Report of COMP2005 Coursework

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Contents

Introduction

This report is a description of the main.m file which separates green plants from the background using techniques including superpixels, color space choice, thresholding and binary image processing methods.

Separation Steps

Superpixels

Description

The first step is to divide the input image into 150 super pixels.
As is shown in Figure 1, most superpixels contain only foreground or background. The number of pixels is reduced and the space distribution of foreground and background is conserved to the largest extent. However, superpixels do not perform well on tiny stems for they are too small to be exclusively contained in superpixels and consequently, these parts are often combined with nearby background.

```
% divide the image into 150 superpixels
[labels,num_labels] = superpixels(A,150);
```

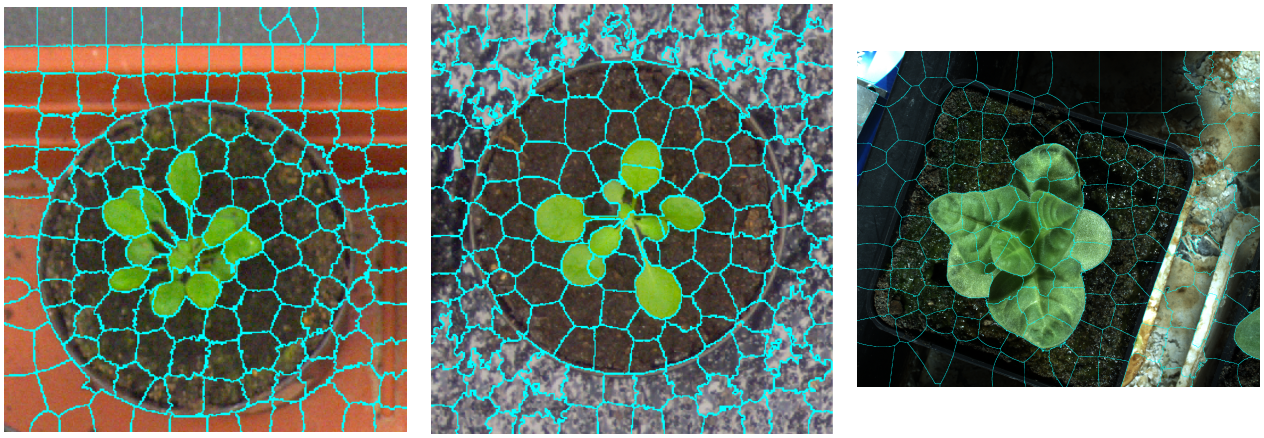

Figure 1: Segmentation with 150 superpixels

Advantages

The first advantage of superpixels is that pixels belong to the plant tend to cluster together. This is particularly helpful for plant_223rgb.png because both shaded parts of the leaves and some pixels of the soil are dark green. As is shown in Figure 2, most of the pixels belong to similar intensity intervals either is RGB or HSV color space, except for some local maximums. Hence, it is hard to distinguish them by direct thresholding, which only considers pixel values. However, Superpixels exploits the position of pixels. Dark green soil is combined with nearby black soil. When the pixels in a superpixel is averaged, the contrast in color became

more obvious.

Another advantage of super pixels is that it reduces the amount of data to be processed, making it easier to find appropriate threshold. This is will be further discussed in the Thresholding section.

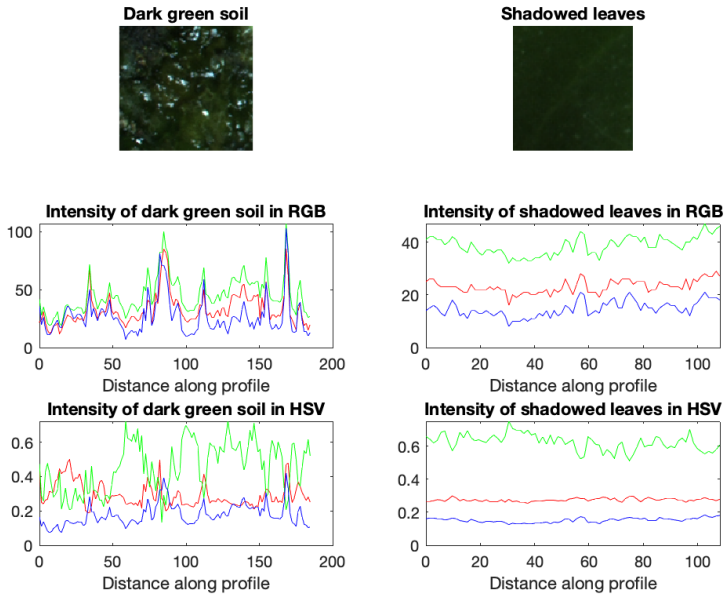

Figure 2: Intensity distribution of dark green soil and shadowed leaves

Disadvantage

A trade off needs to be achieved when using this method. When the number of pixels increase, the area of each super pixel decrease and tiny stems can be better separated from the nearby soil (Figure 5). But this does not simplify the image enough, and it is still hard to find the correct threshold (Figure 6). When the number of superpixels is small, it becomes easy to threshold the pixels (Figure 4), but part of the plants are mixed with background in the super pixels (Figure 3). After trial and error, 150 superpixels yielded the best performance. All the superpixels are separated as desired with the minimum number of regions that blend stem and soil.

Moreover, superpixel segmentation does not result in smooth edges, especially for plant_223rgb. This flaw is alleviated in Binary Image Processing part.

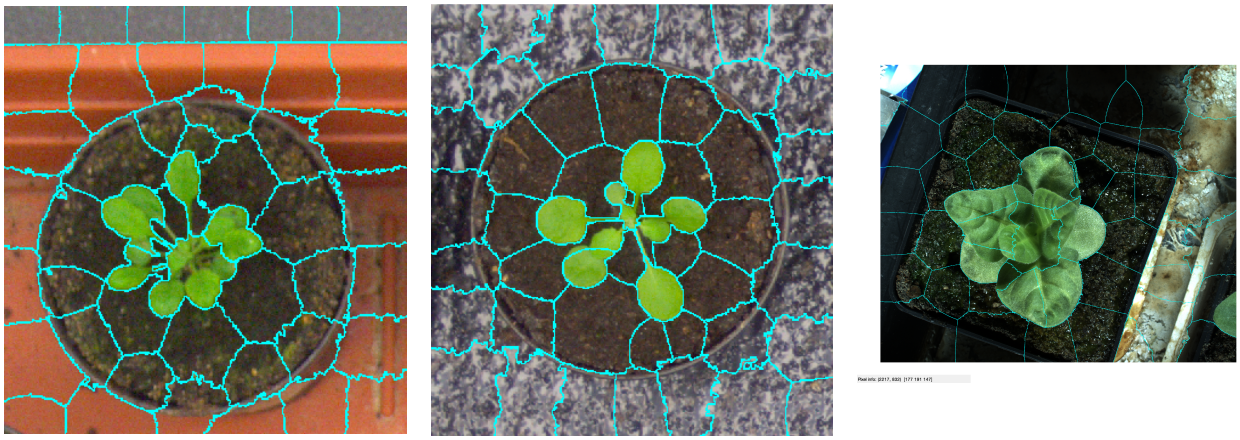

Figure 3: Segmentation with 50 superpixels

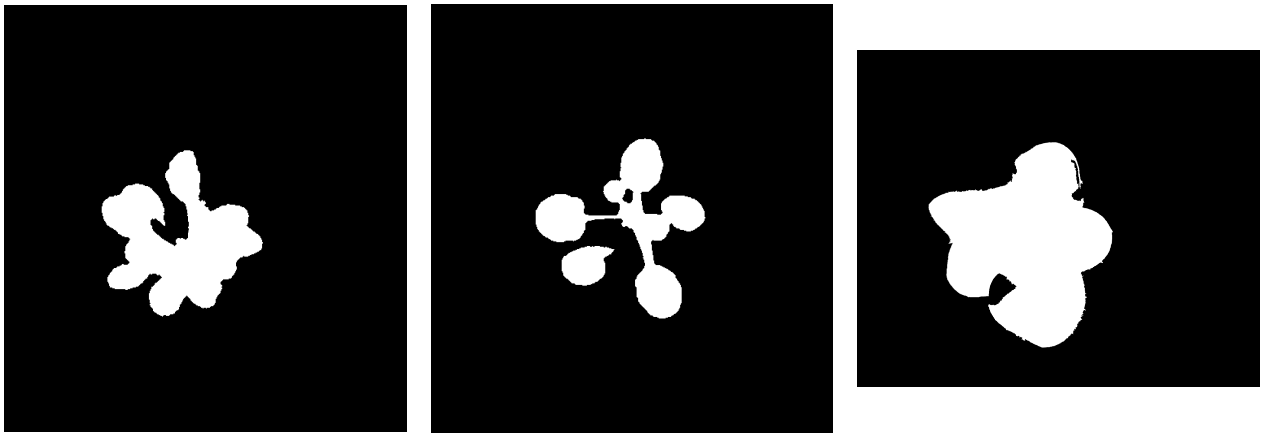

Figure 4: Final outputs with 50 superpixels

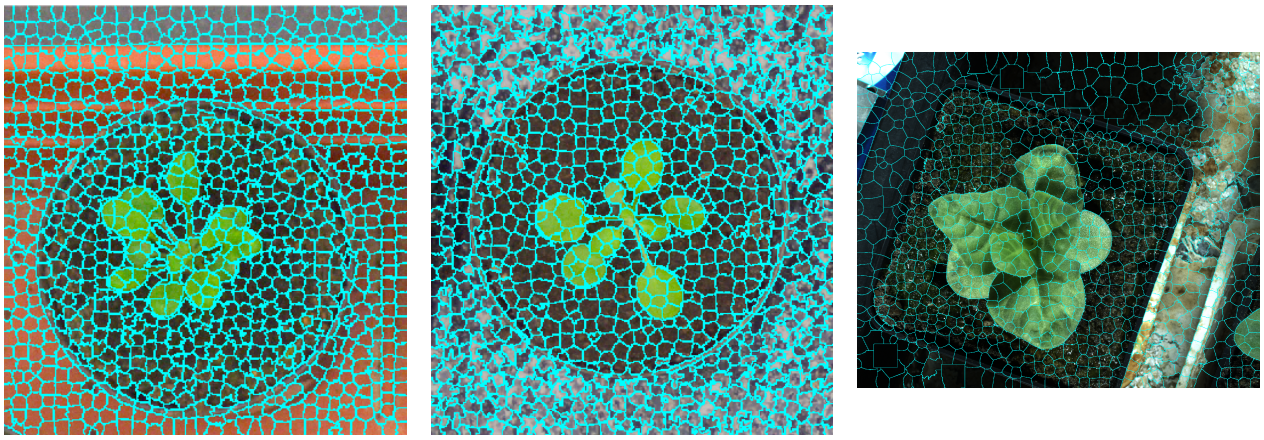

Figure 5: Segmentation with 1000 superpixels

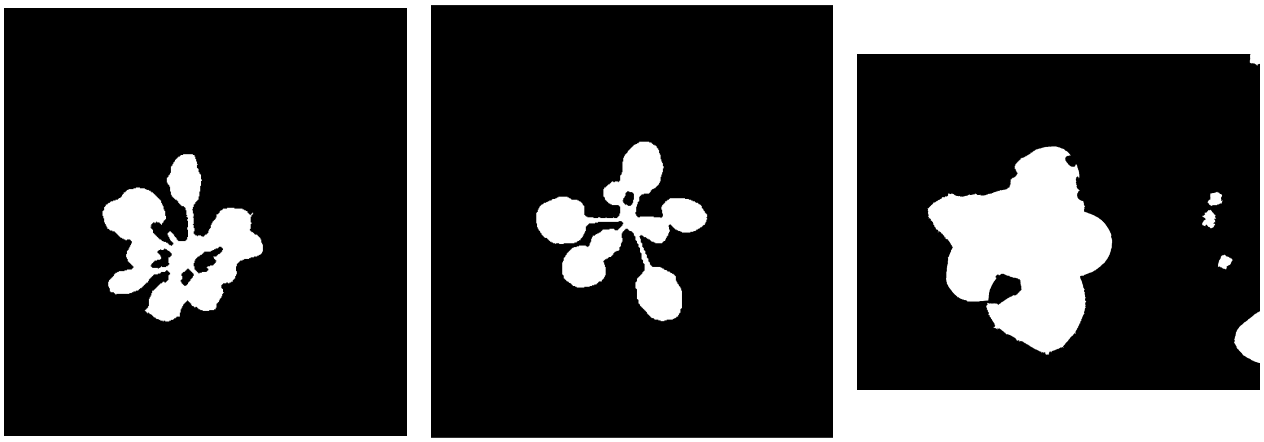

Figure 6: Final outputs with 1000 superpixels

Color Space Choice

Description

The next step is to unify pixels within each superpixel. A mean is of each superpixel is taken under the RGB color space. The results are given in Figure 7. Superpixels containing the plants appear green, strongly contrasting the background. Particularly, the shadowed parts in plant_233rgb are successfully distinguished from the dark green soil, which is unified with black pixels of the soil and appear much darker than shadowed leaves.

```
%% average pixels in superpixels

average = zeros(size(A),'like',A);
idx = label2idx(labels);

% unify pixels within superpixels by taking the mean in GRB
for labelVal = 1:num_labels

    redIdx = idx{labelVal};
    average(redIdx) = mean(A(redIdx));

    greenIdx = idx{labelVal}+area;
    average(greenIdx) = mean(A(greenIdx));

    blueIdx = idx{labelVal}+2*area;
    average(blueIdx) = mean(A(blueIdx));

end
```

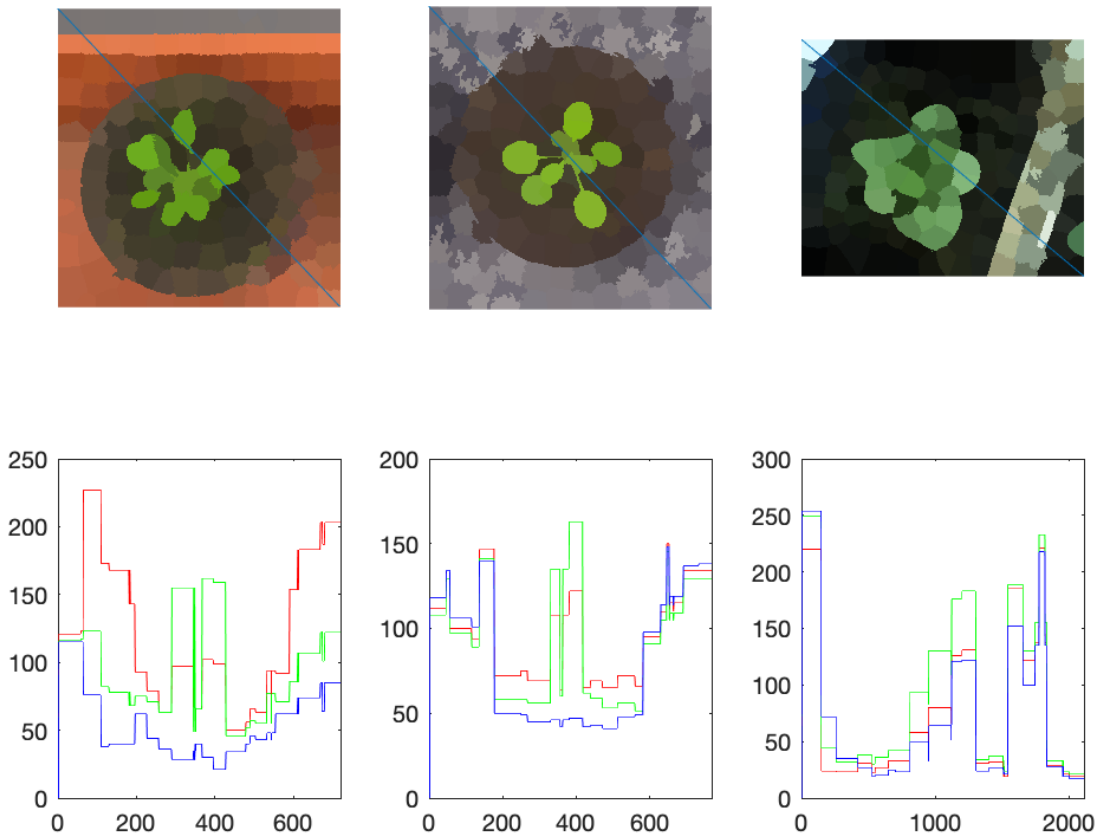

Figure 7: Unified superpixels in RGB color space

Advantage

Assuming that the superpixel segmentation is correct, threshold can be found easier and the result will be accurate given the limited number pixels and strong contrast between foreground and background.
By unifying the pixels, noise can be reduced. The principle behind this is similar to a mean filter.

Disadvantage

Once superpixel containing both foreground and background is unified, it will become almost impossible to separate them anymore.

Color spaces tried but abandoned

One-dimension color space greenness (G-(B+R)/2) was also tried since superpixels also work with grayscale images but abandoned. Greenness has only one dimension and does not contain enough information. The result of unified superpixels does not distinguish the foreground from the background (Figure 8). For both shadowed and bright parts of the leaves, similar pixel values can be found in the background.

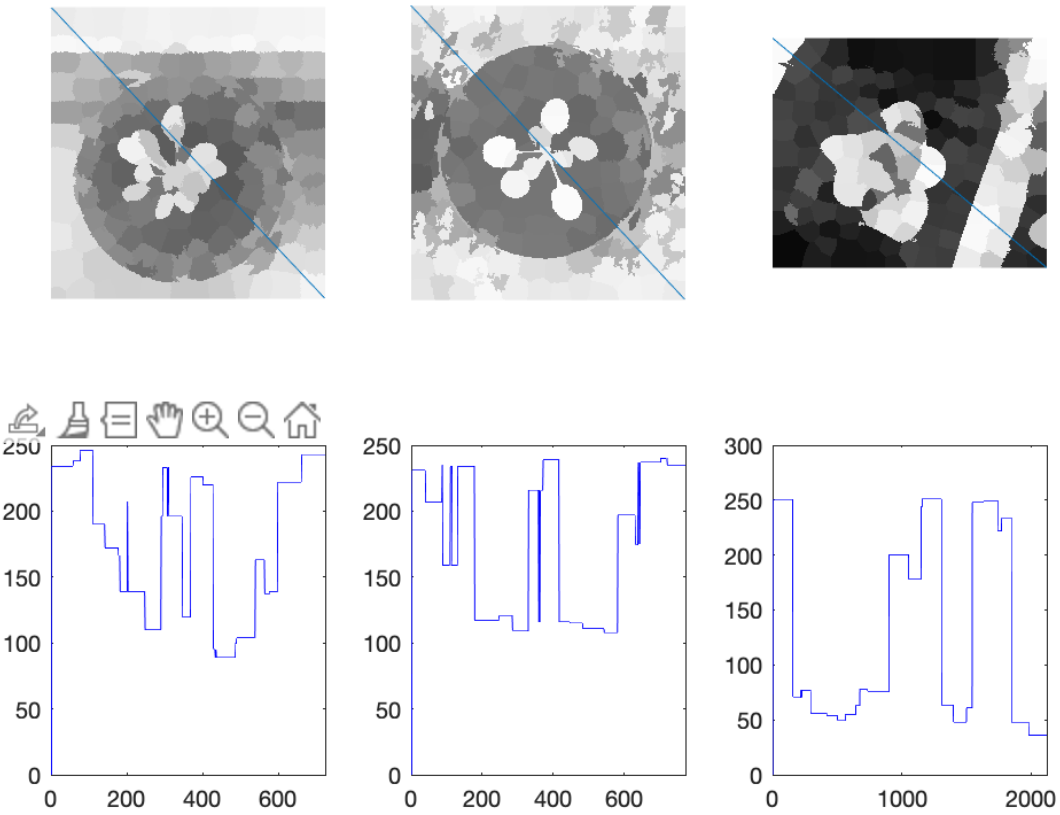

Figure 8: Unified superpixels in Greenness color space

Thresholding

Description

Then thresholding is applied to the image twice. The fist thresholding selects superpixels that are green enough (G-R>=22 and G-B>=23). The results are given in Figure 9. The differences of the green channel between other two channels are taken into consideration because for all the superpixels that represent plant, the value of green channel is significantly higher, regardless of the brightness (Figure 7). The thresholding values of 22 and 23 identified all the superpixels that represent green plant, with the least number of background superpixels misclassified (only one in plant_223rgb, at right-top corner). Higher thresholding pairs tend to exclude darker leaves (Figure 10) while low values misclassify the background superpixels that are similar to green leaves (Figure 11).

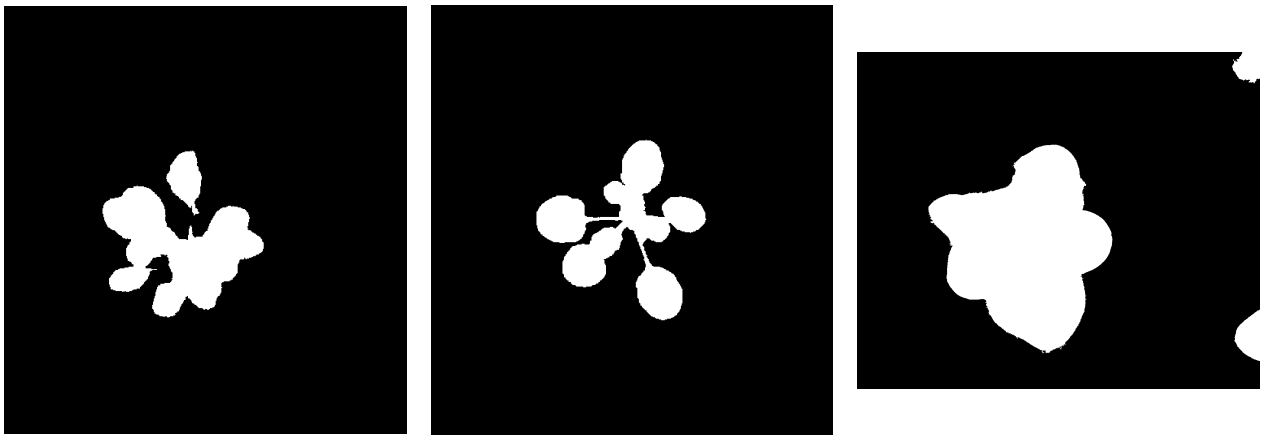

Figure 9: After first thresholding (G-R>=22 and G-R>=23)

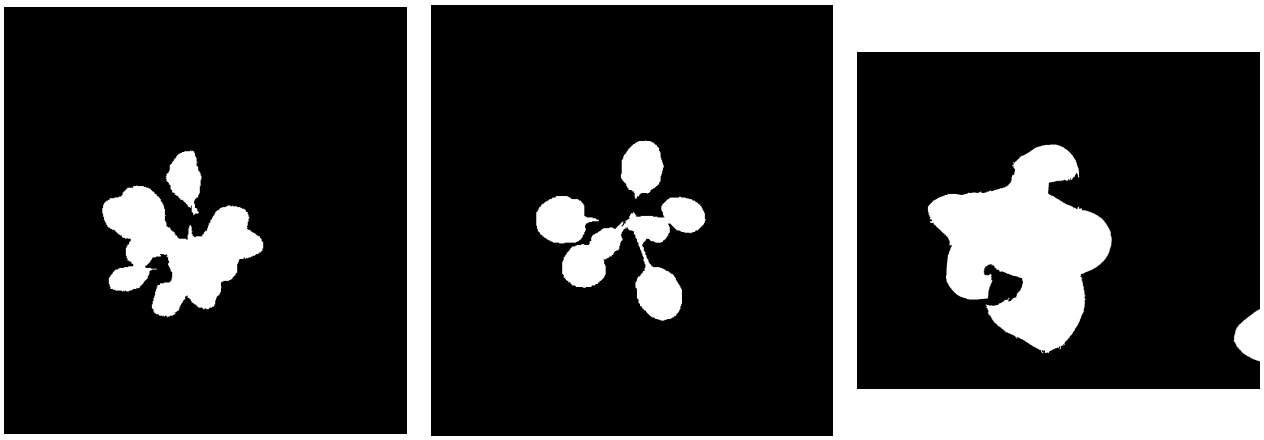

Figure 10: After first thresholding (G-R>=30 and G-R>=30)

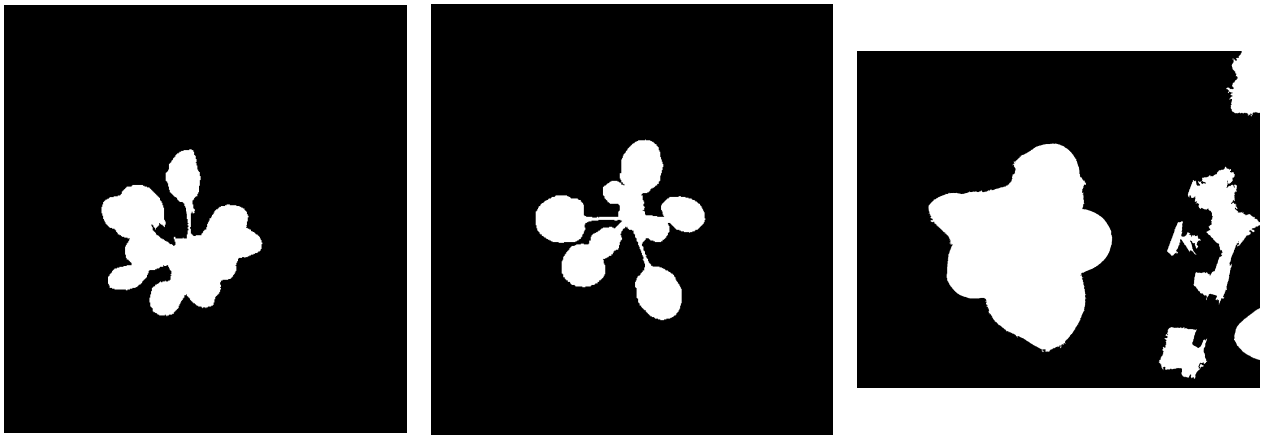

Figure 11: After first thresholding (G-R>=15 and G-R>=15)

The purpose of next thresholding is to set the background in the top-right corner of plant_223rgb with pixel value [177 205 182] to 0 without influencing the performance of other regions. The

following simple thresholding is applied. As is described in previous section, tiny parts of the plant are either eliminated or mixed with background (Figure 12).

```
% eliminate noise
greenness(aG>=170 & aR >=170 & aB>=170) = 0;
```

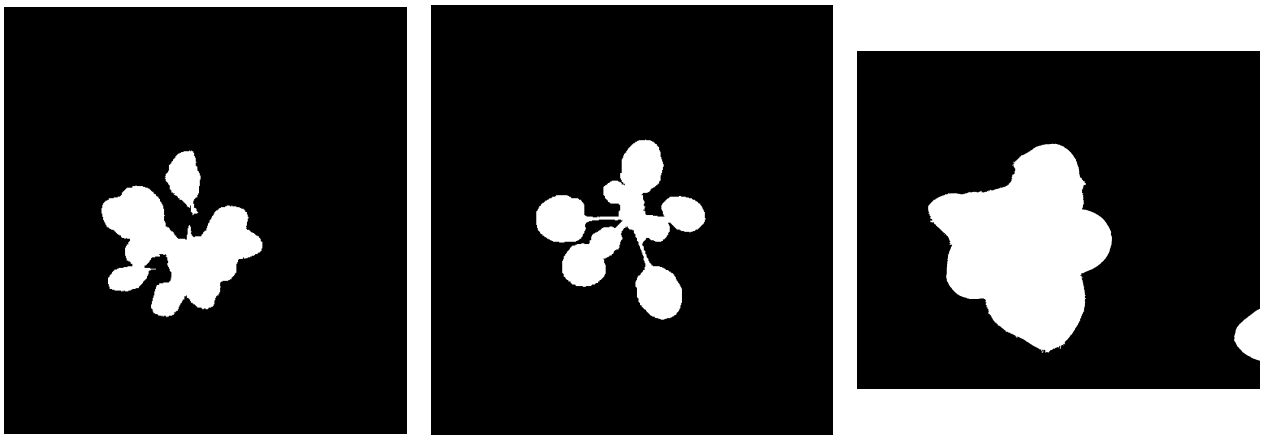

Figure 12: After second thresholding

Binary Image Processing

Description

The final step is to smooth the boundaries considering that whereas there are no small gaps or holes to fill, protrusions at the boundaries need to be smoothed. Open is used instead of close so as not to break tiny stems. The shape of the structure element is sphere, which is similar to the natural shape of leaves and the size is tailored to the size of the image in order to generalize the solution to inputs of different sizes. To be more specific, the radius of the structure element is in direct proportion to the geometrical mean of width and height. Otherwise, large structure elements overly smooth small images (Figure 15) and small structure element does not have significant effect on large images (Figure 14). The results are given in Figure 13.

```
% calculate structure element size
seSize = floor(sqrt(width*height)/250);

% open
se = strel('sphere',seSize);
output = imclose(greenness,se);
```

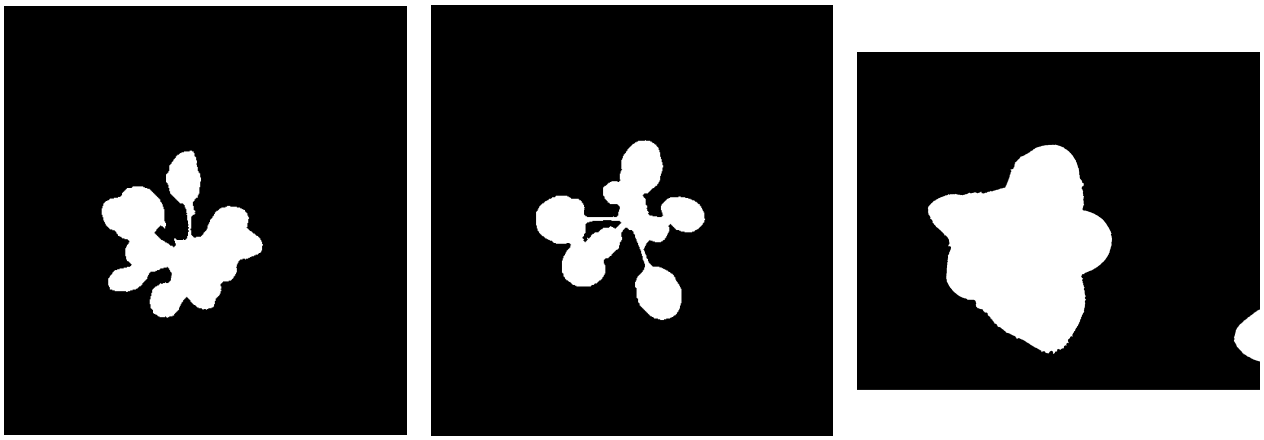

Figure 13: Openning with adaptive structure element size

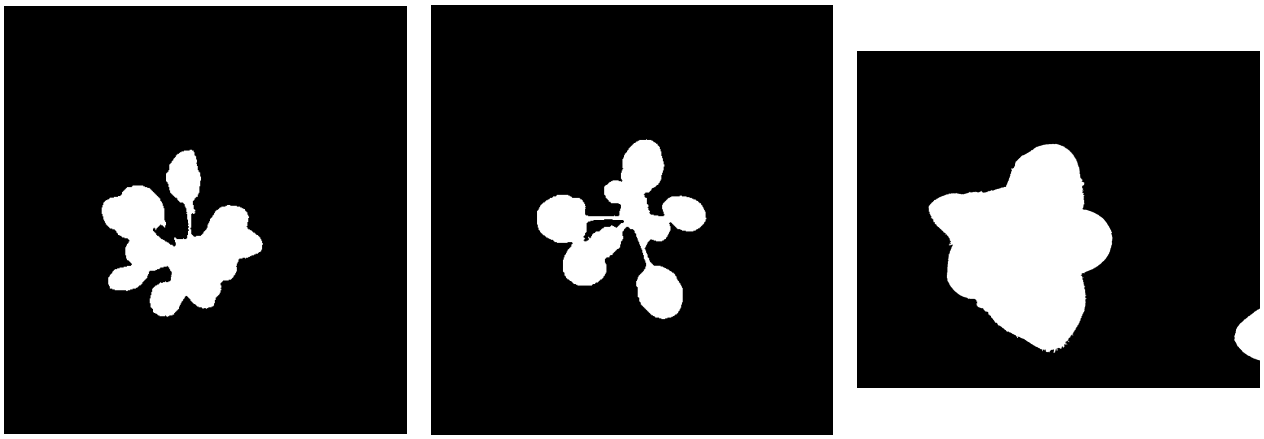

Figure 14: Openning with seSize = 1

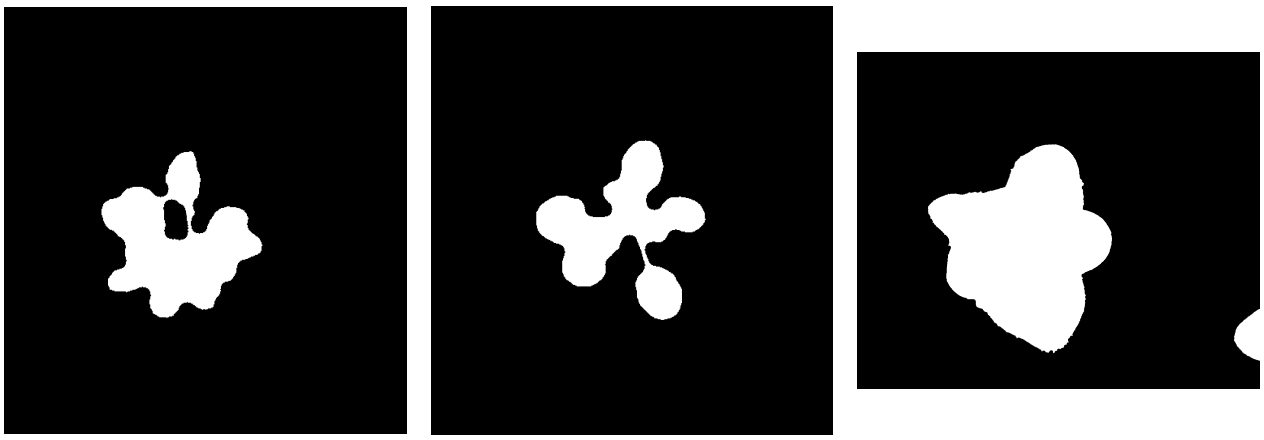

Figure 15: Openning with seSize = 10

Conclusion

In conclusion, the input is first segmented into superpixels, which are further unified and thresholded. Finally, opening is applied to smooth the boundaries. The major advantage of this method is that it simplifies searching threshold and improves the performance of thresholding. However, this does not work well for plant parts that are too small for a superpixel and the boundaries are not smooth.