EE-559-MATHEMATICAL PATTERN RECOGNITION
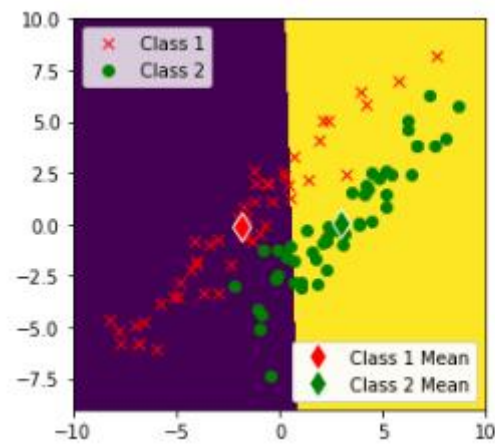
HOMEWORK-1-WRITTEN REPORT

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USC ID-7890-1614-34

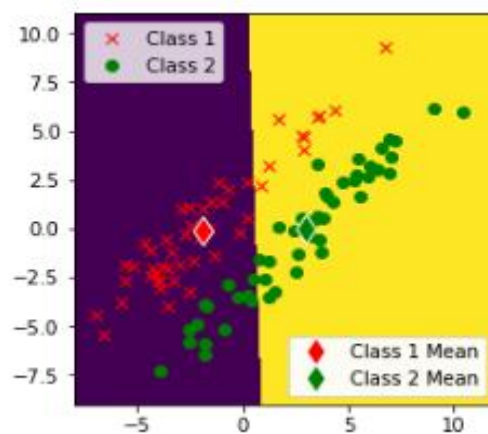*Email-rpandura@usc.edu*

1. a)
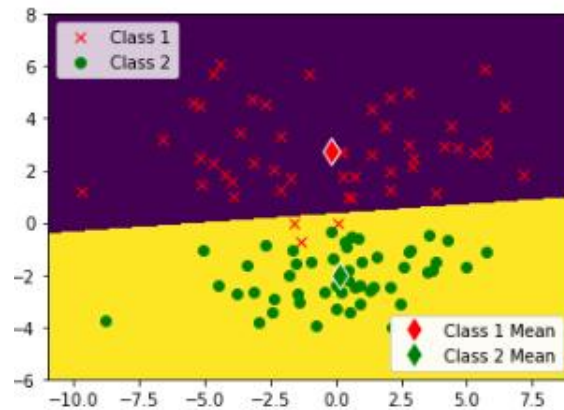

Fig 1. Plot of Synthetic1 Training-set along with Class Means, Decision Boundaries and Decision Regions

```
The error rate for Synthetic 1 Training data set is 21.0
The success rate for Synthetic 1 Training data set is 79.0
```


Fig 2. Plot of Synthetic1 Testing-set along with Class Means, Decision Boundaries and Decision Regions

```
The error rate for Synthetic 1 Testing data set is 24.0
The success rate for Synthetic 1 Testing data set is 76.0
```

Fig 3. Plot of Synthetic2 Training-set along with Class Means, Decision Boundaries and Decision Regions

```
The error rate for Synthetic 2 Training data set is 3.0
The success rate for Synthetic 2 Training data set is 97.0
```
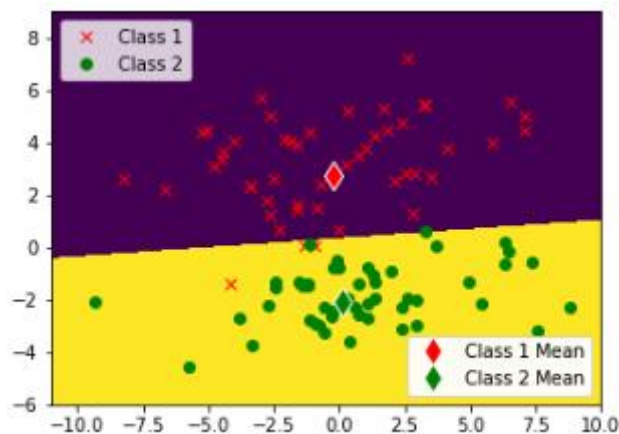

Fig 4. Plot of Synthetic2 Testing-set along with Class Means, Decision Boundaries and Decision Regions

```
The error rate for Synthetic 2 Testing data set is 4.0
The success rate for Synthetic 2 Testing data set is 96.0
```

1. b) **Yes, there is a significant change in the error rates.**

Training set difference – 17%

Testing set difference – 20%

This change in the error rates is because-

- o **In Synthetic dataset 1 the distance measure between data points and sample mean is more compared to the distance measure between the data points and sample mean of Synthetic data set 2.**

Due to which, there is a huge dissimilarity between the data points and the mean which in turn makes the training of the Synthetic data set 1 harder than the Synthetic dataset 2.
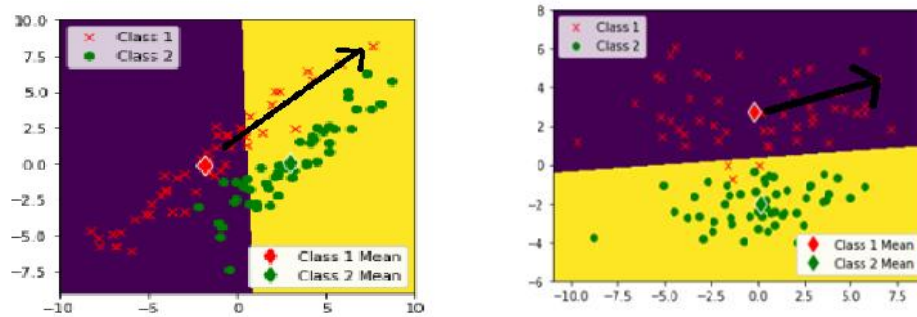

Fig 5. Plots of Synthetic1 Training-set and Synthetic2 Training set comparing their distance measures of the last data point from their respective sample means

1. c) **For the Wine dataset with total C = 3 Classes and picking the first two features -> x1 – Alcohol Content**

        x2–Malic Acid Content

Fig 6. Plot of Wine Training-set along with Class Means, Decision Boundaries and Decision Regions for first two features

The error rate for Wine Training data set is 20.224719101123593
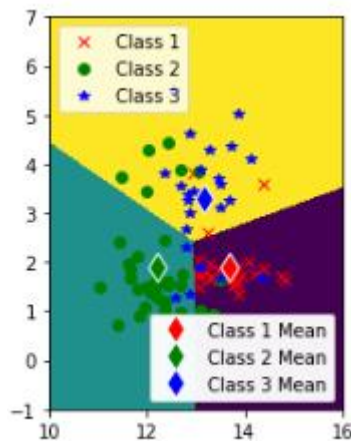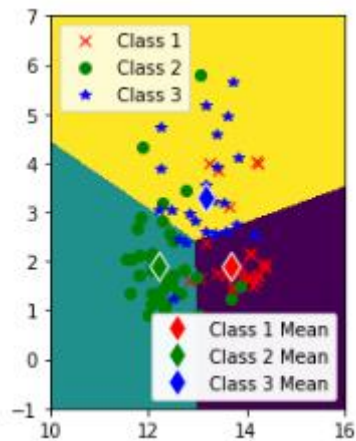**The success rate for Wine Training data set is 79.7752808988764**

Fig 7. Plot of Wine Testing-set along with Class Means, Decision Boundaries and Decision Regions for first two features

The error rate for Wine Testing data set is 22.47191011235955
The success rate for Wine Testing data set is 77.52808988764045

1.e)

For the Wine dataset, taking all the combinations of features, the respective error rates and success rates are-

```
The error rate of f1 =  1  f2 = 2  of Wine Training data set is  20.2247191
01123593
The error rate of f1 =  1  f2 = 2  of Wine Testing data set is  22.47191011
235955
The error rate of f1 =  1  f2 = 3  of Wine Training data set is  31.4606741
5730337
The error rate of f1 =  1  f2 = 3  of Wine Testing data set is  28.08988764
044944
The error rate of f1 =  1  f2 = 4  of Wine Training data set is  44.9438202
247191
The error rate of f1 =  1  f2 = 4  of Wine Testing data set is  40.44943820
224719
The error rate of f1 =  1  f2 = 5  of Wine Training data set is  56.1797752
8089888
The error rate of f1 =  1  f2 = 5  of Wine Testing data set is  44.94382022
47191
The error rate of f1 =  1  f2 = 6  of Wine Training data set is  14.6067415
73033707
The error rate of f1 =  1  f2 = 6  of Wine Testing data set is  15.73033707
8651685
The error rate of f1 =  1  f2 = 7  of Wine Training data set is  8.98876404
494382
The error rate of f1 =  1  f2 = 7  of Wine Testing data set is  11.23595505
6179774
```

The error rate of f1 = 1 f2 = 8 of Wine Training data set is 33.7078651
6853933
The error rate of f1 = 1 f2 = 8 of Wine Testing data set is 28.08988764
044944
The error rate of f1 = 1 f2 = 9 of Wine Training data set is 16.8539325
84269664
The error rate of f1 = 1 f2 = 9 of Wine Testing data set is 24.71910112
3595504
The error rate of f1 = 1 f2 = 10 of Wine Training data set is 25.842696
629213485
The error rate of f1 = 1 f2 = 10 of Wine Testing data set is 22.4719101
1235955
The error rate of f1 = 1 f2 = 11 of Wine Training data set is 25.842696
629213485
The error rate of f1 = 1 f2 = 11 of Wine Testing data set is 26.9662921
3483146

The error rate of f1 = 1 f2 = 12 of Wine Training data set is
7.865168539325842
The error rate of f1 = 1 f2 = 12 of Wine Testing data set is
12.359550561797752

The error rate of f1 = 1 f2 = 13 of Wine Training data set is 24.719101
123595504
The error rate of f1 = 1 f2 = 13 of Wine Testing data set is 30.3370786
51685395
The error rate of f1 = 2 f2 = 3 of Wine Training data set is 39.3258426
96629216
The error rate of f1 = 2 f2 = 3 of Wine Testing data set is 38.20224719
101123
The error rate of f1 = 2 f2 = 4 of Wine Training data set is 39.3258426
96629216
The error rate of f1 = 2 f2 = 4 of Wine Testing data set is 42.69662921
348314
The error rate of f1 = 2 f2 = 5 of Wine Training data set is 57.3033707
8651685
The error rate of f1 = 2 f2 = 5 of Wine Testing data set is 43.82022471
910113
The error rate of f1 = 2 f2 = 6 of Wine Training data set is 29.2134831
46067414
The error rate of f1 = 2 f2 = 6 of Wine Testing data set is 29.21348314
6067414
The error rate of f1 = 2 f2 = 7 of Wine Training data set is 20.2247191
01123593
The error rate of f1 = 2 f2 = 7 of Wine Testing data set is 23.59550561
7977526
The error rate of f1 = 2 f2 = 8 of Wine Training data set is 32.5842696
6292135

The error rate of f1 = 2 f2 = 8 of Wine Testing data set is 39.32584269
6629216
The error rate of f1 = 2 f2 = 9 of Wine Training data set is 40.4494382
0224719
The error rate of f1 = 2 f2 = 9 of Wine Testing data set is 37.07865168
539326
The error rate of f1 = 2 f2 = 10 of Wine Training data set is 24.719101
123595504
The error rate of f1 = 2 f2 = 10 of Wine Testing data set is 22.4719101
1235955
The error rate of f1 = 2 f2 = 11 of Wine Training data set is 38.202247
19101123
The error rate of f1 = 2 f2 = 11 of Wine Testing data set is 44.9438202
247191
The error rate of f1 = 2 f2 = 12 of Wine Training data set is 42.696629
21348314
The error rate of f1 = 2 f2 = 12 of Wine Testing data set is 37.0786516
8539326
The error rate of f1 = 2 f2 = 13 of Wine Training data set is 24.719101
123595504
The error rate of f1 = 2 f2 = 13 of Wine Testing data set is 30.3370786
51685395
The error rate of f1 = 3 f2 = 4 of Wine Training data set is 47.1910112
3595505
The error rate of f1 = 3 f2 = 4 of Wine Testing data set is 50.56179775
280899
The error rate of f1 = 3 f2 = 5 of Wine Training data set is 57.3033707
8651685
The error rate of f1 = 3 f2 = 5 of Wine Testing data set is 46.06741573
033708
The error rate of f1 = 3 f2 = 6 of Wine Training data set is 32.5842696
6292135
The error rate of f1 = 3 f2 = 6 of Wine Testing data set is 28.08988764
044944
The error rate of f1 = 3 f2 = 7 of Wine Training data set is 14.6067415
73033707
The error rate of f1 = 3 f2 = 7 of Wine Testing data set is 22.47191011
235955
The error rate of f1 = 3 f2 = 8 of Wine Training data set is 51.6853932
5842697
The error rate of f1 = 3 f2 = 8 of Wine Testing data set is 32.58426966
292135
The error rate of f1 = 3 f2 = 9 of Wine Training data set is 38.2022471
9101123
The error rate of f1 = 3 f2 = 9 of Wine Testing data set is 40.44943820
224719

The error rate of f1 = 3 f2 = 10 of Wine Training data set is 30.337078
651685395
The error rate of f1 = 3 f2 = 10 of Wine Testing data set is 23.5955056
17977526
The error rate of f1 = 3 f2 = 11 of Wine Training data set is 30.337078
651685395
The error rate of f1 = 3 f2 = 11 of Wine Testing data set is 26.9662921
3483146
The error rate of f1 = 3 f2 = 12 of Wine Training data set is 29.213483
146067414
The error rate of f1 = 3 f2 = 12 of Wine Testing data set is 28.0898876
4044944
The error rate of f1 = 3 f2 = 13 of Wine Training data set is 24.719101
123595504
The error rate of f1 = 3 f2 = 13 of Wine Testing data set is 30.3370786
51685395
The error rate of f1 = 4 f2 = 5 of Wine Training data set is 42.6966292
1348314
The error rate of f1 = 4 f2 = 5 of Wine Testing data set is 38.20224719
101123
The error rate of f1 = 4 f2 = 6 of Wine Training data set is 47.1910112
3595505
The error rate of f1 = 4 f2 = 6 of Wine Testing data set is 47.19101123
595505
The error rate of f1 = 4 f2 = 7 of Wine Training data set is 42.6966292
1348314
The error rate of f1 = 4 f2 = 7 of Wine Testing data set is 41.57303370
786517
The error rate of f1 = 4 f2 = 8 of Wine Training data set is 47.1910112
3595505
The error rate of f1 = 4 f2 = 8 of Wine Testing data set is 50.56179775
280899
The error rate of f1 = 4 f2 = 9 of Wine Training data set is 44.9438202
247191
The error rate of f1 = 4 f2 = 9 of Wine Testing data set is 48.31460674
157304
The error rate of f1 = 4 f2 = 10 of Wine Training data set is 21.348314
60674157
The error rate of f1 = 4 f2 = 10 of Wine Testing data set is 29.2134831
46067414
The error rate of f1 = 4 f2 = 11 of Wine Training data set is 47.191011
23595505
The error rate of f1 = 4 f2 = 11 of Wine Testing data set is 50.5617977
5280899
The error rate of f1 = 4 f2 = 12 of Wine Training data set is 43.820224
71910113

The error rate of f1 = 4 f2 = 12 of Wine Testing data set is 44.9438202 247191

The error rate of f1 = 4 f2 = 13 of Wine Training data set is 24.719101 123595504

The error rate of f1 = 4 f2 = 13 of Wine Testing data set is 30.3370786 51685395

The error rate of f1 = 5 f2 = 6 of Wine Training data set is 56.1797752 8089888

The error rate of f1 = 5 f2 = 6 of Wine Testing data set is 44.94382022 47191

The error rate of f1 = 5 f2 = 7 of Wine Training data set is 56.1797752 8089888

The error rate of f1 = 5 f2 = 7 of Wine Testing data set is 41.57303370 786517

The error rate of f1 = 5 f2 = 8 of Wine Training data set is 57.3033707 8651685

The error rate of f1 = 5 f2 = 8 of Wine Testing data set is 46.06741573 033708

The error rate of f1 = 5 f2 = 9 of Wine Training data set is 56.1797752 8089888

The error rate of f1 = 5 f2 = 9 of Wine Testing data set is 44.94382022 47191

The error rate of f1 = 5 f2 = 10 of Wine Training data set is 49.438202 24719101

The error rate of f1 = 5 f2 = 10 of Wine Testing data set is 43.8202247 1910113

The error rate of f1 = 5 f2 = 11 of Wine Training data set is 57.303370 78651685

The error rate of f1 = 5 f2 = 11 of Wine Testing data set is 46.0674157 3033708

The error rate of f1 = 5 f2 = 12 of Wine Training data set is 56.179775 28089888

The error rate of f1 = 5 f2 = 12 of Wine Testing data set is 43.8202247 1910113

The error rate of f1 = 5 f2 = 13 of Wine Training data set is 24.719101 123595504

The error rate of f1 = 5 f2 = 13 of Wine Testing data set is 30.3370786 51685395

The error rate of f1 = 6 f2 = 7 of Wine Training data set is 22.4719101 1235955

The error rate of f1 = 6 f2 = 7 of Wine Testing data set is 24.71910112 3595504

The error rate of f1 = 6 f2 = 8 of Wine Training data set is 34.8314606 74157306

The error rate of f1 = 6 f2 = 8 of Wine Testing data set is 35.95505617 977528

The error rate of f1 = 6 f2 = 9 of Wine Training data set is 40.4494382
0224719

The error rate of f1 = 6 f2 = 9 of Wine Testing data set is 32.58426966
292135

The error rate of f1 = 6 f2 = 10 of Wine Training data set is 28.089887
64044944

The error rate of f1 = 6 f2 = 10 of Wine Testing data set is 22.4719101
1235955

The error rate of f1 = 6 f2 = 11 of Wine Training data set is 32.584269
66292135

The error rate of f1 = 6 f2 = 11 of Wine Testing data set is 28.0898876
4044944

The error rate of f1 = 6 f2 = 12 of Wine Training data set is 24.719101
123595504

The error rate of f1 = 6 f2 = 12 of Wine Testing data set is 25.8426966
29213485

The error rate of f1 = 6 f2 = 13 of Wine Training data set is 24.719101
123595504

The error rate of f1 = 6 f2 = 13 of Wine Testing data set is 30.3370786
51685395

The error rate of f1 = 7 f2 = 8 of Wine Training data set is 16.8539325
84269664

The error rate of f1 = 7 f2 = 8 of Wine Testing data set is 24.71910112
3595504

The error rate of f1 = 7 f2 = 9 of Wine Training data set is 16.8539325
84269664

The error rate of f1 = 7 f2 = 9 of Wine Testing data set is 26.96629213
483146

The error rate of f1 = 7 f2 = 10 of Wine Training data set is 21.348314
60674157

The error rate of f1 = 7 f2 = 10 of Wine Testing data set is 15.7303370
78651685

The error rate of f1 = 7 f2 = 11 of Wine Training data set is 15.730337
078651685

The error rate of f1 = 7 f2 = 11 of Wine Testing data set is 24.7191011
23595504

The error rate of f1 = 7 f2 = 12 of Wine Training data set is 13.483146
06741573

The error rate of f1 = 7 f2 = 12 of Wine Testing data set is 17.9775280
8988764

The error rate of f1 = 7 f2 = 13 of Wine Training data set is 24.719101
123595504

The error rate of f1 = 7 f2 = 13 of Wine Testing data set is 30.3370786
51685395

The error rate of f1 = 8 f2 = 9 of Wine Training data set is 42.6966292
1348314

The error rate of f1 = 8 f2 = 9 of Wine Testing data set is 47.19101123595505

The error rate of f1 = 8 f2 = 10 of Wine Training data set is 30.337078651685395

The error rate of f1 = 8 f2 = 10 of Wine Testing data set is 23.595505617977526

The error rate of f1 = 8 f2 = 11 of Wine Training data set is 33.70786516853933

The error rate of f1 = 8 f2 = 11 of Wine Testing data set is 34.831460674157306

The error rate of f1 = 8 f2 = 12 of Wine Training data set is 40.44943820224719

The error rate of f1 = 8 f2 = 12 of Wine Testing data set is 32.58426966292135

The error rate of f1 = 8 f2 = 13 of Wine Training data set is 24.719101123595504

The error rate of f1 = 8 f2 = 13 of Wine Testing data set is 30.3370786651685395

The error rate of f1 = 9 f2 = 10 of Wine Training data set is 30.337078651685395

The error rate of f1 = 9 f2 = 10 of Wine Testing data set is 24.719101123595504

The error rate of f1 = 9 f2 = 11 of Wine Training data set is 37.07865168539326

The error rate of f1 = 9 f2 = 11 of Wine Testing data set is 39.325842696629216

The error rate of f1 = 9 f2 = 12 of Wine Training data set is 34.831460674157306

The error rate of f1 = 9 f2 = 12 of Wine Testing data set is 31.46067415730337

The error rate of f1 = 9 f2 = 13 of Wine Training data set is 24.719101123595504

The error rate of f1 = 9 f2 = 13 of Wine Testing data set is 30.3370786651685395

The error rate of f1 = 10 f2 = 11 of Wine Training data set is 30.337078651685395

The error rate of f1 = 10 f2 = 11 of Wine Testing data set is 23.595505617977526

The error rate of f1 = 10 f2 = 12 of Wine Training data set is 26.96629213483146

The error rate of f1 = 10 f2 = 12 of Wine Testing data set is 22.47191011235955

The error rate of f1 = 10 f2 = 13 of Wine Training data set is 24.719101123595504

The error rate of f1 = 10 f2 = 13 of Wine Testing data set is 30.337078651685395

The error rate of f1 = 11 f2 = 12 of Wine Training data set is 40.44943
820224719
The error rate of f1 = 11 f2 = 12 of Wine Testing data set is 32.584269
66292135
The error rate of f1 = 11 f2 = 13 of Wine Training data set is 24.71910
1123595504
The error rate of f1 = 11 f2 = 13 of Wine Testing data set is 30.337078
651685395
The error rate of f1 = 12 f2 = 13 of Wine Training data set is 24.71910
1123595504
The error rate of f1 = 12 f2 = 13 of Wine Testing data set is 30.337078
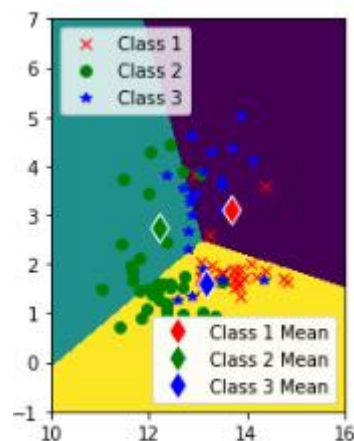651685395

Yes, there is a significant difference in the error rates. Because-
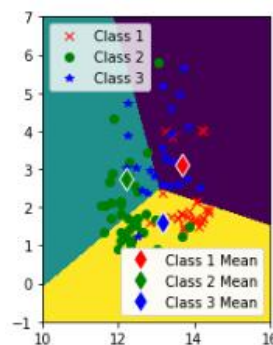- o **Each pair of features differentiates the data into three classes
  uniquely.**

**But, the data can be easily and best differentiated with Feature 1 and Feat
ure 12.**

1.d)

As seen in 1.e), the error rates are minimum for Feature 1 and Feature 12.

*Fig 6. Plot of Wine Training-set along with Class Means, Decision Boundaries and Decision Regions
for best two features*

*Fig 6. Plot of Wine Testing-set along with Class Means, Decision Boundaries and Decision Regions for
best two features*