Name: Lau Qi Ming

Student ID: 20202456

Module Name: Introduction to Image Processing (Report)

Module Code: COMP 2032 (IIP)

Table of Contents

Introduction

Image segmentation is a type of digital image processing that analyses an image and divides it into several image segments, also known as image regions or objects depending on the pixels' attributes. It entails transforming a picture into a collection of pixel regions denoted by a mask or a tagged image. Several image segmentation algorithms and techniques have been developed over the years using domain knowledge to effectively solve segmentation problems in that specific application area, such as medical imaging, to detect and label pixels in an image or voxels of a 3D volume that represents a tumour in a patient's brain or other organs. For example, another frequent method is to look for similarities in different areas of an image. Region expanding, clustering, and thresholding are some strategies that follow this strategy.

Description of pre-processing techniques employed

With the functions of the Image Processing Toolbox in MATLAB software, I am able to perform several different kinds of pre-processing techniques in my image before segmentation. Image pre-processing is the process of preparing images by improving and modifying them before using in model training and inference.

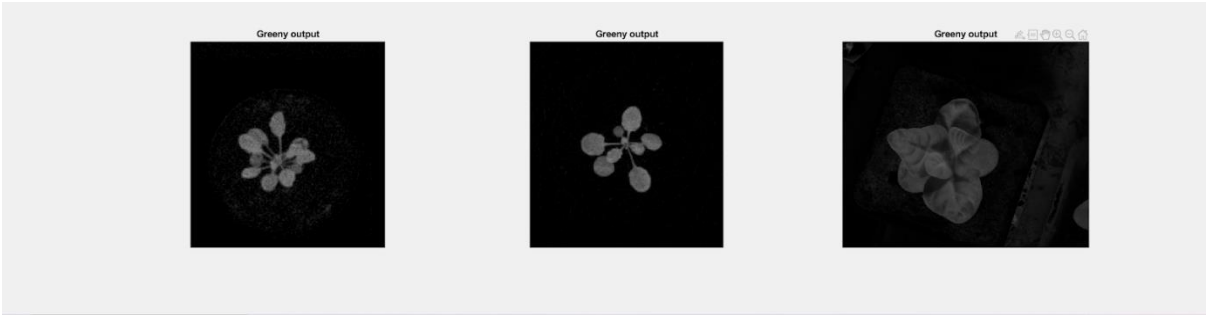

Figure: Greeny Technique

Firstly, I have applied the Greeny technique by using the green channel in the RGB colour space to obtain the image of leaves from the three images. By applying the Greeny's formula: G - (R + B) / 2.0), it helps to detect the green colour from the leaves and convert it into a grayscale image.

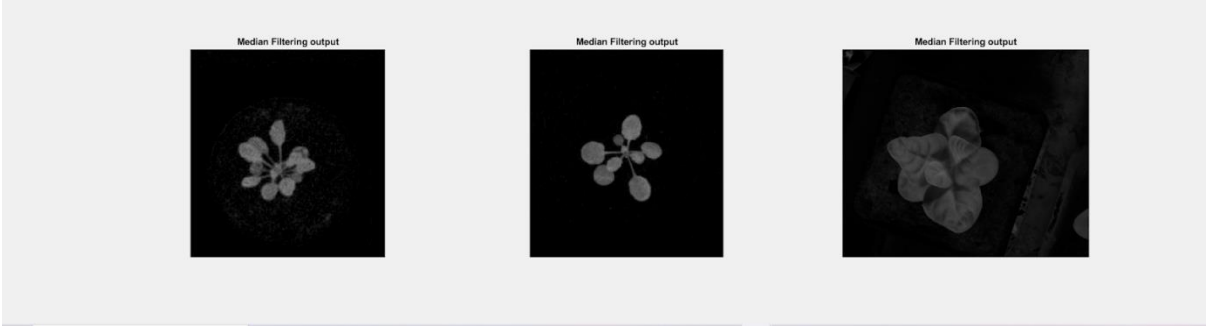

Figure: Median Filtering using medfilt2

Followed by median filtering, medfilt2 to remove the noises and background noise of the leaves such as “salt and pepper. Median filter has slightly more advantages than the Gaussian filter. For example, the Median filter is easy to implement and is less susceptible to extreme values such as outliers than the mean where they can be removed effectively. It doesn’t need to generate new pixel value but in the meantime, the Gaussian filter is only good and effective in removing Gaussian noise but it takes too much time and reduces the details while removing the noises. Therefore, it is more preferable to use the Median filter than Gaussian filter.

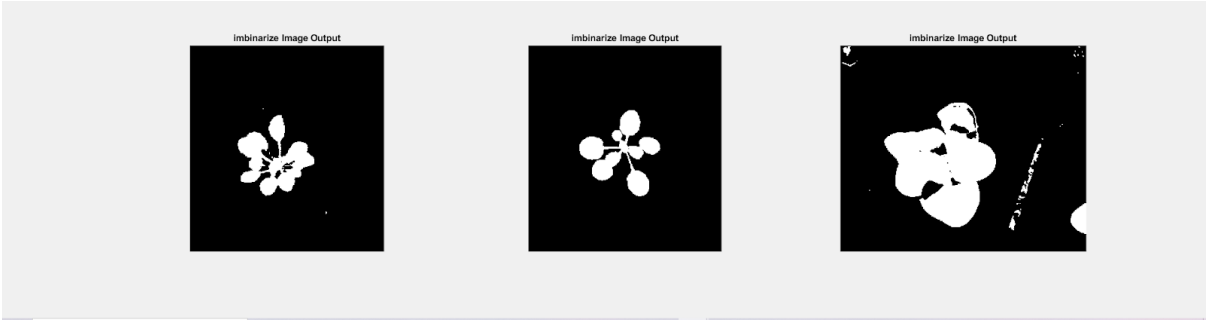

Figure: imbinarize function

Secondly, I’m using the imbinarize function to create the binary image from the leaves by using the thresholding method which is specified as ‘global’.

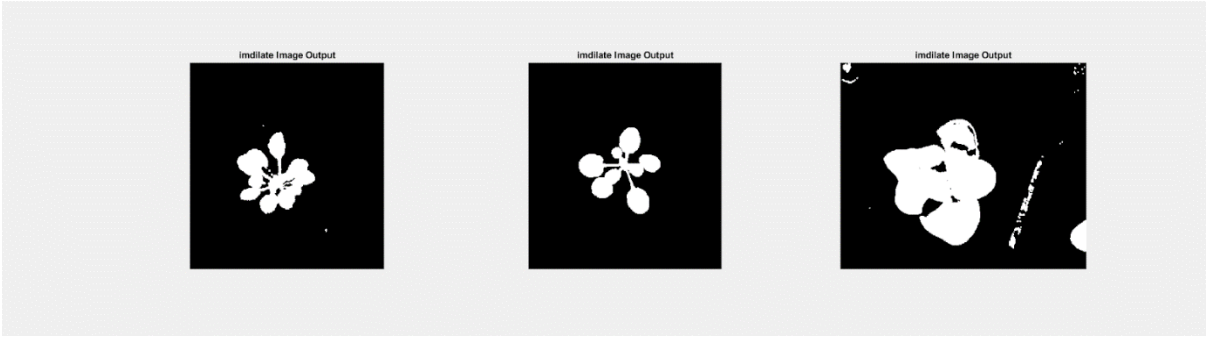

Figure: imdilate function

Besides that, the dilation technique, imdilate is used too to dilate the binary image by using the structuring element from a disk structuring element with a radius of 1.0. Hence, the holes in the leaves will be filled and the pictures of the leaves will be more visible.

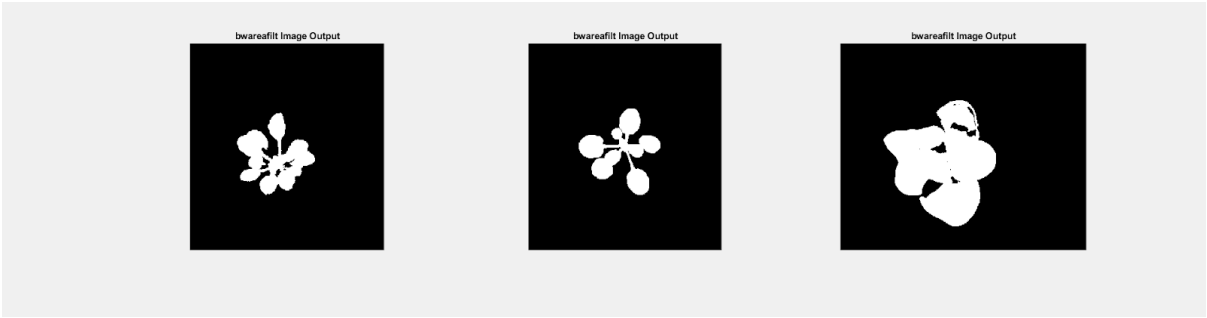

Figure: bwareafilt function

In addition, bwareafilt is then used to retain objects with area of 1 biggest object only by extracting all connected objects based on a specific range from the binary image. Besides that, it gets rid of the noises from the background as well.

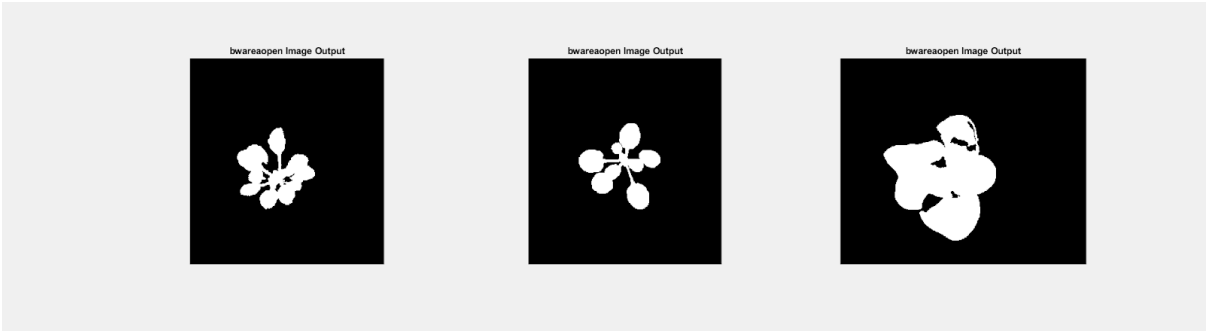

Figure: bwareaopen function

In order to avoid overlapping leaves, bwareaopen is applied to remove all of the small objects that are connected which have less than 20 pixels.

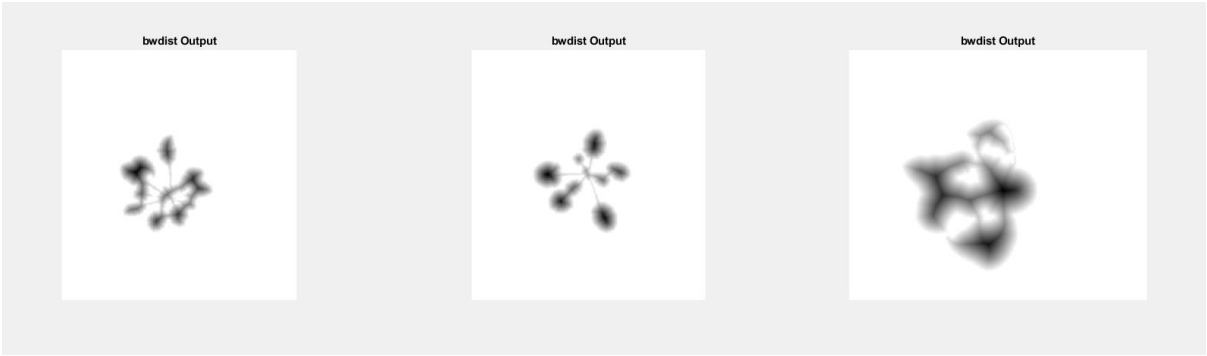

Figure: bwdist function

For my last pre-processing, I have used the bwdist function to compute the distance transform of my binary image. The distance transform assigns a number to each pixel in my binary picture that

represents the distance between that pixel and the image's nearest non-zero pixel.

Description of segmentation method employed

For the segmentation technique, there are many different kinds of techniques such as thresholding, edge-based and region-based segmentation but after I did some research and compared among each other, I've decided to use watershed segmentation. This segmentation method refers to a ridge that divides areas drained by distinct river systems. According to the geological watershed, three-dimensional features would undoubtedly be present in a landscape valley and ridges. The watershed would reflect the image's three-dimensional representation and produce regions named "catchment basins" as a result. Therefore, the "catchment basins" and "watershed ridge lines" in the image will be transformed by using this segmentation method, which treats the image as a surface with light pixels at the top and dark pixels at the bottom.

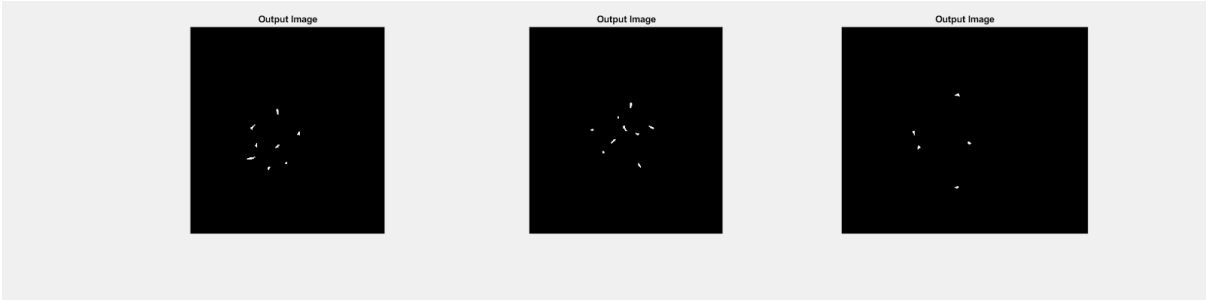

Figure: imextendedmin function

Firstly, I have computed the extended-minima transform by using the imextendedmin function which is the regional minima of the 2-minima transform to obtain a result of 'mask'. Regional minima are pixels that are connected and have a constant intensity value, especially all of their external boundary pixels will have a greater value. As a result, tiny spots will appear in the middle of the cells after they are segmented.

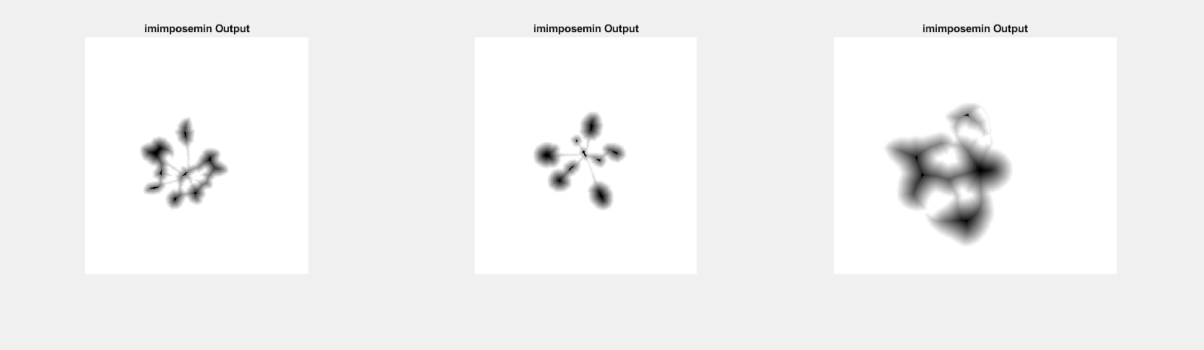

Figure: imimposemin function

After that, I'm using the function of imimposemin to use morphological reconstruction to change the intensity picture so that it only contains regional minima no matter when 'mask' is non zero and D is the binary image, resulting in D2.

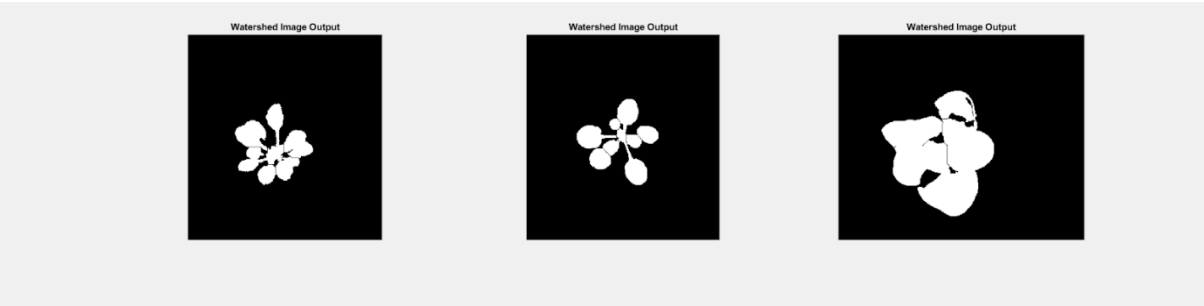

Figure: Watershed segmentation

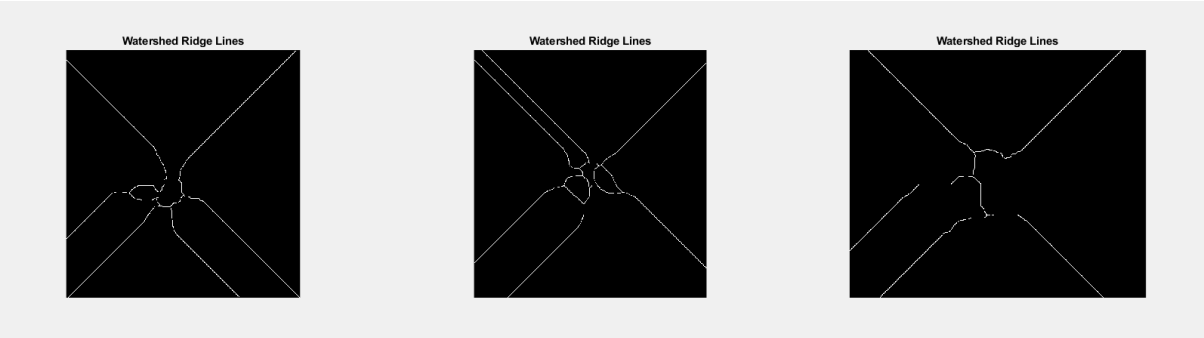

Figure: Watershed Ridge Lines

Besides that, I have computed the watershed transform of D2 with ws. Consequently, the watershed ridge lines will correspond to ws == 0. The ridge lines are used to segment the binary image by converting the matching pixels into background in this function.

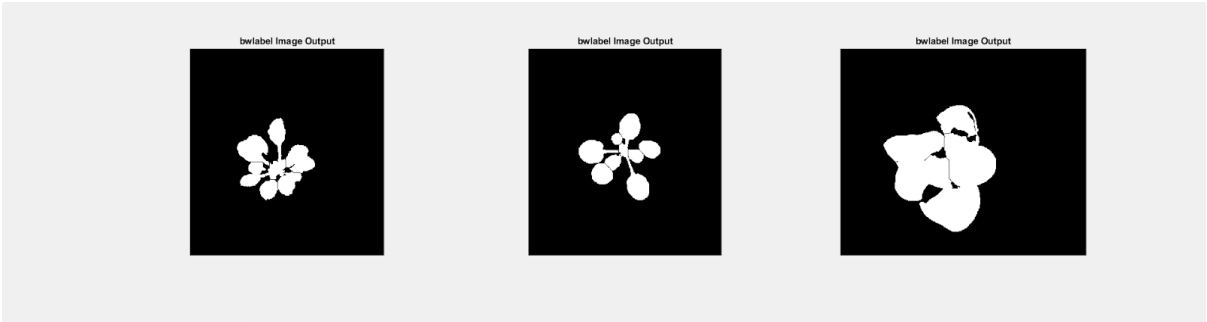

Figure: bwlabel function

From there on, I'm using the function of bwlabel to return the label matrix L that contains labels for all of the connected objects found in my BW4 image.

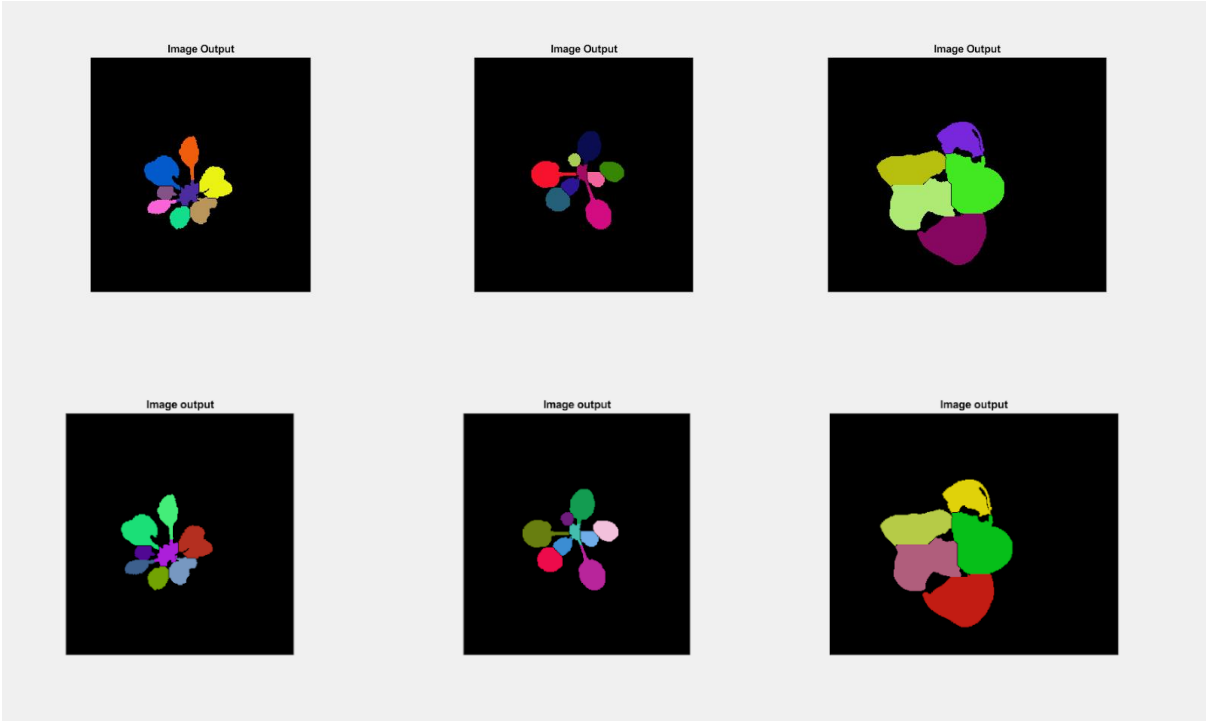

Figure: label2rgb function

Lastly, I'm displaying my result of the label matrix as an RGB image by using the label2rgb function by assigning the random colours function 'map' to the leaves and displaying them in a black background. The random colours function 'map' gets the number of maximum labels from the three segmentations and randomises a cmap matrix.

Evaluation Method

Strengths

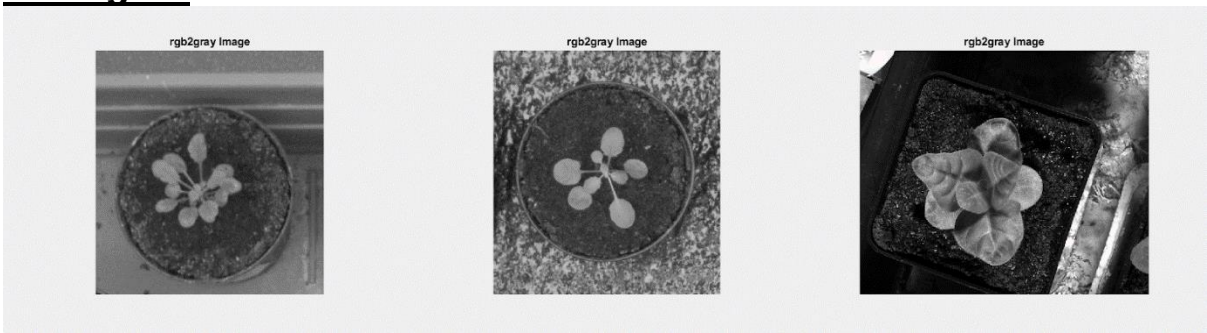

Figure: rgb2gray Formula

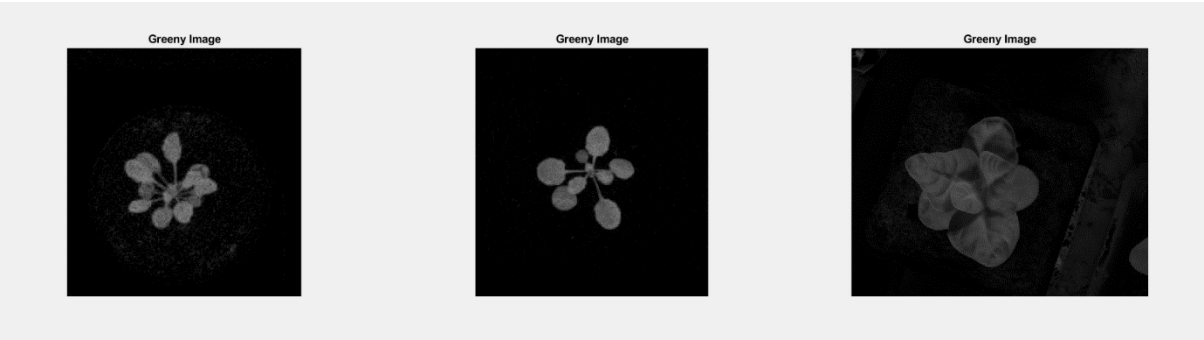

Figure: Greeny's Formula

In order to proceed to image segmentation, it is preferable to convert the image into a grayscale image first which makes the segmentation easier. Therefore, there are two ways to convert into grayscale images which are rgb2gray formula and Greeny's formula. Although the rgb2gray formula seems easier to be used, the output given will have shadows at the background which doesn't make it a perfect grayscale image for segmentation. On the other hand based on (John D'Errico, 2014), the Greeny's formula will detect the green colour from the leaves and convert the others to a grayscale image which produces a better results than the rgb2gray formula.

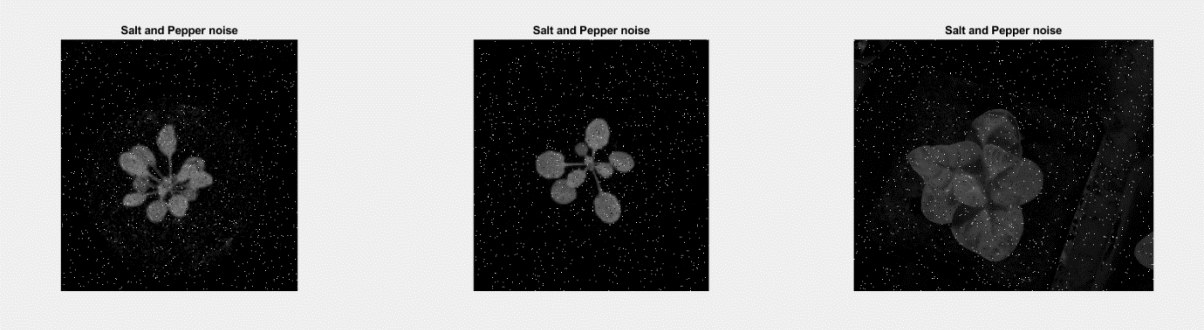

Figure: Salt and Pepper noise

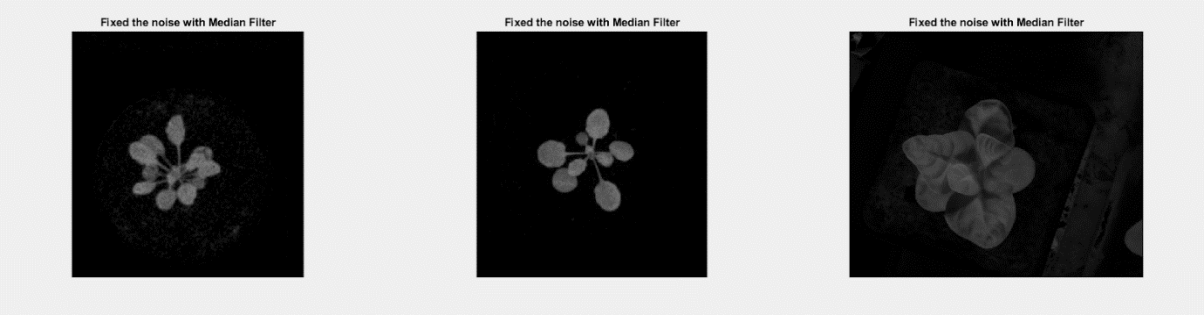

Figure: Fixed the noise with Median Filter

Based on the results shown above, it can be seen that the output images of the leaves are segmented without any additional noises at the background image due to the implementation of pre-processing like the Median filter (Lim, Jae S., 1990).

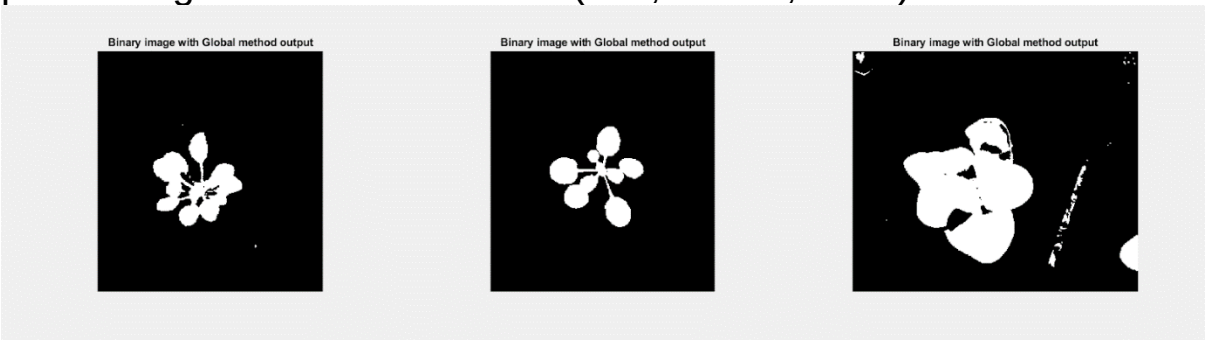

Figure: Binary image in Global Method

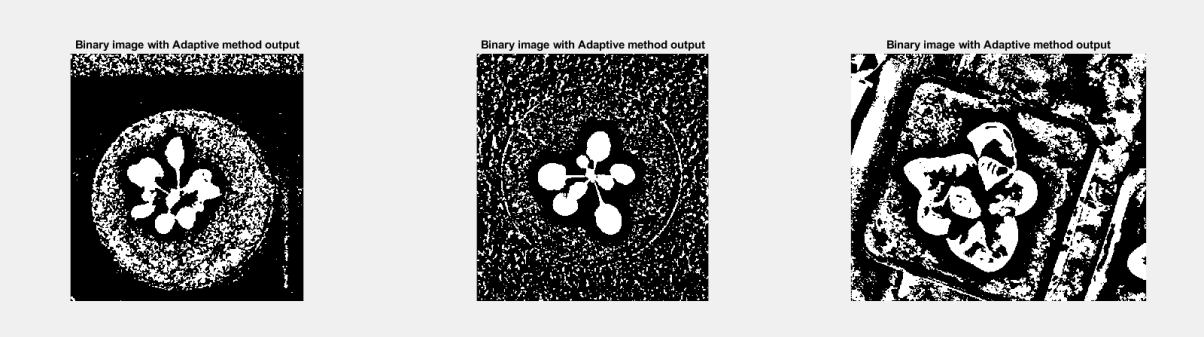

Figure: Binary image in Adaptive method

Additionally, using imbinarize with the global method brings a better binary image output than using the imbinarize with the adaptive method. According to (Otsu,N.,1979), the image output from the global method is easier to perform watershed segmentation because it uses the Otsu's method.

Apart from that, watershed segmentation has a few advantages too. One of the advantages is it requires lower time complexity for the program to operate which reduces the amount of computer time needed to run the program. Watershed segmentation is also a simple, quick and automatic method for us because it is straightforward to grasp when implementing it in a software (Kumar, Gradient Based Techniques for the Avoidance of Oversegmentation 2010). This segmentation technique will result in a complete partition of the image which allows us to readily identify the leaves from every plant image.

Weakness

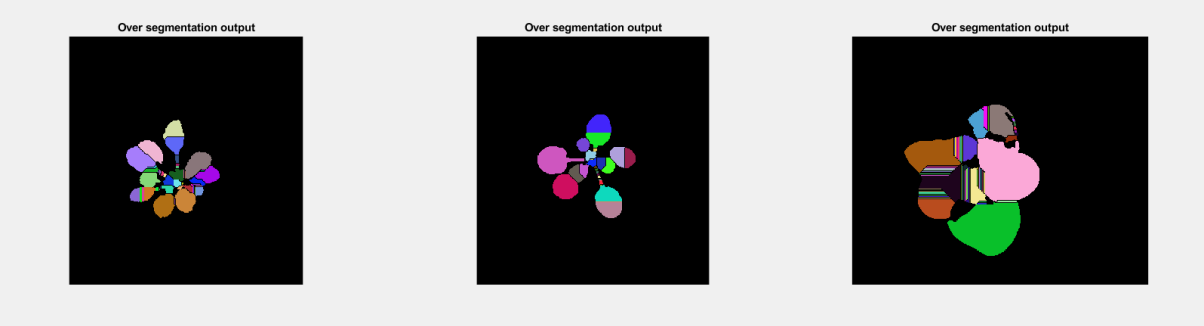

Figure: Over Segmented Image

The "raw" watershed is really easy to cause over-segmentation. This is because no matter how little, each local minimum in the leaves, it becomes a catchment basin. Therefore according to (Steve, 2016) , the imextendedmin function is used to filter out tiny local minima and construct small spots that are roughly in the middle of the cells to be segmented. Besides that, the imimposemin function is also used to change the distance transform so that no minima appear at the filtered out locations.

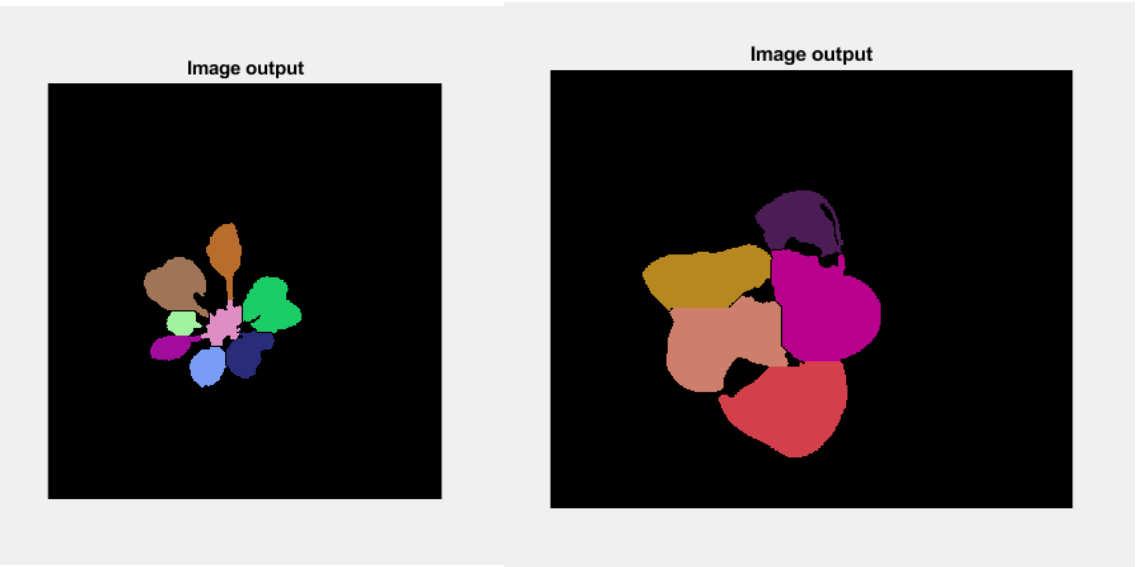

Figure: Overlapping among the leaves in plant 1 and plant 3

From the output images from plant 1 and plant 3, this segmentation method will still obtain overlapping among the leaves in the plant. There are supposed to have 15 leaves with different colours shown in the end results for plant 1 but mine has only 8 colours which means there are overlapping between the leaves. This shows one of the disadvantages with watershed segmentation technique is the under-segmentation where unwanted regions are included in the segmentation results. Besides that, this watershed method has one more disadvantage where it is highly sensitive to local minima, since at each minima a watershed is created. When there is an image with noise, this will influence the segmentation.

Conclusion

Image Processing has become very important to our daily life and has become a very highly demanded field of study. In terms of health, education, defence, traffic, homes, offices, cities, and other areas, the future of digital image processing has a high possibility of contributing to the creation of a smart and intelligent world.

References

1. Otsu, N.(1979), "A Threshold Selection Method from Gray-Level Histograms." *IEEE Transactions on Systems, Man, and Cybernetics*. Vol. 9, No. 1, pp. 62–66.
2. Kumar, N.(June 2010)" Gradient Based Techniques for the Avoidance of Oversegmentation."
3. Steve, E.(2016)"Watershed Transform." Link from : https://www.mathworks.com/content/dam/mathworks/tag-team/Objects/w/88385_93006v00_Watershed_Transform_2016.pdf
4. John D'Enrico(March 2014)"Greeness of an RGB image". Link from: https://www.mathworks.com/matlabcentral/answers/119804-greenness-of-an-rgb-image
5. Lim, Jae S., *Two-Dimensional Signal and Image Processing*, Englewood Cliffs, NJ, Prentice Hall, 1990, pp. 469-476.