

## **Assignment 2**

Assignment of  
ELL 784: Introduction to Machine Learning

by

**Lovlesh Roy**

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Under the Guidance of  
**Prof. Sumeet Agarwal**



**INDIAN INSTITUTE OF TECHNOLOGY DELHI**

**NEW DELHI - 110016**

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## Part 1

- **Binary Classification with first 10 features**
  - **Classes 0 and 1**

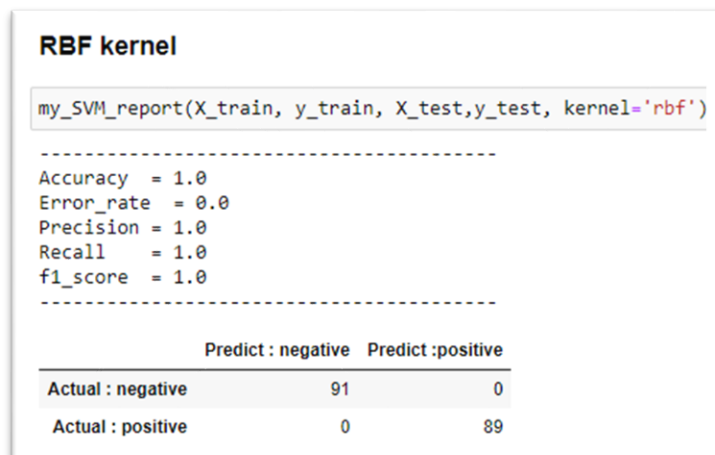


Fig 1: SVM Report Polynomial Kernel

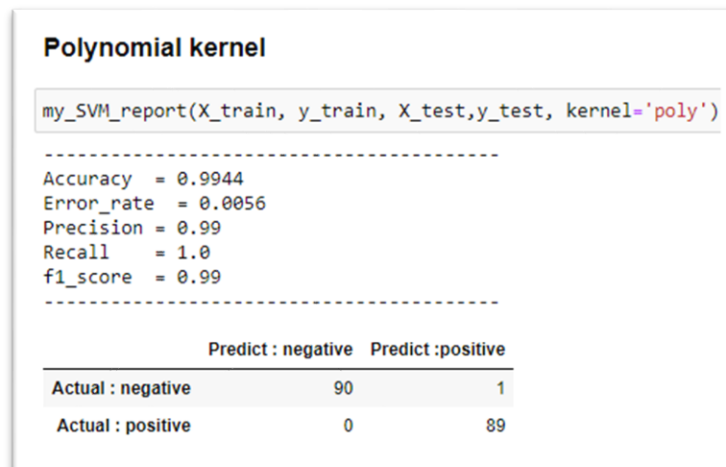


Fig 2: SVM Report Polynomial Kernel

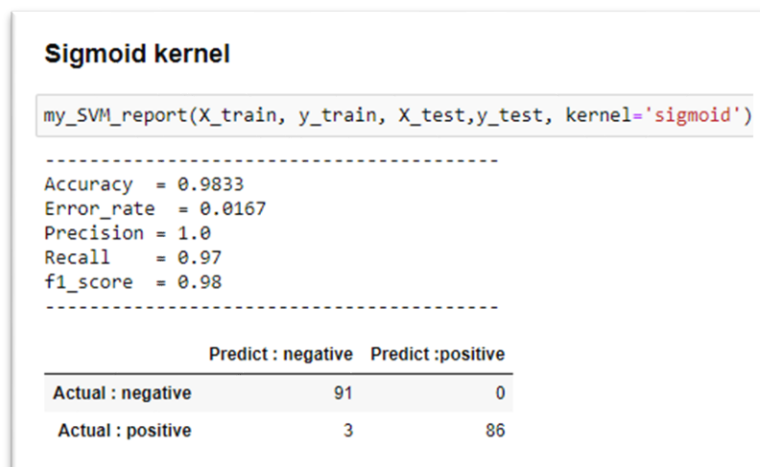


Fig 3: SVM Report Sigmoid Kernel

- Classes 2 and 3

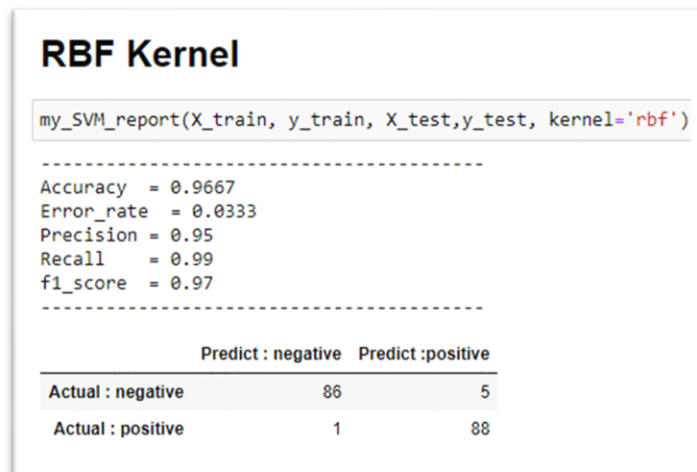


Fig 4: SVM Report RBF Kernel

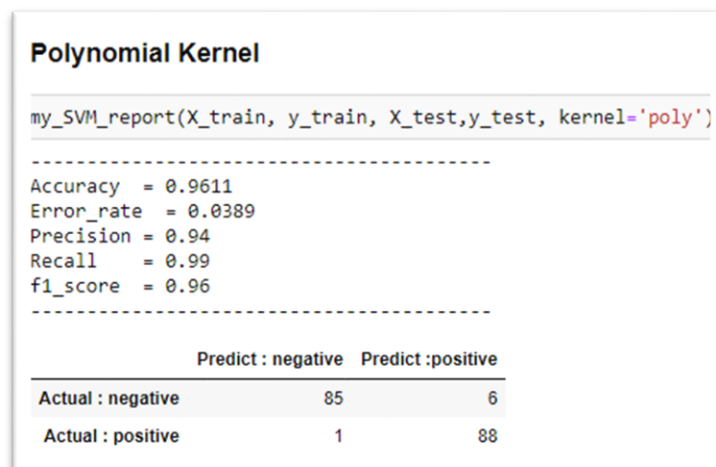


Fig 5: SVM Report Polynomial Kernel

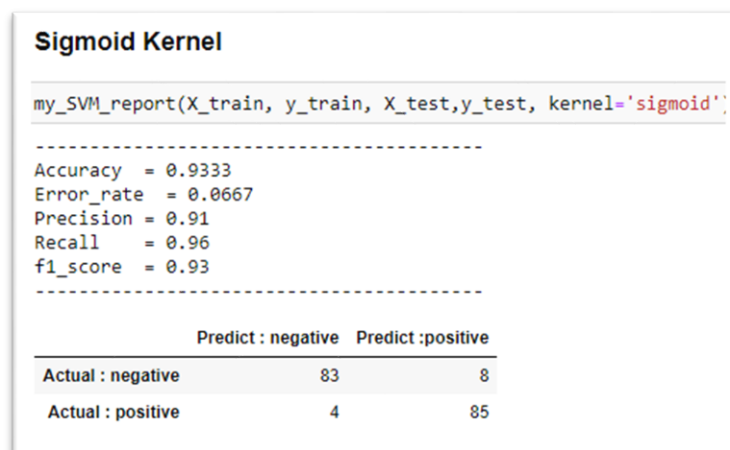


Fig 6: SVM Report Sigmoid Kernel

- Classes 4 and 5

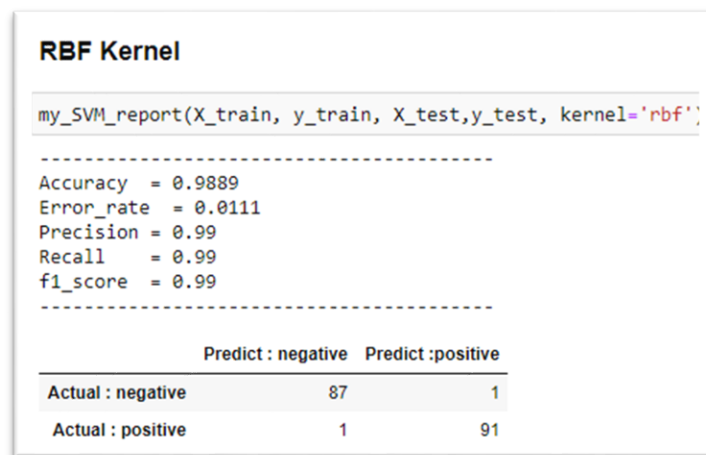


Fig 7: SVM Report RBF Kernel

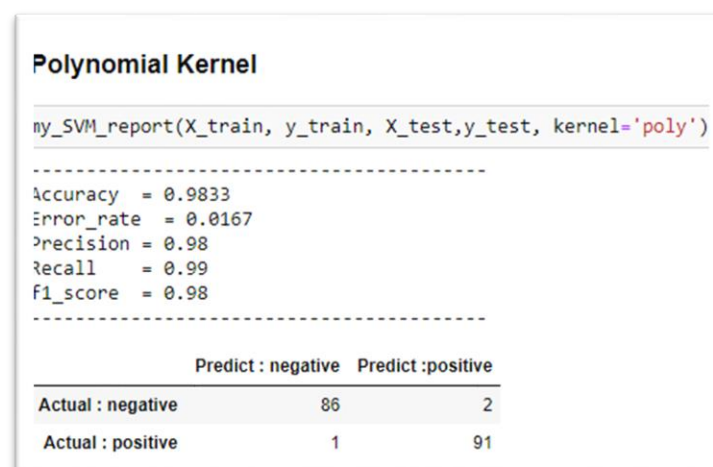


Fig 8: SVM Report Polynomial Kernel

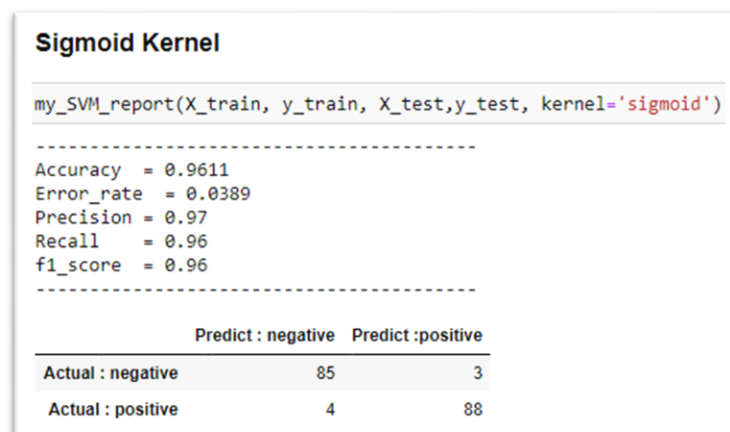


Fig 9: SVM Report Sigmoid Kernel

➤ **Binary Classification with first 25 features**

- **Classes 0 and 1**

## RBF kernel

```
my_SVM_report(X_train, y_train, X_test,y_test, kernel='rbf')
```

```
-----  
Accuracy   = 1.0  
Error_rate = 0.0  
Precision  = 1.0  
Recall     = 1.0  
f1_score   = 1.0  
-----
```

|                   | Predict : negative | Predict :positive |
|-------------------|--------------------|-------------------|
| Actual : negative | 91                 | 0                 |
| Actual : positive | 0                  | 89                |

Fig 10: SVM Report Polynomial Kernel

## Polynomial Kernel

```
my_SVM_report(X_train, y_train, X_test,y_test, kernel='poly')
```

```
-----
```

Accuracy = 0.9778  
Error\_rate = 0.0222  
Precision = 0.96  
Recall = 1.0  
f1\_score = 0.98

```
-----
```

|                   | Predict : negative | Predict :positive |
|-------------------|--------------------|-------------------|
| Actual : negative | 89                 | 4                 |
| Actual : positive | 0                  | 87                |

Fig 11: SVM Report Polynomial Kernel

## Sigmoid Kernel

```
my_SVM_report(X_train, y_train, X_test,y_test, kernel='sigmoid')
```

```
-----
```

Accuracy = 1.0  
Error\_rate = 0.0  
Precision = 1.0  
Recall = 1.0  
f1\_score = 1.0

```
-----
```

|                   | Predict : negative | Predict :positive |
|-------------------|--------------------|-------------------|
| Actual : negative | 93                 | 0                 |
| Actual : positive | 0                  | 87                |

Fig 12: SVM Report Sigmoid Kernel

- Classes 2 and 3

## RBF Kernel

```
my_SVM_report(X_train, y_train, X_test,y_test, kernel='rbf')
```

```
-----  
Accuracy   = 0.9889  
Error_rate = 0.0111  
Precision  = 1.0  
Recall     = 0.98  
f1_score   = 0.99  
-----
```

|                   | Predict : negative | Predict :positive |
|-------------------|--------------------|-------------------|
| Actual : negative | 81                 | 0                 |
| Actual : positive | 2                  | 97                |

Fig 13: SVM Report RBF Kernel

## Polynomial Kernel

```
my_SVM_report(X_train, y_train, X_test,y_test, kernel='poly')
```

-----

Accuracy = 0.9833  
Error\_rate = 0.0167  
Precision = 1.0  
Recall = 0.97  
f1\_score = 0.98

-----

|                   | Predict : negative | Predict :positive |
|-------------------|--------------------|-------------------|
| Actual : negative | 81                 | 0                 |
| Actual : positive | 3                  | 96                |

Fig 14: SVM Report Polynomial Kernel

## Sigmoid kernel

```
my_SVM_report(X_train, y_train, X_test,y_test, kernel='sigmoid')
```

```
-----  
Accuracy   = 0.9722  
Error_rate = 0.0278  
Precision  = 0.97  
Recall     = 0.98  
f1_score   = 0.97  
-----
```

|                   | Predict : negative | Predict :positive |
|-------------------|--------------------|-------------------|
| Actual : negative | 78                 | 3                 |
| Actual : positive | 2                  | 97                |

Fig 15: SVM Report Sigmoid Kernel

- Classes 4 and 5

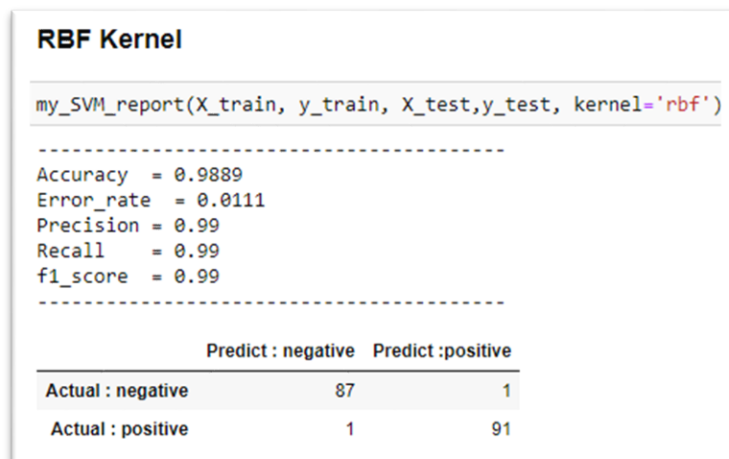


Fig 16: SVM Report RBF Kernel

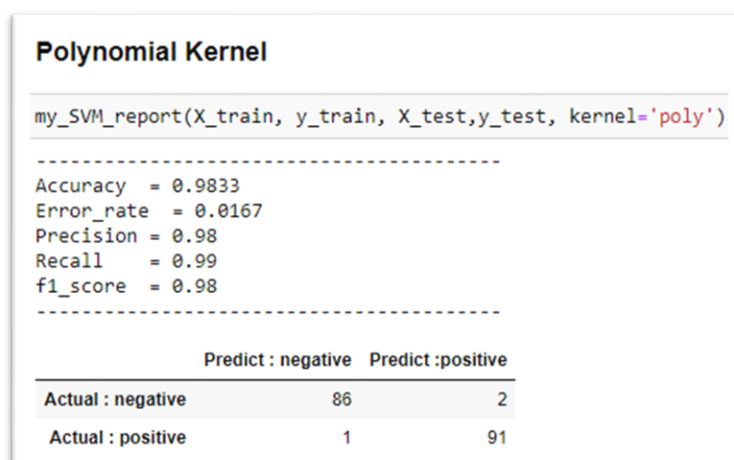


Fig 17: SVM Report Polynomial Kernel

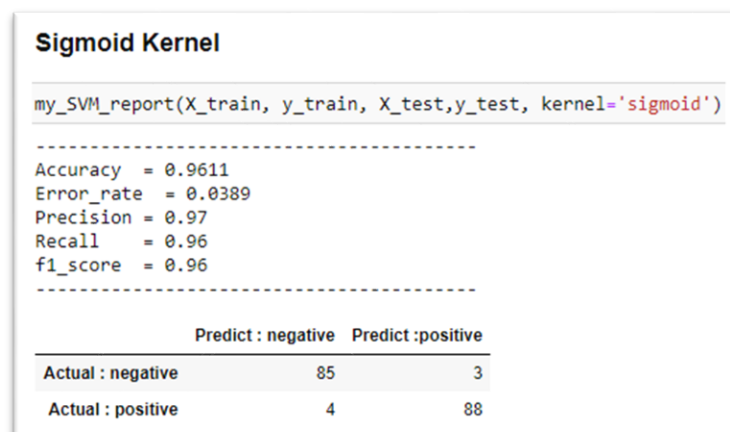


Fig 18: SVM Report Sigmoid Kernel



## ➤ Feature visualization

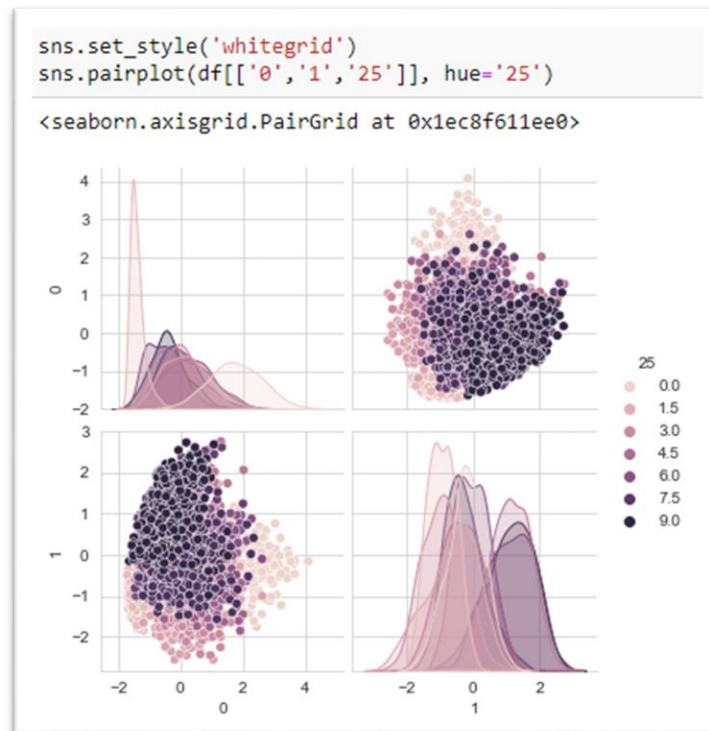


Fig 19: Distribution of first 2 feature with respect to classes

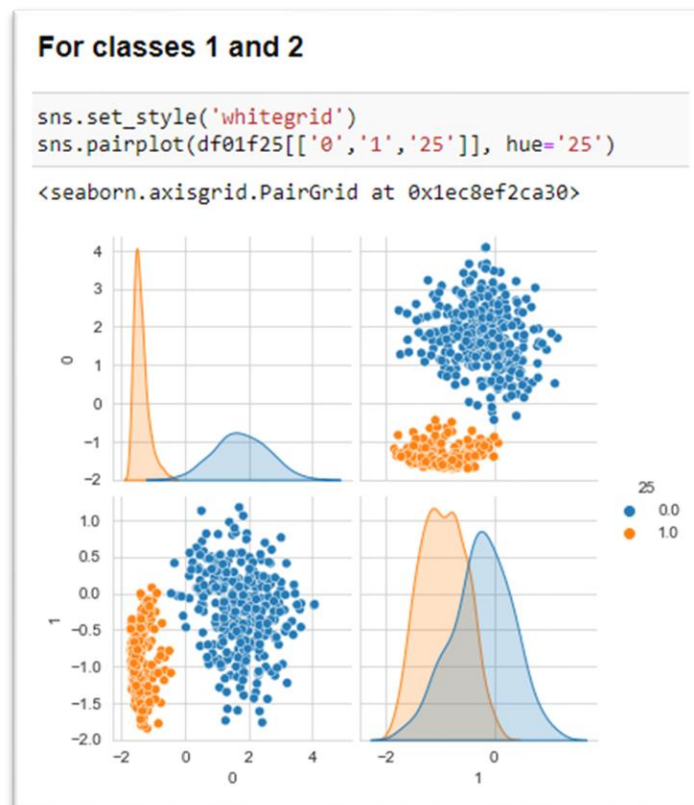


Fig 20: Distribution of first 2 feature with respect to classes 0 and 1

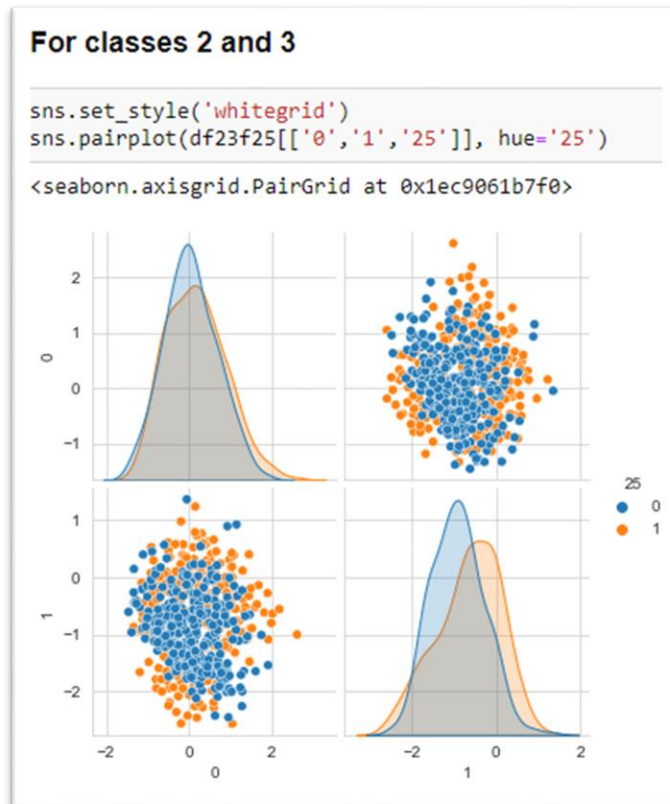


Fig 21: Distribution of first 2 feature with respect to classes 2 and 3

### ➤ Multiclass classification with 10 features

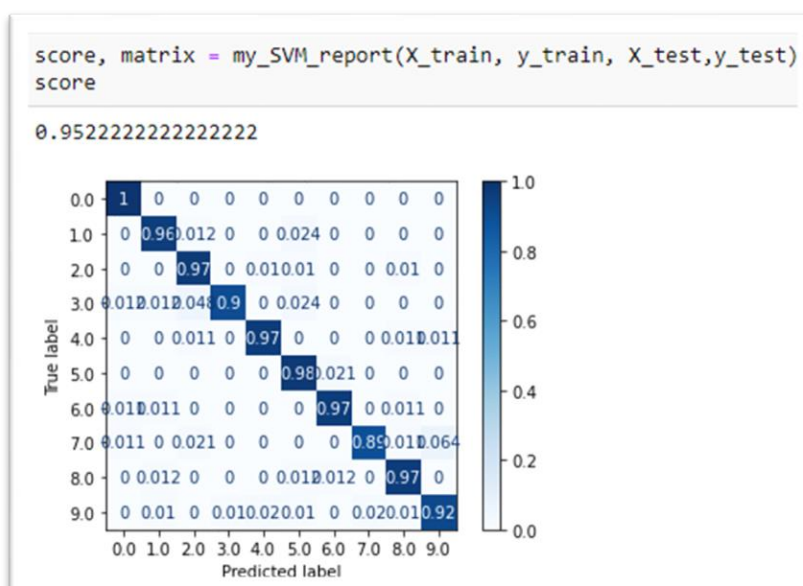


Fig 22: Accuracy and confusion matrix for multiclass classification

➤ **Multiclass classification with 25 features**

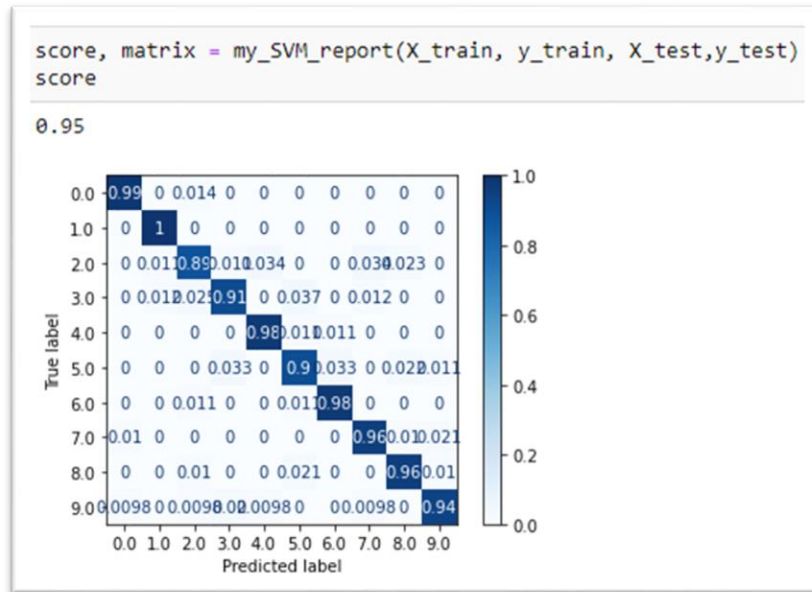


Fig 23: Accuracy and confusion matrix for multiclass classification

➤ **Hyper parameter Tuning for multiclass classification**

|    | C    | Gammma | Kernel | score    |
|----|------|--------|--------|----------|
| 0  | 1    | scale  | rbf    | 0.950000 |
| 1  | 1    | 0.05   | rbf    | 0.958889 |
| 2  | 1    | 0.06   | rbf    | 0.958889 |
| 3  | 10   | scale  | rbf    | 0.961111 |
| 4  | 10   | 0.05   | rbf    | 0.962222 |
| 5  | 10   | 0.06   | rbf    | 0.960000 |
| 6  | 100  | scale  | rbf    | 0.962222 |
| 7  | 100  | 0.05   | rbf    | 0.963333 |
| 8  | 100  | 0.06   | rbf    | 0.960000 |
| 9  | 1000 | scale  | rbf    | 0.962222 |
| 10 | 1000 | 0.05   | rbf    | 0.963333 |
| 11 | 1000 | 0.06   | rbf    | 0.960000 |

Fig 24: Hyper parameter tuning for multiclass classification

## Part 2

### ➤ Feature Visualization

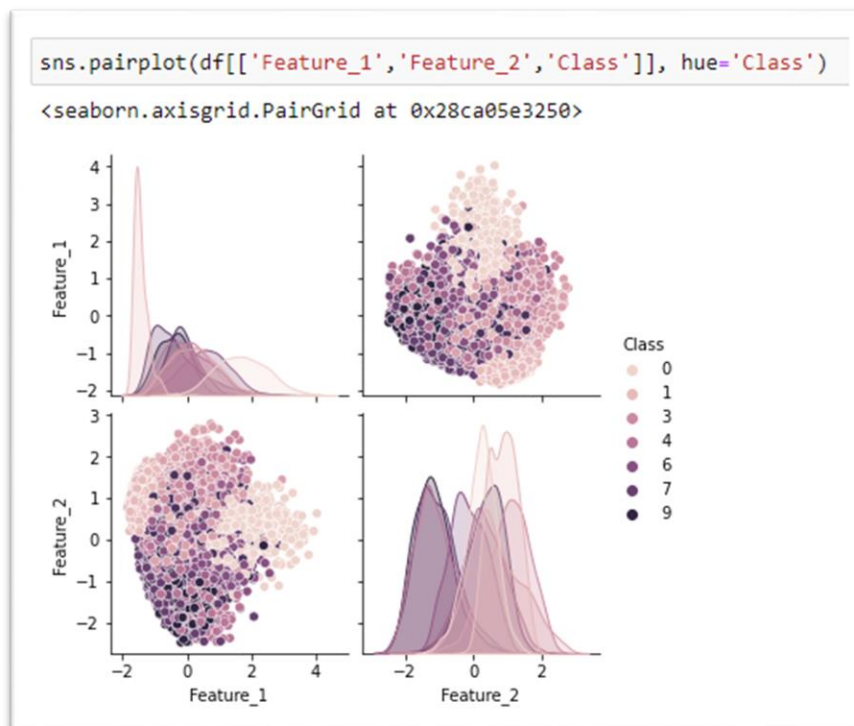


Fig 25: Feature visualization with respect to class

### ➤ Hyper parameter tuning

|    | C    | Gammma | Kernel | score    |
|----|------|--------|--------|----------|
| 0  | 10   | scale  | rbf    | 0.964130 |
| 1  | 10   | 0.1    | rbf    | 0.972283 |
| 2  | 10   | 0.01   | rbf    | 0.954891 |
| 3  | 9    | scale  | rbf    | 0.968478 |
| 4  | 9    | 0.1    | rbf    | 0.965761 |
| 5  | 9    | 0.01   | rbf    | 0.952717 |
| 6  | 100  | scale  | rbf    | 0.960326 |
| 7  | 100  | 0.1    | rbf    | 0.959783 |
| 8  | 100  | 0.01   | rbf    | 0.945109 |
| 9  | 1000 | scale  | rbf    | 0.962500 |
| 10 | 1000 | 0.1    | rbf    | 0.969565 |
| 11 | 1000 | 0.01   | rbf    | 0.953804 |

Fig 26: Hyper parameter tuning

## ➤ Prediction

| y_hat |     |
|-------|-----|
| Class |     |
| 0     | 8   |
| 1     | 7   |
| 2     | 1   |
| 3     | 7   |
| 4     | 1   |
| ...   | ... |
| 1995  | 1   |
| 1996  | 0   |
| 1997  | 1   |
| 1998  | 9   |
| 1999  | 3   |

2000 rows × 1 columns

Fig 26: Predictions