Individual Lab Report

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1 individual progress overview

There were two major focus area in the past 2 weeks, which is (1) deciding a different metric to evaluate Mask-RCNN's performance and (2) getting the segmented leaves area from the stereo images

1.1 Deciding a different metric for evaluating Mask-RCNN

1.2 Motivation

Last time we discovered that our model achieved roughly 60% for both recall and precision, which was not satisfying. However, the qualitative evaluation (Fig1) showed that the neural network was actually working to some degree (red means holes, blue means fungus). Therefore some works were put into investigating different metric

1.3 Metrics

1.3.1 Pixel by Pixel evaluation did not work

The original paper uses pixel-wise evaluation and computed a binary cross-entropy loss function. An initial trial to evaluate pixel-wisely our model output with human labeled ground truth actually makes the quantitative performance drop by 20-30%, so we decide not to pursue this path anymore. This result was unsurprisingly though since pixel-wise evaluation is more demanding than the contour to contour comparison (intersection over union) metric that we were using last time.

1.4 Switch gear to approximated metric

After talking with our faculty sponsor George, we realized there have been 2 potential problems behind our ground truth. One is that we are not able to identify the fungus/holes confidently every-time since there is some ambiguity. Two is that there can be significant error when we labeled the ground truth data pixel-wisely. As a result, we do not really have good ground truth to evaluate our model. e.g. sometimes a model predicts an ambiguous area as fungus, and it would be counted toward false positive. Instead, our sponsor suggested we approximate the metric with something easier to deal with, e.g. given an image, try to report whether a fungus/hole is presented. Thus, we proposed to use discrete severity level (mild, moderate, alarming) to replace the area ratio metric. In other words, we would like to map continuous area-ratios into 3 discrete states. At this time being, we are waiting for farmers' response to this modification.

1.5 Backup plan: regression with features

If a simple area-ratio conversion to severity (e.g. more than 0.3 hole area over leaves area corresponds to alarming) does not work out, the backup plan is to use segmented leaves area, hole area, fungus area as features, and try to fit a regression model (not necessary a straight line) to the ground truth in discrete severity levels.

Figure 1: qualitative results seem well

2 Use depth disparity to segment out leaves area

2.1 Motivation

In order to find out the total leaves area, we need a way to segment it out from a given image. Color segmentation e.g. looks for anything green, does not work because we have plants in purple and other colors (Fig2), and weeds also appear in green as well. Therefore, we looked into the semi-global matching method with stereo images to segment our leaves from ground and weeds.

2.2 Convert depth image into binary image

Given the left and right stereo image, a depth disparity image can be generated with OpenCV function (semi-global matching). A global threshold is then applied to the image to segment out the background. Afterwards, small, noisy blobs were filtered out base on their areas. Finally, a series of erosion and dilation operation with increasing kernel sizes were applied. Specifically, elliptical kernels were used in order to achieve rounded contour. As a result, the segmented leaves area can be obtained. The full pipeline can be seen in Fig3

2.3 Limits of the approach

It's worth pointing out that there are some noticeable error margin observed, and that this method works better with taller crops. For smaller crops such as cabbage, the height of crop can be approximately the same as weeds and therefore weeds would be mistakenly picked up by this method.

Figure 2: crops with special colors

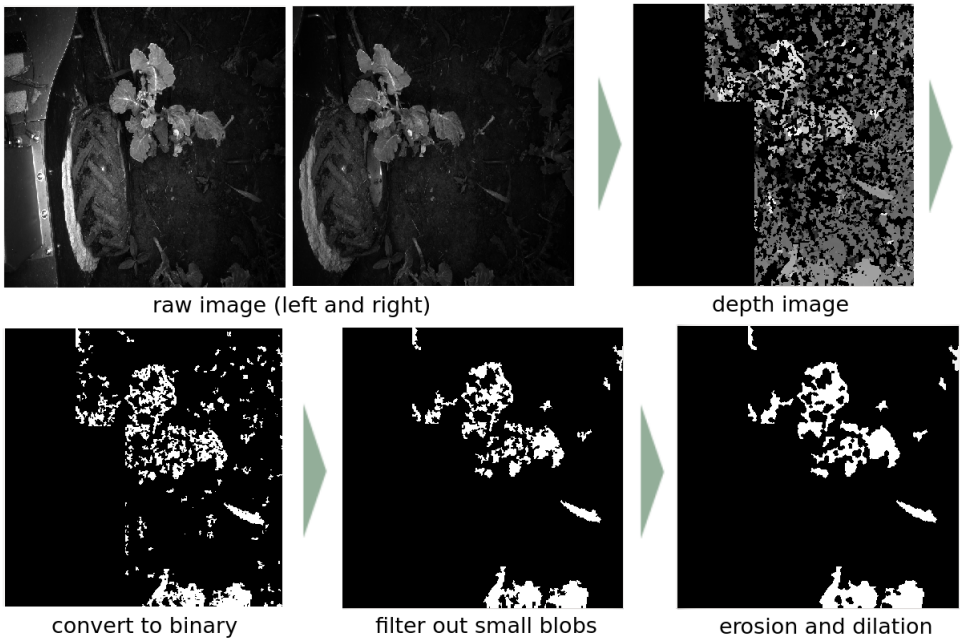

Figure 3: pipeline for segmenting leavs area

3 Challenges

Given the work hours that we have, trying to add more data and train the neural net does not seem viable. It's for sure that some new method needs to be applied, but it's uncertain which method would actually generate the desired output. At the same time, switching metrics also means we need new ground truth – potentially with the help from farmers to label the data. All these factors pose potential scheduling risks to the monitoring pipeline.

4 Future plans

A simple discrete conversion from area-ratio (hole/fungus area over leaves area) to 3 severity level would be performed with a specific type of plant which has a lot of training data. If that works out, the same pipeline would be applied to other types of plants with more training data labeled. If it does not work out, a regression model would then be applied to do the conversion task.

5 Teamwork

In this week, I have (1) talked to George and decide to change our evaluation metric (2) use depth image to segment out leaves area. Meanwhile, John has supported me in connecting stereo camera on the robot platform. As for in-field navigation, John, Aaditya, and Aman have formed a new subteam to conduct path planning, controller, etc. Specifically, Aman has been working on generating paths given map file generated from RTK GPS while John and Aaditya have been working on sensor fusion algorithms. On the other hand, Hillel has been working on designing PCB part for the fan cooling system and assembling the electronic subsystem.