DISEASE CLASSIFICATION FROM POTATO LEAF IMAGES: AN EMPIRICAL STUDY ON IMAGES CAPTURED IN UNCONSTRAINED ENVIRONMENTS

A Thesis

submitted by

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in partial fulfilment for the degree of

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DECLARATION

I hereby certify that the work which is being presented in the thesis titled **"DISEASE CLASSIFICATION FROM POTATO LEAF IMAGES: AN EMPIRICAL STUDY ON IMAGES CAPTURED IN UNCONSTRAINED ENVIRONMENTS"** in the requirement for the award of the degree of **MASTER OF SCIENCE** and submitted in the **School of Computing and Electrical Engineering**, **Indian Institute of Technology Mandi**, is an authentic record of my work carried with the guidance of **Dr. Dileep A. D.** and **Dr. Renu Rameshan**, Indian Institute of Technology Mandi, India. Due acknowledgement has been made wherever the work has referred to the findings of the other researchers. The work presented in this thesis has not been submitted by me for the award of any other degree of this or any other institute.

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THESIS CERTIFICATE

This is to certify that the thesis titled **"DISEASE CLASSIFICATION FROM POTATO LEAF IMAGES: AN EMPIRICAL STUDY ON IMAGES CAPTURED IN UNCONSTRAINED ENVIRONMENTS"**, submitted by **Soma Ghosh**, to **Indian Institute of Technology Mandi**, for the award of the degree of **MASTER OF SCIENCE**, is a bona fide record of the research work done by her under our guidance. The contents 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.

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- Soma Ghosh

Dedicated to my parents

ABSTRACT

The aim of this work is to classify potato plant diseases from images of potato leaves, captured in the field. Such images are characterised by a rich background consisting of multiple leaves, weeds, ground patches etc. In addition, there are possibilities of a wide range of illumination variation and defocus. All these make discriminative feature learning an exceedingly difficult task. The diseases being considered are *early* and *late blight* which predominantly affect the leaves and present as discolouration of varying sizes. This work focuses on classifying a given leaf image as *healthy* or affected by *early* or *late blight*.

An initial classification study reveals many anomalies, the most significant one being that classification accuracy does not improve despite using the segmented foreground leaf. In order to explain this, a detailed analysis of learnt weights and the features is carried out. The latter was done using visualisation methods to identify the regions in an input image which contributed towards the features. The analysis shows the impact of dataset bias, and domain adaptation and generalisation seems to be possible directions for building an effective classifier. However, the analysis also reveals a more severe issue that most architectures do not learn features from relevant regions (disease spots and healthy leaf) in the image due to the fact that the percentage of pixels representing disease spots are too less. Also, the appearance of these regions vary a lot with illumination and defocus making them look like healthy regions. This finding questions most of the reported results of similar works. In addition, it also points to the fact that it is essential to have either an attention based solution or a solution which is region based.

A region based solution is explored using faster region based convolutional neural network (faster R-CNN) as region of interest (ROI) detector followed by a classifier. A ground-truth overlap index of 91.85% and an overlap recall of 83.06% show that the relevant regions are extracted. This in turn improves the classification accuracy remarkably. In order to test the generalisability and hence the reliability of a model, the notion of *cross-testing* is introduced wherein a classifier trained with one dataset is tested using a different dataset, the difference being in the nature of backgrounds.

Unlike the other models, the ROI-based classifier shows exceptionally good classification accuracy during *cross-testing*. While the conventional CNN-based classifiers gave an average *cross-testing* accuracy around 50%, the faster R-CNN-based classifier exhibited a *cross-testing* accuracy of 84.76% on *lab-prepared* dataset. If not for the low resolution images of the *lab-prepared* dataset, this accuracy could have been higher. This classifier achieved 96.95% testing accuracy for the *in-field* dataset, on which the model was trained. Following the observations and analysis of all the results, we come up with a set of clear directions to create an image dataset, which can lead to a reliable leaf image based plant disease classifier.

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