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Plant Disease Detection and Classification by Deep Learning

Pritee Patil[1] and Trimbak Kokare [2]
Assistant Professor, Department of IT[1]
Student, P.G. Department of IT[2]
Veer Wajekar ASC College, Phunde, Uran

Abstract: *Deep learning has made huge progress, leading to better technology for identifying images. In agriculture, deep learning helps analyze big data and can be very useful in identifying plant diseases. This technology looks at the features of an image to gather information and classify it. Clim caused by bacteria, viruses, fungi, and other harmful agents. These diseases can slow down plant growth and reduce crop production. The proposed system uses a Convolutional Neural Network (CNN) to detect plant diseases from leaf images. After identifying the disease, it suggests the right pesticide to treat it. The system also provides more details about the disease affecting plants in a specific area.This technology can help farmers decide when to use pesticides. It can also identify which plants are more vulnerable to certain diseases so they can be protected in advance.*

Keywords: Deep learning, plant leaf disease detection, Visualization, small samples, CNN algorithm

I. INTRODUCTION

Plant diseases can harm crops and reduce food production. To protect plants, it is important to find diseases early and treat them quickly. Traditional methods rely on people checking plants, but this can be slow and sometimes inaccurate. A better way to do this is by using computers to analyze pictures of plant leaves.

Leaf images help identify diseases because diseases change the color, texture, shape, and size of leaves.However, checking these images by hand takes a lot of time and requires expert knowledge.

Artificial intelligence (AI) provides a faster and more accurate solution. A special type of AI, called Convolutional Neural Networks (CNNs), is very good at recognizing patterns in images.

For plant disease detection, CNNs are trained using many pictures of leaves with different diseases. Once trained, they can quickly identify diseases in new images and even suggest possible treatments. This helps farmers take action faster and protect their crops more effectively.

CNN (Convolutional Neural Network)

A Convolutional Neural Network (CNN) is a special type of artificial intelligence designed to understand and analyze images. It is widely used in tasks like recognizing objects in pictures, detecting specific items, and breaking images into different parts. CNNs have become an important tool in computer vision and deep learning.

Unlike regular neural networks that treat images as simple lists of numbers, CNNs understand the structure of images. They can recognize patterns, shapes, and features by looking at different parts of an image. This makes them very effective for image- related tasks.

A key part of a CNN is the convolutional layer. This layer scans the image using small filters (also called kernels). These filters move across the image, analyzing small sections at a time. This helps CNNs detect important details, like edges, textures, and patterns, which are useful for identifying objects or recognizing diseases in plant leaves.

II. LITERATURE SURVEY

The rapid advancement of deep learning technology has spurred significant research into detection methodologies. This survey reviews recent literature from 2022 to 2024, highlighting key contributions to the field.

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1) One significant paper is "Deep Learning in Leaf Disease Detection (2024): A Visualization-Based Bibliometric Analysis" by JYOTISMITA CHAKI (Senior Member, IEEE), And DIBYAJYOTI GHOSH published in IEEE ACCESS in 2024. The research paper concludes that deep learning has made substantial progress in leaf disease detection, with a notable increase in publications and the identification of key methodologies, underscoringthe need for interdisciplinary collaboration to tackle challenges like data insufficiency and environmental variability. However, drawbacks include the exclusion of non-English publications, lack of quality filtering for journals, and reliance on supervised learning, which may hinder the exploration of unsupervised techniques and limit the comprehensive understanding of the field's impact.

2) In 2024, Md Abu Bakar Laskar, Zhou Jinzhi, Md Mehedi Hasan, Md Tanvin Ashan published "Plant Leaf Disease Detection Using Deep Learning" in the LC INTERNATIONAL JOURNAL OF STEM. The conclusion of the paper emphasizes the successful development and evaluation of the YOLOv5 model for detecting tomato leaf diseases, showcasing its commendable performance in precision, recall, and overall accuracy. This advancement signifies a significant step forward in utilizing deep learning for agricultural applications, ultimately contributing to improved sustainability and resource management in tomato cultivation. However, the study acknowledges certain drawbacks, including the need for further refinement of the model architecture, exploration of alternative backbone networks, and the necessity for additional validation through comparisons with related research to enhance the model's adaptability and accuracy in diverse agricultural contexts.

3) The paper "Leaf disease identification and classification using optimized deep learning " by Yousef Methkal Abd Algani, published Measurement: Sensors in 2023, The study's findings demonstrate the significance of early diagnosis for successful crop management and show that the Ant Colony Optimization with ConvolutionNeuralNetwork(ACO-CNN) method significantly improves the accuracy of plant leaf disease detection. It additionally points out several disadvantages, such as how time-consuming model training is, how dependent it is on big and varied datasets, how environmental variability may affect image quality, and how difficult it is to be flexible and adaptive to various plants and illnesses. In general, the technique seems feasible.

4) The, "Leaf Disease Detection of Multiple Plants Using Deep Learning " by Shital Pawar published in 2022 International Conference on Machine Learning, Big Data, Cloud and Parallel Computing, The recommended CNN-based process explain the entire process and gives farmers useful information, such as disease names and recommended pesticides, by effectively detecting leaf illnesses in many plants with up to 93%accuracy. The drawbacks of the approach is difficult to train for different plant species, which calls for more study to improve, and that it has limited generalizability since it depends heavily on a single dataset. It can additionally have accuracy problems due to poor image quality.

5) Shujuan Zhang, Plant Disease Detection and Classification by Deep Learning, IEEE Access publishes on 08 April 2021, The paper's conclusion highlights how deep learning approaches—in particular, the recently suggested ARNet model—perform better than other models, such as VGG16, in the classification of plant diseases. It emphasizes how important visualization techniques, like heat maps, are for comprehending the model's decision-making process and locating important illness characteristics. In order to improve the efficacy of plant disease management systems, the report also urges additional research to address the difficulties associated with early disease identification and classification based on small sample numbers

6) Hongkun Tian, ―Computer vision technology in agricultural automation‖. The paper identifies several drawbacks, including the limited applicability of existing computer vision techniques to single species detection and the need for comprehensive agricultural databases. Additionally, it notes challenges such as slowimage acquisition, response times to environmental changes, and the experimental phase of many results, which may hinder practical implementation. Lastly, the robustness and reliability of systems in complex conditions require further improvement.

7) R. Sujatha, ―Performance of deep learning vs machine learning in plant leaf disease detection‖. The majority of the work is a review; no actual application of the suggested approaches is presented. It also emphasizes the necessity of additional study and advancement in the field of plant disease detection, suggesting that current techniques might still

have drawbacks. Finally, it is mentioned that two major issues influencing farmers' livelihoods are the usage of traditional techniques and the possibility of overusing pesticides.

8) Canh Nguyen, ―Early Detection of Plant Viral Disease Using Hyperspectral Imaging and Deep Learning‖. The main flaw in the paper is that deep learning approaches are not as effective because of the tiny training sample size available for hyperspectral image-wise models. Furthermore, the 3D-CNN architecture's high computing resource requirements and complexity could make it difficult to use in real-world scenarios. Finally, pixel-wise techniques can overlook crucial spatial details, which would affect the performance of the model as a whole.

III. METHODOLOGY

Plant leaf identification of diseases involves collecting identical datasets, initial processing, extraction of features, the process of segmentation and classification, the CNN technique accelerates these processes. The suggested CNN method for disease prediction.

1. Image Pre-processing

Preprocessing is done on the input image to enhance its quality and facilitate the model's analysis. Resizing, noise reduction, normalization, and augmentation methods like rotation or scaling are examples of preprocessing procedures.

2. Feature Extraction

The previously processed image is used to extract its features. This might entail methods like using convolutional filters (in the case of a CNN) to identify patterns, edges, and textures in the picture. These traits serve as the leaf's primary visual cues for disease identification.

3. Training Dataset

A deep learning model is trained during the training phase using features that have been collected from a labelled dataset of healthy and diseased leaves. Through parameter optimization based on the labelled data, the model gains the ability to discriminate between different diseases.

4. Testing

The model is assessed with new, tested photos once it has been trained. Similar to how it did during training, the model takes features out of these pictures and tries to categorize them using the patterns it discovered.

5. Classified Leaf Disease

The system produces its final output at the Classified Leaf Disease step, recognizing the leaf disease. Depending on the architecture and integration features of the system, the output may be as straightforward as a disease label or as complex as a treatment plan with supporting data.

IV. MATHEMATICAL MODEL

In the context of deep learning detection, mathematical calculations play a crucial role in analyzing input image and detecting manipulations. Here‘s a brief overview of the key mathematical aspects involved:

1. Feature Extraction:

CNN Processing: Convolutional Neural Networks (CNNs) use mathematical operations such as convolutions and pooling to extract features from images. The convolution operation involves calculating
the dot product between the input image and the convolutional filter, producing feature maps that highlight important visual patterns.

2. Anomaly Detection:

Statistical Analysis: CNN models analyze facial features and anomalies by comparing data with known dataset. The Techniques such as mean squared error (MSE) and cross- entropy loss are used to quantify the difference between predicted and actual outcomes, guiding the model's learning process.

3. Similarity Measures:

Cosine Similarity: To compare the input image with datasets, cosine similarity measures the angle between feature vectors derived from the image. The formula is cosine similarity=A·B // A // // B // where A and B are feature vectors.

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These mathematical calculations are integral to ensuring accurate and efficient disease detection, allowing the model to analyze, compare, and detected the disease.

I. FLOW DIAGRAM

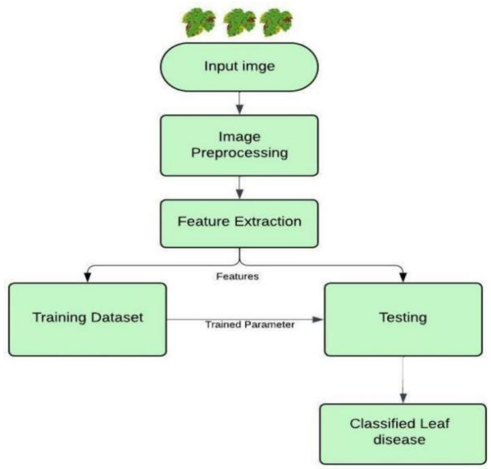
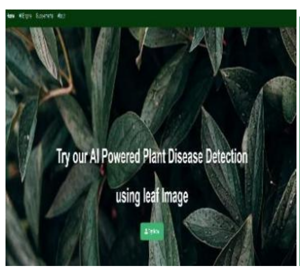
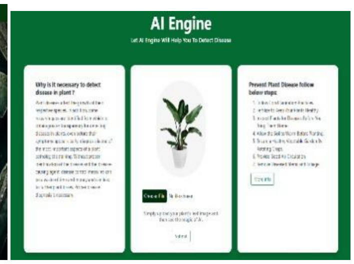


FIG 1. FLOW DIAGRAM

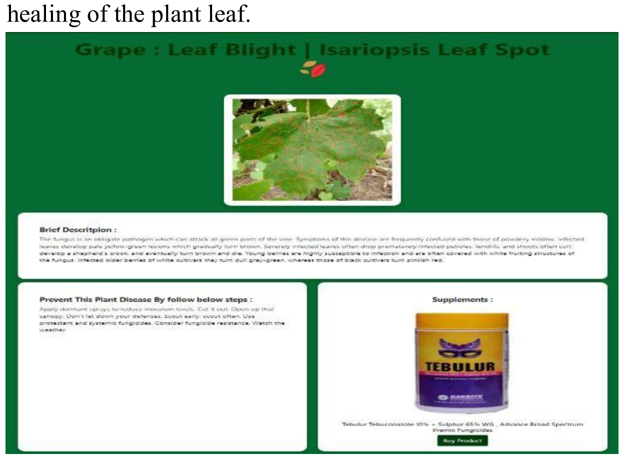
II. RESULT & DISCUSSION

Developed the user interface: Designed and created the simple interface with ease in accessing and understanding for the user interaction.





Detection of Leaf Disease: Therefore, the resultant output shows the brief description of the leaf disease, steps to cure it and supplements required for healing of the plant leaf.



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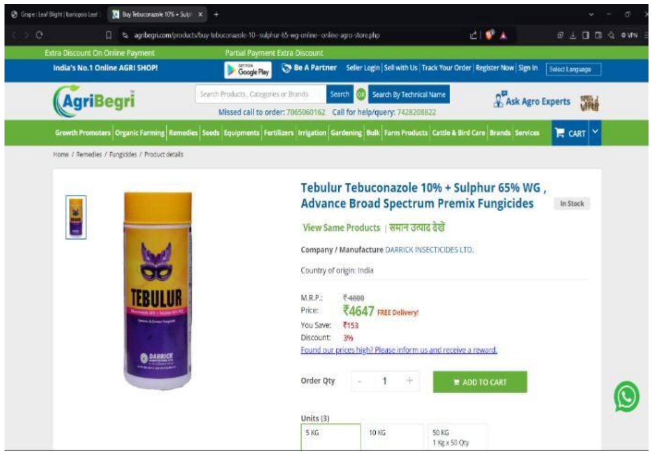
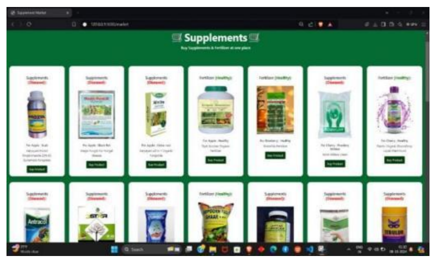
Recommendation of Supplements:



URL Product



All Available Supplements

V. CONCLUSION

In this paper, we have examined the basic principles of deep learning and presented an in-depth review of recent studies on the diagnosis of plant leaf diseases by deep learning. Provided sufficient data is given for training, algorithms that use deep learning have the ability of identifying plants diseases especially impacting the leaves There has been discussion about the value of collecting large, highly variable datasets, data augmentation, transfer learning, and CNN activation map visualization in improving classification accuracy, as well as the importance of hyperspectral scanning in identifying plant diseases early on and the significance of plant leaf disease detection in a small sample. Most of the DL frameworks that have been proposed in the literature have great detection performance on their datasets

Predicting the category of what appeared on a plant leaf is the goal of this work. An uncontrolled method called Convolution Neural Network (CNN) is employed for this prediction. Among the most significant One tool used in image processing is picture recognition, which is an essential instrument for early disease diagnosis in order to raise the production of crops. This tool will assist in cutting down on time and the price of making intelligent choices. By considering every aspect that contribute to thinking Ultimately, it can be said that the Convolution Neural Networks provide remarkable accuracy in diagnosing illnesses.

Additionally, this technique can be expanded to produce a true equipment capable of identifying illness in several plants. the train accuracy is 96.7 %, with the test accuracy of 98.9 % and the validation accuracy is 98.7 %.

Leaf diseases can be detected from a variety of geographic regions. Not only will name of the leaf disease be identified, but also its multiple phases. The system can be connected to a particular mobile application that allows users to find plant leaf photographs.

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