Leaf Segmentation and Counting

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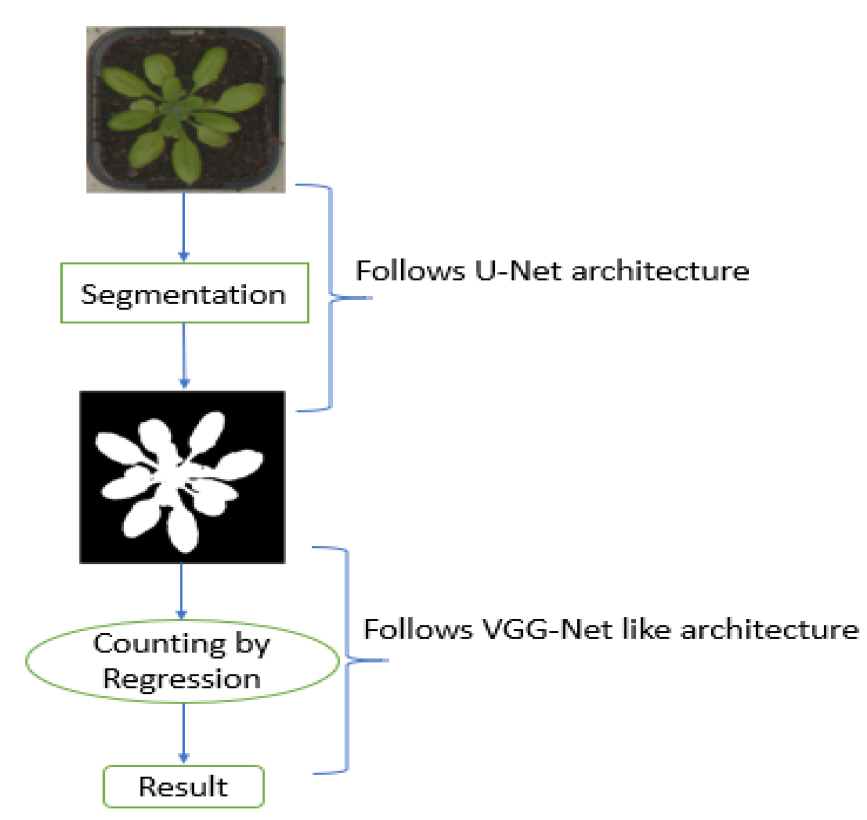
Motivation and Goals

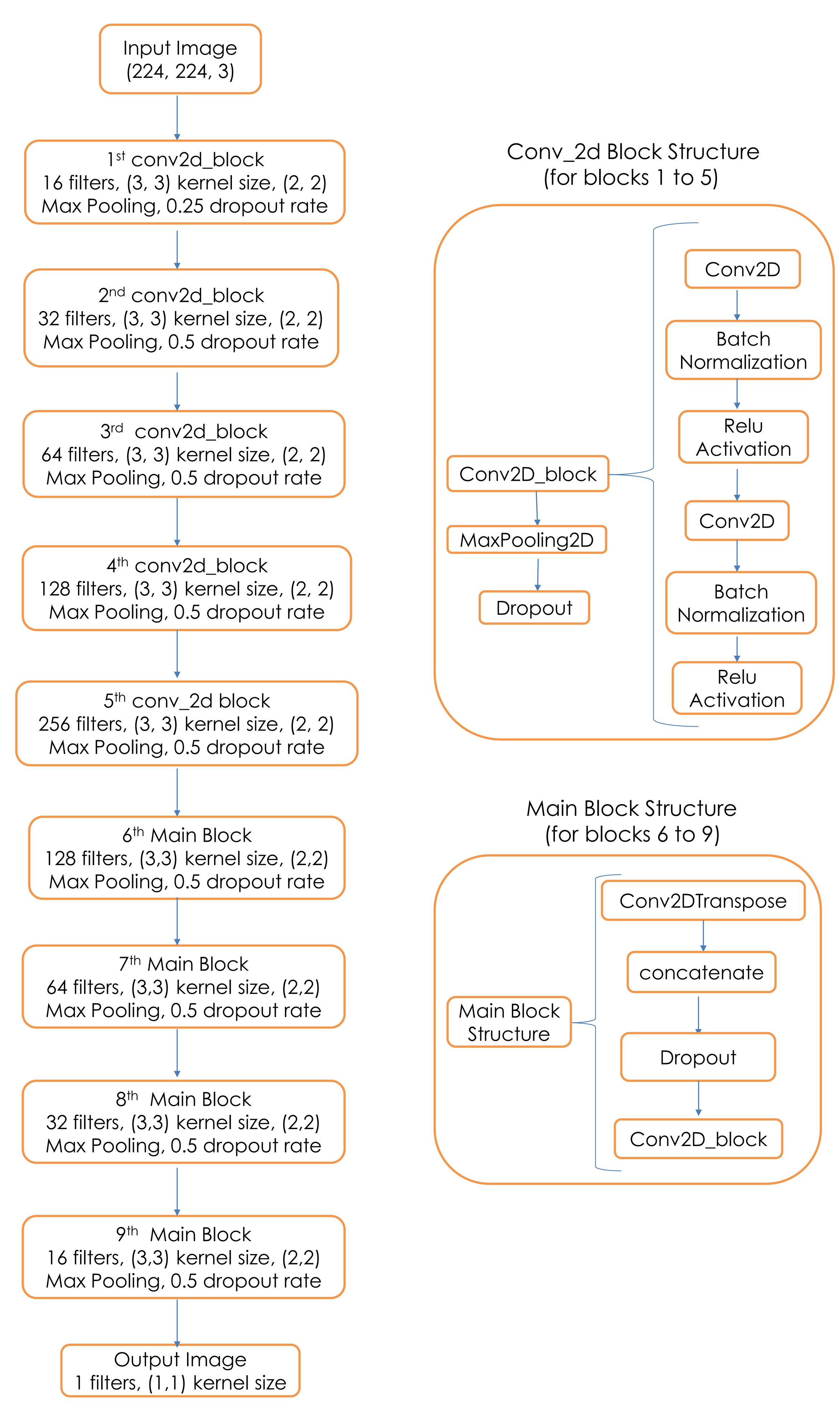
The major motivation behind this project is that the traditional manual measurement of plant traits is a slow, tedious and expensive task. The manual measurement techniques use sparse random sampling followed by the projection of the random measurements over the whole population which might incorporate measurement bias. Moreover, plant phenotyping is a bottleneck in modern plant breeding and research programs. Hence, this served as a motivational factor to develop a neural network based architecture that can accurately perform image segmentation and leaf counting.

The goal of this project is to use Deep Neural Network Architectures to perform image segmentation of a leaf and count the number of leaves in an image. Due to the availability of very small number of plant images, we use image augmentation to create new images for the purpose of model training reducing overfitting as much as possible. Here we use U-Net Model to create a convolution-deconvolution network for image segmentation and then pass the segmented image to a VGG-Net like structure to create a model that can accurately count the number of leaves given a segmented image.

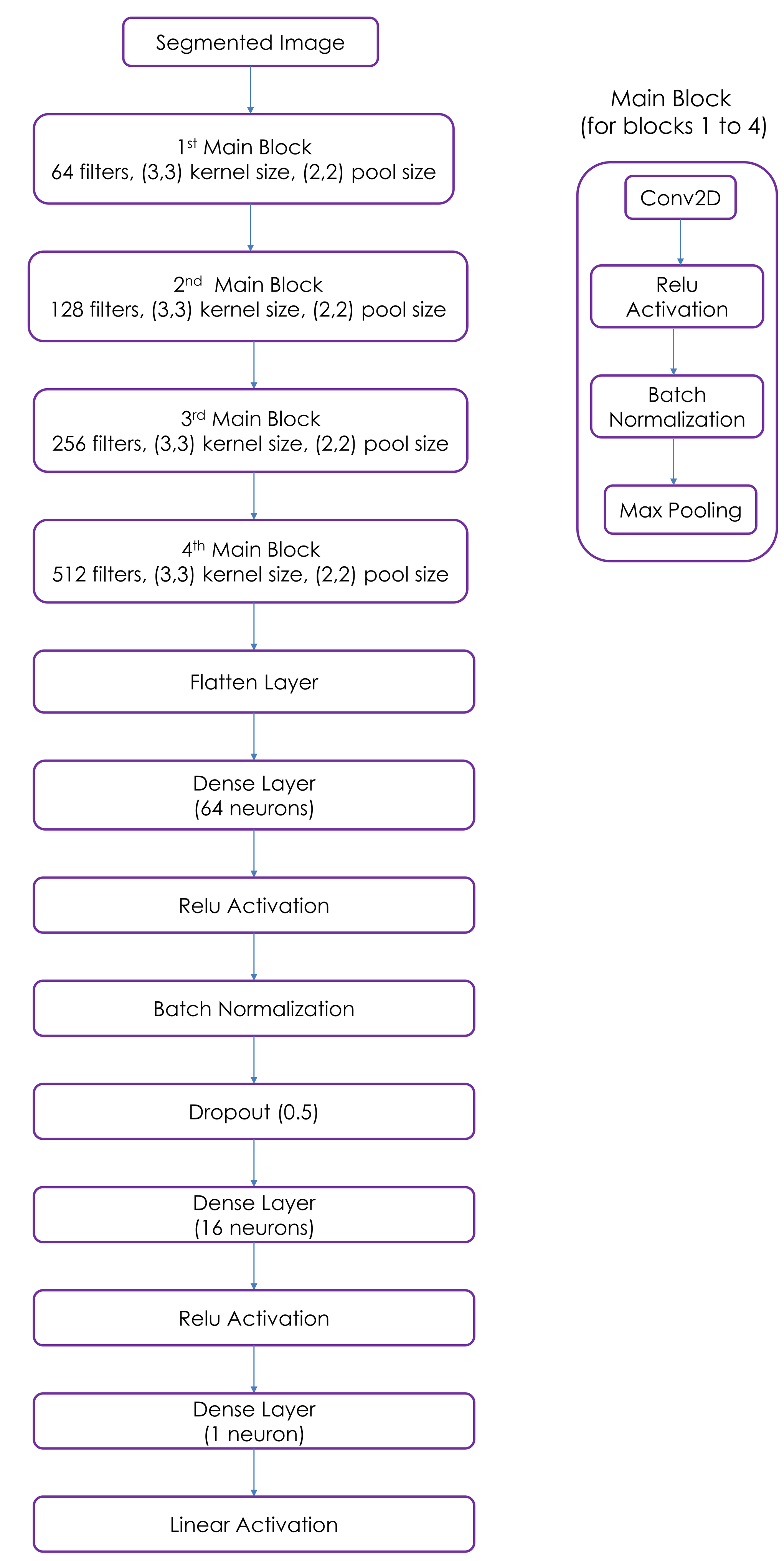
Methodology and Results



Block Diagram
Approach for Image Segmentation and Counting



Block Diagram
U-Net Architecture for Generating Image Segmentation



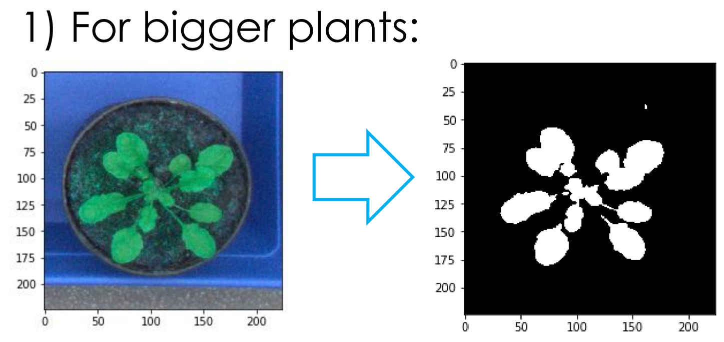
Block Diagram
VGG-Net like architecture for Leaf Counting

Results

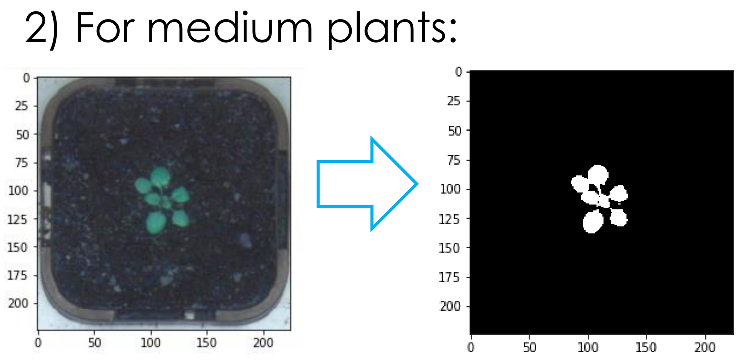
U-Net Model is trained for 40 epochs.

Below are the segmentation results obtained.

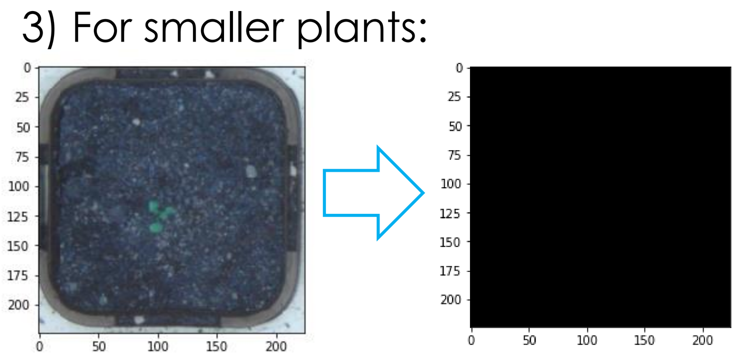
1) For bigger plants:



2) For medium plants:



3) For smaller plants:



From the above diagrams, it is clear that the segmentation results were satisfactory for the medium and large size plant images but for very small sized images, the segmentation did not give expected results. We used Dice Coefficient to measure the results obtained from image segmentation and for the test set, we got a value of 0.97. This value of dice coefficient close to 1 suggests that the model performs very well on the test data with almost complete overlap between the true and predicted binary segmentation results.

Conclusion and Extensions

In the above experiment, plant segmentation is done prior to counting with the assumption that the additional foreground segmentation channel guides the regression model to extract the necessary features only from the plant region and thus train the model correctly. We conclude that the current segmentation model performs well for large and medium size plant images but does not perform well on very small plant images.

As a plan for improvement, a modified approach can be tried where both the original RGB image and the segmentation mask can be provided as input to the network (VGG-Net) for counting. Both images given as input should help the network to recover any missed plant regions as well as reject any false detections from the original image with the help of segmentation masks. Another space search for improving performance can be made by using instance segmentation based easier to train non-recurrent neural networks.

Reference

[1] Leaf Counting with Deep Convolutional and Deconvolutional Networks by Shubhra Aich and Ian Stavness

[2] U-Net: Convolutional Networks for Biomedical Image Segmentation by Olaf Ronneberger, Philipp Fischer and Thomas Brox

[3] Deep Plant Phenomics: A Deep Learning Platform for Complex Plant Phenotyping Tasks by Jordan R. Ubbens and Ian Stavness

[4] Recurrent Instance Segmentation by Bernardino Romera –Paredes and Philip Hilaire Sean Torr