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Plant leaf disease detection and control : A survey

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Abstract

The most important aspect of the Indian economy is agriculture. It is very common and natural to have a disease in plants with varying climatic conditions. This further leads to the crop quality getting deteriorated. With the recent changes in the weather cycles, achieving the best quality and quantity of crop is the most challenging task for farmers. With such challenges at the forefront, image processing has been proved as the best technique to detect the initial stages of disease based on the color, texture, and shape of the crop leaf. There are many different feature extraction techniques like color histogram, canny and Sobel edge detector, gray level co-occurrence matrix, Gabor filter which are used for extracting the feature of the disease in a crop leaf. Once disease features are extracted then classification algorithms like Support Vector Machine, Artificial Neural Network, Backpropagation, Convolution Neural Network, Feed Forward Neural Network, Probabilistic Neural Network, and Radial Neural Network are used to classify the disease. Once disease reason is identified, then proper treatment can be applied after identifying the reason behind the disease. These image processing and classification techniques have been proved accurate but feature extraction is the most time-consuming method as it is done manually using the different methods. Also, image processing with classification works for the small dataset. Convolutional

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Neural Networks as a part of deep learning, and it's a most effective sub branch of image processing. Many applications for the automatic identification of plant leaf diseases have been developed. These applications could serve as a basis for the development of expert assistance. Such types of tools could contribute great and sustainable agricultural practices and greater food production security. To examine the potential of these networks for such applications, we survey research studies that relied on CNNs to automatically identify plant leaf diseases. We describe their performance and main implementation aspects. Our survey allows us to identify the issues in this research area. This work covers the survey of different types of the disease occur in plants, its causes, symptoms, and treatment policy with the image processing and classification methods used. This survey also discussed the limitations of existing research work which provides the direction for further improvements in plant disease identification and preventive measures.

Subject Classification: 68T30

Keywords: Plant disease, Disease identification, Plant leaf Symptoms, Treatment policy

1. Introduction

In agriculture, plant diseases happen because of climate changes and changes in weather cycles from place to place. Due to the climate changes such as excessive/lack of raining and extremely hot/cold conditions, crops may be getting infected by the virus, fungal and bacterial infections. A plant disease damages the crop and deteriorates the crop quality. Hence to produce the best crop quality and quantity is a challenging task for the farmers. The identification of plant disease is always a challenge for crop production and plant growth. Early detection of these diseases can allow taking preventive measures and mitigate economic and production losses [1]. To produce the best quality of the crop it is necessary to control and stop the spreading of disease in the entire farm. To control the growth of the diseases, it is necessary to identify the disease based on symptoms, find the reason and try to control it. Plant diseases may damage the plant above and below the ground level as well [2]. Leaf disease identification can be based on the symptoms like yellow dots, brown dots, spotting, etc. while the controlling can be done by taking care that the dots will not happen in the future in the crops like rice, wheat, oat, potato, tomato, pomegranate, etc. Most of the time, farmers used the naked eyes to identify the disease, but this process is quite time consuming and is inaccurate in the agriculture sector. Sometimes farmers need to take the help of experts to identify the disease. The availability of automatic processes for such tasks makes it easier to identify disease more accurately which in turn reduces the requirement of effective manpower and cost of farmers.

Such automatic processes that identify the plant diseases through optical observation of the symptoms on plant leaves incorporate a significantly high degree of complexity as well [3].

Identification of the disease in the crops and at the same providing a better solution to control it will be helpful to farmers to produce a good quality crop.

This research work is related to the survey of the existing work done in this era and finding the research gap to provide a better solution for plant leaf disease identification. The organization of the paper is as follows: Section 2 describes the steps for disease identification. Section 3 describes the different plant leaf disease. section 4 covers work already done for plant disease identification and controlling it. Issues uncovered are discussed in section 5 and conclusion and future work are described in sections 6 and 7, respectively.

2. Disease Identification Steps

Plant disease decreases the overall production and quality of the crop. Controlling plant disease is the most important aspect of agriculture. The identification of plant diseases is divided into three steps: 1) image acquisition, 2) the second image preprocessing and feature extraction and 3) image classification as shown in Figure1[4].

1. Image acquisition

Images are taken through the webcam, mobile device or smart camera located at a specific distance or in the variable distance for the image analysis [5-6].

2. Image pre-processing and feature extraction

After capturing and removal of noise from the images, all images are converted from RGB(red, green, blue) to HIS(hue, saturation, intensity) using image processing algorithms [7-8]. Feature extraction methods like grey level co-occurrence matrix, color histogram, carry and sobel edge detector are used to find the existence of the disease in the leaf based on the color, shape, and texture [9].

3. Image classification

Image classification algorithms like support vector machine, artificial neural network, backpropagation, convolution neural network etc. are

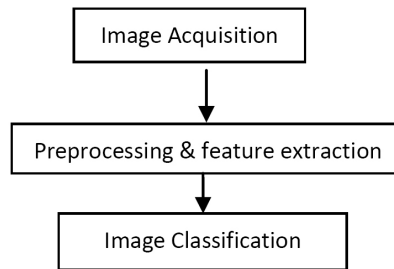


Figure 1
Disease identification steps

used to identify the specific disease on leaf. This process applies to the images after feature extraction [9].

Once a disease is identified, it needs to be controlled using appropriate actions like using the disease-free seeds, avoid overhead watering, better air circulation, etc. so that the same disease will not happen in future.

3. Plant Leaf Disease and Symptoms

A plant becomes diseased when it is continuously disturbed by the casual agent. This results in an abnormal physiological process that disrupts the plant's normal shape, growth, function, or other activities. This type of interference with one or more of a plant's essential physiological or biochemical systems elicits characteristic pathological conditions or symptoms. Plant diseases can be classified according to the nature of their primary agent, either infectious or noninfectious. Plant diseases can affect plants by interfering with several processes such as the absorbance and translocation of nutrients and water, photosynthesis, flower and fruit development, plant growth and development and cell division and enlargement. Plant diseases caused by different types of fungi, bacteria, phytoplasma, viruses, viroids, nematodes and other agents.

Some diseases like Bacterial spot, Bacterial blight, Bacterial wilt, Scab, Rot, etc. happen due to the bacteria. Some disease happens due to the fungus the diseases like Aphids, Grey mold, Downy mildew, Powdery mildew, *Cylindrocladium*, Mealybugs and Mosaic, Spotted Wilt, Curly top are the examples of the virus.

Every plant has some unique characteristics based on that we can identify the disease where it has been developed due to bacteria, fungus

or the virus. The symptoms of the disease used to identify the specific disease and its reason.

a) *Bacterial Disease*

Bacterial spot: The scientific name of the disease is *Pseudomonas* spp. An infected leaf has small dark spots and plenty of water-soaked spots appear on the leaf. The spot is small but it is visible from both the sides of the leaf. When the disease becomes older then it has a tan color. This disease happens to poor soil drainage, wet environment, humid temperature, poor air circulation, and frequent rain.

Bacterial blight: In this disease, an infected leaf has yellow color water-soaked lesions at the margin of its leaf blade. Bacterial discharge appears on lesion early in the morning. The lesion looks like a milky dewdrop. The bacteria further develop and the spots turn brown, scabby, slightly sunken, and sometimes surrounded by rings. The disease may be developed due to warm temperature, frequent rain, high humidity, poor air circulation, low sunlight, and poor soil drainage.

Bacterial wilt: The scientific name of the disease is *Ralstonia solanacearum*. This disease may happen due to the very hot and wet season. Infected leaves wilt during the sun and sometimes they recover during the cool hours. Wilt is similar to the lack of water. During the fast development of the disease, the entire plant wilts quickly without yellowing. This disease may happen due to infertile soil, injured roots due to farm tools, high soil pH and nematodes present in the soil.

Scab: The scab disease may be particularly severe when potatoes are grown in neutral or alkaline soils. Disease may happen due to the Soil pH and soil moisture environment. Disease may increase due to the warm and dry soil condition. This disease may happen due to the *Streptomyces* scabies.

Rot: The scientific name of the disease is *Erwinia carotovora*. initial infection occurs on the outer petiole which is in contact with the soil and then progresses to its head. An infected head has a complete head rot and it is watery. The affected area becomes mushy, soft and generally turns dark in color. The disease happens due to the hot and damp weather with plenty of rainfall [10].

b) *Fungal Disease*

Fungal diseases are the most common parasites which causes the plant disease. It's very small and it can be seen with a microscope. Fungi

usually produce spores and which, when carried to the plant, can begin an infection. For fungus spores to start new infections, adequate moisture and the right air temperature are required. These diseases are common in wet and humid environment [11-17].

Grey mold: The scientific name of this disease is *Botrytis cinerea*. This disease travels quickly through gardens, especially during damp, mild and cool weather. The symptoms appear as greyish to red soft, mushy spots on leaves, stems and flowers. Stems, petals and buds can also be infected. Generally, the spot appears water-soaked and will form on the leaf.

Aphids: The tree leaves dripping sap the usual cause is tree aphids. These pesky insect pests can cause serious stress to trees. These lead to disease soft bodies, pear-shaped insects can be almost any color.

Downy mildew: The scientific name for this disease is *Peronospora* spp. The infection begins with the yellow color spots on the upper leaf surfaces. Then they become dark yellow. The internal part of the leaf spot becomes brown with a yellow margin. Disease may develop due to the poor plant aeration and cool and warm moist weather condition.

Powdery mildew: The scientific name of this disease is *Erysiphe orontii*. In this disease, the leaf becomes the dusty-white to gray coating. The disease begins as circular shape and powdery-white spots that turn yellow-brown and finally black. These symptoms commonly found on the upper side of the leaf. It also infects the underneath surface of the leaf. Disease may spread due to overcrowded plant, warm and dry climate conditions.

Cylindrocladium: The symptoms of the disease is, brown spots, stem lesions, blight, and defoliation. Leaf spots generally have colors in grayish brown, dark brown or nearly black; young leaf spots are brown, lesions often gray in the center and may have a brownish-black edge [15].

Mealybugs: Mealybug infestations appear on plants as small, soft-bodied insects surrounded by a fuzzy, white mess around the leaf nodes stems. This disease has been found in warmer growing climates, mealybugs are soft-bodied, wingless insects that often appear as white cottony masses on the stems, leaves and fruit of plants. Usually covered leaf with a white or gray mealy wax [18-21].

c) *Viral Disease*

Virus diseases are spread very slowly and the leaf curl either outward or inward. The leaves are thicker than normal, with a leathery texture. The

young leaves have yellowish color. They look like cupped, thick, and rubbery.

Mosaic: An infected leaf has white, pale-yellow or pale-green spots. It is often distorted, twisted, and stunted. Disease may happen due to the stressed plant, weedy field, and infected planting material.

Spotted Wilt: This disease may spread due to insects that feed on a variety of plants by puncturing the leaves and sucking the plant's contents. Symptoms include bronze-colored or dark-spotted leaves, dark streaking in the plants terminal stems, stunted growth and possible die-back of the plant's growing tips.

Curly top: The scientific name of the disease is Begomovirus. Infected leaf becomes with the yellow curl [16]. The infected plant has stunted young leaves and shoots. It grows very slowly, becomes bushy, and dwarfed. Disease may spread due to the weedy field and infected transplant condition [21].

4. Literature Survey

Plant diseases can be caused by different types of fungi, bacteria, phytoplasma, viruses, viroids, nematodes and other agents. There are different types of plant disease. Disease like Aster yellows, Bacterial wilt, Fire blight, Rice bacterial blight, Canker, Crown gall, Rot, Basal rot, Scab are examples of bacterial disease. Some of the fungal disease are Anthracnose, Black knot, Blight, Chestnut blight, Late blight, Canker, Clubroot, Damping off, Dutchelm disease, Ergot, Fusarium wilt, Panama disease, Leaf blister' mildew, Downy mildew, Powdery mildew, Oak wilt, Rot, Basal rot, Gray mold rot, Rust. Some disease happens due to virus which is like Curly top, Mosaic, Psorosis, Spotted wilt, etc. The microorganisms that cause plant diseases include nematodes, fungi, bacteria, and mycoplasmas [14]. They gradually grow on the plants, damage those plants and as well as may spread in the entire crop. Plant diseases can affect plants by interfering with several processes such as the absorbance and translocation of water and nutrients, photosynthesis, flower and fruit development, plant growth and development and cell division and enlargement. Internet penetration, smart phones and unmanned aerial vehicle technologies offer new tools for in-field plant disease selection based on automated image recognition that can aid in early detection at a large scale. Plant disease is very harmful for the crops. Once disease is diagnosed, the reason for disease is investigated and after

Table 1
Plant disease symptoms, causes and control policy[15][16][22][23]

Disease	Symptoms	Caused by	Control Policy
Blight - Late blight - Early blight	Sudden and severe yellowing, browning, spotting, withering or dying leaves	Bacteria or fungus	overhead watering - better air circulation - use fungicides and antibiotic
		Humid region temp ranges 4 and 29c	
		Warm moist spring weather	
Bacterial wilt	- Wilt from tip of the leaves - leave become yellow at their bases	- bacteria - high temperature - soil moisture - low pH - infected seeds	keep beetle populations as low as possible
Spindle Tuber Viroid	- smaller leaves curl downward - plant have growth upright habit	Viral disease spread through pollen and infected seeds	Use pesticides
Septoria leaf spot	- Small, round to irregular spots with a grey centre and dark margin on leaf - Spots usually start on lower portion of leaves and extend to upward - At later stage spots coalesce and leaves are blighted	- Fungus - nutrition deficiency - high humidity - moist weather with intermittent shower	- improve air circulation around the plant - remove diseased leaves - Mulch around the base of the plants - avoid overhead watering

that certain preventive actions are to be applied to stop the spread of the disease in future [11].

Lot of research work has been done in agriculture area to identify the disease in the different part of the crops like root, fruit, leaf, soil, weeds etc. Plant diseases may have different reasons and symptoms. Table1 describe the certain disease symptoms, causes and control policies for plant leaf [15][16][22].

Amanda Ramcharan et. al. used the inception convolution neural network for identifying the disease in cassava leaves. They used the image processing for the feature extraction and then applied the CNN for the disease identification. This process is 98% accurate for the cassava leaf disease. They have also developed the mobile application for the fast disease identification [2, 4]. Deep learning model for plant disease detection and diagnosis shows that there are different types of convolution neural network architecture like AlexNet, AlexNetOWTBn, GoogLeNet, Overfeat and VGG for plant disease detection [3]. Amongst all these architectures, VGG gives the high success rate and the best match between laboratory data and the real data. They have also used the morphological concept for the plant disease identification. Plant Leaf Disease Detection and Classification Based on CNN and LVQ Algorithm show the plant disease identification using Learning Vector Quantization method for feature extraction [9]. The method identified the diseases like bacterial spot, late blight, septoria leaf spot and yellow curved leaf disease on tomato crops. CNN classifier is used after feature extraction for the disease identification and tested on the collected dataset from village plant.

Mrunmayee Dhakate Ingole A. B has identified the disease on the pomegranate plant[6] using the grey level co-occurrence matrix for the feature extraction and Artificial Neural Network for the classification [12]. Diseases like bacterial blight, fruit spot, fruit rot and leaf spot are identified by this algorithms.

Monzurul Islam et. al. used the masking concept for the feature extraction and support vector machine for disease identification. SVM used to identify the diseases like early blight and late blight disease on the potato plant.

Detection of unhealthy region of plant leaves using Image Processing and Genetic Algorithm demonstrates the identification of disease on the rose, beans, lemon, banana, mango, tomato and jackfruit crop[7]. Genetic algorithm used for the feature extraction and classification method is not used for the disease classification.

Jobin Francis et al. used the masking grey pixel and threshold based segmentation and grey level co-occurrence matrix for feature extraction on pepper plant and used neural network for the classification [8][13]. Using these concepts they identified the diseases like berry spot and quick wilt. Also, they have identified the reason for the disease and applied the preventive action to control and spread of the disease.

Robert G. de Luna et al. identify the anomaly detection, leaf disease detection and provide the treatment for the same of the tomato crop [18]. F-RCNN (Fully-Region Convolution Neural Network) used for finding the anomaly in the plant and CNN used for the disease detection. After identification of disease they suggested the treatment for the specific disease. Automatically images are captured through the box and this prototype used for the any tomato crop. This method is providing a good accuracy for finding the diseases like Phoma Rot, Leaf Miner and Target Spot.

R.Meena Prakash et al. proposed the method for the plant leaf disease detection using image processing and Classification [19]. Proposed work use the image acquisition, image processing, segmentation using k means clustering, GLCM(Gray Level Co-occurrence method) for feature extraction and support vector machine for the classification process. This method is used for the citrus leaves.

Srdjan Sladojevic et al. proposed the disease identification model with convolution neural network. This model first collects the images and removes the duplication of the images. Then apply the pre-processing manually to resize the images and apply the augmentation process for increasing the data size and introducing the slight distortion to the images. C++ using OpenCV library used for the augmentation process. Finally CaffeNet framework used for the convolution neural network classification to identify the disease like peach powdery mildew, apple powdery mildew and grapevine wilt disease of the crop. Augmentation process had greater influence to achieve respectable results.

5. Research Gap

This literature survey gives the glimpse of the work done in the area of the plant leaf disease identification. Though lot of research work has been done in this area, still there are certain limitations which give future direction to the researchers. Some of the limitations are:

- An Image processing algorithms like color histogram, canny and Sobel edge detector, gray level co-occurrence matrix, Gabor

filter which are used for feature extraction and SVM, Bayesian classification, decision tree etc. like classification algorithm were generally developed for the laboratory dataset.

- The algorithms which were implemented using the deep learning concepts work for only single dataset whether synthetic or real.
- The algorithms that have been developed worked for only few diseases and that too for single crop.
- Image processing-based algorithms support small datasets and take more time to execute.
- Limited algorithms have been developed which provide necessary controlling action to avoid the disease to reoccur in the future.

6. Conclusion

This work reviewed currently existing methods for detection of plant diseases caused by pathogens such as viruses, fungi and bacteria. Though the image processing and classification techniques are available for the plant disease detection they are very time consuming and only support small synthetic datasets. Thus, deep learning can be the best option to focus on increasing the leaf disease recognition rate and classification accuracy.

7. Future Work

Deep learning, a subset of machine learning can be used to overcome the limitation of the image processing with classification method. Though deep learning is taking more time to train the dataset but it has the automatic functionality of feature extraction and also support large and real time datasets which reduce overall execution time. So, deep learning techniques can be considered for future research in the agriculture area like root, land, weeds, leaf and fruits for disease identification. Also it is possible to develop algorithms which can work for a variety of crops.

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