Assignment 1

Mean Shift Clustering

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CAP 6415 Computer Vision
Spring 2020
Date Submitted: November 24, 2020

1. Introduction

Mean Shift Algorithm in this assignment will help us in providing modes of color space. As a part of this algorithm we find weighted mean for each pixel. Output will be an image of clustered color space. This a non-parametric approach. MSA is used as a clustering mechanism for this assignment. Basic mathematical expression below will provide an idea about mean shift algorithm [1].

$$f(x) = \sum_i K(x - x_i) = \sum_i k\left(\frac{\|x - x_i\|^2}{h^2}\right)$$

K(x) can be any kernel, flat kernel or gaussian kernel. Xi is a neighboring pixel of X. h defines color and spatial bandwidths for clustering.

Flat Kernel [1] :

$$k(x) = \begin{cases} 1 & \text{if } x \leq \lambda \\ 0 & \text{if } x > \lambda \end{cases}$$

Gaussian Kernel [1] :

$$k(x) = e^{-\frac{x}{2\sigma^2}},$$

2. Description of Algorithm/Code

Code/Script consists of 12 functions for various operations. List of functions is as follows,

a. **rgb_xy(image):** adds (x,y) to the image
b. **rgbtoxyz(image):** converts [r,g,b] to [x,y,z] space
c. **xyztolab(image):** converts [x,y,z] to [l,a,b]
d. **nearest_pixels(image, current_pixel, hs, hr, sdhs, sdhr):** provides a list of pixels which are closest to the current pixel in spatial range and color range.
e. **dist(this_pixel, other_pixel):** computes the euclidean distance between 2 pixels in color space.
f. **dist_spatial(this_pixel, other_pixel):** computes the euclidean distance between 2 pixels in spatial space.
g. **apply_kernel(cur_pixel, adjacent_pixel, hs, hr):** computes the weight of a neighboring pixel of a current pixel. For this assignment, gaussian kernel is used.
h. **remove_xy(image):** removes the (x,y) component from the pixels of the image

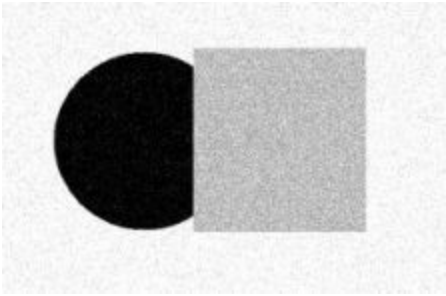
i. **labtoxyz(image):** converts [l,a,b] to [x,y,z] color space
j. **xyztorgb(image):** converts [x,y,z] to [r,g,b] color space
k. **GS_to_rgb(image):** converts a grayscale pixel to 3d rgb pixel.

Packages used for the assignments are numpy(for basic matrix operations), imageio(for input/output of images), math(for basic math operations). Input file (data.txt) will provide

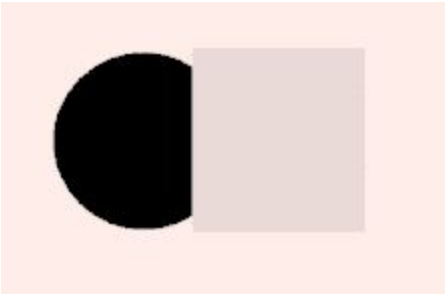
3. Results

hs, hr, sdhs, sdhr, m, M values can be provided by the user as input. m range between 5 and 10. 5 iterations would give better results.

Input Image



Output Image



(hs,hr,sdhs,sdhr,m,M) = (7, 8, 3, 3, 5, 40)

(hs,hr,sdhs,sdhr,m,M) = (7, 8, 3, 3, 5, 40)

4. Conclusion

In this assignment, mean shift algorithm is implemented and color segmentation is done. Difficulties were to apply mean shift algorithm on larger images. Because the computational complexity of script is $O(m * R^2 * C^2)$, where m is the number of iterations for which we apply mean shift algorithm, R and C are number of rows and columns of the image. With such complex algorithm, implementation with larger images was a time taking process. To reduce the time, images are resized to 50*50 (baboon.png) and 222*146 (shapes.png).

5. References

[1] https://en.wikipedia.org/wiki/Mean_shift (for equation images)