Color Image Segmentation Using Expectation-Maximization Algorithm

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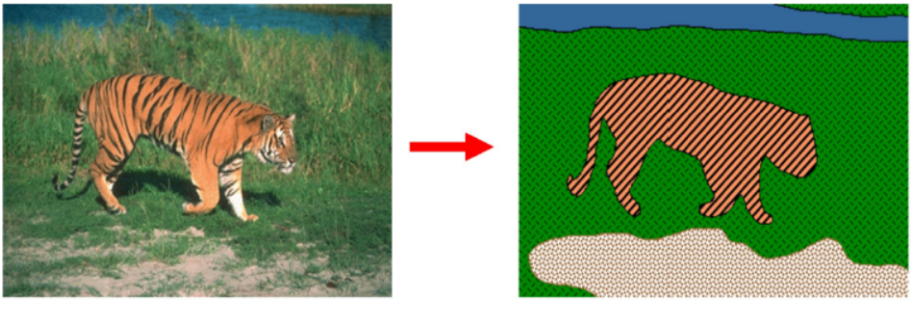
Abstract

This report describes the Image Segmentation in general and the Color Image segmentation using EM algorithm. It also shows the results & observations drawn along with the key points and understandings gained from this assignment work.

1 Introduction

Image segmentation is splitting of a image into multiple segments (different sets of pixels called as blob or super-pixel) based on some distinctive features . Here we are segmenting image into different regions based on pixel color. Human eye can easily distinguish different cwolor regions but how we will a computer do ?? There are various algorithms for color image segmentation, we are using EM Algorithm here. Image segmentation is an important technique/tool for rapid digital image processing and is used in various machine learning, computer vision and deep learning applications.
Image segmentation can be used to locate distinct objects in the image to draw meaningful insights. Self driving cars, satellites, medical imaging involves image segmentation technique. A more lot of things can be done using color image segmentation as it helps computer to understand images at semantic level and add perception capabilities.



2 Expectation-Maximization Algorithm

EM algorithm is an unsupervised learning algorithm that works as follows :-

1) Initialization step : Involves initializing/guessing the values of the parameters for each cluster i.e. pi(k), k=1...nSegments and mu(k) and the weights in our case.

2) E-step : Assignment of pixels to the clusters i.e, giving a membership label to all pixels. It assigns each of the pixel to a particular cluster, expressed as the weight W(i,k) of the pixel for the cluster.

3) M-step : Update or recompute parameters as per the new membership labels. The pi and mu matrices are recomputed from the updated values of the weights W(i,k).

Algorithm iterates by alternating between the E and M steps to learn maximum a-posteriori (MAP). Iterations continue until convergence i.e., till the change in the parameters is below a certain threshold. Max 20 EM iterations were taken.

2.1 Methodology

The images were segmented using EM on a multi-modal Gaussian distribution, which assumes that we know the number of segments in the image apriori. We assume the number of segments for each image and then perform segmentation.

:: After the EM algo we use KMeans to cluster the pixel values, assuming number of clusters equal to the number of segments assumed to be present in the image.

:: Each pixel membership label is updates to the cluster center label and are colored same.

:: We finally clip the pixel values to be in range [0-1] and apply Gaussian smoothing with sigma = 2 to obtain the final segmented image.

3 Results & Observations

3.1 Water Coins Image

a) Image was segmented into two parts i.e, coins and water with different colors.

b) For two segments case, coins and water was properly segmented. Converged within the first 5 iterations. This was expected because the image background and coins had quite consistent distinction w.r.t color and contrast.

c) As per my view, best result came with 2 segments assumption.

d) For three & four segments case, shadows were highlighted near the coin edges.

e) For five segments case, the marks and mintings on the coins were highlighted.

3.2 Jump Image

a) Image was segmented into man, snow and rest background with different colors.

b) For two segments case, foreground snow and sky got segmented quite satisfactorily from rest of image.

c) For three segments case, it segmented light and dark blue shades of sky along with some portion of the man. Convergence achieved at 17th iteration.

d) For four segments case, it segmented the snow, light & dark shades of sky and the jumping man close to perfect.

e) For five segments case, it further tried to segment the man's upper and lower clothing based on color variation.

f) As per my view, best result came with 4-5 segments.

g) The gradient of the sky shade gets more expressed as the segments increase.

3.3 Tiger Image

a) Image was segmented into tiger, grass and land with different colors.

b) For two segments case, tiger was nearly segmented from the foreground.

c) For three & four segments case, tiger along with grass & land got segmented.

d) For five segments case, the black stripes on tiger and other finer details gets highlighted. The water behind gets a different segment in itself. Best result came with 5 segments, tiger is properly separated from grass and land.

3.4 Conclusions

:: Segmentation improves with the number of iterations of EM steps.

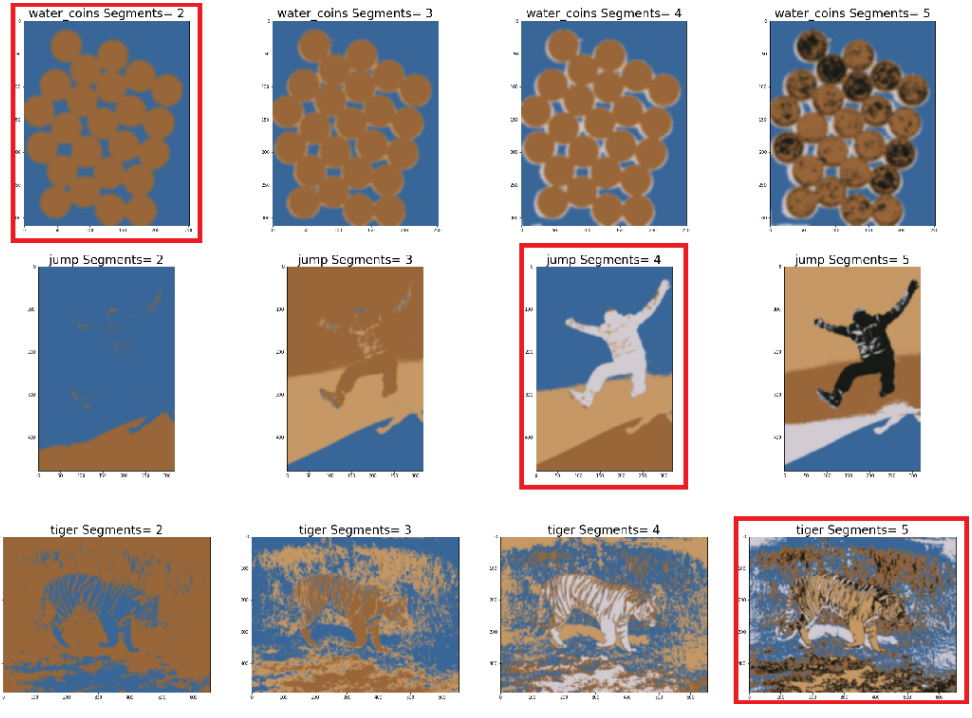
:: With increase in the number of segments, the algorithm tries to find dissimilarities in different entities present in the image. Eg:- In water coins image, two segments segmented coin and background while three segments further highlighted the edges near the coins.

:: Better segmentation is achieved when number of segments assumed equals the number of objects/entities present in the image. Eg:- 2 segments in case of coin image and 4 segments in case of jump image.

:: Some of the images converges before 20 iterations as mean and deviation difference comes below a threshold value early. As the no. of iteration increases, mean and sigma of different colors starts converging to the actual means and sigmas. Good initial guess of parameters gives better output.

:: The tiger image was the most difficult image to segment as there were many variations and entities in the image. The image was segmented but there was some noise in each segmented entity.

4 Final Output



5 References

[1] Lecture slides and videos
[2] Online resources