

Pattern Recognition

Programming Assignment 2

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1 Introduction

A Gaussian Mixture Model (GMM) is a parametric probability density function represented as a weighted sum of Gaussian component densities. GMMs are commonly used as a parametric model of the probability distribution of continuous measurements or features in a biometric system, such as vocal-tract related spectral features in a speaker recognition system.

GMM parameters are estimated from training data using the iterative Expectation-Maximization (EM) algorithm or Maximum A Posteriori (MAP) estimation from a well-trained prior model.

A Gaussian mixture model is a weighted sum of M component Gaussian densities as given by the equation

$$p(x|\lambda) = \sum w_i g(x|\mu_i, \Sigma).$$

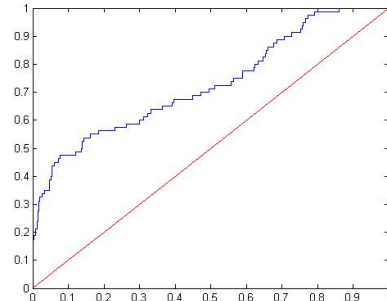
2 Observations and Plots

2.1 Gaussian Mixture Model (GMM)

The following are the Confusion matrix and ROC plots :

IMAGE DATA SET :

Confusion Matrix									
Output Class	1	2	3	4	5	6	7	8	
	17 2.7%	0 0.0%	3 0.5%	1 0.2%	1 0.2%	0 0.0%	1 0.2%	1 0.2%	70.8%
	30 4.7%	70 10.9%	34 5.3%	21 3.3%	20 3.1%	65 10.2%	22 3.4%	23 3.6%	24.6%
	4 0.6%	0 0.0%	19 3.0%	8 1.3%	2 0.3%	0 0.0%	0 0.0%	3 0.5%	52.8%
	1 0.2%	0 0.0%	2 0.3%	10 1.6%	0 0.0%	0 0.0%	2 0.3%	4 0.6%	47.2%
	16 2.5%	6 0.9%	10 1.6%	12 1.9%	51 8.0%	6 0.9%	10 1.6%	27 4.2%	37.0%
	12 1.9%	4 0.6%	6 0.9%	1 0.2%	4 0.6%	8 1.3%	0 0.0%	4 0.6%	20.5%
	0 0.0%	0 0.0%	6 0.9%	26 4.1%	2 0.3%	1 0.2%	45 7.0%	11 1.7%	49.5%
	0 0.0%	0 0.0%	0 0.0%	1 0.2%	0 0.0%	0 0.0%	0 0.0%	7 1.1%	87.5%
									35.5%
									64.5%
									Target Class



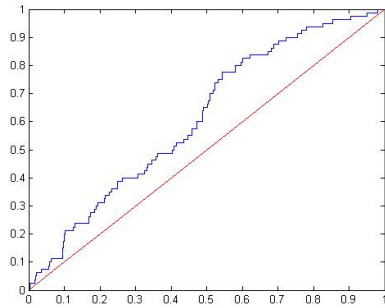
2.2 Parzen Window Method (Gaussian Kernel)

The following are the Confusion matrix and ROC plots :

Confusion Matrix

1	11 1.4%	0 0.0%	12 1.5%	5 0.6%	10 1.3%	9 1.1%	1 0.1%	2 0.3%	22.0%
2	56 7.0%	95 11.9%	31 3.9%	33 4.1%	39 4.9%	40 5.0%	29 3.6%	28 3.5%	27.1%
3	4 0.5%	0 0.0%	13 1.6%	0 0.0%	5 0.6%	16 2.0%	6 0.8%	3 0.4%	27.7%
4	5 0.6%	0 0.0%	20 2.5%	41 5.1%	20 2.5%	15 1.9%	22 2.8%	12 1.5%	30.4%
5	14 1.8%	4 0.5%	13 1.6%	4 0.5%	13 1.6%	10 1.3%	14 1.8%	30 3.8%	12.7%
6	8 1.0%	0 0.0%	2 0.3%	1 0.1%	5 0.6%	1 0.1%	2 0.3%	1 0.1%	5.0%
7	2 0.3%	1 0.1%	9 1.1%	16 2.0%	8 1.0%	8 1.0%	26 3.3%	24 3.0%	27.7%
8	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 0.1%	0 0.0%	0 0.0%	0.0%
	11.0% 39.0%	95.0% 5.0%	13.0% 87.0%	41.0% 87.0%	13.0% 87.0%	1.0% 99.0%	26.0% 74.0%	0.0% 100%	25.0% 75.0%
	1	2	3	4	5	6	7	8	

Target Class



s

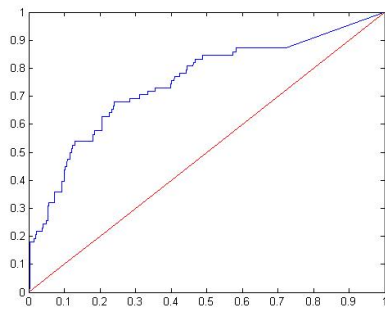
2.3 Parzen Window Method (Spherical Kernel)

The following are the Confusion matrix and ROC plots :

Confusion Matrix

1	32 4.0%	1 0.1%	14 1.8%	26 3.3%	35 4.4%	23 2.9%	29 3.6%	31 3.9%	16.8%
2	20 2.5%	83 10.4%	5 0.6%	16 2.0%	14 1.8%	21 2.6%	11 1.4%	8 1.0%	46.6%
3	15 1.9%	2 0.3%	32 4.0%	9 1.1%	7 0.9%	9 1.1%	4 0.5%	9 1.1%	36.8%
4	4 0.5%	3 0.4%	6 0.8%	26 3.3%	10 1.3%	8 1.0%	16 2.0%	5 0.6%	33.3%
5	12 1.5%	2 0.3%	11 1.4%	3 0.4%	26 3.3%	8 1.0%	4 0.5%	10 1.3%	34.2%
6	13 1.6%	6 0.8%	16 2.0%	7 0.9%	1 0.1%	20 2.5%	3 0.4%	4 0.5%	28.6%
7	2 0.3%	3 0.4%	13 1.6%	9 1.1%	6 0.8%	2 0.3%	25 3.1%	17 2.1%	32.5%
8	2 0.3%	0 0.0%	3 0.4%	4 0.5%	1 0.1%	9 1.1%	8 1.0%	16 2.0%	37.2%
	32.0% 68.0%	33.0% 17.0%	32.0% 68.0%	26.0% 74.0%	26.0% 74.0%	20.0% 80.0%	25.0% 75.0%	16.0% 84.0%	32.5% 67.5%
	1	2	3	4	5	6	7	8	

Target Class



S

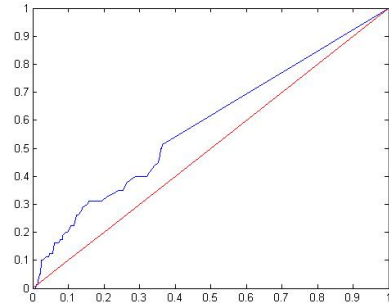
2.4 Perceptron Method

The following are the Confusion matrix and ROC plots :

Confusion Matrix

	1	2	3	4	5	6	7	8	
1	0	0	0	0	0	0	0	0	NaN%
2	23	49	3	8	6	37	4	8	35.5%
3	35	15	75	65	25	29	70	39	21.2%
4	0	0	0	0	0	0	0	0	NaN%
5	22	16	2	7	49	14	6	33	32.9%
6	0	0	0	0	0	0	0	0	NaN%
7	0	0	0	0	0	0	0	0	NaN%
8	0	0	0	0	0	0	0	0	NaN%
	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	NaN%
	100%	38.7%	6.3%	100%	61.3%	38.7%	100%	100%	73.0%
	1	2	3	4	5	6	7	8	

Target Class



S

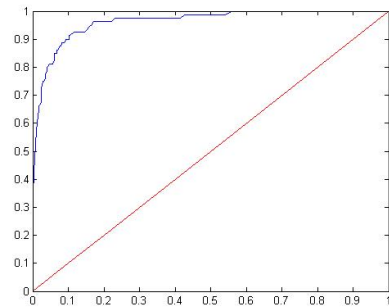
2.5 SVM Method

The following are the Confusion matrix and ROC plots :

Confusion Matrix

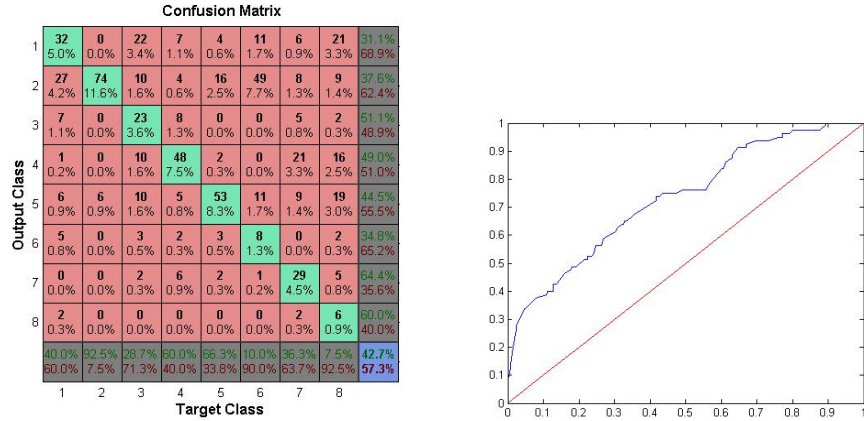
	1	2	3	4	5	6	7	8	
1	57	1	6	1	0	4	1	1	80.3%
2	14	71	1	3	5	42	2	5	49.7%
3	2	0	50	0	0	0	1	0	94.3%
4	0	0	6	64	2	3	8	8	70.3%
5	4	8	5	0	67	7	7	6	64.4%
6	2	0	6	2	3	22	0	2	59.5%
7	1	0	5	9	3	2	57	7	67.9%
8	0	0	1	1	0	0	4	51	89.6%
	8.9%	0.2%	0.9%	0.2%	0.0%	0.6%	0.2%	0.2%	19.7%
	2.2%	11.1%	0.2%	0.5%	0.6%	6.6%	0.3%	0.8%	50.3%
	0.3%	0.0%	7.6%	0.0%	0.0%	0.0%	0.2%	0.0%	5.7%
	0.0%	0.0%	0.9%	10.0%	0.3%	0.5%	1.3%	1.3%	29.7%
	0.6%	1.3%	0.8%	0.0%	10.5%	1.1%	1.1%	0.9%	35.6%
	0.3%	0.0%	0.9%	0.3%	0.5%	3.4%	0.0%	0.3%	40.5%
	0.2%	0.0%	0.8%	1.4%	0.5%	0.3%	8.9%	1.1%	32.1%
	0.0%	0.0%	0.2%	0.2%	0.0%	0.0%	0.6%	8.0%	10.5%
	71.3%	88.8%	62.5%	80.0%	83.8%	27.5%	71.3%	63.7%	68.6%
	28.7%	11.3%	37.5%	20.0%	16.2%	72.5%	28.7%	36.3%	31.4%
	1	2	3	4	5	6	7	8	

Target Class



2.6 K-Nearest Neighbors Method

The following are the Confusion matrix and ROC plots :



3 Observations

From the above confusion matrices we can observe the following :

- 1] The accuracy of the image dataset is 35.5% using GMM.
- 2] The accuracy of the image dataset is 25% using parzen window method with a gaussian kernel.
- 3] The accuracy of the image dataset is 32.5% using parzen window method with a spherical kernel.
- 4] The accuracy of the image dataset is 27% using perceptron method.
- 5] The accuracy of the image dataset is 27% using k-nearest neighbor 42.7% method.
- 6] The accuracy of the image dataset is 68.6% using svm method.

4 Conclusions

From the above observations and experiments it can be seen that SVMs perform better in spacial datasets. Even k-nearest neighbors method is also better than perceptron and parzen window methods.