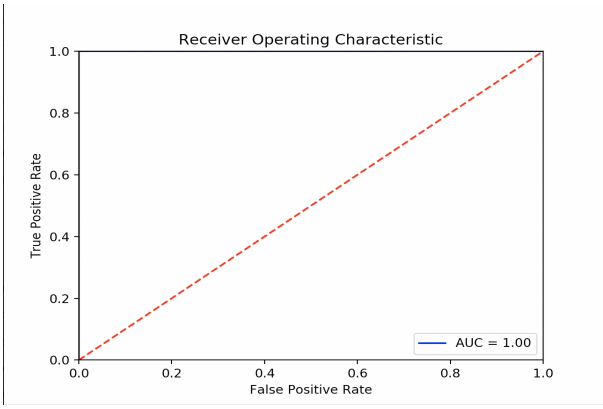
  Accuracy: 0.7578092959671907
  Specificity: 0.8717053464237511
  Sensitivity: 0.5382652975089014
  Precision: 0.6884103608868742
  F-measure: 0.6008505361904428
  Prediction: 558 210
  Actual Class label: 500 268



Bagging

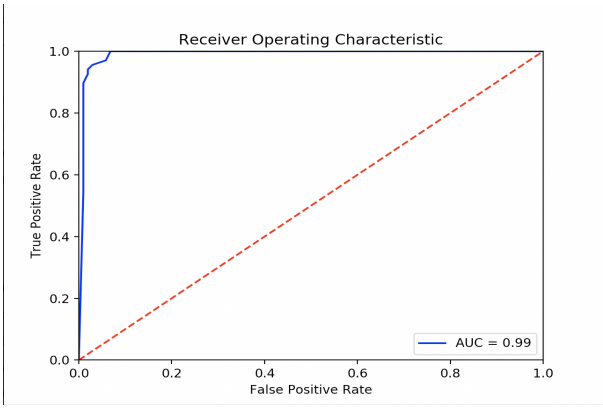
- **BankNote Authentication Dataset**

  Accuracy: 0.9890722521950703
  Specificity: 0.9896917509541462
  Sensitivity: 0.9877610134963074
  Precision: 0.9864901343593644
  F-measure: 0.9870368301341568
  Prediction: 761 611
  Actual Class label: 762 610



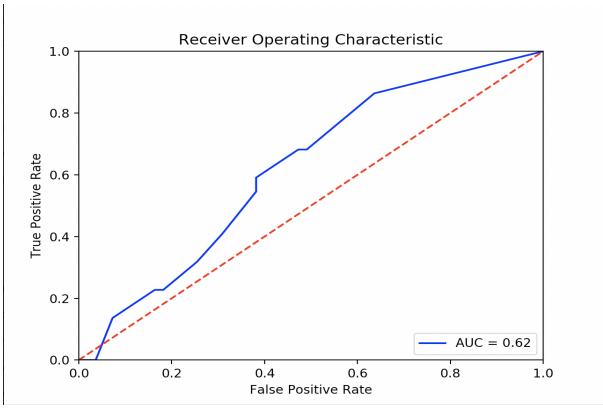
- **Breast Cancer Wisconsin Dataset**

  Accuracy: 0.954688832054561
  Specificity: 0.9653364376651545
  Sensitivity: 0.9291794364314386
  Precision: 0.9425795315795316
  F-measure: 0.9340692263711133
  Prediction: 445 238
  Actual Class label: 444 239



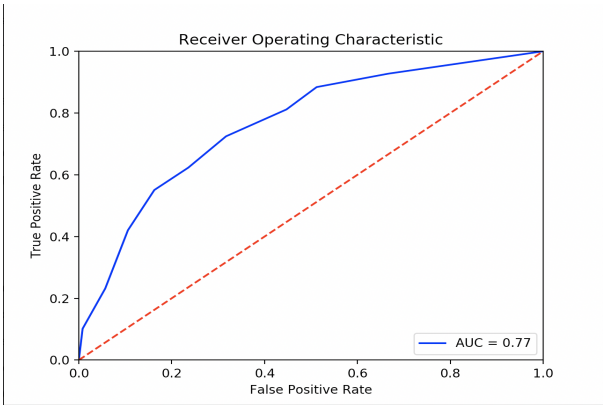
- **Haberman's Survival Dataset**

  Accuracy: 0.6762365591397849
  Specificity: 0.8227567441084066
  Sensitivity: 0.2894993894993895
  Precision: 0.3866666666666666
  F-measure: 0.30789904539904545
  Prediction: 244 62
  Actual Class label: 225 81



- **Pima Indian Diabetes Dataset**

  Accuracy: 0.7435577580314423
  Specificity: 0.8529084524070729
  Sensitivity: 0.5348681311816619
  Precision: 0.6604950540602714
  F-measure: 0.5862814191475204
  Prediction: 549 219
  Actual Class label: 500 268



For each classifier, I have computed the following performance measure metrics using 10-fold cross validation.

1. Accuracy
2. Specificity
3. Sensitivity
4. Precision
5. Recall
6. F-Measure

Also, I have included the number of samples predicted as belonging to each class versus actually belonging to each class in the displayed output. And I have drawn the ROC curves for each case as well.

Four different datasets have been used for testing each of the five classifiers.

1. BankNote Authentication Dataset
2. Breast Cancer Wisconsin Dataset
3. Haberman's Survival Dataset
4. Pima Indian Diabetes Dataset

On the basis of all the analysis performed, one general conclusion that I can draw is that the BankNote Authentication Dataset and the Breast Cancer Wisconsin Dataset seem relatively easily to classify or cluster because all algorithms achieve nearly perfect results for these 2 cases. Whereas for the other datasets, the algorithms only have average performance.
