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Leaf Guard : AI Based Plant Disease Detection System

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Abstract –

Domain: *Artificial Intelligence*

Subdomain: *Computer Vision*

Problem Statement: *Plant diseases significantly reduce crop yield and quality. Traditional disease detection methods rely on manual observation, which is often slow, inaccurate, and not easily accessible to all farmers. There is a need for an automated system that can quickly and accurately detect plant diseases using technology.*

Solution: *The Plant AI-Based Disease Detection System is a desktop web application that uses deep learning to identify plant leaf diseases. Users upload a leaf image, which is analyzed by a trained CNN model to detect the disease. The system then displays the disease name along with precautionary measures, helping users take timely action and improve crop productivity.*

Key Words: Plant Disease Detection, Artificial Intelligence, Computer Vision, Deep Learning, Convolutional Neural Network (CNN), Image Classification, Agriculture Technology, Machine Learning

1.INTRODUCTION

Plant diseases have long posed significant threats to agricultural productivity. They can occur due to various biological agents like fungi, bacteria, and viruses, or due to non-living factors like temperature extremes, pollution, and nutrient deficiency. Early symptoms may be subtle and overlooked until the damage is severe. In many cases, by the time visual signs appear, the infection may have already spread significantly, resulting in reduced yield or complete crop failure. Traditional disease detection methods involve manual inspection, which requires the expertise of agricultural officers or plant pathologists. However, in remote or rural areas, such resources are not readily available. Farmers often rely on visual cues and peer advice, which may lead to incorrect diagnosis and ineffective treatment. This causes overuse or misuse of pesticides and affects the environment and soil quality. With the evolution of AI and mobile technologies, it is now possible to develop applications that can analyze leaf images, detect disease patterns, and recommend treatments in real-time. By training AI models on large datasets of diseased and healthy leaf images, the system learns to identify patterns associated with various conditions. This project aims to combine such AI capabilities with user-friendly interfaces to bring reliable and accessible disease detection tools to farmers, promoting informed decision-making and sustainable farming.

2. RELATED WORK

Previous research has focused on applying deep learning and computer vision techniques for plant disease detection. Various CNN-based models like VGG16, ResNet, and MobileNet have been used to classify leaf diseases with high accuracy using datasets such as PlantVillage.

2.1. EfficientNetB0 + LIME (IEEE Access, 2024)

Researchers implemented a deep convolutional neural network (CNN) using the EfficientNetB0 architecture to classify 38 types of plant diseases. The model was enhanced with Explainable AI (XAI) using the LIME technique, which helps visualize and interpret important regions of the image influencing the prediction. This approach provided interpretability and transparency in model predictions, addressing the “black box” nature of deep learning.
Advantages: The model achieved exceptionally high accuracy (99.69%) and is scalable to large datasets.
Disadvantages: It is computationally expensive and requires significant processing power and large annotated datasets for optimal performance.

2.2. Feature Engineering + Machine Learning (Elsevier, 2024)

This study focused on using handcrafted image features such as color, texture, and shape descriptors, which were then classified using traditional ML algorithms like Support Vector Machines (SVM) and Decision Trees. By extracting key features manually, the model avoided deep learning’s heavy computational requirements and achieved reasonable accuracy with smaller datasets.
Advantages: Works efficiently on small datasets, requires low computational resources, and can be implemented on basic hardware.
Disadvantages: Model performance heavily depends on the quality of selected features, and it lacks the ability to generalize to unseen or complex data.

2.3. Systematic AI/DL Survey (IIIT Pune Review, 2024)

A detailed review was conducted covering various Machine Learning (ML) and Deep Learning (DL) approaches for plant disease detection. The survey compared CNN, ResNet, and MobileNet models and discussed preprocessing methods such as image segmentation and feature extraction. The paper provided a consolidated overview of existing models, datasets, and their performance metrics.
Advantages: Offers a comprehensive understanding of the

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techniques and their effectiveness in agricultural disease detection.

Disadvantages: The study is theoretical and lacks a practical model implementation, focusing mainly on summarizing previous research.

2.4. AI + IoT for Plant Detection (Frontiers in Plant Science, 2024)

This approach integrates Artificial Intelligence with the Internet of Things (IoT) to enable real-time field monitoring and disease detection for crops like tomato, potato, chili, and cucumber. IoT sensors capture environmental data, while AI models process the leaf images to detect possible infections. The system helps in automating crop health monitoring and supports smart farming.

Advantages: Enables real-time disease monitoring, remote access, and seamless integration with modern smart farming systems.

Disadvantages: Requires IoT hardware and reliable connectivity, making it expensive and complex to deploy on a large scale.

2.5. MobileNetV2 + Transfer Learning (IEEE Access, 2022)

This research utilized MobileNetV2, a lightweight deep learning model optimized for speed and efficiency, along with transfer learning and data augmentation techniques. The model was trained specifically for tomato leaf disease classification and demonstrated high performance even on mobile devices. Transfer learning reduced training time and improved accuracy on smaller datasets.

Advantages: Achieved high accuracy (99.30%), suitable for mobile and embedded applications due to its lightweight architecture.

Disadvantages: Limited to specific datasets and may struggle with highly varied or complex image backgrounds, reducing generalization in real-world conditions.

3. PROPOSED SOLUTION

The proposed system utilizes deep learning and computer vision techniques to automatically detect plant leaf diseases from uploaded images. It is implemented as a desktop web application that identifies the disease and provides corresponding precautionary measures.

3.1 Architecture

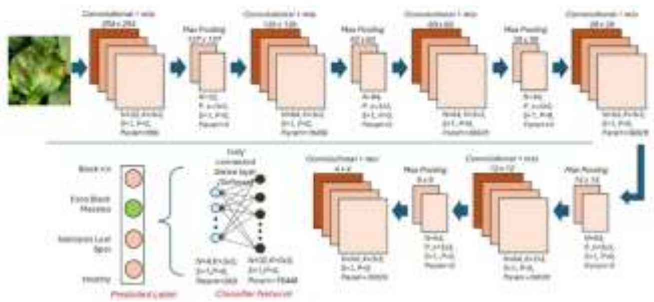

Fig -1: System Architecture Diagram

3.2 Block Diagram

Fig -2: Block Diagram

4. EXPECTED RESULT

The expected results of this project are aimed at improving the efficiency, accuracy, and accessibility of crop disease detection and management. Below are the key outcomes anticipated from the implementation of the proposed system:

1. Accurate Disease Identification: The system is expected to correctly detect and classify various crop diseases using image processing and machine learning techniques.
2. Early Detection: It should enable farmers to identify plant diseases at an early stage, reducing crop damage and improving yield quality.
3. User-Friendly Interface: The application will provide an intuitive and easy-to-use interface for farmers, even those with minimal technical knowledge.
4. Quick and Reliable Results: The model should deliver rapid results after analyzing images, allowing timely decision-making and treatment.
5. Improved Crop Yield: By facilitating timely disease management, the system will help farmers increase overall productivity.
6. Reduced Dependency on Experts: Farmers will be able to independently detect and manage diseases without waiting for expert inspections.
7. Scalability: The system should be adaptable for use with different crops and disease types through continuous dataset expansion.
8. Integration Potential: The solution can be further integrated with IoT and cloud-based systems for enhanced monitoring and large-scale data analysis.

5. CONCLUSION

The *Plant AI-Based Disease Detection System* successfully demonstrates how Artificial Intelligence and Computer Vision can be applied to agriculture for early and accurate disease detection. By analyzing leaf images through a deep learning model, the system efficiently identifies plant diseases and provides useful precautionary measures. The desktop web application ensures accessibility and ease of use, helping farmers and researchers make informed decisions. Overall, the project contributes to improving crop health, reducing losses, and promoting the adoption of smart farming practices.

6. FUTURE SCOPE

The future scope of this project is extensive and holds significant potential for development in various domains of agriculture and technology. With the growing importance of precision agriculture and the need for efficient crop management, this system can be enhanced and integrated with several emerging technologies to make it more reliable, scalable, and accessible.

In the future, the project can be extended into a mobile application that allows farmers to capture real-time images of crop leaves using their smartphones. This would provide instant disease detection and treatment suggestions, eliminating the need for expert intervention in remote areas. The application could also be made multilingual, enabling farmers from different regions to use it easily.

Additionally, integrating the system with cloud-based platforms can help in data storage, processing, and analytics at a larger scale. This would allow agricultural departments and research organizations to analyze regional disease patterns and predict potential outbreaks using AI-based predictive analytics. The use of IoT devices, such as drones and smart sensors, can further enhance the system by enabling continuous monitoring of crops across large farmlands, detecting diseases early, and even automating responses like pesticide spraying.

The model can be expanded to cover multiple crop varieties and diverse diseases, improving its applicability across different agricultural sectors. By incorporating real-time weather data and soil conditions, the system can offer personalized disease prevention strategies. Moreover, continuous updates and retraining of the model with new image datasets will improve its accuracy and adaptability to evolving agricultural conditions.

In the long term, this system could contribute to sustainable farming practices, reduce crop losses, and support the digital transformation of agriculture. By combining artificial intelligence, machine learning, and IoT technologies,
it can play a crucial role in building a smart, data-driven agricultural ecosystem that empowers farmers and promotes global food security.

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