Color Image Segmentation Using Expectation-Maximization Algorithm

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Abstract

In this project, we aim to perform Image segmentation on a coloured image using the EM algorithm. In this report we try to explain the The Image segmentation process in general and how EM algorithm is used for this process.We divide three different colour images and analyse the results.

1 Introduction

Image segmentation is a process of dividing an image into multiple segments called as image objects. Statistical partitioning of colour images into meaningful blobs is of very high importance in the field of image anaysis and computer vision. Every pixel of the image is assigned a label and this helps to differentiate the different parts the image is comprised of and it plays a vital role in medical detection, object detection, sattelite imaging etc. Color segmentation techniques that have been proposed include histogram-based segmentation [1] [2], probabilistic space partitioning and clustering methods [3], Markov random field and simulated annealing [1].

In this project we segment our images using the EM algorithm for distinguishing segments based on their colour distributions. THe EM algorithm aims to partition the image into set different no of segments. It starts with the initial set of values for the parameters and then the parameters keep getting updated until it reaches the convergence.

2 Methodology

2.1 Input

2.1.1 Images

In this project, we use three coloured images named Tiger, water coins and Jump. Figure 1, 2 , 3 shows the three input images

2.1.2 Initial Parameters

1. **nSegments :** The number of segments, we will partition the image is already assumed to four different values i.e 2,3,4,5

2. **maxIterations :** The maximum number of iterations that the algorithm will perform is set at 20

3. **Initial guesses for π & μ :** We initialize the values of π & μ representing mixture coefficient and mean values for each segment.

Figure 1: Jump

Figure 2: Water Coins

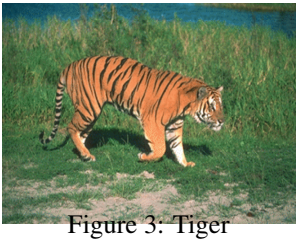


Figure 3: Tiger

2.1.3 E-M Algorithm

EM Algorithm is a type of unsupervised learning that is used to perform clustering tasks in the data. It involves following steps:

1. **Initialization:** Start with the initial guess of the parameters like mixture coefficient and segment color means i.e π_k and μ_k
2. **Expectation Step:** In the E-step of the algorithm, we estimate the likelihoods and membership weights (Ws) for each pixel. These weights indicate the likelihood that a pixel belongs to a particular color cluster.
3. **Maximation Step** In the M-step of the algorithm, we update the π and μ based on the new cluster label values obtained from the E-step
4. **Iteration:** The algorithm iterates between E an M step until the values of the parameters stop changing significantly.
5. **Convergence :** If the parameters don't show any significant change in their values, it means the process has found a good segmentation in the image and any more iteration won't improve it any further.

2.2 Post Convergence

After each pixels in the image is assigned to the clusters following steps are followed to find the best segmentation for the assumed no of segments:

1. The segmented image is them reshaped and converted to a greyscale image.
2. K-means clustering is applied on the image to further cluster it into the assumed no of segments.
3. Next we used Gaussian smoothing with $\sigma = 2$ to improve the quality of the segmentation

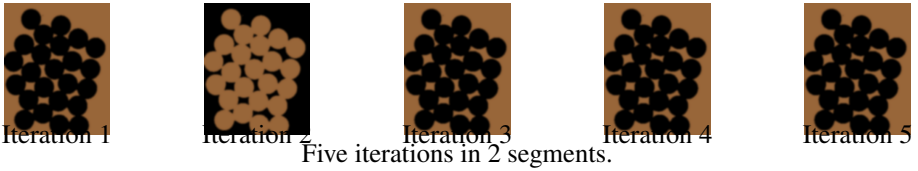
4. Colours are assigned to each cluster of the greyscale image and hence converting it back to coloured image

5. Save the image produced rom this iteration.

3 Result

3.1 Water coins

- The coins and the water were properly segmented when the number of segments were 2. The algorithms converged after 5 iterations. The coins and water are easily distinguished to the human eye.
- For 3 segments, the convergence criteria is met at iteration 15.
- For the 4 segments we can see the boundary of the coins have been segmented as well.
- The different writing on the coins , the boundary have also been segmented when the no of segments are assumed as 5.



Five iterations in 2 segments.

Segmentation of the water coins image.

3.2 Jump

- The image contains man, snow and different layers of the sky(atmosphere).
- For 2 segments, the image is segmented into the snow and rest of the image.
- For 3 segments, the algorithm converges after 17 iterations. The two layers of sky, and the snow have been very distinguishably segmented.
- The 4 segments give us the best segmentation with the man the snow and the layers of sky segmenting quite visibly.
- The 5 segments also give us a very good segmentation. Along with the man, the snow, the light and dark layers of sky, the person's jacket is also segmented in the image.


Original

2 segments

3 segments

4 segments

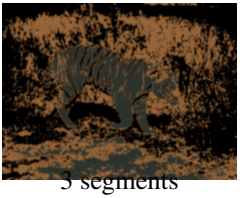
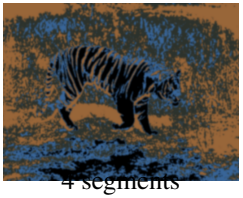
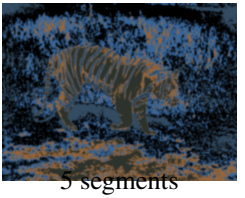
5 segments

Segmentation of the Jump image.

3.3 Tiger

- This image needs the most number of segments to get optimally partitioned.
- The image contains a tiger(body and the stripes), grass of different colours at different points of the image, water, sand etc.
- When the number of segments are 2, we can clearly see the tiger differentiated from the rest of the objects of the image.
- For three segments, the sand, the tiger and the rest(grass and water body) were segmented.
- When the number of segments is 4, The image shows clear distinctions between the tiger, thesand, and the grass
- For 5 segments the image was comparatively better segmented with the tiger, its stripes , different colours of the the grass and the sand segmented.
- In my opinion if we increase the number of segments, the image will be better segmented wth the grass and water body will also be differentiated.


Original

2 segments

3 segments

4 segments

5 segments

Segmentation of the Tiger image.

4 Conclusion

1. The EM algorithm is employed to estimate the parameters of a mixture model iteratively representing different blobs of an image.

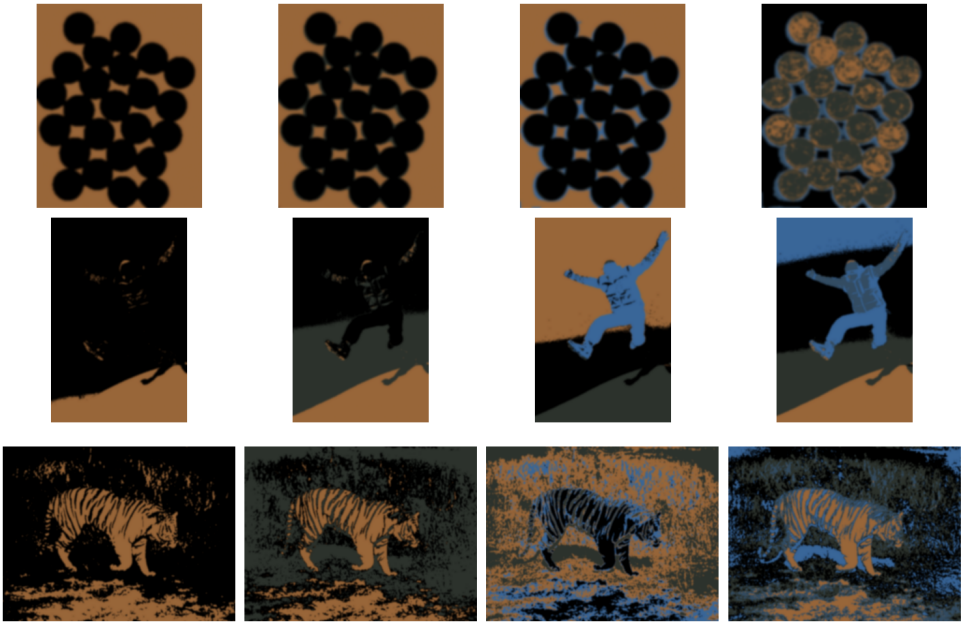


Figure 4: Segmented Images

2. Unless the algorithm is converging, the more number of iterations give is better segmentation.

3. Similar is not true with the number of segments. We need proper assumptions for the number of segments to obtain best segmentation.

4. The algorithm convergence depends heavily on the mean and pi values.

References

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[3] D. Comaniciu & P. Meer, *A robust approach toward feature space analysis,*, IEEE Trans. Pattern Analysis Machine Intell, 24(5), 2002, 603-619.