Machine Learning for Computer Vision (EE5177)
Programming Assignment #2

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EE14B127

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Contents

1 Fitting Gaussian Mixture Models using the EM Algorithm

1.1 Goal

The objective of this problem is to do face detection by fitting Gaussian Mixture Models (GMMs) using Expectation Maximization (EM) Algorithm.

1.2 Approach

The data is provided in the form of 22 x 22 images and a training set of 800 faces and 800 non faces is provided. We fit a Gaussian Mixture Model on the training data using the gmdistribution.fit function in MATLAB. We constrict the covariance matrix to be a diagonal which reduces our estimation order to n components instead of $O(n^2)$. To avoid ill-conditioned covariance matrices,we use the following precautions :

- Set 'CovType' to 'diagonal'
- Set 'SharedCov' to true to use an equal covariance matrix for every component
- Use 'Regularize' to add a very small positive number(0.01) to the diagonal of every covariance matrix

We fit the data for number of components in GMM as 1,2 and 3 and report the accuracies.

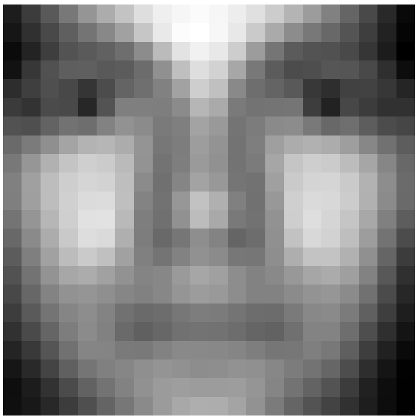
1.3 Results

1.3.1 GMM with 1 component

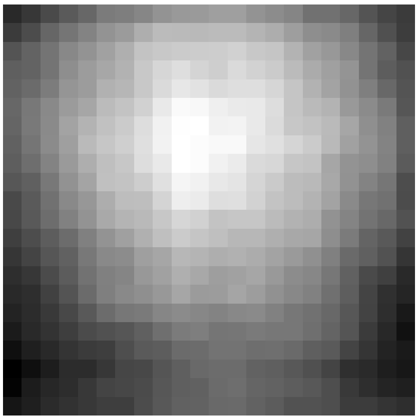
Accuracy Obtained
The accuracy obtained on the test data of 496 data points using the GMM fit with 1 component is **82.056452%**.

Visualization of the Means for 1 Components

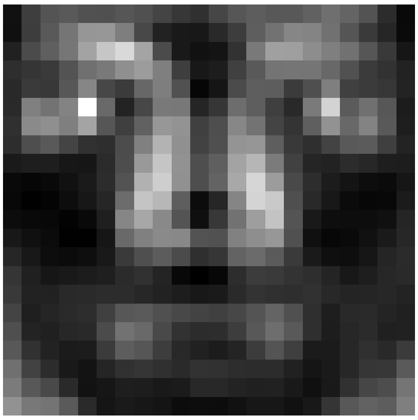
Visualization of the mean of face data fitted with 1 component:



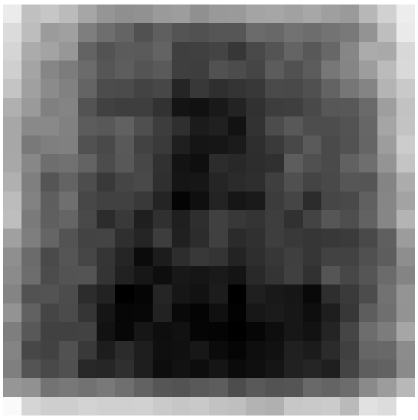
Visualization of the mean of non face data fitted with 1 component:



Visualization of the covariance of face data fitted with 1 component:



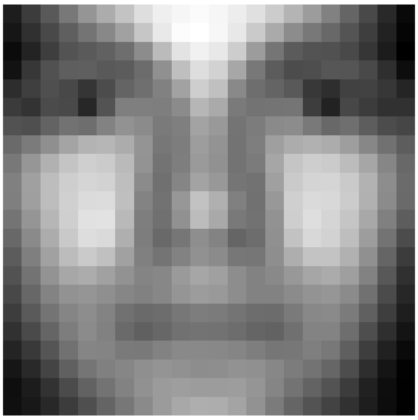
Visualization of the covariance of non face data fitted with 1 component:



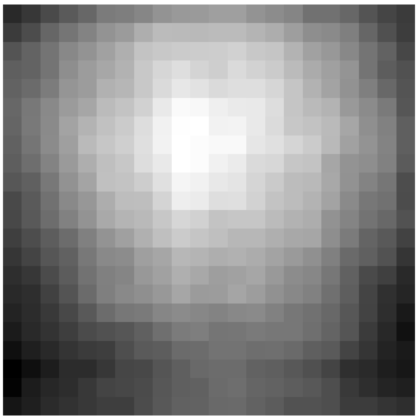
1.3.2 GMM with 2 components

Accuracy Obtained
The accuracy obtained on the test data of 496 data points using the GMM fit with 2 components is **92.338710%**.

Visualization of the Means for 2 Components
Visualization of the mean of face data fitted with 2 components:



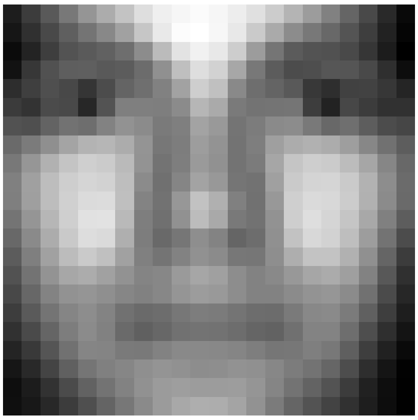
Visualization of the mean of non face data fitted with 2 components:



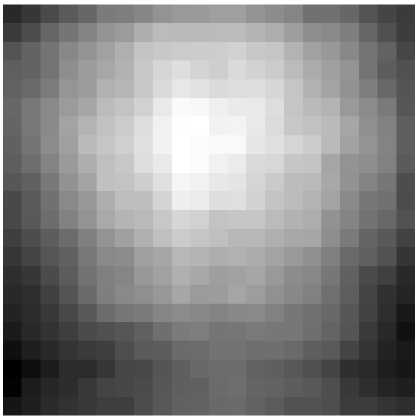
1.3.3 GMM with 3 components

Accuracy Obtained
The accuracy obtained on the test data of 496 data points using the GMM fit with 3 components is **93.145161%**.

Visualization of the Means for 3 Components
Visualization of the mean of face data fitted with 3 components:



Visualization of the mean of non face data fitted with 3 components:



2 K-means Clustering Algorithm

2.1 Goal

In this problem, we study the K-means clustering algorithm which aims to assign every point in a data set to one of the clusters so as to minimize the sum of the distance of each point to its cluster's centroid.

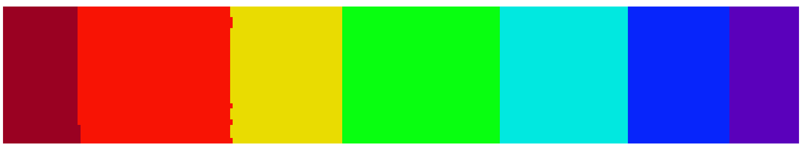
2.2 Approach

The approach to the problem is well-defined in problem statement and is not repeated here for the purposes of brevity.

2.3 Results

2.3.1 Question A

The segmented image with the initial mean values from pixels equally spaced in the horizontal direction in the centre row of the image is shown below.



2.3.2 Question B

The segmented image with the initial mean values selected randomly are shown below.

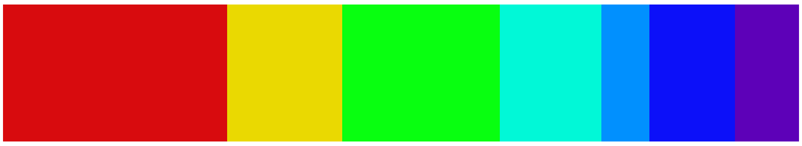


Figure 1: Random Initialization 1

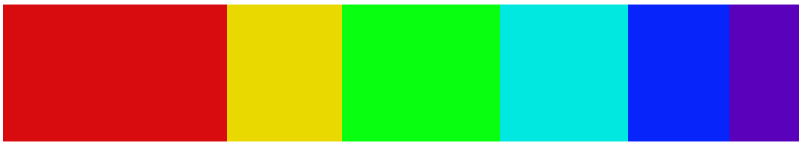


Figure 2: Random Initialization 2

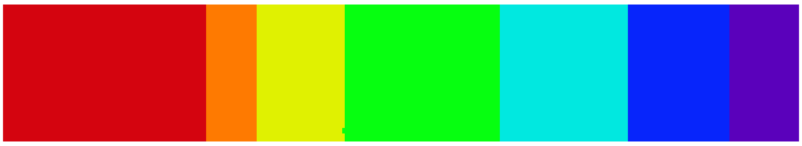


Figure 3: Random Initialization 3

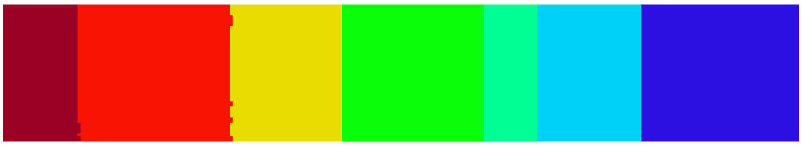


Figure 4: Random Initialization 4

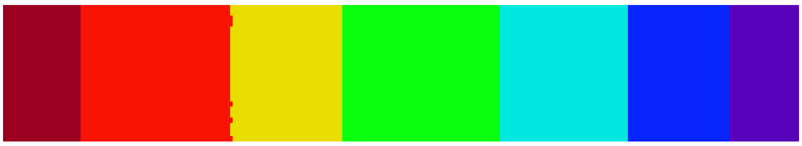


Figure 5: Random Initialization 5

2.3.3 Question C

The following images present the data required in the question. The images and plots are labelled correctly.

Figure 6: Segmented Image K = 2

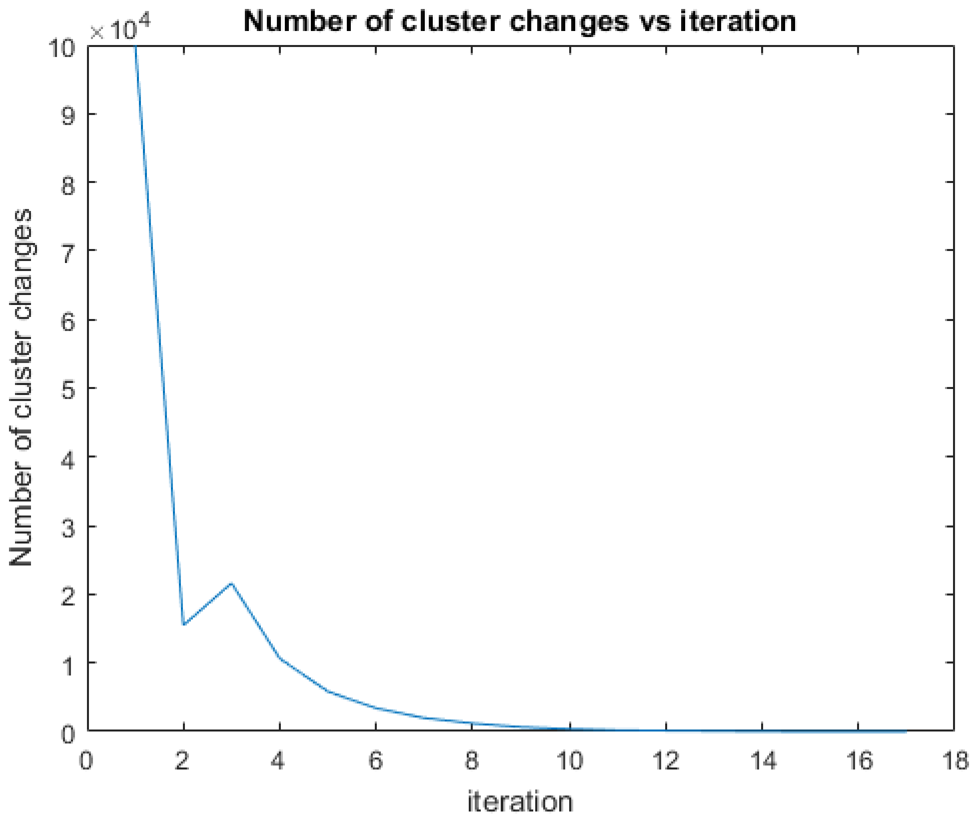


Figure 7: Plot of cluster change vs iteration, K = 2

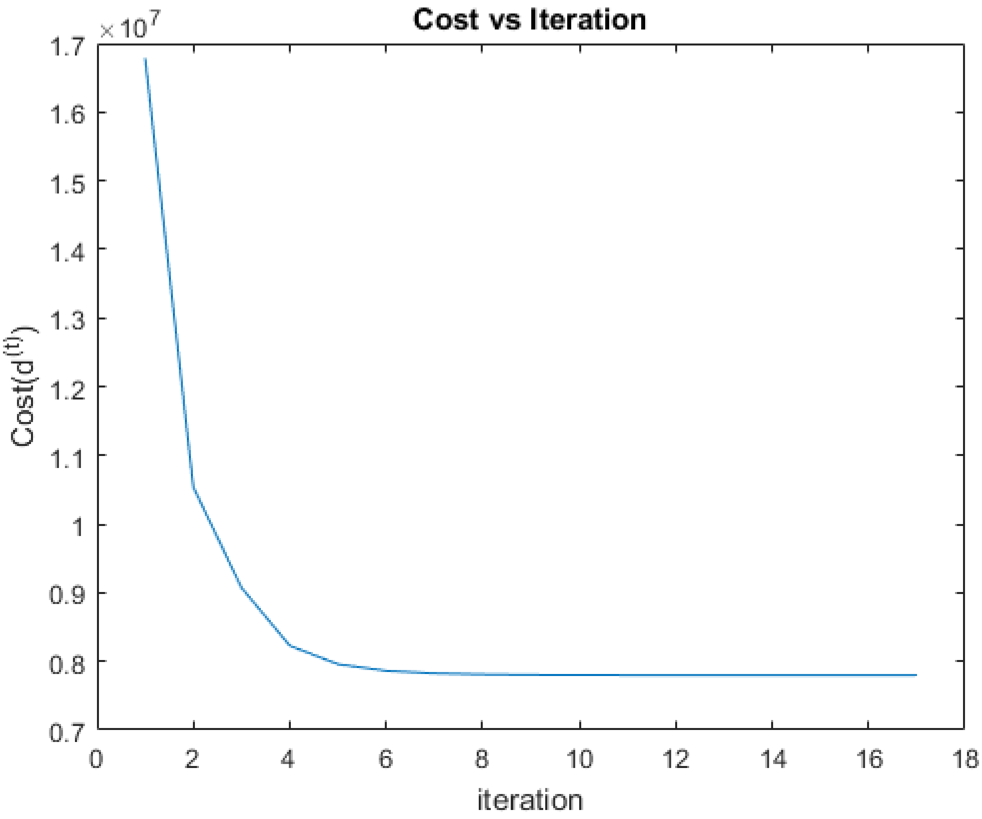


Figure 8: Plot of cost vs iteration, K = 2

Figure 9: Iteration 1, K = 2

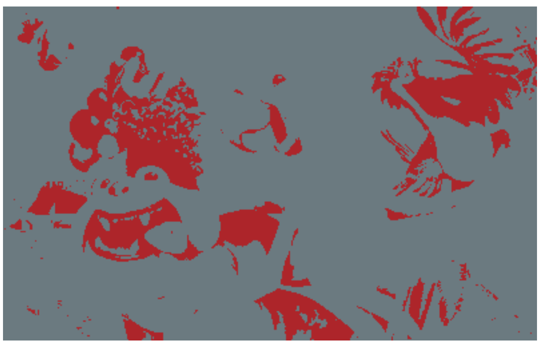


Figure 10: Iteration 2, K = 2

Figure 11: Iteration 3, K = 2

Figure 12: Iteration 4, K = 2

Figure 13: Iteration 5, K = 2

Figure 14: Iteration 6, K = 2

Figure 15: Iteration 7, K = 2

Figure 16: Iteration 8, K = 2

Figure 17: Iteration 9, K = 2

Figure 18: Iteration 10, K = 2

Figure 19: Segmented Image K = 4

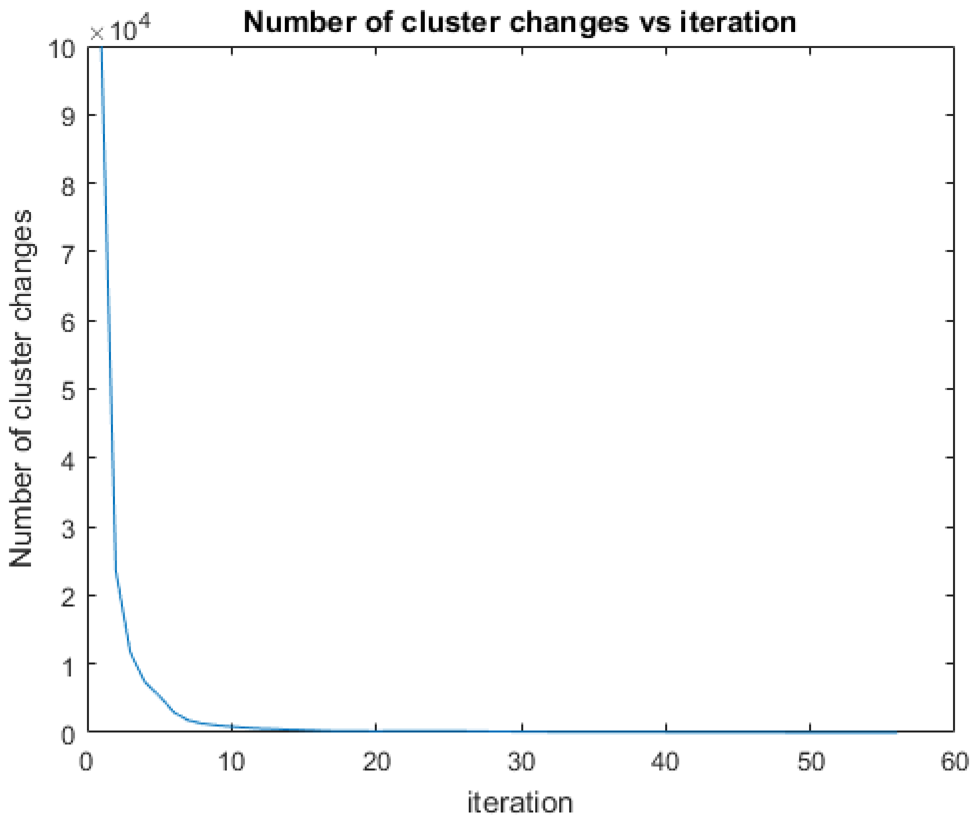


Figure 20: Plot of cluster change vs iteration, K = 4

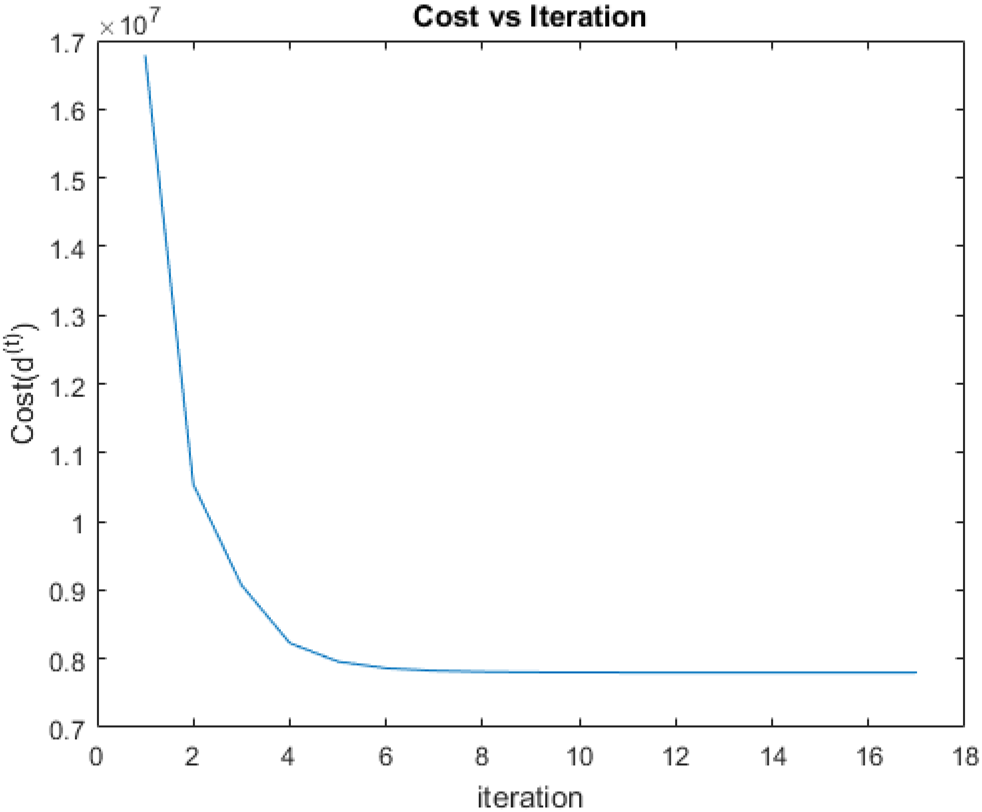


Figure 21: Plot of cost vs iteration, K = 4

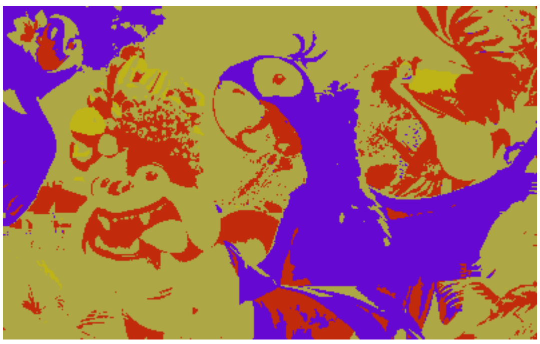


Figure 22: Iteration 1, K = 4

Figure 23: Iteration 2, K = 4

Figure 24: Iteration 3, K = 4

Figure 25: Iteration 4, K = 4

Figure 26: Iteration 5, K = 4

Figure 27: Iteration 6, K = 4

Figure 28: Iteration 7, K = 4

Figure 29: Iteration 8, K = 4

Figure 30: Iteration 9, K = 4

Figure 31: Iteration 10, K = 4

Figure 32: Segmented Image K = 8

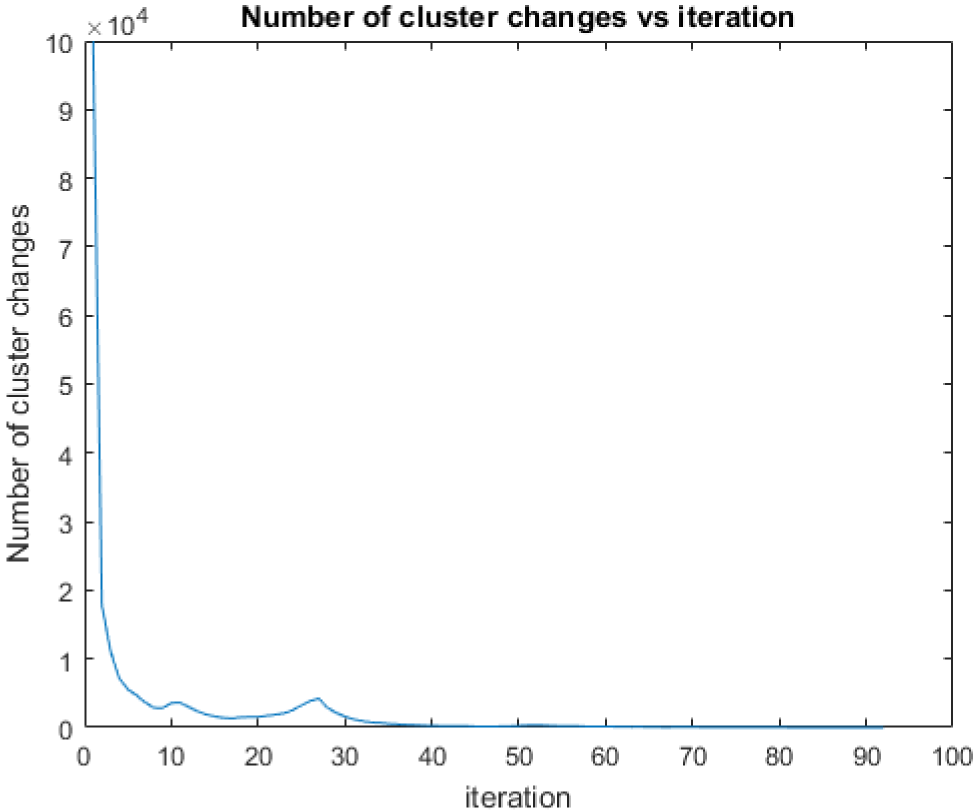


Figure 33: Plot of cluster change vs iteration, k = 8

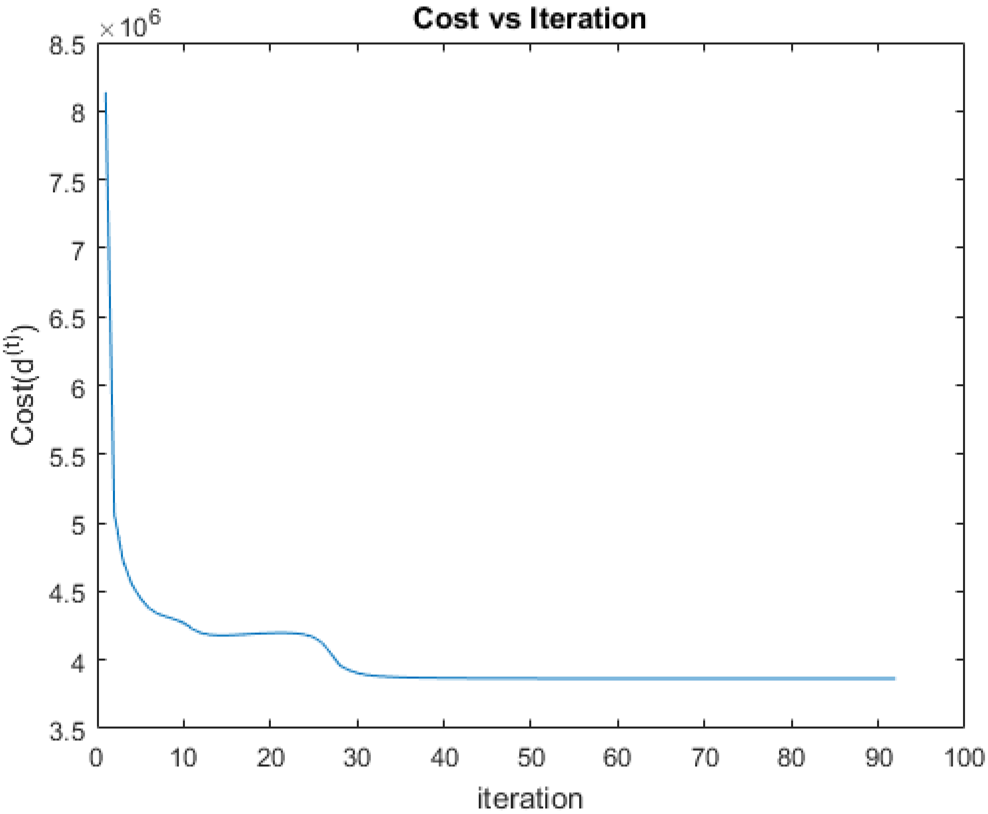


Figure 34: Plot of cost vs iteration, K = 8

2.3.4 Question D

K-means guarantees a local minimum. It converges to a global minimum only probabilistically.