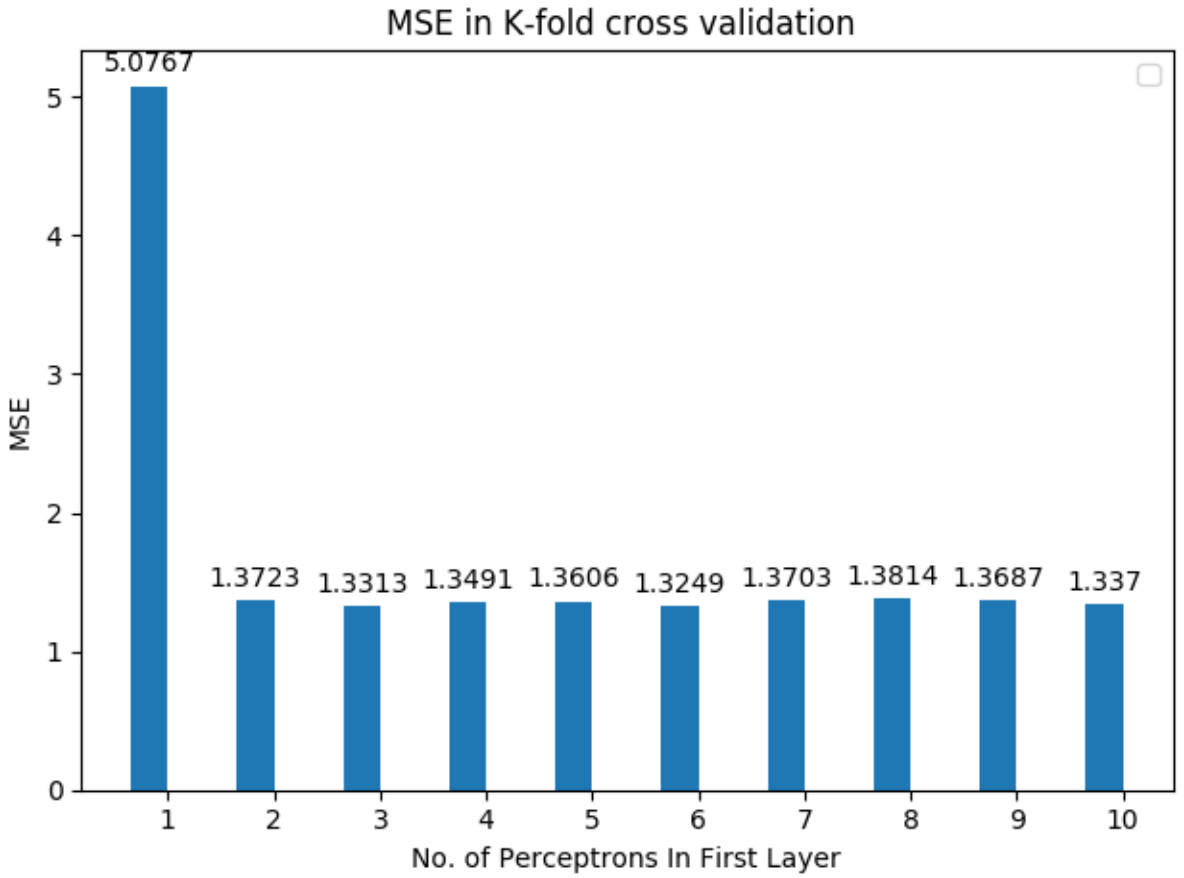
Question 1:

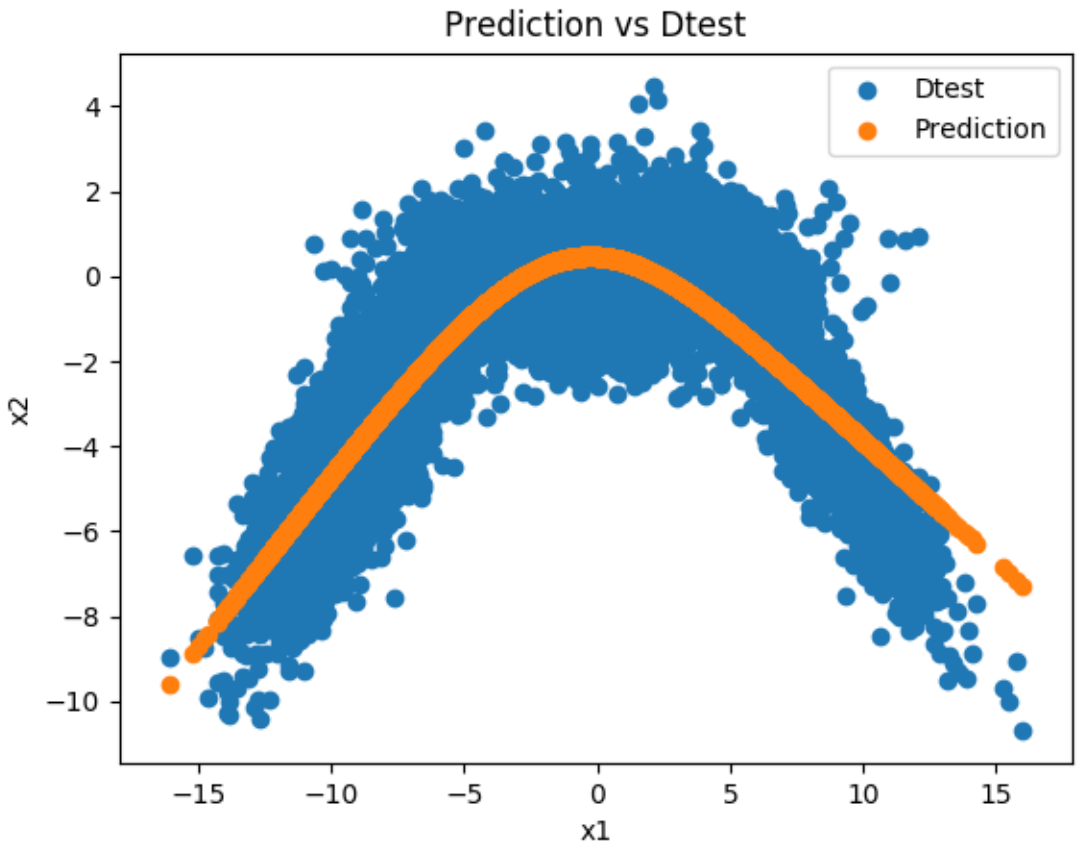
The problem is to estimate X2 with X1 using MLP whose output approximates expected value of X2 given X1. The MLP has one hidden layer with softplus activation function. The number of perceptrons is the hidden layer is determined by k-fold cross validation.

There are 10 competing models (1-10 perceptrons in the hidden layer). Each model is trained with an objective to minimize Mean Square Error(MSE). 10-fold cross validation is performed for model selection. In every fold, the dataset is split for training and validation, the models are trained to minimize MSE loss using training set, MSE is calculated for the validation set and this value is averaged for all 10 folds. This gives the performance measure for every competing model. The model with the least avg mean square error is selected and again trained with entire training data samples.

This model is evaluated on the validation set with 10k samples and MSE is calculated.



Selected No. of Perceptrons: 6 **Corresponding MSE:** 1.3249

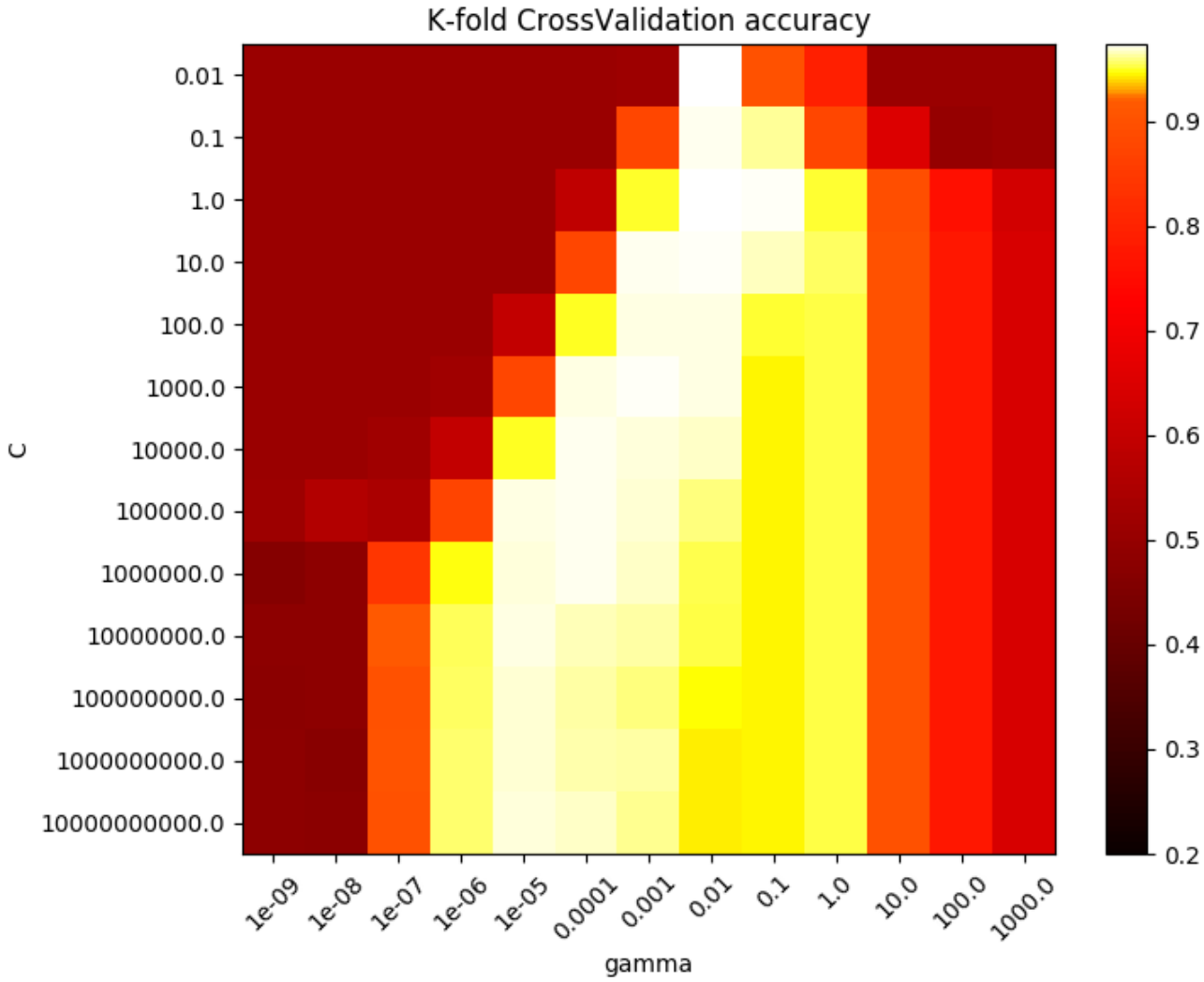


MSE on Dtest: 1.4967

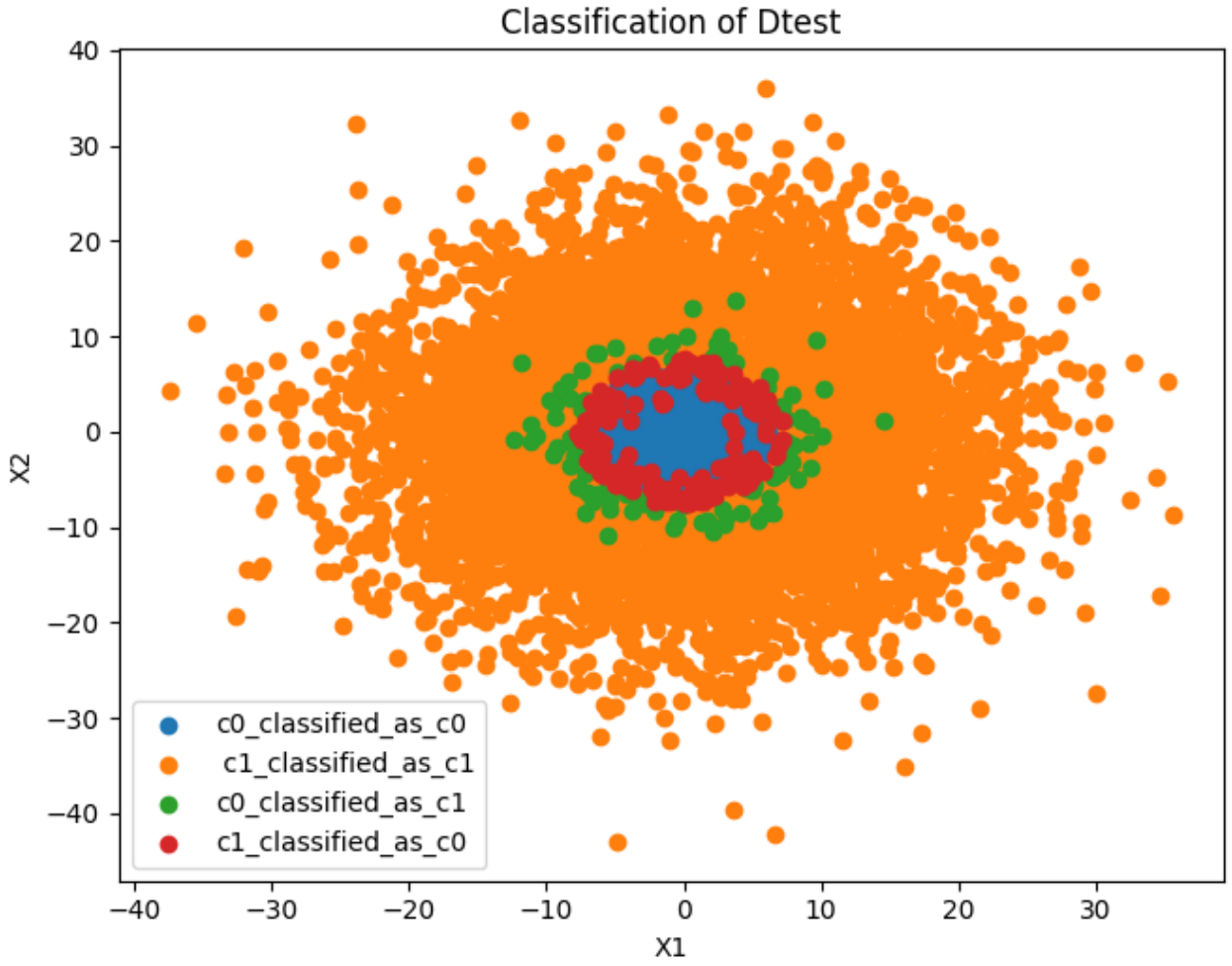
Question 2:

The problem is to classify 2D real vectors into 2 classes using Support Vector Machines with Gaussian/RBF kernel. 10-fold cross validation is performed to find the best hyperparameter C and gaussian kernel width parameter sigma using the training dataset with 1k samples.

In every fold of 10-fold cross validation, the ratio of number_of_correct_classifications/total_no_samples is calculated and this value is averaged for all 10 folds. This gives the performance measure for every competing model. The model with greatest performance measure is selected and again trained with entire training data samples and evaluated using 10k validation samples.



Selected hyperparameter C: 1 **Sigma:** 0.01 **Corresponding Accuracy:** 0.97

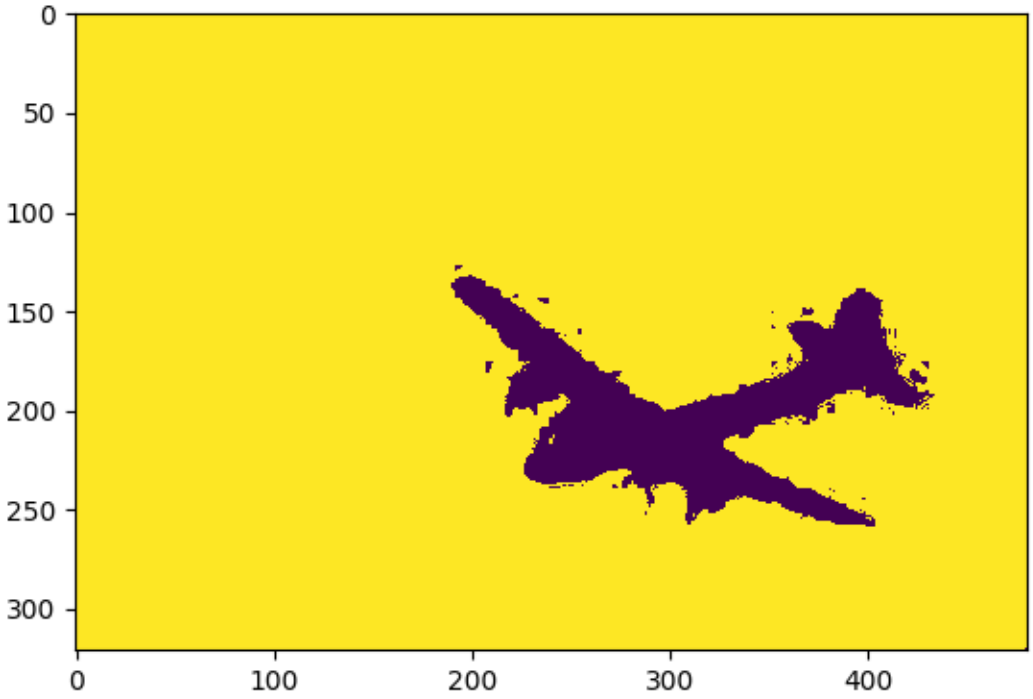


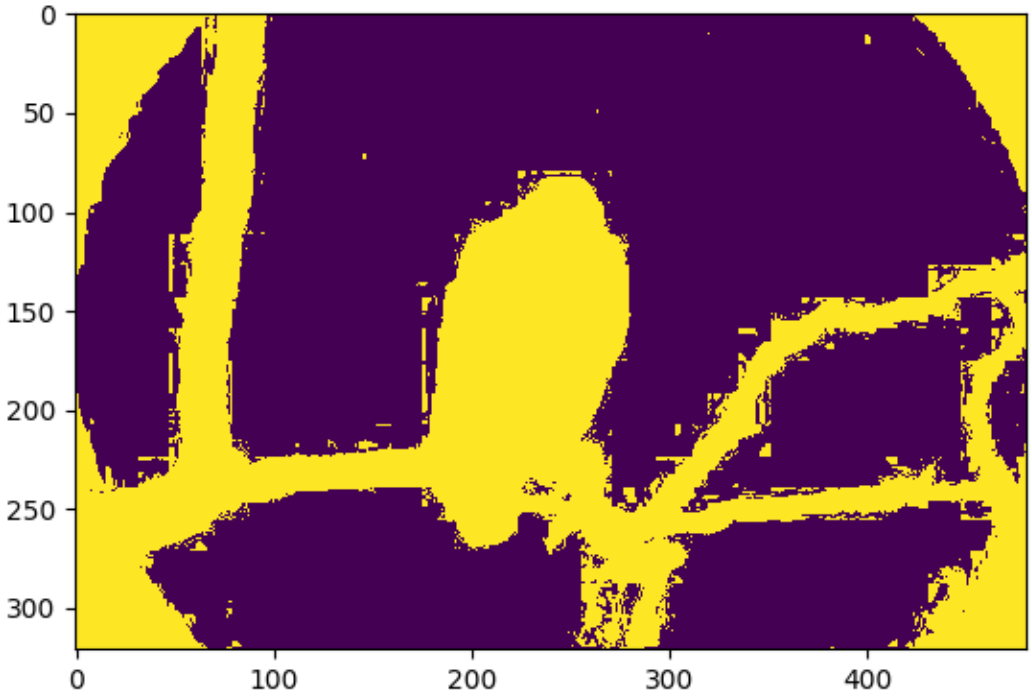
Probability of correct classification on validation set: 0.9732

		Decision	
		0	**1**
True Label	**0**	4971	99
	1	169	4761

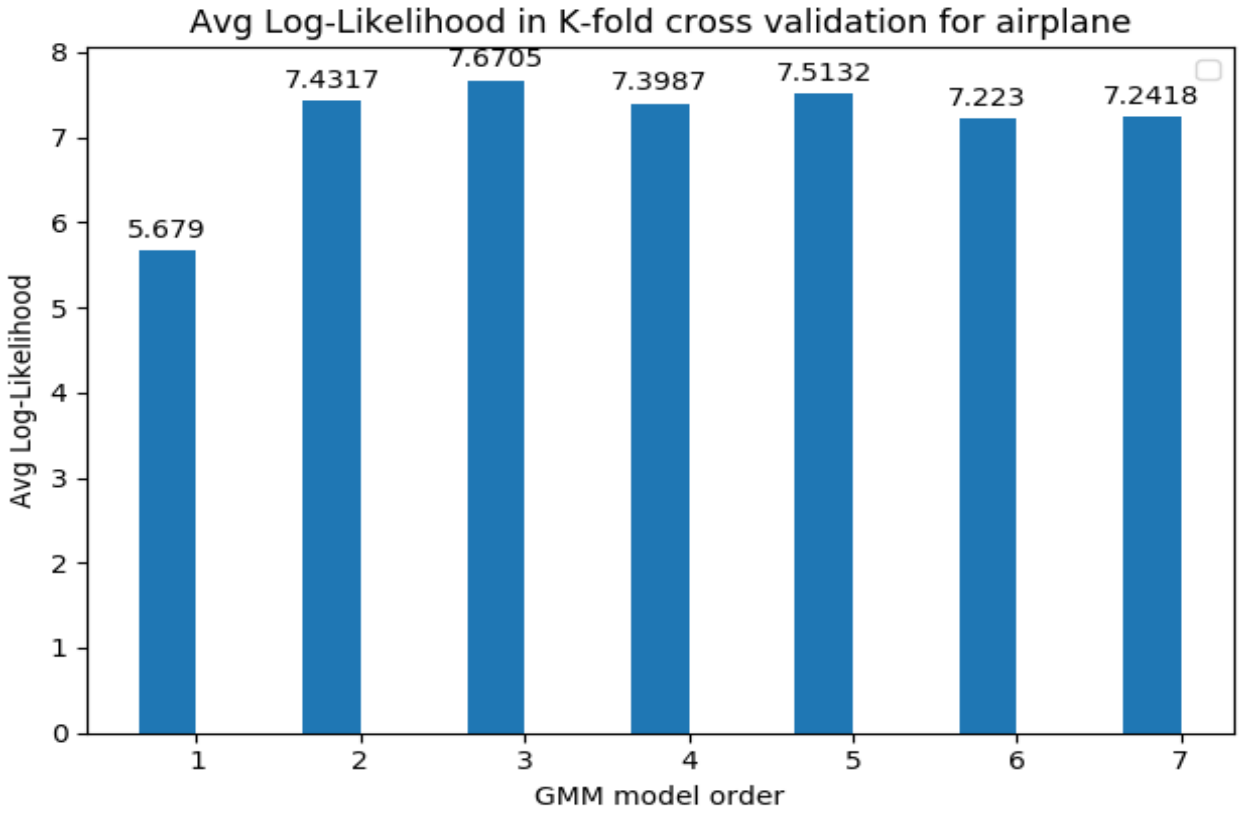
Question 3:

1) The given images are converted to 5D vectors(by appending the row and column index, and normalizing) which forms our dataset. The dataset is modelled as GMM with two components. The parameters of GMM are estimated using Expectation Maximization algorithm which performs maximum likelihood parameter estimation. Every sample in a dataset is classified into two classes using MAP rule where each component of GMM is a class conditional pdf. The following images show the result for the bird image and airplane image.

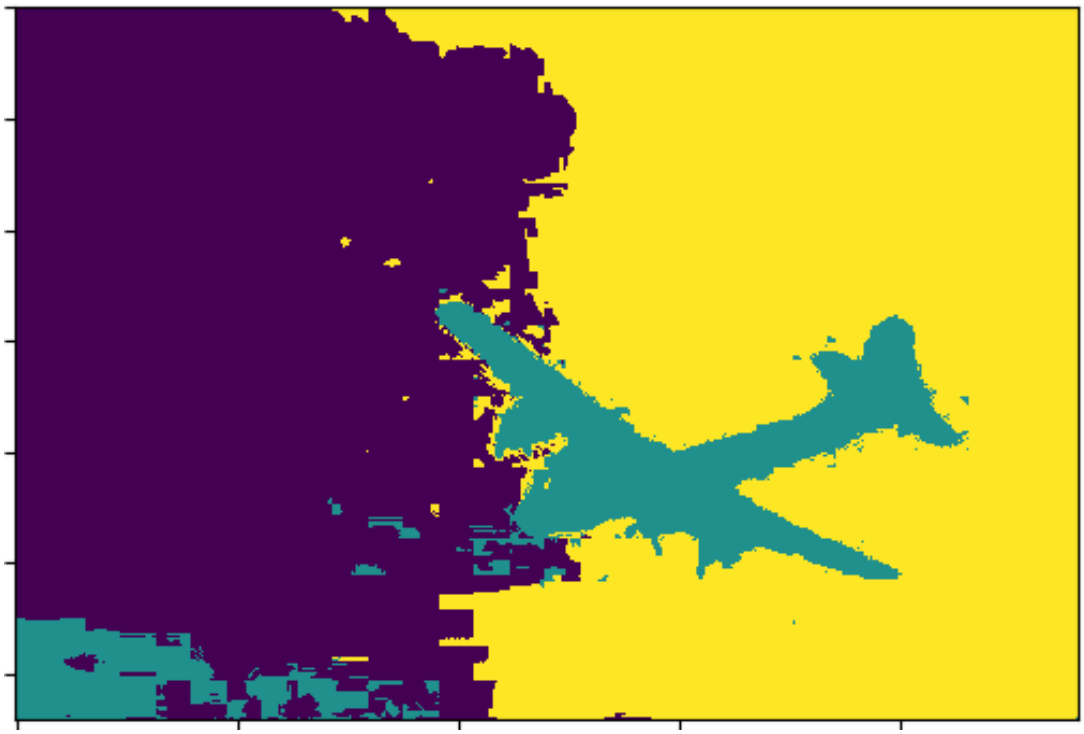


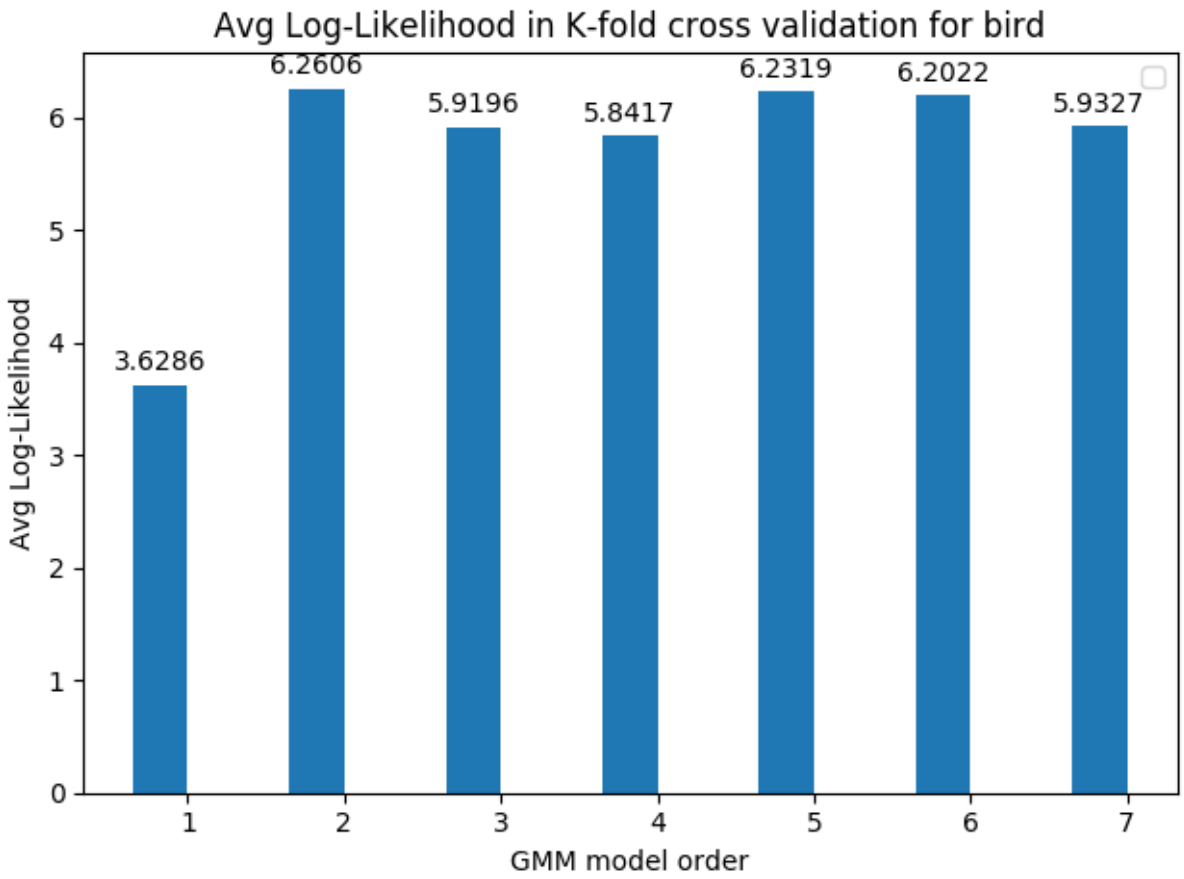


2) In this step, 10-fold cross validation is performed to select an optimal model order for the class conditional PDFs. The GMM parameters are estimated using Expectation-Maximization. The model(for class conditional PDFs) which has maximum average log-likelihood for validation data is selected in the K-fold step. Then the selected model's parameters are estimated using EM using the entire training data and classified using MAP rule into number of classes which equals to the number of components in the GMM.



Selected Model Order for airplane: 3 **Corresponding avg log-likelihood:** 7.6705





Selected Model Order for bird: 2 **Corresponding avg log-likelihood:** 6.2606

CODE LINK: https://github.com/veeraragav/EECE5644_Into_To_ML/tree/master/Assignment_4