Computer Engineering Department
TED University

Spring 2023 – CMPE 362 / CS 563 Digital Image Processing
Assignment 3
Due Date: May 24th, 2023 at 23:59

This assignment is to be done either individually or in pairs.

If you work in pairs, only one group member should do the submission. Names of both members should be included both in the codes and in the report.

Download Plant Phenotyping Dataset via https://www.plant-phenotyping.org/datasets-download

Consider RGB images in the folder Ara2012 which ends with “_rgb.png”.

Choose 2 different images.

For each of those images you choose, you will do the following three operations.

1. Segmentation of the plant from the background (40 points)

Segment the image using k-means clustering where each pixel is represented using the values coming from Red, Green and Blue channels of the image. Use kmeans function of OpenCV library.

Try different values of k, display the results for each k and discuss how the results change as k changes.

In order to better understand this operation, see an example input image in Figure 1 and the k-means segmentation results obtained for k = 2, k = 3, k = 4, and k = 5 in Figure 2.

Considering the segmentation results, notice that they have the same number of rows and columns as in the input image but, at each pixel, it is equal to segment label of the corresponding pixel.

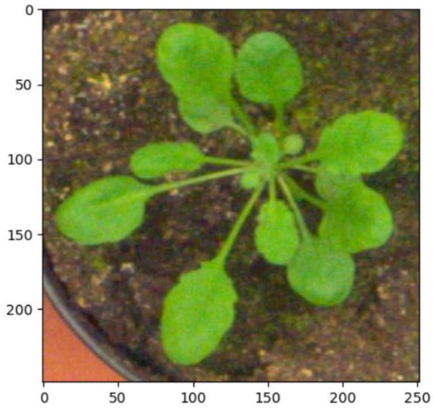

Figure 1. An example input image

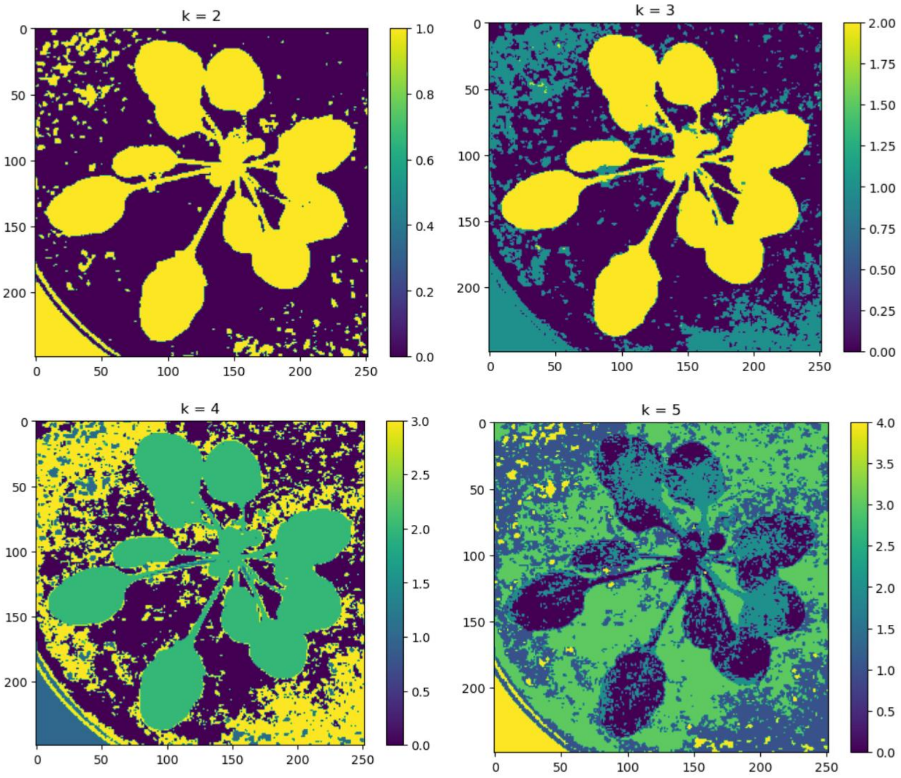

Figure 2. k-means segmentation results for the example image in Figure 1 for k = 2, k = 3, k = 4 and k = 5, respectively.

Now, choose one of the segmentation results which provides better segmentation of the plant. For example, considering the results in Figure 2, the segmentation of the plant is better for k = 3 and k = 4.

After choosing the segmentation result, compute binary mask of the plant (the mask will be 1 on the pixels whose label is equal to segment label of the plant and 0 at the remaining pixels). Display the binary mask of the plant as in Figure 3.

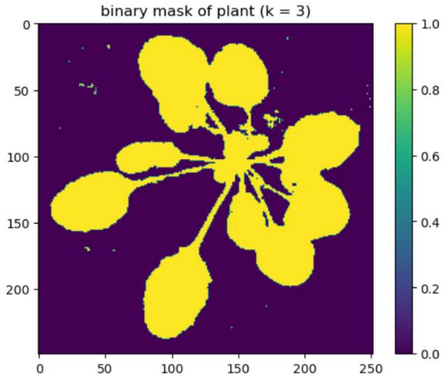

Figure 3. Binary mask of the plant obtained considering the segmentation result in Figure 2 for k = 3.

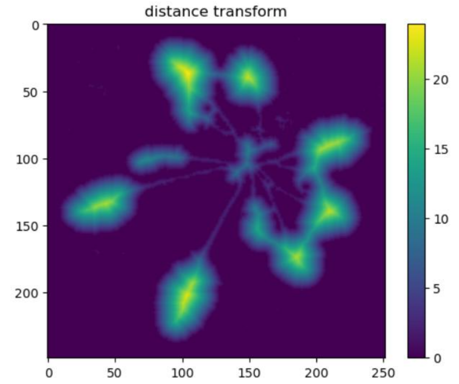

Figure 4. Distance transform of the binary mask in Figure 3.

2. Detection of leaves (40 points)

The aim of this part is to detect leaves of the plant in the input image. As leaves have circular shape, you will detect the leaves by finding circles using Hough Transform. Use HoughCircles function of OpenCV. Read the documentation of HoughCircles function carefully.

In order to determine minRadius and maxRadius parameters of HoughCircles function, first compute distance transform of the binary mask of the plant you obtained in the previous step. Use distanceTransform function of OpenCV by choosing distanceType as DIST_L2 and maskSize as 3. In Figure 4, we see the distance transform of the mask in Figure 3. What is the maximum value of the distance transform? Considering the smaller leaves, what is the value of the distance transform at their centers? By answering these questions, find the appropriate values for minRadius and maxRadius parameters. For example, considering the distance transform in Figure 4, its maximum value is around 24 and it is around 6 at the center of smaller leaves. We might consider to choose minRadius as 6 and maxRadius as 30 (around 1.25 times the maximum value).

You could choose the other parameters of HoughCircles function as follows:

- method parameter as HOUGH_GRADIENT
- dp parameter as 1
- minDist parameter as 0.1 * (the minimum of image width and height)

Convert the original RGB image to La*b* color space and take a* channel (see Figure 5 [Left]). Apply median filtering to a* channel using medianBlur function of OpenCV (see Figure 5 [Right]). You could choose ksize parameter as 5.

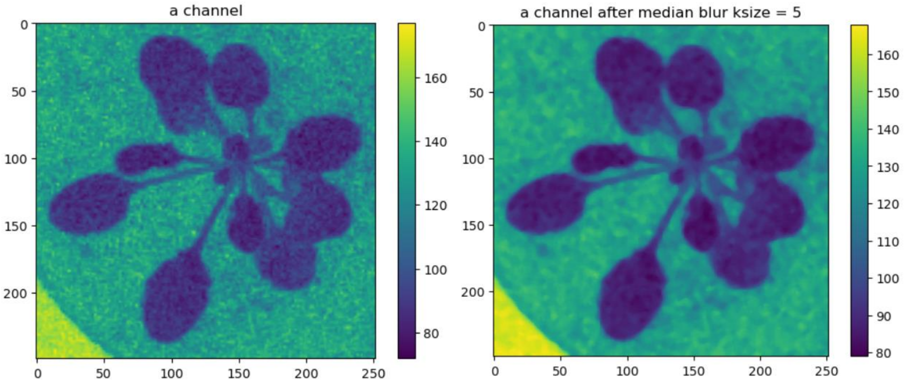

Figure 5. [Left] a channel of the input image in Figure 1 after converted to Lab color space. [Right] Result of median filtering with applied to a channel with ksize = 5.

Use the blurring result (shown in Figure 5 [Right]) as the input to HoughCircles function along with minRadius and maxRadius parameters you have determined.

- First, obtain a detection result for param1 = 40 and param2 = 10.
- Second, obtain a detection result for param1 = 80 and param2 = 10. → param1 is increased and param2 is the same as in the first setting.
- Third, obtain a detection result for param1 = 80 and param2 = 15. → param1 is the same as in the second setting and param2 is increased.

Show the obtained results (there are a total of 3 detection results for each input) along with the corresponding parameters. See Figure 6. You could use circle function of OpenCV for visualization of detected circles.

Note that param1 and param2 values that you use could be different than the values in this document. The important point is that you try different combination of values and observe the effect of each parameter.

Discuss the effect of these parameters. How do the results change as these parameters change?

3. Elimination of Invalid detections (20 points)

Use binary mask of the plant to eliminate the circles whose centers are not located at the plant. In this part, you need to visualize 3 detection results for each input after doing this elimination. See Figure 7.

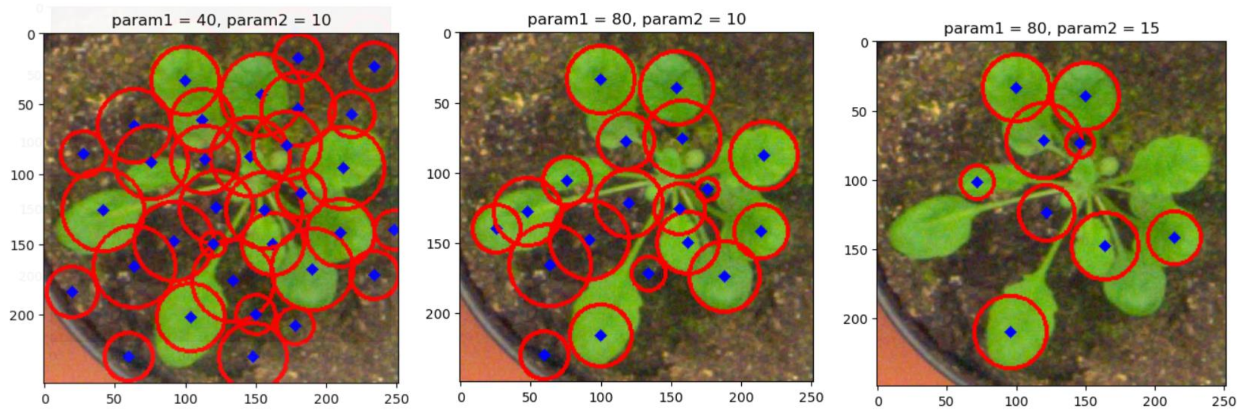

Figure 6. Circles detected using Hough transform for three different parameter settings.

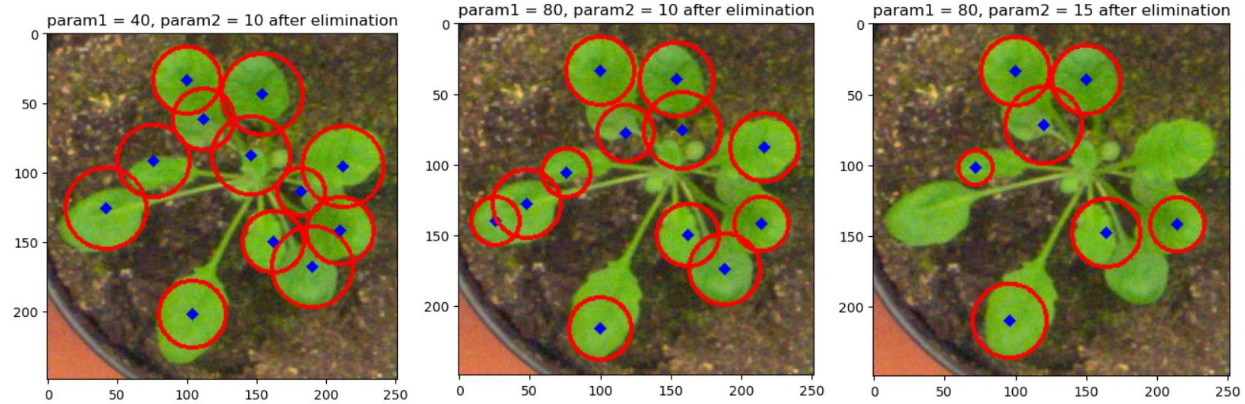
param1 = 40, param2 = 10 after elimination
param1 = 80, param2 = 10 after elimination
param1 = 80, param2 = 15 after elimination
0
50
100
150
200
250

Figure 7. Circles in Figure 6 whose centers are not inside the plant mask in Figure 3 are eliminated.

What to hand in:

- Codes
  hw3_input1.ipynb
  hw3_input2.ipynb
  These ipynb files should include all the codes and the results for each input image. Your input files need to be different from the input file (ara2012_plant002_rgb.png) in this document.
- Report
  In your report, you are expected to include the following information:
  - Brief explanation of what you have done
  - The results that you have obtained together with the corresponding parameters
  - Discussion of the results

It is important that you include all your results and discussion in the report.