

# Pattern Recognition Assignment III

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## 1 Visual Inference

### Intuition and Inference

Given data is non linearly separable. Also, we could infer that we may need ample amount of Gaussian Mixtures to approximate the given data. Idea is to increase the Gaussian mixtures till we can classify the given data properly.

## 2 Synthetic Data

### 2.1 Classification with Full Covariance

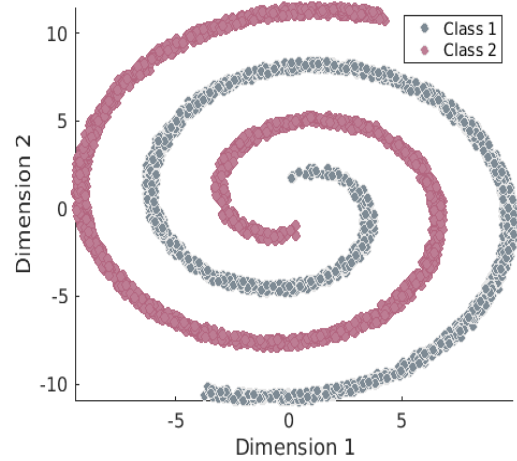
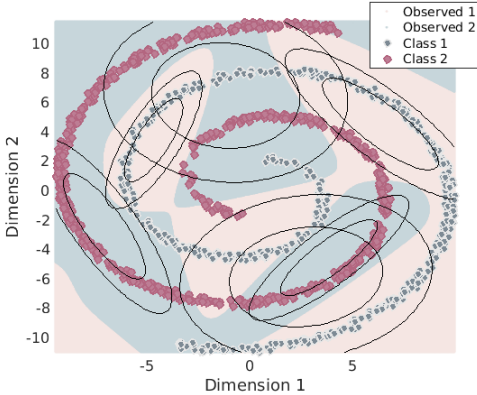
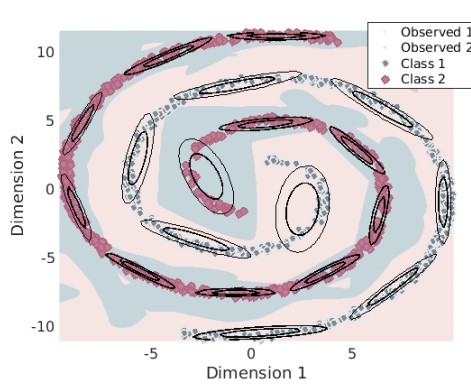


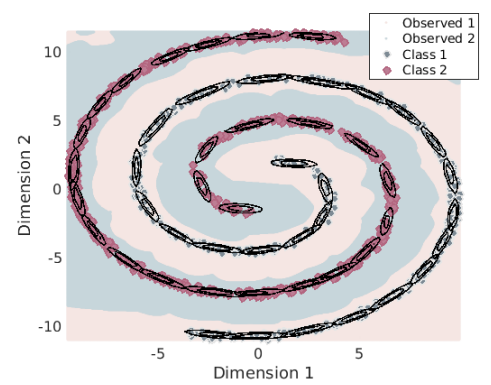
Figure 1: Visualization of Data



(a) Three Gaussian Mixtures for each Class



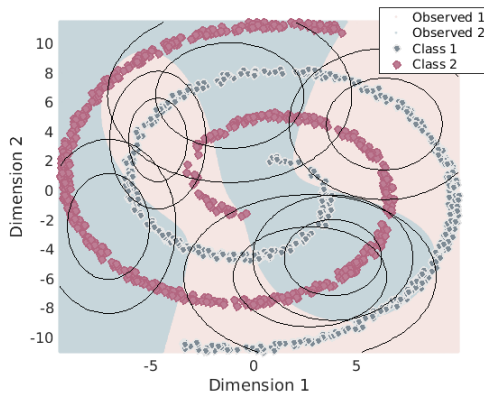
(b) Eight and Eleven Gaussian Mixtures for first and second Class



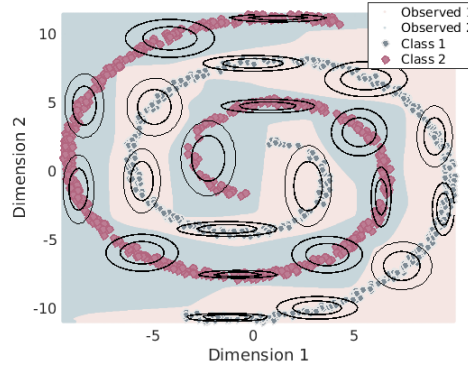
(c) Twenty five Gaussian Mixtures for each Class

Figure 2: Classification with Full Covariance

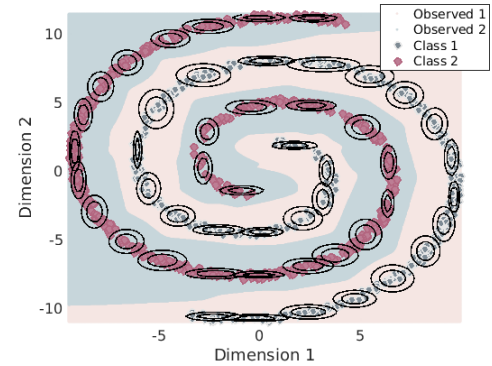
## 2.2 Classification with Diagonal Covariance



(a) Three Gaussian Mixtures for each Class



(b) Eleven Gaussian Mixtures for each Class



(c) Twenty five Gaussian Mixtures for each Class

Figure 3: Classification with Diagonal Covariance

## 2.3 Analysis

Mixtures	2	3	5	8	10	11	15
2	59%	74%	84%	94%	96%	97%	94%
3	71%	85%	93%	97%	98%	98%	99%
5	85%	93%	97%	98%	98%	99%	99%
8	96%	97%	97%	98%	99%	99%	100%
10	96%	98%	98%	99%	99%	100%	100%
15	98%	99%	99%	100%	100%	100%	100%

(a) Accuracy on Various Gaussian Mixtures with Full Covariance

Mixtures	2	3	5	10	11	15
2	63%	64%	79%	93%	95%	94%
3	67%	70%	82%	94%	95%	95%
5	77%	81%	86%	96%	97%	97%
8	92%	92%	95%	99%	99%	99%
10	94%	94%	96%	99%	99%	99%
15	95%	96%	98%	99%	100%	100%

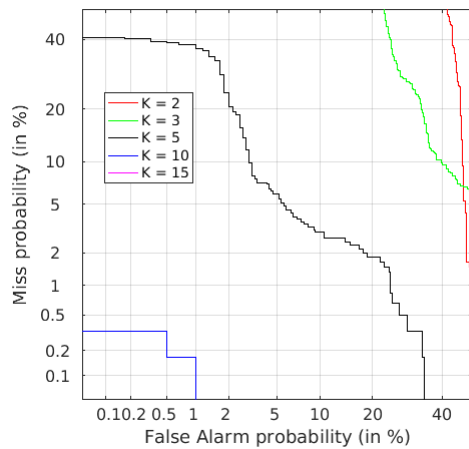
(b) Accuracy on Various Gaussian Mixtures with Diagonal Covariance

Table 1: Classification accuracy for Synthetic Data with various Gaussian Mixtures

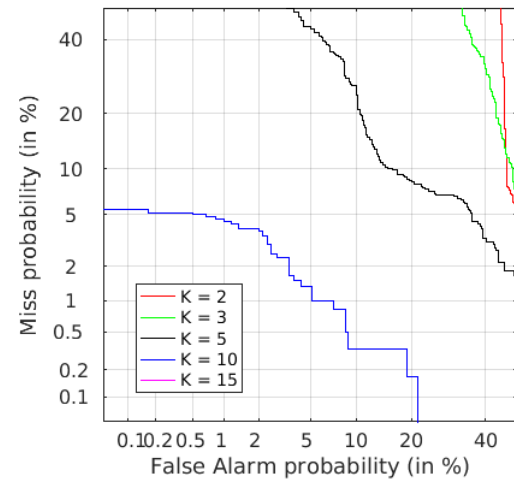
### Intuition and Inference

- From the accuracy table shown above, we can infer that, as we increase the Gaussian mixtures, accuracy increases.
- Since we are getting cent percent accuracy we are presenting DET curves alone for synthesized data.
- DET curves for Gaussian mixtures with full covariance and diagonal covariance is shown below.

## Analysis on Gaussian Mixtures with Full Covariance



(a) DET Curves for various Gaussian mixtures with full covariance



(b) DET Curves for various Gaussian mixtures with diagonal covariance

Figure 4: Classification Synthesis Data

## 2.4 Inference

- As we increase the Gaussian mixtures, we tend to have a better classification.
- For Gaussian mixtures with full covariance, it is enough to approximate the data with Eleven mixtures to get cent percent accuracy. For Gaussian mixtures with diagonal covariance, it is enough to approximate the data with Fifteen mixtures to get cent percent accuracy.
- On the other hand, increase in Gaussian mixture needs a large amount of data for covariance estimation.
- As expected, Gaussian mixtures with full covariance performs better than Gaussian mixtures with diagonal covariance. Accuracy and DET curves obtained evidently the inference.
- For the same number of Gaussian mixtures, Decision region for Gaussian mixtures with diagonal covariance is smoother than that of Gaussian mixtures with full covariance.

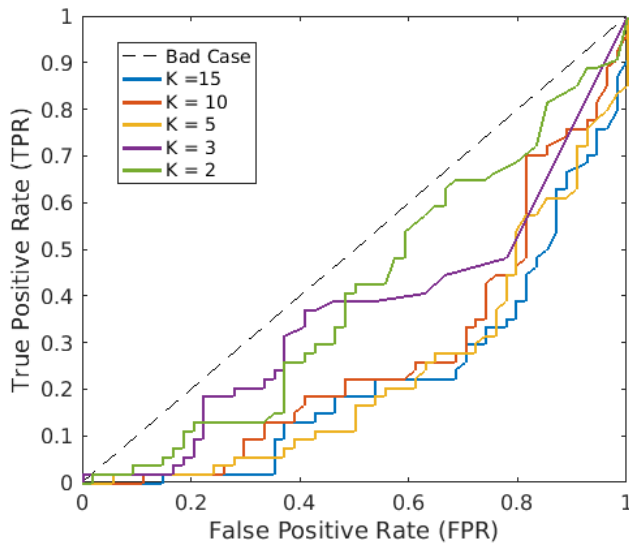
## 3 Image Data

### Intuition and Inference

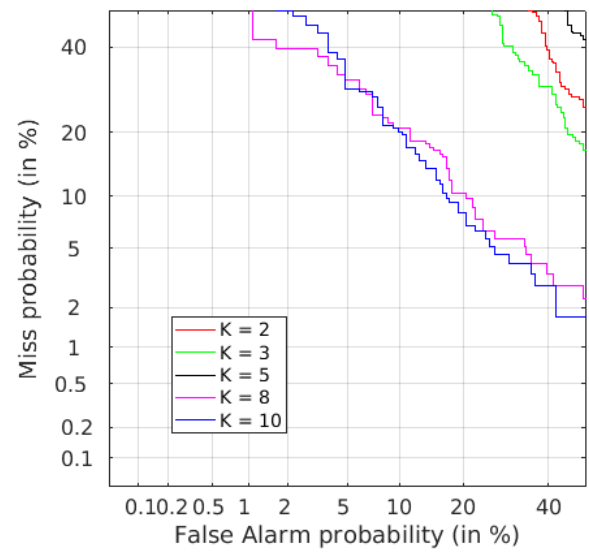
As we have 36 feature vectors for each image, we estimate maximum likelihood for each class and classify the image to the class which gives maximum voting or average.

- We train the Gaussian mixtures till mixtures converges or till reaching certain number of iteration.
- We classify the images based on voting method.

### 3.1 Classification with Full Covariance



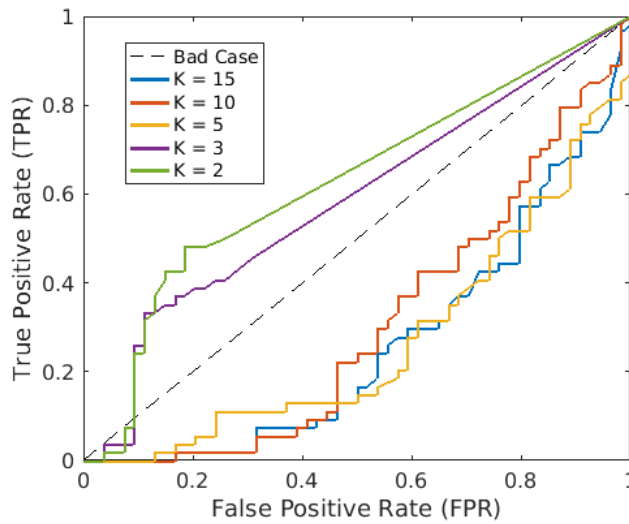
(a) ROC Curves for various Gaussian mixtures with full covariance



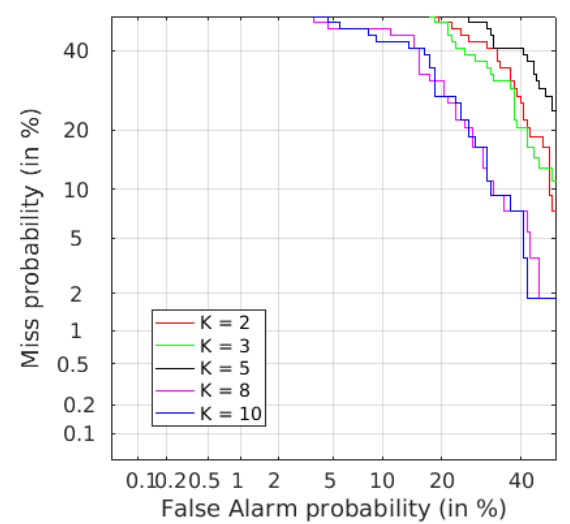
(b) DET Curves for various Gaussian mixtures with full covariance

Figure 5: Classification with Full Covariance

### 3.2 Classification with Diagonal Covariance



(a) ROC Curves for various Gaussian mixtures with diagonal covariance



(b) DET Curves for various Gaussian mixtures with diagonal covariance

Figure 6: Classification with Diagonal Covariance

### 3.3 Analysis

#### Classification Accuracy

	Target Classes			
	1	2	3	
Predicted Classes	1	45	9	0
	2	5	42	7
	3	0	2	52

(a) Accuracy on Various Gaussian Mixtures with Full Covariance

	Target Classes			
	1	2	3	
Predicted Classes	1	48	6	0
	2	24	18	12
	3	0	2	52

(b) Accuracy on Various Gaussian Mixtures with Diagonal Covariance

Table 2: Classification accuracy for Synthetic Data with various Gaussian Mixtures

### 3.4 Inference

- We performed the score normalization using Z score norm and T norm. For the given image data, T norm performed comparatively better than Z score norm.
- We got 72.8% of accuracy and 82.8% of accuracy by Gaussian Mixtures with diagonal covariance and full covariance respectively.
- As expected, Gaussian mixtures with full covariance performs better than Gaussian mixtures with diagonal covariance.
- In Gaussian Mixtures with diagonal covariance, most of the class two images are predicted to class one. But, this is not a case in Gaussian mixtures with full covariance.

## 4 References

- Bishop, Christopher M., "Pattern Recognition and Machine Learning", Information Science and Statistics, 2006.
- R.O.Duda, P.E.Hart and D.G.Stork, "Pattern Classification", John Wiley, 2001.
- Martin, A and R. Doddington, George and Kamm, Terri and Ordowski, Mark and Przybocki, Mark, "The DET curve in assessment of decision task performance", Fifth European Conference on Speech Communication and Technology, EUROSPEECH 1997.
- <https://www.mathworks.com/>
- NIST DETWare