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Tomato Leaf Disease Detection Model-A Real time IoT Prototype

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***Abstract*—Leaf disease always play a vital role in any sustainable agriculture management system. Tomato leaf diseases leads to economic losses to farmers as they have a huge impact on both the quality and yield of the crops. Therefore, the development of a system for detecting and treating tomato leaf diseases is essential. This paper demonstrates an architecture for a tomato leaf disease detection and fertilizer spraying system using a Raspberry Pi and relay switch. The system consists of a camera module, LED lights, motor, pump, and relay switch, all controlled by a Raspberry Pi. The camera module captures images of the tomato leaves, which are then processed using an image processing algorithm to detect any signs of disease. Based on the detection results, the Raspberry Pi activates the fertilizer spraying mechanism, consisting of the motor and pump, through the relay switch. The flow of fertilizer is controlled by the motor and pump, which spray the fertilizer onto the tomato plants as needed. The users can interact with system for monitoring the detection and spraying through a graphical interface and the system setting can be changed whenever required. Overall, the developed system provides a low-cost and flexible solution for detecting tomato leaf disease and applying fertilizer as needed, using image processing and control systems controlled by a Raspberry Pi by providing potential to significantly improve tomato crop yields and reduce economic losses for farmers.**

***Index Terms*— leaf diseases, agriculture, crop yield, image processing.**

I. INTRODUCTION

Agriculture has been essential to development. The entire economy will be impacted by a decrease in agricultural output. Therefore, good management of resources such as soil [11], seed, water, and fertilizers is essential to sustainability. Growing economies depend heavily on agriculture, therefore using digital farming in rural areas would benefit this industry [17]. Since diseases are unavoidable, diagnosing them is crucial. The color, fruit set, and nutritional value of fruit are all influenced by temperature and light intensity [12]. Bacterial, viral, and fungal infections are especially dangerous for plants [1]. Plant diseases affect the number and quality of agricultural products that are produced. Plant diseases must be manually identified, which is time-consuming and can yield unreliable findings. Farmers will experience health effects from prolonged pesticide exposure [4].
The use of automatic pesticide spraying will reduce health issues that farmers face. In order to diagnose tomato and paddy leaf diseases, the current work offers an efficient method for using image processing techniques [3]. To identify the pathogens on tomato and paddy leaves, the study was conducted using image processing techniques [8]. The moment the disease is identified, pesticides are applied. The bulk of plant illnesses are

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caused by fungi, bacteria, and viruses, thus early detection is essential [13]. Changes in leaf morphology are a sign of the fungal initial stage. Bacteria are considered to be more embryonic in comparison to fungi. Their shortened life cycles and morphologically altered leaves aid in their identification.

Chemical testing and visual inspection are usually used to identify and classify natural plant diseases. In large-scale farming, it is not possible to see every plant, every day. Farmers are unaware of diseases that are not native. Expert consultation would be a more costly and time-consuming choice. Natural resources like water, soil, air, and the food chain are at danger when pesticides are used needlessly. Precautions must be taken in order to avoid contaminating food items with pesticides. In order to spray the right amount of chemical onto the plant and identify plant illnesses, we need a procedure. Therefore, the model that has been built aims to avoid leaf disease in its early stages.

II. SCOPE OF THE SYSTEM

The developed model will be able to identify the plant disease at the early stage. The leaf disease detection and pesticide spraying software will be used to identify leaf diseases in plants and apply pesticides automatically. The software will be designed to work with a range of plants.

III. RELATED ANALYSIS

The technique of finding and diagnosing plant disease based on the symptoms present on the plant's leaves is known as "leaf disease detection." This is an important task in agriculture and forestry, as diseases can cause significant damage to crops and forests if left untreated .There are several methods for leaf disease detection, including visual inspection, laboratory analysis, and digital image processing. Machine learning [2] and computer vision techniques have also been used to evaluate images of plant leaves and identify signs of disease.

One approach for leaf disease detection is by using a large dataset of labelled images of healthy and diseased leaves to train a neural network [9]. Using the features it has learned, the network can then be used to categorize new images. Another strategy is to extract properties from the images, such as colour, texture, and shape, using computer vision techniques, and then use machine learning algorithms to categorize the images.

Leaf disease detection systems can be used for both on-site and remote monitoring of plant health. On-site systems may use handheld devices or drones [14] to capture images of plant leaves, while remote systems may use satellite imagery or other remote sensing technologies [15]. These systems can provide valuable information for farmers and foresters, allowing them to detect diseases early and take action to prevent further spread. With the emergence of the Internet of Things (IoT) industry, innovative solutions for the new agricultural era are being proposed [16].

Disadvantages:

Limited accuracy: The precision of the image processing methods and the clarity of the images itself may have limitations on leaf disease detection systems. In some cases, it may be difficult to distinguish between different types of diseases or to accurately identify the severity of an infection.

High cost: Leaf disease detection systems can be expensive to develop and implement, especially if they rely on advanced imaging technology or machine learning algorithms.

Limited applicability: Leaf disease detection systems are typically designed to detect specific types of diseases in specific crops or plants, and may not be useful for other applications.

Dependence on environmental conditions: The accuracy of leaf disease detection systems can be influenced by environmental conditions, such as lighting or weather. This can make it difficult to obtain consistent and reliable results.

Limited availability: Leaf disease detection systems may not be widely available or accessible to farmers or researchers, especially in developing countries or rural areas.

IV. CURRENT ANALYSIS

Leaf disease detection and pesticide spraying are two related but distinct areas of concern in agriculture. Leaf disease detection involves identifying the presence and severity of diseases affecting crops, such as fungi, bacteria, viruses, and other pathogens. Pesticide spraying, on the other hand, is a method used to control pests, including insects, mites, and rodents that can cause significant damage to crops. There are several ways to detect leaf diseases in crops, including visual inspection, laboratory testing, and the use of technology. Visual inspection involves trained personnel examining the leaves and identifying visible signs of damage or disease.

Laboratory testing involves taking samples of the affected leaves and analysing them for the presence of pathogens or other indicators of disease.
Technology-based approaches to leaf disease detection are increasingly common in modern agriculture. For example, machine learning algorithms can be trained to analyse images of leaves and detect patterns that indicate disease. Similarly, sensors can be placed in fields to measure various environmental factors, such as temperature and humidity [10] that can affect plant health. Pesticide spraying is typically done using specialized equipment, such as sprayers or drones that can distribute pesticides evenly over a crop. The timing and frequency of pesticide spraying can depend on several factors, including the type of pest, the severity of the infestation, and the crop being treated. The overuse of pesticides, however, should be considered and closely regulated because it can have detrimental effects on both the environment and human health.
In summary, both leaf disease detection and pesticide spraying are essential components of modern agriculture. By detecting diseases early and using pesticides judiciously, farmers can help ensure that their crops remain healthy and productive while minimizing the potential negative impacts on the environment and human health.
The present system represents a Leaf disease detection and pesticide spraying using a ESP32 model to extract the features of the leafs. The system is developed using convolutional neural network and the image segment is done using K-means algorithm. Some of the benefits of the present system is mentioned below:

Advantages:
Early detection of leaf diseases: With the use of advanced technology, leaf diseases can be detected early on, which allows for timely intervention and management of the disease. Early detection can help prevent the spread of the disease and minimize crop loss.
Increased yield: By detecting leaf diseases early and using appropriate measures, the yield of the crop can be increased. Pesticide spraying can help control pests that may damage the crop, resulting in a healthier and more productive plant.
Reduced cost: Early detection of leaf diseases and targeted pesticide spraying can help reduce the overall cost of crop management. This is because timely interventions can prevent the need for extensive and costly treatments.
Improved quality: By maintaining the health of the crop, the quality of the produce is also improved. This can result in higher market value and increased profits for the farmer.
Environmentally friendly: The use of targeted pesticide spraying can help reduce the overall use of chemicals in agriculture, making it a more environmentally friendly practice. This is because pesticides are only applied where needed, reducing the potential negative impact on non-target organisms.

V. SYSTEM IMPLEMENTATION

In the steps below, a detailed working of the proposed model is demonstrated. Real-time images of different tomato leaf diseases are recorded with a camera and saved in a database. The recorded photos are then subjected to a number of image-processing algorithms in order to extract useful information for the ensuing analysis process. Further calculations are made for each image in terms of contrast, correlation, energy, skewness, and entropy using Convolutional Neural network [7][5]. The output of the convolutional layer is known as the Feature Map, which provides us with the essential details of the image.

A. Data Aquicition

The recorded RGB images of a leaf is saved in .png format to get highest level of accuracy. These recorded images are then enlarged and given contrast boost. The sample recorded image is shown in the below figure 1.

Figure 1. Sample leaf image at initial stage

B. Edge Detection

The features of a recorded image are observed carefully in this step. The crucial features required for the study with respect to grey scale are extracted here.

Figure 2: Grey scale extracted image sample

C. Image optimization

The acquired features like contrast, correlation, energy, skewness, and entropy is compared to the pre-processed versions. The sickness (if discovered) will be directed to User interface and the required fertilizers to prevent it will be displayed.

D. Feature extraction of the image

This step of converting the input (raw image) into numerical data is crucial to the overall illness diagnosis procedure. To emphasize the disorders, certain picture elements like color are adjusted.

E. ESP32 Module

The model act as a microcontroller and helps in image tracking as well as image recognition. The model is responsible to capture the defected image with built in camera and sharing it to the server. It also helps to collect the environmental data such as humidity, temperature.

F. Sensors

The total water content of the soil is measured using soil sensors. The soil moisture is captured using sensing probes. When the sensors are inserted into the soil, the electromagnetic wave are responsible to capture and monitor the water content. It was observed that Soil moisture content plays an important role in plant health.

G. Raspberry PI

The Raspberry Pi [6] serves as the central processing unit in the tomato leaf disease detection and fertilizer spraying system. It runs the image processing algorithm that analyses the images captured by the camera to detect any signs of disease on the tomato leaves. The algorithm uses machine learning techniques to classify the images as healthy or diseased. Based on the detection results, it activates the fertilizer spraying mechanism, which consists of a motor and pump controlled by the Raspberry Pi.

The Raspberry Pi sends signals to the motor and pump to control the flow of fertilizer that is sprayed onto the tomato plants. It also serves as the user interface for the system, which has a graphical user interface through which users can interact to monitor the detection and spraying process, and adjust system settings as needed.

VI. RESULTS

The final developed prototype (working) is displayed in the figure 3.

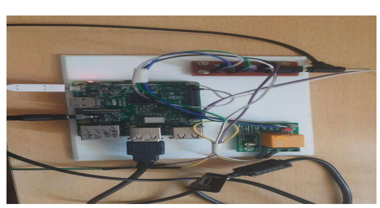

Figure 3: Developed prototype

The Python scripting is used to control the system. The image with disease is loaded followed by contrast enhancement as shown in figure 4.

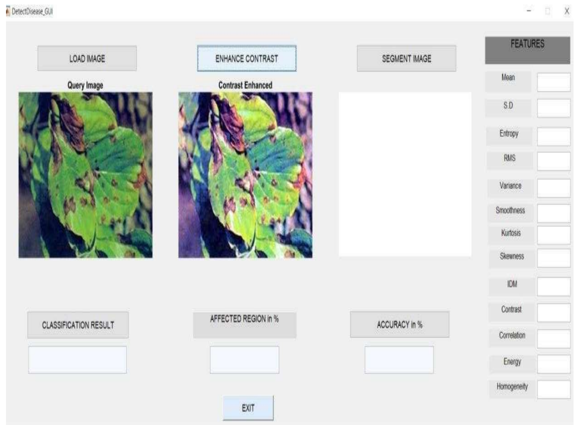

Figure 4. Contrast Enhanced Image

The detailed analysis of the defected image by applying the segmentation using k-means algorithm and varying the cluster size with the selection of the appropriate feature is represented in the Figure 5.

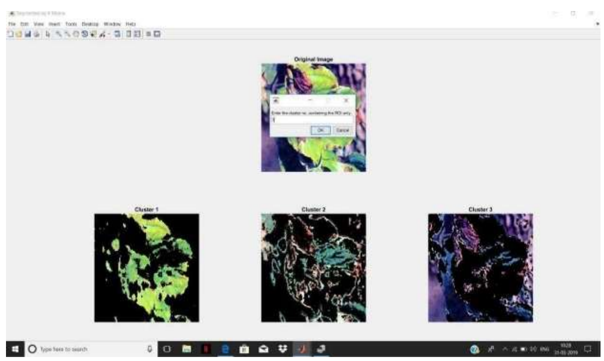

Figure 5. Results of detailed disease analysis

VII. Conclusion and Future Enhancement

The present study represents the system to detect the leaf diseases in tomato plant at the early stage. The developed prototype helps to build effective management of the diseases and prevents the potential reduce of the yield loss. The Image processing techniques have shown the prominent result in detecting the diseases. The segmentation methods using K-means algorithms have clearly identified the diseases.
The model is developed as a prototype for the present study considering only Tomato crop. In future the model could be developed to identify the leaf diseases in other crops too. The model could also be implemented using other algorithms like genetic etc., for better performance and for large volume of data.

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