International Journal of Research in Engineering, Science and Management
Volume 5, Issue 4, April 2022
https://www.ijresm.com | ISSN (Online): 2581-5792

Improved Plant Disease Detection Techniques using Convolutional Neural Networks: A Survey

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***Abstract*: Predicting and detection of plant disease has always been a very serious problem faced in agricultural field. People with low financial backgrounds cannot bear the expenses of regular checkups of their crops and fields. Thus, a technique which can fulfill the needs of the poor farmers will be game changing invention. The proposed model in this paper has come forward with a system capable of detecting whether a plant is healthy or not. Further if the plan is unhealthy then the cause of the disease is also identified via taking two inputs such as plant leaves and soil sample from the plot where the diseased plant is present. The model is trained in order to classify whether the disease found is bacterial or fungal or due to pest attack. If the plant doesn't show any symptoms of being infected then the report of soil nutrient content is too generated and collectively provides the final result. The result will further be accompanied by recommending the required fertilizer or pesticide to tackle the problem and thereby reducing the loss in the production.**

***Keywords*: Convolutional Neural Networks, Fertilizer recommendation, Plant disease detection, Soil nutrient deficiency detection using IoT.**

1. Introduction

Agriculture is a field which contributes to a major part of India's economic growth and serves as the biggest employment source for all categories of people. Thus, the profit share of agricultural field is essential for everyone. The quality of crops grown or product generated collectively defines the profit rate and therefore farmers are concerned about their crop's health status, soil nutrient content, water supply for irrigation, amount of sunlight available for them and so on. Among these the health of crops is of utmost importance as if after all the necessities are provided, if the plant dies or get infected by any pest or bacteria then the investment as well time will be wasted. Precision agriculture (PA) is a modern technology and methodology that provides sophisticated methods and tools for optimizing and modernizing agricultural field. Through making use of these sophisticated technologies, Economic development in agriculture can be achieved. PA can be used for many applications, such as plant pest identification, weed identification, crop yield production and detection of plant diseases, etc. [2]. Plant disease detection is very essential and farmers are always in search of a technology that can sufficiently carry out this work with less investment and time. Plant disease detection can be carried out by using image processing techniques accompanied by machine learning techniques to make the process smooth and accurate.

Digital image processing tools and pre-processing methods are employed by the researchers to procure the fine and desired ouput which is often invisible to the human eye. The observations made by the human eye are usually procured for coming to the conclusion that whether the diseases are severe in the area of production or not. The significant development has done by the image processing in the field of agriculture [3]. One of the methods used is SVM i.e. linear SVM is a method used for classifying the data into two or more classes as it is multi- class separator these two classes are one with most inefficient data and one with efficient data, thus reducing the issues in accuracy.

The main objective behind this paper was to provide with a method to detect the disease present in the plant and to classify the plants into healthy and diseased plant. It's goal to detect whether the disease is due to plant's infection or due to lack of nutrients in the soil. The broad objective is to further classify what kind of attack is found on the plant like fungal, bacterial or pest attack. Depending on the kind of disease pesticide or fertilizer is recommended to the farmer to use in farm. The entire process involves IOT, image processing, machine learning, deep learning and many related techniques. The Paper also gives the real time, cloud-based soil nutrients observations framework. The Soil nutrients and constants such as humidity, ph, temperature is sized by our proposed setup, and can made available anywhere in the world with help of the valid cloud channel verification credentials. An important contribution of the proposed work is that farmers get a real time application of soil parameter analysis at their door step. Thus, the proposed cloud-based soil nutrient analysis setup can be used as an application by farmers for adding soil nutrients and enhancing the crop growth without anticipating for results from testing labs [7].

2. Literature Survey

This paper presents study on various methods that can be used in order to detect, classify and recommend necessary solution to the plant's disease based on whether the cause

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behind it is a lack soil nutrient or due to any pest or fungal attack on the plant. In order to systematically carry out the process of disease detection, two broad categories are considered namely –leaf input and soil input. Firstly, in order to process the leaf input methods like K-Nearest Neighbor Classifier, Convolutional Neural network, Artificial neural network and Support Vector Machine are used. In paper, based on CNN with LVQ Algorithm, by Melike Sardogan, 400 training and 100 test datasets were taken of tomato leaves. The proposed model was capable of detecting diseased plants by classifying the various bacterial, late blight, Septoria leaf spot and yellow leaf curl. The paper made use of Convolutional Neural Network model and learning vector quantization (LVQ) Algorithm. The accuracy obtained was around 86% [1]. In another paper, Plant Leaf Disease Detection using Machine Learning by, Amrita S. Tulshan. The disease detection was carried out using K- Nearest Neighbor (KNN) Algorithm for classification.it also included methods of image pre- processing, image segmentation and feature extraction as well. The accuracy gained was around 98.5%

[3] In paper, Tea leaf disease detection using multi-objective image segmentation, by Somnath Mukhopadhyay, leaf considered was tea leaves and the methods used were NSGA-II based image clustering, Multi-class SVM, PCA and feature reduction [4]. It was able to produce an accuracy of around 83% and was able to detect five different tea leaf diseases such as

Table 1
Comparative study of literature survey

Author & Ref No.	**Network & Methodology used**	**Plant name**	**Disease**	**Dataset**	**Accuracy (%)**	**Advancement**
Melike Sardogan, Adem Tuncer [1], 2019	CNN, with LVQ Algorithm	Tomato Leaf	Bacterial spot, late blight, septori a leaf spot and yellow curved leaf diseases.	500 leaves image	86	To improve recognition rate in classification process different filters or different size of convolution s can also be used.
R. Sujatha, Jyotir Moy Chatterjee [2],2021	SVM, CNN, ML (SGD, RF, SVM & DL)	Citrus leaf	Citrus leaf disease, black spot, canker, greening, melanose	609 image	89.5	Plans to utilize fuzzy logic & bio-inspired methods which may have a significant impact in case of better CA of the system even after using a small-sized dataset.
Amrita S. Tulshan, NataashaRaul [3], 2021	KNN, Image Segmentation, ML		Sun burn disease, Fungal disease, early scorch, bacterial leaf spot, frog eye leafspot, mosaic virus.	200 image	98.56	Enhancement work can be done on more dataset andcan work on more accuracy
Somnath Mukhopadhya, Munti Paul [4], 2021	(NSGA-II), SVM, HEO, KNN	Tea leaf	Red Rust,Red Spider, Thrips, Helopeltis, and Sunlight Scorching. (tea leaf diseases)	Tea Gardens such as Rose Candy, Haticherra, and Silcoorie, Cachar, Assam	83	The clusteringalgorithm will be attempted inthe future forbetter segmentation results. In the future, Hyperspectral plant images willbe consideredfor remotely detecting diseases in tea
S. Nandhini, K Ashok kumar [5], 2021	CNN, SVM Regression techniques, ICRMBO	Tomato leaf	Tomato mosaic virus,sept orial leafspot, Bacterial spot	plantVill age	99.98 &99.94	Plans to enhance the model to identify the leaf diseases of different crops along with its severity level
Jiang Lu [6], 2017	DMIL-WD D (VGG- FCNVD16 and VGG- FCN-S)	Maize Leaf Diseases	Leaf blotch, stripe rust, powdery mildew, leaf rust, smut, black chaff	Wheat Disease Database 2017 (WDD20 17)	97.95% and 95.12%	Working with other types of plant leaves

Author & Ref. No.	Network & Methodology used	Soil name	Temperature of Soil Sample	Humidity (in %)	Soil moisture (in %)	Advancement
Varsha Kiran Patil, Aniket Jadhav, Someshwar Gavhane, Venkatesh Kapare [7], 2021	DHT11 sensors for detecting temperature and for humidity ESP8266 WIFI Module	Black Soil	27.4	91.5%	53.9%	Requires soil-samples in specific calibration and expensive data logger
K. Spandana and Suresh Pabboju [8], 2020	TDR and FDR to calculate the average of moisture content	Literate Soil	25	40 %	70 %	Power consumption, moderate accuracy
Swapnil Sunil Raut and Vidya Chitre [9] 2020	PH sensor, Ultrasonic sensor, temperature sensor, stickiness sensor	Red Soil	30	60	60%	Very Expensive, requires soil specification calibration and temperature correction
P. Sukumar, T. Kavitha, A. Deepika, V. Jashnavi [10], 2018	The system has Arduino board, moisture sensor, PH, Humidity sensor	Black Corson Soil	29	37	68%	Humidity corrections required for good accuracy

RedRust, Red Spider, Thrips, Helopeltis and sunlight scorching.

Almost in every soil analysis literature we can observe that soil nutrient analysis is being performed by electrochemical sensing, optical visual acuity and electro conductivity sensing. Also, most popular method in soil testing literature is color sensing controller-based method.

Hence, we are adapting a framework based around the color sensing controller-based method [7].

Below are the gaps the most of the work couldn't address:

1. Many existing techniques couldn't extract enough features from the images. Need for proper combination of feature extraction technique is needed.
2. Images with overlapping leaves are not identified.
3. Images with multiple objects were not addressed.
4. Complex background, blurred images and images captured having low illumination were not considered.
5. Dataset with huge number of images were not considered.
6. New techniques under machine learning need to be explored for better accuracy.

3. Methodology

The methods followed in the process of plant disease detection and pesticide or fertilizer recommendation is huge and in order to make the representation more accurate and less complex, we have separated the methodology of pesticide recommendation via plant infection process as process 1 (P1) and the method of fertilizer recommendation via soil nutrient insufficiency as process 2 (P2). The output of the two processes together presents the output.

Process-1 (P1): It is related to the determination of plant diseases and more based on image diagnostics with statistical inference method support. Holistically – Nested Edge Detection (HED) is used to fill up the gaps present in Canny Edge Detector method via an end-to-end deep neural network.it accepts an RGB image as an input and then produces an edge map as an output.it is capable of preserving boundaries. HED makes use of the side outputs of intermediate layers.it consists of 5 convolutional layers which are fused together to generate the final predictions. HED method is not only more accurate but also faster than them too.

Fig. 1 gives a summarized flow diagram of process-1.

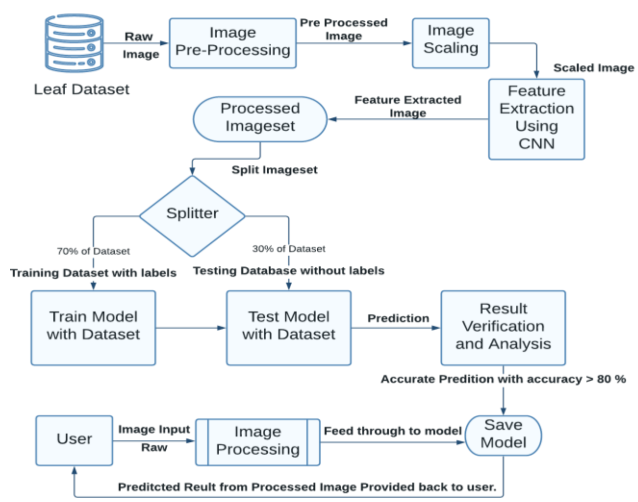

Fig. 1. Flow diagram of process-1

Process-2 (P2):

Step 1: Collecting of Samples of soil from the farm:

In order to select the soil for testing, there are different methods. In our proposed work we have used grid sampling. The sampling methods can be summarized as follows:

Grid sampling method: For this method, we need to collect 5–8 soil samples per acre. All these soil samples are mix together. This soil sample is taken for analysis of Soil contents. This method is Grid sampling [7], Bench mark sampling involves within a field of half hectors, soil samples are collected from uniquely different areas, Random sampling involves collection of soil samples in a random pattern of a large field.

Step 2: System Design:

The framework comprises of three main parts: sensor framework, microcontroller and the cloud. We need to design two subsystems specifically first as a Sensor framework for assessment of supplements present in the soil and second subsystem for smart framework for storing a capacity of information for additional assessment at remote location. With these two proposed subsystems, we are examining climate and soil supplements. The first subsystem of soil nutrient detection part of system consists of doctor plus kit for detection of NPK content. TCS3200(The Colour sensor) is sensor that converts light to digital Frequency signal. The output of colour conversion sensor is values of the R, G, B. The values of RGB are mapped to soil nutrient contents by program mapping values of R, G, B to values of soil nutrient contents N, P, K. The Second subsystem has DHT11 sensor for the environment analysis of soil for measuring temperature, pH and moisture respectively. Fig. 2 gives the summarized view of the entire proposed model.

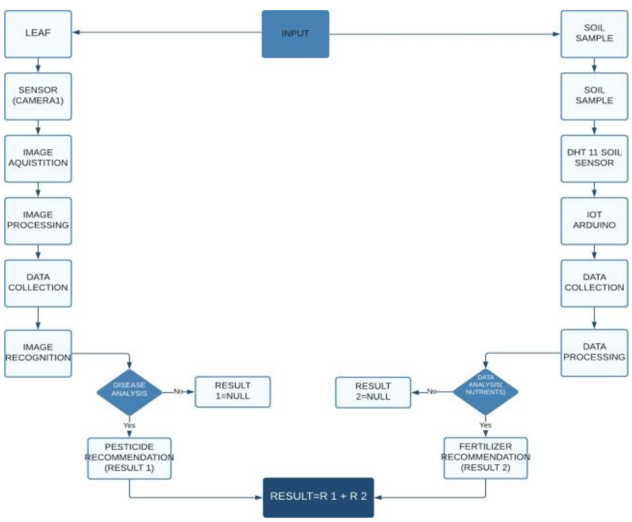

Fig. 2. View of the model

4. Conclusion

In this paper, leaf disease detection and classification method are carried out based on Convolutional Neural Network with HED technique on a dataset of 500 images. It is a model using deep learning based on edge detection on the collected images and soil sample.it performs visual feature extraction from each sample input such as leaf and soil sample and then collectively produces the final output. it is model which not only detects the disease but simultaneously provides a solution to it as well by recommending fertilizer or pesticide. In this model the issues and obstacles faced by many authors are addressed and tackled. The image processing efficiency has been improved from its previous experiments and the complexity of IoT has also been reduced to some extent. Since the soil sampling papers read were still in process, this model plans to come to a conclusion with the prescribed techniques and methodologies.

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