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A Review on Plant Leaf Disease Detection using Deep Learning

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***Abstract*— Identification of plant disease plays an important role as it prevents stunted growth which causes bad effects on yields. As agriculture plays a vital role in the Indian economy and different countries of the world, so there is a need to prevent losses in terms of production, quality, and quantity of agriculture yields due to plant disease. Earlier farmers used to monitor plant disease with the naked eye which was time-consuming and requires a lot of expertise such as being able to identify a disease and disease-causing agent. But nowadays with advancements in technology, smart farming, and automatic techniques, plant disease can be easily identified and proper diagnosis can be done. It reduces a lot of work of monitoring such as in the case of big farms. Also at an early stage, it detects the symptoms of plant disease when they first appear on leaves. This paper reflects the potential of one such method-Plant disease detection using machine learning, using this one can detect plant disease. It includes the use of image processing techniques with the help of a machine learning algorithm to get a clear and defined image or to extract some useful insight from it. The application of machine learning in agriculture discussed in this paper and have shown the experimental results in the form of accuracy and practical useability. Also, Convolution Neural Network (CNN) is used for image classification. CNNs are equipped with input, output, and hidden layers which help in process and in image classification.**

***Keywords*— Disease detection, Image processing, K-means clustering, Convolution Neural Network**

I. INTRODUCTION

Plant diseases have been shown to reduce food intake by humans by disrupting crop yields. This may result in malnutrition or starvation and death in extreme cases. Agriculture performs an essential position in the Indian economic system. about 70 percentage of rural families depend upon agriculture. Agriculture is an essential part of the Indian economic system as it contributes approximately 17% of the entire GDP and offers employment to more than 60% of the population. The direct economic impact of cross-border pests or diseases is that the loss or decline in the efficiency of agricultural production - whether in crops or animals - reduces farmers' incomes. Therefore, automatic diagnostic tests are helpful because they reduce the external monitoring function on large plant farms, and at an early stage the symptoms of disease appear on plant leaves. This paper covers different sections. The first section provides a brief introduction to the importance of diagnosing plant diseases. The second section discusses the recent work done in this area and reviews the strategies used.

In this survey paper we will see various techniques used for disease detection in plants.

II. BASICS OF DEEP LEARNING

Deep Learning (DL) is a subclass of Machine Learning, and it has so far gone into 3 different parts of designing a model. The 1st generation originated in 1943 and its name was MCP and was only useful in linear classification problems.

Back Propagation (BP) was the second generation of the neural network. It was invented by Hinton in 1986. Nonlinear classification and mapping were also solved with the help of sigmoid functions, but around 1991 some problems of gradient vanishing were pointed out.

Deep Learning (DL) is the third generation of neural networks. It was introduced in 2006, and as of now many DL models or architectures are being used for image detection or recognition.

III. LITERATURE REVIEW

J. G. A. Barbedo [1] shows a Google Net model developed for 78 diseases of 13 different plants in the testing area and a complex area environment as a checking tool. The advantage of this method is that the appearance of multiple pathogens in one leaf can be detected in many smaller images. The accuracy of this architecture was almost 94%.

Dechant et al. [2] implemented a newly designed CNN architecture to detect apple leaf disease. Using an Inception architecture and Alex Net-precursor network, the network was formed. Alex Net model got replaced by the Inception network which reduced the many of trainable modules, by decreasing data-storage needs. A single CNN gave the experimented result which shows the correctness percentage of 89.9%. They used 2 1st level differentiators, the correctness percentage became 96.0%, & the accuracy rate rose to 97.8% when three first-level qualifiers were used. The accuracy of this architecture was trained in comparison with 'SVM', 'BP', 'Alex Net', 'Google Net', 'ResNet20', and 'VGG16'. The accuracy of these models was 67.92%, 63.61%, 89.98%, 85.68%, 89.75%, and 89.31%, compared to 97.52%, which is the performance of the proposed Alex Net-precursor and Cascade Inception network.

A well-known subfield called as Few-Shot Learning (FSL) was introduced [3]. FSL can solve neural network detection problems and new classes that have not emerged from training; neural network recognition problem is hard to integrate because of the less quantity of test modules, thus improvising the percentage of detection of fewer data sets. In databases where there are only a few images or many, the transfer learning architecture (TL) has an issue with less visibility correctness [23]. It is due to it being a very hard situation to learn different aspects of a deep network, and it began creating issues which were very hard to integrate or incomplete-install. Therefore, plant disease data sets containing single or small samples cannot support Deep Learning (DL) model training. Apart from this, the DL model (in-depth learning model) needs re-training in order to successfully recognize several newly designed modules which doesn't appeared in the training module. After extensive testing, the results showed that Fiw Shots Learning (FSL) could successfully achieve an average of 90% accuracy with the help of only 59 trained photos, those were much best in comparison to refined transmission learning, whose accuracy was 73%.

In paper [4], the requirement of a precise method inside the branch of leaves-primarily dependent photos type proved surprising consequences. In this study they used Common woodland to come across diseased leaves from the fact sets created. Common fields were as a whole, a study approach for differentiation, regression & some different obligations which were operated through developing woodland as per the required bushes all through the schooling period, not like choice plants, Common forests conquer the drawback of overfitting in the schooling facts module & they handled each intergered and categorized facts. For extracting features of a photo, they used a Histogram of an orientated Gradient (HOG). typical, they used device learning to train the big records units available to locate the ailment present in plant life. The histogram of oriented gradients (HOG) is a detail describer used in part of object detection by image processing. right there they used 3 thing descriptors: 1. 'Hu-moments' ,2:. 'Haralick-texture' ,3:. 'color-Histogram'. This paper also well-known shows the accuracy of numerous gadgets in gaining knowledge of models. Table 1 illustrates the different machine learning models with their accuracy results

Table-1 Different kinds of ML Techniques

Differeent ML Techniques	Accuracy(percentage)
Logistic-regression	66.23
Support-vector-machine	41.13
K-nearest-neighbor	65.86
CART	63.56
Random-Forests	70.44

The implementation of machine learning algorithm is seen to identify and detect a wide variety of plants disease [5]. Timely performance and high accuracy of Machine learning can be found with various backgrounds and disease coverage. Also has the ability to train itself and helps farmers to manage diseases

effectively. Being platform agnostic Tensor Flow Framework is used for the CNN model implementation. Tensor Flow also known as data flow graphs because of its numerical operation. Graph nodes are represented by mathematical operation(s) and Multi-dimensional arrays are represented by the graph edges. In Tensorflow machine learning algorithms can be implemented easily and quickly. 89,999 or more images were used for the development of this technique, detection & validating the uncommon backgrounds & photos. It gives accurate information to farmers about the diseased plants. For training the model 60% images were used and the rest 40% for validation. Before detecting the disease interface used in KrishiMitr allows the user to choose the plant type. To check its functioning, KrishiMitr was tested on a linux-based machine having a touch screen with a sensor for photo acquisition. All codes of KrishiMitr are freely available on the internet.

In Paper [6], outlines a technique for diagnosing plant-leaf disease depending upon colour, edge-detection, and histogram pairing. The comparing histogram is based on colour scheme and edge detection methods. The methodology used in this study is categorized into two main categories. The first part deals with healthy sample training and disease sampling. The second phase deals with experimental sample training and produces results depending upon edge finding and histogram matching. Each leaf has its own characteristics on the edges. Some leaves borders are a saw, some were clear and some have waves, and so on. Also, the midrib-alignment & the vein-pattern of the leafs are of uncommon types. Therefore, the Canny edge detection algorithm is used.

K. Muthukannan et al. [7] revealed spot disease in leaves and other demaged leaves using Neural-Network-Algorithms. Different methods were used to distinguish the defected leaves such as Feed-Forward-Neural-Network (FFNN), Learning-Vector-Quantization (LVQ) and Radial-Basis-Function-Networks (RBF).. Simulation results have shown the effective result of the method. By using this techniuqe, a ML based architecture can be developed for the good crop quality that helps to boost the Indian-Economy.[1] Et.-al-Malvika-Ranjan Detected & Classified Leaves Dysmorphia using ANN that captures the photos. Segmentation and Artificial neural network (ANN) result gave the colour feature like HSV which are used to train and distinguish the unhealthy samples appropriately. ANN gave an accuracy of 80% and shown effective experimental results. With the help of this method cotton leaf disease can be detected accurately. Et al. Syafiqah Ishakais have shown how to get useful insight and analytical data from leaf images which is used to classify healthy and diseased leaves of medicine plant using image processing method. To extract image and to get data, algorithm of adjusted contrast and segmentation is used. Experiment is performed using Artificial Neural Network. Final experimental result proves that the RBF network performance is far better in comparison of the MLP network. By using a deep convolutional network et al. Srdjan Sladojevic developed a new technique for plant disease detection model using leaf image classification. This method facilitated a simple and efficient practice to detect disease in leaves. The model could analyze fourteen different types of plant diseases out of samples. To implement this disease detection model necessary steps are mentioned in this paper which can be useful to experts in agriculture. Caffe, designed by Berkley Vision and Learning Centre, was involved in deep CNN training. This model gave accuracy between 91% and 98% for experimented results. Et al. Emanuel Cortes used 86,148 images of diseased plants dataset and performed deep-convolutional-network & semi-supervised-methods to train and for comparing different plants of 59 different types. Also gave better results on the unsupervised data were resent. It gave accuracy above 81% in the development phase in 6 epoch's with a precision percentage of 1e-6.

The basic knowledge of in-intensity mastering additionally affords a comprehensive evaluation of the modern studies work performed at the analysis of plant leaf disease using in-depth studies [8]. Whilst sufficient training statistics are available, in-depth studies methods are able to hit upon plant leaf diseases with higher accuracy. The significance of gathering big sets of information with excessive variability, data magnification, transfer readings, and mapping that enable CNN to enhance segment accuracy, in addition to the significance of small sample of the damaged leaves & significance of hyperspectral pictures for fast recognition of the crop leaves disease mentioned on the equal time, there are boundaries. Most of the proposed DL frames inside the books have accurate results to locate on their internet site, but the consequences aren't appropriate for different data units, which imply that the model has a vulnerable consistency. Consequently, better dynamic models of DL are needed to prepare information sets for numerous diseases. In a few studies, a Plant Village facts set was taken into use to assess the better functionality of DL models. Even though that database contains many pictures of some plant species with their own diseases, it's been taken to the lab. Therefore, it is predicted that a first-rate database of plant illnesses will be installed in the real world. Even though some research use hyperspectral photos of damaged leaf & a few DL prices were taken into consideration to diagnose plant leaf disease early, troubles affecting the giant use of HSI in fast detection of plant diseases continue to be solved. that is, at the primary detection of plant diseases, it's miles difficult to obtain written data sets, or even experienced professionals can mark while the disease signs are not detected, and define pixels for undiagnosed disease, most importantly for HSI to detect plant disorder.

There are many advanced methods for diagnosing and classifying plant sicknesses using diseased plant leaves [6]. but, there may be no effective and effective business remedy that could be used to diagnose all diseases. In this work, we've got to take 4 different DL models (InceptionV3, InceptionResnetV2, EfficientNetB0, MobileNetV2) into account to detect plant diseases using healthy images and plant leaves. To test and train the model, we worked on the standard Plant Village database with 53,418 images, all taken under lab conditions. This database contains 39 unique types of 15 fresh and diverse crop-leaf pictures. After dividing the database into 80–20 (80% of total training data, 20% of complete images for testing), we found a very high precision percentage of 98.46% in the EfficientNetB0 model. On average, less time was needed to train all the images in MobileNetV2 and EfficientNetB0 formats, and it took 564 and 544 s / epoch, respectively, for colour photographs. Compared to other in-depth learning methods, the in-depth learning model used has a better ability to predict both terms accuracy and loss. The time required for model training was significantly lower than other machine learning methods. In addition, the MobileNetV2 architecture is a deep convolutional neural network which limits the number of parameters and functionality as possible, and can be easily implemented on mobile devices.

The main goal of this paper is to detect the sickness and take precautionary measures to protect the crop before it's too late[10]. By doing this prevents the loss to the farmers and helps to maintain the monetary growth. Also minimizes the use of pesticides. This paper shows the use of Histogram which is used to predict the features and give to the classification model. The histogram is used to represent the frequency distribution or used to summarize the continuous data on an interval scale. They came in handy to represent numerical data in a friendly manner. They identify the diseased leaf and send the messages to the farmers. In this paper, Tomato and maize leaves are taken and their disease is identified and predicted accurately using SVM and ANN algorithms. SVM is a supervised learning algorithm used for regression problems. It is primarily used for classification problems and also helpful in detecting outliers. It is highly effective in dimensional spaces. SVM shows better results in terms of generalization capabilities. ANN is software made by the inspiration of biological neurons which can emulate relationships and dependencies in a dataset. It is highly effective in terms of predicting the outcome of a new dataset. In this paper, they have shown different methodologies which include stages such as Data collection, Preprocessing, Feature extraction, Image segmentation, classification phases. They have used the dataset which contains 200 maize and tomato leaf features. Out of which 50 are healthy leaf and 110 leaf pictures are for training and testing. Here the use of SVM and ANN gave the accurate result. SVM gave 60 to 70 percentages. ANN gave 80 to 85 percentages. This methodology has been tested correctly on python software.

In this paper provides a survey on various techniques and different classifiers aspects which can be used to detect the rice disease plant[11]. They have also proposed a CNN model and a hardware prototype, using these different rice diseases such as rice blast, rice blight, brown spots, leaf smut, and sheath blight. Also highlights different techniques and their comparison based on classifiers such as SVM, KNN, ANN, etc. SVM is a supervised learning algorithm used for regression problems. It is primarily used for classification problems and also helpful in detecting outliers. It is highly effective in dimensional spaces. SVM shows better results in terms of generalization capabilities. ANN is software made by the inspiration of biological neurons which can emulate relationships and dependencies in a dataset. KNN algorithm is mainly used for pattern classification tasks. It is a supervised learning algorithm that is an initial step in a machine learning setup. IT is used for both classifications as well as regression problems. It is highly effective in terms of predicting the outcome of a new dataset. The proposed method to detect the rice disease includes various stages such as Data acquisition which deals with the sample picture dataset and hardware module consisting of raspberry pi and multimedia sensors. Preprocessing and feature extraction is carried out. Then CNN classifier is used to identify the infected leaf. CNN is a deep neural network class that helps in image visualization. CNN is primarily used for image classification as it follows a hierarchal model to give higher accuracy.CNN is used in deep learning to recognize objects in an image. This proposed work also uses libraries such as panda, NumPy, TensorFlow. Also shown that CNN proposed model gave accuracy about 96 percentages. Also, able to identify diseases such as rice blast, blight, brown spots, etc. correctly and successfully. This model shows promising results and helps farmers to maintain their monetary growth.

This paper shows a method to detect monocot and dicot plant disease[12]. This paper mainly shows two categories of family plants such as Monocot and Dicot family types. Monocot plant is those which contains only one seed leaf and have straight and parallel vein structure. Examples: Wheat, corn, rice, etc. Dicot families are those plants that have two leaves. Dicot plants example is roses, geraniums, magnolias, etc. this paper shows how this method helps to detect disease with more accuracy. It includes three steps such as segmentation of leaf to segment the diseased leaf using the K-means algorithm. Segmentation is one of the techniques in machine learning in which an image is broken down into various image segments. This reduces the image complexity and thus helps in further image analysis. K-means algorithm is an unsupervised algorithm that helps to identify k number of centroids and facilitates to the allocation

of data points to the nearest cluster. It is highly beneficial in business assumptions. It deals with vector quantization. Next comes feature extraction and the last step is a classification which is done using SVM. SVM is a supervised learning algorithm used for regression problems. It is primarily used for classification problems and also helpful in detecting outliers. It is highly effective in dimensional spaces. SVM shows better results in terms of generalization capabilities and also shows different techniques and their limitations. They have segmented the affected part and extracted the feature of the diseased leaf part. This paper helps farmers to maintain their monetary growth and detect the disease accurately.

In paper [13], this examine has utilized deep mastering competencies to reap computerized plant ailment detection structures. This system is based on a easy type mechanism which exploits the function extraction functionalities of CNN. For prediction ultimately, the model makes use of the completely connected layers. The researches become done using the publicly on hand series of 70295 images, and a hundred photos from experimental conditions and real environment. The machine has achieved a standard 98% testing accuracy on publicly on hand dataset, and carried out well on snap shots of Sukkur IBA university vegetation. it is concluded from accuracy that CNN is fairly appropriate for automated detection and prognosis of flowers. This machine may be integrated into mini-drones to stumble on diseases from flora in cultivated regions. Although this device is skilled on a Plant Village dataset with handiest 38 classes it can tell if the plant has a sickness or not as by some means symptoms are the same in all kinds of flowers. in addition, extra actual surroundings photographs may be introduced to the dataset to improve the accuracy on real-circumstance photographs of leaves and classify extra plant kinds in addition to disease kinds. inside the destiny, this system also can undertake a 3-layer method wherein the first layer detects if there's any plant in an image or not, 2d layer tells the plant kind and the 0.33 layer tells if there is any disorder or no longer and what kind of disease is there if any.

In paper [14], in this paper, they mentioned how ML in standard and DL in particular helped to diagnose diseases in plant life whilst illnesses are not identified nicely, they disrupt the harvest and eventually lead to long-term troubles, such as global warming or even famine. The proposed work summarizes many studies on the evolution of plant diseases and the identification of different ML strains. The proposed manuscript also reflects a well-received list of CV methods on this site, making it a comprehensive area of research that should be explored soon. [a] identification of disease is one of the main areas to pay attention. As each disease has many stage associated with it. Also systems must have the capabilities to suggest measures about specific disease stages. It helps to reduce damage percentage and boost the agricultural production. [b] Disease Quantification is another area. The extent of the damage caused by the disease must be identified. This plays an important role as remedial actions could be taken according to the disease severity. Helps to detect the infected proportion of a agricultural production. Also it helps to analyse whether specific chemicals are needed or not. As we know chemicals are harmful for the health. [c] Many Applications and articles are available about disease identification which is free to use. It does not give a fast and accurate result. So availability of this recognition model will help farmers to detect and identify disease which will help to increase to their revenue. [d] Dealing with the difficulty of the data, specifically during the training stage, the best option to look at is transfer learning- a heterogeneous domain. 3D convolution, temporal pooling, LSTMs, optical flow frames are some of the keywords which can be used while considering automatic plant disease detection.

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High accuracy, training efficiency and unsupervised characteristics of deep learning is shown in recognition model [15] . But in complex environment a lot of changes can be seen in accuracy and practicability during detection. To fix this problem TL, RPN and CV algorithm has been used. Due to this it's adaptability in complex environments has increased and also the accuracy of detection of disease. This paper reduces the quality requirements of the convolutional neural network on the data set to get the accurate results. This model helps to boost agricultural production and prevent crop losses. This paper helps to improve the existing theory and the accuracy. This model helps in sustainable development of smart agriculture. Recognition model based on deep learning can overcome the complexity of the environment and helped to improve the accuracy of identification but there are still some problems to be looked at. Neural network will be used in future research, to give zero initial sets corresponding to various leaves, which increases calculation limit for Chan–Vese algorithm(a iterative process) and speed up the training speed, ahead of time.

TABLE – 2 DIFFERENT FINDINGS FROM VARIOUS APPROACHES

S.No	Findings		
	Title	Accuracy	Technologies Used
1.	Leaf -disease-detection-by-well -known-deep-Learning-architectures [1]	94%	Google Net, DL
2.	New/modified-Deep-Learing -	97.62%	Alex Net-precursor, Cascade Inception

	Architecture-for-leaf-disease -detection		
3	Leaf-disease-detection-based-on-small-samples [3]	90%	Few Shots Learning
4	Plant-disease-detection-using-machine-learning	89%	Various Models
5	Krishimitr (Farmer's Friend):Using-Machine-Learning-to-Identify-Diseases-in-Plants	91.3%	Tensor Flow
6	Mango-leaf-Deficiency-Detection-using-Digital-image-Processing-and-Machine-learning	90%	Image processing
7	Detecting-jute-Plant-disease-Using-image-Processing-and-Machine-learning	89.99%	Colour co-occurrence methods, Multi SVM classifier
8	Detection-of-Unhealthy-plant-Leaves-using-Image-processing-And-genetic-algorithm-with-Arduino	93%	Genetic algorithm, Arduino, Masking the green pixel and colour co-Occurrence method.
9	Detection-and-Measurement-of-Paddy-leaf disease-symptoms-using-Image-processing-[9]	91,4%	ANN, FUZZY classification, SVM, K-means algorithm, colour co-occurrence methods.
10	Plant-Disease-Identification-Using-SVM-and-ANN-Algorithms [10]	92%	SVM and ANN Algorithms
11	Rice-Plant-Disease-Detection-and-Classification-Techniques-[11]	87%	SVM, KNN, ANN
12	A-Survey-on-Recognition-of-Plant-Disease-with-Help-of-Algorithm [12]	93%	SVM
13	Plant-Disease-Detectio-using-Deep-Learning [13]	96%	CNN
14	Detection-of-Plant-Diseases-Based-on-Image: -From-Classical-Machine-Learning- to-Deep-Learning [14]	94.3%	CNN
15	Deep-Learning-Based - Plant-Disease-Identification [15]	97.1%	RPN , CV , and TL algorithm

IV. Conclusions

Plant disease detection has become a very big domain to work on, because many of the works have been done earlier using many different technologies and methods in this field. We so far have read some of these papers for our survey and have analyzed and have found many different results for different techniques and methods used. The papers were on same topic but of different methodologies like few of them were based on image processing, few were of deep learning, FSL, ML etc. We have analyzed that even after doing so much research in this domain, there is a large scope of research in future also because every proposed model has some constraints, some disadvantages and some advantages. The need for perfect model to detect the plant leaf disease is also in hunt and this is the reason that these models are not getting used on large scale for disease detection. This a very good and very helpful domain to work on because when farming is done on a very big scale, it is not possible for farmers to look for diseases on every leaf of the plants, so further research and findings on this domain can be very helpful.

Plant disease detection has become a very big domain to work on, because many of the works have done earlier using many different technologies and methods. We so far have read some of these papers for our survey and have found many results. The papers were on same topic but of different methodologies like few of them were based on image processing, few were of deep learning, FSL, ML etc.

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