Dataset 1 Details:

	Class 1	**Class 2**	**Class 3**
Training data	250	250	250
Test data	100	100	100
Validation data	150	150	150

Table I : Linearly separable dataset size

	Class 1	**Class 2**
Training data	250	250
Test data	100	100
Validation data	150	150

Table II: Non-Linearly separable dataset size

	Class 1	**Class 2**	**Class 3**
Training data	250	250	250
Test data	100	100	100
Validation data	150	150	150

Table III : Overlapping dataset size

Model 1 (a): K-Nearest Neighbour classifier for linearly separable data.

K(number of nearest neighbors)	Train data accuracy	validation data accuracy
12	100%	100%
20	100%	100%
25	100%	100%
27	**100%**	**100%**
30	100%	100%

Table 1.1.1 : Accuracies for linearly separable data set

Observations :

From this table we see that in all cases we get the accuracy is 100%,so the best case is chosen as K =27.

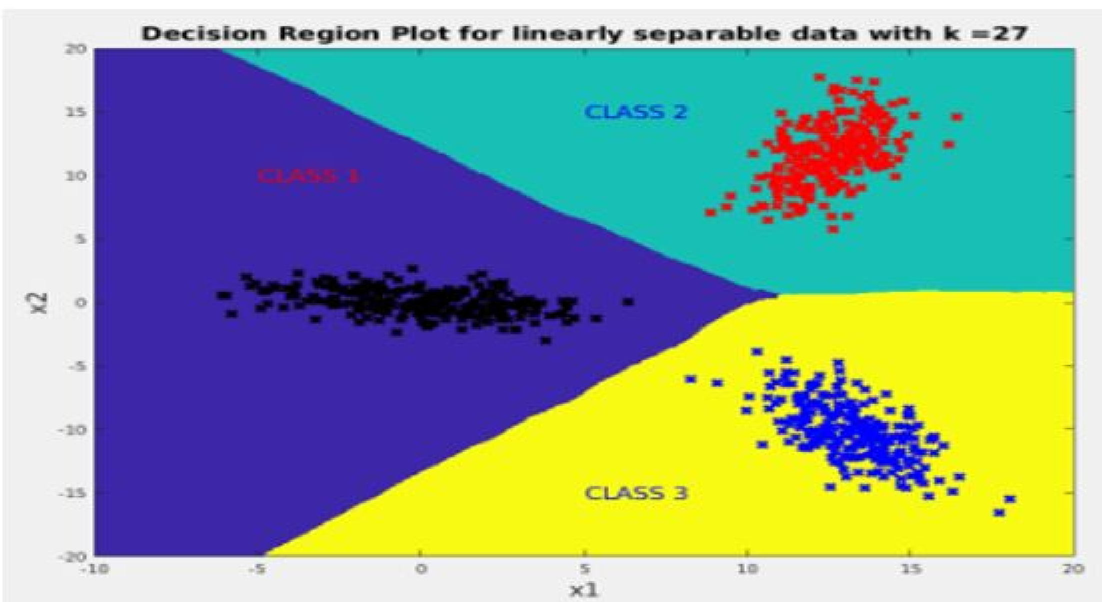

Figure 1.1.2 : plot for best performing model of training data points showing values of x1 plotted against x2 , with three different classes. Also shown is the classification of the input space given by k-nearest neighbour algorithm for k = 27.

Test Data	**Class 1**	**Class 2**	**Class 3**
Class 1	100	0	0
Class 2	0	100	0
Class 3	0	0	100

Table 1.1.3:Confusion Matrix for best model on test data for k=27

Train Data	**Class 1**	**Class 2**	**Class 3**
Class 1	250	0	0
Class 2	0	250	0
Class 3	0	0	250

Table 1.1.4:Confusion Matrix for best model on training data for k=27

Model 1 (b): K-Nearest Neighbour classifier for Non- linearly separable data .

K(number of nearest neighbors)	Train data accuracy	validation data accuracy
12	100%	100%
20	100%	100%
23	**100%**	**100%**
27	100%	100%
30	100%	100%

Table 1.2.1 : Accuracies for non - linearly separable data set

Observations :

From this table we see that in all cases we get the accuracy as 100%,so the best case is chosen as k=23.

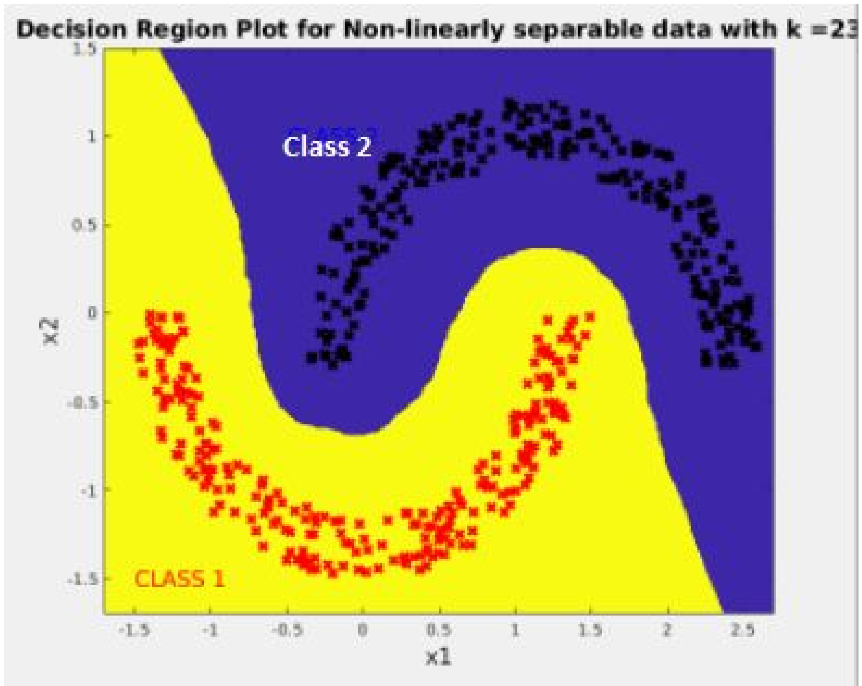

Figure 1.2.1 : Plot for best performing model of 500 data points showing values of x1 plotted against x2 , where the red and black points correspond to class 1 and class 2 , respectively . Also shown is the classification of the input space given by k-nearest-neighbour algorithm for k = 23.

Test Data	**Class 1**	**Class 2**
Class 1	100	0
Class 2	0	100

Table 1.2.2:Confusion Matrix for best model on training data for k = 23

Train Data	**Class 1**	**Class 2**
Class 1	250	0
Class 2	0	250

Table 1.2.3:Confusion Matrix for best model on test data for k = 23

Model 1 (c): K-Nearest Neighbour classifier for overlapping data .

K(no. of nearest neighbors)	Train data accuracy	validation data accuracy
15	**99.33%**	**99.47%**
20	99.00%	99.47%
25	99.00%	99.47%
27	99.67%	99.33%
30	99.33%	99.33%
70	99.00%	99.20%

Table 1.3.1 : Accuracies of overlapping data set

Observations :
On comparing the accuracies from the table , k=15 is chosen as the best case .
On taking very high values of k i.e. when k becomes nearly equal to no. of data points , the accuracy decreases.

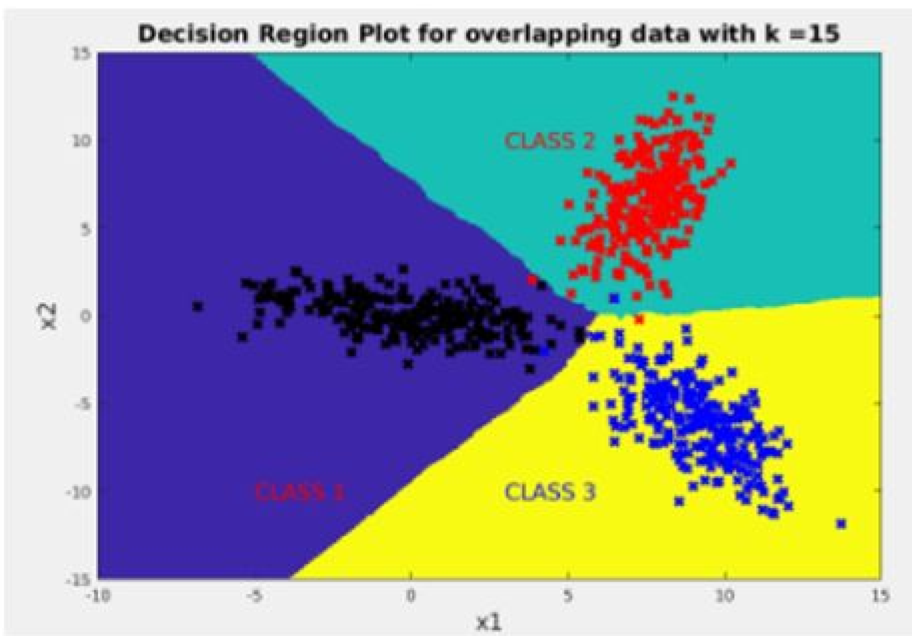

Figure 1.3.1 : Plot for best performing model of 750 data points showing values of x1 plotted against x2 , where the black , red and blue points correspond to class 1 ,class 2 and class 3 , respectively . Also shown is the classification of the input space given by k-nearest-neighbour algorithm for k = 15.

Test Data	Class 1	Class 2	Class 3
Class 1	100	0	0
Class 2	0	100	0
Class 3	2	0	98

Table 1.3.2:Confusion Matrix for best model on test data for k=15

Train Data	Class 1	Class 2	Class 3
Class 1	250	0	0
Class 2	1	248	1
Class 3	1	1	248

Table 1.3.3:Confusion Matrix for best model on train data for k=15

Model 2 : Naive-Bayes classifier with a Gaussian distribution for each class

1 (a) . Covariance matrix for all the classes is the same and is $\sigma^2 I$ on linearly separable data

Train data	100%
Test data	100%
Validation data	100%

Table 2.1 : Accuracies on linearly separable data set

Test Data	Class 1	Class 2	Class 3
Class 1	100	0	0
Class 2	0	100	0
Class 3	0	0	100

Table 2.2 : Confusion Matrix for test data

Train Data	Class 1	Class 2	Class 3
Class 1	250	0	0
Class 2	0	250	0
Class 3	0	0	250

Table 2.3 : Confusion Matrix for train data

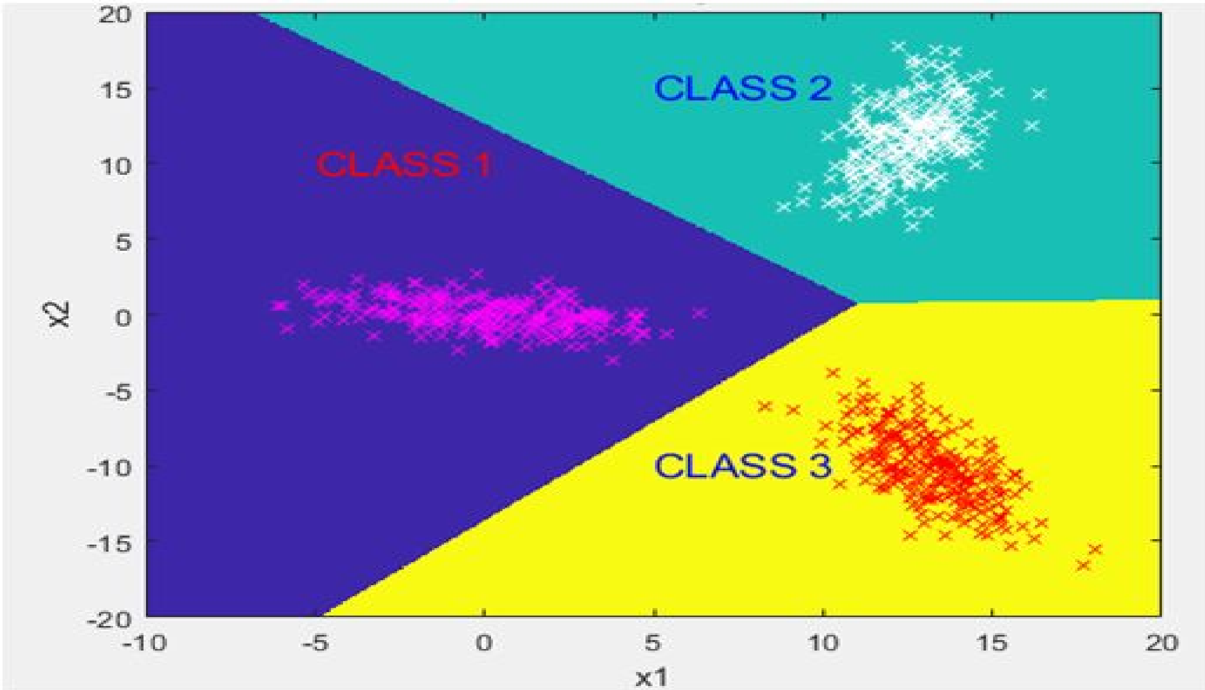

Fig 2.1 : Decision region plot for naive bayes classifier on linearly separable data with C = σ^2 I

1 (b) . Covariance matrix for all the classes is the same and is $\sigma^2 \mathbf{I}$ on Non-linearly separable data

Train data	84.60%
Test data	82.50%
Validation data	88.33%

Table 2.4: Accuracies for Non-linearly separable data

Test Data	**Class 1**	**Class 2**
Class 1	78	22
Class 2	13	87

Table 2.5: Confusion Matrix for Test data

Train Data	**Class 1**	**Class 2**
Class 1	213	37
Class 2	40	210

Table 2.6: Confusion Matrix for Train data

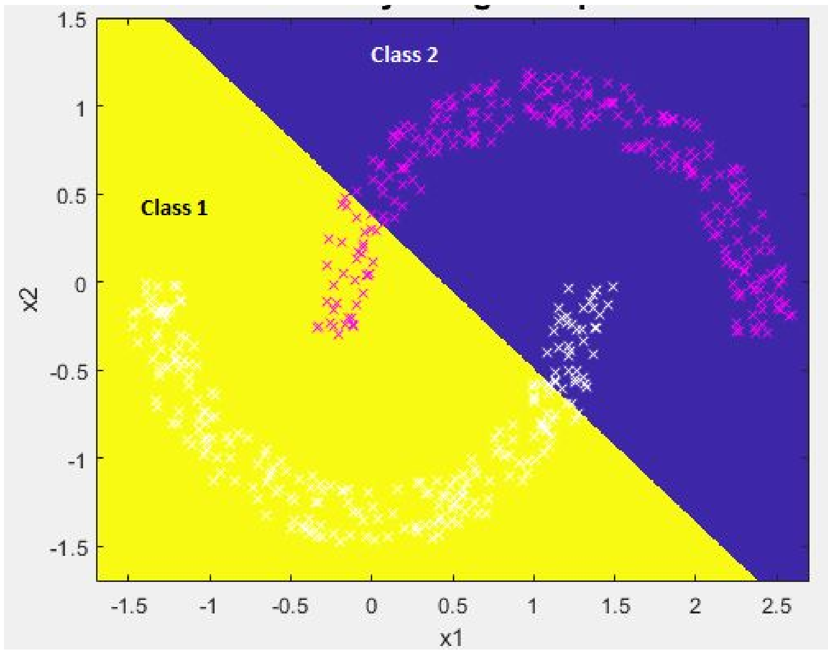

figure 2.2: Decision region plot with naive bayes classifier on non-linearly separable data for *$C= \sigma^2 I$*

Observations :

In this case all the plots are linear because the covariance matrix for all the classes is same and is $C= \sigma^2 I$.

1 (c) . Covariance matrix for all the classes is the same and is $\sigma^2 I$ on overlapping data

Train data	99.33%
Test data	99.47%
Validation data	98.44%

Table 2.7 : Accuracies for Overlapping data

Test Data	Class 1	Class 2	Class 3
Class 1	100	0	0
Class 2	0	100	0
Class 3	1	0	99

Table 2.8 : Confusion Matrix for test data on overlapping data

Train Data	Class 1	Class 2	Class 3
Class 1	250	0	0
Class 2	2	247	1
Class 3	1	1	248

Table 2.9: Confusion Matrix for train data on overlapping data

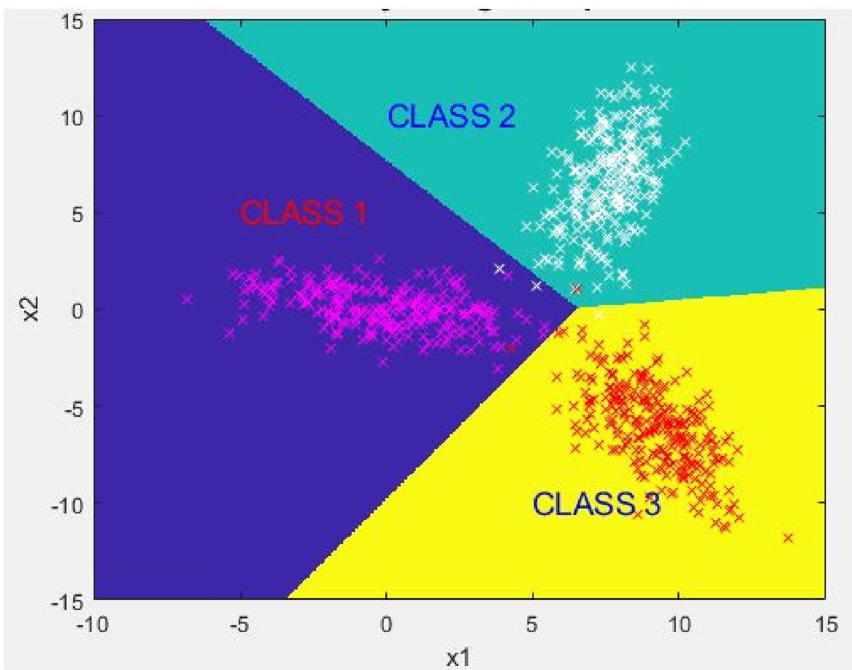

Fig.2.4 : Decision region plot with naive bayes classifier for $C = \sigma^2 I$

Observations :

Since the covariance matrix for all the classes is same viz. $C = \sigma^2 I$. So, the boundaries are linear.

2(b) : Covariance matrix for all the classes is the same and is C on linearly Separable data

Train data	100%
Test data	100%
Validation data	100%

Table 2.10 : Accuracies for linearly separable data set

Test Data	Class 1	Class 2	Class 3
Class 1	100	0	0
Class 2	0	100	0
Class 3	0	0	100

Table 2.11 : Confusion Matrix for test data

Train Data	Class 1	Class 2	Class 3
Class 1	250	0	0
Class 2	0	250	0
Class 3	0	0	250

Table 2.12 : Confusion Matrix for train data

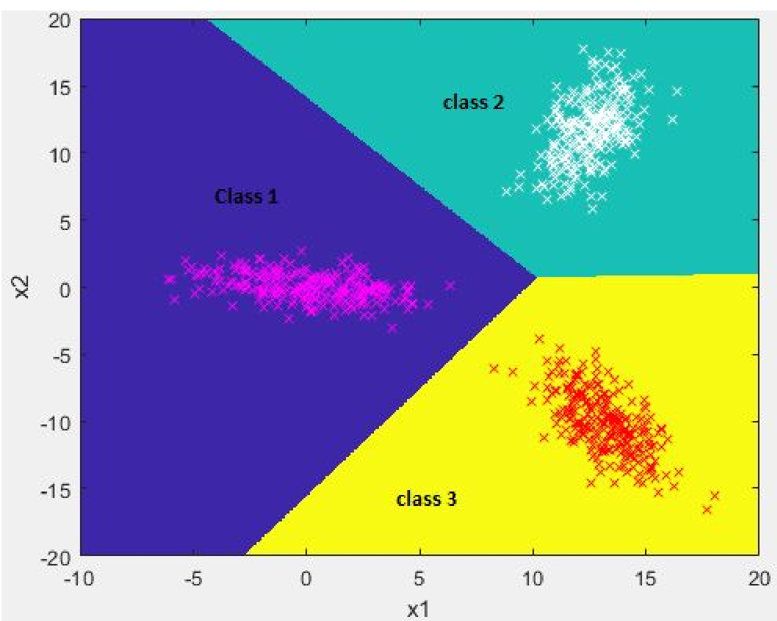

Fig 2.5 : Decision region plot with naive bayes classifier on linearly separable data with same covariance matrix for all classes

Model 1.2(b): Naive Bayes Classifier with same covariance matrix for Non-linearly separable data .

Train data	93.40%
Test data	92.00%
Validation data	96.33%

Table 2.13: Accuracies for Non-linearly separable data

Test Data	Class 1	Class 2
Class 1	89	11
Class 2	5	95

Table 2.14 : Confusion Matrix for Test data

Train Data	Class 1	Class 2
Class 1	234	16
Class 2	17	233

Table 2.15 : Confusion Matrix for Train data

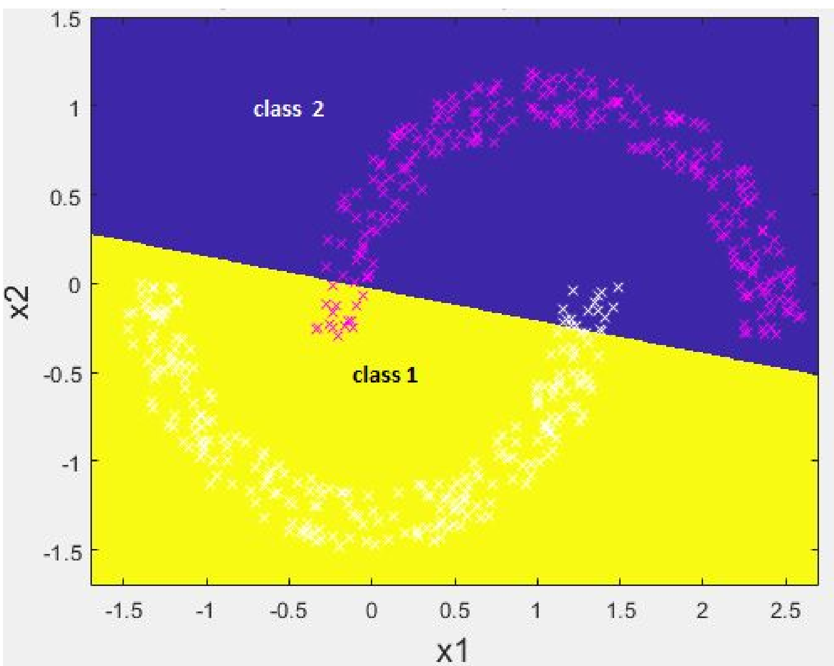

Fig 2.7: Decision region plot with naive bayes classifier on non-linearly separable data with same covariance matrix for all classes

Model 1.2(c): Naive Bayes Classifier using same covariance matrix for all classes on overlapping data

Train data	99.33%
Test data	99.33%
Validation data	98.67%

Table 2.16: Accuracies for Overlapping data

Test Data	**Class 1**	**Class 2**	**Class 3**
Class 1	99	0	1
Class 2	0	100	0
Class 3	0	1	99

Table 2.17 : Confusion Matrix for test data on overlapping data with same covariance matrix for all classes

Train Data	**Clas s 1**	**Class 2**	**Class 3**
Class 1	249	0	1
Class 2	1	248	1
Class 3	1	1	248

Table 2.18: Confusion Matrix for train data on overlapping data with same covariance matrix for all classes

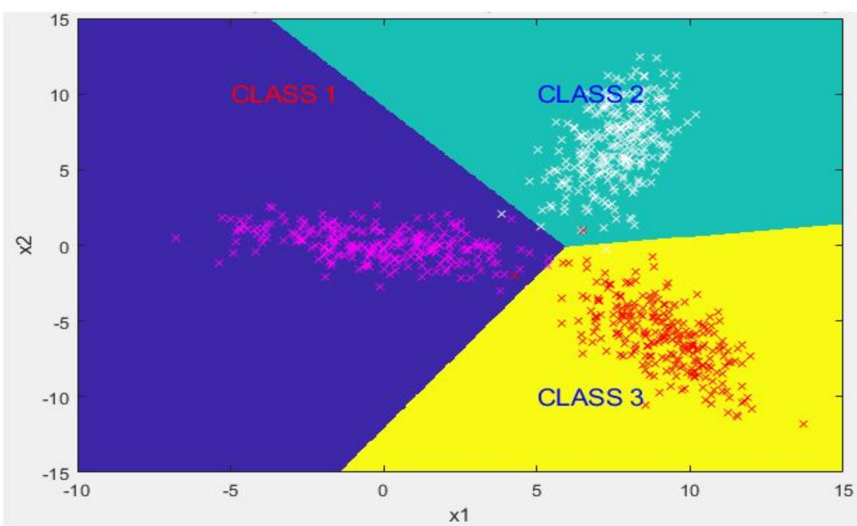

Fig 2.8: Decision region plot with naive bayes classifier on overlapping data with same covariance matrix for all classes

Observations :
These decision region plots shows posterior probabilities classes .The decision boundaries are shown. Here , it can be seen that , the boundaries between all three classes are linear because they have the same covariance matrix.

2(c) : Covariance matrix for all the classes is different on linearly Separable data

Train data	100%
Test data	100%
Validation data	100%

Table 2.19 : Accuracies for linearly separable data set

Test Data	Class 1	Class 2	Class 3
Class 1	100	0	0
Class 2	0	100	0
Class 3	0	0	100

Table 2.20 : Confusion Matrix for test data

Train Data	Clas s 1	Class 2	Class 3
Class 1	250	0	0
Class 2	0	250	0
Class 3	0	0	250

Table 2.21 : Confusion Matrix for train data

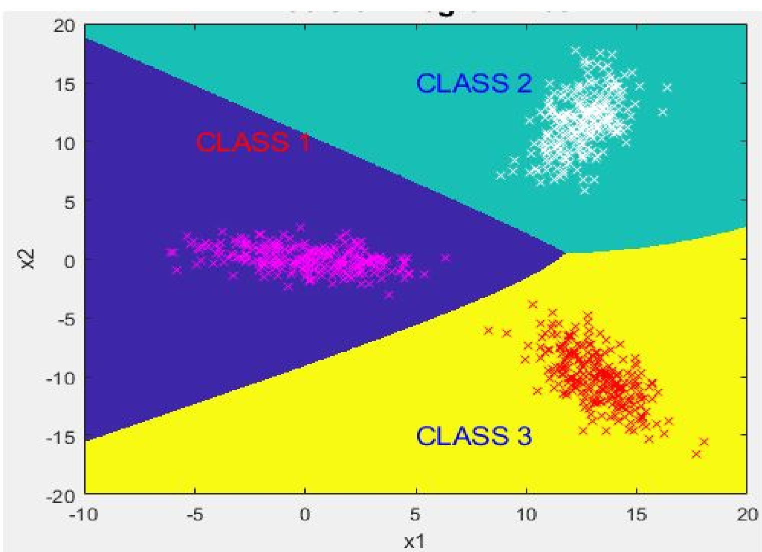

Fig 2.9: Decision region plot with naive bayes classifier on linearly separable data with different covariance matrix for all classes

Model 2.2(b): Naive Bayes Classifier with different covariance matrix for Non-linearly separable data .

Train data	93.40%
Test data	92.00%
Validation data	96.33%

Table 2.22: Accuracies for Non-linearly separable data

Test Data	**Class 1**	**Class 2**
Class 1	89	11
Class 2	5	95

Table 2.23: Confusion Matrix for Test data

Train Data	**Class 1**	**Class 2**
Class 1	234	16
Class 2	17	233

Table 2.24: Confusion Matrix for Train data

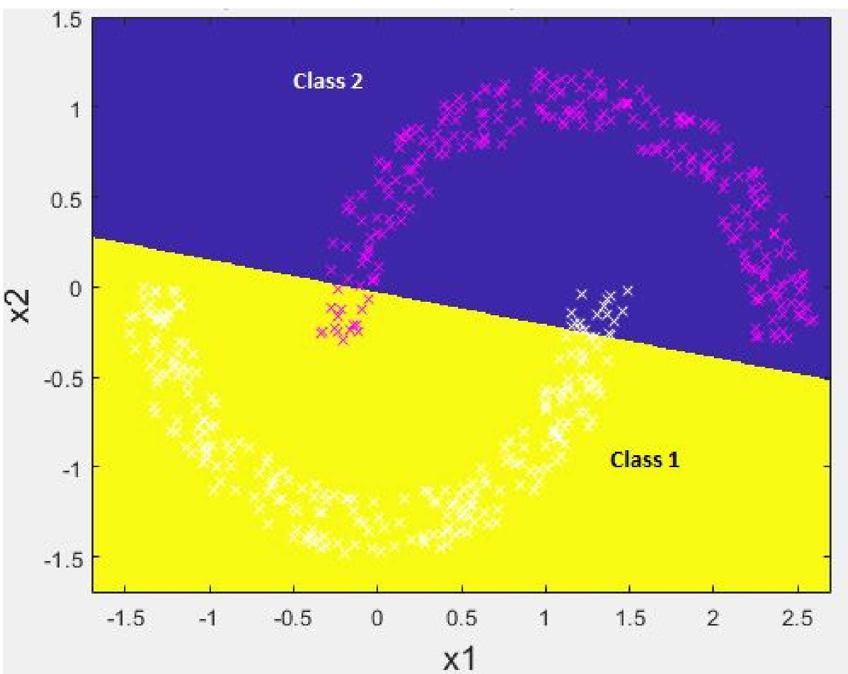

Fig 2.10: Decision region plot with naive bayes classifier on non-linearly separable data with different covariance matrix for all classes

Model 1.2(c): Naive Bayes Classifier using same covariance matrix for all classes on overlapping data

Train data	99.20%
Test data	99.00%
Validation data	98.67%

Table 2.25 : Accuracies for Overlapping data

Test Data	**Class 1**	**Class 2**	**Class 3**
Class 1	100	0	1
Class 2	1	99	0
Class 3	2	1	98

Table 2.26: Confusion Matrix for test data on overlapping data with different covariance matrix for all classes

Train Data	**Class 1**	**Class 2**	**Class 3**
Class 1	250	0	0
Class 2	2	248	0
Class 3	3	1	246

Table 2.27 : Confusion Matrix for train data on overlapping data with different covariance matrix for all classes

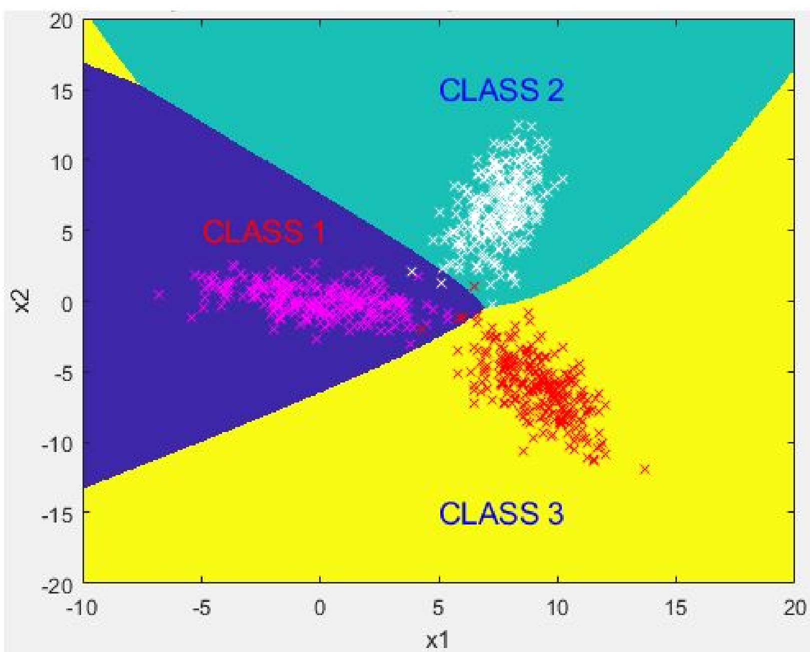

Fig 2.11: Decision region plot with naive bayes classifier on overlapping data with different covariance matrix for all classes

Observations:

These plots shows the decision region boundaries for the classes viz. Non-linear because the covariance matrices for all the classes are different .

Model 3 : Bayes classifier with a Gaussian distribution for each class with same covariance matrices for all the classes

3.1(a) : On Linearly separable data

Train data	100%
Test data	100%
Validation data	100%

Table 3.1 : Accuracies for linearly separable data set

Test Data	**Class 1**	**Class 2**	**Class 3**
Class 1	100	0	0
Class 2	0	100	0
Class 3	0	0	100

Table 3.2 : Confusion Matrix for test data

Train Data	**Class 1**	**Class 2**	**Class 3**
Class 1	250	0	0
Class 2	0	250	0
Class 3	0	0	250

Table 3.3: Confusion Matrix for train data

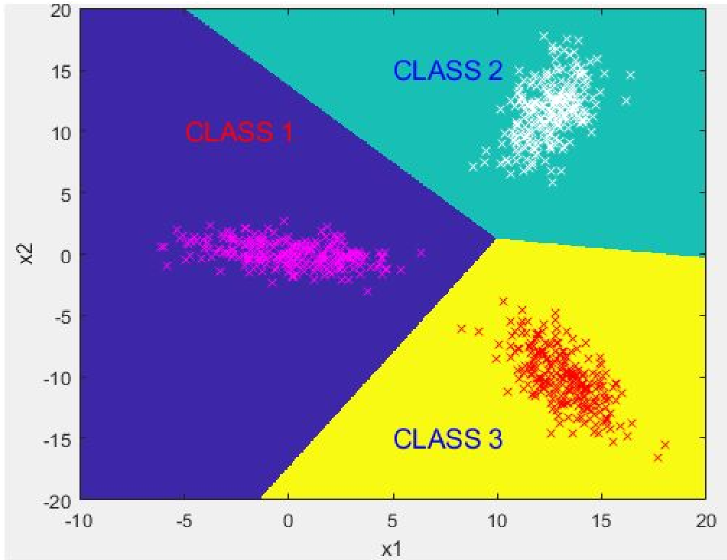

Fig 3.1 : Decision region plot using bayes classifier on linearly separable data with same covariance on all the classes .

3.1(b) : For Non-linearly separable data .

Train data	93.20%
Test data	91.00%
Validation data	96.00%

Table 3.4: Accuracies for Non-linearly separable data

Test Data	**Class 1**	**Class 2**
Class 1	89	11
Class 2	7	93

Table 3.5: Confusion Matrix for Test data

Train Data	**Class 1**	**Class 2**
Class 1	234	16
Class 2	18	232

Table 3.6: Confusion Matrix for Train data

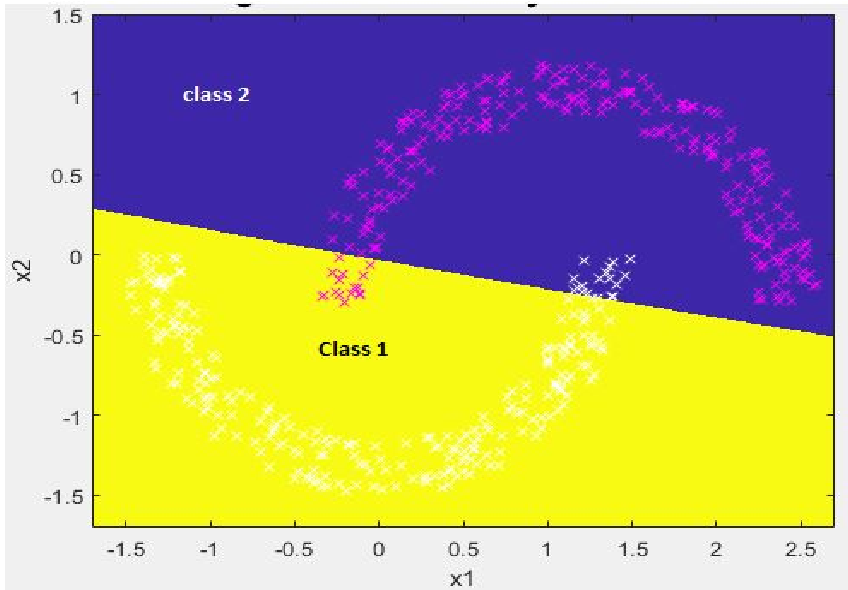

Fig 3.2 : Decision region plot using bayes classifier on non-linearly separable data with same covariance on all the classes .

Observations :
These plots shows the posterior probabilities of the classes . The decision region boundaries are linear because the covariance matrices for all the classes is same .

3.1(c) : For overlapping data

Train data	99.07%
Test data	99.67%
Validation data	98.67%

Table 3.7 : Accuracies for Overlapping data

Test Data	Class 1	Class 2	Class 3
Class 1	99	0	1
Class 2	0	100	0
Class 3	0	0	100

Table 3.8: Confusion Matrix for test data

Train Data	Class 1	Class 2	Class 3
Class 1	248	0	2
Class 2	2	247	1
Class 3	1	1	248

Table 3.9: Confusion Matrix for train data

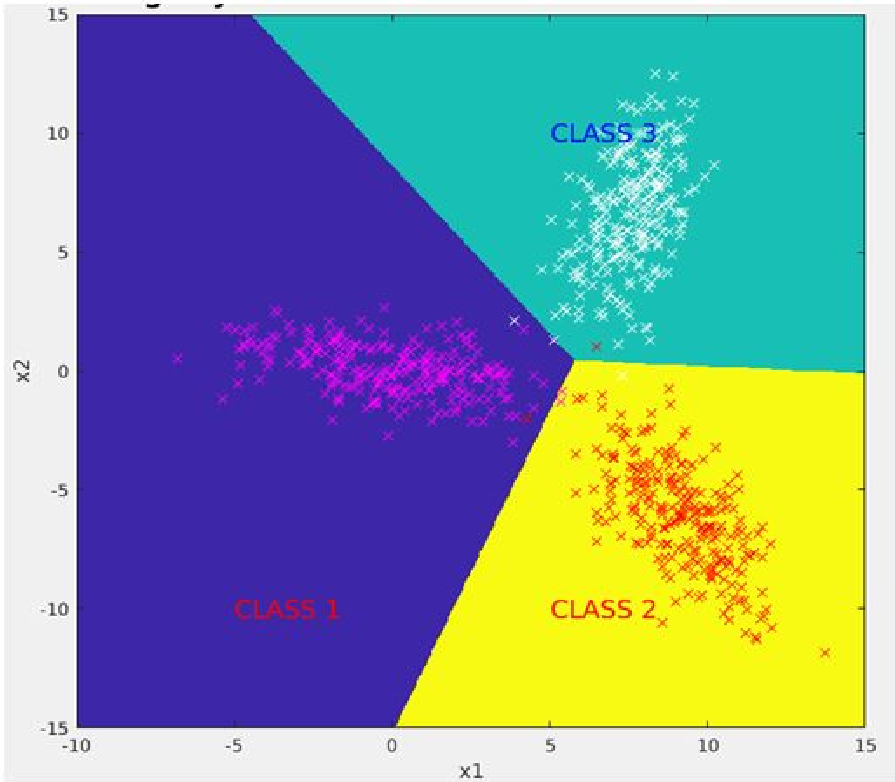

Fig 3.3: Decision region plot with naive bayes classifier on overlapping data with same covariance matrix for all classes

Observations:

These plots shows the decision region boundaries for the classes which is linear because the covariance matrices for all the classes are same.

Model 3 : Bayes classifier with a Gaussian distribution for each class with different covariance matrices for all the classes

3.2(a) : On Linearly separable data

Train data	100%
Test data	100%
Validation data	100%

Table 3.10 : Accuracies for linearly separable data set

Test Data	Class 1	Class 2	Class 3
Class 1	100	0	0
Class 2	0	100	0
Class 3	0	0	100

Table 3.11: Confusion Matrix for test data

Train Data	Class 1	Class 2	Class 3
Class 1	250	0	0
Class 2	0	250	0
Class 3	0	0	250

Table 3.12 : Confusion Matrix for train data

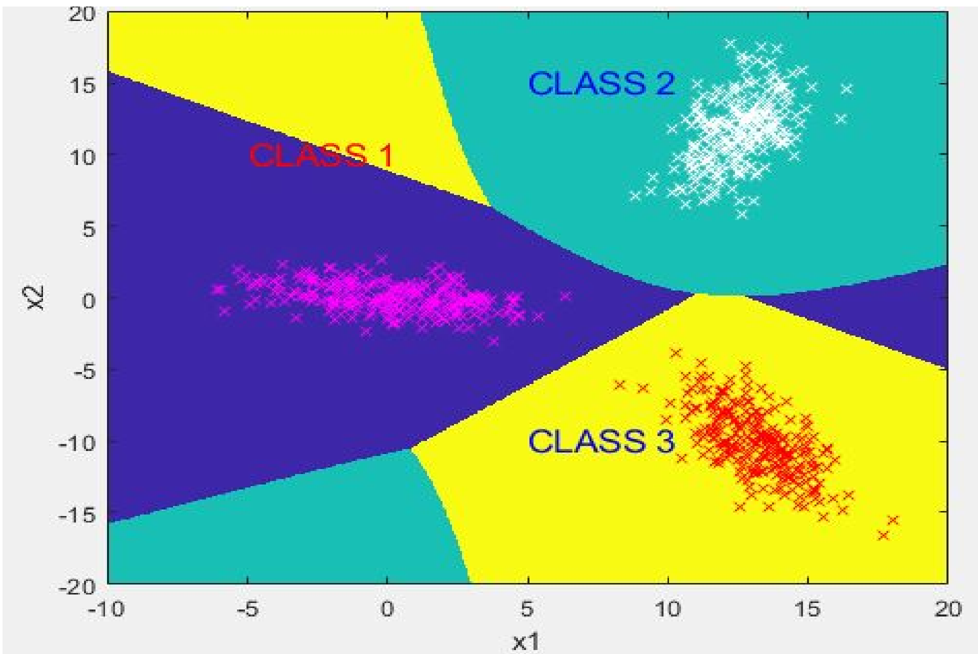

Fig *3.4* : Decision region plot using bayes classifier on linearly separable data with different covariance of the classes .

Observations :

This plot shows the posterior probabilities of the classes . The decision region boundaries are non-linear because the covariance matrices for all the classes is different.

3.2(b) : For Non-linearly separable data .

Train data	92.80%
Test data	91.00%
Validation data	96.00%

Table 3.13 : Accuracies for Non-linearly separable data

Test Data	Class 1	Class 2
Class 1	89	11
Class 2	7	93

Table 3.14 : Confusion Matrix for Test data

Train Data	Class 1	Class 2
Class 1	233	17
Class 2	19	231

Table 3.15 : Confusion Matrix for Train data

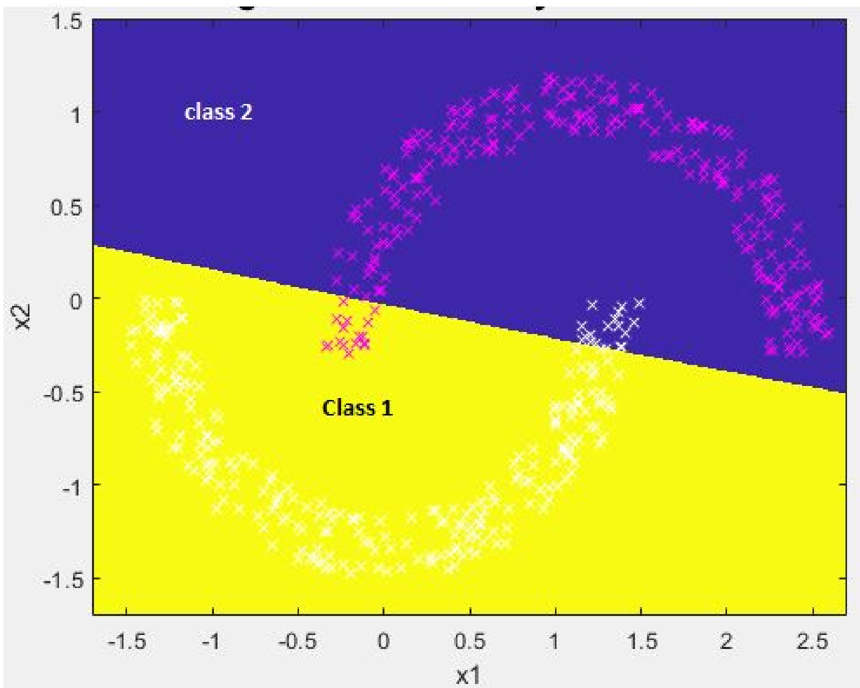

Fig 3.5 : Decision region plot using bayes classifier on non-linearly separable data with different covariance for all the classes.

3.2(c) : For overlapping data

Train data	99.47%
Test data	99.00%
Validation data	98.89%

Table 3.16: Accuracies for Overlapping data

Test Data	Class 1	Class 2	Class 3
Class 1	100	0	0
Class 2	0	100	0
Class 3	2	1	97

Table 3.17 : Confusion Matrix for test data

Train Data	Class 1	Class 2	Class 3
Class 1	250	0	0
Class 2	1	248	1
Class 3	1	1	248

Table 3.18 : Confusion Matrix for train data

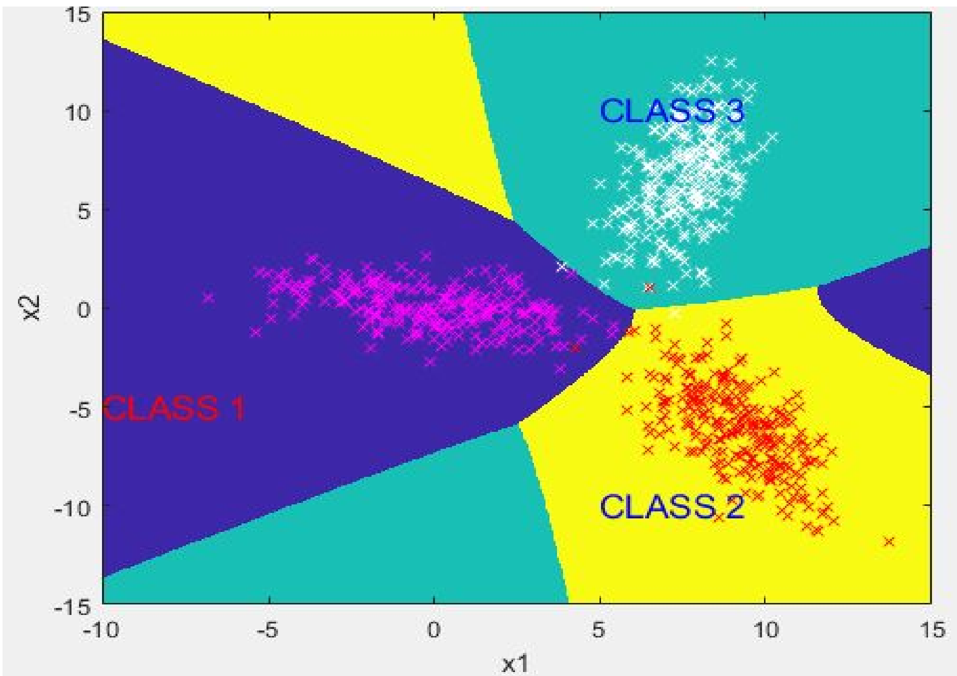

Fig : Decision region plot with bayes classifier on overlapping data with different covariance matrix for the classes

Observations:

This plot shows the decision region boundaries for the classes viz. non-linear because the covariance matrices for all the classes are different .

Model 4 - Naive-Bayes classifier with a GMM for each class

4.1 - Linearly Separable Dataset

K1	K2	K3	Train data accuracy	Validation data accuracy
3	2	3	100%	100%
3	3	3	100%	100%
2	2	3	100%	100%

Table 4.1.1: linearly separable data

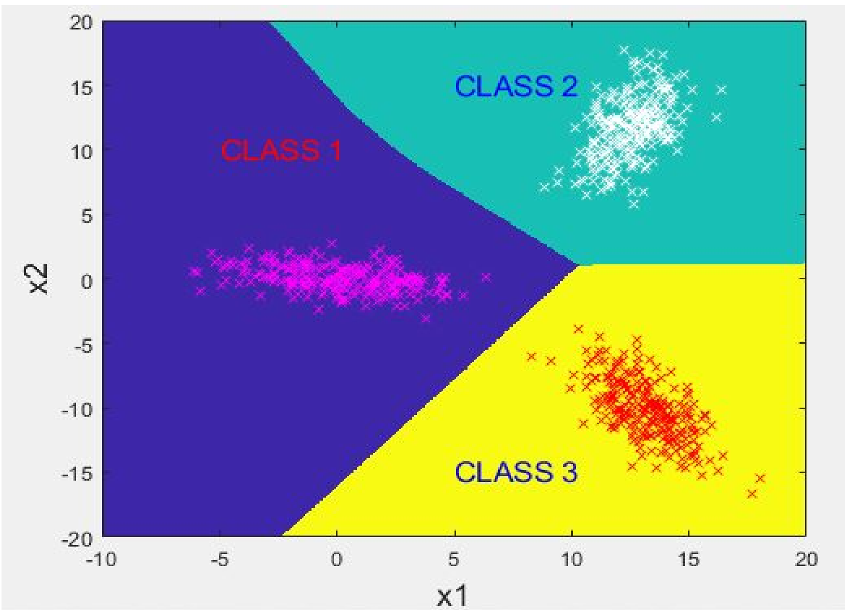

Figure 4.1.1: decision region plot on linearly separable data

Test Data	Class 1	Class 2	Class 3
Class 1	100	0	0
Class 2	0	100	0
Class 3	0	0	100

Table 4.1.2 : Confusion Matrix of Test data for best case

Train Data	Class 1	Class 2	Class 3
Class 1	250	0	0
Class 2	0	250	0
Class 3	0	0	250

Table 4.1.3 : Confusion Matrix of train data for best case

4.2 - Non linearly Separable Data

K1	K2	Train data accuracy	validation data accuracy
3	3	100%	100%
3	2	99.20%	97.50%
2	3	93.00%	100%
2	2	95.20%	94.00%

Table 4.2.1 : Accuracies for non - linearly separable data set

Observations : Best case Chosen is with k1 = 3 and k2 =3 . since it gives the highest accuracy. The values of k1 and k2 are smaller because of the dataset.

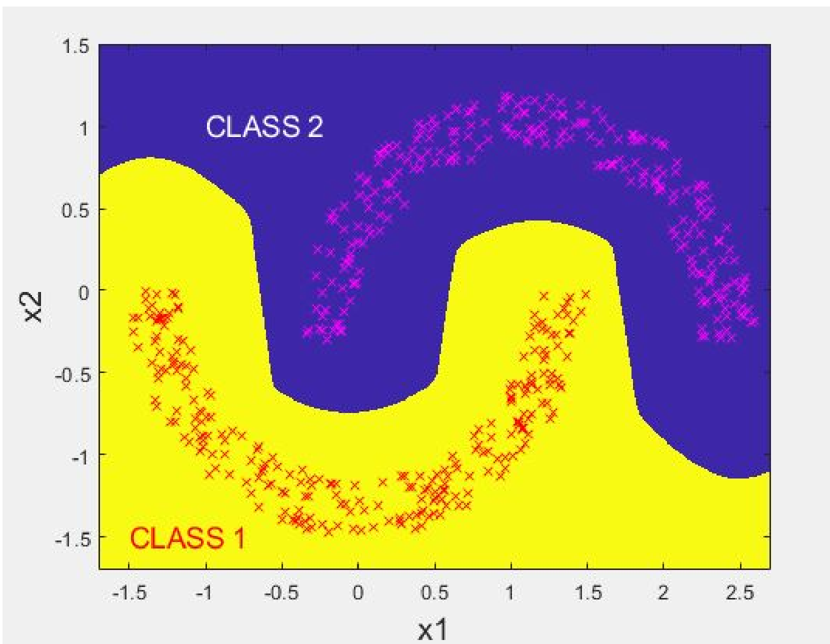

Figure 4.2.1 : Decision region plot for non-linearly separable data

Test Data	Class 1	Class 2
Class 1	100	0
Class 2	0	100

Table 4.2.2:Confusion Matrix for best model on test data

Train Data	Class 1	Class 2
Class 1	250	0
Class 2	0	250

Table 4.2.3:Confusion Matrix for best model on train data

4.3 - Overlapping Data

K1	K2	K3	Train data accuracy	validation data accuracy
3	2	3	99.20%	98.89%
2	2	2	99.20%	98.67%
3	3	2	99.07%	98.89%
2	3	3	98.93%	98.44%

Table 4.3.1 : Accuracies for Overlapping data

Observations : Best case chosen : k1=3 , k2= 2 , k3=3

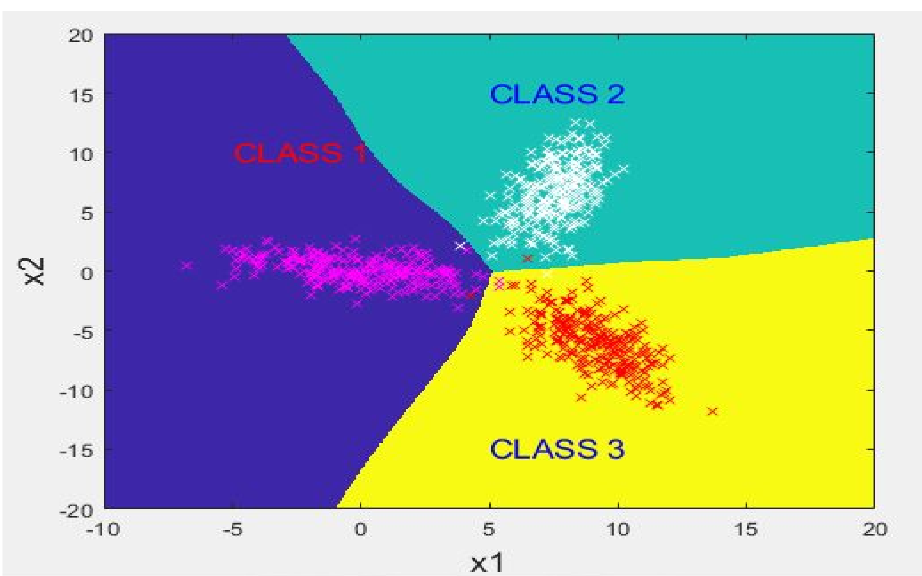

Figure 4.3.1 :Decision region plot for overlapping data

Test Data	Class 1	Class 2	Class 3
Class 1	100	0	0
Class 2	0	100	0
Class 3	0	1	99

Table 4.3.2 : Confusion Matrix of Test data for best case with k1 = 3, k2= 2 , k3=3

Train Data	Class 1	Class 2	Class 3
Class 1	248	0	2
Class 2	1	248	1
Class 3	1	1	248

Table 4.3.3 : Confusion Matrix of train data for best case with k1 = 3, k2= 2 , k3=3

Model 5. Bayes classifier with a GMM for each class

5.1 : Linearly Separable Data

K1	K2	K3	Train data accuracy	validation data accuracy
3	3	3	100%	100%
2	2	3	100%	100%
3	2	2	100%	100%
3	2	3	100%	100%

Table 5.1.1 : Accuracies for linearly separable data

Observations :
Here , since the data is linearly separable , accuracies are equal for all cases .Best case is chosen with k1=3 , k2=2 and k3 = 3 depending upon the data.

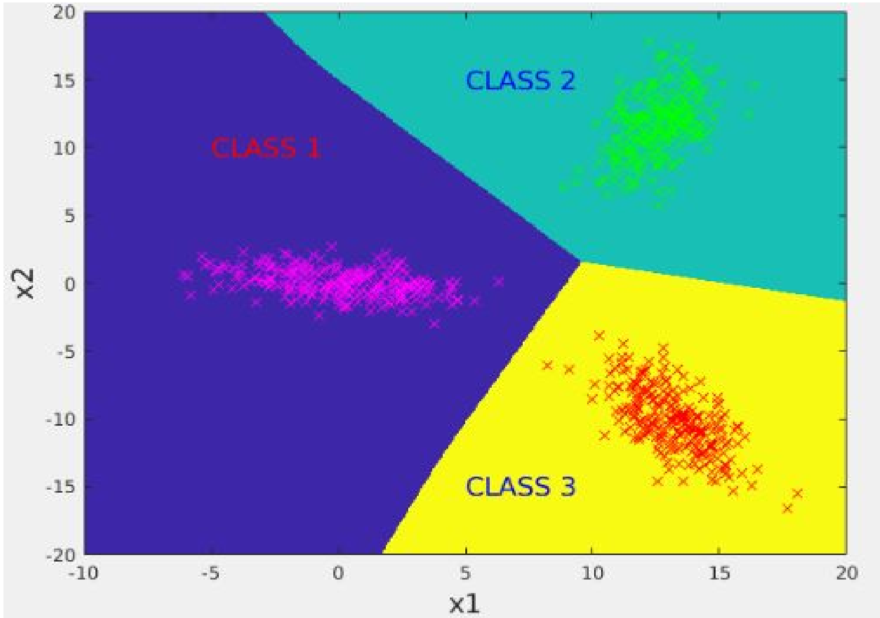

Figure 5.1.1 - :Decision region plot for linearly separable data

Test Data	Class 1	Class 2	Class 3
Class 1	100	0	0
Class 2	0	100	0
Class 3	0	0	100

Table 5.1.2:Confusion Matrix of Test data for best case with k1 = 3, k2= 2, k3 = 3

Train Data	Class 1	Class 2	Class 3
Class 1	250	0	0
Class 2	0	250	0
Class 3	0	0	250

Table 5.1.3 : Confusion Matrix of train data for best case with k1 = 3, k2= 2,k3=3

Model 5.2 : Non linearly Separable Data

K1	K2	Train data accuracy	validation data accuracy
3	3	91.80%	90.33%
3	2	89.00%	92.67%
2	3	94.00%	95%
2	2	97.00%	98.33%

Table 5.2.1 : Accuracies for non - linearly separable data set

Observations : Best case Chosen is with k1 = 2 and k2 =2 . since it gives the highest accuracy. The values of k1 and k2 are smaller because of the dataset.

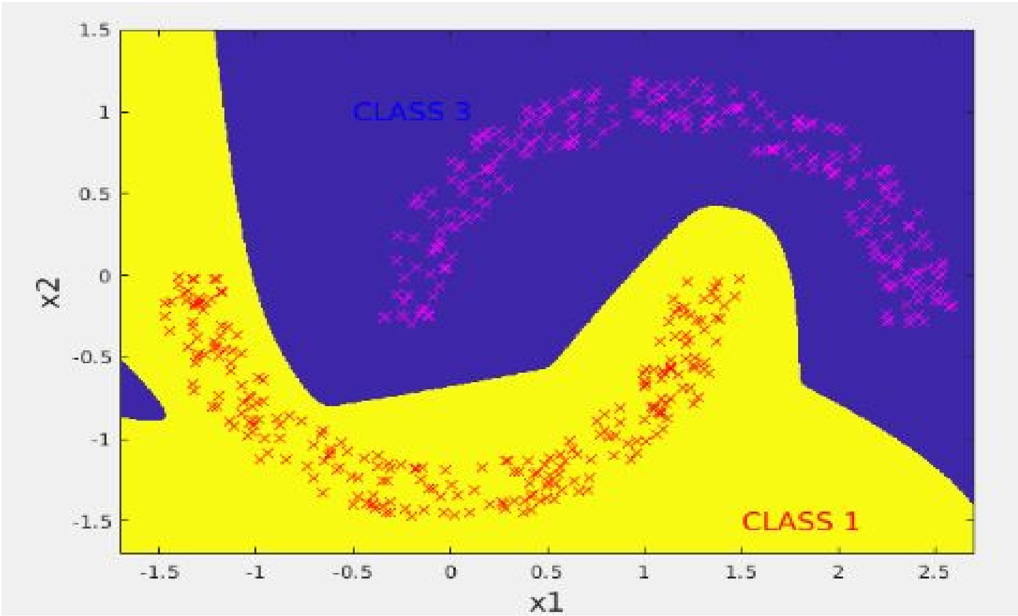

Figure 5.2.1 : Decision region plot for non-linearly separable data

Train Data	**Class 1**	**Class 2**
Class 1	237	13
Class 2	2	248

Table Table 5.2.3 : Confusion Matrix of Test data for best case with k1 = 2 and k2 = 2

Test Data	**Class 1**	**Class 2**
Class 1	100	0
Class 2	0	100

Table 5.2.4 : Confusion Matrix of Test data for best case with k1=2 and k2 =2

Model 5.3 : Overlapping Data

K1	**K2**	**K3**	**Train data accuracy**	**validation data accuracy**
2	3	3	97.56%	98.53%
3	3	2	98.00%	98.93%
2	2	2	96.44%	98.53%
3	2	3	97.78% (Best)	99.07%

Table 5.3.1 : Accuracies for Overlapping data

Observations : Best case chosen : k1=3 , k2= 2 , k3=3

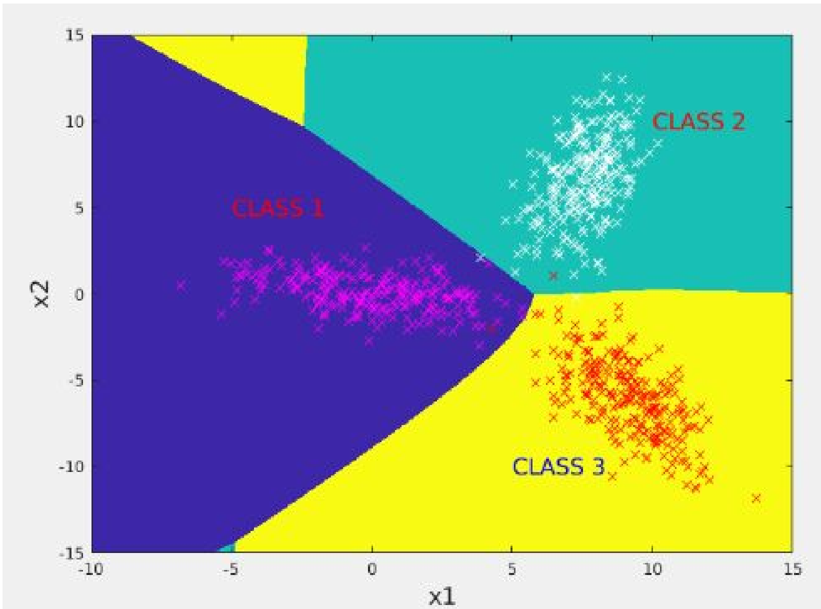

Figure 5.3.1 Decision region plot for overlapping data

Train Data	Class 1	Class 2	Class 3
Class 1	248	0	2
Class 2	1	248	1
Class 3	0	2	248

Table 5.3.2 : Confusion Matrix of Train data for best case with k1 = 2, k2= 3 , k3=3

Test Data	Class 1	Class 2	Class 3
Class 1	100	0	0
Class 2	0	100	0
Class 3	0	0	100

Table 5.3.3 : Confusion Matrix of Test data for best case with k1 = 2, k2= 3 , k3=3

Model 6. Bayes classifier with K-nearest neighbours method for estimation of class-conditional probability density function

6.1-Linearly Separable Data

K(number of nearest neighbors)	Train data accuracy	validation data accuracy
4	100%	100%
6	100%	100%
10	**100%**	**100%**
12	100%	100%

Table 6.1.1 : Accuracies for linearly separable data set

Observation - We see that all accuracies are 100% as the data is linearly separable and the best case is chosen as K = 10

Test Data	**Class 1**	**Class 2**	**Class 3**
Class 1	100	0	0
Class 2	0	100	0
Class 3	0	0	100

Table 6.1.2:Confusion Matrix for best model on test data for k=27

Train Data	**Class 1**	**Class 2**	**Class 3**
Class 1	250	0	0
Class 2	0	250	0
Class 3	0	0	250

Table 6.1.3:Confusion Matrix for best model on training data for k=27

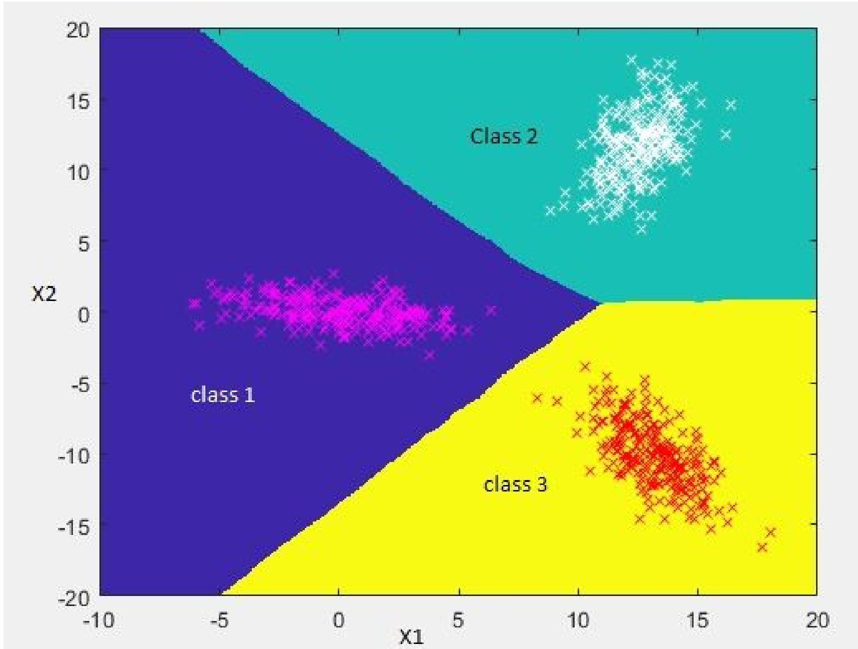

Figure 6.1.1 **-** *Decision region plot on linearly separable data using Bayes classifier with K-nearest neighbours method for estimation of class-conditional probability density function*

6.2-Non- linearly separable data

K(number of nearest neighbors)	Train data accuracy	validation data accuracy
3	100%	100%
5	100%	100%
8	100%	100%
10	100%	100%
12	**100%**	**100%**

Table 6.2.1 : Accuracies for non - linearly separable data set

Observations : We see that all accuracies are 100% , we choose the best case as K = 12.

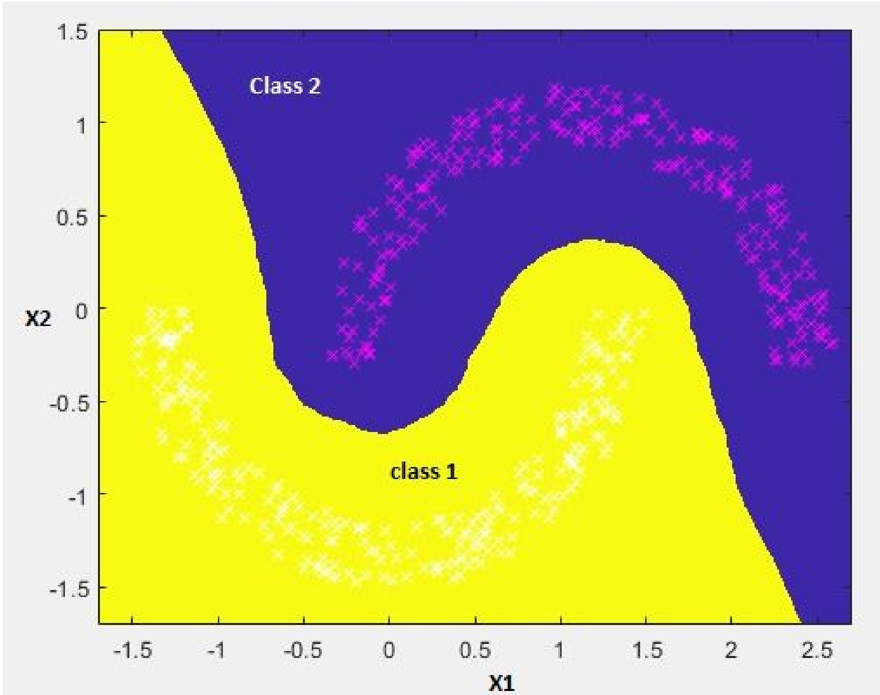

Figure 6.2.1 - Decision region plot on non-linearly separable data using Bayes classifier with K-nearest neighbours method for estimation of class-conditional probability density function

Test Data	Class 1	Class 2
Class 1	100	0
Class 2	0	100

Table 6.2.2:Confusion Matrix for best model on test data

Train Data	Class 1	Class 2
Class 1	250	0
Class 2	0	250

Table 6.2.3:Confusion Matrix for best model on training data

6.3-Overlapping data

K(number of nearest neighbors)	Train data accuracy	validation data accuracy
5 and 6	99.33%	98.89%
7	99.47%	98.09%
12	99.47%	98.67%
15	**99.33%**	**98.67%**

Table 6.2.1 : Accuracies for overlapping dataset

Observations : The best case is chosen as K = 15

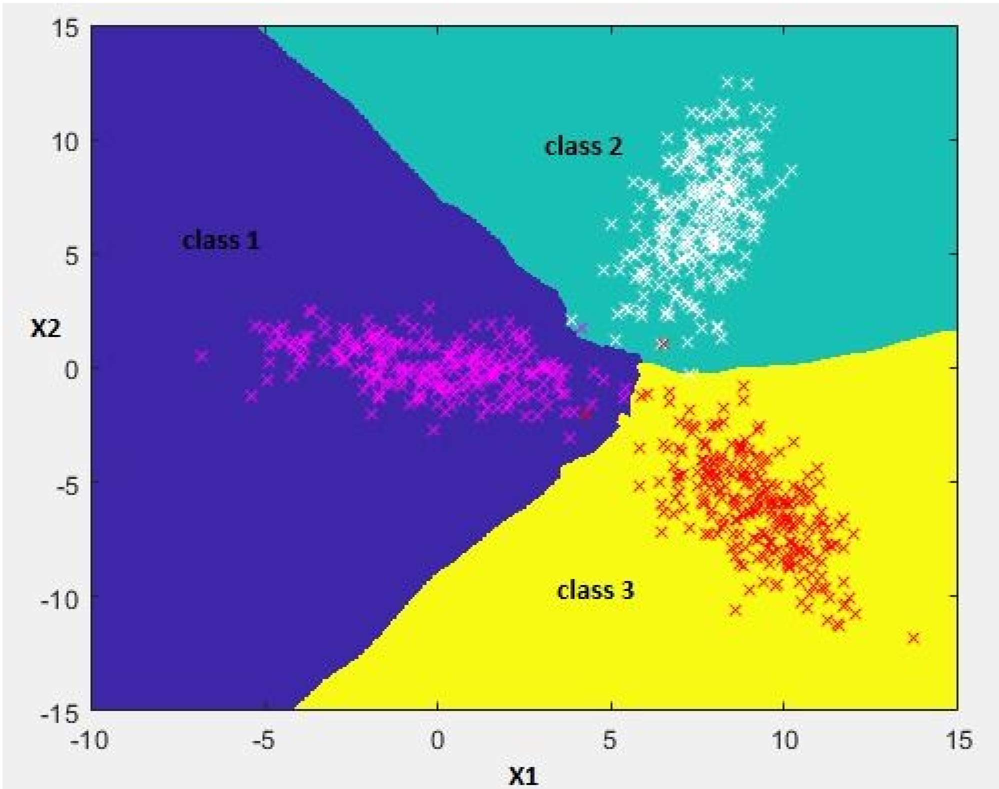

Figure 6.2.1 - Decision region plot on overlapping data using Bayes classifier with K-nearest neighbours method for estimation of class-conditional probability density function

Test Data	**Class 1**	**Class 2**	**Class 3**
Class 1	100	0	0
Class 2	0	100	0
Class 3	1	1	98

Table 6.2.2:Confusion Matrix for best model on test data for k=27

Train Data	**Class 1**	**Class 2**	**Class 3**
Class 1	250	0	0
Class 2	2	247	1
Class 3	1	1	248

Table 6.2.3:Confusion Matrix for best model on training data for k=27

<u>For Dataset 2</u>

Model 1.1 - Naive-Bayes classifier with a GMM for each class

Data set for static pattern classification

- **Method:** The naive Bayes classifier is an approximation to the Bayes classifier, in which we assume that the features are independent given the class.
- **Classes in Dataset: 2**
- **Hyperparameter, K1 and K2 are number of components(clusters) of class1 and class2 respectively.**
- Used Expectation Maximization (EM) method for GMM.

1. Table of classification accuracies of model on training data and validation data for different values of hyperparameter

Training Data Size = 489, 10 features		
K1	**K2**	**Accuracy(%)**
1	1	95.0920
2	2	95.9100
3	2	95.7055
4	2	94.2740
5	4	96.1145

Table 1.1.1 : Accuracies of model on training data

validation Data Size = 69, 10 features		
K1	**K2**	**Accuracy(%)**
1	1	94.2029
2	2	95.6522
3	2	97.1014
4	**2**	**98.5514**
5	4	95.6522

Table 1.1.2 : Accuracies of model on validation data

2. Classification accuracy of the best configuration of the model on test data

- From table of Accuracies of model on validation data, k1=4 and k2=2 gives the highest accuracy and as we increase the value of k1 and k2 accuracy decreases. So k1=4 and k2=2 for best configuration of the model.

Test Data Size = 141, 10 features		
K1	**K2**	**Accuracy(%)**
4	2	100

Table 1.1.3 : Accuracy of best model on test data

3. Confusion matrix for the best for configuration of model, on training data and test data

	Class 1	**Class 2**
Class 1	106	0
Class 2	0	35

Table 1.1.4 : Confusion matrix for best model on training data

	Class 1	**Class 2**
Class 1	290	5
Class 2	23	171

Table 1.1.5 : Confusion matrix for best model on test data

(b) Image data set for varying length pattern classification

- Dataset classes: gorilla, horse, penguin, t shirt, airplanes.

1. Table of classification accuracies of model on training data and validation data for different values of hyperparameter

Training Data Size = 1247 image files, 64 features					
K1	**K2**	**K3**	**K4**	**K5**	**Accuracy(%)**
2	2	2	2	2	36.9687
3	3	3	3	3	40.4170

Table 1.2.1: Accuracies of model on training data

Validation Data Size = 176 image files, 64 features					
K1	**K2**	**K3**	**K4**	**K5**	**Accuracy(%)**
2	2	2	2	2	92.6136
3	3	3	3	3	52.2727

Table 1.2.2: Accuracies of model on validation data

2. Classification accuracy of the best configuration of the model on test data

Test Data Size = 361 image files, 64 features					
K1	**K2**	**K3**	**K4**	**K5**	**Accuracy(%)**
2	2	2	2	2	44.8753

Table 1.2.3: Accuracy of best model on test data

3. Confusion matrix for the best for configuration of model, on training data and test data

	Class 1	**Class 2**	**Class 3**	**Class 4**	**Class 5**
Class 1	115	20	0	7	5
Class 2	152	18	2	6	10
Class 3	76	7	0	6	15
Class 4	135	4	1	37	71
Class 5	129	5	1	42	291

Table 1.2.4: Confusion matrix for best model on training data

	Class 1	Class 2	Class 3	Class 4	Class 5
Class 1	36	0	1	1	5
Class 2	48	1	0	1	5
Class 3	23	0	0	1	7
Class 4	31	4	0	17	20
Class 5	36	1	0	15	108

Table 1.2.5: Confusion matrix for best model on testing data

2. Bayes classifier with a GMM for each class

(a) Data set for static pattern classification

1. Table of classification accuracies of model on training data and validation data for different values of hyperparameter

Training Data Size = 489, 10 features		
K1	**K2**	**Accuracy(%)**
1	1	95.0920
2	2	96.3190
3	2	97.7505
4	3	98.1595
5	4	98.7730

Table 2.1.1 : Accuracies of model on training data

validation Data Size = 69, 10 features		
K1	**K2**	**Accuracy(%)**
1	1	94.2029
2	2	94.6322
3	2	94.2029
4	**3**	**95.6522**
5	4	94.2522

Table 2.1.2: Accuracies of model on validation data

2. Classification accuracy of the best configuration of the model on test data

Test Data Size = 141, 10 features		
K1	**K2**	**Accuracy(%)**
4	3	100

Table 2.1.3: Accuracy of best model on test data

3. Confusion matrix for the best for configuration of model, on training data and test data

Train Data	Class 1	Class 2
Class 1	294	1
Class 2	8	186

Table : Confusion matrix for best model on training data

Test Data	Class 1	Class 2
Class 1	106	0
Class 2	0	35

Table 2.1.4: Confusion matrix for best model on testing data

(b) Image data set for varying length pattern classification

1. Table of classification accuracies of model on training data and validation data for different values of hyperparameter

Training Data Size = 1247 image files, 64 features					
K1	**K2**	**K3**	**K4**	**K5**	**Accuracy(%)**
3	3	3	3	3	41.1387

Table 2.2.1: Accuracies of model on training data

Validation Data Size = 176 image files, 64 features					
K1	**K2**	**K3**	**K4**	**K5**	**Accuracy(%)**
3	3	3	3	3	35.2273

Table 2.2.2: Accuracies of model on validation data

2. Classification accuracy of the best configuration of the model on test data

Test Data Size = 361 image files, 64 features					
K1	**K2**	**K3**	**K4**	**K5**	**Accuracy(%)**
3	3	3	3	3	32.9640

Table 2.2.3: Accuracy of best model on test data

3. Confusion matrix for the best for configuration of model, on training data and test data

Train Data	Class 1	Class 2	Class 3	Class 4	Class 5
Class 1	117	2	0	6	22
Class 2	62	2	0	21	103
Class 3	68	1	0	4	31
Class 4	137	0	1	64	46
Class 5	227	3	1	10	319

Table 2.2.4: Confusion matrix for best model on training data

Test Data	Class 1	Class 2	Class 3	Class 4	Class 5
Class 1	32	2	1	2	6
Class 2	41	4	0	2	7
Class 3	26	0	0	1	4
Class 4	28	4	0	21	19
Class 5	56	7	3	32	62

Table 2.2.5: Confusion matrix for best model on testing data

3. Bayes classifier with K-nearest neighbours method for estimation of class-conditional probability density function

(a) Data set for static pattern classification

1. Table of classification accuracies of model on training data and validation data for different values of hyperparameter

K	Training data	Validation data
7	67.2802	66.6667
11	65.8487	73.9130
18	65.2352	75.3623
24	64.8262	**81.1591**
30	64.2127	79.7101

Table 3.1.1: Accuracies (in %) of model with Training data size = 489 and validation data size = 69 , both with 10 features.

2. Classification accuracy of the best configuration of the model on test data

Test Data Size = 69, 10 features	
K	**Accuracy(%)**
24	73.7589

Table 3.1.2: Accuracy of best model on test data

3. Confusion matrix for the best for configuration of model, on training data and test data

Train Data	Class 1	Class 2
Class 1	271	24
Class 2	148	46

Table 3.1.3: Confusion matrix for best model on training data

Test Data	Class 1	Class 2
Class 1	101	5
Class 2	32	3

Table 3.1.4: Confusion matrix for best model on testing data

- **Observation:** For K<=7, Accuracy of model on validation data of both class1 and class2 is less. As we increase value of K starting from 8, Accuracy of model on validation data of both class1 is increases. Accuracy of model on validation data of both class2 is very less(from table).

(b) Image data set for varying length pattern classification

1. Table of classification accuracies of model on training data and validation data for different values of hyperparameter

Training Data Size = 1247 image files, 64 features		**Validation Data Size = 176 image files, 64 features**	
K	**Accuracy(%)**	**K**	**Accuracy(%)**
7	49.9700	7	47.3570

Table 3.2.1: Accuracies of model on *Table 3.2.2: Accuracies of model on*
validation training data *data*

2. Classification accuracy of the best configuration of the model on test data

Test Data Size = 361 image files, 64 features	
K1	**Accuracy(%)**
7	52.6871

Table 3.2.3 : Accuracy of best model on test data

3. Confusion matrix for the best for configuration of model, on training data and test data

	Class 1	Class 2	Class 3	Class 4	Class 5
Class 1	104	5	4	10	24
Class 2	49	42	7	16	88
Class 3	60	2	18	4	20
Class 4	137	1	1	63	46
Class 5	133	7	5	17	396

Table 3.2.4: Confusion matrix for best model on training data

	Class 1	Class 2	Class 3	Class 4	Class 5
Class 1	30	2	3	2	6
Class 2	22	20	0	2	7
Class 3	13	0	14	1	3
Class 4	16	3	0	42	11
Class 5	47	7	3	26	77

Table 3.2.5: Confusion matrix for best model on testing data