ENPM673 Project 3

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Link to Results: https://drive.google.com/open?id=1jfllFwXjeDdrOl2VhvVs97f36Axhwo6o

1 Introduction

The project is implementation of Gaussian mixture models and Expectation Maximization techniques for color segmentation. The video sequence that is captured underwater has three buoys of different colors i.e. yellow, orange and green which are distinctly colored. However, conventional segmentation techniques, for example color thresholding did not work well in underwater scenarios. This is most probably because of various noise and varying lighting conditions. The average RGB Histograms for each colored buoy is plotted. The images of the three buoys of yellow, orange and green are trained on the basis of their color distributions and their respective Gaussian distributions are generated using these trained data set. Now, the buoys are identified in the video sequence using the probability distribution of each Gaussian distribution of their respective channels.

2 Data preparation

We used a script to extract 100 frames of images from the video. For each frame, we used a VGG annotator tool for drawing contours around the buoys. This VGG annotator gave us a better fitting bounding shapes compared to the other methods. We obtained a json file. Parsing this json file allowed to access the indices of the pixels that belong to the Region Of Interest (ROI). the pixel values were stored in an array without consisting of any labels for each pixels, ready for unsupervised learning.

3 Average color histogram for each channel of the sampled RGB images

Figure 1, 2 and 3 represent the average color histogram for green, orange and yellow buoys

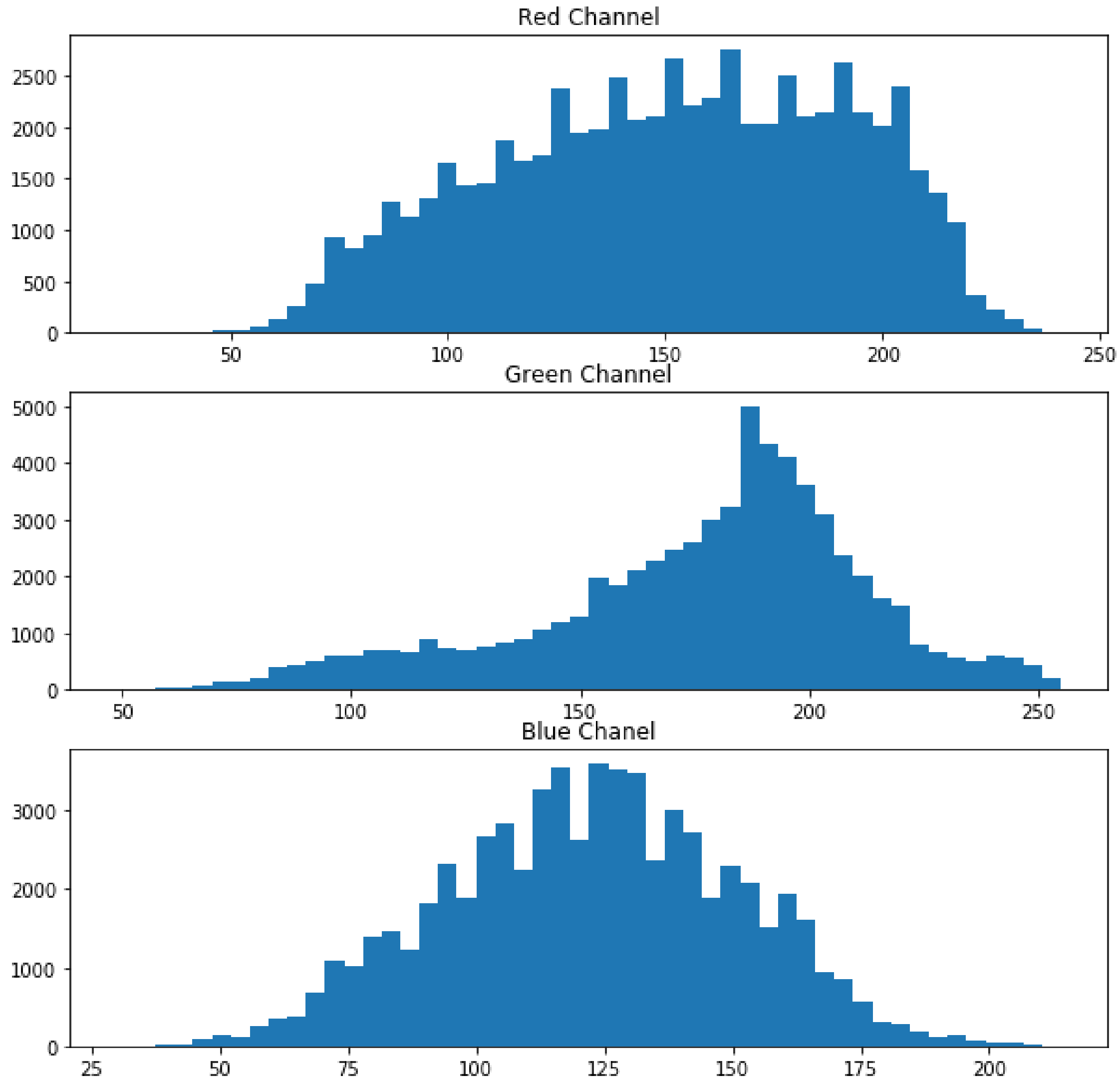

Figure 1: Green Histogram

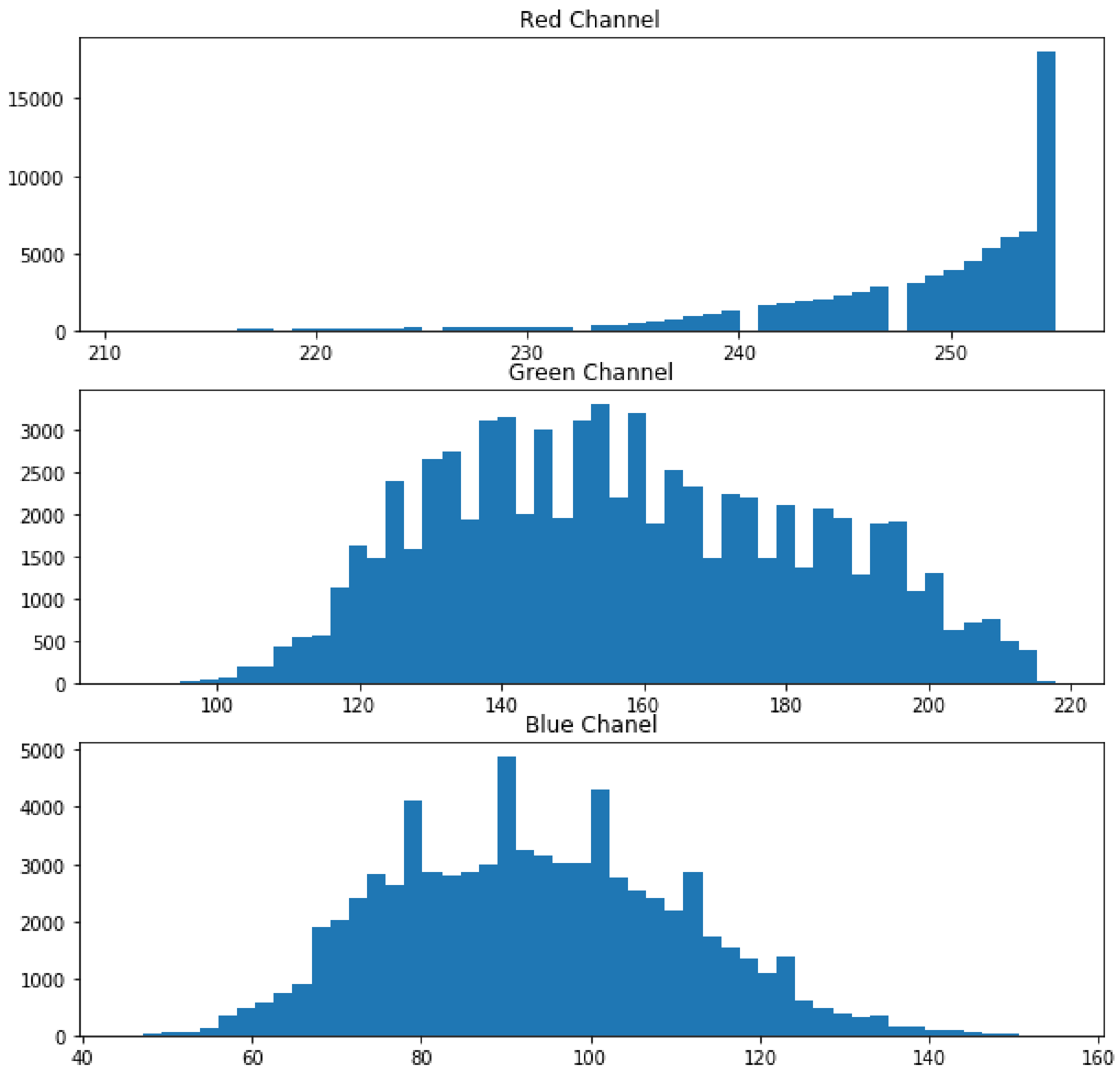

Figure 2: Orange Histogram

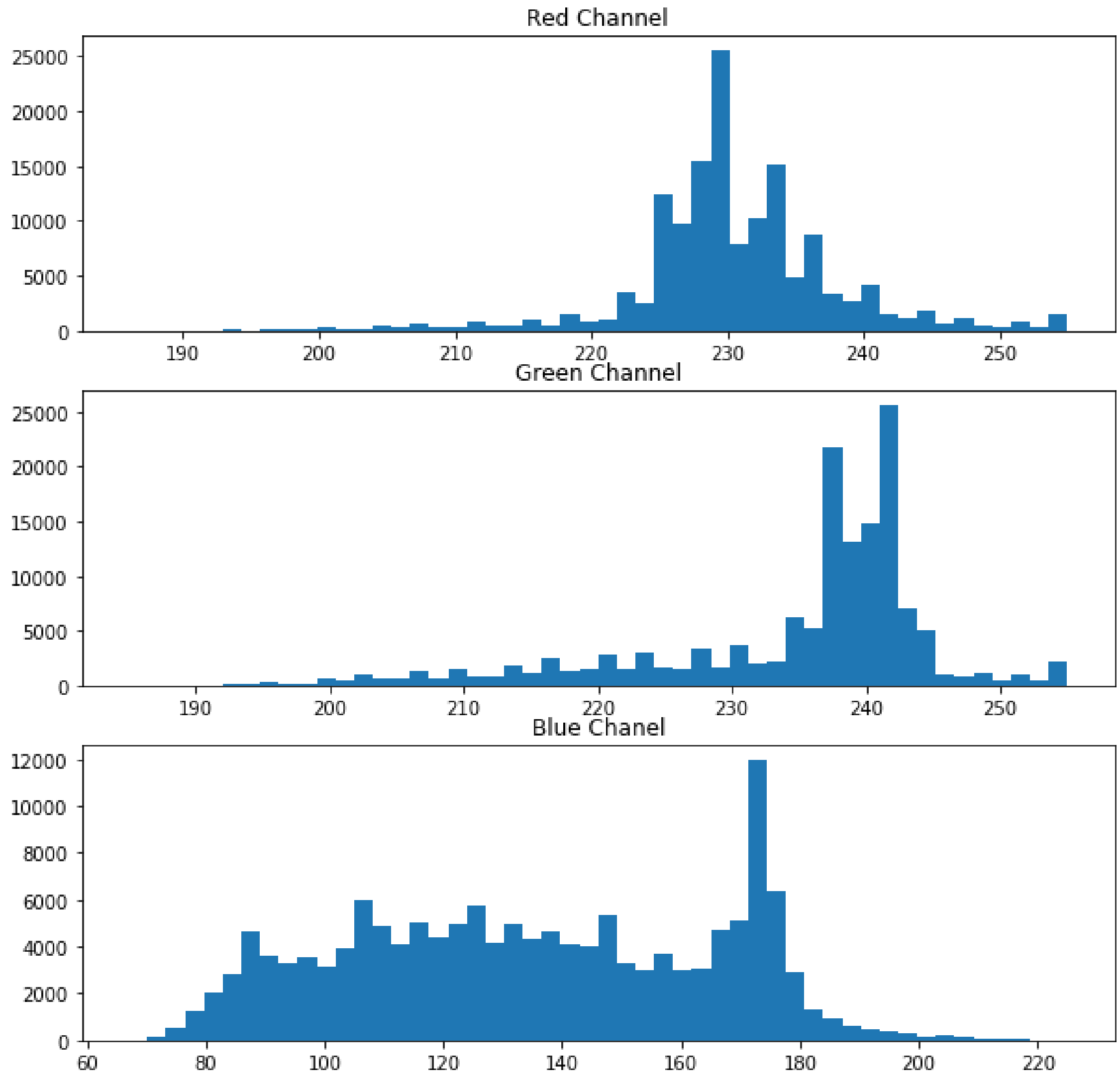

Figure 3: Yellow Histogram

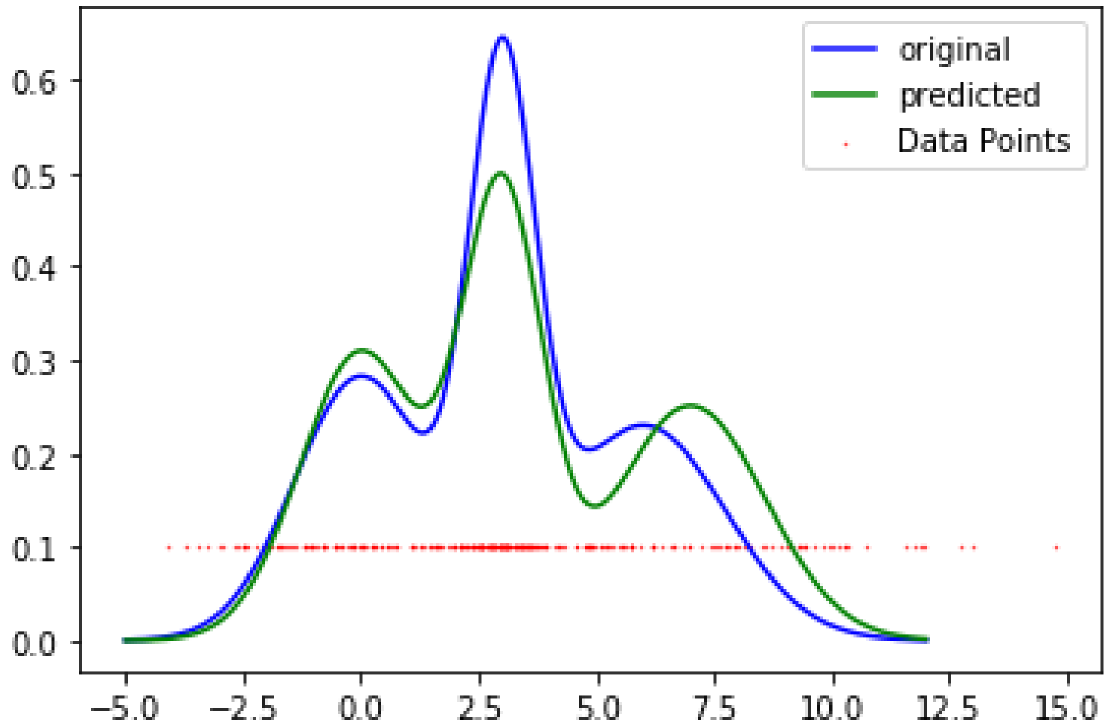

Figure 4: 1 Dimensional Gaussian Mixture Model

4 Gaussian Mixture Model (GMM) for 1D data set

We generated a data set filled with randomly generated data from 3 different Gaussian distribution with means 0,3 and 6 and standard deviation 2, 0.5 and 3 respectively. We then fitted this data set to a GMM which computed the means and co-variances. The resulting means were 0,3 and 7 with co-variances as 1.82,0.7 and 1.94 respectively. Figure 4 represents the 1 Dimensional Gaussian Mixture Model

5 Learning Color Models

We assumed 3D Gaussian's (1 dimension for each channel) which formed 3 clusters (yellow, green and orange). We fit the unlabelled pixel values to the GMM to obtain the mean and co-variance.

5.1 Observations

- We had approximately 200,000 pixels which we used for training. Due to this, the training time was long.
- Since, there is a summation step for calculating mean and co-variances, there were times when we were obtaining INF values or NAN values for the parameters. This was tackled in 2 ways. Firstly, running the training process multiple times for proper random initialization steps. Secondly, we only considered using a diagonal matrix for co-variances (We assumed each color is independent of each other i.e., no correlation between channels)
- The parameters outputed by the GMM for the color segmentation as follows.
  means = [(122,176,151),(93,157,248),(134,234,230)]
  covariances = [[(28.17,0,0),(0,35.86,0),(0,0,39.66)], [(17.10,0,0),(0,25.5,0),(0,0,7.5)], [(30.78,0,0),(0,11.08,0),(0,0,8.09)]]

6 Buoy Detection Pipeline

Our pipeline consists of following steps

- Cropping the image
- Gaussian Blur
- Canny Edge Detection
- Hough Circle Detection
- For each centre, classify the centre pixel to the appropriate colour using the parameters from the fitted GMM.
- draw the circle around each buoy from the parameters from Hough Circle and color from the classified GMM.

6.1 Observations

- Fine tuning the Gaussian blur and hough circle transform helps in better detection while a properly fit GMM gives better classification
- The performance of the GMM is directly proportional to the size of the number of pixels used for training
- A few false circles were detected due to the rough background.
- The green buoy has a similar color to the background. Due to this, the canny edge detection sometimes fails to properly find it.

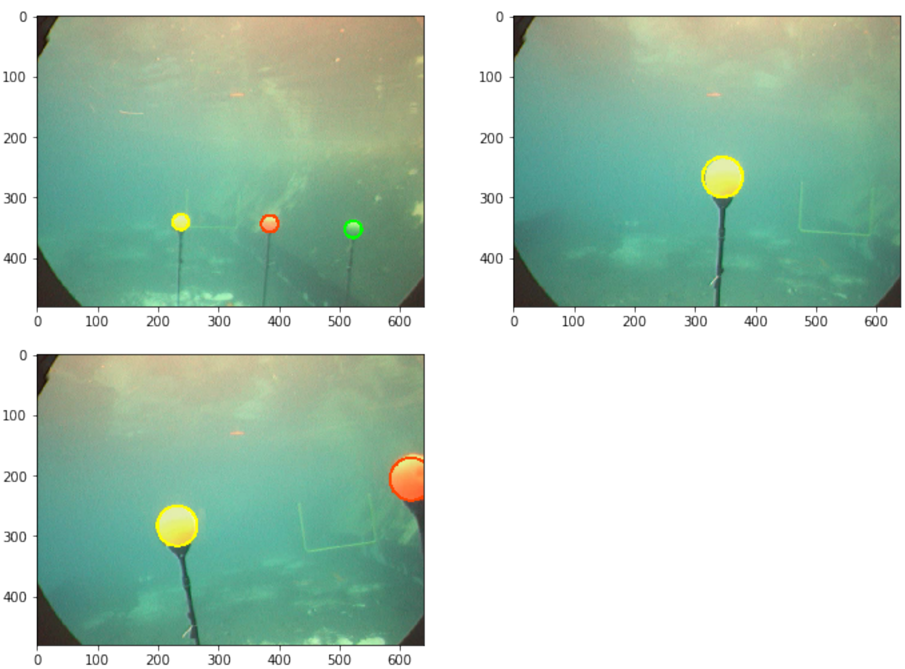

Figure 5: Segmented Images

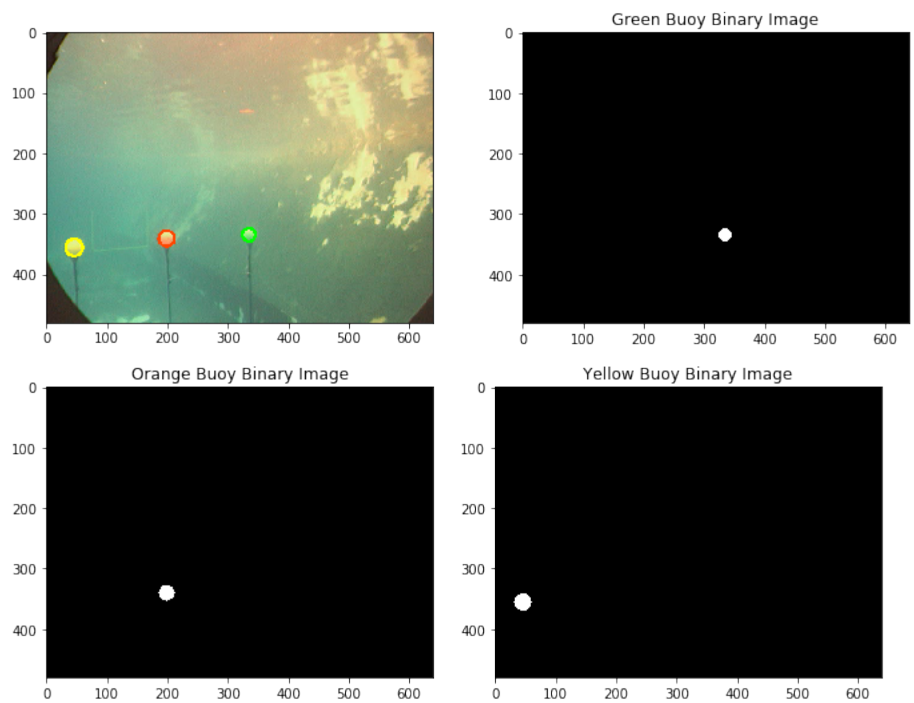

Figure 6: Results and Binary masks of each buoy

7 Results

We convert the segmented image to binary scale image and observe the green, orange and yellow buoys individually. Refer the segmented image with their green, orange and yellow buoys respectively from figure 6.