Digital Image Processing: Homework #3

Due on May 31st, 2020 at 11:59pm

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Problem 1

Solution

1) **Algorithm Description**
For subproblem 1, I use the region grow algorithm, which can be described as:

(a) First, select a list of points in background, named $Point_{init}$.

(b) Then, we prepare a queue Q which contains the initial points, and a mask M with the same shape as the image.

(c) Initial the mask:

$$\forall(i,j) \in M, M(i,j) = 1$$

(d) Each time we pop the first point (x, y) in the queue, mark the mask $M(x, y) = 0$, then check the neighbours $(x+1, y)$, $(x, y+1)$, $(x-1, y)$ and $(x, y-1)$. if the color gradient between the poped pixel and its neighbour smaller than the threshold, then we add this neighbour pixel into the queue, and mark the mask $M(neighbour_x, neighbour_y) = 1$.

(e) We repeat step (3) until the queue is empty.

(f) Finally we get the mask M, hence we can get the new image:

$$NewImg = OriginalImg(Mask == 1)$$

For subproblem 2, I use the superpixel algorithm first:

(a) First, we divide the image into K small grids, and make K clusters according to the grids. To avoid starting on edges, we can move slightly within 3x3 neighborhood to lie on lowest gradient position. For each cluster, initialize a 5-D vector (l, a, b, x, y) (I use LAB color sapce instead of RGB).

(b) For each cluster center c_i, compute distance bwt c_i and each pixel in a neighborhood of c_i The distance between two clusters are defined as:

$$D_{LAB} = \sqrt{(L_i - L_j)^2 + (A_i - A_j)^2 + (B_i - B_j)^2}$$

$$D_{XY} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}$$

$$D = \sqrt{(\frac{D_{LAB}}{|LAB|})^2 + (\frac{D_{XY}}{|XY|})^2}$$

(c) Assign pixel to cluster i if its distance is better than its current value.

(d) This is not a global algorithm, so we only search in neighborhood, the region size depends on the number of K

Then, let the average RGB value in a cluster to represent the RGB value of this cluster, use the threshold to determine the Red, green and white parts.

2) **Results of Part I**
The results of the segmentation line of foreground and background:

Problem 1 continued on next page...

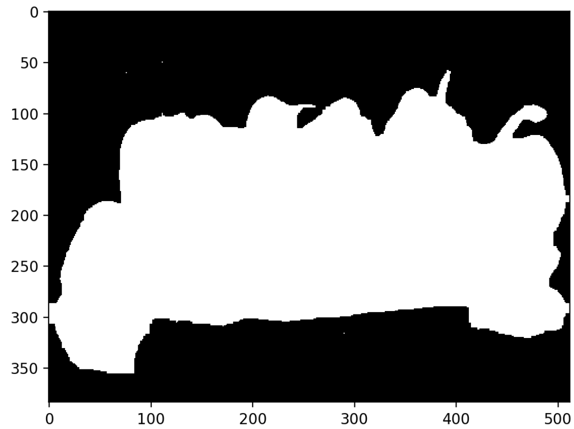

Figure 1: The segmentation line

The results of the segmented foreground:

Figure 2: Foreground

3) **Results of Part II**

The results of the of three type objects in the foreground: red peppers, green peppers and white garlics:

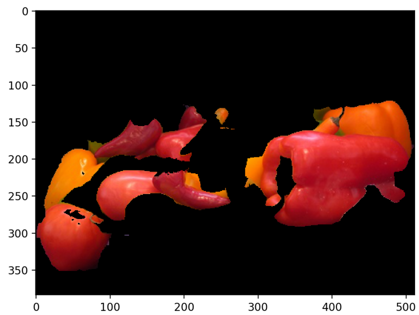

Figure 4: Red peppers

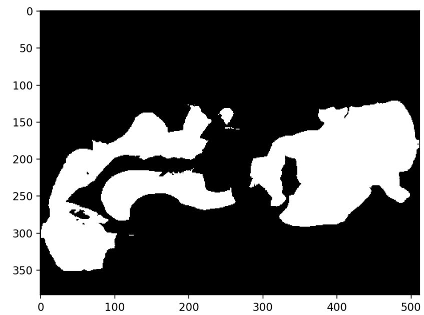

Figure 5: Red pepper mask.

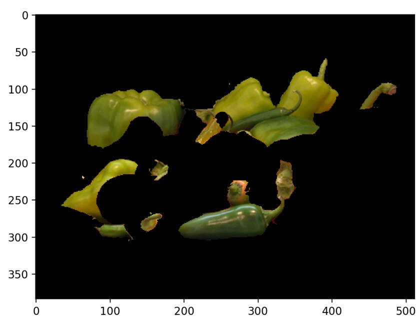

Figure 6: Red peppers

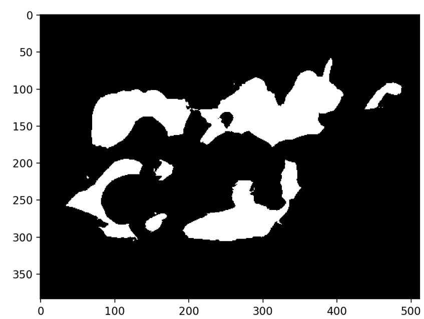

Figure 7: Green pepper mask

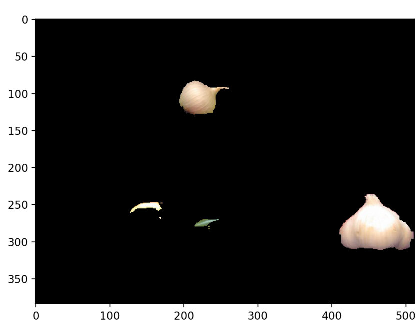

Figure 8: White garlics

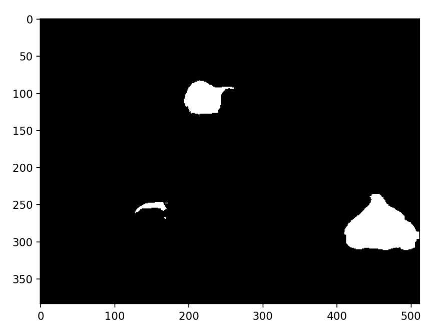

Figure 9: White garlics mask

Problem 2

Solution

1) **Algorithm Description**
In this problem, I use the graph cut algorithm:

   (a) First, the input is an image with size $M * N$. We need to construct a graph with $M * N$ nodes, a source S and a sink T.

   (b) Then, we have some prior information: let FG denotes the points that are determined to foreground manually, and BG denotes the points that are determined to background manually.

   (c) Calculate the histogram of FG and BG, then we can use these histograms to determine the probability of a given point that belongs to foreground or background.

   (d) For each node P, add a link from S to P and a link from P to T, which are called $T-links$. The weight of P and S is the probability that P belongs to foreground, and the weight of P and T is the probability that P belongs to background.

   (e) For each node P, adc links between P and its neighbours, which are called $N-links$. The weight of each $N-link$ is defined as:
$$W_{ij} = e^{\frac{\|I_i - I_j\|_2}{2\sigma^2}}$$

   (f) Find the maxflow in this graph

   (g) By the maxflow-mincut theorem, find the min-cut and segment the image

For multi-class graph cut, we select 4 labels of points. When we find the first region, let the first label be the foreground points, the others are the background points. And when we find the region with label 2, just let the points with label 2 be the foreground, other points be the background.

2) **Results of Part I**

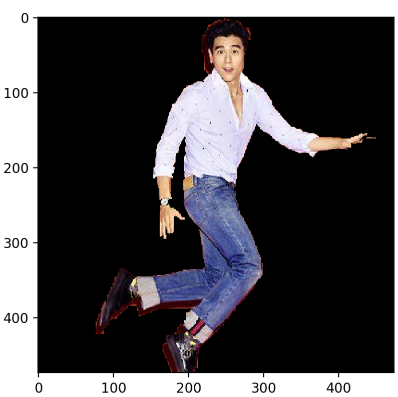

Figure 9: Result of graph cut

Problem 2 continued on next page. . .

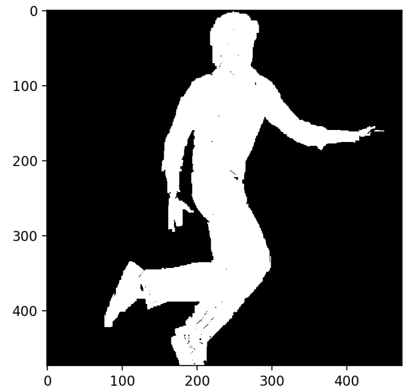

Figure 10: Mask of graph cut

3) **Results of Part II**
First, select points with 4 different labels:

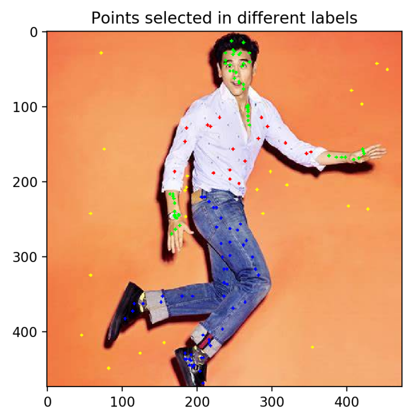

Figure 11: Points selected

Apply multi-class graph cut algorithm to get the mask and the results:

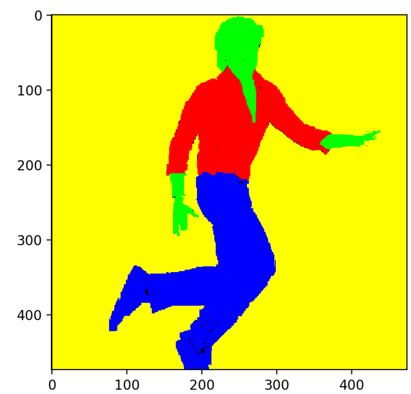

Figure 12: Mask of graph cut

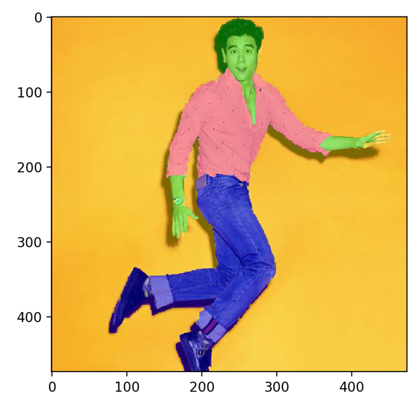

Figure 13: Mask of graph cut