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Plant leaf Disease Detection Using Convolutional Neural Network

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Abstract: Agriculture is the backbone of civilization as well as It has equal importance like the technological growth. Agriculture is one of the world's most important sectors, providing food, raw materials, and economic benefits. Agriculture field has a high impact on our life. Agriculture is the most important sector of our Economy. Proper management leads to a profit in agricultural products. Farmers do not expertise in leaf disease so they produce less production. Plant leaf diseases detection is the important because profit and loss are depends on production. CNN is the solution for leaf disease detection and classification. Main aim of this research is to detect the apple, grape, corn, potato and tomato plants leaf diseases. Plant leaf diseases are monitoring of large fields of crops disease detection, and thus automatically detected the some feature of diseases as per that provide medical treatment. Proposed Deep CNN model has been compared with popular transfer learning. Plant leaf disease detection has wide range of applications available in various fields such as Biological Research and in Agriculture Institute. Plant leaf disease detection is the one of the required research topic as it may prove benefits in monitoring large fields of crops, and thus automatically detect the symptoms of diseases as soon as they appear on plant leaves.
Keywords: Classification, leaf disease, pre-trained CNN, image resizing, image normalization, features extraction, Deep learning and neural networks

I. INTRODUCTION

Plant disease detection applications have revolutionized agriculture by providing timely, accurate, and scalable solutions to monitor plant health. These applications help farmers and agricultural workers reduce losses, minimize the use of chemicals, and maintain the health of crops and plants. With advances in AI, deep learning, and smartphone technology, plant disease detection is becoming increasingly accessible, improving overall agricultural practices and food security worldwide. Green space management ensures that cities can maintain healthy, vibrant green environments that contribute to public health, ecological balance, and community well-being. Disease detection not only aids in maintaining the health of individual plants but also helps cities achieve their long-term sustainability goals by ensuring that green spaces continue to provide their many benefits for future generations. Leaf disease detection is important because profit and loss depend on production. So that here use deep learning techniques to detect apple, grape, corn, potato, and tomato etc plant leaves diseases. That contains different types of leaf diseases and twenty-four thousand leaves images are used. Apple, grape, corn, potato, and tomato plant leaves which are categorized total different types of labels apple label namely: Apple scab, Black rot, apple rust, and healthy. Grape label namely: Black rot, Esca, healthy, and Leaf blight. Corn label namely: Corn Cercospora spot Gray spot, Corn rust, Corn healthy, Corn Northern Blight. Potato label namely: Early blight, healthy, and Late blight. Tomato label namely: bacterial spot, early blight, healthy, late blight, leaf mold, septoria leaf spot, spider mite, target sport, mosaic virus. Dataset consist of 70,295 images of apple, grape, potato and tomato, all Images are resized, that images divided into two parts training and testing dataset.

1. Apple scab 2. Grape Esca 3.Corn leaf spot 4.potato Early 5.Tomato Bligh Spot

Fig 1: Leaves with Disease part

In Fig.1 we can see vegetable and fruit leaves like potato, tomato, corn, apple, grape with diseased part this disease can be easily detected using deep learning techniques. One of the most promising technologies in this area is Convolutional Neural Networks (CNNs), a class of deep learning algorithms that have shown remarkable success in various image classification tasks, including plant disease detection. CNNs can automatically learn hierarchical patterns and features from images, making them ideal for tasks that require the analysis of complex visual data, such as identifying and classifying symptoms of plant diseases.

II. LITERATURE SURVEY

The literature reveals that plant disease detection has evolved significantly with the introduction of remote sensing, image processing, and machine learning techniques. This section includes information related to different implementation method for Plant Leaf Disease Detection.

1) *Automated Image Capturing System for Deep Learning-based Tomato Plant Leaf Disease Detection and Recognition [1].*

Smart farming system using necessary infrastructure is an innovative technology that helps improve the quality and quantity of agricultural production in the country including tomato. The current advance computer system innovation made possible by deep learning that have cover the way for camera captured tomato leaf disease. A specific breed of tomato which is Diamante Max was used as the test subject. The system was designed to identify the diseases namely Phroma Rot, Leaf Miner, and Target Spot. The system used Convolution Neural Network to identify which of the tomato diseases is present on the monitored tomato plants. The F-RCNN trained anomaly detection model produced a confidence score of 80% while the Transfer Learning disease recognition model achieves an accuracy of 95.75%. The automated image capturing system was implemented in actual and registered 91.67% accuracy in the recognition of the tomato plant leaf diseases [1].

2) *CNN based Leaf Disease Identification and Remedy Recommendation System [2].*

Agriculture field has a high impact on our life. Agriculture is the most important sector of our Economy. Farmers are difficult to identify the leaf disease so they produce less production. Though, videos and images of leaves provide better view for agricultural scientists can provide a better solution. So that can solve the problem of related to crop disease. It is required to note that if the productivity of the crop is diseased then, it has high risk of providing good nutrition. Due to the improvement and development in technology where devices are smart enough to recognize and detect plant diseases. Acknowledge diseases faster treatment in order to lessen the negative impacts on harvest. In this paper focus on plant disease detection using image processing techniques. This paper access open dataset images that consist 5000 images of healthy and diseased plant leaves, and there used semi supervised techniques for crop types and detect the disease of four classes.

3) *An advanced deep learning models-based plant disease detection [3]*

Plants play a crucial role in supplying food globally. Various environmental factors lead to plant diseases which results in significant production losses. However, manual detection of plant diseases is a time-consuming and error-prone process. It can be an unreliable method of identifying and preventing the spread of plant diseases. In this paper, the recent advancements in the use of ML and DL techniques for the identification of plant diseases are explored. This study also addresses the challenges and limitations associated with using ML and DL for plant disease identification, such as issues with data availability, imaging quality, and the differentiation between healthy and diseased plants. The research provides valuable insights for plant disease detection researchers, practitioners, and industry professionals by offering solutions to these challenges and limitations, providing a comprehensive understanding of the current state of research in this field, highlighting the benefits and limitations of these methods, and proposing potential solutions to overcome the challenges of their implementation.

4) *Leaf Disease Detection and Classification[4]*

The notion of smart farming is gaining traction in the agricultural industry these days, and it makes use of sensors and a variety of machine learning based technologies. According to recent surveys, 56 percent of the agricultural industry is facing significant losses because of diseases developing on plant leaves. This paper presents a comparative analysis between support vector machines (SVM) model, K-Nearest Neighbor (KNN) model and convolution neural network (CNN) model. The three different models are presented and examined in this research, and they can detect eight different leaf diseases.

The CNN model has achieved an accuracy of 96 percent when trained with the images of soybean leaf disease dataset, outperforms the KNN and SVM models, which have accuracy of 64 percent and 76 percent, respectively.

TABLE 1: Comparisons among Different classification papers

Key Featurs	[1]	[2]	[3]	[4]
Title	Automated Image Capturing System for Deep Learning-based Tomato Leaf Disease Detection & Recognition	CNN based Leaf Disease Identification and Remedy Recommendation System	Advanced Deep Learning Models-based Plant Disease Detection	Leaf Disease Detection and Classification
Methodology	Automated image capturing system with deep learning (CNN).	CNN-based image processing for disease detection.	Deep learning and machine learning tech for disease identification.	CNN, SVM, and KNN models for leaf disease classification.
Diseases Identified	Phroma Rot, Leaf Miner, Target Spot	Four types of leaf diseases	Various plant diseases	Eight different leaf diseases
Dataset	Custom image capturing box; Diamante Max tomato plants	Open dataset with 5000 images	-	Soybean leaf disease dataset
Model Used	F-RCNN, Transfer Learning	Semi-supervised techniques, CNN	-	CNN, SVM, KNN
Accuracy of Model/ Scope of Issues	91.67%	High accuracy assumed from dataset size	-	CNN: 96% accuracy, SVM: 76%, KNN: 64%

III. PROPOSED SYSTEM

The images for plant detection are in the form of RGB. Following that images are resized in (128,128). Following the images are normalized for faster convergence of the model. Moreover, Convolutional neural networks can be used for the computational model creation that works on the unstructured image inputs and converts to output labels of corresponding classification. They belong to the category of multi-layer neural networks which can be trained to learn the required features for classification purposes.

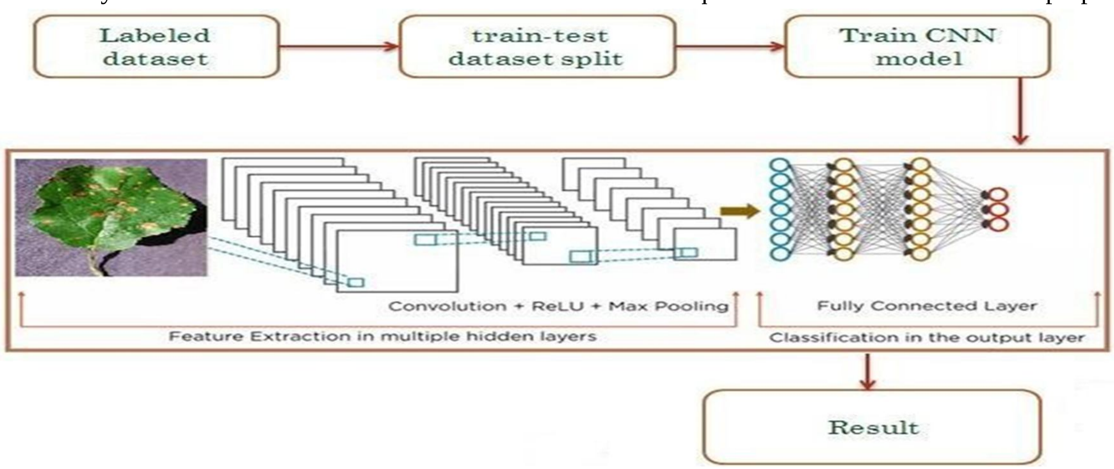

Fig 2: Proposed System

IV. METHODOLOGY

The methodology for plant leaf disease detection using Convolutional Neural Networks (CNN) follows a structured approach, from data collection and preprocessing to model training and evaluation.

A. *Dataset Collection*

- Data Sources: The first step is to gather a diverse dataset consisting of images of plant leaves. This dataset will contain both healthy and diseased leaves from various plant species.

- Categories of Diseases: Each image will be labeled with the disease it represents (e.g., Bacterial Leaf Spot, Powdery Mildew, Early Blight, etc.) or classified as healthy.
- Class Imbalance: If there is an imbalance in the number of images across different classes (diseases), techniques like oversampling, undersampling, or synthetic data generation using data augmentation can be applied.

B. Data Preprocessing

- Resizing: Images will be resized to a consistent dimension (e.g., 224x224 pixels) to match the input size expected by the CNN.
- Normalization: The pixel values will be normalized, typically to a range between 0 and 1, to improve convergence during training.
- Augmentation: Data augmentation techniques like rotation, flipping, scaling, shearing, zooming, and color jittering will be applied to artificially increase the size and diversity of the dataset, preventing over fitting.
- Image Segmentation: In cases where regions of interest (ROIs) need to be identified (e.g., specific parts of the leaf), segmentation techniques might be used to isolate those regions before feeding them into the model.

C. Model Architecture

- Convolutional Neural Network (CNN): CNNs are ideal for image classification tasks as they can automatically learn hierarchical features from the images.
- The proposed model will include:
- Convolutional Layers: These layers will detect local features like edges, textures, and shapes in the images of plant leaves. This is the first step in the process of extracting valuable features from an image. A convolution layer has several filters that perform the convolution operation.
- Pooling Layers: Max-pooling layers will be used to reduce the spatial dimensions of the image while retaining the most important features.
- Fully Connected Layers: These layers will flatten the output of the convolutional layers and pool layers into a 1D vector, which is then passed through dense layers to classify the image.
- Activation Functions: The ReLU activation function will be applied after each convolution and fully connected layer, followed by a softmax activation in the output layer for multi-class classification.

D. Model Training

- Train-Test Split: The dataset will be split into training (80%) and testing (20%) sets to evaluate the model’s performance. Cross-validation may also be employed to further ensure the robustness of the model.
- Loss Function: For multi-class classification, Categorical Crossentropy will be used as the loss function to calculate the error between the predicted class probabilities and the actual labels.
- Optimization Algorithm: The model will be optimized using the Adam optimizer, which is an adaptive learning rate method that helps in achieving faster convergence.
- Epochs and Batch Size: The number of epochs (iterations over the entire dataset) will be chosen carefully based on model performance, and the batch size will be adjusted to fit the computational resources.
- Regularization: Techniques like Dropout and L2 regularization will be used to prevent overfitting and improve the model's generalization ability.

E. Model Evaluation

After training the CNN model, it will be evaluated on the test dataset using various performance metrics:

- Accuracy: Measures the percentage of correctly classified images.Accuracy tells you the overall percentage of test images that the CNN correctly classifies.
- Precision: For each class (disease or healthy), precision, recall, and F1-score will be calculated to assess how well the model performs for each disease category. Precision focuses on how precise the CNN is when it predicts a particular class
- Recall: Recall looks at how well the CNN identifies all instances of a particular class.
- F1-Score: The F1 Score combines precision and recall into a single metric by calculating their harmonic mean.

V. FUTURE ENHANCEMENTS & CONCLUSION

We have studied about existing system feature based approach. It’s done by image processing technique in this we have studied steps like image Acquisition, image pre- processing, Image Segmentation, features extraction, classification. Proposed system to achieve this purpose, we have use CNN and get accuracy is 97.23%.

In future we can add more classes of leaves and disease type and provide remedy for the disease that is detected.

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