



CS 669: Pattern Recognition

Assignment 1 – Bayes Classifier Odd Semester 2017

Submitted by –

Group 2

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Dataset 1 (2 Dimensional artificial data of 3 classes)

a) Linearly Separable dataset

Mean Vector for each case -

- Class 1 - $[19.783 \quad -5.867]^T$
- Class 2 - $[8.932 \quad 9.968]^T$
- Class 3 - $[-2.887 \quad -4.941]^T$

Case 1: $\Sigma = \sigma^2 I$ (same for all classes)

Classification Accuracy (Class 1) – 1.0

Classification Accuracy (Class 2) – 1.0

Classification Accuracy (Class 3) – 1.0

Mean Classification Accuracy – 1.0

Precision (Class 1) – 1.0

Precision (Class 2) – 1.0

Precision (Class 3) – 1.0

Mean Precision – 1.0

Recall (Class 1) – 1.0

Recall (Class 2) – 1.0

Recall (Class 3) – 1.0

Mean Recall – 1.0

F-Measure (Class 1) – 1.0

F-Measure (Class 2) – 1.0

F-Measure (Class 3) – 1.0

Mean F-Measure – 1.0

Mean Covariance Matrix -

5.640	0
0	5.640

Confusion Matrices -

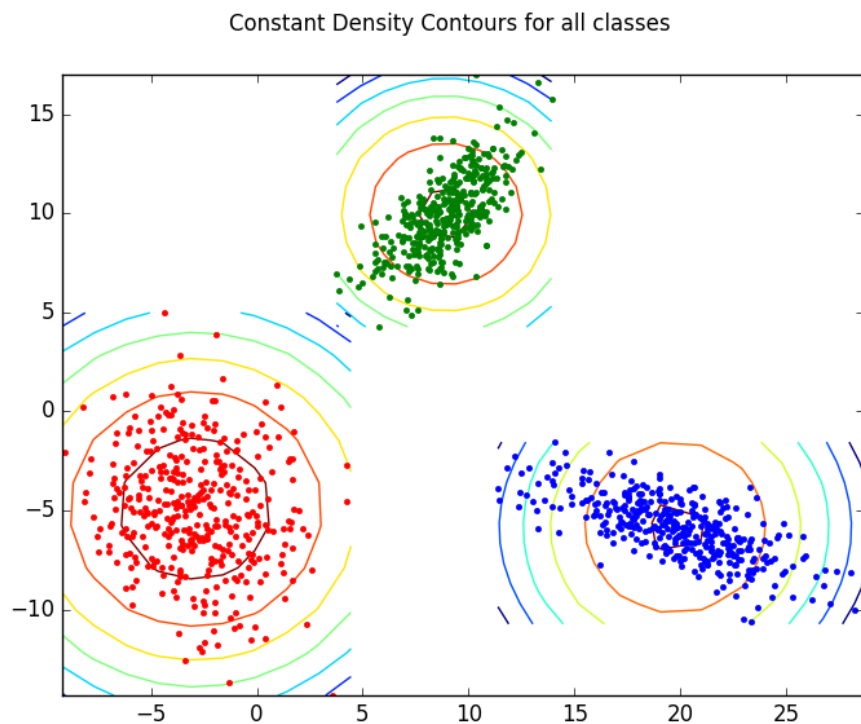
- Class 1, 2 and 3 (same for all the classes in this case)

125	0
0	250

- All classes together

125	0	0
0	125	0
0	0	125

Constant density contour plot for all the classes -

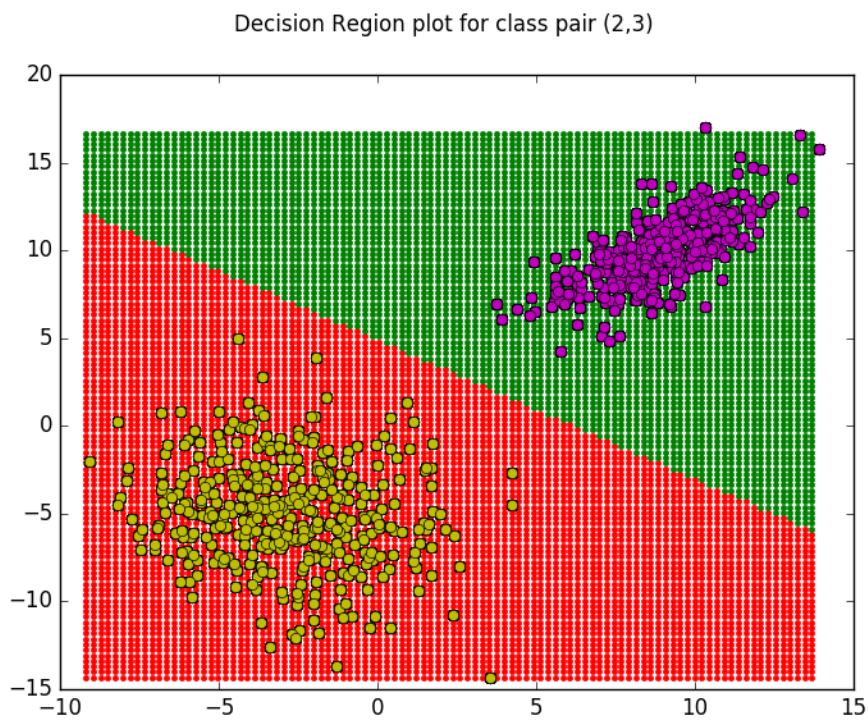


Pairwise Decision region plots -

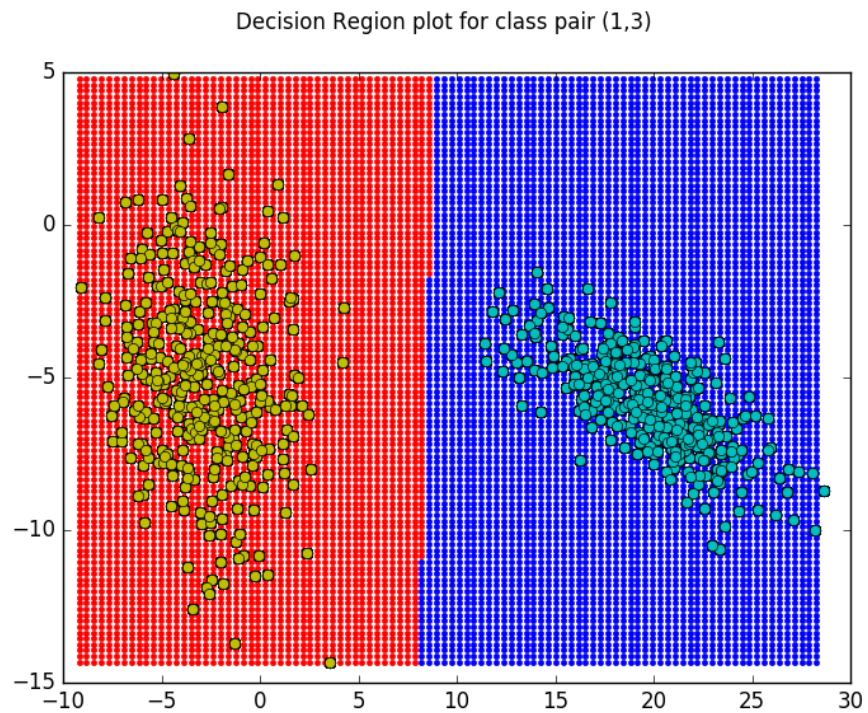
- Class 1 and 2



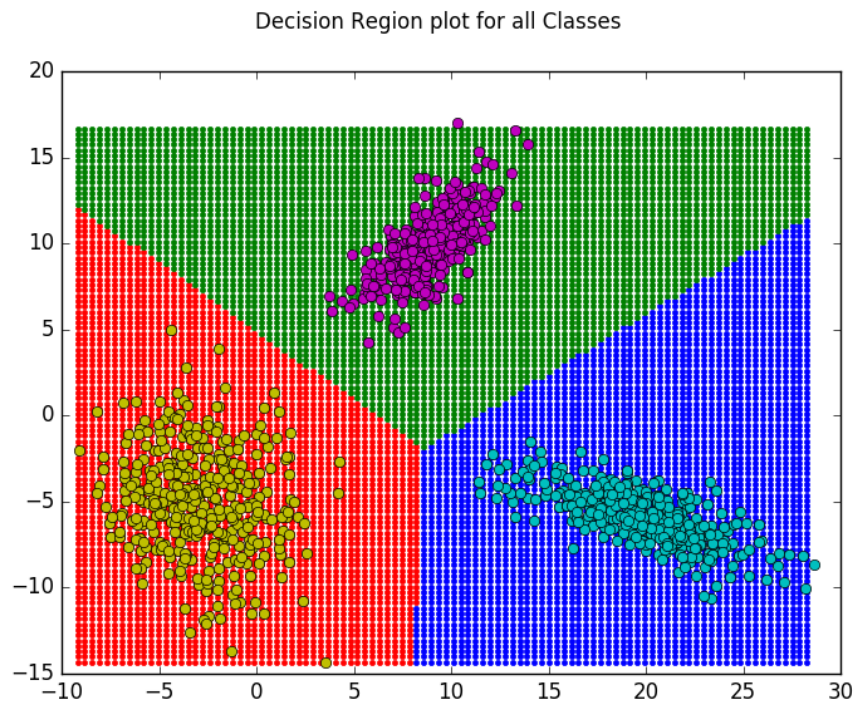
- Class 2 and 3



- Class 1 and 3



Decision region plot for all the classes -



Case 2: Full covariace matrix(Σ) is same for all the classes

Classification Accuracy (Class 1) – 1.0

Classification Accuracy (Class 2) – 1.0

Classification Accuracy (Class 3) – 1.0

Mean Classification Accuracy – 1.0

Precision (Class 1) – 1.0

Precision (Class 2) – 1.0

Precision (Class 3) – 1.0

Mean Precision – 1.0

Recall (Class 1) – 1.0

Recall (Class 2) – 1.0

Recall (Class 3) – 1.0

Mean Recall – 1.0

F-Measure (Class 1) – 1.0

F-Measure (Class 2) – 1.0

F-Measure (Class 3) – 1.0

Mean F-Measure – 1.0

Mean Covariance Matrix -

6.179	-0.784
-0.784	5.102

Confusion Matrices -

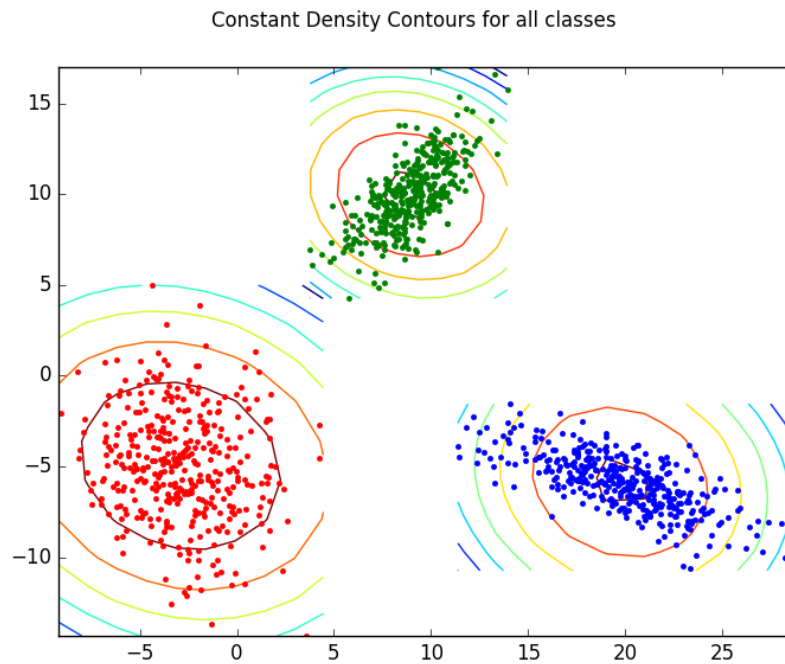
- **Class 1, 2 and 3 (same for all the classes in this case)**

125	0
0	250

- **All classes together**

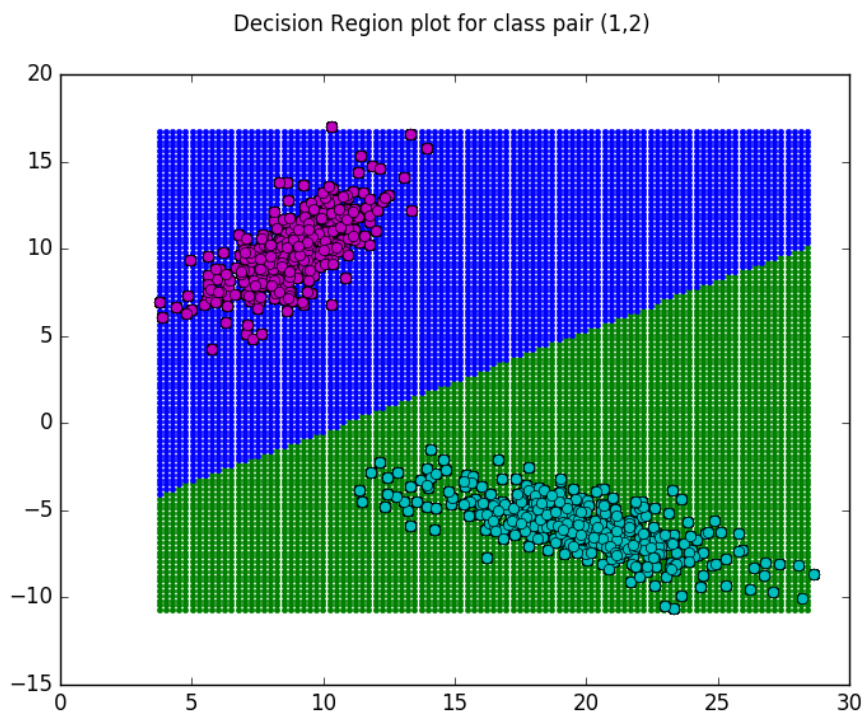
125	0	0
0	125	0
0	0	125

Constant density contour plot for all the classes -

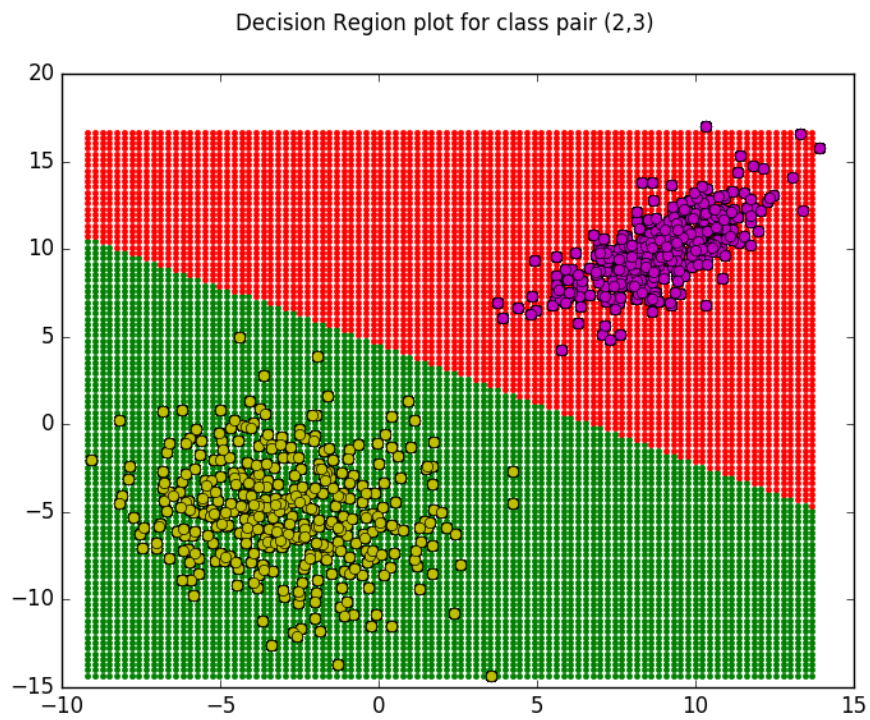


Pairwise Decision region plots -

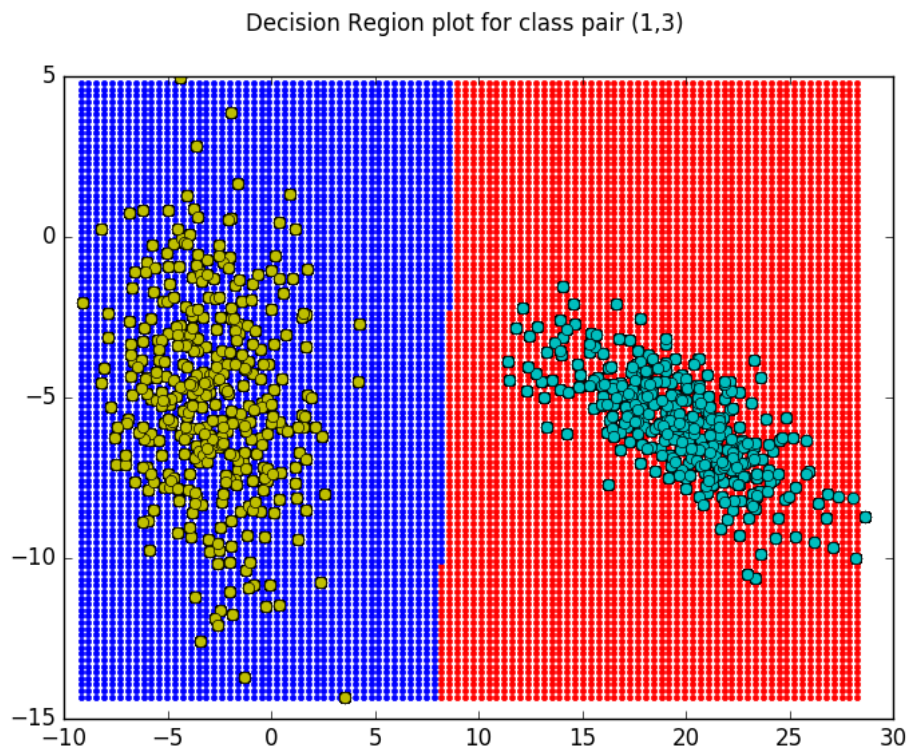
- Class 1 and 2



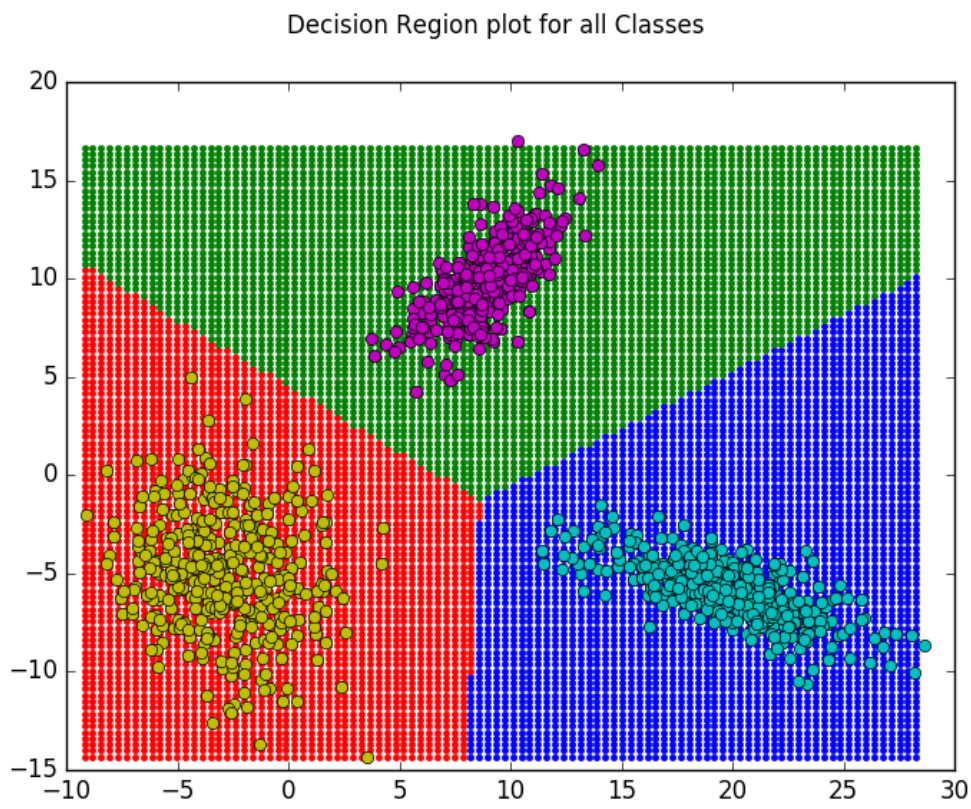
- Class 2 and 3



- Class 1 and 3



Decision region plot for all the classes -



Case 3: Diagonal Covariance matrix (different for all classes)

Classification Accuracy (Class 1) – 1.0

Classification Accuracy (Class 2) – 1.0

Classification Accuracy (Class 3) – 1.0

Mean Classification Accuracy – 1.0

Precision (Class 1) – 1.0

Precision (Class 2) – 1.0

Precision (Class 3) – 1.0

Mean Precision – 1.0

Recall (Class 1) – 1.0

Recall (Class 2) – 1.0

Recall (Class 3) – 1.0

Mean Recall – 1.0

F-Measure (Class 1) – 1.0

F-Measure (Class 2) – 1.0

F-Measure (Class 3) – 1.0

Mean F-Measure – 1.0

Covariance Matrix for each class -

- **Class 1**

9.898	0
0	2.409

- **Class 2**

2.800	0
0	3.818

- **Class 3**

5.838	0
0	9.078

Confusion Matrices -

- Class 1, 2 and 3 (same for all the classes in this case)

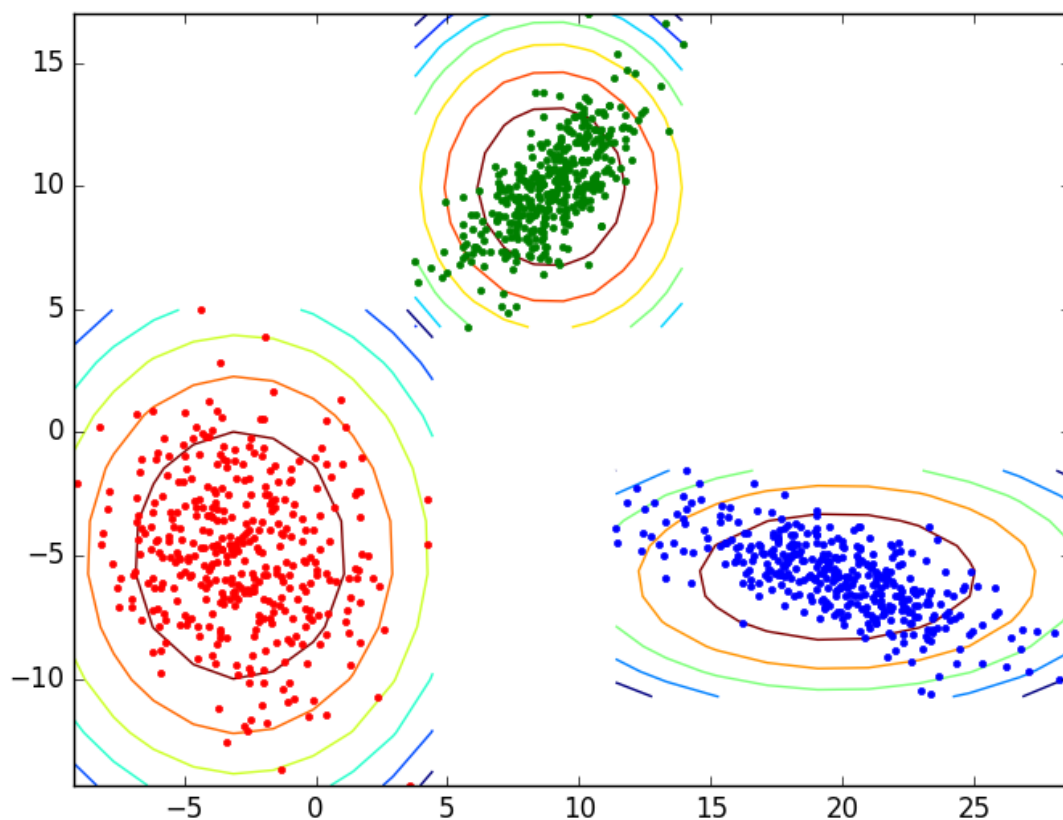
125	0
0	250

- All classes together

125	0	0
0	125	0
0	0	125

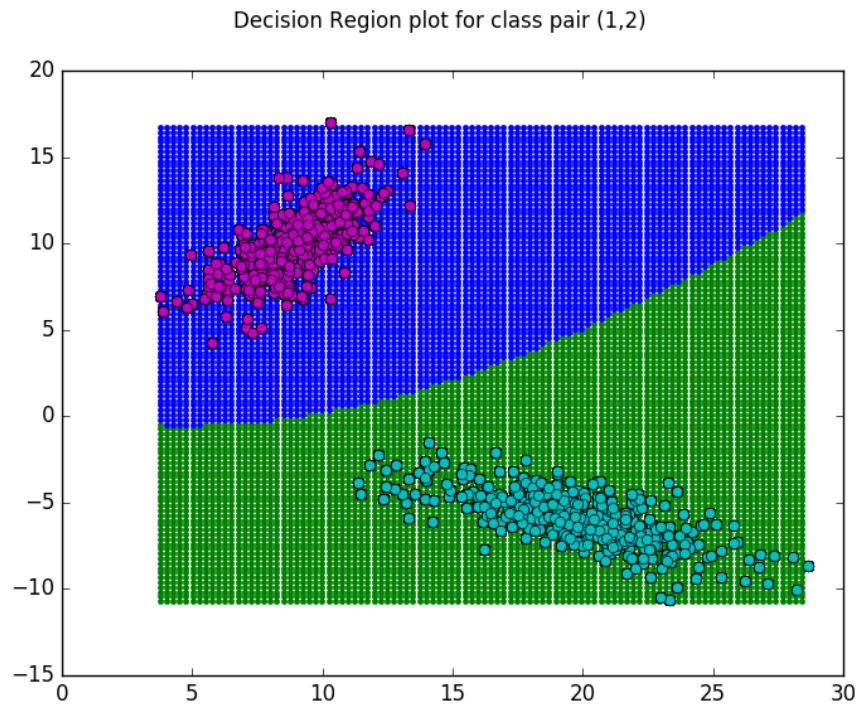
Constant density contour plot for all the classes -

Constant Density Contours for all classes

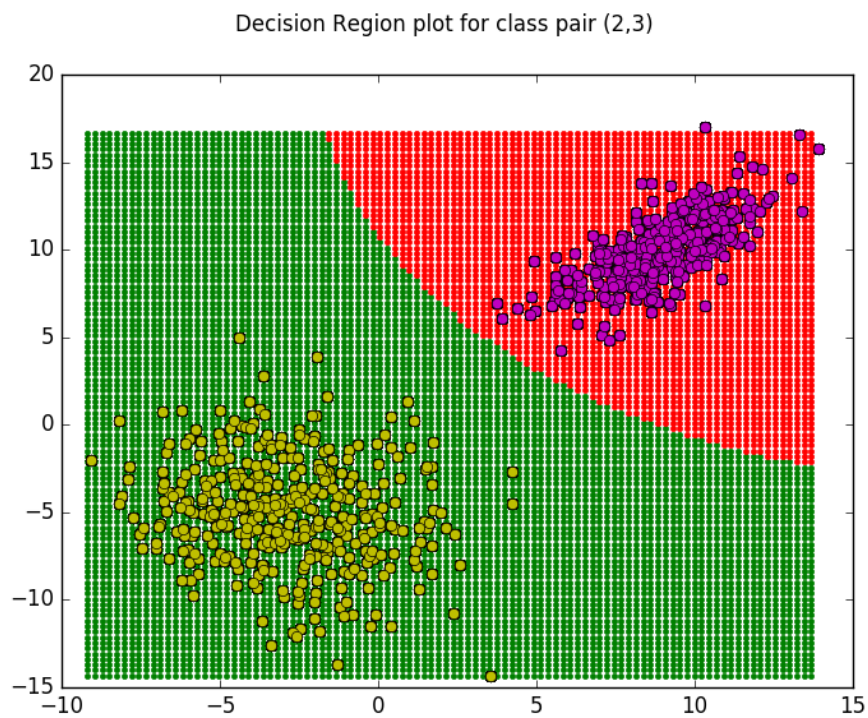


Pairwise Decision region plots -

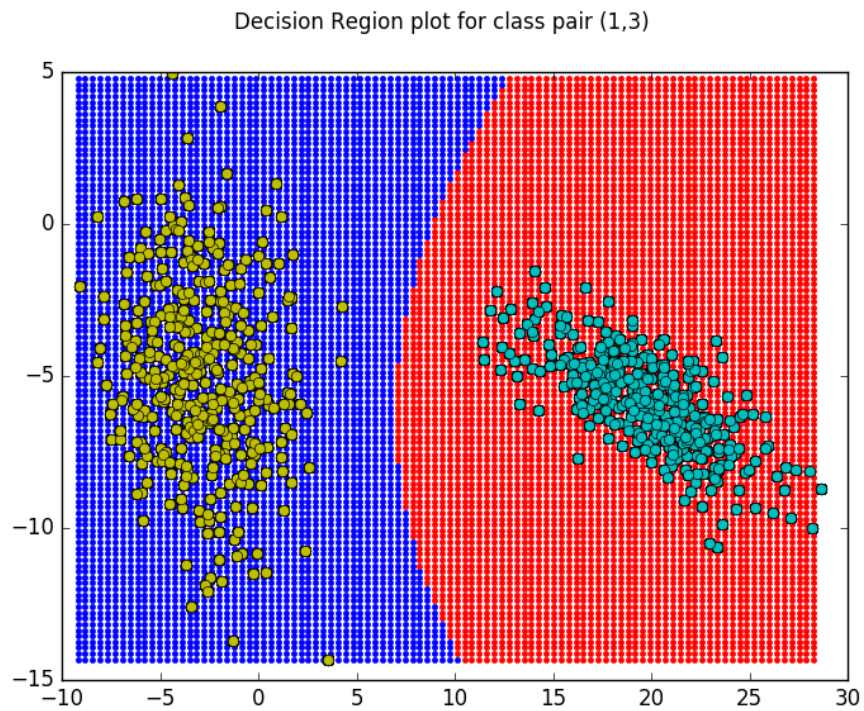
- Class 1 and 2



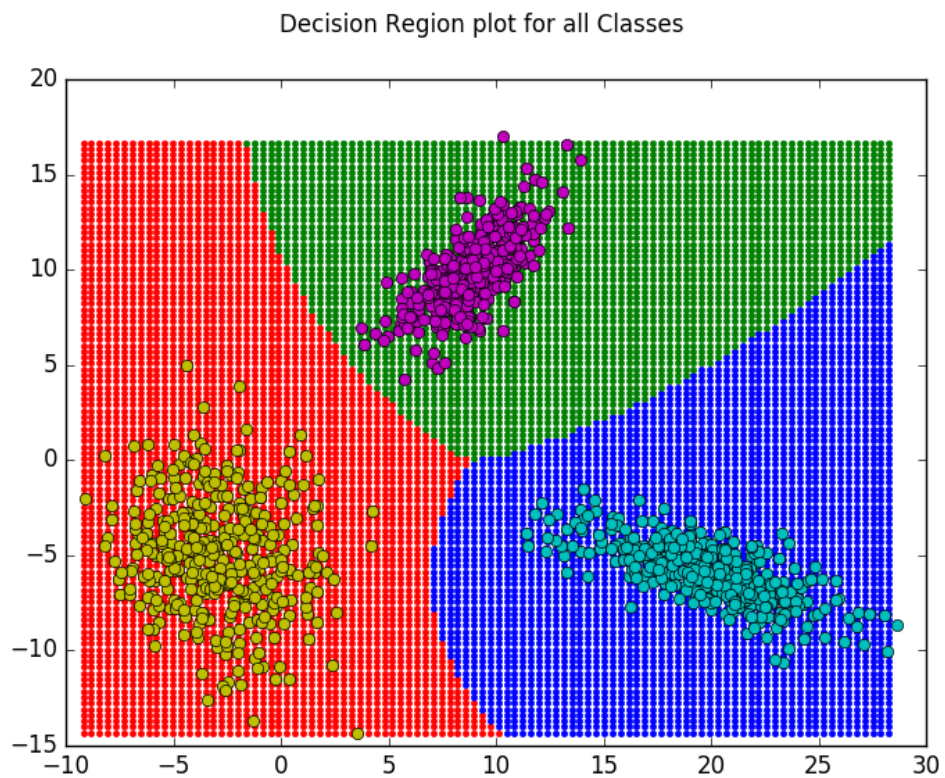
- Class 2 and 3



- Class 1 and 3



Decision region plot for all the classes -



Case 4: Different full covariance matrix for each class

Classification Accuracy (Class 1) – 1.0

Classification Accuracy (Class 2) – 1.0

Classification Accuracy (Class 3) – 1.0

Mean Classification Accuracy – 1.0

Precision (Class 1) – 1.0

Precision (Class 2) – 1.0

Precision (Class 3) – 1.0

Mean Precision – 1.0

Recall (Class 1) – 1.0

Recall (Class 2) – 1.0

Recall (Class 3) – 1.0

Mean Recall – 1.0

F-Measure (Class 1) – 1.0

F-Measure (Class 2) – 1.0

F-Measure (Class 3) – 1.0

Mean F-Measure – 1.0

Covariance Matrix for each class -

- **Class 1**

9.898	-3.443
-3.443	2.409

- **Class 2**

2.800	2.234
2.234	3.818

- **Class 3**

5.838	-1.143
-1.143	9.078

Confusion Matrices -

- Class 1, 2 and 3 (same for all the classes in this case)

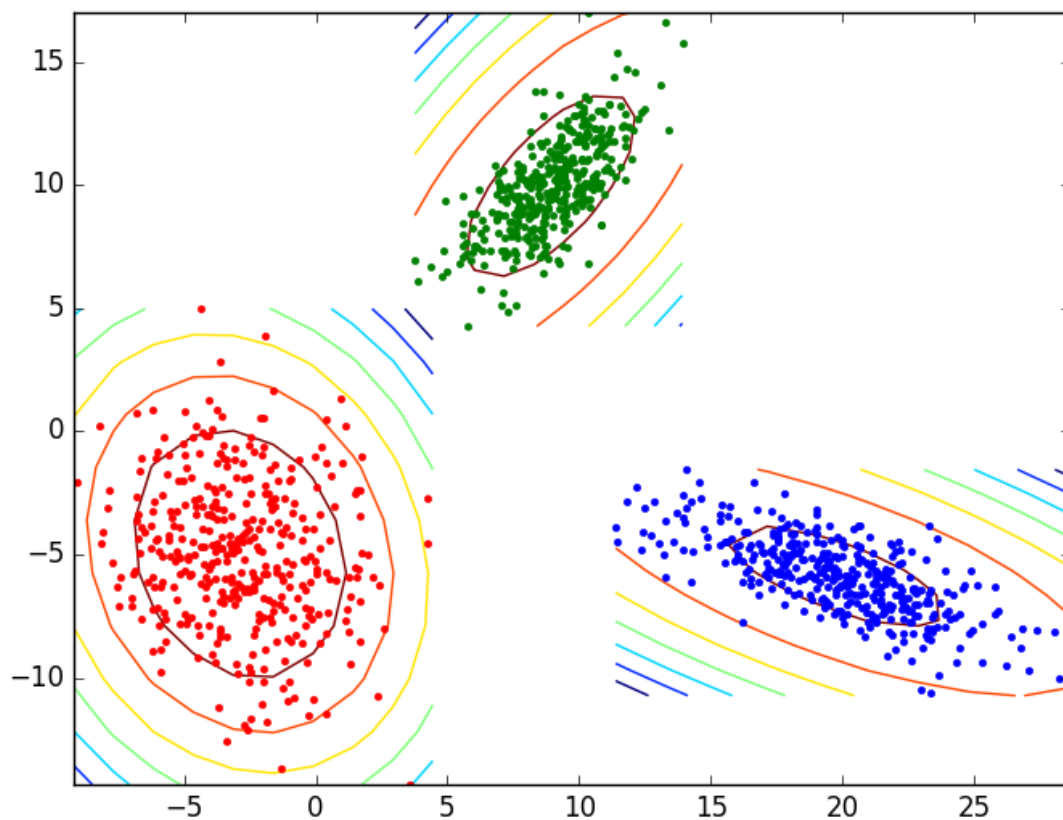
125	0
0	250

- All classes together

125	0	0
0	125	0
0	0	125

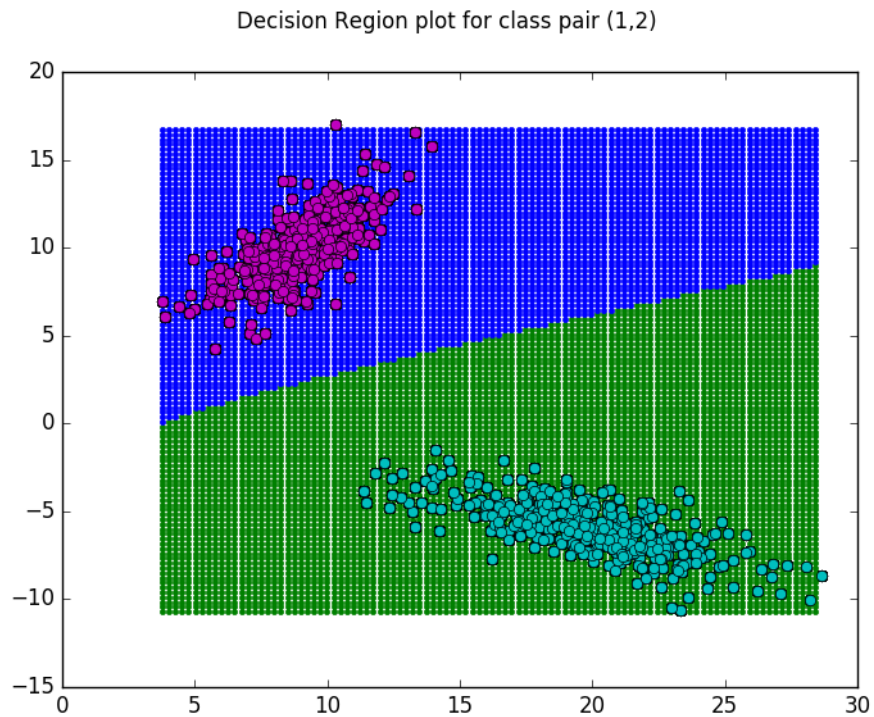
Constant density contour plot for all the classes -

Constant Density Contours for all classes

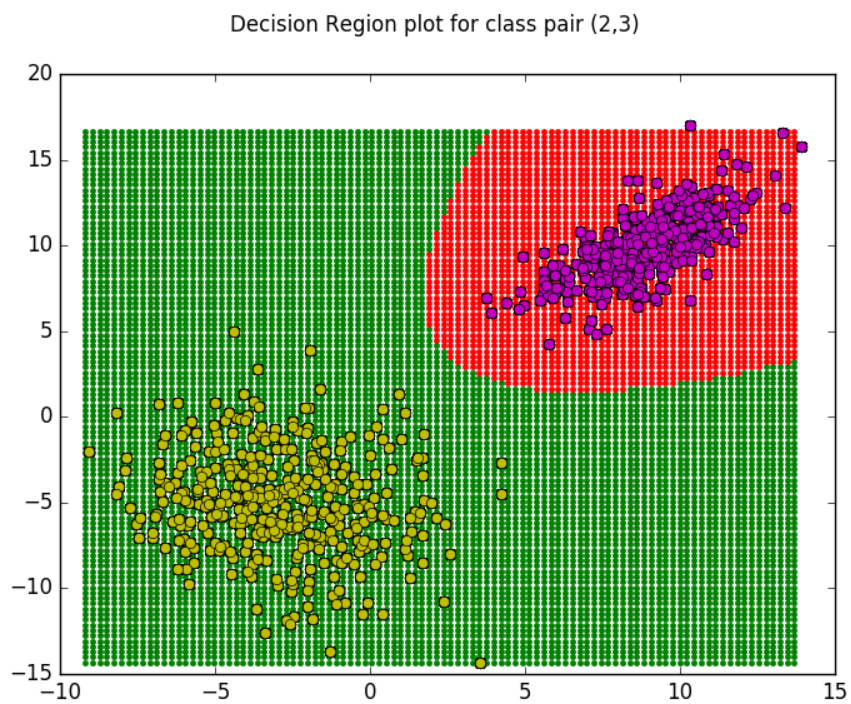


Pairwise Decision region plots -

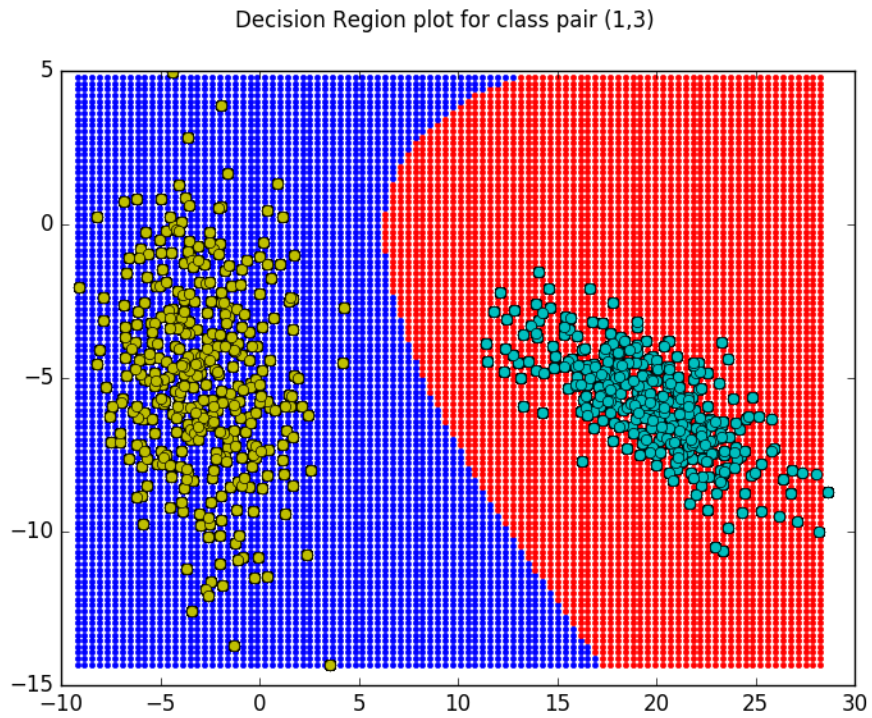
- Class 1 and 2



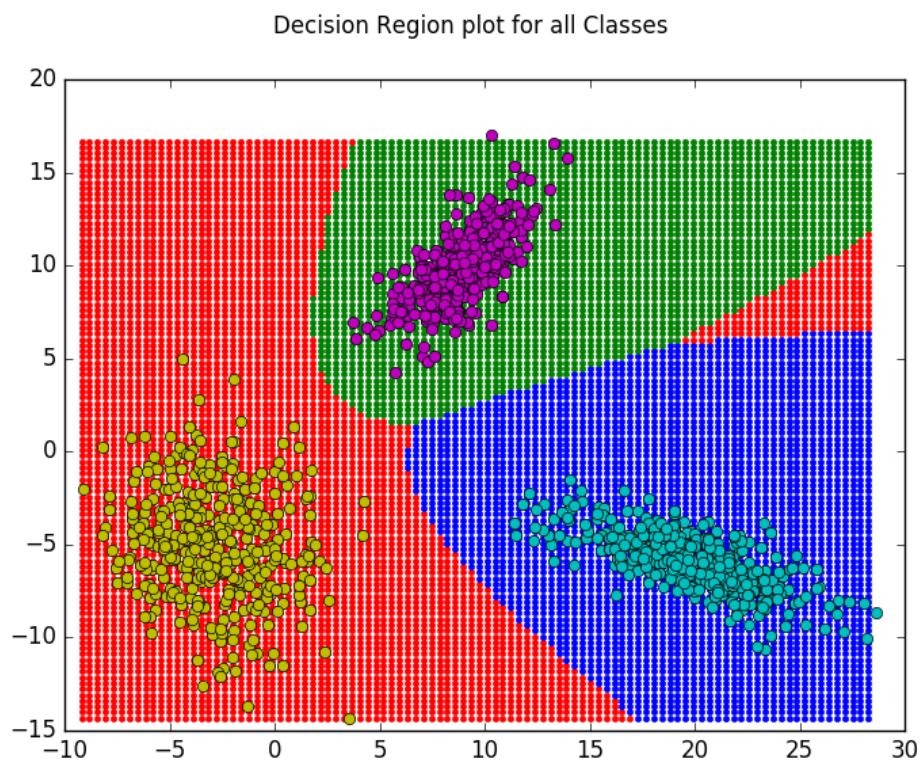
- Class 2 and 3



- Class 1 and 3



Decision region plot for all the classes -



b) Non-Linearly Separable dataset

Mean Vector for each case -

- Class 1 - $[1.551 \quad 0.712]^T$
- Class 2 - $[-0.448 \quad -0.848]^T$
- Class 3 - $[3.052 \quad -0.848]^T$

Case 1: $\Sigma = \sigma^2 I$ (same for all classes)

Classification Accuracy (Class 1) – 0.797

Classification Accuracy (Class 2) – 0.920

Classification Accuracy (Class 3) – 0.877

Mean Classification Accuracy – 0.865

Precision (Class 1) – 0.713

Precision (Class 2) – 0.868

Precision (Class 3) – 0.802

Mean Precision – 0.794

Recall (Class 1) – 0.656

Recall (Class 2) – 0.896

Recall (Class 3) – 0.840

Mean Recall – 0.797

F-Measure (Class 1) – 0.683

F-Measure (Class 2) – 0.882

F-Measure (Class 3) – 0.820

Mean F-Measure – 0.795

Covariance Matrix for each class -

- **For All Classes**

0.648	0
0	0.648

Confusion Matrices -

- **Class 1**

82	33
43	217

- **Class 2**

112	17
13	233

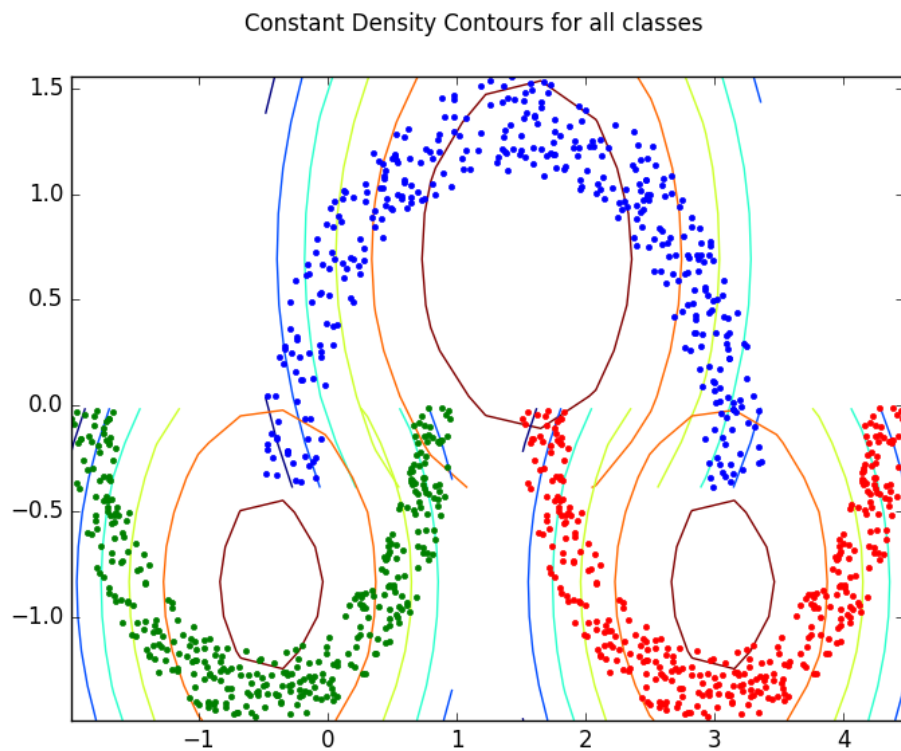
- **Class 3**

105	26
20	224

- **All classes together**

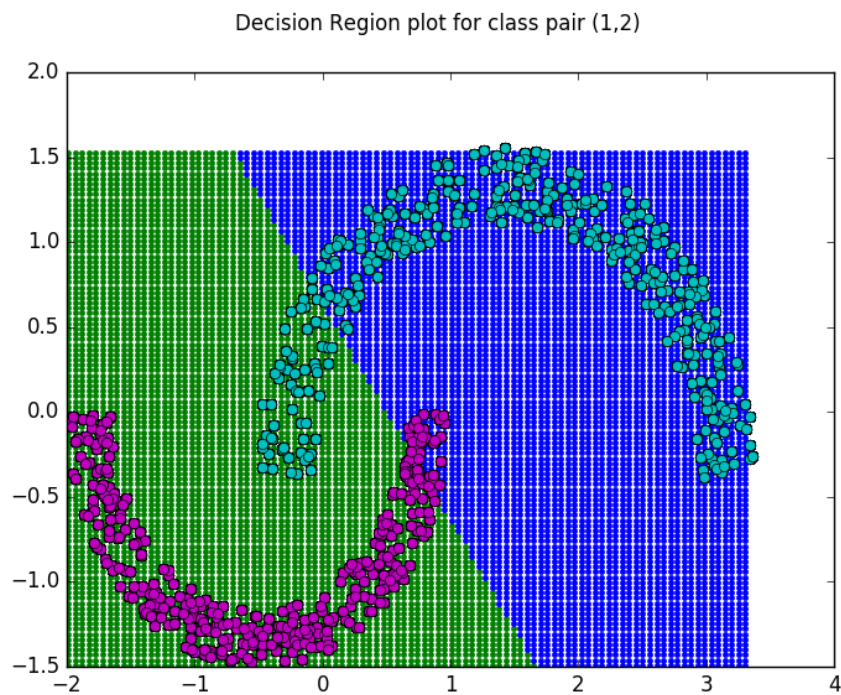
82	13	20
17	112	0
26	0	105

Constant density contour plot for all the classes -

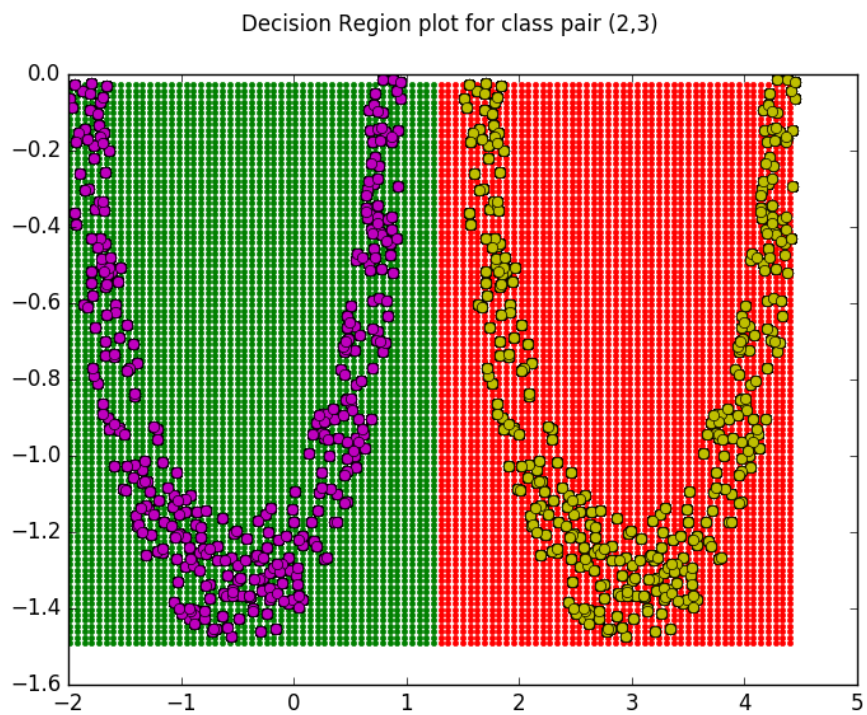


Pairwise Decision region plots -

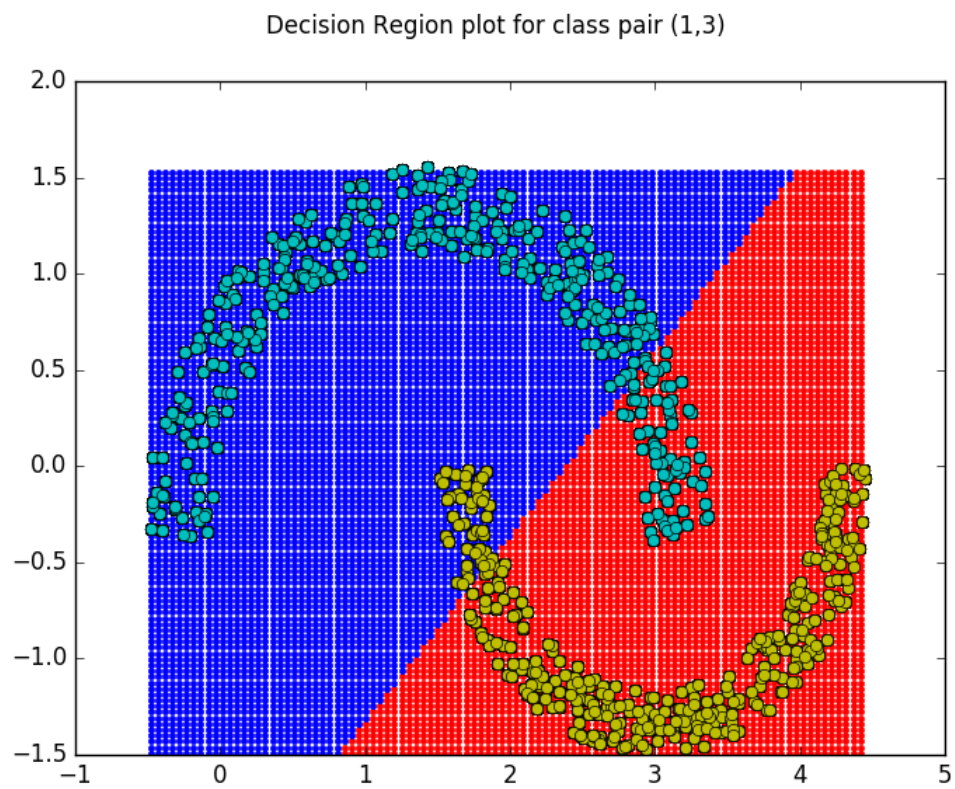
- Class 1 and 2



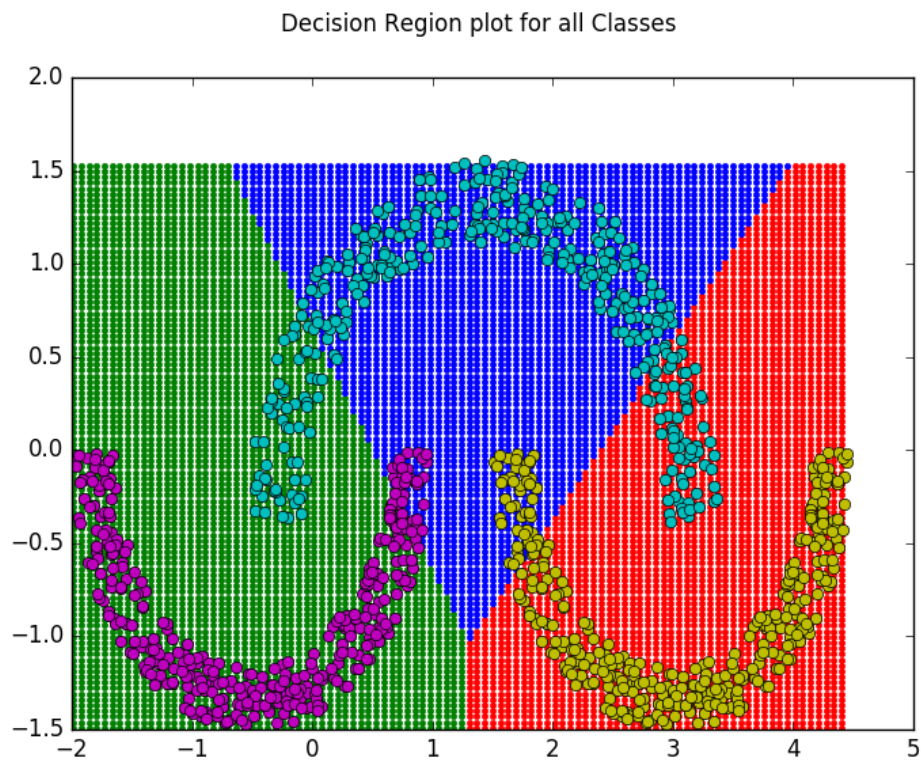
- Class 2 and 3



- Class 1 and 3



Decision region plot for all the classes -



Case 2: Full covariace matrix(Σ) is same for all the classes

Classification Accuracy (Class 1) – 0.915

Classification Accuracy (Class 2) – 0.973

Classification Accuracy (Class 3) – 0.941

Mean Classification Accuracy – 0.943

Precision (Class 1) – 0.891

Precision (Class 2) – 0.946

Precision (Class 3) – 0.906

Mean Precision – 0.914

Recall (Class 1) – 0.848

Recall (Class 2) – 0.976

Recall (Class 3) – 0.920

Mean Recall – 0.915

F-Measure (Class 1) – 0.869

F-Measure (Class 2) – 0.961

F-Measure (Class 3) – 0.913

Mean F-Measure – 0.914

Average Covariance Matrix for each class -

1.079	-0.002
-0.002	0.216

Confusion Matrices -

- Class 1

106	13
19	237

- Class 2

122	7
3	243

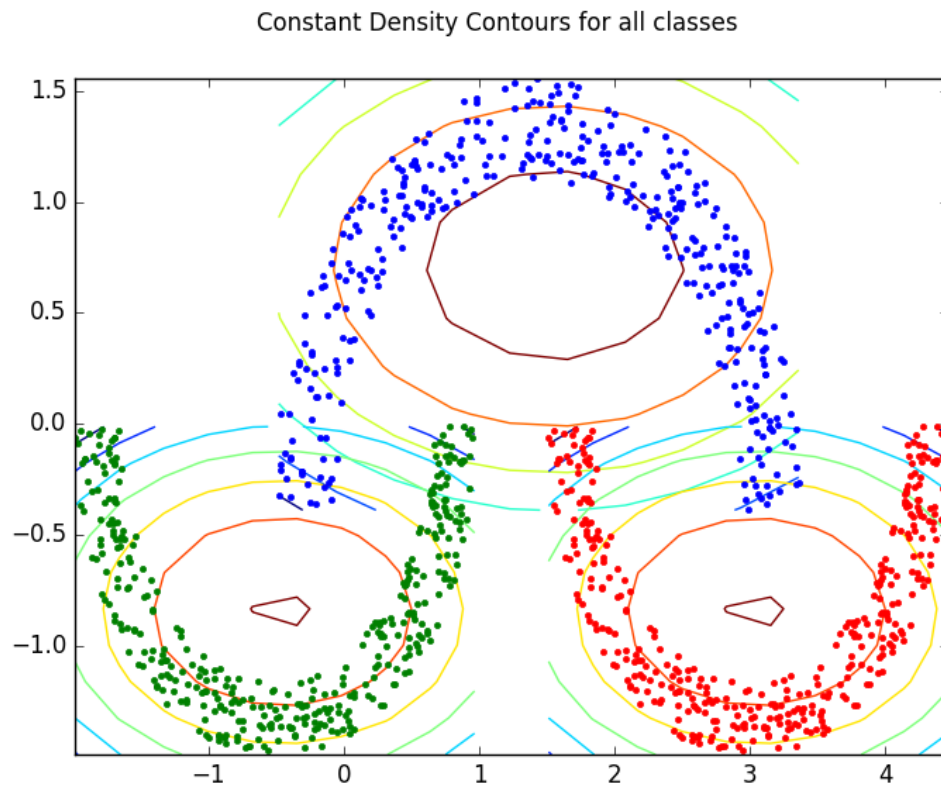
- Class 3

115	12
10	238

- All classes together

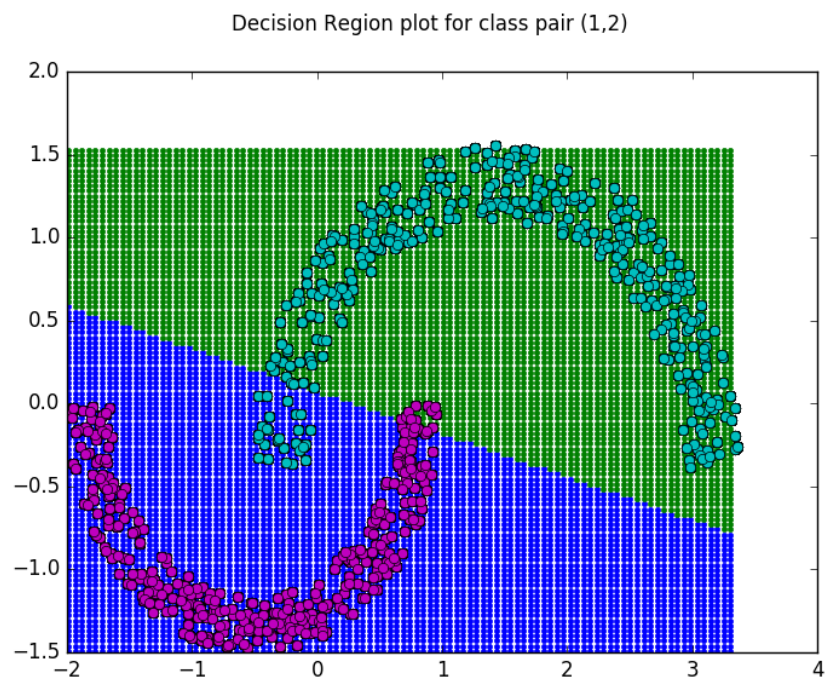
106	3	10
7	122	0
12	0	115

Constant density contour plot for all the classes -

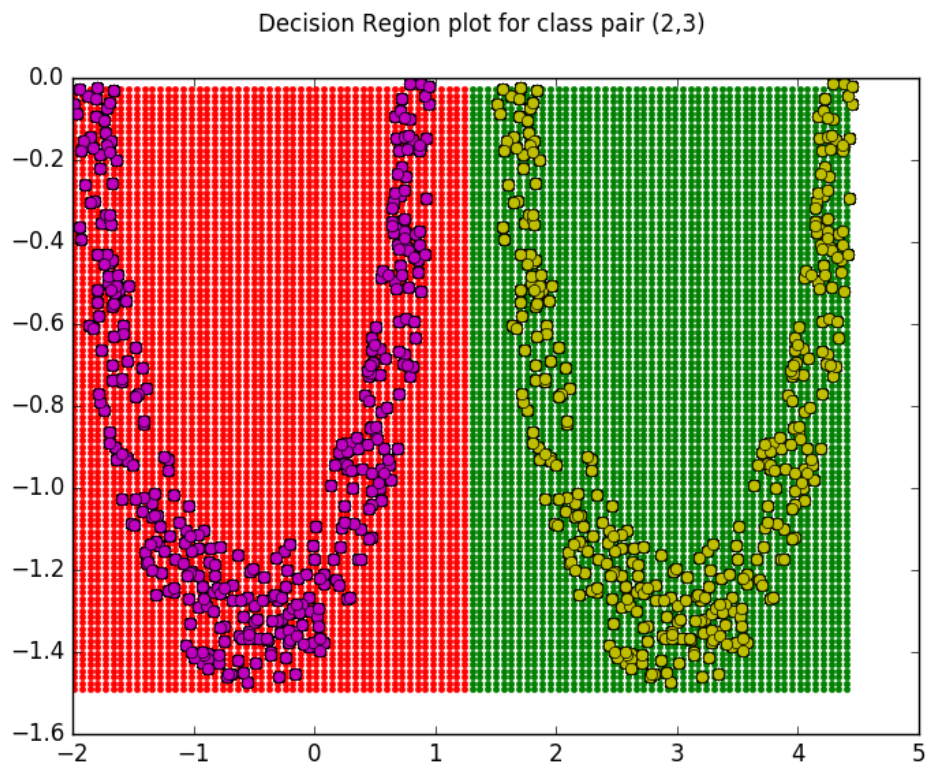


Pairwise Decision region plots -

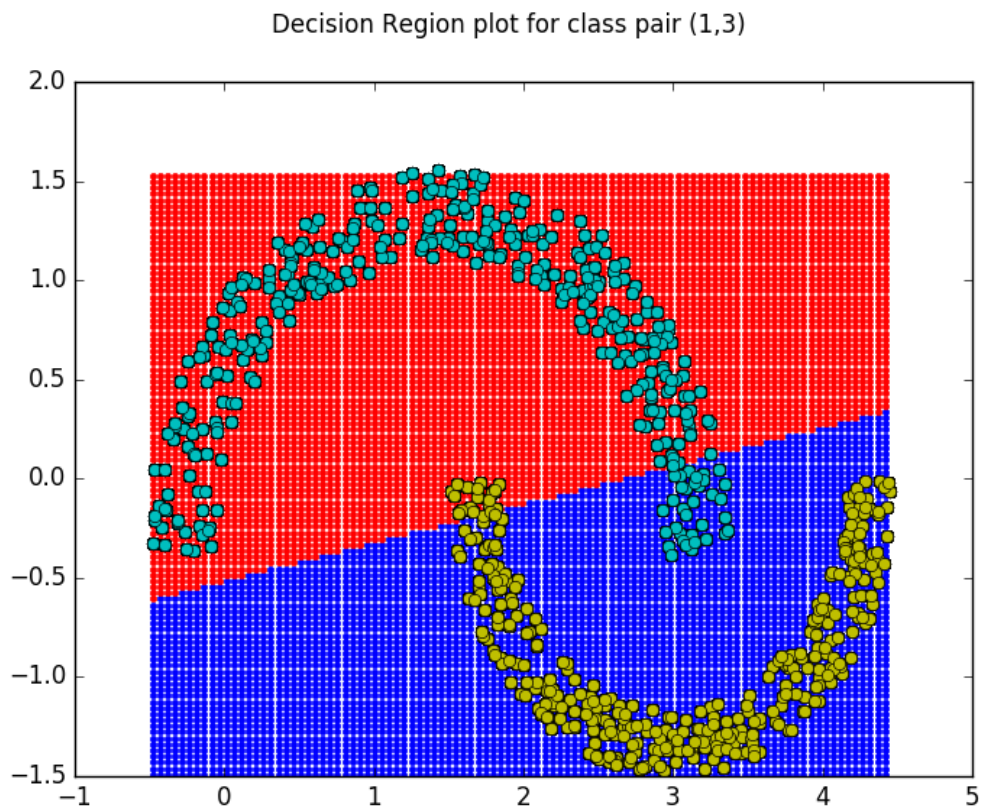
- Class 1 and 2



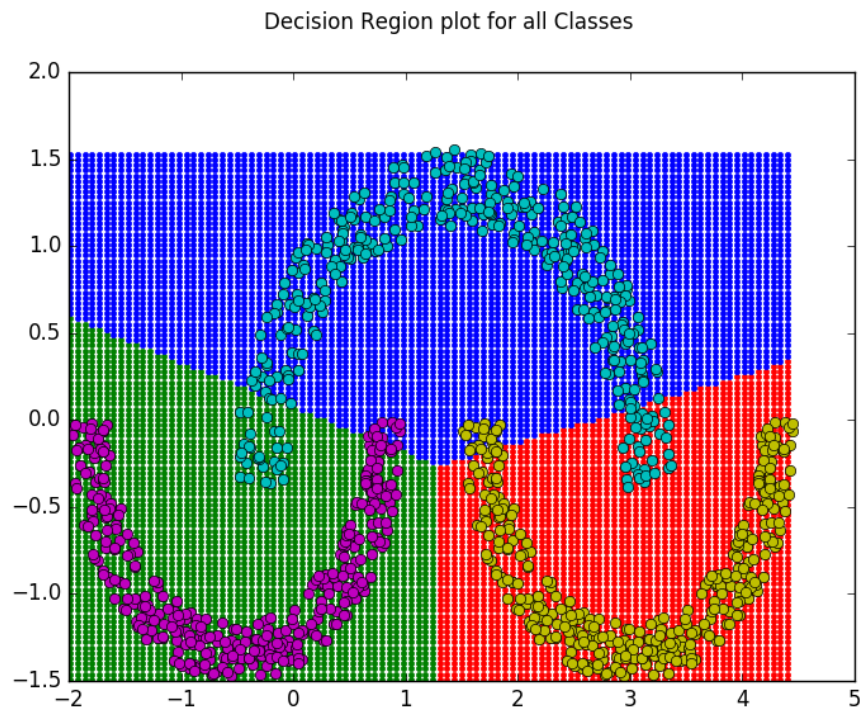
- Class 2 and 3



- Class 1 and 3



Decision region plot for all the classes -



Case 3: Diagonal Covariance matrix (different for all classes)

Classification Accuracy (Class 1) – 0.904

Classification Accuracy (Class 2) – 0.971

Classification Accuracy (Class 3) – 0.933

Mean Classification Accuracy – 0.936

Precision (Class 1) – 0.845

Precision (Class 2) – 0.967

Precision (Class 3) – 0.903

Mean Precision – 0.905

Recall (Class 1) – 0.872

Recall (Class 2) – 0.944

Recall (Class 3) – 0.896

Mean Recall – 0.904

F-Measure (Class 1) – 0.858

F-Measure (Class 2) – 0.955

F-Measure (Class 3) – 0.900

Mean F-Measure – 0.904

Covariance Matrix for each class -

- **Class 1**

1.488	0
0	0.276

- **Class 2**

0.875	0
0	0.187

- **Class 3**

0.875	0
0	0.187

Confusion Matrices -

- **Class 1**

109	20
16	230

- **Class 2**

118	4
7	246

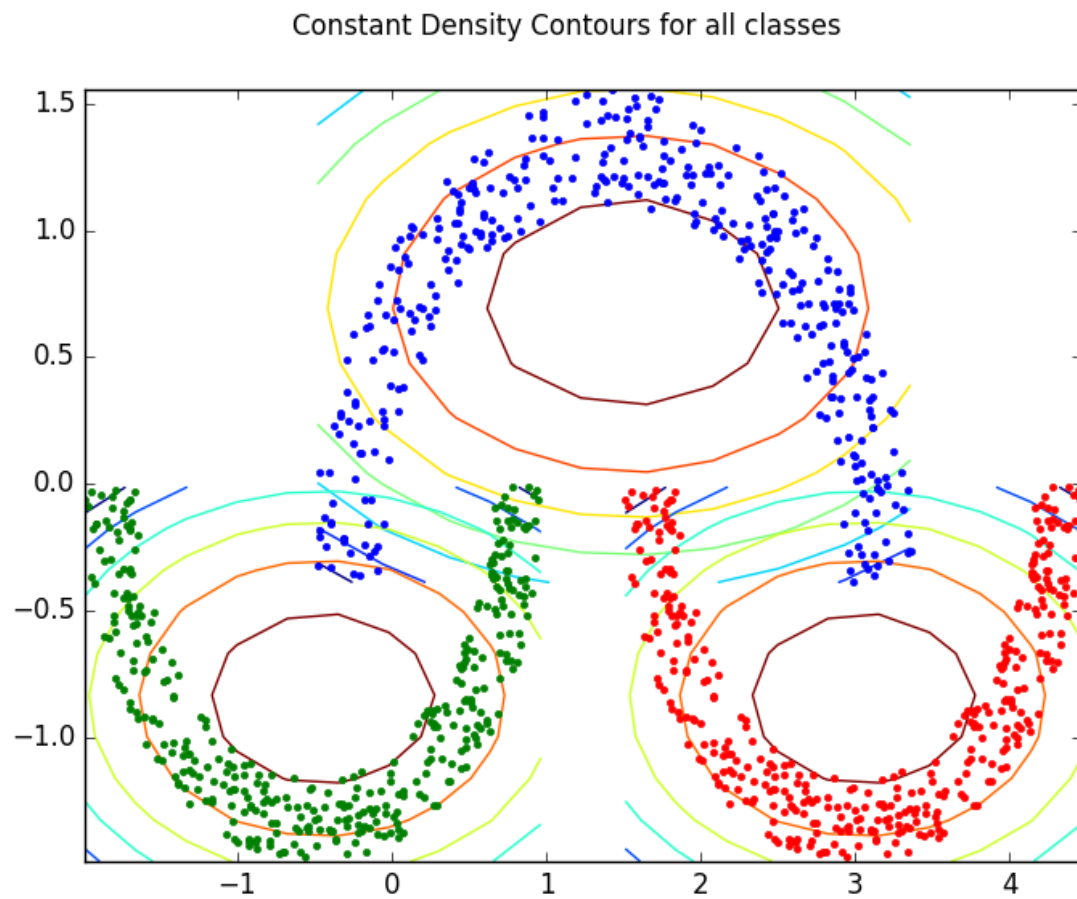
- **Class 3**

112	12
13	238

- All classes together

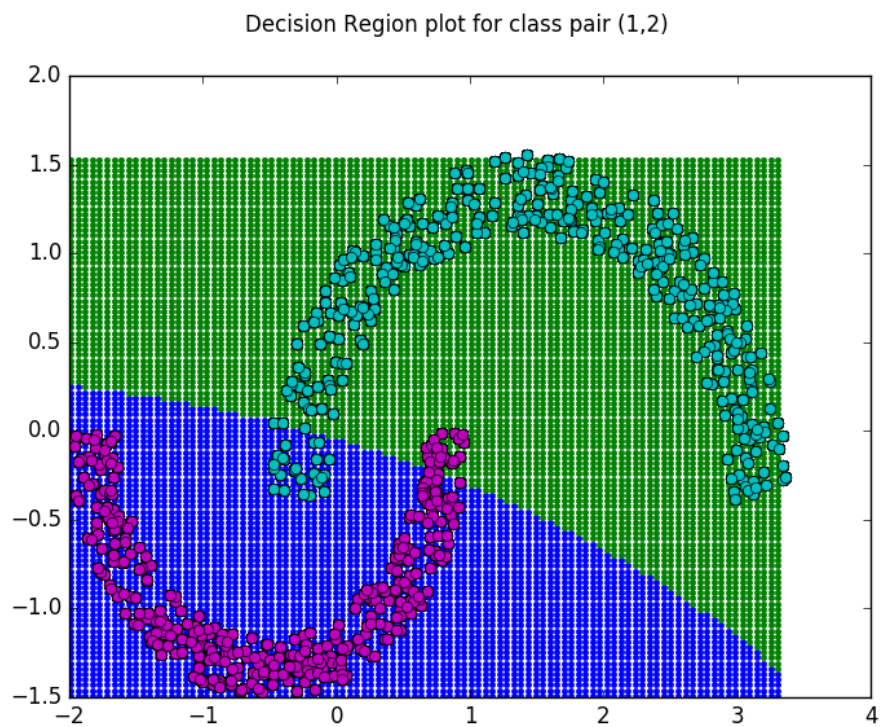
109	7	13
4	118	0
12	0	112

Constant density contour plot for all the classes -

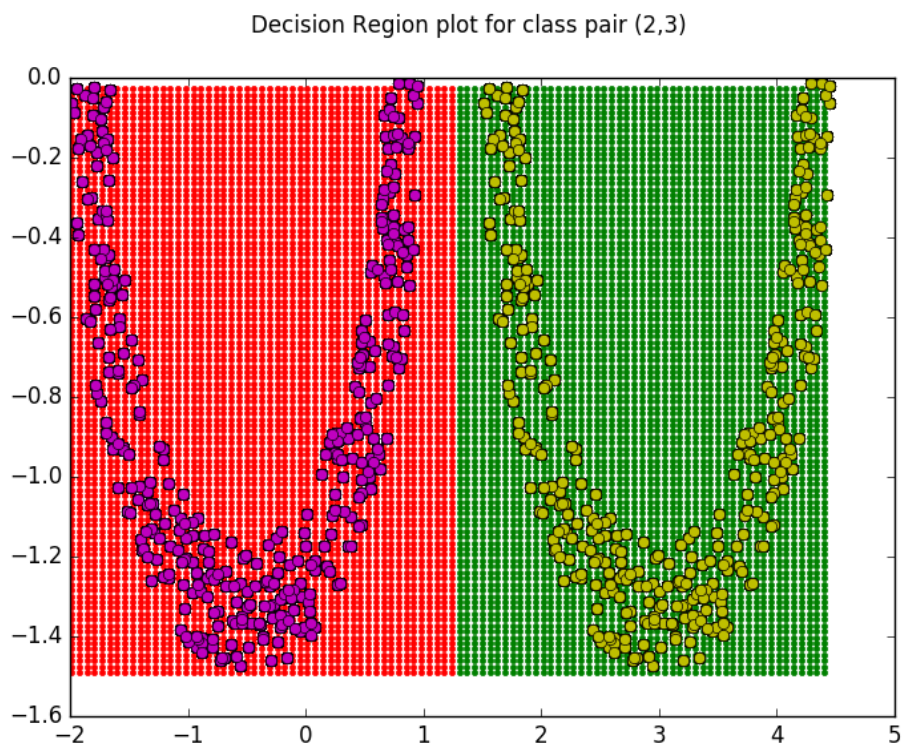


Pairwise Decision region plots -

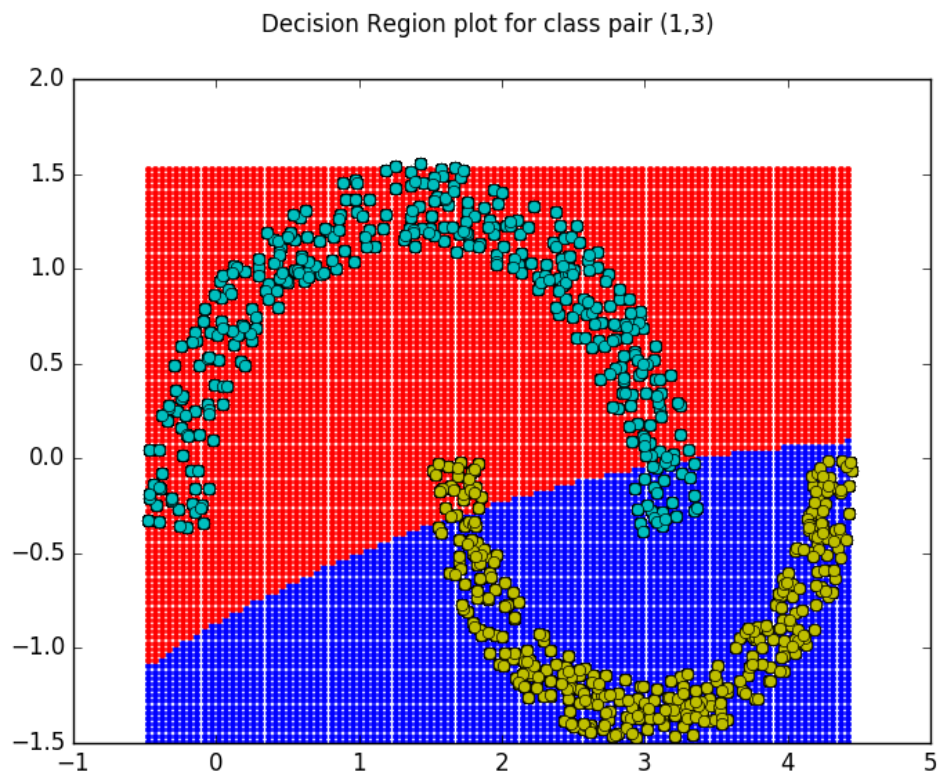
- Class 1 and 2



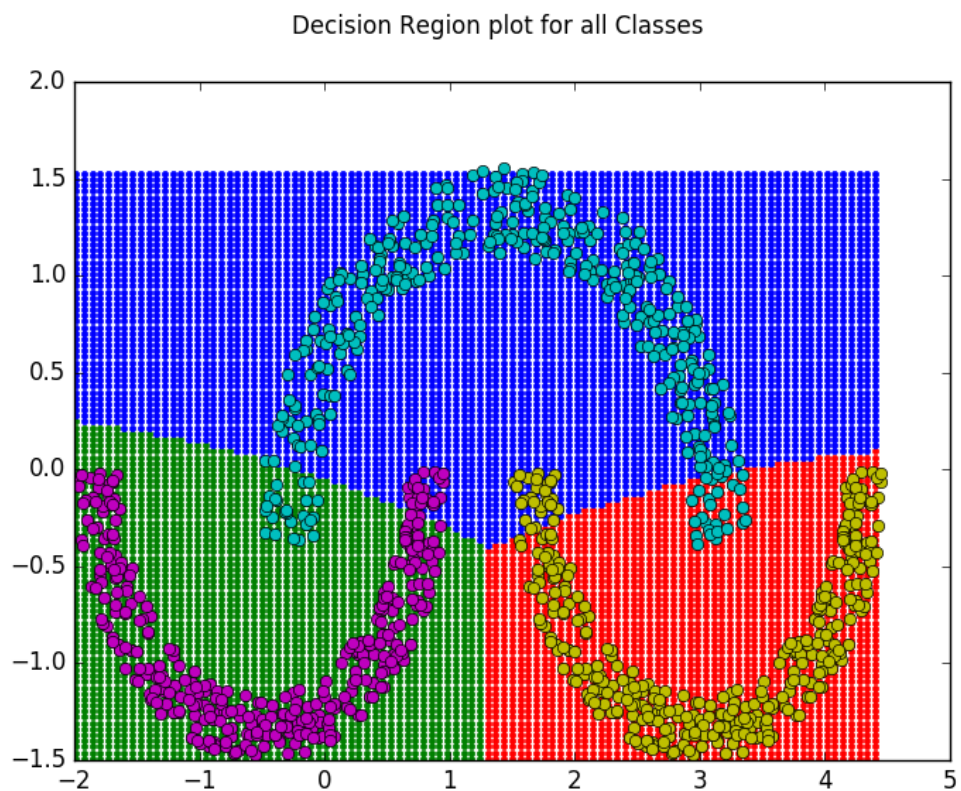
- Class 2 and 3



- Class 1 and 3



Decision region plot for all the classes -



Case 4: Different full covariance matrix for each class

Classification Accuracy (Class 1) – 0.909

Classification Accuracy (Class 2) – 0.976

Classification Accuracy (Class 3) – 0.933

Mean Classification Accuracy – 0.939

Precision (Class 1) – 0.858

Precision (Class 2) – 0.960

Precision (Class 3) – 0.910

Mean Precision – 0.909

Recall (Class 1) – 0.872

Recall (Class 2) – 0.968

Recall (Class 3) – 0.888

Mean Recall – 0.909

F-Measure (Class 1) – 0.865

F-Measure (Class 2) – 0.964

F-Measure (Class 3) – 0.899

Mean F-Measure – 0.909

Covariance Matrix for each class -

- **Class 1**

1.488	-0.039
-0.039	0.276

- **Class 2**

0.875	0.017
0.017	0.187

- **Class 3**

0.875	0.017
0.017	0.187

Confusion Matrices -

- **Class 1**

109	18
16	232

- **Class 2**

121	5
4	245

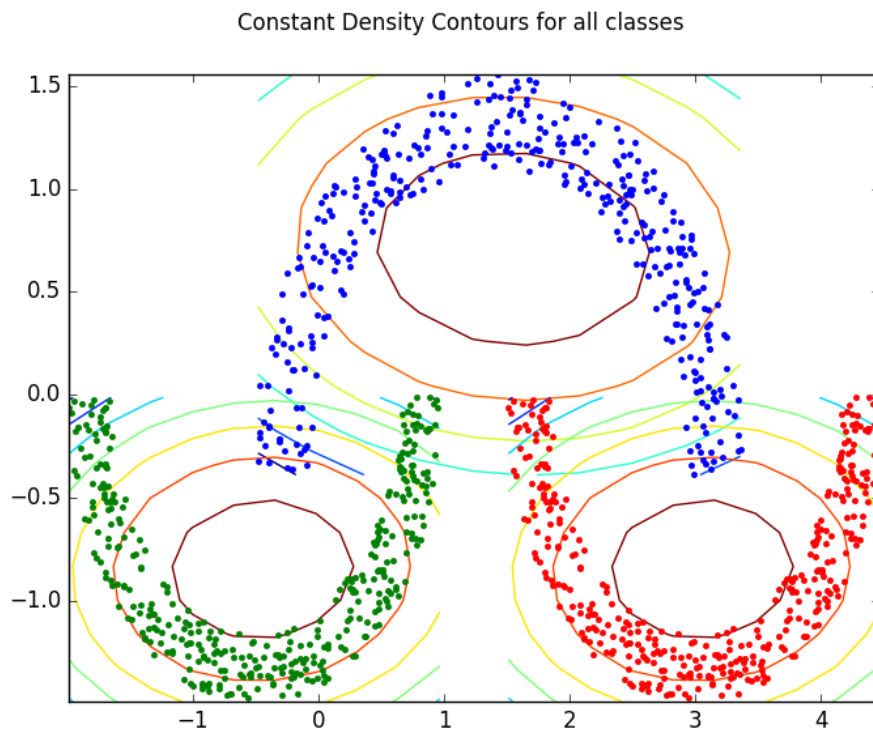
- **Class 3**

111	11
14	239

- **All classes together**

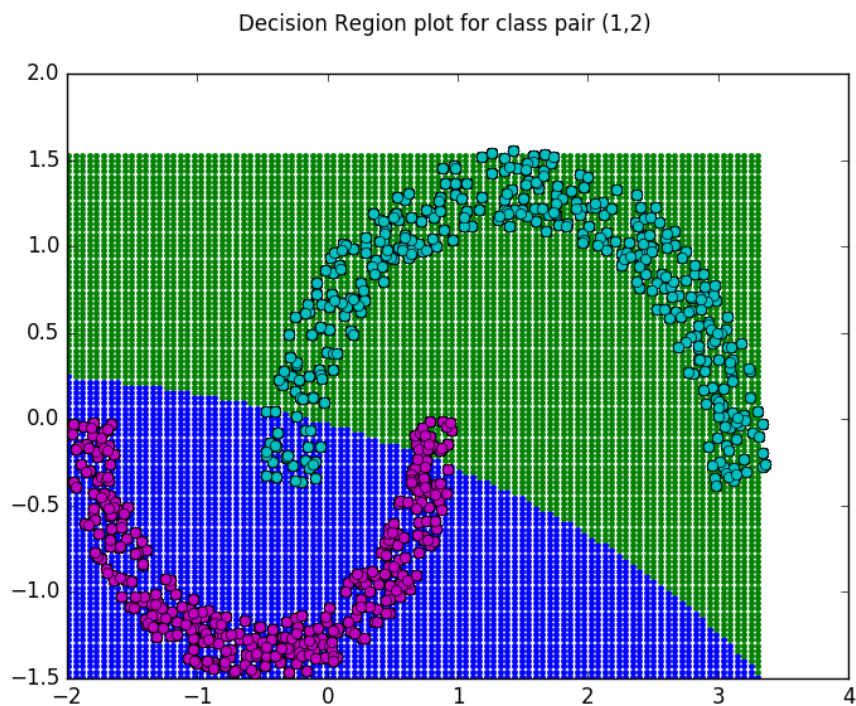
109	4	14
5	121	0
11	0	111

Constant density contour plot for all the classes -

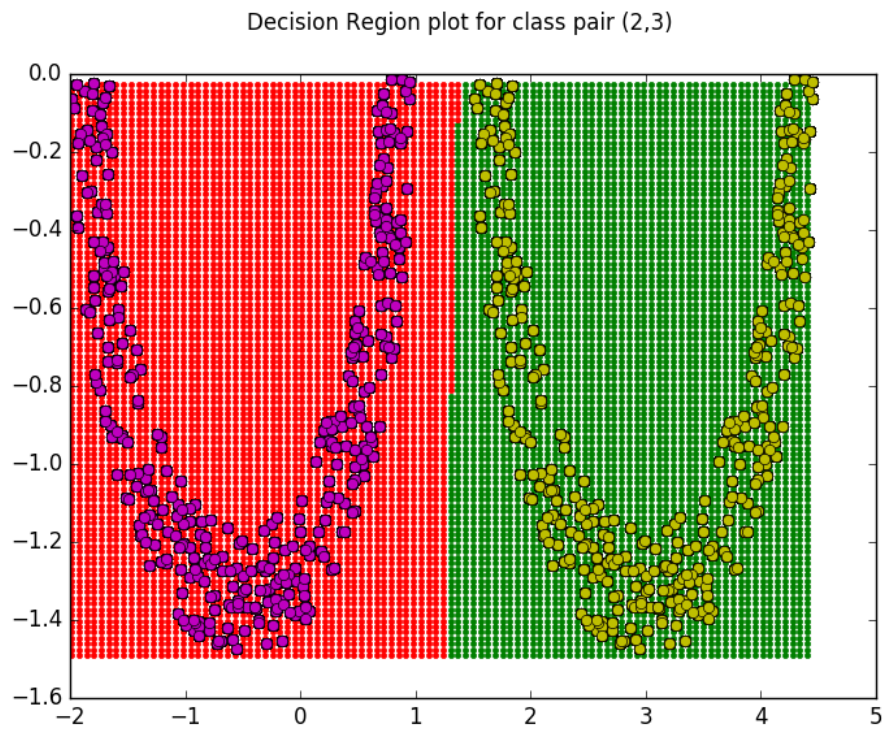


Pairwise Decision region plots -

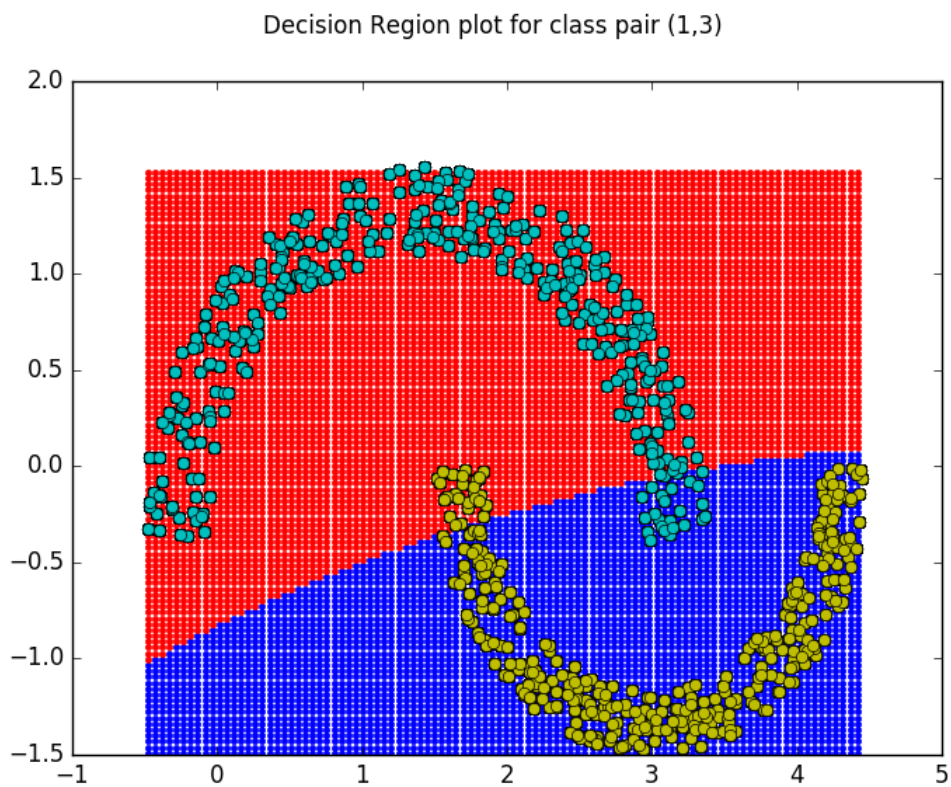
- Class 1 and 2



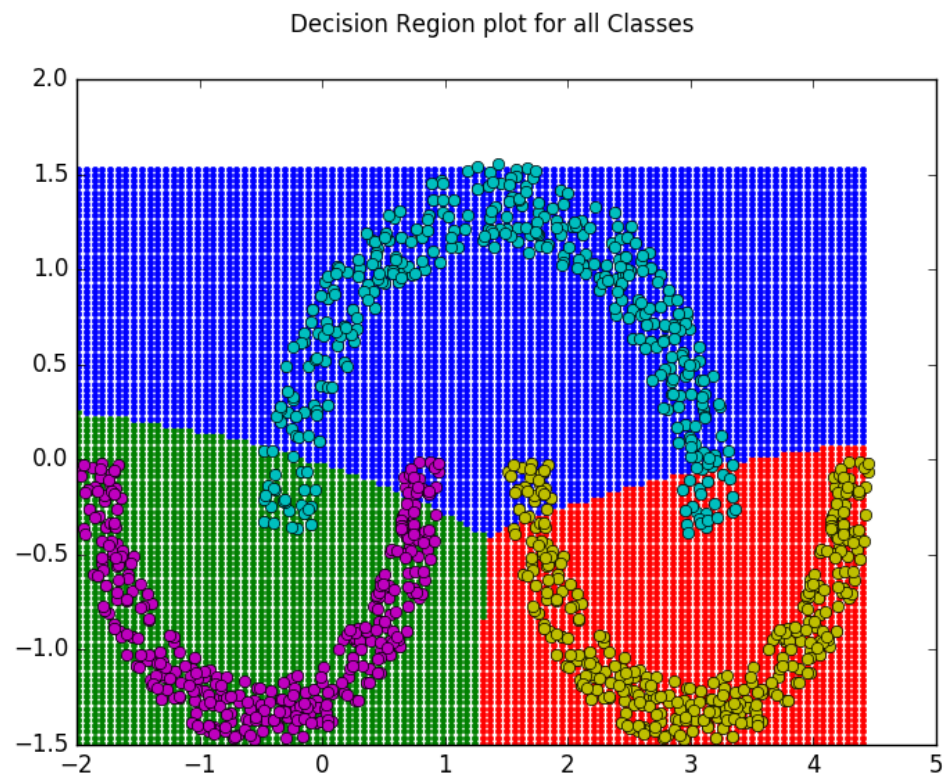
- Class 2 and 3



- Class 1 and 3



Decision region plot for all the classes -



Dataset 2 (Real world dataset of 3 classes)

Mean Vector for each case -

- Class 1 - $[316.284 \quad 2274.908]^T$
- Class 2 - $[369.999 \quad 761.888]^T$
- Class 3 - $[733.737 \quad 1121.756]^T$

Case 1: $\Sigma = \sigma^2 I$ (same for all classes)

Classification Accuracy (Class 1) – 0.996

Classification Accuracy (Class 2) – 0.978

Classification Accuracy (Class 3) – 0.977

Mean Classification Accuracy – 0.984

Precision (Class 1) – 1.0

Precision (Class 2) – 0.953

Precision (Class 3) – 0.975

Mean Precision – 0.976

Recall (Class 1) – 0.988

Recall (Class 2) – 0.986

Recall (Class 3) – 0.950

Mean Recall – 0.975

F-Measure (Class 1) – 0.994

F-Measure (Class 2) – 0.969

F-Measure (Class 3) – 0.962

Mean F-Measure – 0.975

Covariance Matrix for each class -

- For All Classes

5116.934	0
0	5116.934

Confusion Matrices -

- **Class 1**

590	0
7	1163

- **Class 2**

613	30
9	1108

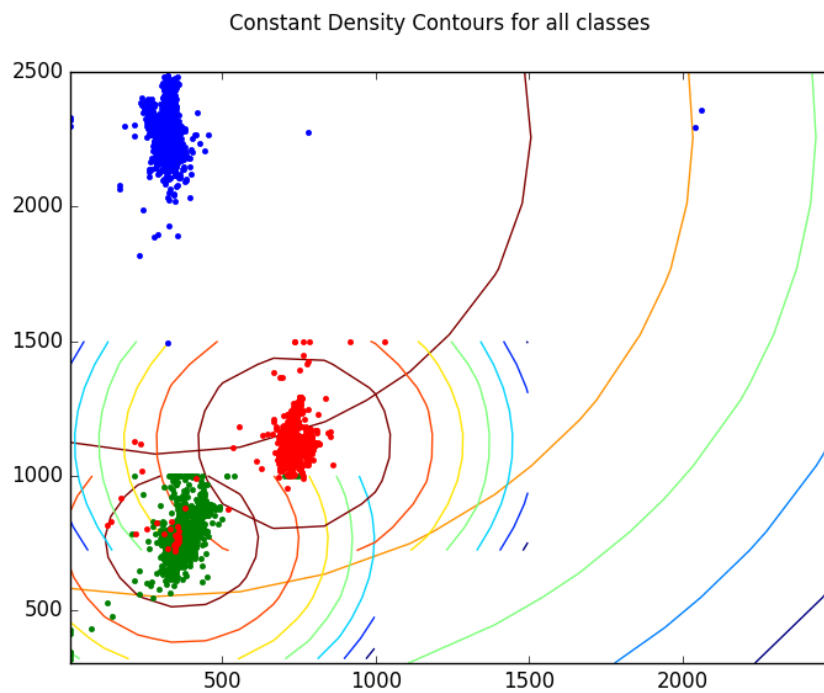
- **Class 3**

514	13
27	1206

- **All classes together**

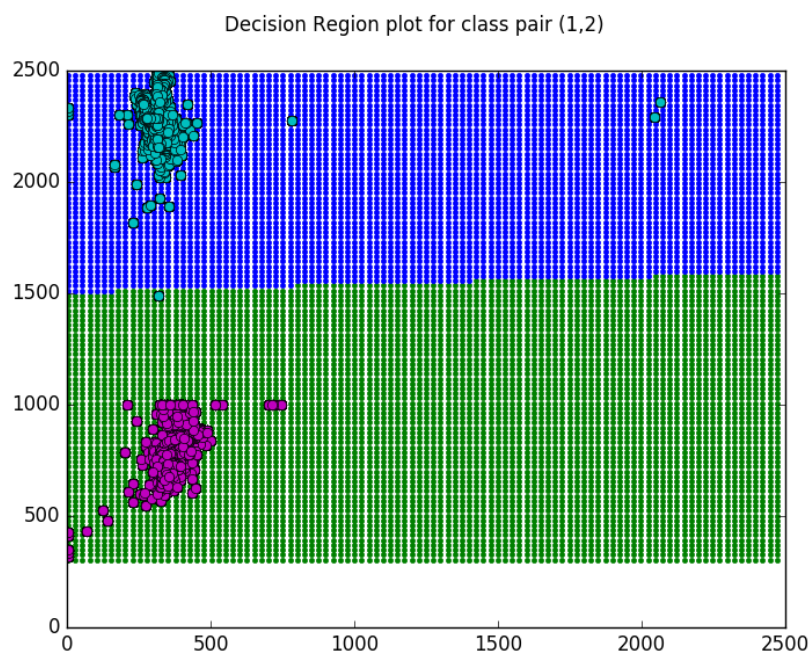
590	0	0
3	613	27
4	9	514

Constant density contour plot for all the classes -



Pairwise Decision region plots -

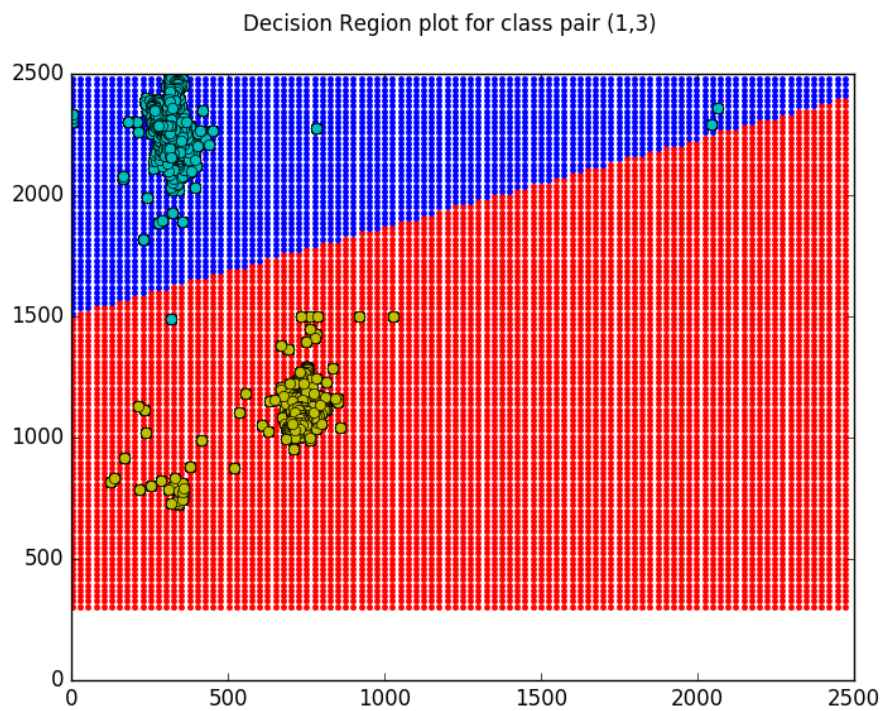
- Class 1 and 2



- Class 2 and 3



- Class 1 and 3



Decision region plot for all the classes -



Case 2: Full covariace matrix(Σ) is same for all the classes

Classification Accuracy (Class 1) – 0.990

Classification Accuracy (Class 2) – 0.977

Classification Accuracy (Class 3) – 0.970

Mean Classification Accuracy – 0.979

Precision (Class 1) – 0.998

Precision (Class 2) – 0.952

Precision (Class 3) – 0.957

Mean Precision – 0.969

Recall (Class 1) – 0.972

Recall (Class 2) – 0.986

Recall (Class 3) – 0.946

Mean Recall – 0.968

F-Measure (Class 1) – 0.985

F-Measure (Class 2) – 0.968

F-Measure (Class 3) – 0.952

Mean F-Measure – 0.968

Average Covariance Matrix for each class -

3767.705	1524.447
1524.447	6466.162

Confusion Matrices -

- Class 1

580	1
17	1162

- Class 2

613	31
9	1107

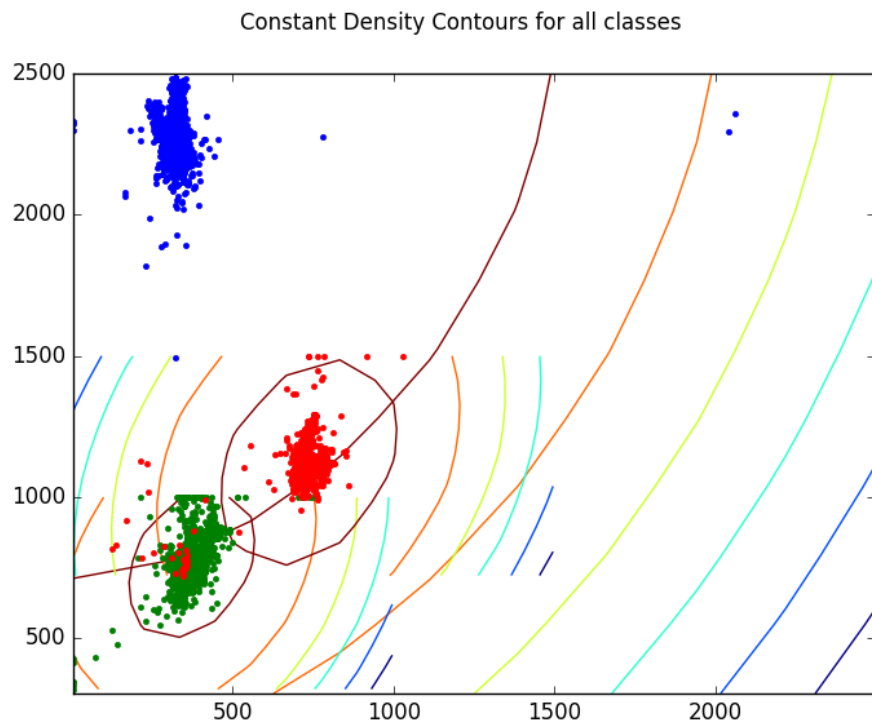
- Class 3

512	23
29	1196

- All classes together

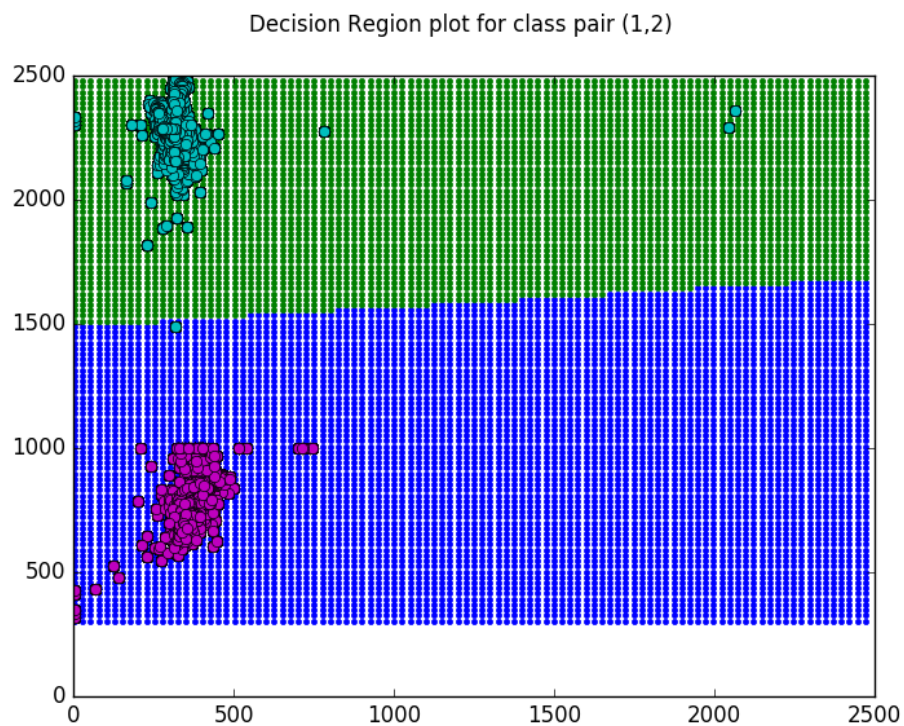
580	0	1
3	617	28
14	9	512

Constant density contour plot for all the classes -

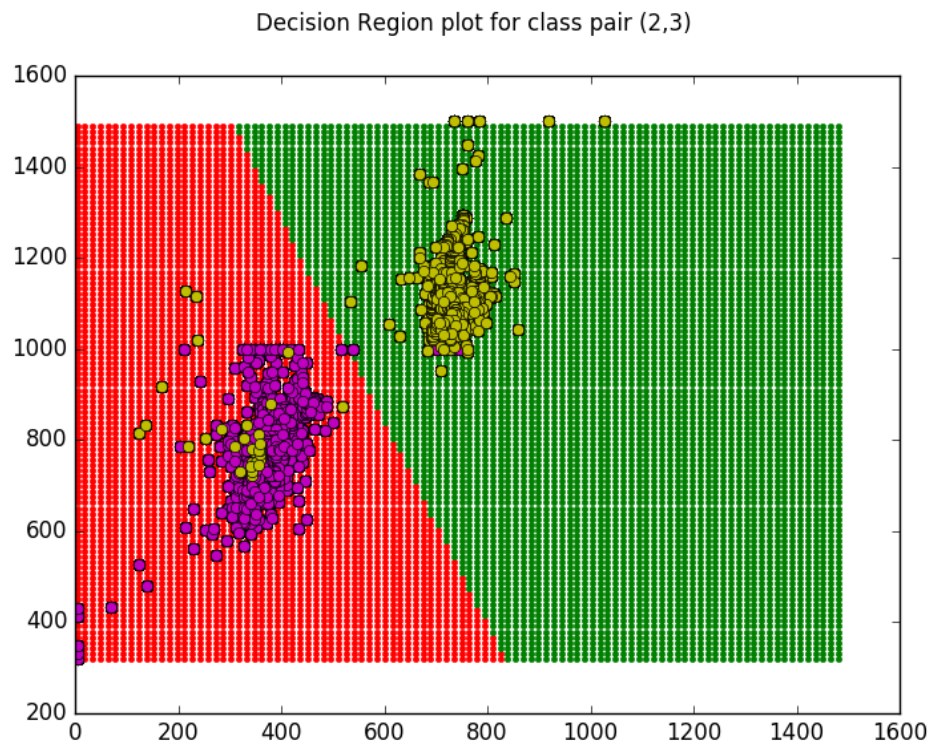


Pairwise Decision region plots -

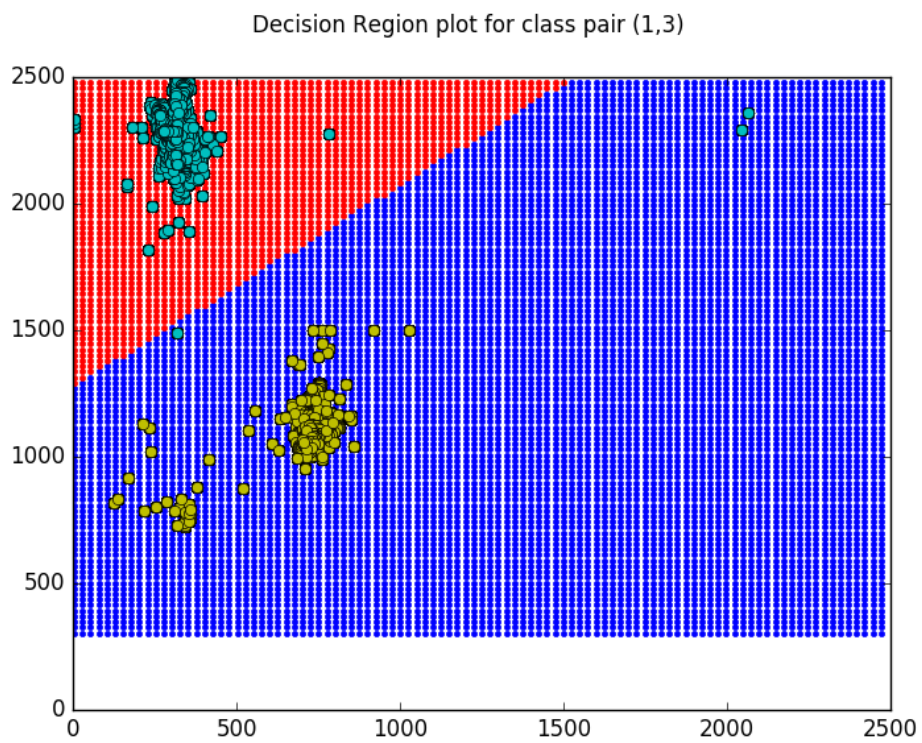
- Class 1 and 2



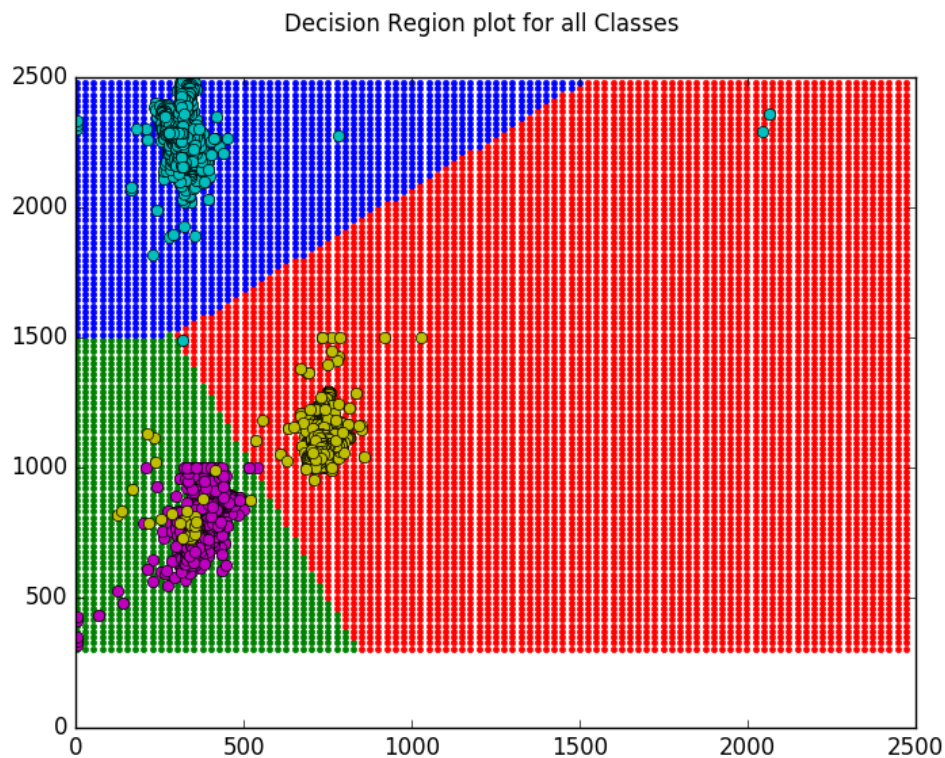
- Class 2 and 3



- Class 1 and 3



Decision region plot for all the classes -



Case 3: Diagonal Covariance matrix (different for all classes)

Classification Accuracy (Class 1) – 0.992

Classification Accuracy (Class 2) – 0.978

Classification Accuracy (Class 3) – 0.973

Mean Classification Accuracy – 0.981

Precision (Class 1) – 0.998

Precision (Class 2) – 0.953

Precision (Class 3) – 0.964

Mean Precision – 0.972

Recall (Class 1) – 0.978

Recall (Class 2) – 0.986

Recall (Class 3) – 0.948

Mean Recall – 0.971

F-Measure (Class 1) – 0.988

F-Measure (Class 2) – 0.969

F-Measure (Class 3) – 0.956

Mean F-Measure – 0.971

Covariance Matrix for each class -

- **Class 1**

4487.057	0
0	7611.523

- **Class 2**

2145.310	0
0	6128.158

- **Class 3**

4670.748	0
0	5858.805

Confusion Matrices -

- **Class 1**

584	1
13	1162

- **Class 2**

613	30
9	1108

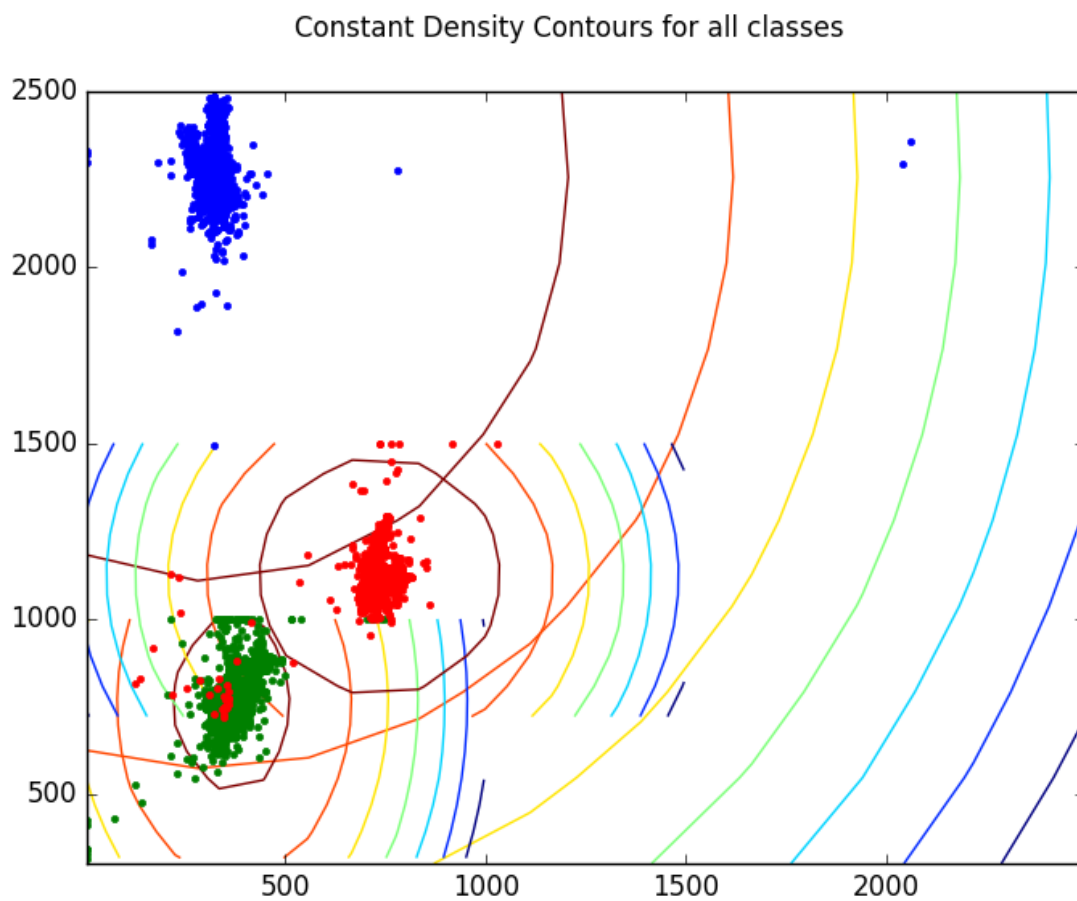
- **Class 3**

513	19
28	1200

- All classes together

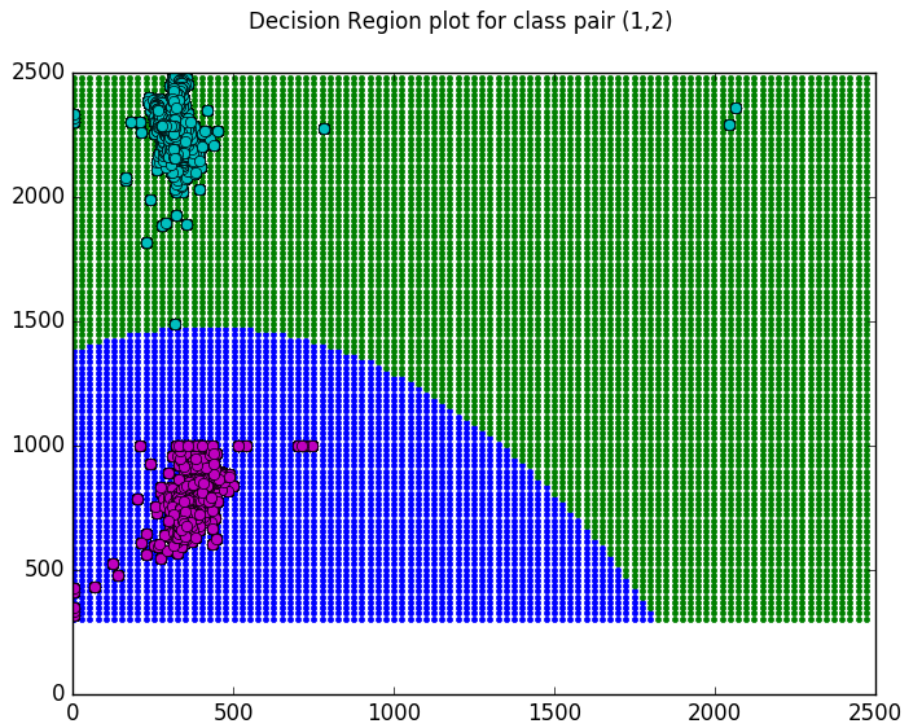
584	0	1
3	613	27
10	9	513

Constant density contour plot for all the classes -

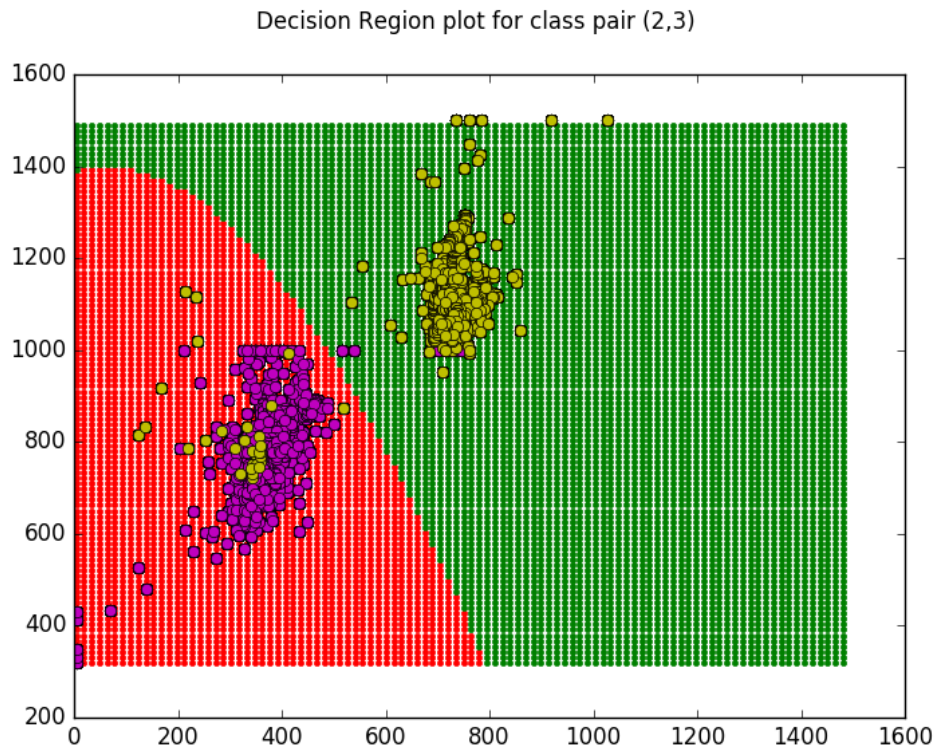


Pairwise Decision region plots -

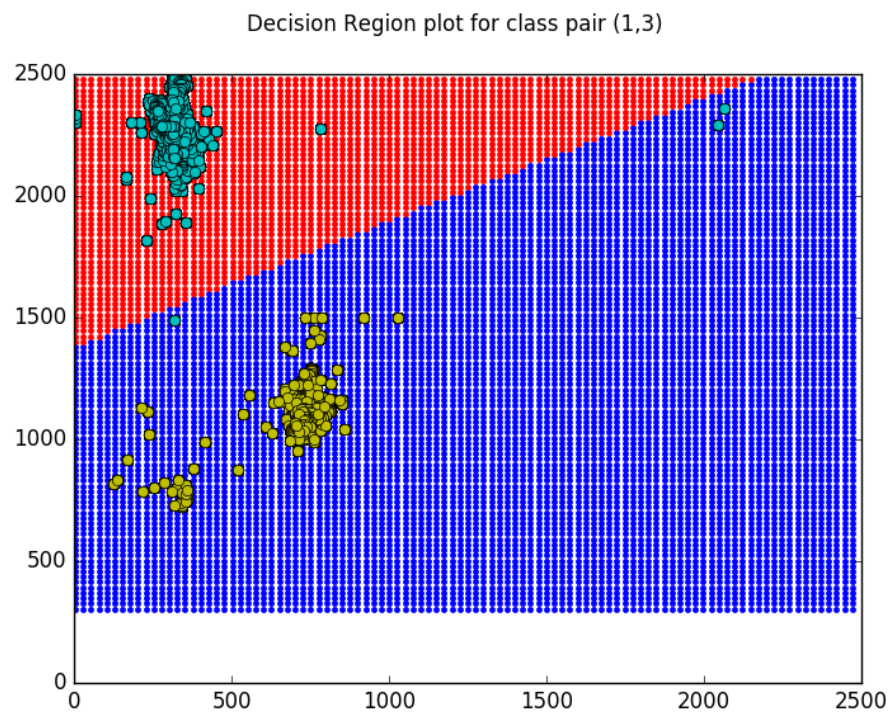
- Class 1 and 2



- Class 2 and 3



- Class 1 and 3



Decision region plot for all the classes -



Case 4: Different full covariance matrix for each class

Classification Accuracy (Class 1) – 0.991

Classification Accuracy (Class 2) – 0.976

Classification Accuracy (Class 3) – 0.970

Mean Classification Accuracy – 0.979

Precision (Class 1) – 0.998

Precision (Class 2) – 0.952

Precision (Class 3) – 0.957

Mean Precision – 0.969

Recall (Class 1) – 0.975

Recall (Class 2) – 0.982

Recall (Class 3) – 0.946

Mean Recall – 0.968

F-Measure (Class 1) – 0.986

F-Measure (Class 2) – 0.967

F-Measure (Class 3) – 0.952

Mean F-Measure – 0.968

Covariance Matrix for each class -

- **Class 1**

4487.057	-310.508
-310.508	7611.523

- **Class 2**

2145.310	2194.074
2194.074	6128.158

- **Class 3**

4670.748	2689.776
2689.776	5658.805

Confusion Matrices -

- **Class 1**

582	1
15	1162

- **Class 2**

611	31
11	1107

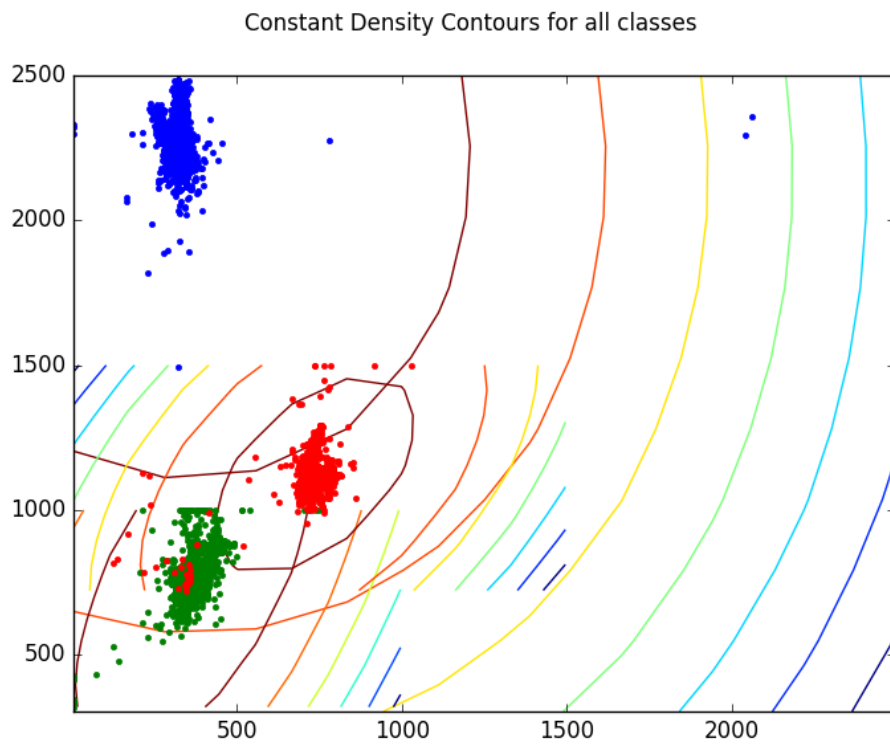
- **Class 3**

512	23
29	1196

- **All classes together**

582	0	1
3	611	28
12	11	512

Constant density contour plot for all the classes -

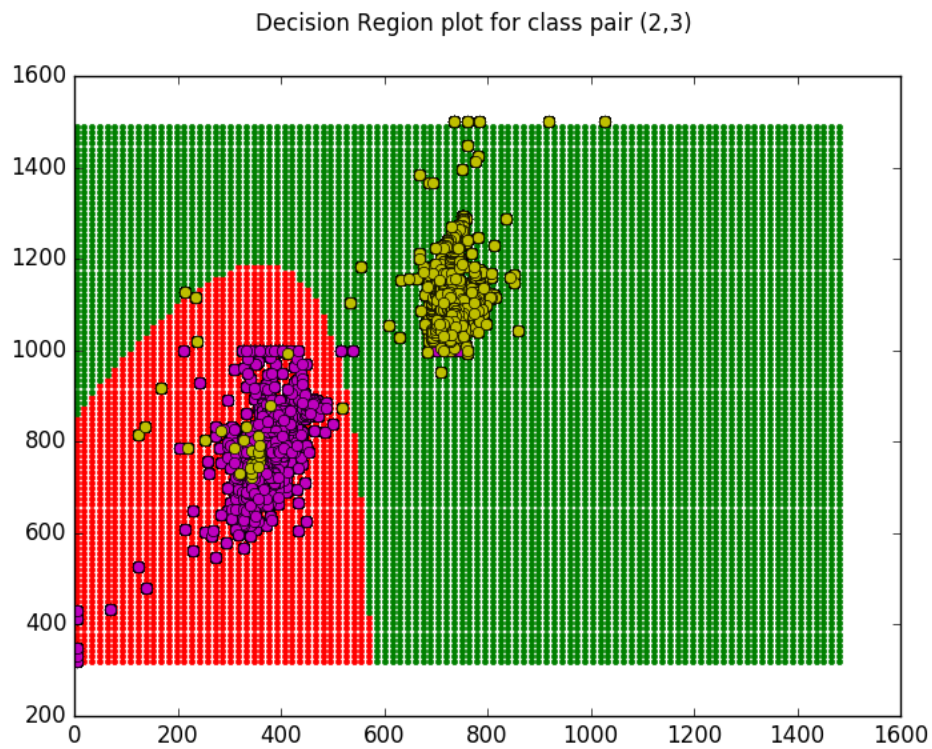


Pairwise Decision region plots -

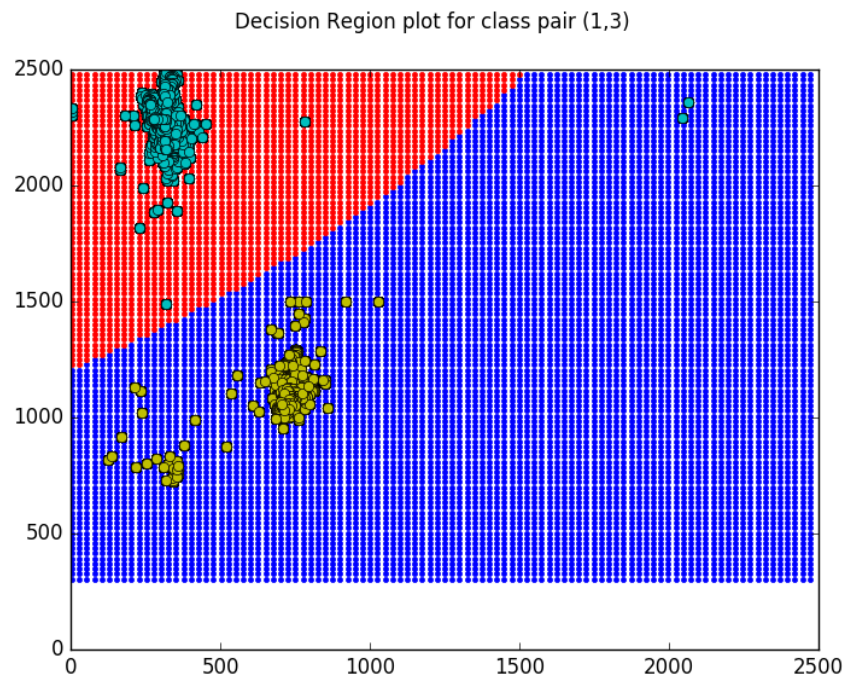
- Class 1 and 2



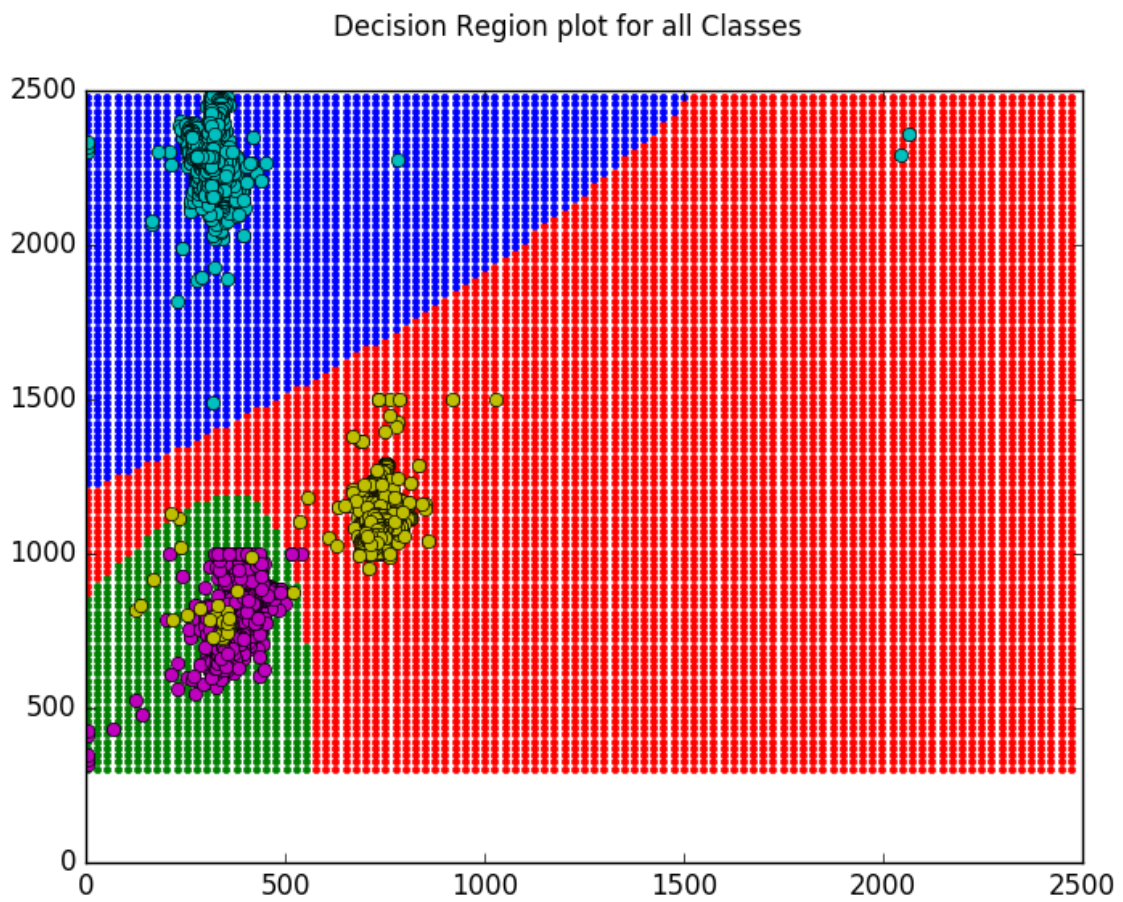
- Class 2 and 3



- Class 1 and 3



Decision region plot for all the classes -



*****END*****