Colour image segmentation with Expectation-Maximization Algorithm

Ajul Thomas
u3253992@uni.canberra.edu.au

Faculty of Science and Technology
University of Canberra
ACT, Australia

Abstract

This document demonstrates the use of the Expectation-Maximization algorithm for color image segmentation. Image segmentation is the technique of partitioning an image into discrete group of pixels, based on color, texture or brightness[1]. The objective of the experiment is to understand the EM algorithm in depth through the image segmentation task and to observe how different levels of segmentation affect the perception of image details.

1 Introduction

The experiment involves segmenting three different color images into separate regions using a Gaussian Mixture Model (GMM) with Expectation-Maximization (EM). Unlike K-means clustering, which assigns each pixel to a hard cluster, GMM treats segmentation as a probabilistic assignment using Gaussian distributions[2]. The EM algorithm works by estimating the maximum likelihood that a pixel is within a color segment[2, 3].

2 Methodology

2.1 Dataset and Preprocessing

The dataset consists of three images: ‘water_coins.png‘, ‘jump.png‘ and ‘tiger.png‘. The images are read using the ‘Matplotlib Image Library‘ or ‘Python Image Library‘. The three-dimensional image vectors are reshaped into two-dimensional images of ‘nPixels‘(total number of pixels per channel) and three columns representing each color channel (red, green, and blue).

2.2 Segmentation

The experiment uses EM algorithm to estimate the maximum likelihood of a pixel being in any of the k segments. The likelihood of which segment generates the pixel is directly proportional to the segment size, and is modeled via mixture coefficients Pi(k),k = 1...K[3].

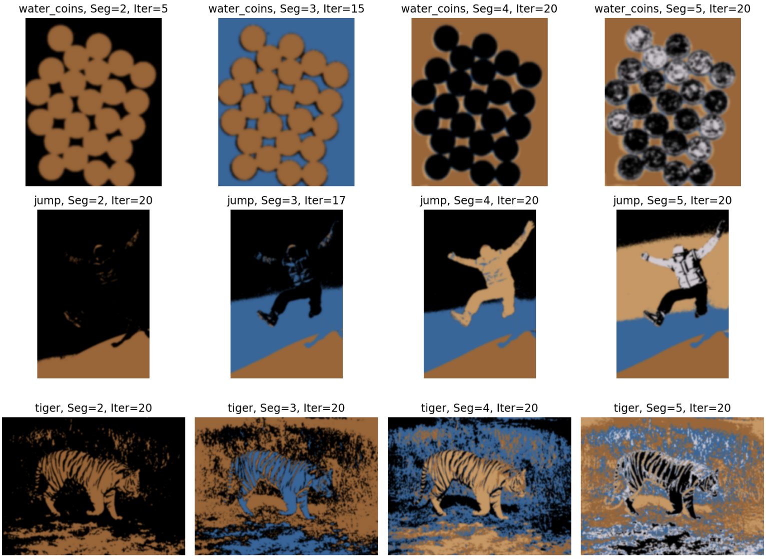

Figure 1: Segmented image output with different values of k.

3 Results and Analysis

The final segmented images for different values of k are shown in Figure 1. The following analysis can be drawn from the results:

3.1 Water Coins image

With K=2, the algorithm converges within the first 5 iterations. Segmentation clearly distinguishes the coins from the background. As the number of segments increases, more finer details including the writings on the coins are detected.

3.2 Jump image

At k=2, the algorithm clearly segregates the sky and icy mountain. Even the patches of snow under the shoes is clearly detected. More finer details including the jackets, pants, shoes, various shades within the sky is clearly detected at k=5.

3.3 Tiger image

The tiger image is the most challenging one among the images used for the experiment, given that it has more complex color distribution. The image could primarily be divided into four segments, Tiger, Grass, Land and Water. The color of dried grass looks much similar to that of land and tiger.

Given the complex distribution of colors, the algorithm was effective in segmenting these colors, including the stripes on the tiger. The algorithm could have better segmented the image, if it was run for more iterations to converge.

4 Conclusion

The experiment illustrates the use of the EM algorithm for color image segmentation and explains how various levels of segmentation affect the output. It is evident from the output that fewer segments lead to faster computation and effective object separation, however for detailed analysis higher segmentation could be beneficial.

References

[1] IBM. What is image segmentation? IBM Think Blog, n.d. URL https://www.ibm.com/think/topics/image-segmentation. Accessed on 23-02-2025.

[2] Viktor Lavrenko. Lecture 17: Expectation maximization algorithm. YouTube, Introductory Applied Machine Learning (IAML), University of Edinburgh, September 2015. Available at: https://youtu.be/3JYcCbO5s6M.

[3] Ram Subramanian. Color image segmentation using expectation maximization (em) algorithm, February 2025. Lecture notes for AI TECHNIQUES PG (6685), Semester 1, 2025. Accessed on 22-02-2025.