Image analysis and synthesis for maize phenotyping

A THESIS

submitted by

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Co-guided by

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"We must have perseverance and above all confidence in ourselves. We must believe that we are gifted for something and that this thing must be attained."

– Marie Curie

I dedicate this thesis:

To my Family and Friends.

Declaration

I hereby declare that the work incorporated in this thesis is the outcome of the studies accomplished by me in the **School of Computing and Electrical Engineering, Indian Institute of Technology Mandi**, under the supervision of **Dr. Srikant Srinivasan** and **Dr. Timothy Gonsalves** . This work has not been submitted elsewhere for any degree or diploma. In keeping with the general practice, due acknowledgments have been made wherever the work described is based on the finding of other investigators. In addition, I certify that no part of this work will, in future, be used for submission in my name, for the award of any other degree at any university.

Place: Mandi **Snehal Dilip Shete**

Date:

Thesis Certificate

This is to certify that the thesis titled **"Image analysis and synthesis for maize phenotyping"**, submitted by **Snehal Dilip Shete**, at the Indian Institute of Technology Mandi for the award of Master of Science (by research) is a bonafide record of the research work carried out by her under our supervision. To the best of our knowledge, the content of this thesis, in full or in parts, have not been submitted to any other institute or university for the award of any degree or diploma.

Dr. Srikant Srinivasan
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– Snehal Dilip Shete

ABSTRACT

Plant phenotyping, the measurements of various important plant traits, is essential to the advancement of plant breeding and precision agricultural practices, for improving agricultural production. This is particularly useful for field crops such as maize, that include several varieties grown in multiple regions and have a wide range of usage in food and non-food products. However, field-based plant phenotyping can pose challenges towards acquiring adequate amounts of reliable data, especially image data and extraction of traits from images.

In this thesis, we address the problem of maize phenotyping using image analytics. In the first part of our work, the focus is on computing lengths of maize tassels, an important component of maize, from field image data. We have developed a pipeline that has tassel detection, localization of foreground tassel and length computation tasks performed sequentially. We have used faster region based convolutional network for detection of tassel objects from field images of maize crop. We utilized the luminance and colour information of the extracted tassel patches using YCbCr model to locate the foreground tassel pixels. Piecewise linear computation of tassel lengths is then obtained using a Hough transform based approach. We have experimentally demonstrated the efficiency of tassel detection and length computation in our pipeline.

In the second part of the thesis we address the limited availability of field data for maize tassel phenotyping. We proposed a method, TasselGAN, for synthetically creating maize tassels against sky background. In this method, we utilized deep convolutional generative adversarial network (DC-GAN) to generate maize tassels and sky patches separately. The generated tassels and sky patches are later merged to form field like maize tassel data. We modified the original design of DC-GAN by removing batch normalization layers and adding residual layers to enable generation of maize tassels. We have also conducted a detailed ablation study related to these changes. Quantitative and perspective qualitative evaluation of generated field-based maize tassel data is carried out to show that the generated data is fairly realistic, and that it can improve the quality of phenotyping.

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