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Year of Study: 4th
Semester: 1st
Subject: Machine Learning Lab
(The Codes used for today's evaluation are available in the following GitHub link: https://github.com/SwapnilSarkar/ML-Lab-Evaluation)

Machine Learning Lab Evaluation

1. a) Support Vector Machine(SVM) :-
   Output for wine dataset :-

```
SVC Linear:
Confusion Matrix
[[17  0  0]
 [ 0 19  4]
 [ 0  0 14]]
-----------------------------------
-----------------------------------
Preformance Evaluation:
              precision    recall  f1-score   support

           1       1.00      1.00      1.00        17
           2       1.00      0.83      0.90        23
           3       0.78      1.00      0.88        14

    accuracy                           0.93        54
   macro avg       0.93      0.94      0.93        54
weighted avg       0.94      0.93      0.93        54

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-----------------------------------
Accuracy Score:
0.9259259259259259
```
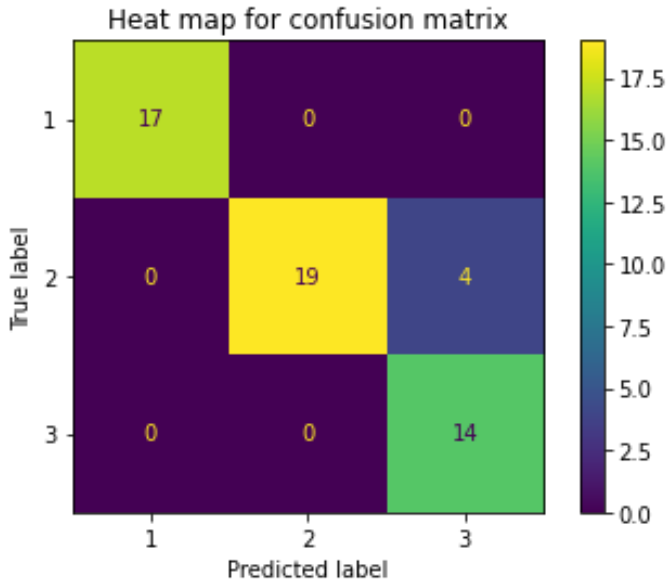
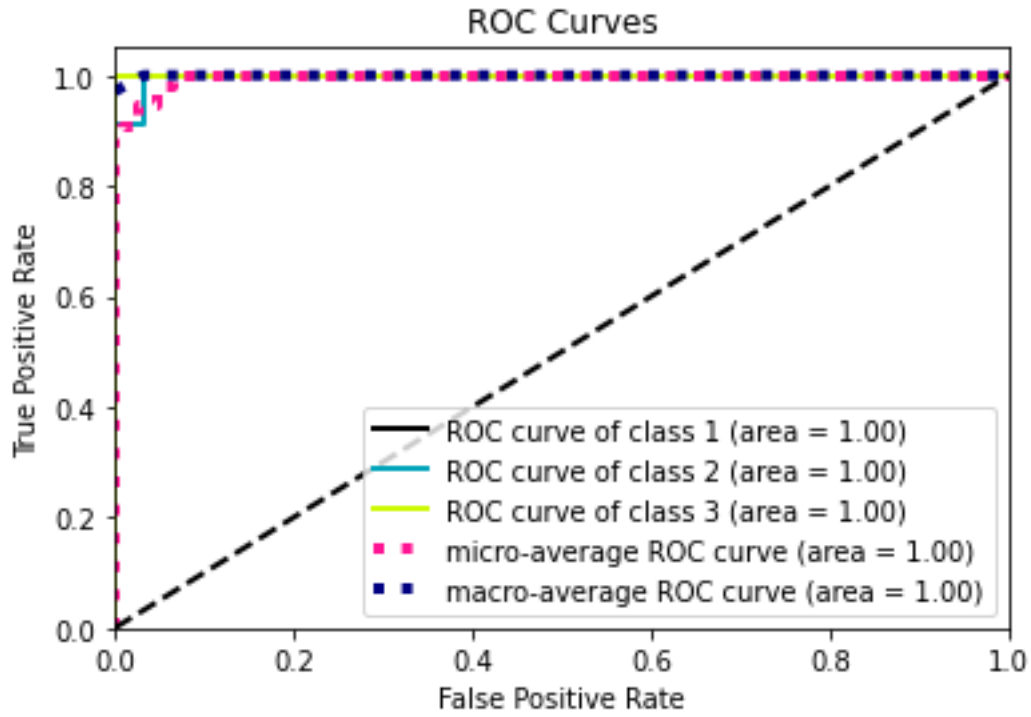

Confusion matrix for SVM :-



ROC Curve for SVM :-



Output for ionosphere dataset :-

```
SVC Linear:
Confusion Matrix
[[26 10]
 [ 3 67]]
-----------------------------------
-----------------------------------
Preformance Evaluation:
              precision    recall  f1-score   support

           b       0.90      0.72      0.80        36
           g       0.87      0.96      0.91        70

    accuracy                           0.88       106
   macro avg       0.88      0.84      0.86       106
weighted avg       0.88      0.88      0.87       106

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-----------------------------------
Accuracy Score:
0.8773584905660378
```
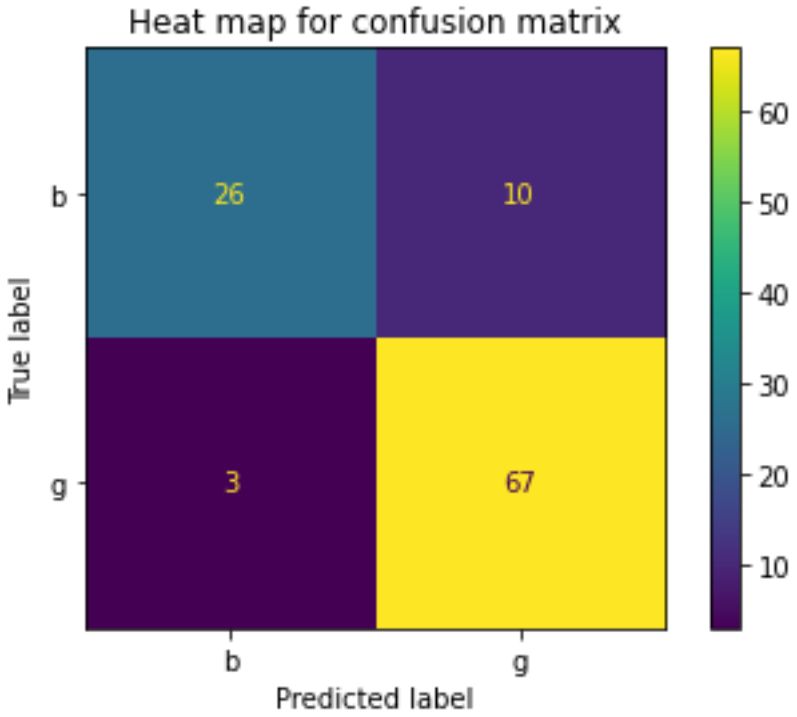
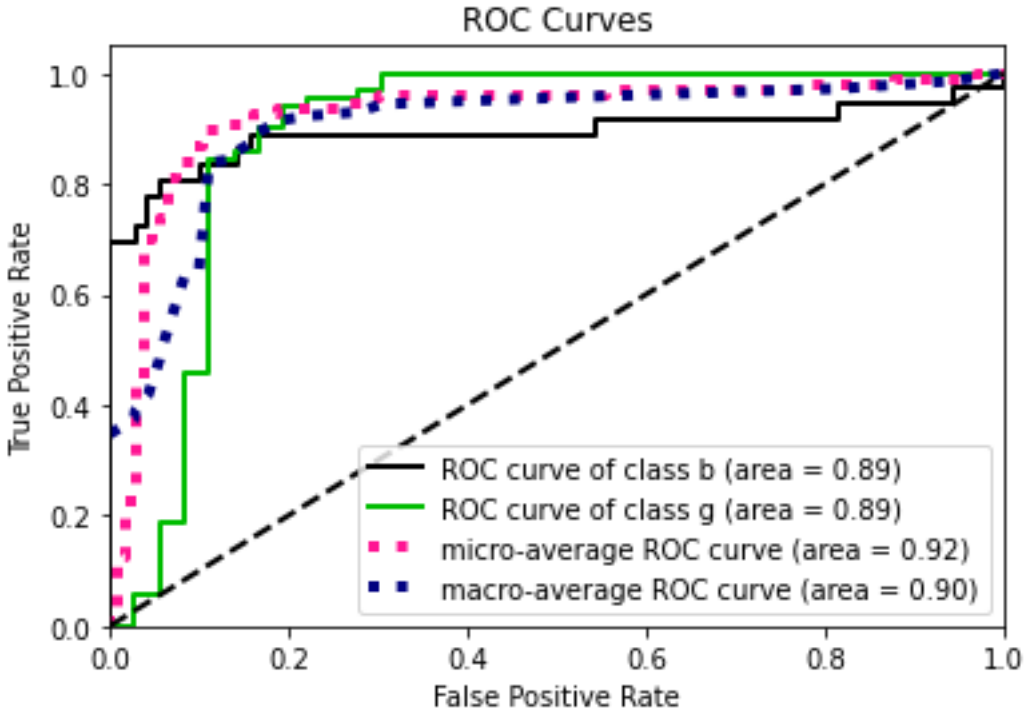

Confusion matrix for SVM :-



ROC Curve for SVM :-



c) Decision Tree :-
Output for Wine dataset :-

```
Decision Tree Classifier:
Confusion Matrix
[[21  2  0]
 [ 1 16  1]
 [ 0  0 13]]
-----------------------------------
-----------------------------------
Preformance Evaluation:
              precision    recall  f1-score   support

           1       0.95      0.91      0.93        23
           2       0.89      0.89      0.89        18
           3       0.93      1.00      0.96        13

    accuracy                           0.93        54
   macro avg       0.92      0.93      0.93        54
weighted avg       0.93      0.93      0.93        54

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-----------------------------------
Accuracy Score:
0.9259259259259259
```

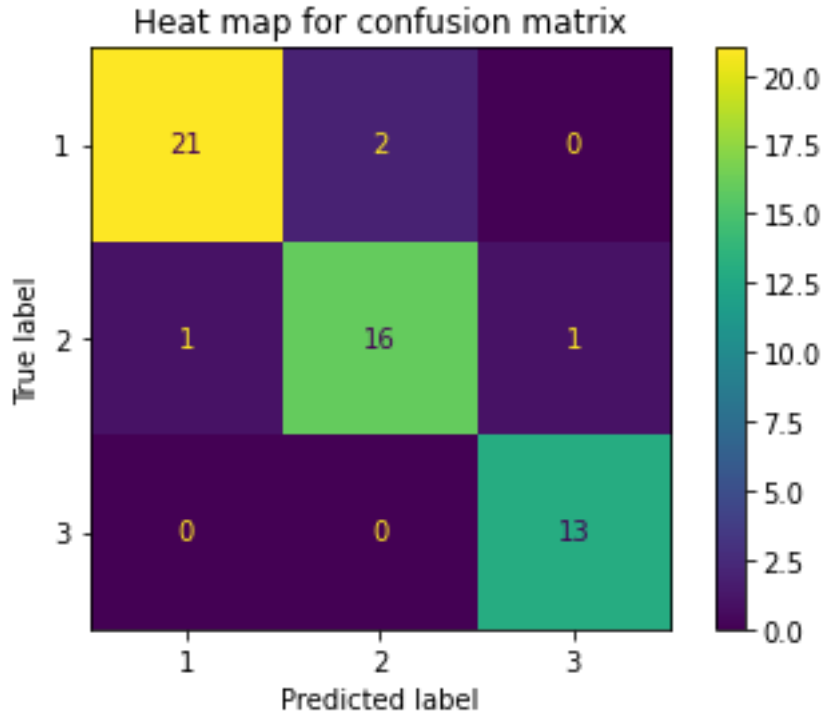

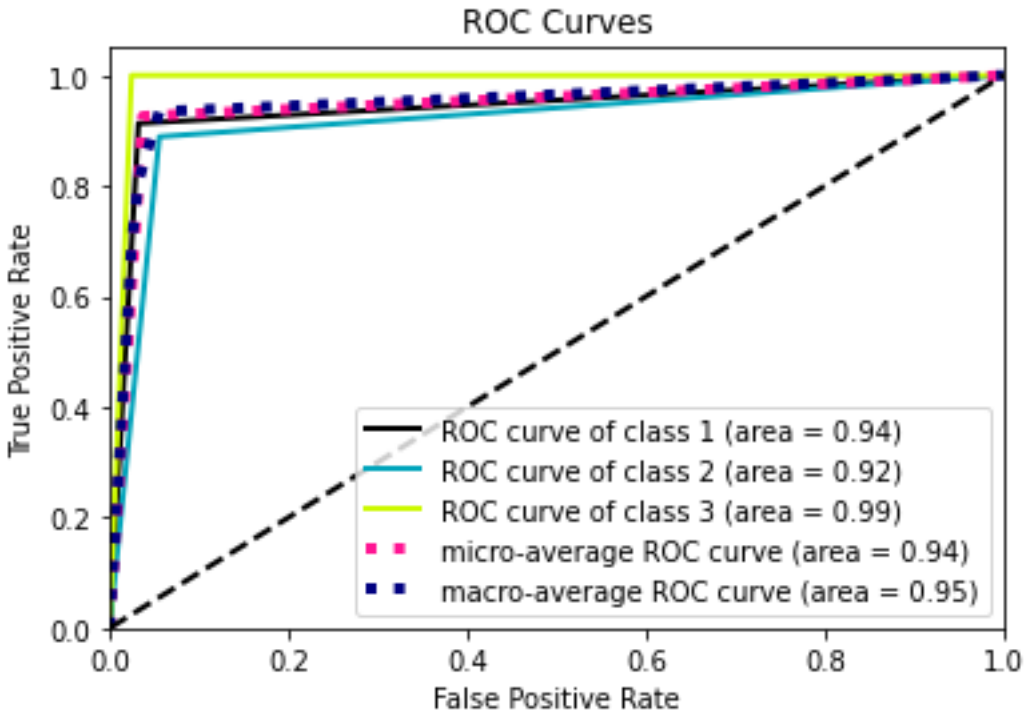

Output for ionosphere dataset :-

```
Decision Tree Classifier:
Confusion Matrix
[[29  6]
 [ 1 70]]
-----------------------------------
-----------------------------------
Preformance Evaluation:
              precision    recall  f1-score   support

           b       0.97      0.83      0.89        35
           g       0.92      0.99      0.95        71

    accuracy                           0.93       106
   macro avg       0.94      0.91      0.92       106
weighted avg       0.94      0.93      0.93       106

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-----------------------------------
Accuracy Score:
0.9339622641509434
```

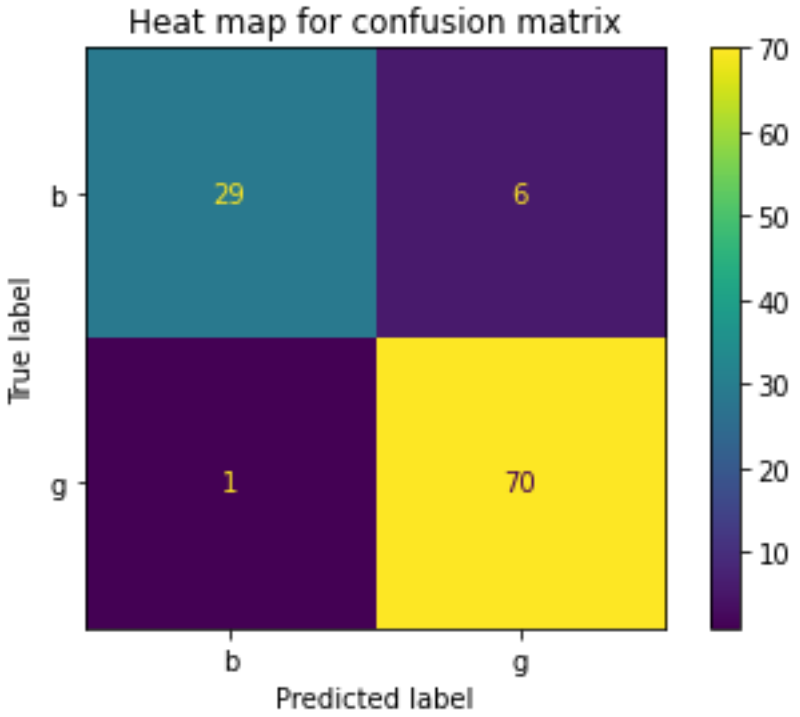

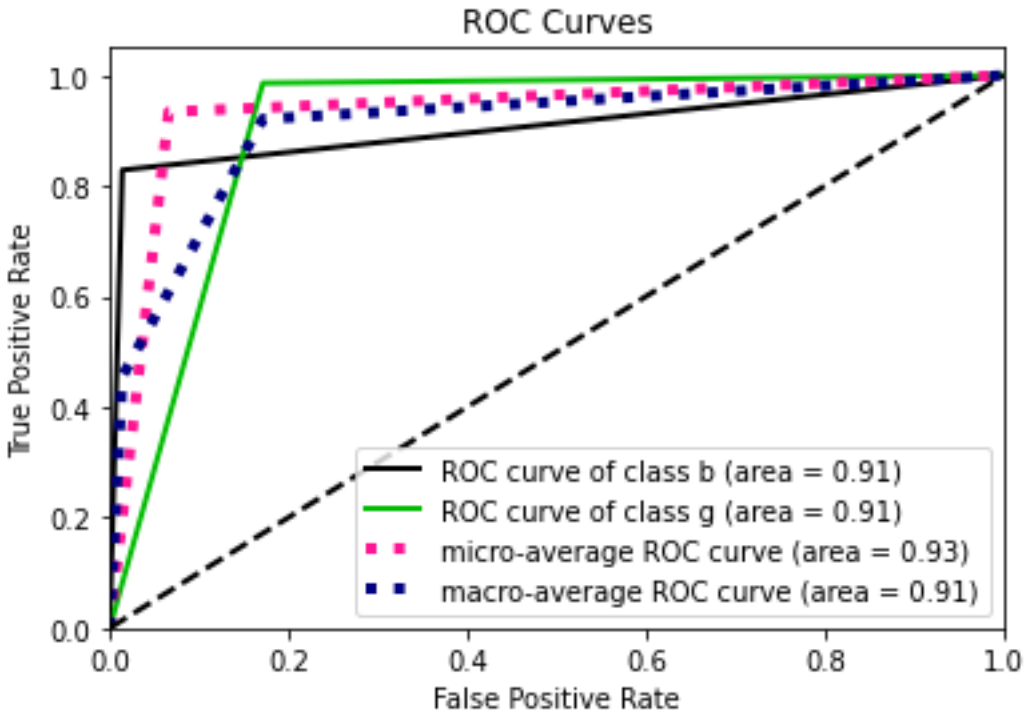

c) Random Forest :-
Output for Wine dataset :-

```
Random Forest:
Confusion Matrix
[[17  0  0]
 [ 0 21  2]
 [ 0  0 14]]
```

```
------------------------------------
------------------------------------
Preformance Evaluation:
              precision    recall  f1-score   support

           1       1.00      1.00      1.00        17
           2       1.00      0.91      0.95        23
           3       0.88      1.00      0.93        14

    accuracy                           0.96        54
   macro avg       0.96      0.97      0.96        54
weighted avg       0.97      0.96      0.96        54

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------------------------------------
Accuracy Score:
0.9629629629629629
```

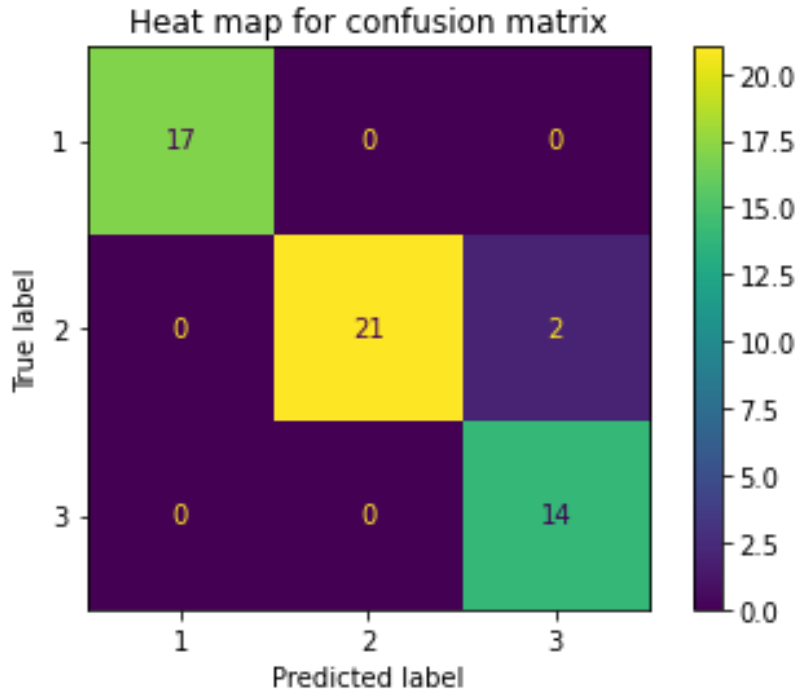

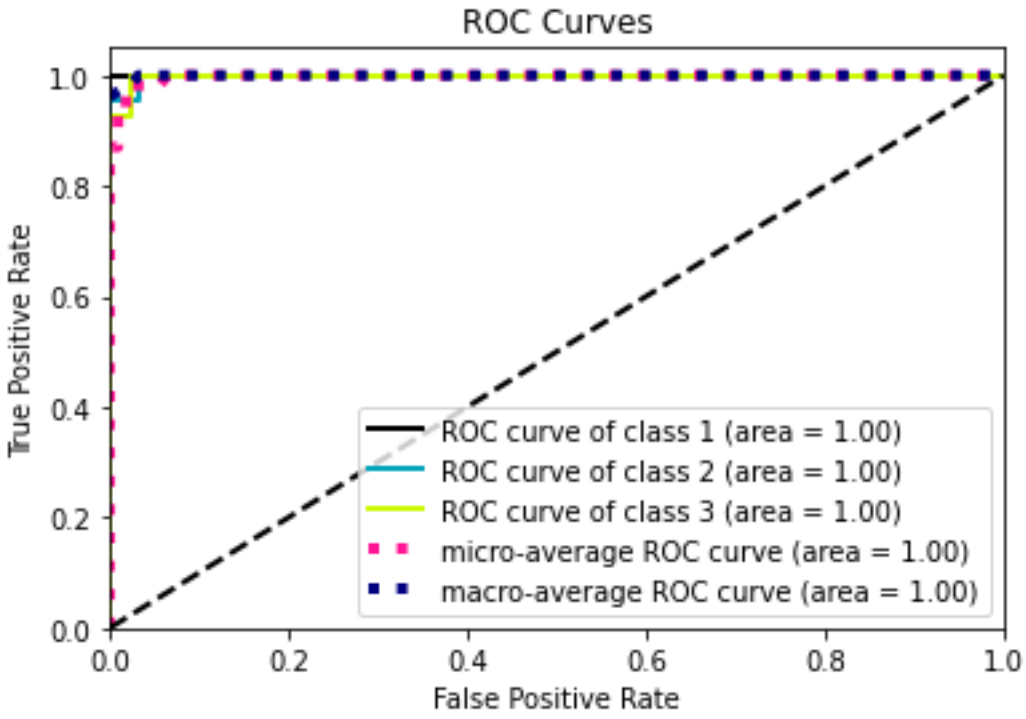

Output for ionosphere dataset :-

```
Random Forest:
Confusion Matrix
[[31  5]
 [ 0 70]]
-----------------------------------
-----------------------------------
Preformance Evaluation:
              precision    recall  f1-score   support

           b       1.00      0.86      0.93        36
           g       0.93      1.00      0.97        70

    accuracy                           0.95       106
   macro avg       0.97      0.93      0.95       106
weighted avg       0.96      0.95      0.95       106

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Accuracy Score:
0.9528301886792453
```
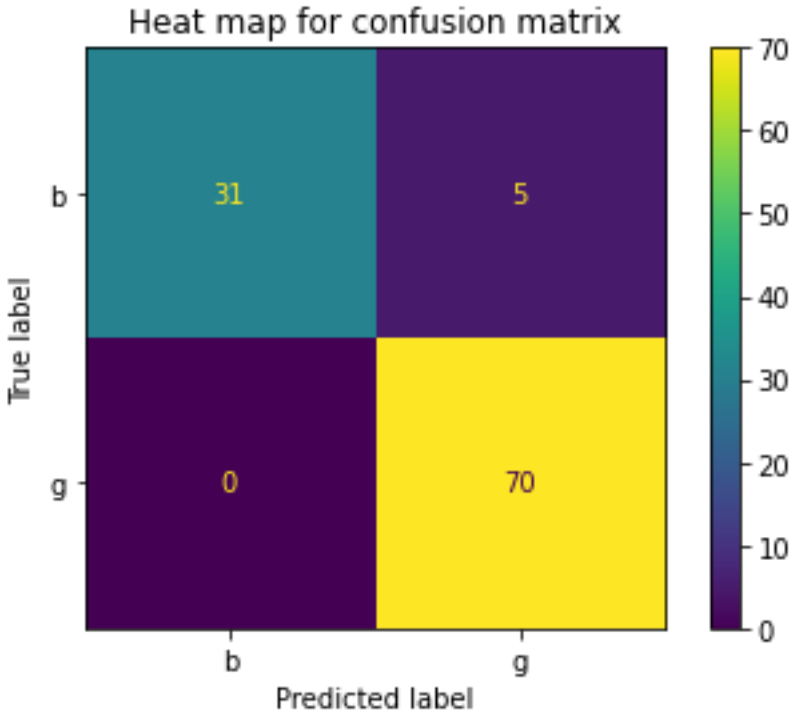
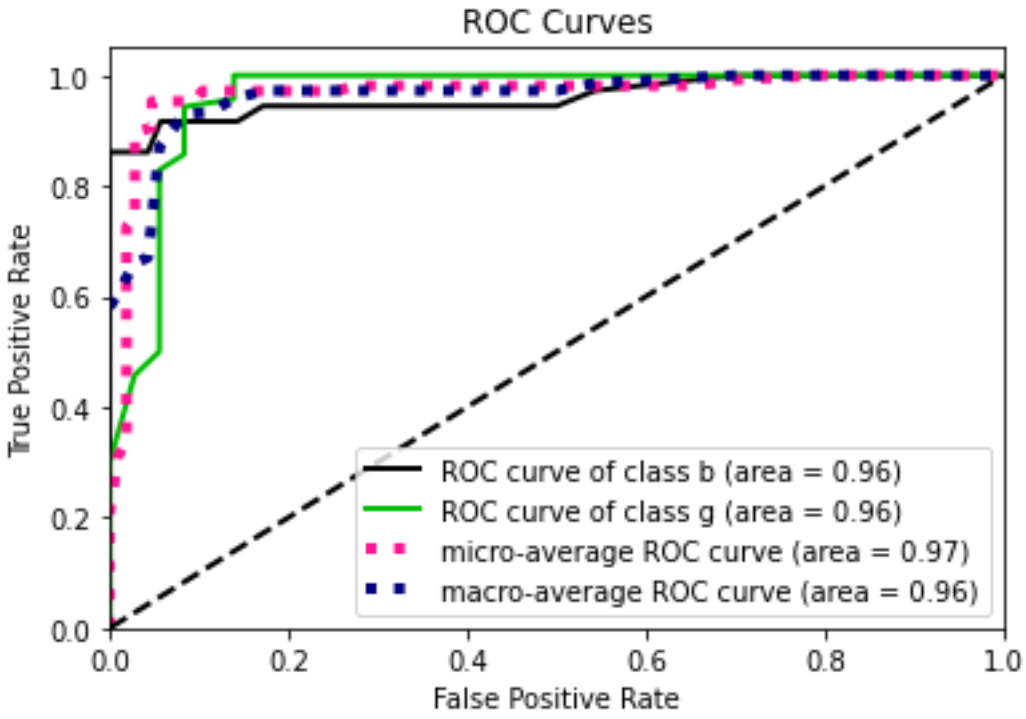


Heat map for confusion matrix
31
5
0
70
b
g
True label
b
g
Predicted label
70
60
50
40
30
20
10
0


ROC Curves
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve of class b (area = 0.96)
ROC curve of class g (area = 0.96)
micro-average ROC curve (area = 0.97)
macro-average ROC curve (area = 0.96)

c) Naive Bayes :-

- Multinomial Naive Bayes:-

Output for Wine dataset :-

```
Multinomial Naive Bayes:
Confusion Matrix
[[17  2  4]
 [ 2 14  2]
 [ 0  2 11]]
------------------------------------
------------------------------------
Preformance Evaluation:
              precision    recall  f1-score   support

           1       0.89      0.74      0.81        23
           2       0.78      0.78      0.78        18
           3       0.65      0.85      0.73        13

    accuracy                           0.78        54
   macro avg       0.77      0.79      0.77        54
weighted avg       0.80      0.78      0.78        54

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------------------------------------
Accuracy Score:
0.7777777777777778
```

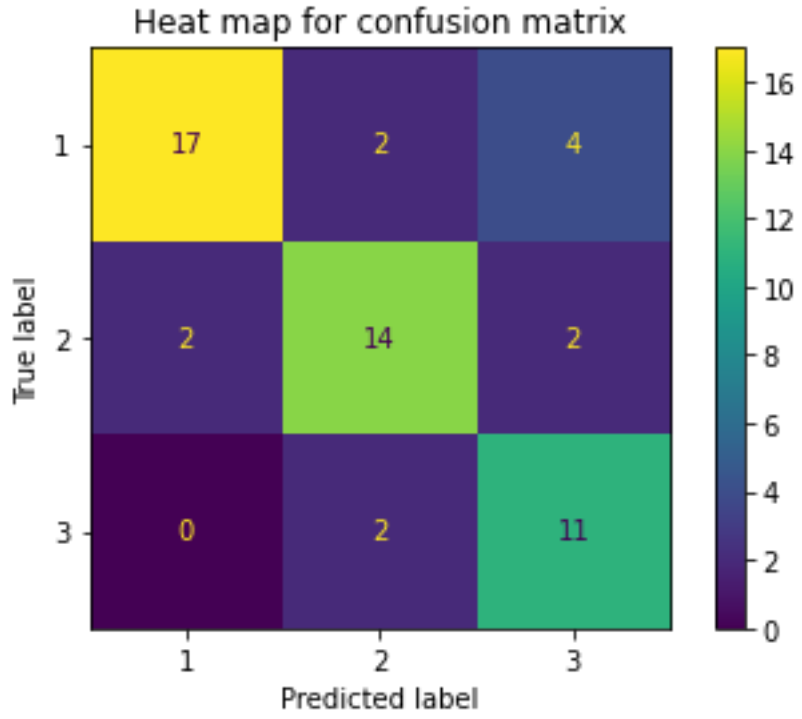

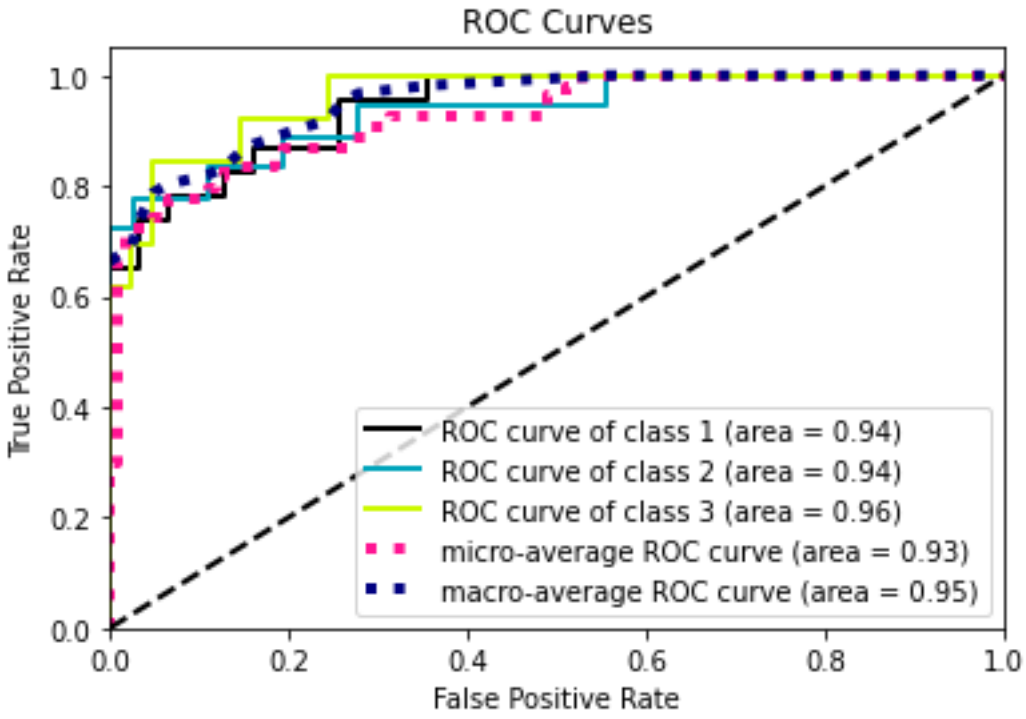

Output for ionosphere dataset :-

```
Multinomial Naive Bayes:
Confusion Matrix
[[ 9 26]
 [ 3 68]]
-----------------------------------
-----------------------------------
Preformance Evaluation:
              precision    recall  f1-score   support

           b       0.75      0.26      0.38        35
           g       0.72      0.96      0.82        71

    accuracy                           0.73       106
   macro avg       0.74      0.61      0.60       106
weighted avg       0.73      0.73      0.68       106

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-----------------------------------
Accuracy Score:
0.7264150943396226
```

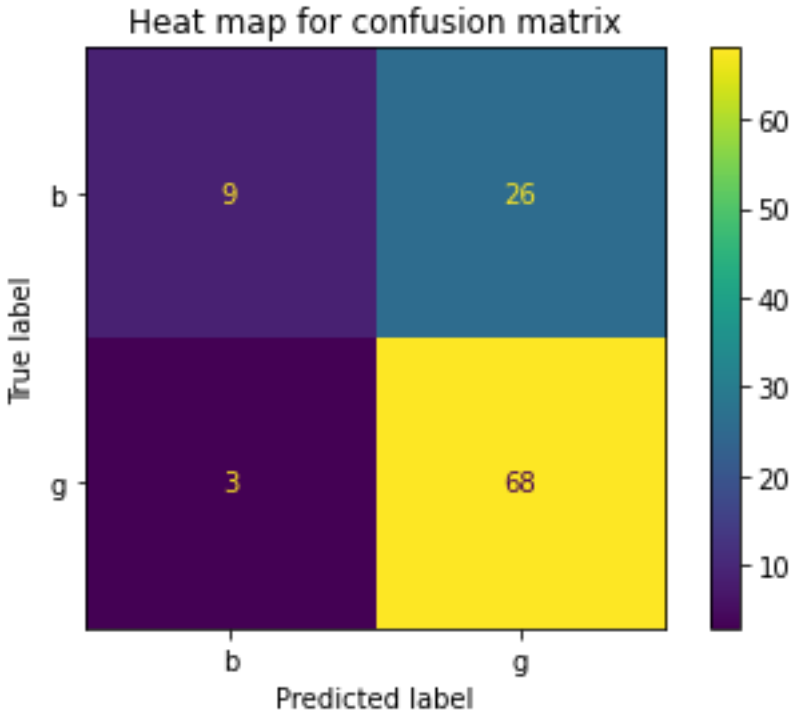

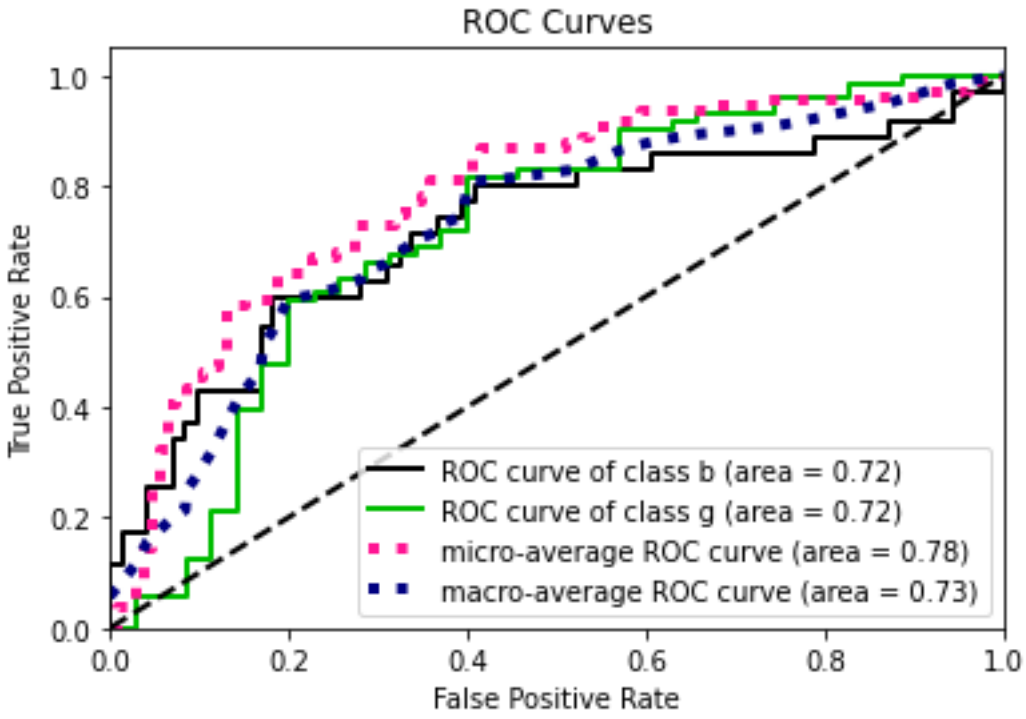

- Bernoulli Naive Bayes:-

Output for Wine dataset :-

```
Bernoulli Naive Bayes:
Confusion Matrix
[[ 0 23  0]
 [ 0 18  0]
 [ 0 13  0]]
```

```
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-----------------------------------
Preformance Evaluation:
              precision    recall  f1-score   support

           1       0.00      0.00      0.00        23
           2       0.33      1.00      0.50        18
           3       0.00      0.00      0.00        13

    accuracy                           0.33        54
   macro avg       0.11      0.33      0.17        54
weighted avg       0.11      0.33      0.17        54

-----------------------------------
-----------------------------------
Accuracy Score:
0.3333333333333333
```

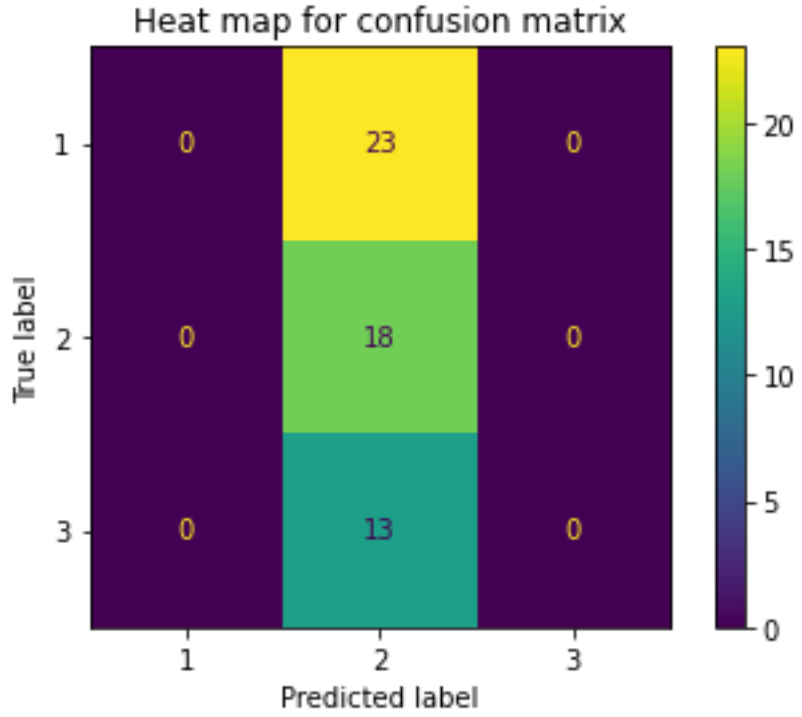

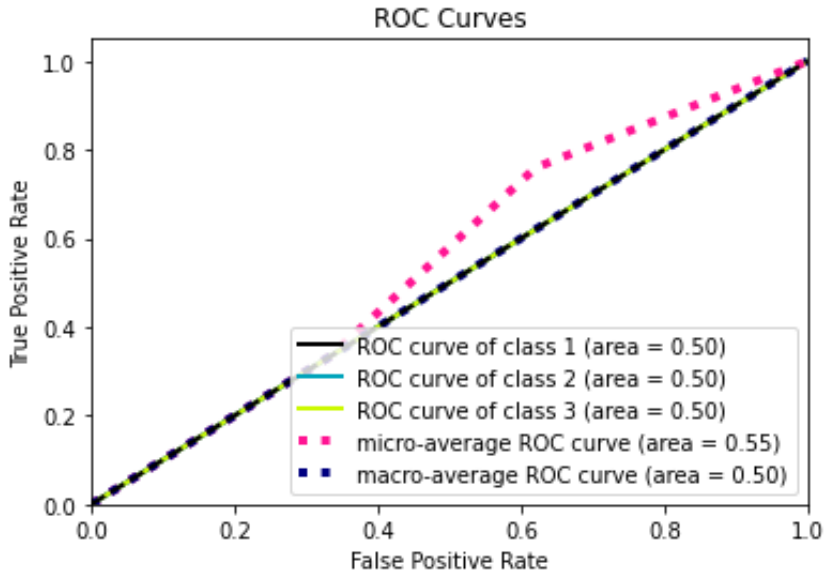

Output for ionosphere dataset :-

```
Bernoulli Naive Bayes:
Confusion Matrix
[[26  9]
 [ 5 66]]
-----------------------------------
-----------------------------------
Preformance Evaluation:
              precision    recall  f1-score   support

           b       0.84      0.74      0.79        35
           g       0.88      0.93      0.90        71

    accuracy                           0.87       106
   macro avg       0.86      0.84      0.85       106
weighted avg       0.87      0.87      0.87       106

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-----------------------------------
Accuracy Score:
0.8679245283018868
```
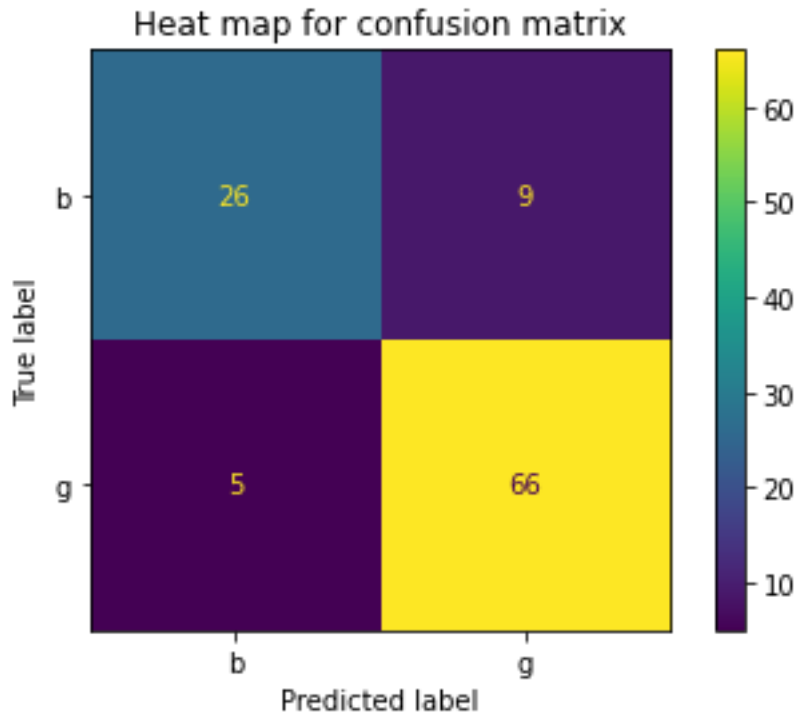
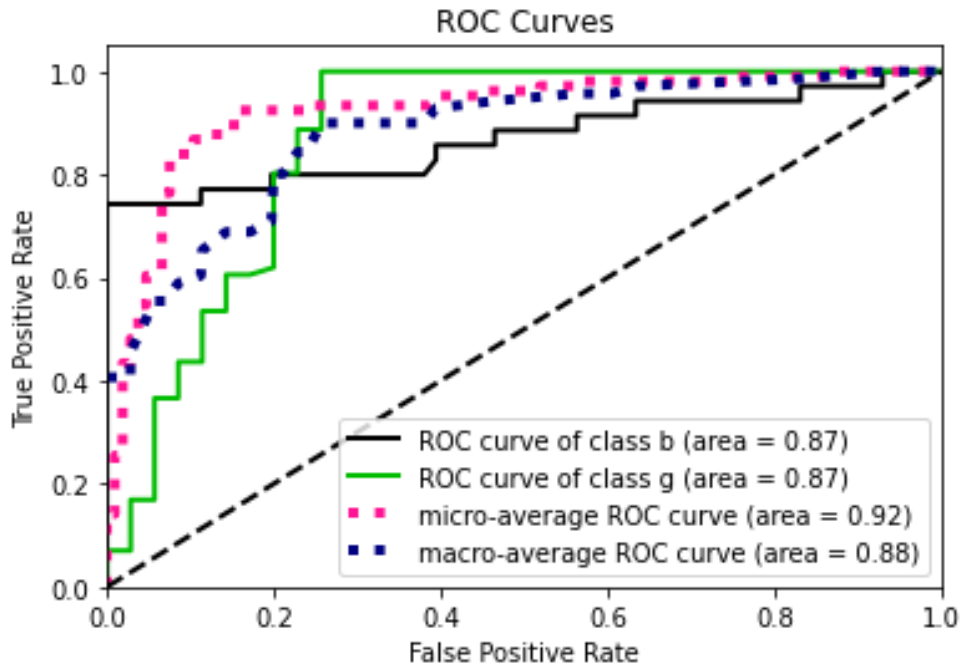
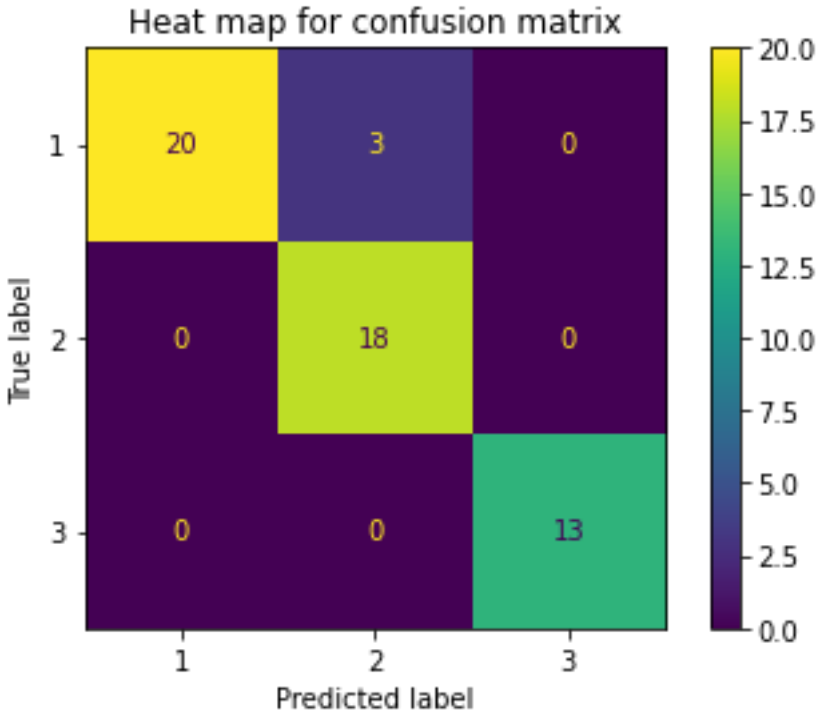



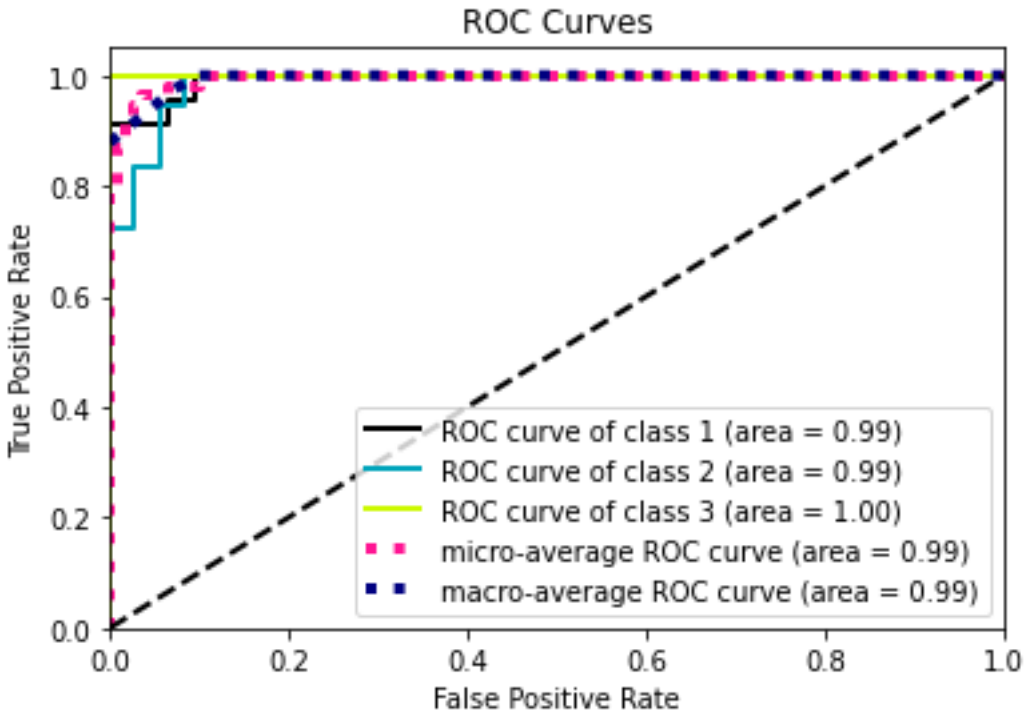


- Gaussian Naive Bayes:-

Output for Wine dataset :-

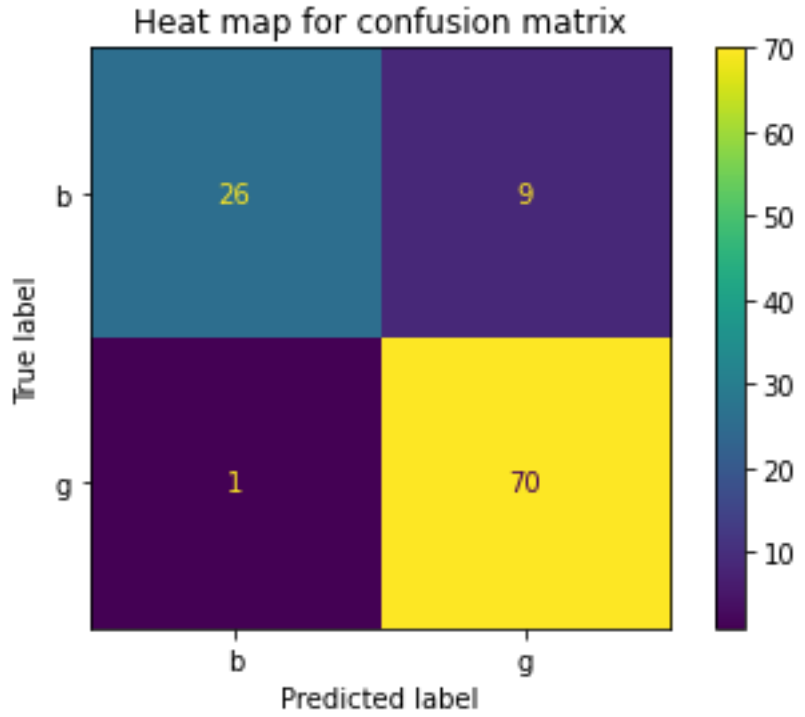
```
Gaussian Naive Bayes:
Confusion Matrix
[[20  3  0]
 [ 0 18  0]
 [ 0  0 13]]
-----------------------------------
-----------------------------------
Preformance Evaluation:
              precision    recall  f1-score   support

           1       1.00      0.87      0.93        23
           2       0.86      1.00      0.92        18
           3       1.00      1.00      1.00        13

    accuracy                           0.94        54
   macro avg       0.95      0.96      0.95        54
weighted avg       0.95      0.94      0.94        54

-----------------------------------
-----------------------------------
Accuracy Score:
0.9444444444444444
```

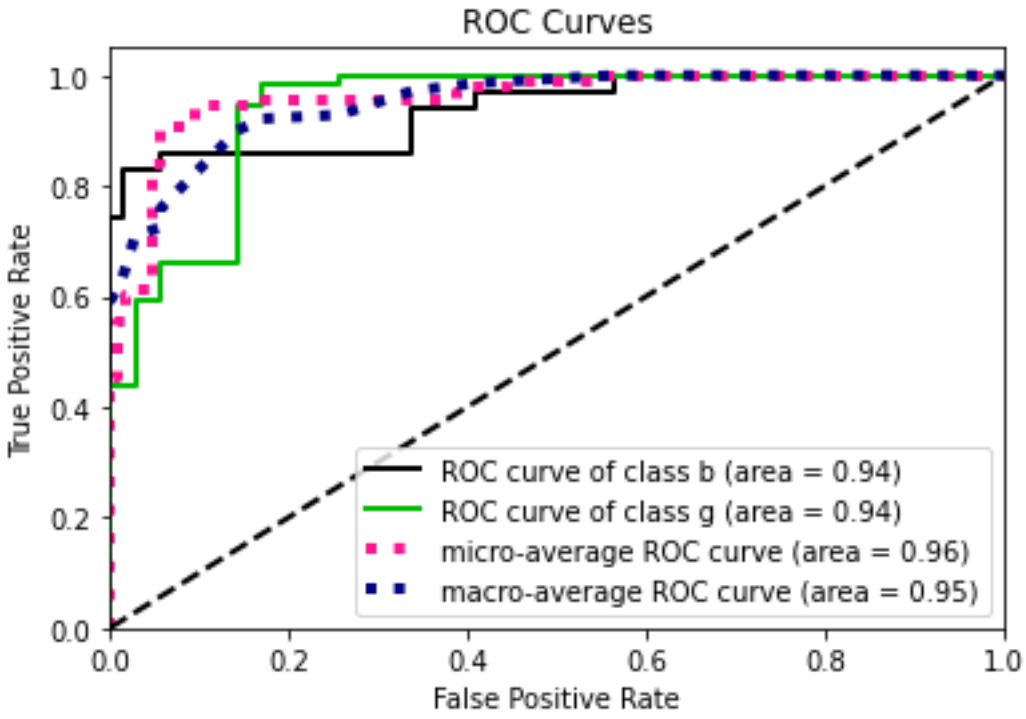

Heat map for confusion matrix
20
3
0
0
18
0
0
0
13
1
2
3
True label
Predicted label
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0


ROC Curves
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve of class 1 (area = 0.99)
ROC curve of class 2 (area = 0.99)
ROC curve of class 3 (area = 1.00)
micro-average ROC curve (area = 0.99)
macro-average ROC curve (area = 0.99)

Output for ionosphere dataset :-

```
Gaussian Naive Bayes:
Confusion Matrix
[[26  9]
 [ 1 70]]
-----------------------------------
-----------------------------------
Preformance Evaluation:
              precision    recall  f1-score   support

           b       0.96      0.74      0.84        35
           g       0.89      0.99      0.93        71

    accuracy                           0.91       106
   macro avg       0.92      0.86      0.89       106
weighted avg       0.91      0.91      0.90       106

-----------------------------------
-----------------------------------
Accuracy Score:
0.9056603773584906
```





Comparison :-

Dataset	**Classifier**	**Precision**	**Recall**	**F1-Score**	**Support**	**Accuracy**
Wine datset	SVM	0.93	0.94	0.93	54	0.92
	Decision Tree	0.92	0.93	0.93	54	0.92
	Random Forest	0.97	0.97	0.96	54	0.96
	Multinomial Naive Bayes	0.77	0.79	0.77	54	0.77
	Bernoulli Naive Bayes	0.11	0.33	0.17	54	0.33
	Gaussian Naive Bayes	0.95	0.96	0.95	54	0.94
Ionosphere datset	SVM	0.88	0.84	0.86	106	0.87
	Decision Tree	0.94	0.91	0.92	106	0.93
	Random Forest	0.97	0.93	0.95	106	0.95
	Multinomial Naive Bayes	0.74	0.61	0.6	106	0.72
	Bernoulli Naive Bayes	0.86	0.84	0.85	106	0.86
	Gaussian Naive Bayes	0.92	0.86	0.89	106	0.9

3.

a) Output for iris dataset :-

- GaussianHMM :-

```
Confusion Matrix
[[18  0  0]
 [ 0 13  0]
 [ 0 14  0]]
-----------------------------------
-----------------------------------
Performance Evaluation:
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        18
           1       0.48      1.00      0.65        13
           2       0.00      0.00      0.00        14

    accuracy                           0.69        45
   macro avg       0.49      0.67      0.55        45
weighted avg       0.54      0.69      0.59        45

-----------------------------------
-----------------------------------
Accuracy Score:
0.6888888888888889
```

- GMMHMM :-

```
Confusion Matrix
[[14  0  0]
 [ 0 18  0]
 [ 0 13  0]]
-----------------------------------
-----------------------------------
Performance Evaluation:
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        14
           1       0.58      1.00      0.73        18
           2       0.00      0.00      0.00        13

    accuracy                           0.71        45
   macro avg       0.53      0.67      0.58        45
weighted avg       0.54      0.71      0.60        45

-----------------------------------
-----------------------------------
Accuracy Score:
0.7111111111111111
```

b) Output for diabetes dataset :-

- GaussianHMM :-

```
Confusion Matrix
[[51 20]
 [19 43]]
----------------------------------
----------------------------------
Performance Evaluation:
              precision    recall  f1-score   support

           0       0.73      0.72      0.72        71
           1       0.68      0.69      0.69        62

    accuracy                           0.71       133
   macro avg       0.71      0.71      0.71       133
weighted avg       0.71      0.71      0.71       133

----------------------------------
----------------------------------
Accuracy Score:
0.706766917293233
```

- GMMHMM :-

```
Confusion Matrix
[[38 22]
 [21 52]]
----------------------------------
----------------------------------
Performance Evaluation:
              precision    recall  f1-score   support

           0       0.64      0.63      0.64        60
           1       0.70      0.71      0.71        73

    accuracy                           0.68       133
   macro avg       0.67      0.67      0.67       133
weighted avg       0.68      0.68      0.68       133

----------------------------------
----------------------------------
Accuracy Score:
0.6766917293233082
```

c) Output for ionosphere dataset :-

- GaussianHMM :-

```
Confusion Matrix
[[33  2]
 [16 55]]
----------------------------------
```

```
-----------------------------------
Performance Evaluation:
              precision    recall  f1-score   support

           0       0.67      0.94      0.79        35
           1       0.96      0.77      0.86        71

    accuracy                           0.83       106
   macro avg       0.82      0.86      0.82       106
weighted avg       0.87      0.83      0.84       106

-----------------------------------
-----------------------------------
Accuracy Score:
0.8301886792452831
```

- GMMHMM :-

```
Degenerate mixture covariance
Confusion Matrix
[[23  7]
 [16 60]]
-----------------------------------
-----------------------------------
Performance Evaluation:
              precision    recall  f1-score   support

           0       0.59      0.77      0.67        30
           1       0.90      0.79      0.84        76

    accuracy                           0.78       106
   macro avg       0.74      0.78      0.75       106
weighted avg       0.81      0.78      0.79       106

-----------------------------------
-----------------------------------
Accuracy Score:
0.7830188679245284
```

Comparison :-

Dataset	**Classifier**	**Precision**	**Recall**	**F1-Score**	**Support**	**Accuracy**
Iris	GaussianHMM	0.49	0.67	0.55	45	0.68
	GMHMM	0.53	0.67	0.58	45	0.71
Diabetes	GaussianHMM	0.71	0.71	0.71	133	0.7
	GMHMM	0.67	0.67	0.67	133	0.67
Ionosphere	GaussianHMM	0.82	0.86	0.82	106	0.83
	GMHMM	0.74	0.78	0.75	106	0.78

5.

a) K Means :-

Output :-

```
Performance Evaluation:
-----------------------------------
-----------------------------------
Silhouette Coefficient
0.571138193786884
-----------------------------------
Calinski Harabasz Score
561.815657860671
-----------------------------------
Davies Bouldin Score
0.5342431775436273
-----------------------------------
```

K Medoids:-

Output:-

```
Performance Evaluation:
-----------------------------------
-----------------------------------
Silhouette Coefficient
0.5708303868116225
-----------------------------------
Calinski Harabasz Score
556.1459974410649
-----------------------------------
Davies Bouldin Score
0.5316801818576816
-----------------------------------
```

Comparison :-

	K Means	K Medoids
Silhouette Coefficient	0.571138193786884	0.5708303868116225
Calinski-Harabasz Score	561.815657860671	556.1459974410649
Davies-Bouldin Score	0.5342431775436273	0.5316801818576816

c) DBSCAN:-

Output:-

```
Performance Evaluation:
-----------------------------------
-----------------------------------
Silhouette Coefficient
0.5131593970763382
-----------------------------------
Calinski Harabasz Score
55.59856582586847
-----------------------------------
Davies Bouldin Score
0.37396418544796095
-----------------------------------
```

OPTICS:-

Output:-

```
Performance Evaluation:
-----------------------------------
-----------------------------------
Silhouette Coefficient
0.2654566747731084
-----------------------------------
Calinski Harabasz Score
28.198952246515542
-----------------------------------
Davies Bouldin Score
5.752797762329204
-----------------------------------
```

Comparison :-

	DBSCAN	OPTICS
Silhouette Coefficient	0.5131593970763382	0.2654566747731084
Calinski-Harabasz Score	55.59856582586847	28.198952246515542
Davies-Bouldin Score	0.37396418544796095	5.752797762329204