Computer Vision task5: Image segmentation

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In this exercise, I will implement mean-shift and Expectation-Maximization approaches to realize image segmentation. The segmentation will be done under L*a*b color space.

1. Image Preprocessing

Figure1 image on the left is the smoothed image, on the right is the image under l*a*b color space

I use 5*5 Gaussian filter to a) smooth the image and b) transfer the image to l*a*b color space.

c) why is it better to do segmentation in the L∗a∗b∗ color space as compared to RGB color space?

The advantage of Lab color space is that it is more perceptually linear than other color space, which means that a change of the same amount of color value should produce a change of about the same visual importance. And visual difference is just the way we segment an image.

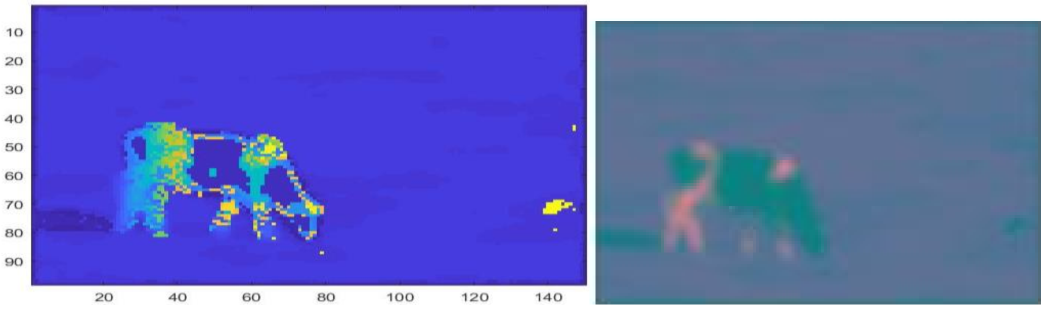
2. Mean-Shift Segmentation

For Mean-shift algorithm, I use matlab command 'im2double' to convert the image pixel to double precision and the value will lie between 0 and 1.

a) first step is to find the mode of the density function for a given pixel. I repeatedly compute the mean of all the pixels that lies within a spherical window of radius r and shifting this window to the mean until convergence.

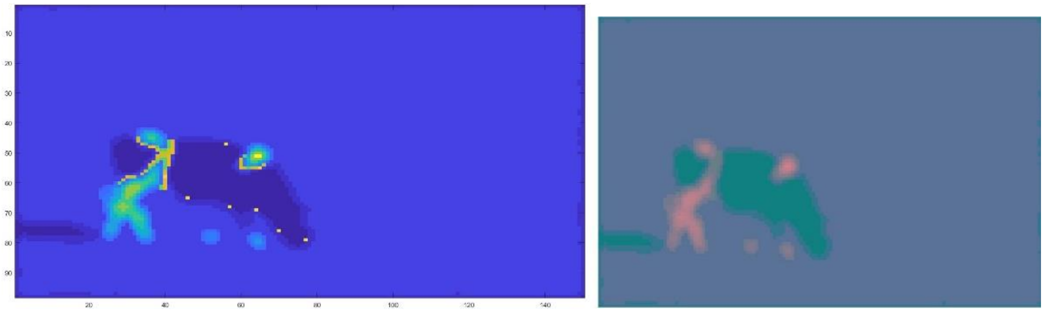
b) I will merge the pixel corresponding to which the peak will be have distance lesser than r/2.

For r to be chosen as 0.01, the whole image is merged into 300 different segments:



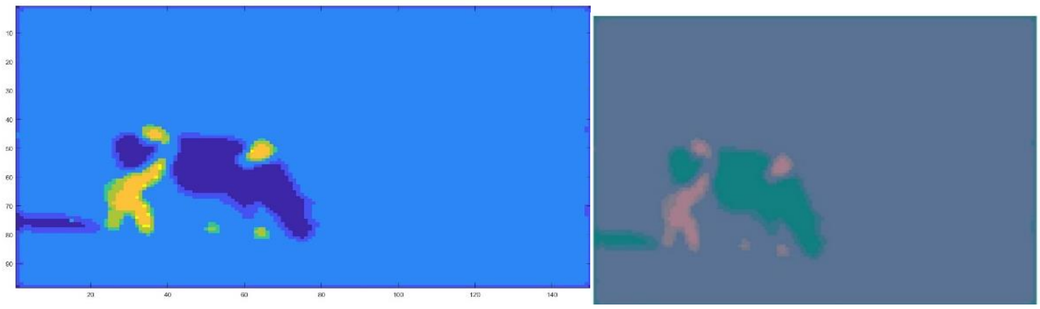
The segmented image with r=0.01

For r to be chosen as 0.03, the whole image is merged into 20 different segments:



The segmented image with r=0.03

For r to be chosen as 0.05, the whole image is merged into 8 different segments:



The segmented image with r=0.05

It can be found that as we increase the value of the radius, the pixels will be segmented into less clusters.

3. EM Segmentation

In EM segmentation algorithm, we fix the number of the segments and each segment is modeled as a gaussian distribution. We try to find the parameters of different models though altering between expectation and maximization steps. I use matlab command 'im2double' to convert the image pixel to double precision and the value will lie between 0 and 1.

a) In expectation step, I will take the current parameters and calculate the probability of pixel x in the segment k.

b) In the Maximization step, I will update the parameter by maximizing the expectation of the complete log likelihood. This process is done until converge.

c) When I choose k=3, the parameters are as follows:

mu =

0.5225	0.3507	0.1918
0.4895	0.4488	0.4757
0.5529	0.5847	0.5473

alpha =

0.0409	0.8078	0.1513

var(:,:,1) =

0.0371	0.0013	0.0003
0.0013	0.0002	-0.0001
0.0003	-0.0001	0.0004

var(:,:,2) =1.0e-03 *

0.8165	0.0007	0.0079
0.0007	0.0120	-0.0025
0.0079	-0.0025	0.0233

var(:,:,3) =

0.0112	-0.0022	0.0033
-0.0022	0.0006	-0.0007
0.0033	-0.0007	0.0011

d) When I choose k=4:

mu =

0.4035	0.0592	0.2871	0.3532
0.4923	0.5045	0.4549	0.4488
0.5426	0.5042	0.5778	0.5846

alpha =

0.0569	0.0432	0.1470	0.7530

var(:,:,1) =

0.0612	0.0005	0.0027
0.0005	0.0002	-0.0001
0.0027	-0.0001	0.0004

var(:,:,2) =1.0e-03 *

0.2349	0.0474	-0.0113
0.0474	0.0384	-0.0138
-0.0113	-0.0138	0.0446

var(:,:,3) =

0.0031	-0.0002	0.0006
-0.0002	0.0001	-0.0001
0.0006	-0.0001	0.0002

var(:,:,4) =1.0e-03 *

0.7018	0.0013	0.0065
0.0013	0.0104	-0.0023
0.0065	-0.0023	0.0218

e) When I choose k=5:

mu =

0.2545	0.3632	0.3355	0.0594	0.4444
0.4627	0.4492	0.4484	0.5045	0.4938
0.5640	0.5822	0.5873	0.5042	0.5453

alpha =

0.0793	0.4021	0.4253	0.0434	0.0499

var(:,:,1) =

0.0014	0.0001	0.0002
0.0001	0.0001	-0.0000
0.0002	-0.0000	0.0001

var(:,:,2) =

0.0082	-0.0019	0.0027
-0.0019	0.0005	-0.0007
0.0027	-0.0007	0.0010

var(:,:,3) =1.0e-03 *

0.7615	0.0032	0.0083
0.0032	0.0115	-0.0027
0.0083	-0.0027	0.0229

var(:,:,4) =

0.0199	0.0001	0.0006
0.0001	0.0001	-0.0000
0.0006	-0.0000	0.0003

var(:,:,5) =

0.0219	-0.0018	0.0030

-0.0018 0.0002 -0.0003
0.0030 -0.0003 0.0006

1) By observing the parameters Mu of different segments, we could find that the main different between them is the value ‘L’, while there is little difference between their values of ‘a’ and ‘b’. This again show the importance of transferring the image into L*a*b color space.

2) I put the pixel with the same Gaussian distribution into the same color. And as I improve the number of the segments, the segmentation is becoming more precise.

3) Another factor that influence precision of the results is the initialization of the parameter. For the initialization of Mu, I randomly select value among the pixel color range. As I launch the commend for several times, the final parameters can be slightly different. While by making the convergence requirement stricter, just as I reduce the convergence threshold, we can make the result more precise.

4) By comparing with the Mean Shit algorithm, I find that EM algorithm has the advantage of being more accurate and faster. But we need to have a prior information of our segmentation parameters.

The images results are shown below, they are the result for k=3,4 and 5.