International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-6, March 2020

Machine Learning Based Nutrient Deficiency Detection in Crops

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Abstract: Indian economy is mainly based on Agriculture, involves the process of cultivating certain plants for producing food and many other desired products and raising of domesticated animals. Nutrients play a major role in agriculture and crop production. There are number of reasons for decreasing of crop yield. One such factor involved is nutrient deficiency. The proper detection of nutrient deficiency and appropriate fertilizer for that deficiency are the major problems faced by many farmers. Hence, in order to improve productivity, Automation in agriculture evolved drastically in recent years. This paper aims at designing an automatic robotic vehicle which detects the nutrient deficiency in crops just by simply capturing the image of leaves of the crop plants. The captured image is then processed by using the convolutional neural networks (CNN). This technique uses captured image, processing it by comparing it with the already available dataset. When the input image is matched or partially matched with any one of the existing images in the dataset, it will provide the result of nutrient deficiency in crops, in terms of the percentage. The name of disease associated with nutrient deficiency and appropriate amount of fertilizer will be displayed in the LCD. This will reduce the problems of the labour force and the burden of farmers.

Keywords: nutrient deficiency detection, automation, CNN, fertilizer.

I. INTRODUCTION

In the developing world, technologies play a vital role in all sectors. Human survival mainly depends on Agriculture. we are still using traditional methods in the agricultural practices. Identifying nutrient deficiency in crops is still difficult for farmers. If we are using ancient methods to identify nutrient deficiency in crops, it will take consume more time, work and cost. If identified wrongly, product yield, money and time will tend to lose.

Manuscript received on March 15, 2020.
Revised Manuscript received on March 24, 2020.
Manuscript published on March 30, 2020.
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In general, this kind of nutrient deficiencies is identified through agricultural laboratories and experienced people(farmers). The predictions on nutrient deficiencies manually may go wrong due to several environmental conditions. The nutrient deficiency in crops can appear in their leaves, stem, flowers, fruits, etc. we are using the leaf for identifying the nutrient deficiency in crops. A plant should need almost twelve nutrients for its efficient growth. They are Nitrogen, Phosphorous, Potassium, Magnesium, Sulphur, Molybdenum, Zinc, Boron, Copper, Calcium, Iron, Chloride.[10] These nutrients are divided into micronutrients and macronutrients. The micronutrients are Molybdenum, Zinc, Boron, Chloride, Copper, and Iron. The macronutrients are Nitrogen, Phosphorous, Potassium, Sulphur, Calcium, and Magnesium. The deficiency in these nutrients will cause many diseases in the crops. This will indirectly affect the yield rate. Generally, the nutrient deficiencies are identified in the leaves of the crop plants by the symptoms like reduction in leaf size, distorted edges, necrosis, blackspots etc., The farmer needs to uproot the entire plant and test the defected plant in the corresponding laboratory to identify the appropriate nutrient deficiencies.

II. LITERATURE SURVEY

Extensive research has been conducted to study various methods for the identification of nutrient deficiencies in plants. This work is mainly focussed on identifying nutrient deficiencies in the leaves.

[1] Pavit Noinongyao, Chaiwat Wattanapaiboonsuk, Puriwat Khantiviriya, Sutsawat Duangsrisai are the author for "Identification of Plant Nutrient Deficiencies Using Convolutional Neural Networks" presented a report about image analysis method for identifying nutrient deficiencies in plants-based on its leaf using Convolutional Neural Networks with the set of black gram (Vigna mungo)plants, grown under nutrient controlled environments. In this paper, they have studied five types of nutrient deficiencies. They are Ca, Fe, K, Mg and N deficiencies, and a group of healthy plants. A dataset of 3,000 leaf images was collected and have used for experimentation. This result indicates the superiority of the proposed method over trained humans in nutrient deficiency identification.

[2] Xihai Zhang, Yue Qiao, Fanfeng Meng, Chengguo Fan, Mingming Zhang are the authors for "Identification Of Maize Leaf Diseases Using Improved Deep Convolutional Neural Networks" presented a report to improve the accuracy of maize leaf diseases identification and reduction of number of network parameters, the improved GoogLeNet and Cifar10 models based on deep learning is proposed for leaf disease recognition in this study.

[3] Amrutha A, Lekha R, Sreedevi A are the authors for "Automatic Soil Nutrient Detection and Fertilizer Dispensary System" the proposed research aims at restoring the levels of Nitrogen, phosphorous, potassium in the soil by the measuring the nutrients present in it. Chemical processes have done for determining the presence of nutrients and they are quantified using sensors. An automated system has been developed for controlled addition of fertilizers in order to avoid excess/ deficient fertilizers in the soil. The working of the system comprises three steps: Soil sample preparation, Estimation of results from it and Dispensing estimated amount of fertilizers to the soil. The results are obtained within 30 minutes in the proposed system. The results, thus obtained from soil tests are given to sensors and the results are analysed using a microcontroller, which in turn needs a few seconds. Hence, the whole process of soil testing for all measurements of the macronutrients requires a maximum of 30-40 minutes after which the field can be fertilized.

[4] S. A. Miller, F. D. Beed, C. L. Harmon are the authors of "Plant Disease Diagnostic Capabilities and Networks" was published in Annual Review of pathology to improve the speed and accuracy of disease diagnostics and pathogen detection. Emerging, re-emerging and endemic plant pathogens continue to challenge the ability to safeguard plant health worldwide. The spread of invasive plant pathogen is increased due to combination of globalization, weather changes, human mobility demands, pathogen, and vector evolution. Accurate diagnoses, pathogen surveillance on local, regional and global scales are necessary to predict outbreaks allow time for development and application of mitigation strategies. Plant disease diagnostic networks have developed worldwide to address the problems of efficient and effective disease diagnosis and pathogen detection, engendering cooperation of institutions and experts within countries.

[5] Komal Bodake, Rutuja Ghate, Himanshi Doshi, Priyanka Jadhav, and Balasaheb Tarle are the authors for "Soil Based Fertilizer Recommendation System Using the Internet of Things" presented to develop a soil-based fertilizer recommendations system which can be used for regional soil analysis which in turn helps the farmer can understand it easily.

[6] Indumathi.R, Saagari.N, Thejuswini.V, Swarnareka.R - the authors for "Leaf Disease Detection and Fertilizer Suggestion" presented a report to identify the disease that has attacked the leaf and the area in the leaf where it gets affected. This was done by the help of Image processing, which predicts the diseases in the leaf. The input image is processed to obtain 13 image characters. They are Mean, Variance, Smoothness, Kurtosis, Skewness, IDM, Contrast, Correlation, SD, Entropy, RMS, Energy and Homogeneity. By these, the disease can be identified. In this study an automatic detection and classification of leaf diseases have been introduced. This method used K-means clustering procedure and (ANNs) Artificial Neural Networks. The Random Forest classification algorithms and the dataset of the algorithm made the systems for best attempt to identify the disease of the input leaf image and the fertilizer to treat it. The computational time of the disease in the infected leaf is reduced in this system and the memory is manageable. This system can be further enhanced by changing different algorithmic pairs to identify the disease in a more accurate way.

III. PROPOSED SYSTEM

The proposed system gives the result as name of nutrient deficiency in terms of percentage along with the respective fertilizer amount.

The extracted features from the image is useful to compare it with the trained dataset and to identify whether it is a healthy or nutrient deficient plant. It will throw the output of nutrient deficiency name along with corresponding fertilizer amount if the test image is a nutrient deficient image. The flow diagram of the proposed system will be given in figure 1,

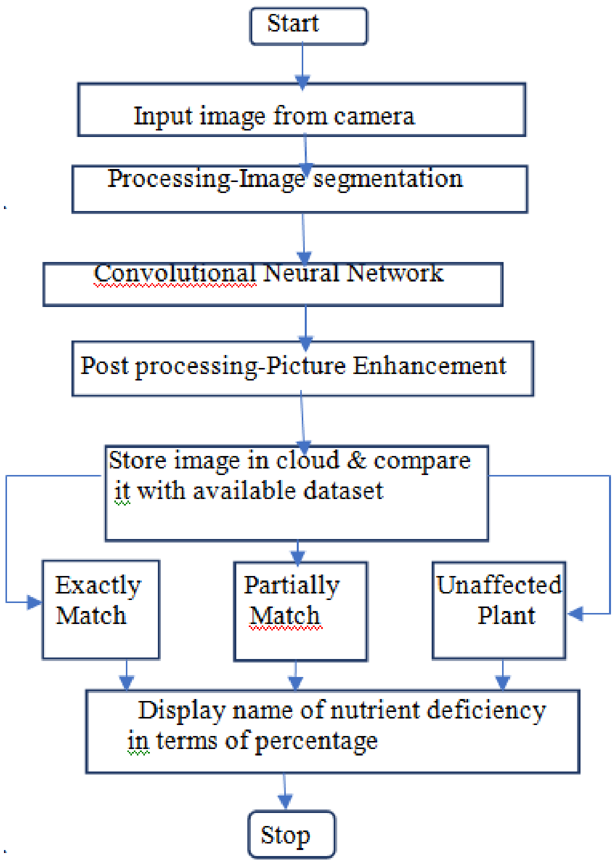


Fig 1: Flow diagram of the submitted system.

IV. METHODOLOGIES

The methodologies used for the final result of nutrient deficiency in the crops are:

i) Image Pre-processing
ii) Image segmentation
iii) Convolutional Neural Networks
iv) Post processing-Image enhancement
v) Matching techniques.

The most important characteristics of an image is its features. The features are Edges, Corners, Ridges, Blobs etc., The edges and corners are used mostly in image processing for differentiating an image from another image Initially, the features from images in the trained dataset are extracted to find the sample threshold values. These features are used to train the system to identify the various nutrient deficiency. The various threshold values denote the degree of various nutrient deficiency.

Once the feature is detected, a local image patch around the feature can be extracted. The result of extraction is known as feature descriptor. Feature extraction starts from the set of measured values and build the derives values indented to be informative.

The learning of features is done after the extraction of features. This is of two types: Supervised and Unsupervised.

The supervised method is the learning of features from labelled data. This enable the system to compute the error degree to fail and the used them as feedback to correct the learning process. The good example for this type is Neural networks.

The Unsupervised method is the learning of features from unlabelled data. This is helpful to identify the low dimensional structures underlying the high dimensional structures. Example of this approach is K-means clustering.

The edges can be detected in an image by variety of operators like Canny, Sobel, SUSAN, Shi & Tomasi etc., The results from Sobel operator cannot produce smooth and thin algorithms as compared to Canny. Hence, Canny operator is used widely in computer vision and image processing techniques for extracting useful structural information. This operator is an edge detecting operator, which detects wide range of edges in an image by a number of multi stage algorithms.

The Canny edge detection algorithm involves, application of Gaussian filter to smoothen the image in order to remove the noise, finding the intensity gradients of the image.

The non-maximum suppression and double threshold techniques are applied to get rid of spurious response and to determine the edges respectively. Ultimately, track the needed edges by suppression.

The equation for Gaussian filter kernel of size (2k+1) x (2k+1) is given by equation (1):

$$H_{ij} = \frac{1}{2\pi\sigma^2} \exp\left(\frac{-(i-(k+1))^2+(j-(k+1))^2}{2\sigma^2}\right); 1 \leq i, j \leq (2k+1) \quad (1)$$

To find the intensity gradient of the image, the equation with first derivative of horizontal and vertical direction is given by equations (2) and (3),

$$\mathbf{G} = \sqrt{\mathbf{G_x}^2 + \mathbf{G_y}^2} \quad (2)$$

$$\boldsymbol{\theta} = \mathbf{atan2}(\mathbf{G_y}, \mathbf{G_x}) \quad (3)$$

V. IMAGE DATASET

The images for training the vehicle are collected from various plant over different places. The collected leaf images are divided into two sets: Test and train dataset. The trained dataset contains the images collected over all areas. These images include healthy and nutrient deficiency leaves. The images of deficiency of almost all nutrients along with the healthy leaf images are trained to the vehicle. The test dataset contains the input images, which are captured by the camera of the vehicle. These input images are then compared with the trained image and gives the result in terms percentage of the deficiency.

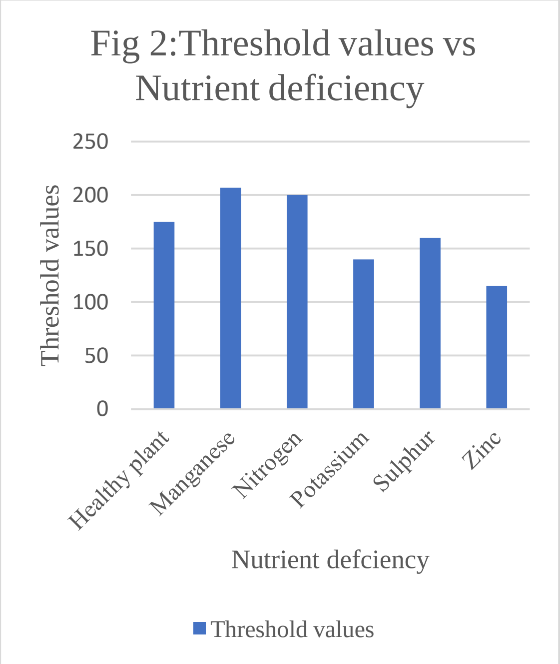
VI. EXPERIMENTAL RESULTS

The system which gives the result based on the thresholding of the images captured by the camera. The thresholding makes the noisy background to become black (0 in grayscale) and needed segment for the system to be white (255 in grayscale). From that threshold values, the boundary, corner, edges and contour can be detected for various images and predicted whether the captured image is healthy or deficient.

If it is a deficient one, then the major nutrient deficiency is determined and will be displayed in the display of the system. The relationship among various nutrient deficient threshold values is tabulated in table 1 and plotted as a graph, shown in the figure 2. From that graph, the threshold values for different nutrient deficiencies are identified and the degree of deficiency affected is determined.

Table 1: Tabulation of threshold values for various nutrient deficiency.

S.No	Nutrient deficiency	Threshold value
1.	Healthy plant	175
2.	Manganese	207
3.	Nitrogen	200
4.	Potassium	140
5.	Sulphur	160
6.	Zinc	115



VII. CONCLUSION & FUTURE WORK

The identification of nutrient deficiencies is done by the convolutional neural network algorithm and is displayed in the system.

The amount of fertilizer for the corresponding nutrient deficiency is also displayed (in terms of percentage). The future work includes the mechanism of fertilizer dressing to the field can be done automatically.

Several techniques are used for the automatic fertilizer dressing. The input from various sensors like soil moisture, humidity, temperature, pH is considered for determining the amount of fertilizer. The system can automatically fertilize the field by means of sprinkling mechanism. The fertilizer tank an also be used for irrigation purposes. The weed remover can be attached with the system to remove the weeds, if they exist. This weed remover is an adjustable and can be replaced with driller for drilling and cutter for harvesting. Thus, entire agricultural work can be integrated in a single system.

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