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A SURVEY ON MACHINE LEARNING TECHNIQUES FORPOTATO LEAF DISEASE DETECTION

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Abstract—India's agriculture sector is heavily affected by crop yields, as low yields lead to higher food prices and hunger among the vulnerable population. Potatoes are a very common vegetable and are consumed along with almost every other vegetable. If the yield is reduced due to pests or any other disease, many problems will arise. To address these challenges, deep learning has emerged as a promising technique. Using deep neural networks, particularly convolutional neural networks (CNN), it is possible to accurately detect plant diseases in the early stages. This early detection enables timely interventions, minimizing crop losses and reducing the overall workload for farmers. Our review of existing research in potato leaf diseases confirms the superior performance of CNNs in identifying leaf diseases and achieving high accuracy rates.

Index Terms—Machine Learning, CNN, Deep Learning, R-CNN, Leaf Disease Detection

I. INTRODUCTION

The COVID-19 pandemic underscored the critical impor- tance of human health and global food security. Agriculture, a cornerstone of both, is particularly vital in countries like India, where a substantial portion of the population relies on it for sustenance. Potatoes, a staple crop constituting nearly 30% of

India's total agricultural production, are especially significant due to their nutritional value and versatility. Maximizing potato yield is essential to meet growing food demands. However, plant diseases pose a major challenge to farmers. Traditionally, disease detection has been a time-consuming manual process, often leading to delayed treat- ments. To address this, the integration of artificial intelligence (AI) has emerged as a promising solution. A specific subset of AI, known as Deep Neural Networks (DNNs), offers potential for accurate and early disease identification in potato plants.

Potatoes, a critical staple crop for food security and nutri- tion, face significant threats from diseases. Despite Indonesia's position as Southeast Asia's largest potato producer, with annual production reaching 850,000 tons, diseases remain a major challenge. These diseases can significantly reduce yield and quality, leading to economic losses for farmers.

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India is a potato powerhouse, ranking as the world's fourth largest producer of this versatile crop. With annual output soaring to approximately 850,000 tons from 60,000 hectares, India's potato production has surged in recent years, boasting a 10% yearly growth rate. This impressive trajectory has solidified the country's position as the leading potato producer in Southeast Asia.

However, the potato industry faces significant challenges. Potato crops are susceptible to various diseases that can strike both during and after harvest. Early detection and treatment are crucial to prevent substantial losses in quality and quan- tity. Unfortunately, untimely identification and misdiagnosis often exacerbate these issues, potentially leading to premature harvesting or even total crop failure.

Rapid and precise identification of potato plant diseases is vital to control their spread and minimize crop damage. Farm- ers often struggle with manual disease detection due to time constraints and the need for specialized knowledge. Delayed identification can allow diseases to proliferate unchecked. Furthermore, relying solely on visual assessments can lead to misdiagnoses as plant symptoms can be easily confused. Farmers may apply incorrect treatments based on inaccurate self-diagnoses without expert advice, potentially harming their crops.

Traditional disease detection methods, reliant on farmers' expertise, are often inaccurate due to the complexity of symp- toms and lack of specialized knowledge. Early and precise disease identification is crucial for effective management but is hindered by time-consuming manual inspections.

II. LITRATURE SURVEY

A method for detecting plant diseases using a neural net- work and the k-means clustering algorithm was proposed by H. Al- Hiary et al. This trained model is able to identify plant

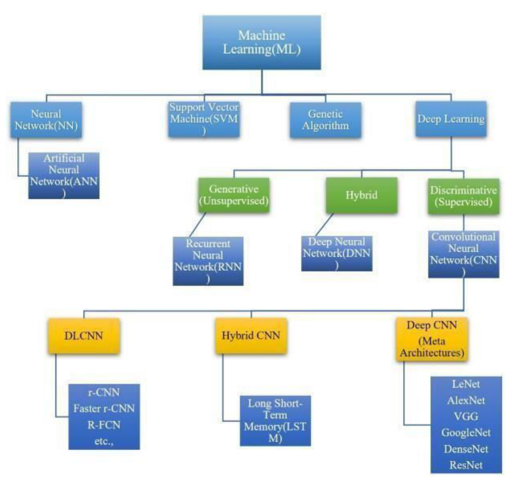

Fig. 1. Concepts of Machine Learning

diseases both in terms of detection and classification. It offers an exact accuracy ranging from 83% to 94% . Benefits include accurate illness detection requiring less computer work. It is discovered that the merits recognition rate has decreased [1].
K-means clustering for segmentation and ANN for leaf disease detection and classification were proposed by Dheeb Al Bashish et al. The diseases were identified by this suggested model 93% of the time. Among its benefits is its exceptional ability to identify illnesses. Among the drawbacks are the need for finer segmentation and feature extraction [2].

Several techniques have been utilized in research focusing on the detection of potato leaf disease, including hybrid mod-els, conventional feature extraction techniques like MGH, LBP, and HOG, typical convolution-based deep learning models, and classical machine learning algorithms. Unlike standard machine learning, which necessitates manual feature selection, deep learning is a machine learning technique that draws inspiration from the human nervous system. It is notable for its capacity to automatically extract features from raw data
[3] Artificial neural networks with deep, complicated structures are used in deep learning to recognize patterns and carry out challenging tasks. The several layers that make up the network structure are referred to as ”deep” layers. Large datasets are easily processed by these models, and they perform exceptionally well in challenging tasks. Automatic feature learning, robust generalisation, representation learning, adaptability, and scalability are among the benefits of deep learning. It is widely used in domains like financial analysis, cyber security, image processing, natural language processing, and medical [3].

The generalisation skills of traditional convolution-based deep learning models are improved as their layers become deeper; these models are especially good at extracting ab- stract characteristics from data or images. On the other hand, convolutional layers can result in higher processing power requirements and higher expenses when used extensively [4].

Depth wise Separable Convolutions (DSC) technology, which enables classification with fewer parameters, cheaper computational costs, and lower processor power needs, can be used to optimize deep learning architectures in order to address this. Furthermore, hybrid systems that in-corporate traditional machine learning techniques can perform better when combined with ensemble learning (EL) models, which combine different machine learning algorithms. Lastly, merging deep learning models allows for the development of an integrated model that can extract deeper features, providing an alternative to the conventional feature extraction techniques like MGH, LBP, and HOG employed in previous studies [5].

In their research, S. Kumar et al. develop a deep learning model that uses photos of different leaves and a specialised convolutional network design to detect plant diseases [6]. The suggested method can handle complex settings and effectively identify various disease types. A 94.6% accuracy percentage in the validation findings highlights the Convolutional Neural
Network’s (CNN) efficacy. The model can identify more than one type of plant disease.

In this study, Divyansh Tiwari created an automated system to detect and distinguish between early blight, late blight, and healthy leaves in potato leaves. The system achieved a classification accuracy of around 98% in several test datasets. Benefits: This method makes it simple for farmers to identify illnesses in their early stages, which enhances agricultural yield[7].

Sanjay K. Hoysala developed a model that identifies dis- eases in potato leaves by using images of the leaves as input. Merits: The proposed model is efficient, fast, accurate, and has a high prediction rate. This system not only finds plant ailments but also offers fixes for the problems it finds. Gaining a

thorough understand ing of the illness and how to treat it can help plants thrive and yield more. Advantages: The framework has an 80% accuracy rate and is developed in Python [8].

In their investigation, Soma Ghosh and Renu Ram used RGB photos to investigate several strategies for developing a powerful classifier for potato leaf diseases. Their observations lead them to suggest the creation of a sizable input dataset. Rather than concentrating only on the leaf and disease regions, their work carries out a thorough investigation of the features that the models learnt, thereby confirming their theory that the features capture the overall structure of an image [9].

Girish Athanikar developed a rapid, automatic, and accurate system for identifying and classifying illnesses in potato leaves using MATLAB's Image Processing and Bioinformatics Toolbox. Benefits: This approach gives farmers a dependable tool for classifying and identifying potato plant diseases [10].

DenseNet is used by A. T. Madhavi's system to recognize and categories several leaf diseases in three different plants: bell pepper, potato, and tomato. PlantVillage provided the dataset that was utilised for identification; all information was gathered using mobile cameras and live detection. Advantages: Future goals for this system include enhancing model accu- racy, lowering processing requirements for smaller devices, such as smartphones, and creating a mobile application to improve its usability and accessibility right away [11].

In order to obtain more accurate results, R. Dhaya's research presents suggested approaches that involve many processes. When compared to single-factor approaches, the two-factor identification technique greatly increased precision. Accuracy decreased when relying solely on machine learning algorithms or image recognition techniques. High prediction accuracy was achieved by the suggested classifier strategy for Fusarium Wilt (FO) disease identification [12].

In her work, Taruna Sharma investigates the use of deep learning methods, particularly Convolutional Neural Networks (CNNs), for the identification and categorisation of leaf dis- eases. Benefits: When working with huge datasets, this ap- proach offers quick and accurate results for identifying leaf diseases. Additionally, the study discovered that deep CNNs outperform other methods in terms of results [13].

H.D. Gada de's research focuses on developing an image processing system to identify diseases affecting potato leaves. The system employs classifiers that accurately diagnose vari- ous leaf diseases. By providing farmers with precise disease information, this technology empowers them to make informed decisions regarding pesticide application. Ultimately, this ap- proach contributes to reduced pesticide use, improved crop health, and increased potato yields [14].

Prajwala et al. used a LeNet CNN model to accurately detect Septoria Leaf Spot and Yellow Leaf Curl, two common tomato leaf diseases. Their research leveraged the Plant Village image dataset. The proposed method achieved impressive accuracy rates between 94% and 95%, demonstrating the potential of CNNs for precise tomato disease diagnosis [15].

Srdjan Sladojevic et al. developed a highly accurate CNN model capable of identifying 13 diseases across five different plant species. Their novel approach achieved an impressive 96.3% accuracy. Similarly, Erika Fujita et al. used the AlexNet CNN architecture to diagnose cucumber diseases, attaining an average accuracy of 82.3%. These studies demonstrate the effectiveness of CNNs in plant disease detection and classification [16].

Raja P. et al. utilized 2,000 maize leaf images from PlantVil- lage to classify three distinct leaf diseases. They employed the Multiclass SVM method in conjunction with the Bag of Features technique. To evaluate the accuracy of their approach, they compared it to feature-based methods like grey level co- occurrence and histogram. The results demonstrated that the Multiclass SVM method significantly outperformed the other techniques, highlighting its effectiveness in maize leaf disease classification [17]. Pranjali B. Padol and Prof. Anjali A. Yadav developed a method to identify disease-affected areas in plant leaves. They employed K-means clustering to segment images and isolate diseased regions. Subsequently, they extracted color and texture features from these regions [18]. Using a Support Vector Machine (SVM) classifier, they achieved an impressive accuracy of 88.89% in classifying plant diseases based on the extracted features.

Jobin Francis et al. employed a Back propagation Neural Network for pepper plant disease classification. They utilized the Gray Level Co-occurrence Matrix (GLCM) to extract image features. Their system could identify diseases like Berry Spot and Rapid Disease [19]. Eftekhar Hossain et al. also used a similar approach, but with a KNN classifier, to detect diseases such as Alternaria Alternata, Anthracnose, Bacterial Rot, Leaf Spot, and Plant Leaf Cancer. Their system achieved a remarkable accuracy of 96.76%. Both studies showcase the potential of image processing and machine learning techniques in accurate plant disease diagnosis [20].

Aakanksha Rastogi et al.[21] employed a combined approach using artificial neural networks and fuzzy logic to diagnose plant diseases based on leaf images. Their research focused on identifying diseases in hydrangea and maple leaves. They categorized leaf diseases into two primary types: burnt leaves, where the disease affects the entire leaf, and leaf spots, where the disease is localized to specific areas. This study aimed to classify and diagnose these diseases based on the analyzed leaf images.

Prior studies have investigated a range of artificial intelligence-based classification approaches, encompassing machine learning and deep learning techniques, with the purpose of identifying illnesses of potato leaves. Iqbal and Talukder [22], for instance, created a detection technique that combines machine learning and image processing. In their method, the photos are pre-processed, segmented, and features are extracted using global feature descriptors. The outcomes are then

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classified using various machine learning techniques. Sholihati et al. [23] used data augmentation methods in conjunction with deep learning architectures—specifically, VGG-16 and VGG-19—to detect illnesses of the potato leaf. Chakraborty et al. used an improved VGG-16 model for disease identification in 2022. In order to identify potato leaf diseases, Nazir et al. [24] developed an end-to-end EfficientPNet model based on the EfficientNet-V2 architecture, which combines the AM method with extra layers. Further- more, Ali et al. (2022) used a technique that combines the Fast Fourier Transform (FF), Principal Component Analysis (PCA), and Linear Discriminant Analysis (LDA) to diagnose potato leaf diseases.

III. BASIC STEPS FOR LEAF DISEASE DETECTION

In this section, we define some basic steps that are necessary for disease detection for any plant.

Gathering data is the initial stage of any algorithm's eval- uation and application. With a larger dataset of photos, the prediction's accuracy increases. The potato leaf disease detec-tion in these images includes a range of leaf patterns, such as healthy leaves, early blight disease, and late blight disease. The dataset also can be distributed based on the number of images in the dataset.

TABLE I
COMPARISON TABLE OF DIFFERENT MODEL ACCURACY

Author Name	Accuracy	Technique Used	Limitation
S. Kumar et al.	94.6%	Deep Neural Network	Method can handle complex settings and effectively identify various disease types.
Divyansh Tiwari et. al.	98%	Classification Algorithm	This method makes it simple for farmers to identify illnesses in their early stages
Eftekhar Hossain et al.	96.76%	KNN classifier	Studies showcase the potential of image processing and machine learning techniques in accurate plant disease

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			diagnosis.
Prajwala et al.	94-95%	LeNet CNN	The proposed method achieved impressive accuracy
Srdjan Sladojevic etal.	96.3%	CNN model	This model capable of identifying 13 diseases across five different plant species.
Erika Fujita et al.	82.3%	AlexNet CNN architecture	Study demonstrate the effectiveness of CNNs in plant disease detection and classification.

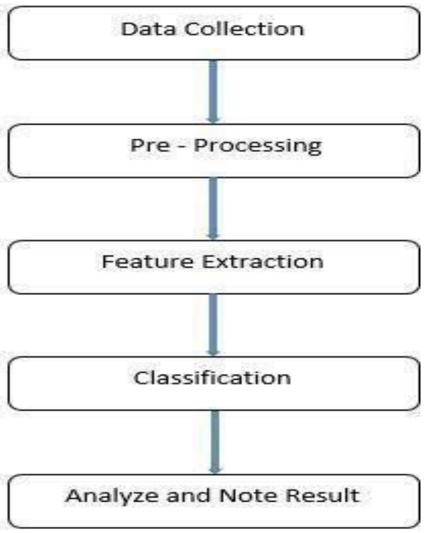

Fig. 2. Basic Steps Leaf Disease Detection

step 2 states that any dataset must be preprocessed in order to yield correct findings. This step suggested that only the focused plant images (potato according to this paper) are standardized to the same size (or resized) if there is any difference between the image sizes. This is because different images may have different patterns, which might alter the classification outcomes. To focus only on the leaf, the rest of the image has been cut out. Only the traits that are absolutely necessary for categorization are kept in the image before any more processing is done; all other elements are eliminated this process known as noise removal from images. After that, the image is filtered to only highlight the most significant and pertinent characteristics by lowering contrast and smoothing the image.

Feature extraction comes next after the previous step. This procedure retains all pertinent information while the image's dimensionality is decreased. Feature extraction simplifies the dataset and removes unnecessary features by emphasizing the important details. This preserves the image's salient elements for additional examination. This stage is essential for maxi- mizing the algorithm's performance because it improves the classification process's efficiency without lowering the caliber or accuracy of the data.

We can use a deep neural network or a classification method like ANN, CNN, or SVM to categorize a picture into a certain target class. CNN is one of them that works very well for classifying images since it consistently produces the highest accuracy when compared to other algorithms. CNN performs excellently in classification tasks due to its ability to automatically detect and learn essential elements from images, making it a preferred choice for applications requiring exact image categorization.

We analyze the results provided by the above steps and note down the accuracy that provides us with the method which is suitable to find the disease of leaf.

IV. CONCLUSION AND FUTURE WORK

In agriculture, leaf disease detection is important and more accuracy is required to detect diseases in real time. Potato is one of the important vegetables in India. For disease detection, we need a method that can quickly identify the disease in potato plant. In this paper, we have described a survey of leaf disease detection algorithms and current detection algorithm approaches. In the paper, we have tried to describe all potato leaf disease detection algorithms. The basic steps used in leaf disease detection in this study have also been described. The table presented in the paper shows the accuracy of various potato leaf disease detection algorithms, which shows that more work is still to be done in this direction. In this direction, we will work on the algorithm to achieve more accuracy.

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