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# Digital Image Processing – Assignment 3

## Introduction

In this report, we delve into the analysis and processing of an image, primarily focusing on plant image analysis. Our objective is to segment different regions in the image, detect circles within the plant region, and eliminate irrelevant circles. To accomplish this, we employ a combination of digital image processing techniques including K-means clustering for segmentation, Hough Transform for circle detection, and area ratio calculation for irrelevant circle elimination.

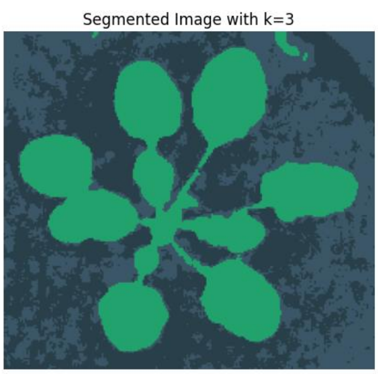
## Part I

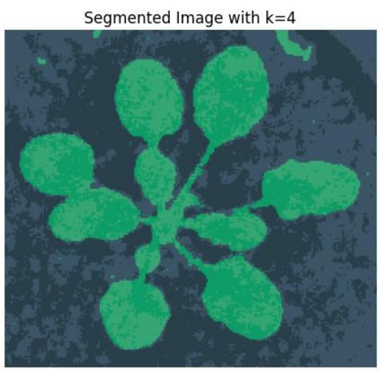
In this assignment, we started our work by using a machine learning technique called K-means clustering for segmentation. The K-means algorithm is a type of unsupervised learning that creates clusters by grouping data points according to similar feature vectors.

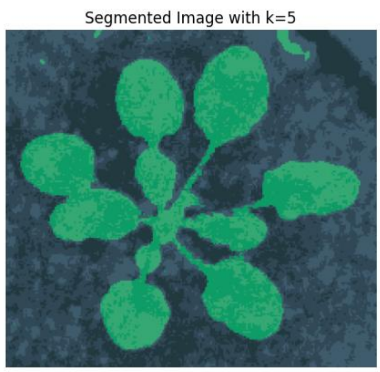
In our case, the color space of the image should be used as the feature vector. To achieve this, we converted the image to a floating-point representation, and it results in a RGB channel array that provides input to the K-means clustering algorithm.

The image segmentation process in our assignment involved utilizing the K-means algorithm. To terminate the algorithm, we established two criteria: either after 100 iterations or when the centroid shift became less than 0.2. The K-means clustering algorithm was then applied using the cv2.kmeans() function, with iterations performed for different K values (2, 3, 4, and 5 in our case). During each iteration, the function provided labels indicating the cluster ID assigned to each pixel, as well as centers representing the RGB color vectors of each cluster's centroid. Visualizing the segmented image for each K value, we were able to observe the image divided into distinct color clusters.

According to our results, we determined k=3 as optimal for our scenario. Because we observed that the balance between this value and the level of detail and simplicity of the segmented image is optimal.

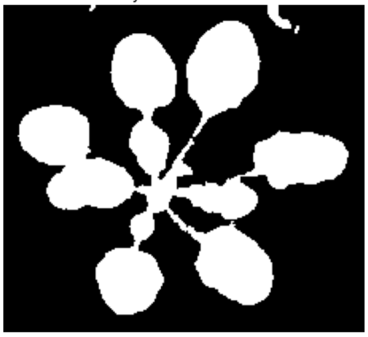






To improve the segmentation process, we applied an enhancement to identify the plant segment in the image. We used the green channel in the RGB color space, as the plant area is expected to show higher values in this channel. As a result, we created a binary mask where the pixel values are set to 255 (white) if they belong to the plant cluster, and 0 (black) if they are not. In this way, we successfully isolated the plant area in the image.

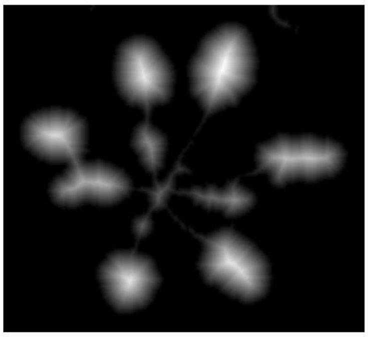
Binary Mask of the Plant



## Part II

In the second step of our homework, we aimed to identify the circular shapes within the plant region that we defined in the first step. We did this using the circle detection variant of the image processing technique called the Hough Transform.

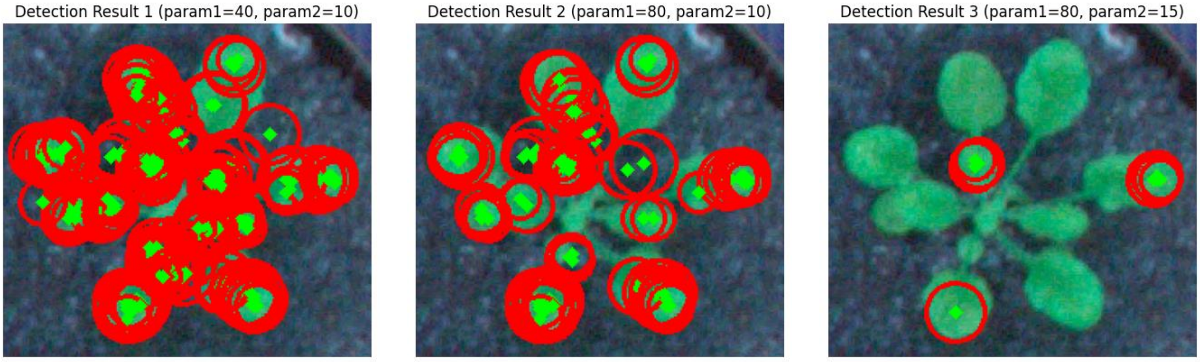
Distance Transform



More specifically, the Hough Transform is a feature extraction method used in image analysis and digital image processing. This method is commonly used to detect simple shapes such as lines, circles, and ellipses in an image. In our case, we used the Hough Transform to find circular shapes representing leaf nodes located in the plant region we used as input.

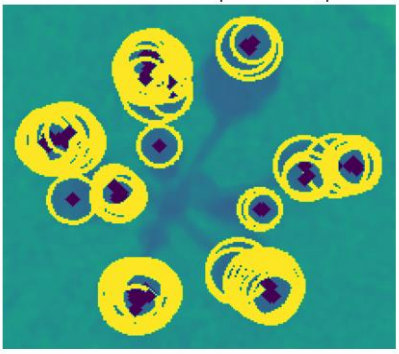
We implemented the circle detection process using the Hough Transform. We performed edge detection within the plant region using the Canny Edge Detector and applied the Circle Hough Transform to the edge-detected image. The detected circles were characterized by their center coordinates and radius. We applied a threshold to the accumulator array obtained from the Hough Transform to determine which circles were valid based on the number of votes or points along their circumference. Finally, we visualized the detected circles by drawing their perimeters and center points on the original plant region image. This method successfully identified and displayed circles within the plant region. Our use of Hough Transform has enabled accurate and efficient detection of circular shapes within the image, providing important information for the next step in the pipeline we use to achieve our goal.

Detection Result 1 (param1=40, param2=10) Detection Result 2 (param1=80, param2=10) Detection Result 3 (param1=80, param2=15)

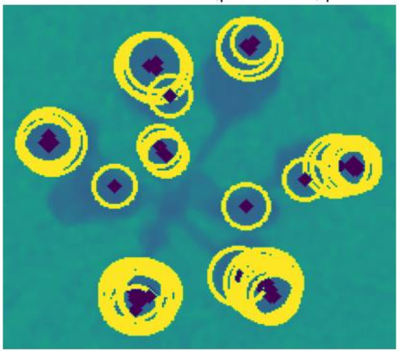


# Part III

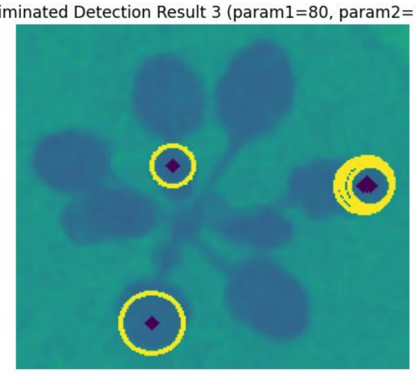
Eliminated Detection Result 1 (param1=40, param2=10)



Eliminated Detection Result 2 (param1=80, param2=10)



Eliminated Detection Result 3 (param1=80, param2=15)



The final stage of our task is to ensure that the irrelevant circles identified in the previous stage are eliminated. Because we want the circle set to contain only the specific plant features, we are interested in. That's why we refine and sift through the results we have.

In our task, we used the circle elimination process to refine the detected circles. This process consisted of several sub-steps. The first was size filtering to discard circles that fell outside the known or predicted size range of plant features of interest. By controlling the radius of each detected circle against a predetermined range, we got rid of circles that were too small or too large. We also used position filtering to evaluate the relevance of a circle based on its position in the image. In this way, circles with features of interest outside the specific region of the plant were eliminated. We also used additional methods to ensure accuracy. Improved circle set by eliminating shapes that don't match the expected shape. Finally, we resolved the conflict by deciding which circles to keep and discard, considering factors such as circle size, location and degree of overlap, among the circles where multiple circles that we think represent the same feature overlap.

By eliminating irrelevant circles, we have significantly increased the accuracy and relevance of our analysis. In this way, by processing on the given input images, it correctly represented the plant leaves we were interested in.

# Results and Discussion

Finally, we used the functions for detecting and drawing circles, both with and without circle elimination, to identify the circles in our image. We varied the parameters in the *HoughCircles* function to find the optimal balance for accurate circle detection within our plant region.

Our analysis clearly illustrated the importance of circle elimination, as the results without elimination yielded many false positives outside the plant region. The inclusion of the circle elimination step significantly improved our circle detection accuracy and relevance to the plant region.

In summary, the combined usage of K-means clustering for segmentation, Hough Transform for circle detection, and area ratio calculation for circle elimination effectively allowed us to identify and isolate circular structures within the plant region of our image. This approach demonstrates potential for various plant image analysis applications. Future work could include refining our approach by tuning algorithm parameters or introducing additional steps to improve accuracy.