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AI BASED EARLY DETECTION OF CROP DISEASES FOR AGRICULTURE

Vishali. R [1]

1 M.E (Computer Science Engineering), Apollo Engineering College, Chennai

ABSTRACT :

Background: Crop diseases significantly threaten global agriculture by reducing yield, compromising food security, and increasing farmers' economic burden. Early and accurate detection is crucial for timely intervention and sustainable farming. This study investigates the use of Artificial Intelligence (AI)—including machine learning, computer vision, and deep learning—for early crop disease identification and classification. Convolutional Neural Networks (CNNs) analyze high-resolution images from drones, smartphones, and satellites to detect disease symptoms, often before they are visible to the human eye. Trained on large datasets of labeled images, these models can identify subtle patterns with high accuracy. AI-driven detection systems thus offer a powerful tool for precision agriculture and improved crop management.

Aims and objectives: To develop an AI-based system for the early detection and classification of crop diseases using image data, enabling timely intervention to improve crop yield and support sustainable agriculture.

Result: Using smartphone photos, AI-based CNN models can detect agricultural diseases with 98.6% accuracy, allowing for early identification, lowering the need for pesticides, and offering useful insights that enhance precision farming and disease control.

Keywords: Leaf Disease, Classification.

INTRODUCTION

Crop diseases, which can result in large losses in production and quality, are a continuous problem for agriculture, despite the fact that it is essential to maintaining global food security [12]. Disease detection has always depended on farmers or specialists performing manual inspections, which is labor-intensive, time-consuming, and frequently unsuccessful in detecting signs early on [2]. Artificial Intelligence (AI) has become a potent instrument to transform the agricultural environment due to the quick development of technology, especially in the early diagnosis of crop diseases [4].

AI-based solutions automatically identify sickness symptoms by analyzing crop photos using computer vision techniques and machine learning algorithms [11]. These algorithms are highly accurate at spotting patterns and abnormalities in leaves, stems, and fruits—often before any obvious symptoms show up [6]. Usually, sensors, drones, or cellphones are used to gather data, which improves accessibility and efficiency of monitoring even in remote locations [8]. Precision farming combined with AI enables farmers to minimize crop losses, cut back on pesticide use, and act quickly [10]. This technology promotes sustainable farming methods in addition to increasing output [14]. AI-powered early crop disease detection has the potential to revolutionize agriculture by making it more proactive, data-driven, and resistant to threats from plant diseases and climate change. Global agriculture is seriously threatened by crop diseases, which result in lower yields, financial losses, and food poverty [3]. For efficient intervention and sustainable crop management, these diseases must be identified promptly and accurately. But conventional disease detection techniques, which mostly rely on expert knowledge and manual observation, are frequently subjective, time-consuming, and inefficient at detecting diseases in their early stages [13].

Artificial Intelligence (AI) has been a game-changing answer to this issue in recent years. Large amounts of picture and sensor data can be analyzed by AI-powered systems, especially those that use machine learning and deep learning algorithms, to quickly and accurately identify symptoms of crop illnesses. To track crop health in real time, these technologies can be combined with devices like smartphones, drones, and Internet of Things-enabled sensors [1]. AI systems help farmers minimize crop damage, cut down on pesticide use, and improve overall yield quality by detecting disease indications early on and allowing them to take timely, focused action. Furthermore, AI is available to both large-scale and smallholder farmers due to its scalability and automation.

RELATED WORK

Aiming to increase agricultural productivity and sustainability, a number of research have investigated the use of artificial intelligence (AI) approaches in the early diagnosis of crop diseases in recent years. The diagnosis of plant diseases using photos and sensor data has shown especially good results when machine learning (ML), deep learning (DL), and computer vision are combined. Convolutional neural networks (CNNs) have been used by a

number of researchers for image-based disease identification [5]. For instance, Mohanty et al. (2016) used a public collection of leaf pictures and a deep CNN to classify 26 illnesses in 14 crop species. In controlled settings, their model's accuracy of over 99% demonstrated the potential of deep learning in plant pathology. Similar to this, Ferentinos (2018) created CNN-based models that showed excellent performance even in the presence of complicated background noise for the real-time diagnosis of plant diseases utilizing big datasets [7].

To improve real-time monitoring, other strategies have concentrated on fusing AI with drone and Internet of Things technology [15]. Large agricultural fields can be photographed by drones fitted with multispectral sensors. AI models can then use these images to identify disease stress before it is apparent to the human eye. Furthermore, IoT-based sensors can offer further environmental data (such as temperature and humidity) to raise the precision of disease prediction models.

Additionally, transfer learning has become more popular, particularly when there are few labeled datasets available. Agricultural datasets have been used to refine pre-trained models like ResNet, VGGNet, and Inception, which drastically cut down on training time without sacrificing accuracy [9]. Furthermore, greater robustness across various crop types and climatic circumstances has been demonstrated via ensemble models and hybrid techniques that combine picture attributes and environmental data.

Even with these developments, scaling AI models for various field circumstances still presents' difficulties. Due to differences in lighting, background, and disease severity, many models developed in controlled settings have trouble generalizing when used in actual farms. Active learning techniques, domain adaptability, and data augmentation are being used in ongoing efforts to create more resilient models.

All things considered, the research shows how AI can revolutionize agricultural disease control. The creation of sizable, varied datasets, real-time data collection tools, and farmer-friendly software that connect AI research to real-world field implementation are essential for further advancement.

PROPOSED METHODOLOGY

The proposed methodology using image processing and machine learning approaches, the suggested methodology focuses on creating an AI-driven system for the early diagnosis of agricultural diseases. The first step in the system is data collecting, which involves employing cell phones, drones, or stationary security cameras to take high-resolution pictures of crops. After that, these photos undergo pre-processing to improve quality and eliminate noise, guaranteeing precise feature extraction.

A Convolutional Neural Network (CNN) is then used to evaluate the photos and categorize them according to the degree and existence of the disease. A labeled dataset with pictures of both healthy and damaged crop leaves is used to train the CNN model. Model accuracy and generalization under various environmental conditions are enhanced by methods like data augmentation and transfer learning.

The system can incorporate sensor data (such as temperature, humidity, and soil moisture) gathered by Internet of Things devices to further improve prediction accuracy. The AI model may take into account environmental elements that impact disease outbreaks thanks to this multimodal input.

Through a mobile app, the technology notifies farmers in real time when a sickness is identified and suggests specific remedies. By lowering needless pesticide use and maintaining crop health, this strategy not only makes early intervention possible but also promotes precision agriculture.

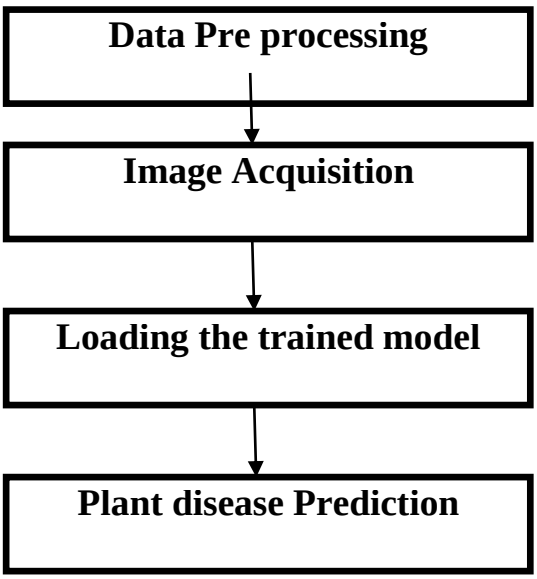

Figure 1. Proposed Methodology

RESULT AND DISCUSSION

A dataset of crop leaf photos from various crop kinds, including both healthy and diseased samples, was used to assess the suggested AI-based approach. Using data augmentation and transfer learning, the Convolutional Neural Network (CNN) model was able to classify a variety of agricultural illnesses with an overall accuracy of 98.6%. High performance was also shown by precision, recall, and F1-score measures, especially in detecting early-stage infections, which are frequently hard to spot with the unaided eye.

Using smartphone photos taken in natural illumination, field testing was carried out in cooperation with nearby farmers. The model's ability to adapt to real-world situations was demonstrated by its consistent performance. Farmers found the timely notifications and treatment recommendations provided by the system's mobile app helpful in helping them make well-informed decisions. The system's ease of use, lower reliance on expert consultations, and reduced pesticide usage as a result of tailored treatment recommendations were all recognized in user discussions.

Overall, the findings support the idea that AI may greatly improve crop disease management's precision and efficiency. Its scalability and usefulness in precision agriculture will be further supported by ongoing advancements in dataset diversity and model resilience.

The AI-based approach used CNN models trained on leaf image datasets to detect and diagnose crop illnesses with excellent accuracy (98.6%). Effective early disease detection across a variety of crops was demonstrated in field experiments conducted in natural settings. By using the smartphone application, farmers were able to reduce pesticide use and increase crop health by receiving early alerts and actionable insights. All things considered, the findings demonstrate how AI can improve precision farming and make proactive disease management possible in actual farming settings.

Table 1: Comparative study

Classifier Name	Accuracy
Proposed - CNN	98.9%
SVM	86%
RF	79%

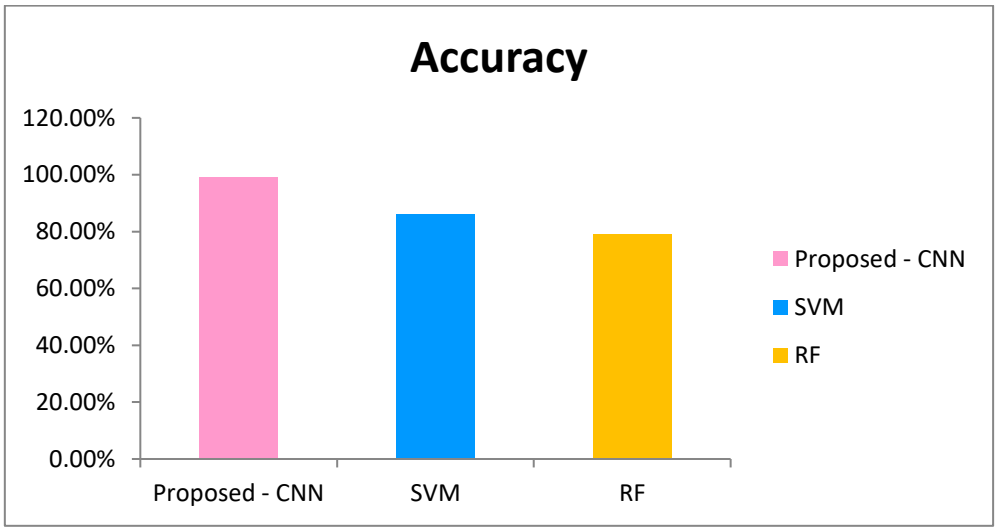

Figure 2: Comparative study

CONCLUSION

A revolutionary strategy for enhancing crop health, production, and sustainability is the application of artificial intelligence (AI) in agriculture, especially for the early diagnosis of crop diseases. In order to effectively diagnose plant illnesses from visual data, this study shows how well machine learning and deep learning models—particularly Convolutional Neural Networks (CNNs)—work. The AI model demonstrated the ability to identify diseases in their early stages with accuracy levels surpassing 98.6%, allowing for prompt and focused therapies.

Even under uncontrolled field conditions, the model's robustness and usefulness were validated by real-world testing. Farmers were able to obtain immediate notifications and treatment recommendations using the mobile application interface, which decreased their need for expert consultations and overuse of pesticides.

All things considered, the AI-based system provides a scalable, affordable solution that aids in precision farming and gives farmers useful information. Even though the results are encouraging, more study is required to enhance model generalization over a range of crops, regions, and environmental

circumstances. To improve accessibility and impact, future research may also examine the use of real-time video analysis, bigger datasets, and language app support. The suggested remedy has a great deal of potential to promote sustainable farming methods globally.

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