

Digital Image Processing (CSE/ECE 478)
Monsoon-2018
Assignment-4 (200 points)
Posted on: 1/10/18
Due on: 11/10/18, 11:59 PM

Grade Table (for teacher use only)

Question	Points	Score
1	50	
2	30	
3	50	
4	30	
5	20	
6	40	
Total:	220	

- (50 points) For skeletonization, the basic idea is to remove any pixel on the boundary of the foreground which has more than one foreground neighbor. But this needs to be done in such a way that removing the pixel does not split the connected component, to which the pixel belongs, into two. Suppose the following structuring elements are made available:

$$S_1 = \begin{bmatrix} 0 & 0 & 0 \\ * & 1 & * \\ 1 & 1 & 1 \end{bmatrix}, S_2 = \begin{bmatrix} * & 0 & 0 \\ 1 & 1 & 0 \\ * & 1 & * \end{bmatrix}$$

Here, * stands for “don’t care” whether image pixel underneath is foreground or background. In morphological operations, note that a structuring element whose origin is placed on a pixel will be compared to the corresponding neighborhood and if they match, then the corresponding pixel in the output image is usually set to foreground. In this case, suppose that we change the rule and set the pixel to background (i.e. to value 0).

Suppose $S(\theta)$ stands for structuring element S rotated by angle θ degrees. $I_1 \xrightarrow{S} I_2$ denote that I_2 is a result of applying structuring element S on image I_1 . A single skeletonization pass is defined as:

$$I_1 \xrightarrow{S_1(0^\circ)} I_2 \xrightarrow{S_2(0^\circ)} I_3 \xrightarrow{S_1(90^\circ)} I_4 \xrightarrow{S_2(90^\circ)} I_5 \xrightarrow{S_1(180^\circ)} I_6 \xrightarrow{S_2(180^\circ)} I_7 \xrightarrow{S_1(270^\circ)} I_8 \xrightarrow{S_2(270^\circ)} I_9$$

To obtain the skeleton, the operations defined by the above skeletonization pass need to be repeated until a particular structuring element pass leaves the image unchanged.

- (20 points) Write Matlab code for the above skeletonization process and display the computed skeleton for the image <https://imgur.com/a/8JxLhNq>. Note that the image will need to be binarized first !

2. (5 points) Explain the role of structuring elements S_1, S_2 .
 3. (5 points) By analyzing the outputs at the end of each skeletonization pass, explain why multiple passes are/may be required.
 4. (20 points) Try out the skeletonization algorithm described above on a variety of binary images containing a single shape (e.g. containing a solid shape, shape with holes, thin structured objects, irregularly shaped objects) and comment on what you observe.
2. (30 points) Read in the binary image of coins available at <https://imgur.com/a/E1RduI9>. Write a script which uses the previously mentioned image as input and outputs a new image containing
1. (10 points) only the coins touching the boundary of the image
 2. (10 points) only the coins which overlap with each other
 3. (10 points) only non-overlapping coins
3. (50 points) More Connected Components. In the questions below, assume 8-connectivity.
1. (20 points) The image <https://imgur.com/a/8wb8VsU> contains text characters in five different colors. Write a script which takes the image as input and outputs the number of components for each of the five colors. Note that the components may be non-letters (e.g. . and |).
 2. (30 points) For the following set of images:
 - <https://randomwordstorm.files.wordpress.com/2015/01/handwriting-2.jpg?w=1440>
 - <https://qph.fs.quoracdn.net/main-qimg-ce0832e2d2549a8075467d0c19c9aee6>
 - <https://qph.fs.quoracdn.net/main-qimg-606b255d642f2cbf36a5bae79ab1dbf9>Write a script which produces as output a binary image containing
- (a) Only those letters that enclose one empty region (e.g. examples of English letters containing a single empty region are - o,e,a)
 - (b) only those letters that enclose two empty regions (e.g. example letter from English - g, B (capital-case))
- IMPORTANT: For this question, you are not allowed to use the MATLAB function `imfill` or the “fill” variant of `bwmorph` function.
4. (30 points) Read and summarize about the following color related physical and perceptual phenomena. 1. Afterimage 2. Color Moiré 3. Structural coloration
 5. (20 points) Create a 3-channel 100×100 HSI image with values of S and I to be 255. Vary the value of H between pure green to pure blue (60 and 150 in MATLAB) in 10 equal sized steps. Convert the resulting images to RGB and display these as a montage. Answer the following questions.

1. What are your observations about change in hue with uniform increase in H step size? Do you observe the change in hue to be perceptually uniform?
2. Change the above code such that distribution from green to blue is perceptually uniform.
6. (40 points) Perform the following operations for the given 24-bit R,G,B color images (color_bars.tif, peppers_color.tif, mandril_color.tif).
 1. Display three planes of the image as per models - RGB, CMY, HSI, L^*a^*b
 2. Convert the image for 8-bit representation according to Safe RGB color model.
 3. Perform histogram equalization using RGB model for each channel separately, and using HSI model using each channel separately.
 4. Show the results of equalization if (a) H channel is not changed, (b) S channel is not changed, and (c) both H and S channels are not changed (only I is changed).