Image Processing Application For Monitoring Plant Health Status, Nutrient Status And Pest Infestation

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Introduction

Plants are an important source of energy and the only primary source to solving the problem of global warming. So, naturally we would always want the plants to be in good health. A plant can be considered healthy if it has sufficient amount of nutrients and is free from pest and disease. The traditional processes of nutrient measurement, though accurate, are time consuming and expensive. In addition to this, the main practise for detection of pest and disease in plants is the naked eye observation of the experts which apart from being time consuming, is also quiet erroneous since the decision making capability of the expert depends on the their physical conditions such as fatigue, eyesight, mental health, working conditions such as improper lightning and bad weather etc. Since, plant health is an important factor for our economy, there is a dire need for development of systems which can detect the pest infestation and the nutrient status of plants accurately and rapidly. These systems should also be portable and cheap so that they are affordable and could be used in the field directly. To help solve this problem, automatic detection of plant disease and nutrient status has been the most effective solution. This has been achieved by using digital image processing which is a discipline highly related to signal processing. To understand it in more detail, we need to first understand the concept of a digital image. An image is defined as a two-dimensional function, *f(x,y)*, where x and y are spatial coordinates, and the amplitude of *f* at any coordinate (x,y) is called the intensity or grey level of image at that point. When x,y, and the amplitude values of *f* are all finite, discrete quantities, we call the image a digital image. So, the field of digital image processing refers to the processing of digital images with the help of computers. Each digital image is composed of a finite number of elements, each of which has a particular location and value. These elements are referred to as a picture element or *pixel*, see figure 1. We will look at the use of the image processing techniques for estimation of nitrogen percentage in plants, pest detection and plant health monitoring.

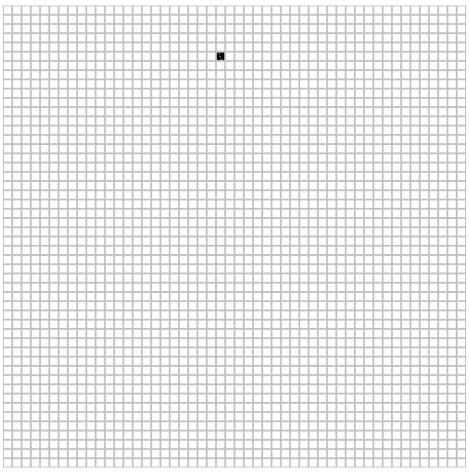

Figure 1: Image pixels or picture elements

General steps in Image processing

The figure below (figure 2) show the general flow diagram of the steps involved in any image processing research or application.

Image acquisition is done by making a self-designed setup which has proper lighting and a device (usually a digital camera) to capture the image. The captured images are pre-processed so as to remove unwanted distortion such as noise and also to enhance image features for further processing. For this, various filters and transformation techniques are used. Feature extraction refers to the extraction of useful features from the pre-processed images which are then used as inputs for the development of a model. A model or a statistical model is used to either predict some particular value such as nitrogen content or for classification such as to classify the different types of diseases. Types of model may include Convolutional Neural Network(CNN), Support Vector Machines(SVM), Random Forest etc. The model gives us an output which is the desired value or class.

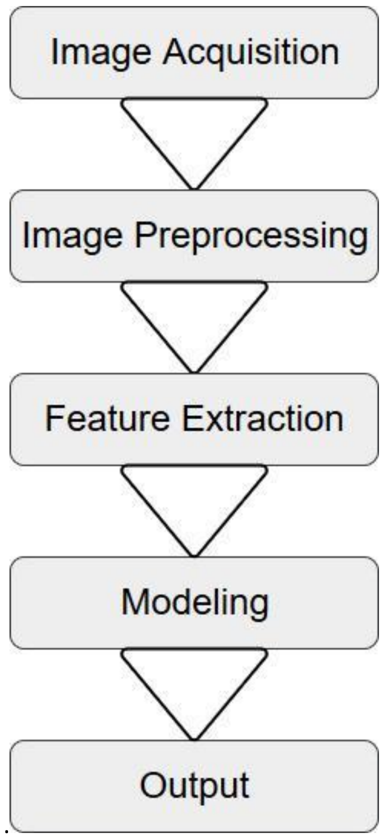

Figure 2: Flow diagram representing steps involved in image processing research

Pest detection using Image Processing and an android application

Pest infestation is a major problem in plants. Image processing is used to identify various types of diseases in the plants accurately in a rapid and easy manner. Since smartphones are becoming cheap and accessible, creating an android app which could help detect various diseases in the plant and would provide the required prevention measures is the way forward which would help farmers save a lot of money and resources.
The system consists of a mobile application, which will enable the farmers to take images of plants using their mobile phones (see figure 4) and send it to a central server where the central system in the server will analyse the pictures based on visual symptoms using image processing algorithms in order to measure the disease type. The detected disease will be displayed on the screen along with the required preventive measures.
The image acquisition setup used here is a digital camera or mobile camera which captures the infected leaf images. The captured images are pre-processed to remove noise. Algorithms like k-means clustering and SVM are used for segmenting the images into different parts and then classifying them into different types of diseases. The set of final centroids produced in the k-means algorithm is used as input for training the SVM which helps in classification of the data. This whole algorithm is integrated in a mobile app using the android studio platform.

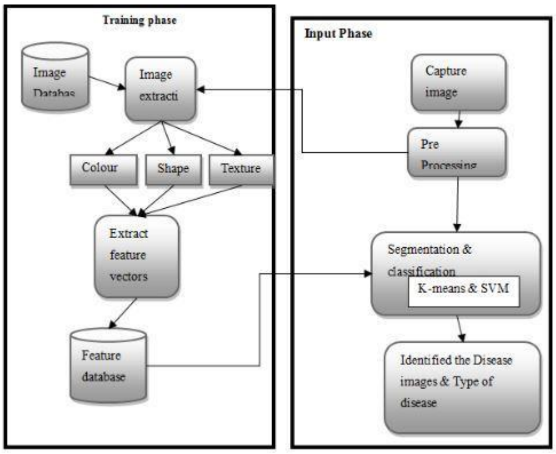

Figure 3: Architecture of the created system

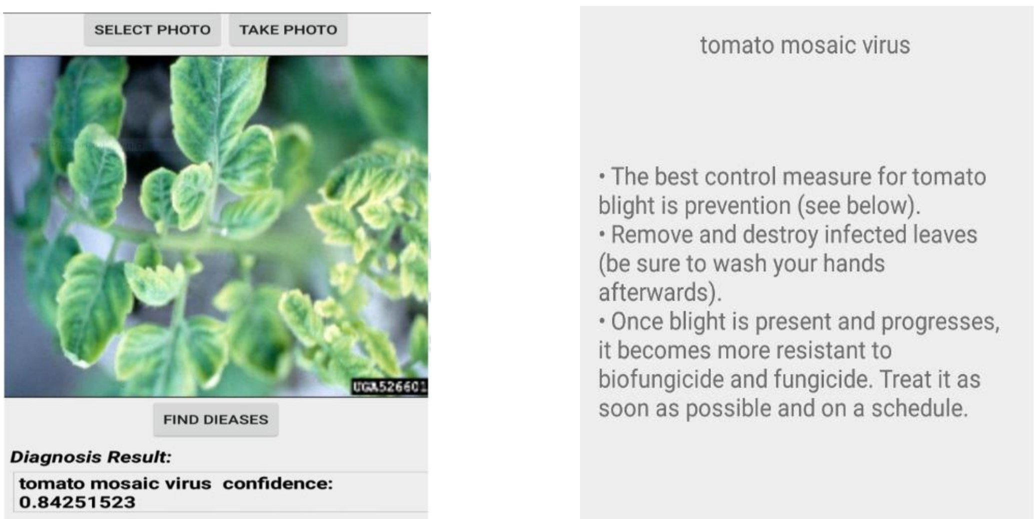

Figure 4: Mobile app detecting tomato mosaic virus with an accuracy of 84.25% and suggesting a preventive measure

Nitrogen estimation in sugarcane leaves using Image processing

Nitrogen is a major nutrient which sugarcane consumes especially in the first growth stages. Nitrogen fertilizer helps sugarcane foliage and trunk to grow. Lack of nitrogen implies lower yields but excessive nitrogen can lead to lower cane quality and increased vulnerability to pests and diseases, apart from the waste of expensive fertilizers. This is the reason why nitrogen management should be necessarily performed. Each plant species has their essential nitrogen amounts for which there are many researches done. But the harder part about nitrogen management is how to determine nitrogen concentration in plant itself. Theoretically, the amount of nitrogen fertilizer that plants need can be calculated from equation Np(plant) = Ns(soil) + Nf(fertilizer). Nitrogen content in soil can be obtained by using chemical method at the initial stage of planting. So the amount of nitrogen in the plant would provide the information on how much nitrogen fertilizer must be manured. In case of sugarcane, the traditional methods for measurement of nitrogen such as SPAD meter, kjeldahl method etc. are either time consuming or too expensive. So, a new method is needed for estimation of nitrogen which will be fast, accurate and cost efficient.

Initially, fully grown sugarcane leaves which are 2 months and 4 months old are collected. Two cameras were used to capture the images, one captured RGB images and the other captured IR (Infra-red) images. The image capturing apparatus was same for both cameras except the lighting conditions. The images captured were of size 1600 x 1200 pixels. The RGB images were thresholded to extract sugarcane leaf from the background and then were converted to YCrCb system which was then thresholded and converted to grey scale to detect edges of the leaves. The two were combined to get the edges of the leaves in greyscale and they were combined with the colored one to get the final picture, see figure 5. The IR images were converted to greyscale and were filtered using sobel filtering followed by thresholding and morphology detection for edge detection. Active contour model was used to determine boundary of the leaf(figure 6). After this, chemical tests were carried out to determine Nitrogen per cent in the laboratory. The samples were separated into two groups, i.e., 2 months old and 4 months old. Now relationship between leaf color and nitrogen percentage is modelled using non-linear regression model. Trying out different combinations the final parameters selected for modelling were R, B^2, G/R, G/B, (G/B)^2, (G/R)^2, (R/B)^2, ((IR – R)/(IR + R)), ((IR – R)/(IR + R))^2. From the results, it can be concluded that IR index is important in estimating nitrogen concentration in sugarcane leaf. IR index can increase model performance greatly. Leaf colour image and leaf IR image have a relationship with nitrogen content of sugarcane, see figure 7.

Figure 5: Initial and final RGB images of sugarcane leaves respectively

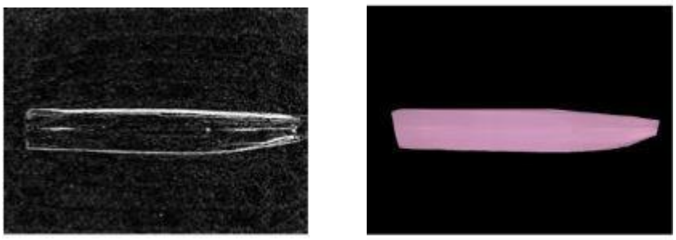

Figure 6: Sobel algorithm result and Active contour model on IR image

Age	Colour Indices	R Square
2 months old	Only RGB	0.7058
	RGB with IR	0.9441
4 months old	Only RGB	0.4766
	RGB with IR	0.6170

Figure 7: Results with and without IR

Conclusion

As discussed above along with a lot more research going on in implementing image processing techniques in various disciplines of agriculture, we can see that use of automated techniques not only decreases time consumption but also can provide better predictions that traditional techniques. Apart from this, with the boom in smartphone market, we might soon see cheap portable devices which can measure the plant as well as soil properties just by a click on your smartphone screen. This will revolutionize the field of agriculture by providing farmers the adequate data as well as the knowledge needed to increase their income and hence support their family.

References

1.) Vignesh Dhandapani, S. Remya, T. Shanthi, R. Vidhy “Plant Health Monitoring Using Image Processing” 2018 IJERCSE, ISSN (Online) 2394-2320

2.) Sachin D. Khirade, A. B. Patil, “Plant Disease Detection Using Image Processing”2015 International Conference on Computing Communication Control and Automation, IEEE

3.) Piti Auearunyawat, Teerasit Kasetkasem, Audthasit Wongmaneeroj, Akinori Nishihara, Rachaporn Keinprasit, “An Automatic Nitrogen Estimation Method in Sugarcane LeavesUsing Image Processing Techniques”, International Conference on Agricultural, Environment and Biological Sciences (ICAEBS'2012) May 26-27, 2012 Phuket

4.) V. K. Tewari, Ashok Kumar Arudra, Satya Prakash Kumar, Vishal Pandey, Narendra Singh Chandel, “Estimation of plant nitrogen content using digital image processing ”, CIJR Journal

5.) Digital Image Processing 2nd edition, Rafael C. Gonzales, Richard E. Woods