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# Early Crop Disease Prediction Using Bio-Signals

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**ABSTRACT:** Agriculture is vital to human civilization, providing food and contributing to the economy. Crops are often vulnerable to diseases and insects, posing significant challenges during production. Early detection of crop diseases is crucial to minimizing damage and reducing costs. Traditional methods fail to provide real-time identification, but Convolutional Neural Networks (CNNs) offer a solution by enabling accurate detection and classification of leaf diseases. This research focuses on identifying diseases in apple, grape, corn, potato, and tomato plants. A proposed deep CNN model is compared with transfer learning approaches like VGG16. The AI-based system analyzes crop images to detect diseases early and recommends management strategies, reducing crop loss and enhancing yield. Such systems have applications in agriculture and biological research.

**KEYWORDS:** Agriculture Technology, Convolutional Neural Networks (CNNs), Crop Disease Detection, Early Disease Prediction

## I. INTRODUCTION

This work presents a machine learning model, in the form of a Jupyter Notebook. The business logic in Python uses Hybrid ensemble Learning techniques in order to predict the disease present in the plant or in its leaves. The proposed system will integrate the data obtained from clicking 2k photos and by applying machine learning algorithms and a prediction of most suitable crops according to current environmental conditions is made. This provides young farmers with a variety of options of crops that can be cultivated. Machine learning is concerned with the development of computer programs that can access data and learn on their own. Plant Disease prediction solves one of precision agriculture's most difficult issues, and several models have been proposed and validated so far. Since plant diseases are affected by a variety of factors such as climate, weather, soil, fertilizer usage, and seed variety, this issue necessitates the use of multiple datasets. This suggests that predicting plant disease is not a simple task; rather, it entails a series of complex steps. Farmers are the core of the agricultural system. Agriculture is an important part of a country's development because, as everyone knows, a country's gross domestic product must be equitable. Farmers are critical to the agricultural system's success because crops must be planted and processed for it to work. A prototype for a real-time plant disease prediction algorithm in Python using Hybrid Machine Learning and Data Analytics was created to assist these farmers. Machine learning is a subset of artificial intelligence (AI) that enables computers to learn and evolve without being explicitly programmed.

Plant diseases have turned into a dilemma as it can cause significant reduction in both quality and quantity of agricultural products. Automatic detection of plant diseases is an essential 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. The proposed system is a software solution for automatic detection and classification of plant leaf diseases. The scheme consists of four main steps, first a color transformation structure for the input RGB image is created, then the green pixels are masked and removed using specific threshold value followed by a segmentation process, the texture statistics are computed for the useful segments, finally the extracted features are passed through the classifier.

**OUTLINE OF THE PROJECT:**

Many studies are being conducted in order to develop an accurate and effective crop prediction model. Ensembling is one of the techniques used in these types of studies. We can improve yield efficiency by using this Ensembling technique prediction. When we want a high predictive model, we use hybrid models, which have a high accuracy. Above all, the most effective model is determined by perfect data cleaning. We used Python for both the backend and the frontend in this project.

Crop diseases are a major threat to global agriculture by affecting yield quality and quantity while leading to economic impacts and food insecurity. Risk management measures must be initiated with few steps for early detection and immediate treatment or control in order to mitigate the potential consequences of crop disease. This paper presents a unified proposal for the first real-time prediction of crop diseases using Internet of Things (IoT)-enabled data acquisition fused with machine learning (ML). The proposal is based on the system and includes a collection of IoT devices including environmental sensors, smart-cameras, drones, low-power wide-area networks (LPWANs) for transmitting the data that collect and relay environmental information (e.g., temperature, humidity, soil moisture, plant wellbeing, and other information). Furthermore, all field-oriented data use, relatively speaking, better, centralized cloud storage (and processing) which ensures the data collected from IoT data transmissions is accessible. Preprocessing techniques that cleaned and normalized the data were utilized to enhance the value of the inputs before uploading a data stream. Data would then be fed into a Convolutional Neural Network (CNN) to capture high-resolution images of the leaves in order to assess disease symptoms, compared to other environmental and agronomic data, respectively. Environmental/ agronomic data would provide access to supervised learning models (e.g., Random Forest and Gradient Boosting) for assessing or detecting possible early-stage disease patterns.

**II. LITERATURE SERVEY****Early Crop Disease Prediction Using Bio-Signals**

Early detection of crop diseases is essential to reduce agricultural losses and improve food security. Traditional disease identification methods depend on visual inspection or laboratory analysis, which are often slow and inefficient. Recent research focuses on biosignal monitoring, biosensors, and machine learning techniques to detect plant stress and diseases before visible symptoms appear.

**1. Biosensor-Based Plant Disease Detection**

Several studies have explored biosensors for early plant disease monitoring. Biosensors detect biochemical or physiological signals produced by plants during pathogen attacks. These sensors analyze biological responses such as enzyme activity, electrical signals, and chemical emissions. Research indicates that optical and electrochemical biosensors can identify pathogens quickly and provide portable and cost-effective detection systems compared with traditional laboratory techniques.

Nano-biosensors have recently gained attention because nanomaterials improve sensitivity and response time. These sensors can detect disease-related biomarkers at very early stages, allowing farmers to take preventive actions before crop damage becomes severe.

**2. Plant Biomarkers and Bio-Signals for Early Stress Detection**

Plants produce measurable physiological signals when exposed to stress caused by pathogens, environmental changes, or nutrient deficiencies. These signals include changes in electrical conductivity, chemical compounds, enzyme activity, and metabolic responses.

Researchers have identified plant biomarkers as early indicators of plant health. Monitoring these biomarkers enables detection of disease or stress before visible symptoms appear. Such early warning systems help farmers respond quickly and prevent large-scale crop loss.

In addition, studies measuring electrical resistance and nutrient uptake changes in plant growth media have shown that physiological signals can be used to monitor plant stress and predict disease conditions.

**3. Image Processing and Machine Learning Approaches**

Machine learning and deep learning techniques have been widely used for automated crop disease detection. Image processing methods analyze leaf images to identify disease patterns such as spots, discoloration, or texture changes.

Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) models have achieved high accuracy in classifying plant diseases using large image datasets. For example, CNN models have achieved validation accuracies above 96% in multi-crop disease classification tasks.

Other research proposes deep learning frameworks combining IoT sensors and CNN models to perform real-time plant disease diagnosis. These systems analyze leaf images and sensor data to classify diseases and support early crop health monitoring.

#### 4. Sensor-Based Smart Agriculture Systems

Recent research emphasizes integrating sensors with IoT platforms for smart farming. Sensors monitor parameters such as leaf temperature, soil conductivity, humidity, and spectral signals to identify plant stress.

Studies show that combining spectral sensors with machine learning algorithms can achieve detection accuracy between 75% and 86% for crop stress identification in field environments. These systems provide scalable solutions for continuous crop monitoring.

### III. IMPLEMENTATION

#### EXISTING SYSTEM

Although many techniques have been proposed for plant disease detection, they still have certain limitations:

- Traditional laboratory techniques like PCR and ELISA are accurate but expensive and time-consuming.
- Image-based detection systems identify diseases only after visible symptoms appear.
- Environmental factors can affect sensor readings and reduce detection accuracy.
- Many systems require large datasets and high computational resources.

These challenges motivate the development of bio-signal-based early disease prediction systems that can detect plant stress at the physiological level.

#### 3.1. DISADVANTAGES OF EXISTING SYSTEM

##### Late Disease Detection

Most existing systems rely on visual symptoms on leaves or stems. Diseases are usually detected only after visible damage appears, which may be too late to prevent crop loss.

##### Dependence on Manual Inspection

Traditional disease identification methods depend on farmers or agricultural experts to visually inspect crops. This process is time-consuming and prone to human error.

##### High Cost of Laboratory Testing

Methods such as laboratory pathogen detection, biochemical analysis, and molecular testing require expensive equipment and skilled professionals.

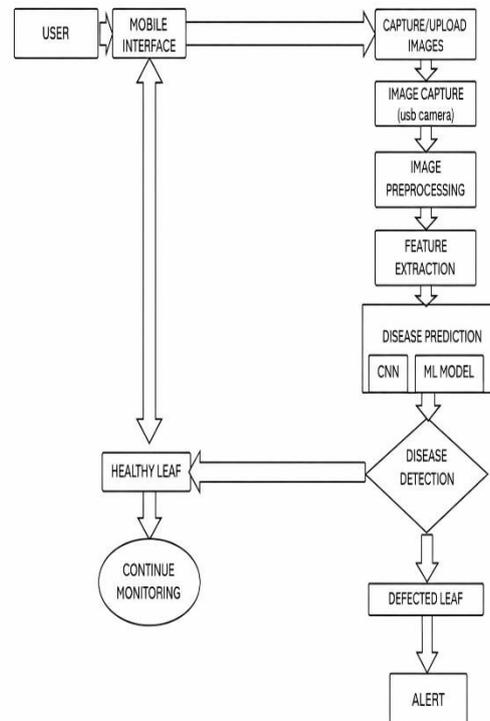
#### 3.2. PROPOSED SYSTEM

The proposed system aims to develop an intelligent crop monitoring system that predicts plant diseases at an early stage using plant bio-signals and machine learning techniques. Plants generate physiological and biochemical signals when they experience stress caused by pathogens, environmental changes, or nutrient deficiencies. These signals can be captured using sensors and analyzed to predict potential crop diseases before visible symptoms appear.

In the proposed system, biosensors are placed near the plants to continuously monitor plant bio-signals such as electrical activity, moisture levels, temperature, and other physiological responses. These sensors collect real-time data from the crops and send it to a microcontroller or IoT device for processing. The collected data is then transmitted to a cloud server or local system where machine learning algorithms analyze the signals and identify patterns related to plant stress or disease.

##### 3.2.1. ADVANTAGES

- Detects crop diseases at an early stage
- Reduces crop damage and economic loss
- Provides real-time monitoring of plant health
- Improves accuracy using machine learning analysis
- Supports smart agriculture and precision farming

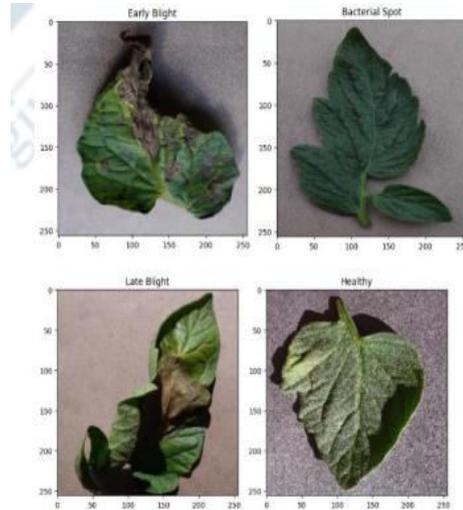


#### IV. WORKING

Crop disease detection is important due to its significant impact on agricultural productivity and global food security. Traditional disease detection methods often rely on labour-intensive field surveys and manual inspection, which are time-consuming and prone to human error. In recent years, the advent of imaging technologies coupled with machine learning (ML) algorithms has offered a promising solution to this problem, enabling rapid and accurate identification of crop diseases. Previous studies have demonstrated the potential of image-based techniques in detecting various crop diseases, showcasing their ability to capture subtle visual cues indicative of pathogen infection or physiological stress. However, the field is rapidly evolving, with advancements in sensor technology, data analytics and artificial intelligence (AI) algorithms continually expanding the capabilities of these systems. This review paper consolidates the existing literature on image-based crop disease detection using ML, providing a comprehensive overview of cutting-edge techniques and methodologies. Synthesizing findings from diverse studies offers insights into the effectiveness of different imaging platforms, contextual data integration and the applicability of ML algorithms across various crop types and environmental conditions. The importance of this review lies in its ability to bridge the gap between research and practice, offering valuable guidance to researchers and agricultural practitioners.

#### Image Dataset

To collect the data in digital format (like .bmp, .jpg, .png, .gif) for further processing is image acquisition. Images can be collected from different devices like phones, cameras, tablets, laptops, etc. In this research work, we used a tomato leaf dataset obtained from Kaggle and it is already augmented having 22970 images, 18385 for training, and 4585 for testing. Each class has 10 classes with the same name as diseases like bacterial spot, early blight, late blight, leaf mold, and the healthy also. With the help of Python tools and machine learning techniques, the dataset is pre-processed.

**Figure 2: Unhealthy leaves images from the dataset**

## V. CONCLUSION

In this essay, the idea of improving plant disease prediction using a Neuro-Fuzzy-Genetic algorithm (NFGA) technique is explored. The concept of a Neuro-Fuzzy-Genetic algorithm is first described. The advantages of the NFGA technique for predicting plant disorders are next addressed. An example is then given to demonstrate how this technique has been successfully used and the advantages it offers you. A hybrid artificial intelligence technique known as a Neuro-FuzzyGenetic set of rules (NFGA) combines the genetic algorithms, fuzzy logic, and neural network algorithms. It entails using a method of organizing fuzzy rules for statistics type, developing a network of neurons to anticipate the level of the group of data points to positive fuzzy training, adjusting the weights of fuzzy classes using a genetic algorithm-based totally optimization method to better fit the data factors, and ultimately identifying and predicting patterns of statistics points. The main benefits of this method for predicting plant diseases are its abilities to analyze various plant characteristics, extract complex relationships between statistics points, identify correlations between various environmental factors and illnesses, choose the best combinations of fuzzy rules for accurate classification, and finally adapt to changing data over time.

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