IoT Based Plant Disease Detection in Smart Farming with Machine Learning Approach: A Systematic Review

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Abstract— Nowadays plant Disease Detection and controlling at early stage are important for the prevention of plant disease efficiently and precisely in the complex environment for better yield and quality crops. Recently Machine learning and deep learning methods have obtained surprising results with IoT based technology to apply them for best recognizing of Plant diseases. This review paper presents existing approaches that have been used in IoT based Smart farming with IoT and ML separately. This paper proposes a different model for plant disease detection and recognition based on machine learning and deep learning, which improves accuracy and efficiency. This paper presents a review of the various Machine Learning, Deep Learning techniques to detect plant diseases using the Internet of Things approach. This survey is to taken for future research to understand the different machine learning and deep learning techniques for identifying plant diseases to improving system performance and accuracy.

Keywords: Internet of Things (IoT), *Smart Farming, Machine Learning, Deep learning*

I. INTRODUCTION

The Internet of Things (IoT) technology primarily focuses on smart human less automated systems for reducing human interaction. In IoT based farming, different remote sensors are used to sense the data, controlled the process data, and actuate the complete remote farming process. The main focus of the IoT in the farming domain is to automate all works of agriculture and its methods to make the farming process efficient [1]. With the help of present Machine Learning approaches and IoT can be used to identify and manage all plant or crop related diseases in the farming sector and prevention to protect crops from various diseases and reduce human efforts [2]. Plant disease can directly have affected the growth of the plant which causes bad effects on crop yields and production [1][3]. Several conditions are the more difficult challenge for researchers due to the different geographic that may block accurate identification [3]. Early stage crop or plant disease identification is the base of powerful prevention and controls the plant diseases. It has to play an important role in the management and decision-making of agricultural production. Nowadays, plant disease detection has been a major issue and therefore, a real and accurate approach is needed to detect plant diseases for gaining profit for the farmer and agriculture businessmen [4]. With the Internet of Things technologies, the availability of a large number of real-time data from various sensors including cloud platform services and sensor networks plays a major role in the agriculture sector. Machine Learning (ML) is one of the classical modern approaches that enable machines to behave similarly to humans. by learning using past data for the next to learn and implement. Machine Learning algorithms have been introduced to increase the recognition rate and the accuracy of plant health. Various researchers have suggested the machine learning strategies for plant disease detection and identification, such as random forest, artificial neural networks, support vector machine (SVM), fuzzy logic, K-means method, Convolutional neural networks, etc. [5].

II. METHODOLOGY

1. Machine Learning

Now a day's different Machine Learning and Deep Learning algorithms are famous for

monitoring, plant disease detection and identification, recognition, content leaf retrieval, image segmentation, and identification with the utilization of integrated deep learning algorithms throughout the whole process [4][5].

Machine learning algorithms are used to learn data from datasets and enhance the performance from past experiences without human interaction. Machine learning algorithms are simple programs used to develop a learning model from the input either trained or testing datasets and enhance from experience without human observation, which minimizes time and increases the accuracy of predictions [5]. The main aim of these algorithms is to develop models for past data use as input to test the data and from these further decisions can be taken. When some new dataset is available, some supervised machine learning algorithms are applied to the labelled dataset to train a function that provides the expected result to make accurate predictions: with Linear and Logistic Regression, Decision Trees, Support Vector Machine (SVM), K-Nearest Neighbour (KNN), and Naive Bayes. The KNN and SVM algorithms were used to determine the moisture in soil and plant disease. The classification of pests may also have been applied using the KNN. It is one of the significant algorithms for supporting classification and regression problems [7].

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2. DEEP LEARNING

Currently Deep Learning (DL) is one of the most used advanced Machine Learning based technology. The main feature of Deep Learning is that it has higher levels of abstraction and the ability to automatically learn patterns present in the images.

To take review in this paper number of articles are studied from quality and famous publishers such as IEEE, Elsevier, MDPI, Springe, google scholar.

CNN

There are 3 layers available in CNN:

1. Input Layer
2. Hidden Layer
3. Output Layer

1. Input Layer: The input layer is the first layer. It contains images that used as an input to the model; in this layer, images are saved in pixels and stored in nodes. Every operation in CNN performed in nodes only.

2. Hidden Layer: This layer's hidden layer use for computations like data processing, feature extraction, and data transformation. 3. Output Layer: The output layer is a fully linked layer where the hidden layer's and outputs are combined and taken as an input. This layer accepts input and turns it into the desired classes [7][8].

III. PURPOSE

a) Deep Learning Methods for Leaf Disease Detection

The first task is leaf retrieval, but many parameters take the challenge of prediction accuracy such as soil and illumination in the complex environment [6]. Hence, the model has investigated RPN (Region Proposal Network) algorithm for manipulating retrieval and represents good adaption in practice. Image segmentation is the second step that is considered to be the most important because prediction precision plays a vital role in detection results.

Additionally, deep learning methods for identifying and classifying diseases are more advantageous for various plants. Based on real-time data or images captured with visual datasets move to different areas of the farm via IoT based camera sensor nodes used in a farm field.

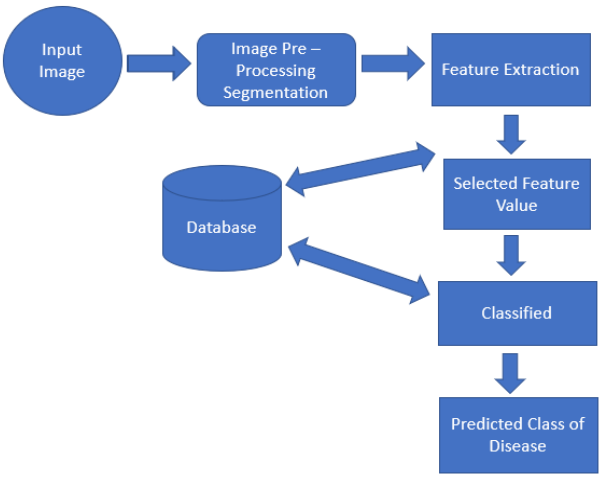

Fig. 1 Steps for image processing to detect plant diseases

Recently smart agricultural technology is so advanced, most smartphones have become a new type of farming tool" for farmers, which is useful and helpful to farmers in identifying plant diseases and insect pests. Currently, researchers develop small mobile apps that help farmers to identify crop pests and diseases. The farmer can take pictures of the plant and uploads the diseased parts of the crop, and the system will return the recognition result within a few seconds and provide users with the diagnosis results. Similarity, disease characteristics, causes, and prevention and control plans for users, so that farmers can control diseases and insects in a modern way and increase crop yields. The main advantages of this method were that occurrence of multi diseases on the same leaf could be found and the data can be augmented by cutting up the leaf image into multiple sub-images.

For example, using CNN for recognizing and classifying the maize crop diseases. These model can capable to detect different conditions such as northern corn leaf blight, common rust, and grey leaf spot etc. A researchers developed automated disease diagnosis system for maize crops with the CNN framework.

b. Deep Learning Methods for fruit Disease Detection

CNN

Specifically, Convolutional Neural Network (CNN) [9] is the main Deep Learning technique used for image processing CNN is a kind of Artificial Neural Network (ANNs) that use convolution operations in at least one of their layers. CNN is the most popular efficient and automated Depp Learning algorithm is widely used to classification and detection for different purposes such as classification of leaf and fruit, detection of leaf and fruit diseases etc. [9]. CNN based approaches A CNN model is trained with this available datasets of images to classify every pixel uniformly to different properties such as shadow, ground, healthy, and symptom. The model identifies with an accuracy of 92% at the grapevine level and 87% at the leaf level. CNN is explored for deep feature extraction from 5932 diseased rice leaf images and this data is used as input for the SVM classifier. The resnet50 with the SVM classification model best classifies with respect to other models with an F1 score of 0.9838[10].

A faster version of CNN i.e. R-CNN by increasing the size of the input layer from 32 x 32 pixels to 600 x 600 pixels and developed an automatic detection and recognition system for leaf spot disease in 3 levels of sugar beet disease severity (mild, moderate, and severe). Faster R-CNN got an accuracy of 95.48% compared to the 92.89% achieved by Faster R-CNN. Aiming at the problem that classification accuracy.

c) New DL Architectures for Leaf Disease Detection

Mixed multiple CNN classifiers to study high-resolution any datasets e.g. corn disease images. The experimental results showed that when a single CNN classier was used the accuracy rate was 90.8%, when two first-level classifiers were used, the accuracy rate rise to 95.9%, and when three first-level classifiers were used and the accuracy rate was 97.8%.

A new CNN structure to identify the apple leaf disease. The network was formed by cascading an Alex Net-precursor network and an Inception network. The Inception network replaced the fully connected layers in the traditional Alex Net model, significantly reducing the number of trainable parameters, and thereby reducing storage requirements [9][10].

d) Visualization Technique

In recent years, the successful application of deep learning technology in plant disease classification provides a new idea for the research of plant disease. Visualization techniques which were included for a correct understanding of plants diseases. Visualisation method increases the transparency of deep learning models and gives deeper evaluation into the symptoms of plant diseases. For user's purpose, a visualisation algorithm supports in understanding the disease by caring the symptoms and the damaged regions of the image. Hence, essential knowledge is extracted from the classifier that help to the farmers, In plant diseases, these visualisations give correct and useful information about the most important

parts used by the network as features. If the classifier conducting correctly, these parts may represent the symptoms or the characteristics of a disease.

e) HYPER-SPECTRAL IMAGING(HSI) WITH DL MODELS

Sometimes plants may be get affected by multiple pathogens at the same time during the plant growth process and some different pathogens may produce similar symptoms and infection [10] and the symptoms are not obvious at the early stage of plant diseases, which makes it easy to use simple computer vision becomes very difficult to detect plant diseases. The electromagnetic spectrum range of hyperspectral sensors is mainly concentrated in the visible and near-infrared (400 - 1000nm), and sometimes includes shortwave infrared (SWIR, 1000-_ 2500nm). This sensor can obtain spectral information from hundreds of narrow spectral bands [11]. These narrow bands are highly sensitive to subtle plant leaf changes caused by diseases and can distinguish different types of diseases so that early asymptomatic detection can be carried out. Therefore, HSI is the focus of recent research, for the early detection of plant diseases [12].

IV. RESULT

The comparison of different machine learning algorithms given is as fallows. Algorithms compared are KNN, Decision trees, SVM, Random Forest, and Naive Bayes.

Machine learning models	**Accuracy (%)**
Logistic regression	65.33
Support vector machine	82.78
KNN	82.64
Random Forests	70.14
Naïve Bayes	78.99
CNN	92
R-CNN	92.89

Table 1. Comparison with different learning models

V. CONCLUSION

IoT-ML-based agriculture is the next evolutional thing in smart agriculture and smart farming. Applying Machine Learning algorithms to data generated from various inputs from farms with the help of the IoT architecture, it can make the system smarter and provide definitive information and make predictions. This study, analyses existing ML applications in agriculture, from process to results, each with its own strengths and weaknesses. Later, because most ML applications needed real-time data to train predictive algorithms, suggestions were made to implement new applications on the IoT. Farm management systems are evolving into reality by applying machine learning to sensor data and the Artificial intelligence (AI) system provides the best suggestions and insights for subsequent work decisions and actions with a range of final production improvements. In the future, this range will be expected and enable the wider use of ML models. This paper introduces the basic knowledge of deep learning and presented a comprehensive review of recent techniques used for research in plant leaf disease and fruit disease detection and recognition using deep learning. Also provided sufficient data is available for training, various advanced deep-learning techniques are capable of recognizing plant diseases with high accuracy. The importance of collecting large datasets with high variability, data augmentation, transfer learning, and visualization of CNN activation maps in improving classification accuracy, and the importance of small sample plant leaf disease detection and the importance of hyper-spectral imaging for early detection of plant disease. hyperspectral technologies for plant disease detection. classification. However, DL classifiers lack interpretability and transparency. The DL classifiers are often considered black boxes without any explanation or details about the classification mechanism.

High accuracy is not only necessary for plant disease classification but also needs to be informed on how the detection is achieved and which symptoms are present in the plant. Therefore, recently, many researchers have tried to make ready themselves for the study of

visualization techniques such as introducing a new concept of visual heat maps and salient maps to better understand the identification of plant diseases. They are focusing on understanding how CNN detects, predicts, classifies, and recognizes disease from images. The model achieved an accuracy of 85%, which was quite a lot higher than the RF classifier (77%). Gui *et al.* divided the early soybean mosaic virus disease (SMV) into 0, 1, and 2 degrees according to its severity. In the case of a small number of experimental soybean samples, they proposed a novel SMV early detection method that combined a convolutional neural network and a support vector machine (CNN-SVM) and achieved an accuracy rate of 96.67% on the training set and 94.17% on the testing set. Most of the DL frameworks proposed in the literature have good detection effects on their datasets, but the effects are not good on other datasets, that is the model has poor robustness. Therefore, better robust DL models are needed to adapt to the diverse disease datasets.

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