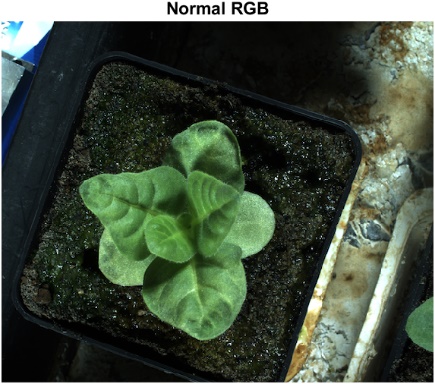
**Introduction to Image Processing (COMP2032) Coursework Report**

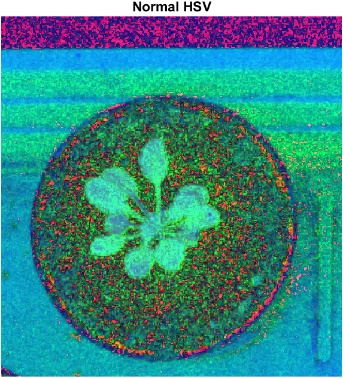
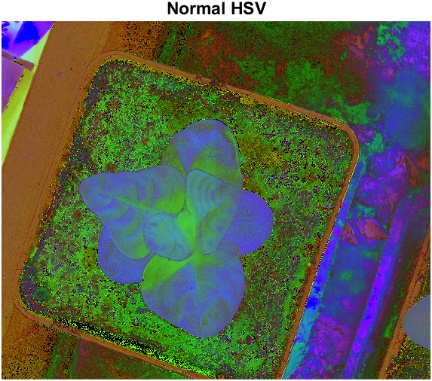
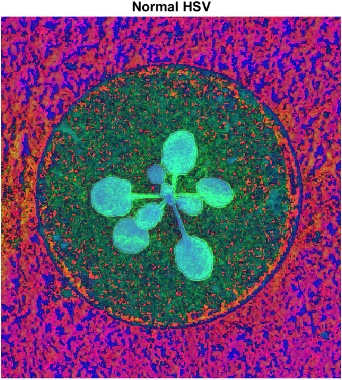
|  |  |
| --- | --- |
| Objective | Detect and Segment Leaf |
| Date | 24/03/2022 |
| Student Name | Tan Zhun Xian |
| Module Convenor | Tissa Chandesa |

**Introduction**

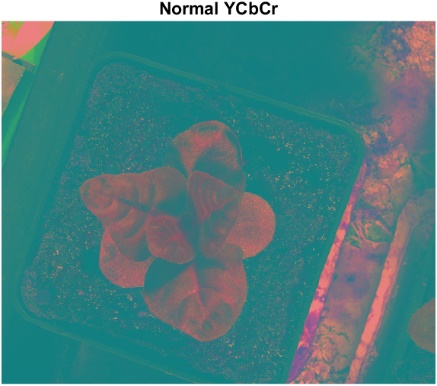
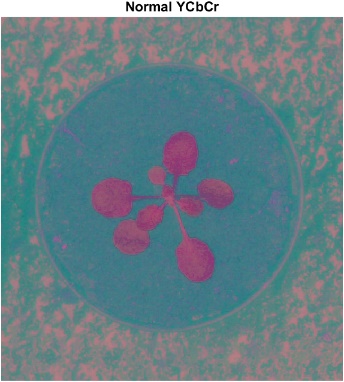
* *The images in the document will be displayed in rows of 3.*
* *The images are arranged in the order plant001.png, plant002.png and plant003.png.*
* *Below are the images used displayed in RGB, HSV and YCbCr.*
  + *RGB*

**

* *HSV*

**

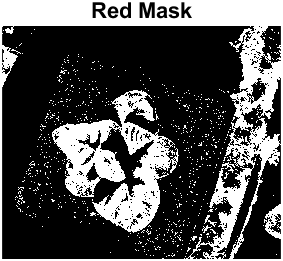
* *YCbCr*

**

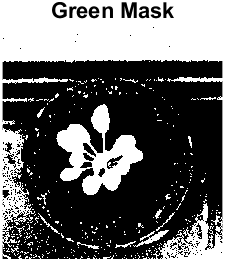
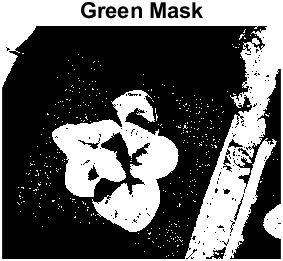
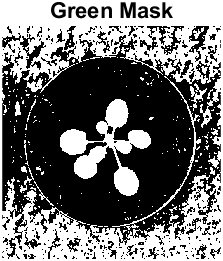
**Pre-processing technique(s)**

**Masking**

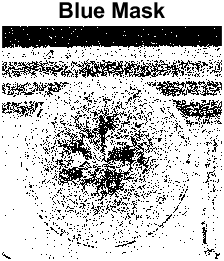
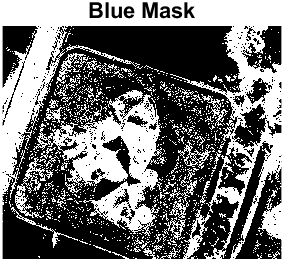
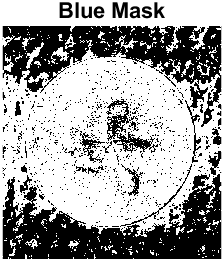
* *Using the RGB, HSV and YCbCr colour spaces, we can construct some masks to only cover the green leaves.*
* *First, we have the RGB masks*
  + *Red Mask (red > 70 & red < 140)*

**

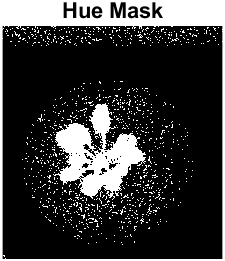
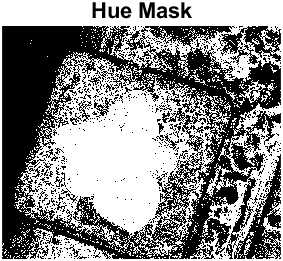
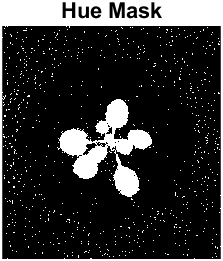
* *Although the plant can be seen in the first image, the plant cannot be clearly seen in the second image while the third image has large pieces of the plant missing. So, this mask is discarded.*
  + *Green Mask (green > 100)*

**

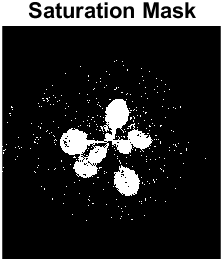
* + *Although the plant can clearly be seen in the first and second image, the third image has large pieces of the plant missing. So, this mask is discarded.*
  + *Blue Mask (blue > 30 & blue < 100)*

**

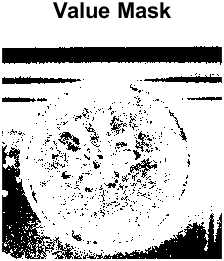
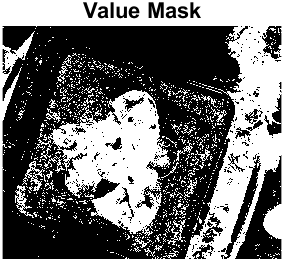
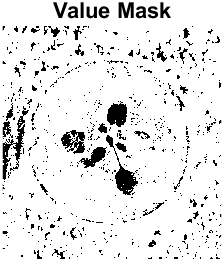
* *The plant cannot be seen clearly in all 3 images. So, this mask is discarded.*
* *Then, we have the HSV masks*
  + *Hue Mask (hue >= 0.2 & hue <= 0.35)*

**

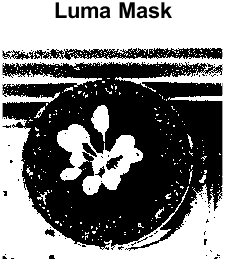
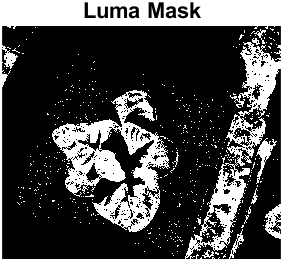
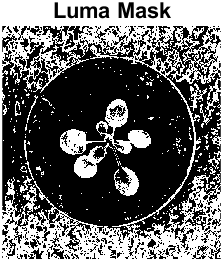
* *Although the main plant can clearly be seen in all 3 images. The side plant to the right in the third image cannot be seen clearly. So, this mask is discarded.*
  + *Saturation Mask (saturation >= 0.6)*

**

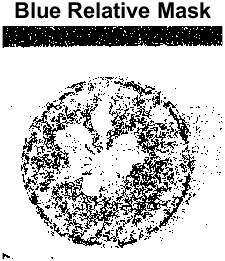
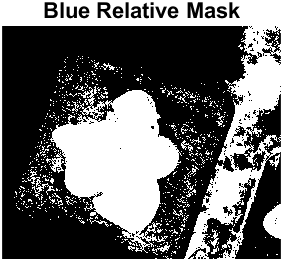
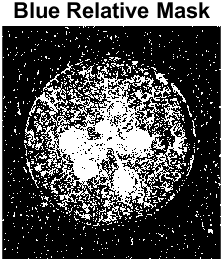
* + *The plant in the first and second image can be seen quite clearly. However, the plant in the third image is almost fully blocked. So, this mask is discarded.*
  + *Value Mask (value >= 0.2 & value <= 0.7)*

**

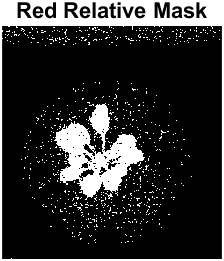
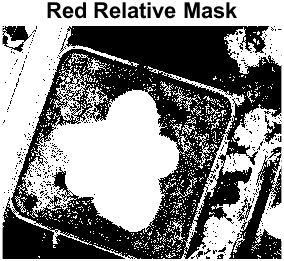
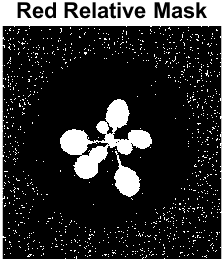
* *The plants cannot be seen clearly in any of the 3 images. So, this mask is discarded.*
* *Then, we have the YCbCr masks*
  + *Luma Mask (luma >= 100 & luma <= 150)*

**

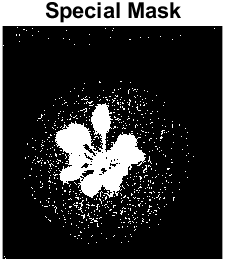
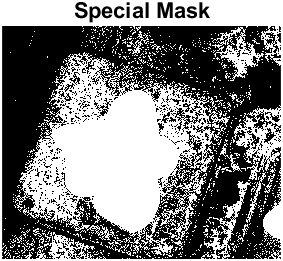
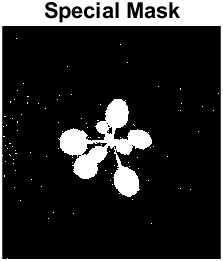
* *Although the plant in the image can be seen clearly, the other 2 images have large pieces of the plant missing. So, the mask is discarded.*
  + *Blue Relative Mask (blueRelative >= 60 & blueRelative <= 121)*

**

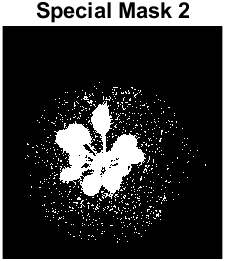
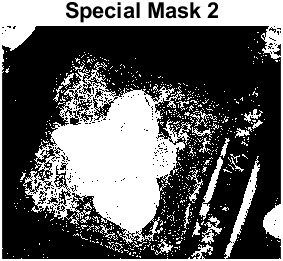
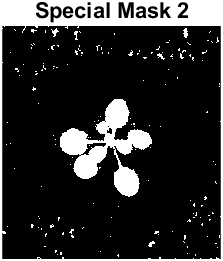
* + *The plants in all 3 images can be seen. Although there is a lot of noise in the first 2 images, it will be removed by the other masks. So, this mask is chosen.*
  + *Red Relative Mask (redRelative >= 100 & redRelative <= 125)*

**

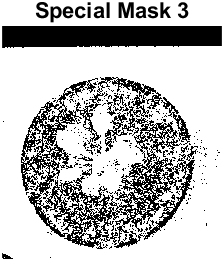
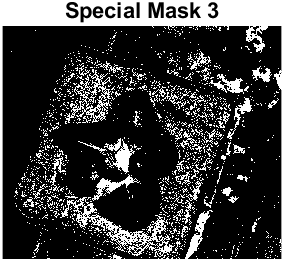
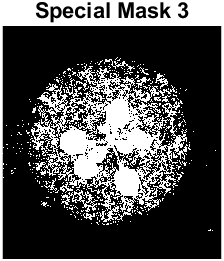
* + *The plant in all 3 images can be seen clearly. Although there is a lot of noise in the third image, it will be removed by the other masks. So, this mask is chosen.*
* *Finally, we have the special masks*
  + *Special Mask 1 (green > 1.1 \* red & green > 1.1 \* blue)*

**

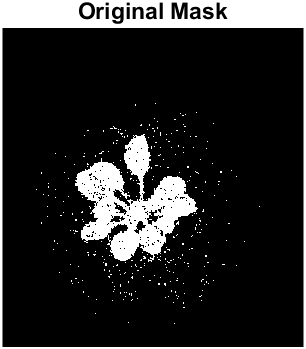
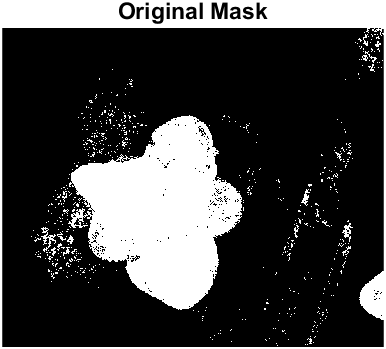
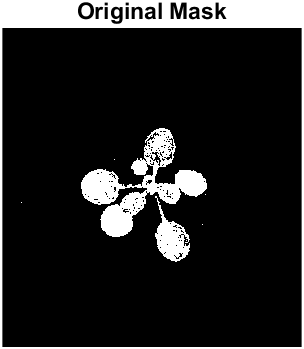
* + *The plant in all 3 images can be seen clearly. Although there is a lot of noise in the third image, it will be removed by the other masks. So, this mask is chosen.*
  + *Special Mask 2 (green > (red + blue) / 1.4)*

**

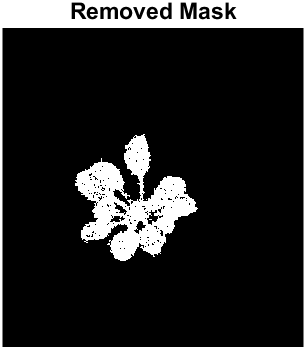
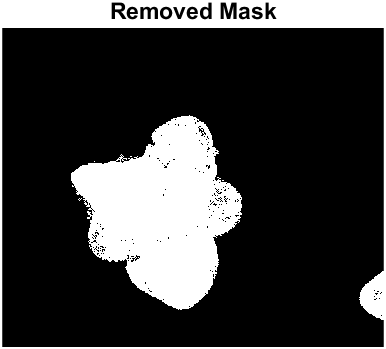
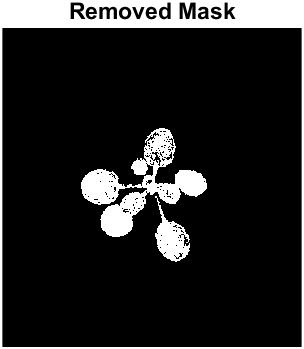
* + *The plant in all 3 images can be seen clearly. Although there is a lot of noise in the third image, it will be removed by the other masks. So, this mask is chosen.*
  + *Special Mask 3 (red > 1.5 \* blue)*

**

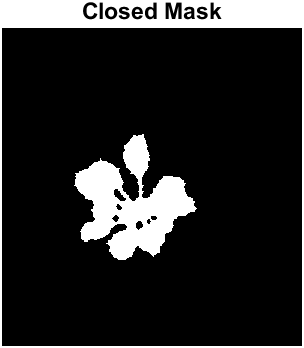
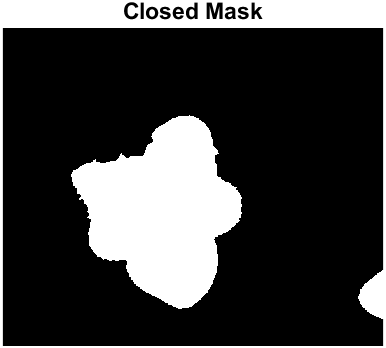
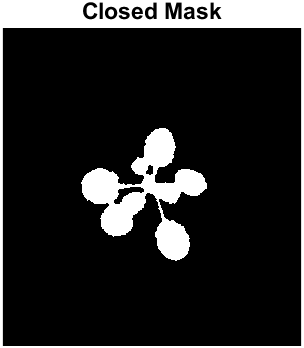
* *The plants in the first 2 images can be seen. However, the plant in the third images is almost fully blocked. So, this mask is discarded.*
* *In the end, the combination of Special Mask 1, Special Mask 2, Blue Relative Mask and Red Relative Mask was found to produce the best mask for separating the leaves from the original image.*
  + *Combined Mask*

**

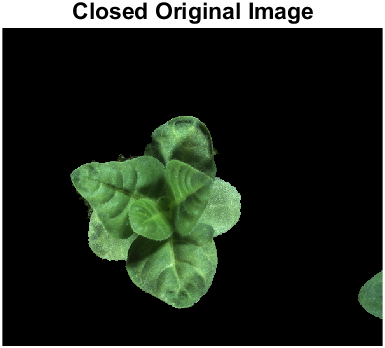
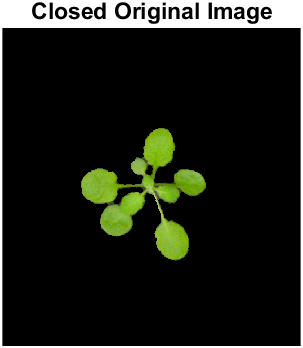
* + *The original combined mask is quite dirty. We clean up the mask below.*
  + *bwareaopen (originalMask,400)*

**

* + *Components with less than 400 pixels have been removed. Now, we morphologically close the mask to remove the holes.*
  + *imclose (originalMask, strel ('disk',3))*

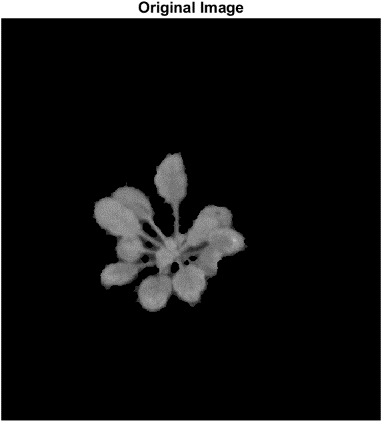
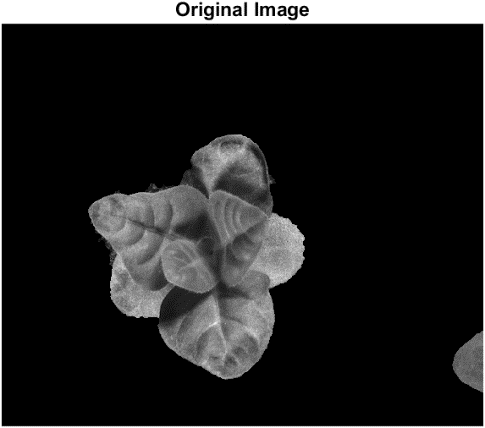
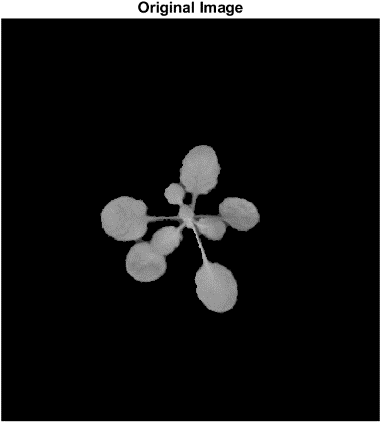
**

* + *The mask is closed with a disk structuring element with radius 4. Now, the mask is ready.*
* *We overlay the mask on the original image to separate the leaves from the background.*
  + *Mask overlayed on original image*

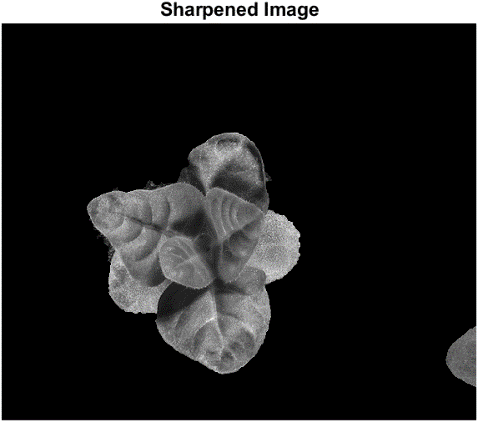
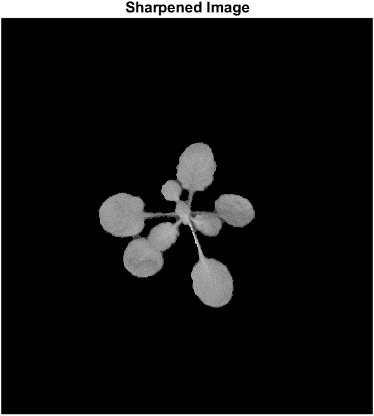
**

**Unsharp Masking**

* *Using unsharp masking, we sharpen the image for further segmentation.*
* *First, we convert the images to grayscale.*
  + *rgb2gray (originalImage)*

**

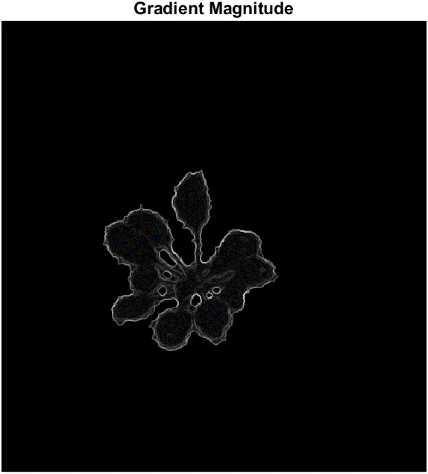
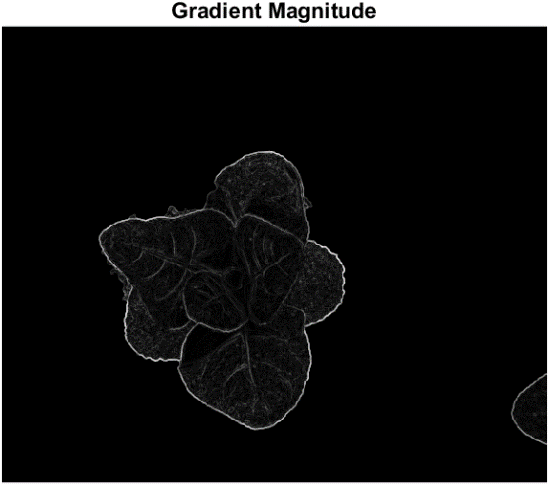
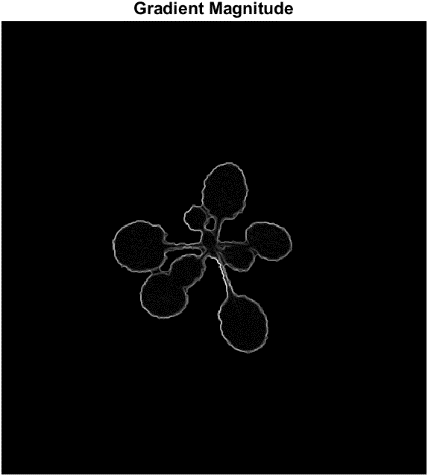
* *Now, we sharpen the images.*
  + *imsharpen (grayScaleImage,'Radius',0.5,'Amount',1.5)*

**

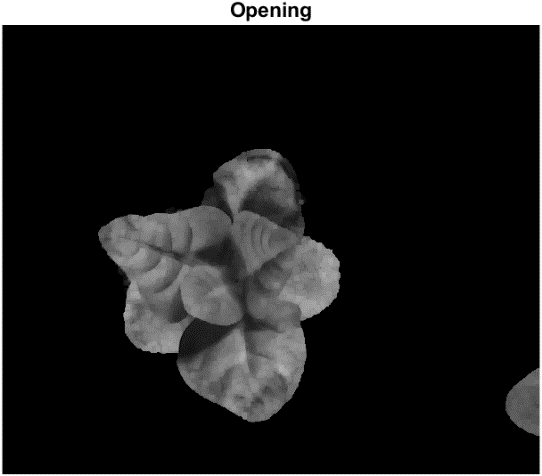
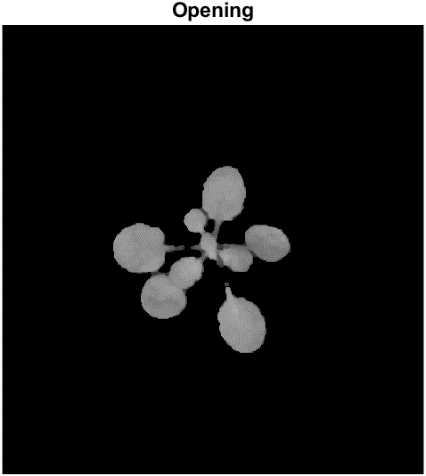
**Segmentation Technique**

**Watershed Segmentation**

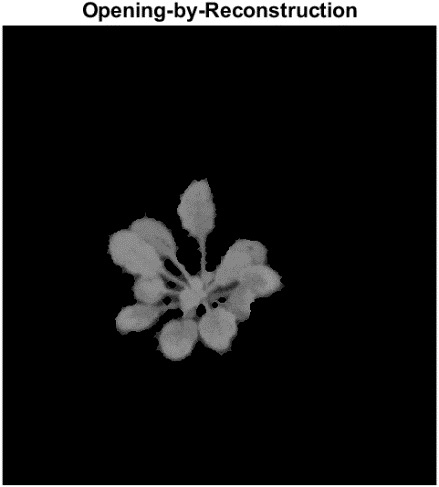
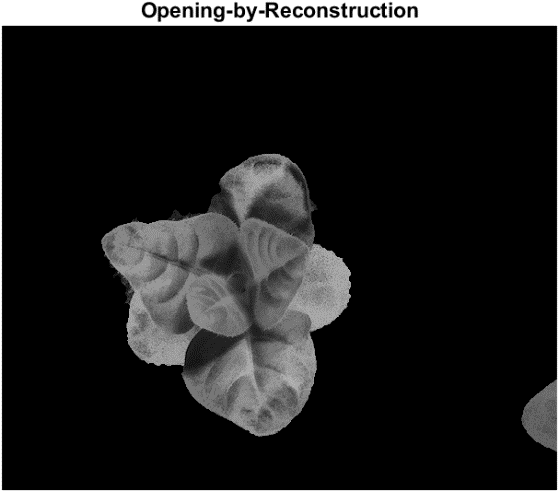
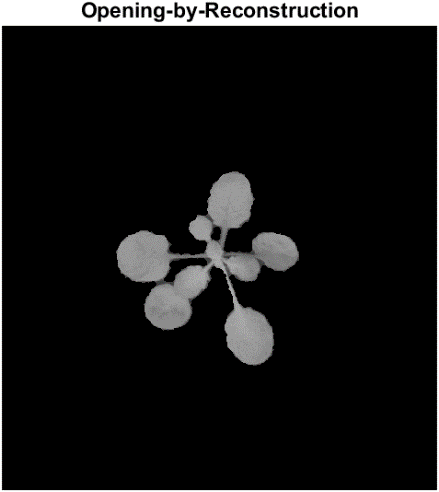
* *Using watershed segmentation, we can separate individual leaves as catchment basins and give each leaf a unique colour.*
* *First, we get the gradient magnitude of the leaves.*
  + *gmag = imgradient (I)*

**

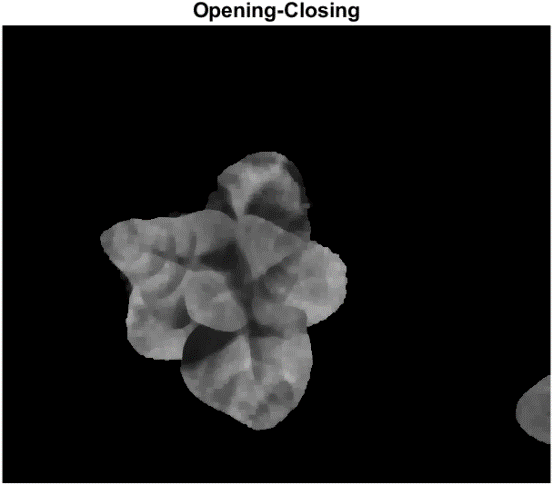
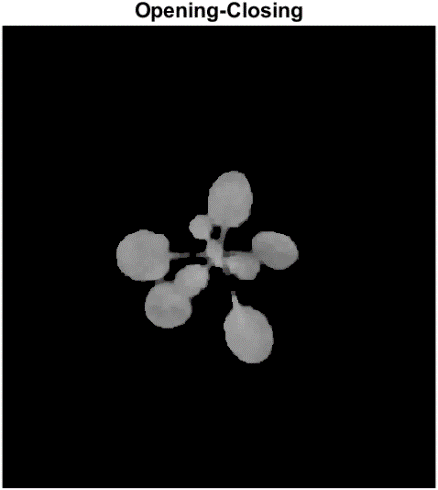
* *We create a disk structing element se with radius 3 for later use.*
  + *se = strel ('disk',3)*
* *Then, we morphologically open the images using se.*
  + *Io = imopen (I,se)*

**

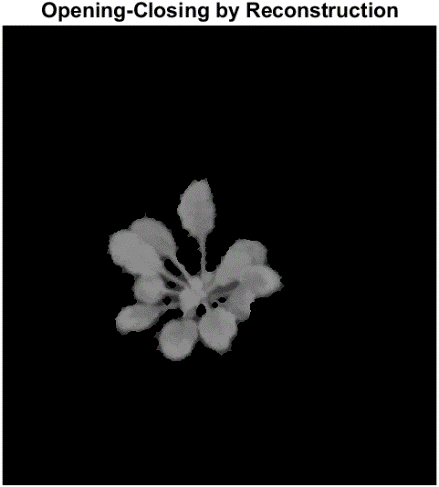
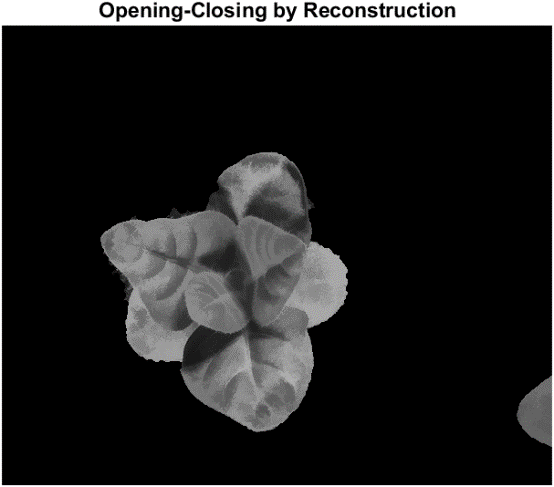
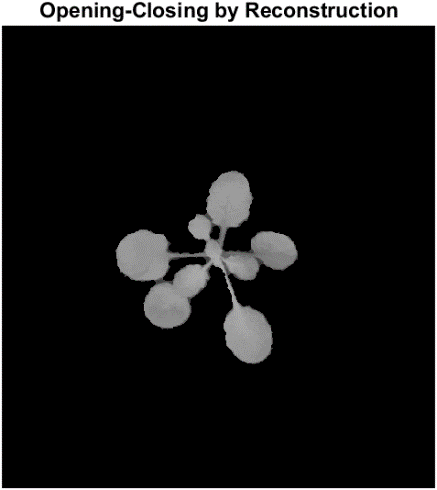
* *Then, we reconstruct the images by opening using se.*
  + *Ie = imerode (I,se)*
  + *Iobr = imreconstruct (Ie,I)*

**

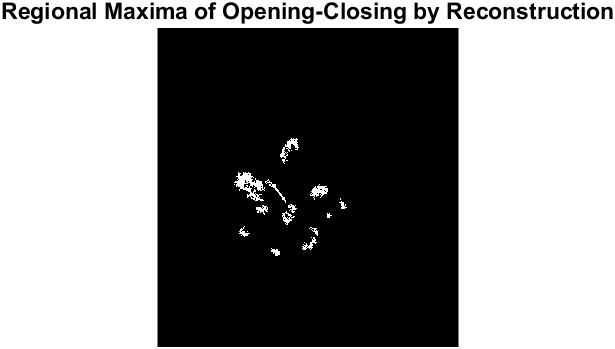
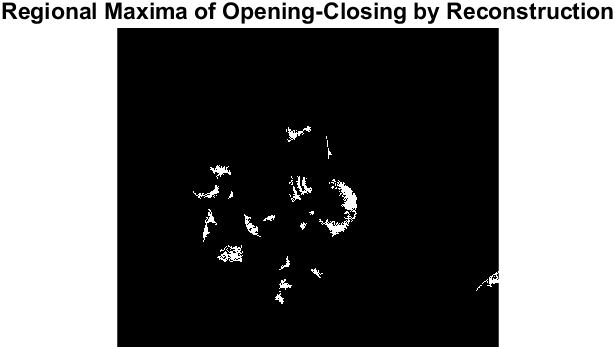
* *Then, we morphologically close the images using se.*
  + *Ioc = imclose (Io,se)*

**

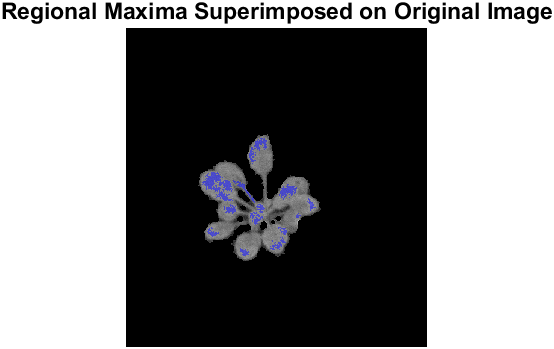
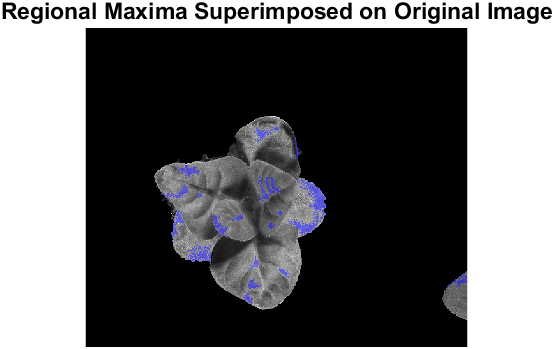
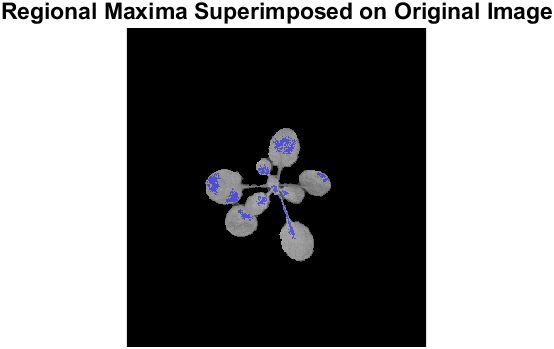
* *Then, we reconstruct the images again.*
  + *Iobrd = imdilate(Iobr,se)*
  + *Iobrcbr = imreconstruct(imcomplement(Iobrd),imcomplement(Iobr))*
  + *Iobrcbr = imcomplement(Iobrcbr)*

**

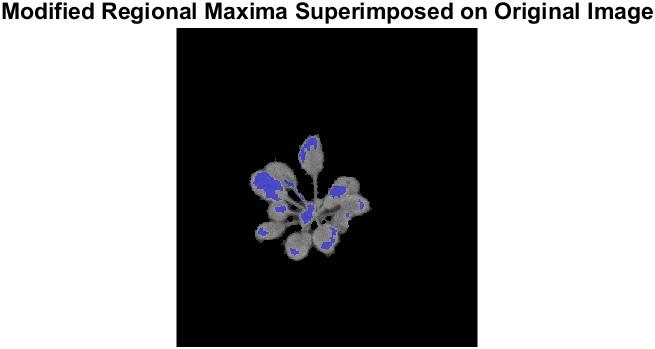
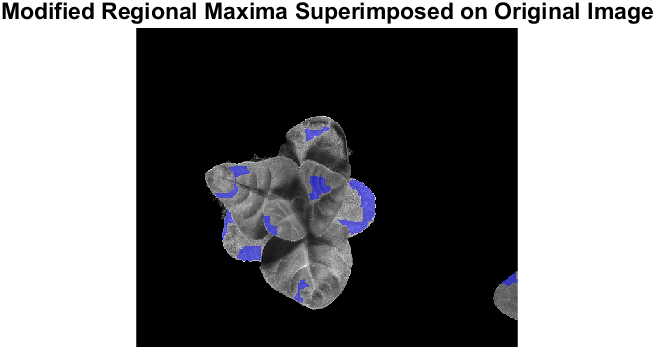
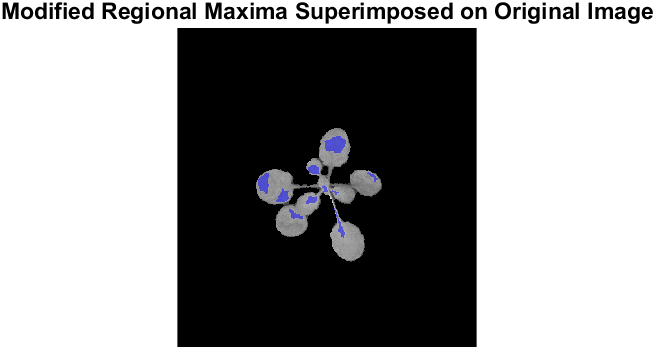
* *Then, we get the regional maxima of the images.*
  + *fgm = imregionalmax(Iobrcbr)*

****

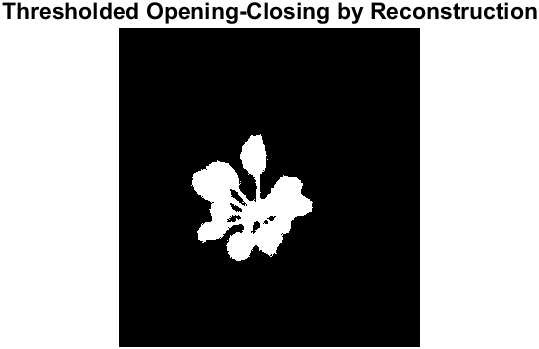
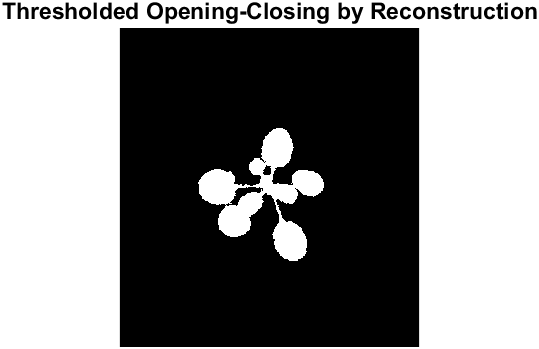
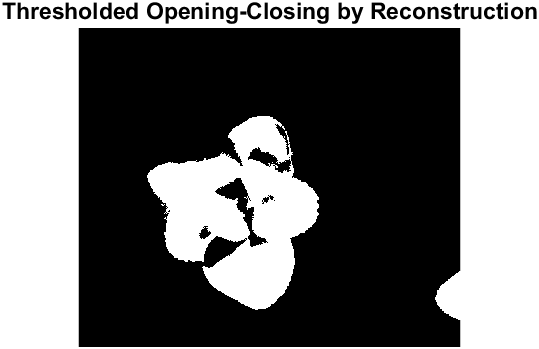
* + *Regional Maxima Superimposed on Original Image*

**

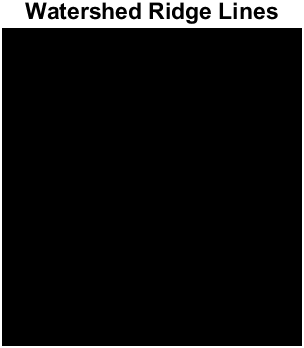
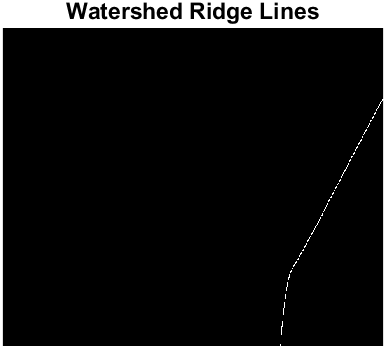
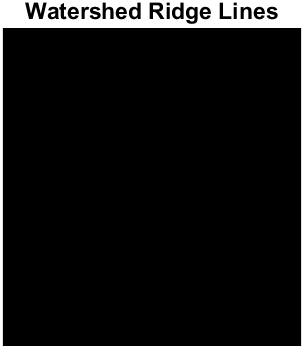
* *Then, we modify the maxima to prepare it for the watershed segmentation.*
* *By using bwconncomp(fgm4).NumObjects, we can count the number of connected components in fgm4 to detect oversegmentation.*
* *In image 3, we find that there are more than 12 connected components.*
* *To rectify this, we use an if else statement to set alternative settings for se2, se3 and fgm4. The alternative functions are listed beside the original functions.*
  + *se2 = strel ('disk',3) / se2 = strel ('disk',7)*
  + *fgm2 = imclose (fgm,se2)*
  + *se3 = strel (ones(2,2)) / se3 = strel (ones(2,2))*
  + *fgm3 = imerode (fgm2,se3)*
  + *fgm4 = bwareaopen (fgm3,20) / fgm4 = bwareaopen (fgm3,150)*
* *We then overlay the modified regional maxima on the original images.*
  + *Modified Regional Maxima Superimposed on Original Image*

**

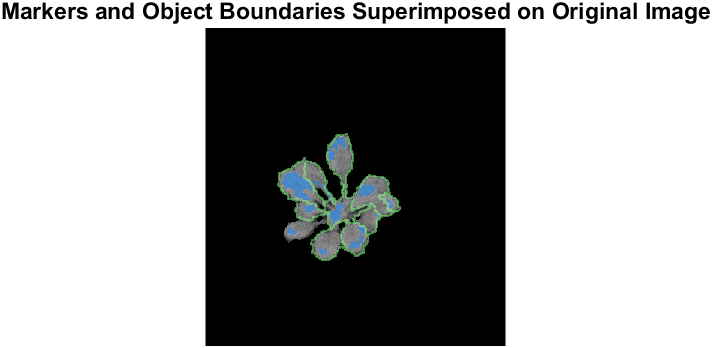
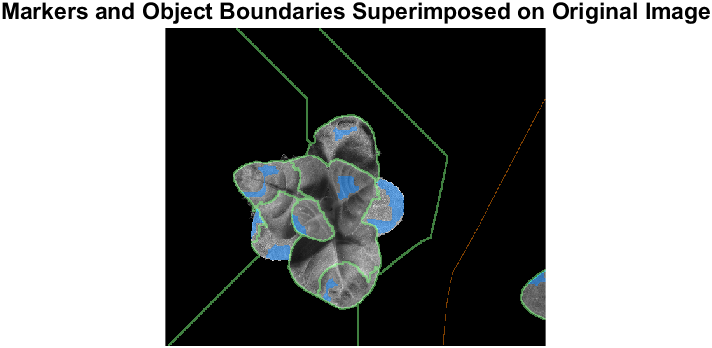
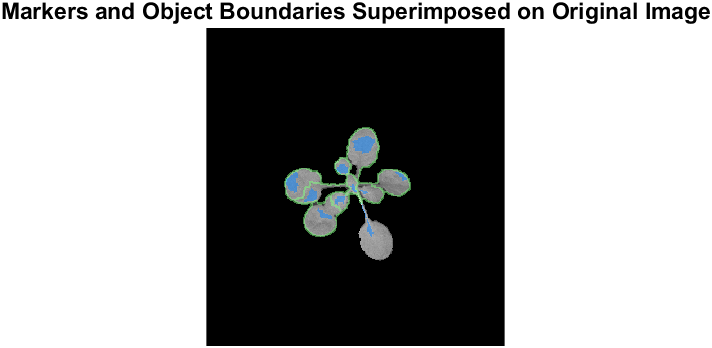
* *Thresholded Opening-Closing by Reconstruction*
  + *imbinarize(Iobrcbr)*

**

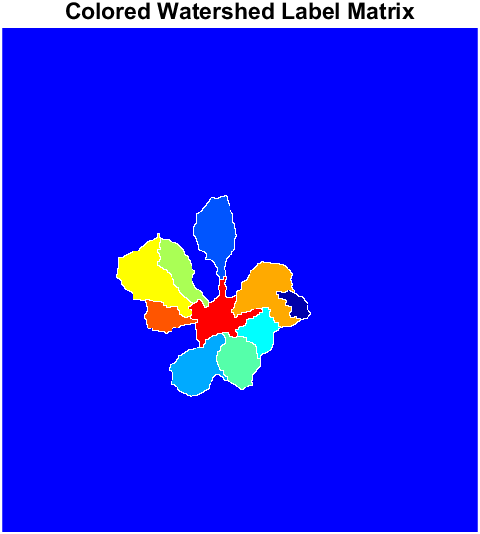
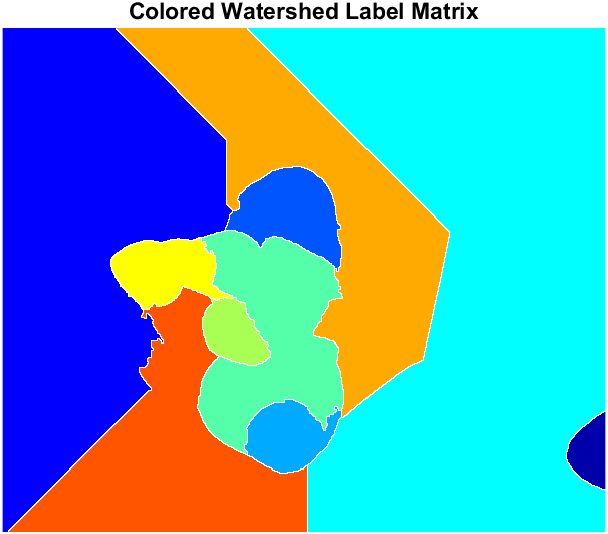
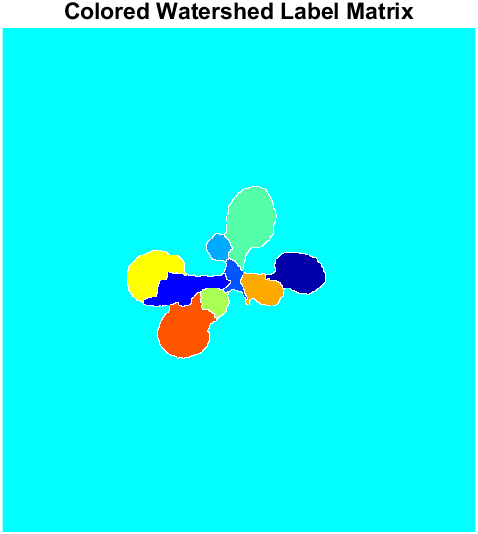
* *Watershed Ridge Lines*
  + *bwdist(bw)*

**

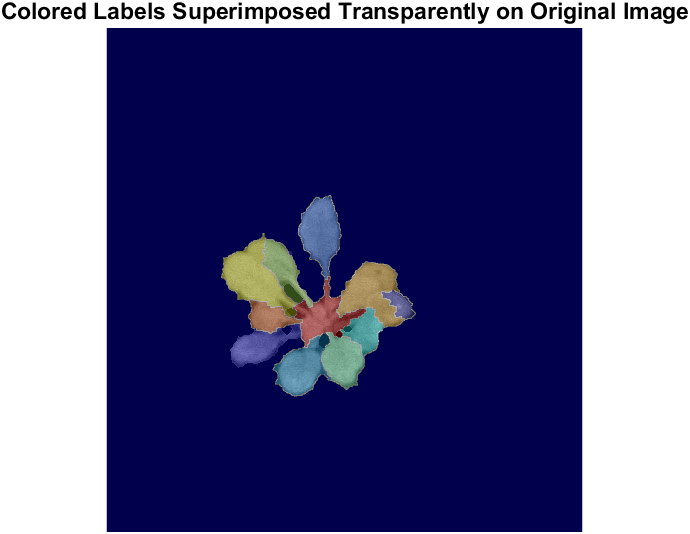
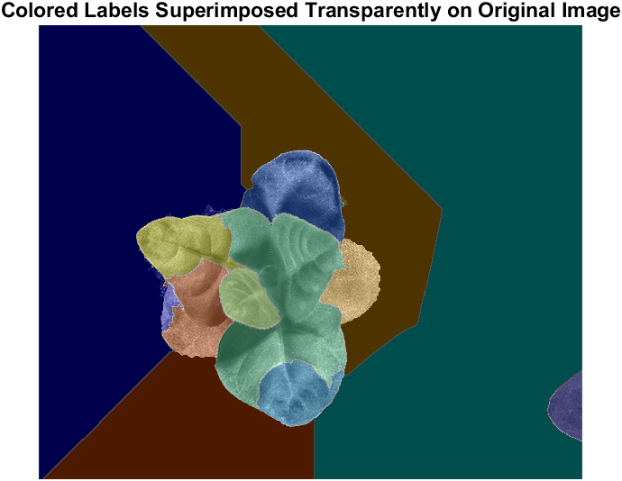
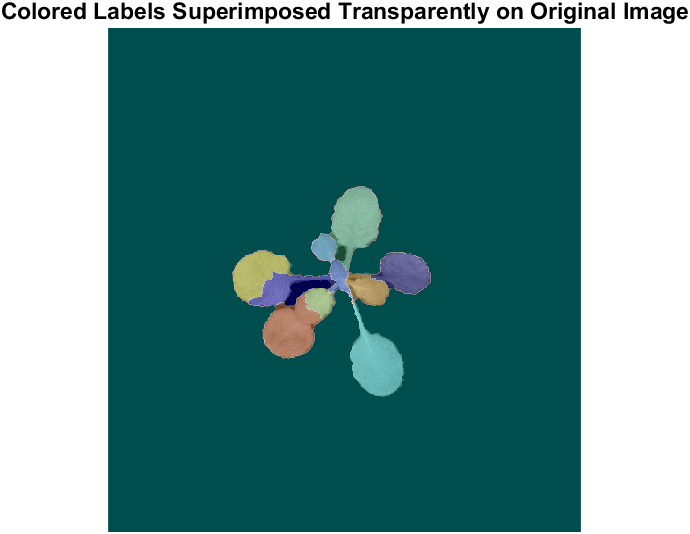
* *Markers and Object Boundaries Superimposed on Original Image*
  + *labels = imdilate (L==0, ones (3,3)) + 2\*bgm + 3\*fgm4*

**

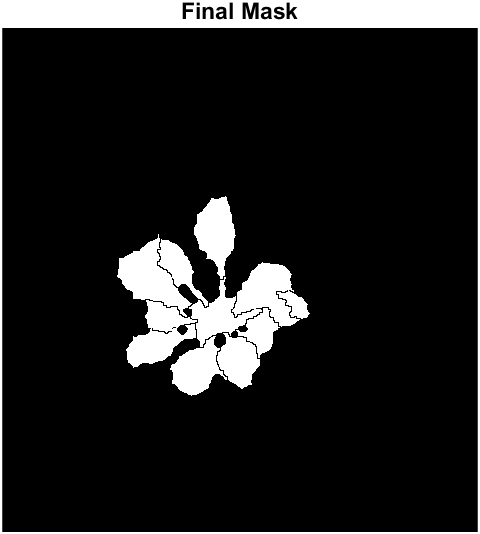
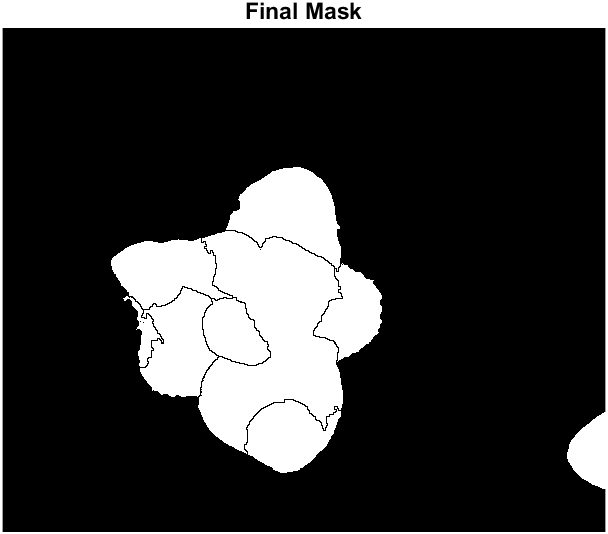
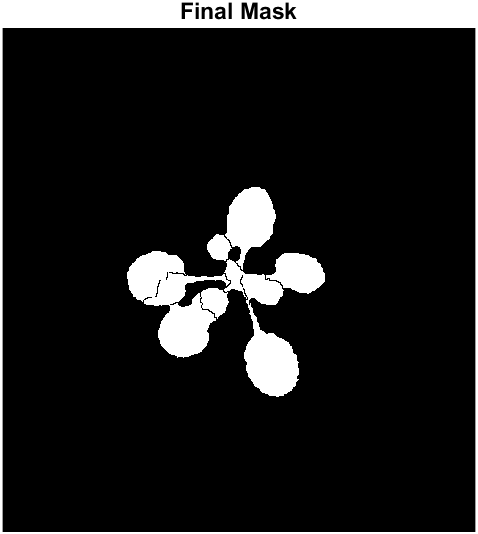
* *Colored Watershed Label Matrix*
  + *label2rgb(L,'jet','w','shuffle')*

**

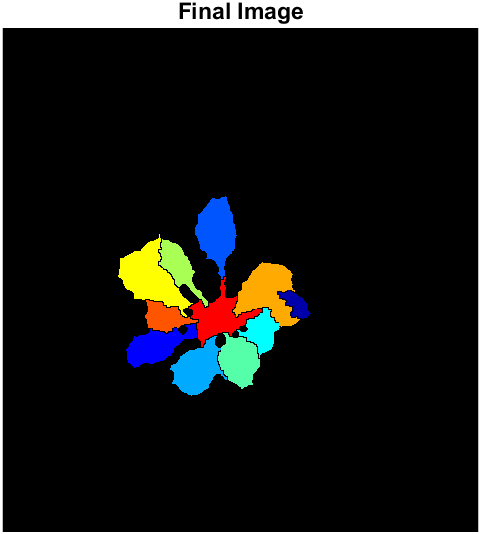
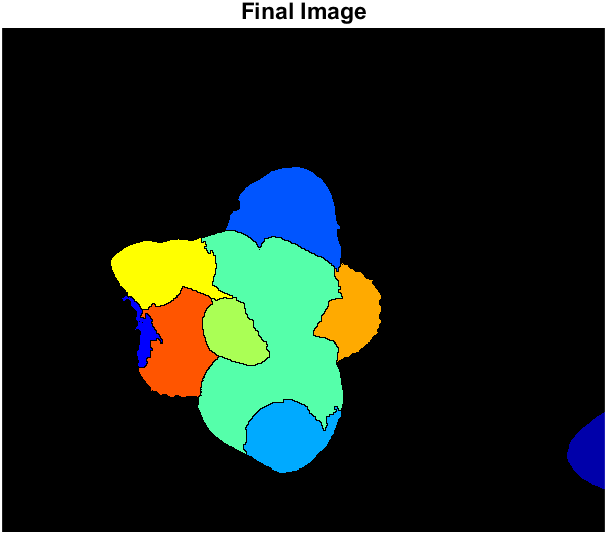
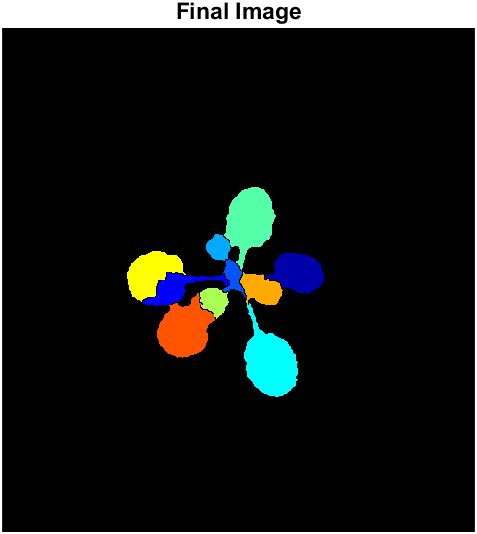
* + *Colored Labels Superimposed Transparently on Original Image*

**

* *Now, we create the final mask for the final image*
  + *Final Mask*

**

* *Now, we have the final image*
  + *Final Images*

**