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Abstract: The rapid development of machine learning (ML) techniques has paved the way for innovative applications in agriculture, including the detection of leaf diseases. Leaf diseases can significantly impact crop yield and quality, making early detection crucial for effective disease management. This study presents a comprehensive approach to detect leaf diseases using ML algorithms. The methodology involves the collection of high-resolution images of diseased and healthy leaves, followed by data preprocessing, feature extraction, and the training of ML models. The results demonstrate the potential of ML in accurately identifying and classifying leaf diseases, enabling farmers to take timely preventive measures. The developed system provides a non-invasive and cost-effective solution, contributing to sustainable agriculture and food security. This research contributes to the advancement of precision agriculture and holds promise for real-time disease monitoring and management, ultimately leading to increased crop productivity and reduced environmental impact.

Index Terms - Machine Learning, Leaf disease detection, Image processing.

I. INTRODUCTION

As we know India is the second largest country in the world, and we need to produce a large amount of food products. Agriculture plays a major role in the development of our country. The major issue is that we need to provide nutritious food as the crop quality has been degrading over the past years due to diseases that are being caused by various pathogens. Leaves are the most easily affected part of the plant which may impact the health and yield of the plant. Traditional methods of detecting leaf disease are time-consuming and exhausting tasks. By using modern technologies we can easily overcome this situation and identify the disease at an early stage and take preventive measures to reduce the risk of plant loss. Machine learning is a subset of Artificial intelligence that develops algorithms to predict the outcome based on previous datasets. Here we use machine learning algorithms to predict the leaf disease by processing previous data and training models to differentiate between diseased and non-diseased leaves.

II. LITERATURE SURVEY

In recent years there has been much research going on in the field of detecting plant leaf disease using image processing, machine learning, and deep learning.

Showmick Guha Paul et al. tested tomato leaves to detect leaf disease. He used CNN algorithm to classify disease and non-disease leaves of different classes. That led to a result classification of ten out of one class to be healthy. He proposed two system phases, one building phase where models are trained, and two deployment phases where prediction of tomato leaves is done. Best performing models are to be chosen from the performance. Analyzing and comparing the models' overall performance with and without augmentation techniques. Conducting an ablation study on the custom CNN model's architecture to identify the best parameters and effective data augmentation methods. Using callback functions during training to select the best models based on validation loss scores, aiming for optimized performance in leaf classification.

Sunil S. Harakannanavar et al., evaluated samples with different disorders to recognize whether the leaf as diseased or not. They tested different machine learning algorithms to find the best solution. For that over 600 sample datasets were collected and tested on the proposed model and got a result of accuracy of 99.5% which also identifies the molds and spots that indicate the diseased leaf.

Fizzah Arshad et al. worked on potato leaves. He used algorithms like Image preprocessing techniques, like normalization and resizing, to optimize images for machine learning models, enhancing their quality and aiding in disease classification. Augmentation techniques, involving photometric and geometric distortions, expand the training dataset, enhancing the model's robustness. The U-Net architecture comprises an Encoder and Decoder, utilizing convolution and pooling layers to generate and reconstruct feature maps, respectively. In essence, preprocessing optimizes images, data augmentation diversifies the dataset, and the U-Net model excels in segmenting images for precise disease identification.

Shifat E. Arman et al. ran a test on banana leaves. The algorithms he used are, Computer Vision and Pattern Recognition: It's valuable for training models to recognize and diagnose diseases affecting banana leaves, aiding in automated disease detection through image analysis. Plant Pathology and Agricultural Sciences: Enables the study of disease patterns in banana plants, supporting research into disease progression and strategies for mitigation. Applied Machine Learning and Data Science: Provides a foundation for developing and refining machine learning models focused on disease detection, contributing to advancements in agricultural technology. Disease Detection and Image Recognition: Facilitates the creation of specialized models for identifying common diseases in banana leaves, offering insights and early detection capabilities for farmers. Accessible through Mendeley Data, this dataset serves as a valuable resource for researchers and practitioners, particularly in Smart Agricultural Technology, fostering innovation and advancements in disease diagnosis and agricultural practices.

Mital V Shewale et al. conducted an experiment on plant leaf disease. His work summarizes that using deep learning for plant disease classification based on image datasets. Three dataset types are described based on image complexity. The importance of balanced datasets and the challenges of class imbalance are highlighted. Image acquisition, preprocessing techniques like resizing and normalization, segmentation, and regularization methods like data augmentation are discussed in detail. The emphasis is on improving model accuracy through various techniques. Experimentation involves varying train-test-validation split ratios to observe model performance. Hardware specifications and the causes of plant diseases are mentioned. The proposed work involves implementing CNN architectures for classification, fine-tuning model parameters, and studying different DL algorithms for effectiveness. The architectural details of the proposed leaf disease detection model are outlined, focusing on convolution, activation, batch normalization, and dropout layers. The goal is to accurately classify plant diseases using neural networks.

S.No	Model	Accuracy
1	KNN	85.9%
2	CNN	78%
3	SVM	86.4%
4	ELM	89.19%
5	GAN	96.2%

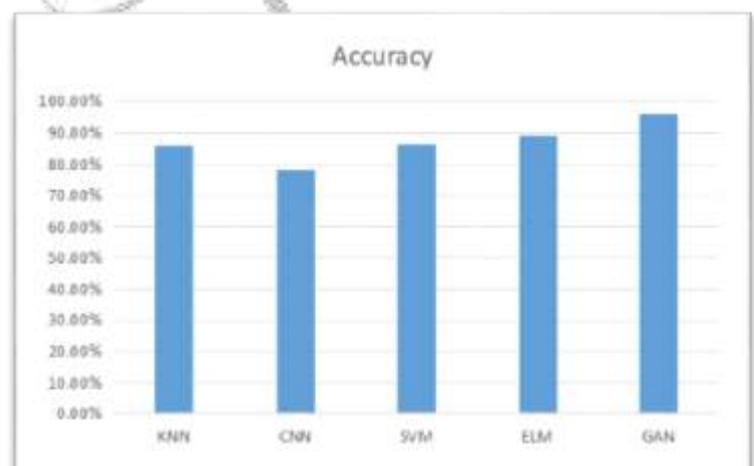Table 1. Models used with accuracy   Fig. 1. Models and its accuracy

II.   METHODOLOGY

1. Dataset Collection

- Identify and collect a diverse dataset of leaf images containing healthy and diseased samples.
- Ensure the dataset covers various types and stages of leaf diseases for robust model training.

2. Preprocessing:

- Image Acquisition: Convert raw leaf images into a standardized format (e.g., JPEG, PNG).
- Resizing and Normalization: Resize images to a uniform size and normalize pixel values to enhance model performance.
- Noise Removal: Apply techniques to reduce noise and enhance image quality if needed.
- Data Augmentation: Augment dataset by applying transformations like rotation, flipping, or adding noise to increase dataset diversity.

3. Feature Extraction:

- Feature Selection: Choose suitable techniques (e.g., CNNs - Convolutional Neural Networks) for feature extraction from images.
- Convolutional Layers: Employ convolutional layers to detect patterns and extract features hierarchically.
- Pooling Layers: Use pooling layers to down sample extracted features while preserving important information.
- Flattening: Flatten the output into a 1D vector to feed into the classification model.

4. Classification:

- Model Selection: Choose appropriate classification algorithms (e.g., SVM, Random Forest, or Neural Networks) based on the dataset size and complexity.
- Training: Split the dataset into training and validation sets. Train the model on the training set.
- Validation: Validate the model using the validation set to adjust hyperparameters and prevent overfitting.
- Evaluation: Assess the model's performance using metrics like accuracy, precision, recall, and F1-score.

5. Detection of Leaf Disease:

- Prediction: Utilize the trained model to predict the type and severity of leaf disease in new images.
- Feedback Loop: Implement mechanisms to refine the model based on feedback and improve accuracy in identifying disease direction.

6. Model Deployment:

- Integration: Integrate the model into an application or system for easy accessibility.
- User Interface: Create an intuitive user interface allowing users to upload images and receive disease direction predictions.
- Continued Monitoring: Continuously monitor model performance and update it periodically to accommodate new data or improve accuracy.

  This methodology outlines the step-by-step process from data collection to deploying a model for identifying leaf diseases and providing the direction of the disease on the leaf. Adjustments and fine-tuning may be necessary based on the specific characteristics of the dataset and the target application.
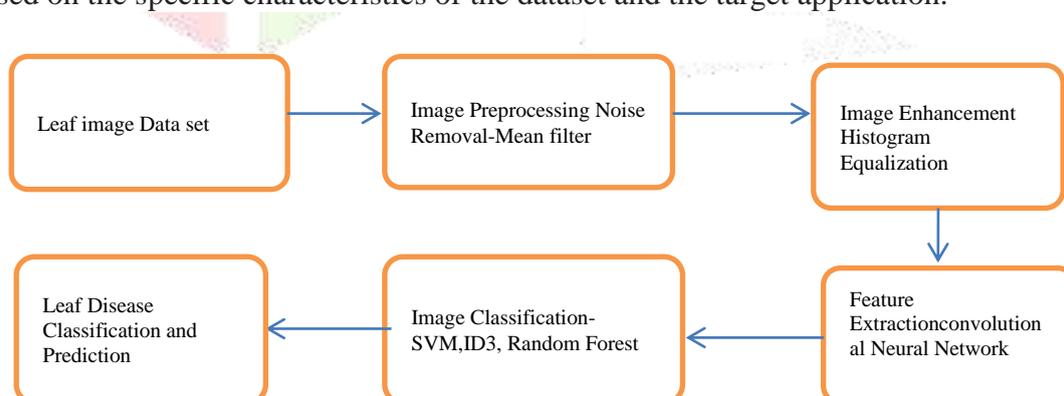

Fig. 2. Workflow chart

IV. CONCLUSION

In conclusion, this research shows the growing interest in applying machine learning algorithms and image processing methods to detect different kinds of leaf diseases. Researchers have explored many algorithms such as KNN, CNN, and SVM that are used for the precise identification of diseases. The common feature between these studies is the adoption of preprocessing techniques to enhance image quality to increase the accuracy of the outcome. These studies show insights about the technological advancements in revolutionizing agricultural practices. This paves the way for more effective and efficient disease management in the agricultural sector.

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