Plant Disease Detection and Pesticide Spraying Robot Using IoT

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Abstract

An autonomous robot for agriculture that uses IoT technology to identify early signs of plant disease and subsequently apply pesticides locally has been developed. The system integrates visual sensing, environmental monitoring and intelligent decision-making to increase crop precision management. Leaf images taken during the robot's navigation through a field are used to determine a specific region of interest, extract structural features and classify the images using a convolutional neural network. Once the disease presence has been confirmed, the robot can apply the pesticide directly onto the affected area, thereby reducing the amount of chemicals used, as well as the amount of chemical exposure to people. Field tests have validated the robot's ability to identify diseases accurately, apply chemicals efficiently and operate consistently in various field conditions, showing a great opportunity for large-scale precision agriculture.

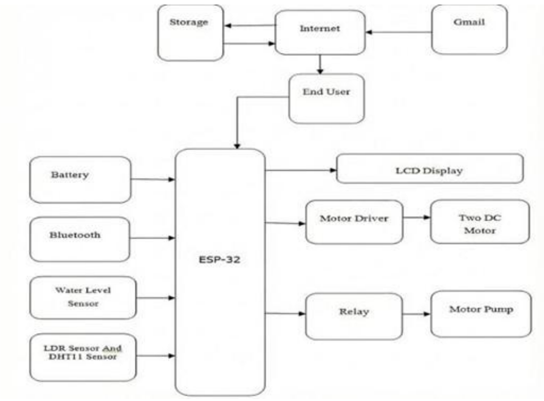
Keywords:plant disease detection,Agriculutural robotics,Internet of Things(IOT),Presision Agriculture,Computer Vision,Deep learning

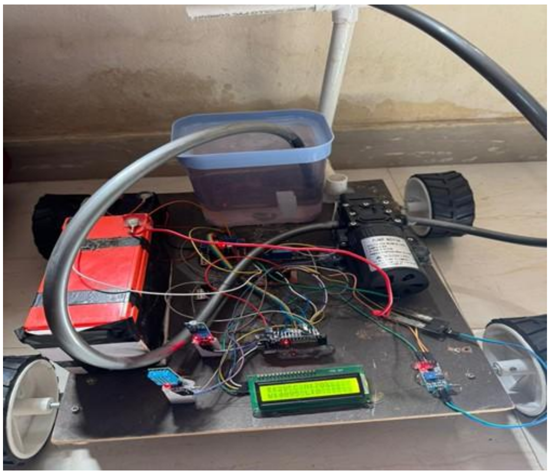
1 Introduction

Crop yields are being reduced by both pest infestations and diseases in plants. Currently, manual inspection of crops is not an effective way to monitor large agricultural areas. An automated plant disease detection and pesticide application robot uses image analysis and Internet of Things (IoT) based monitoring to track plant health. The mobile robot travels around a farm and collects images of leaves as well as environmental information about the plants. A convolutional neural network that has been trained to recognize the early signs of disease will be able to provide early warning so that action can be taken before the disease spreads to other parts of the plant. The pesticide application system will only apply pesticides to areas of a plant that are infected rather than spraying all of the plants in a uniform manner, which will lower the amount of chemicals used and the cost of pesticide applications. The data collected by the robot will be sent to a cloud based platform for monitoring, analysis, and remote management, thereby supporting sustainable farming practices.

1.1 System Implementation

The proposed system for detecting plant diseases and spraying pesticides uses an integrated Internet of Things (IoT), robotic mobility and artificial intelligence (AI) to enable real-time automated agriculture. The system operates in a closed loop starting from imaging and ending at pesticide spraying. This entire process of imaging, identification, determining action and implementing action allows the system to monitor the field continuously and intervene autonomously. The process of execution is graphically presented in Fig. a to show the logical blocks involved and the execution of a robot's physical movements on the field is shown in Fig. b. The two figures demonstrate how the system's sensing intelligence and control function together in the field.





(a) Block Diagram (b) Pesticide Spraying Robot

1.2 Hardware Architecture

An ESP32 microcontroller is responsible for all functions of the robot - collecting data from sensors, communicating with the user, and controlling all operations of robotic actuators. There are several types of sensors that were used to measure environmental conditions: a temperature and humidity sensor; a level sensor for liquid pesticides that allow for the proper and safe dispensing of pesticides; and light intensity sensors to provide information about adaptive robotic operation due to variations in sunlight. The pump is controlled by relaying switch on or off commands from the motor controller and the LCD screen keeps users informed about the current status of the robot while it is operating in the field.

1.3 Image Processing and Feature Extraction

Prior to classification, the onboard camera images of leaves undergo preprocessing steps that help increase classification reliability. These preprocessing steps include colour normalisation and resizing, providing all images with a uniform format. Detection algorithms are then used to extract the leaf portions from the more complex backdrop in the image, thus eliminating any adverse effects from other elements in the background on the analysis. Structural cues (for example, lesion boundary, vein orientation) are extracted from images using HOG. Structural cues provide essential insight into the presence of disease.

1.4 IoT Backend and User Interface

A Django-based backend server is used for the robot's software. It allows for the exchange of information (image data, sensor data, inference results) between the robot, the user interface, and archives that information for future analysis. The web dashboard provides a live view of the robot's status, environmental conditions, and any alerts regarding diseases (if needed), so that users can keep track of their robot from afar and act according to the presented information.

1 Result and Discussion

The System's performance was uniformly assessed under greenhouse and outdoor conditions. It achieved a 96% overall accuracy with a consistent level of accuracy across all disease types. In addition, the hybrid method served to minimize background interference

thereby increasing the consistent performance of the algorithm when the robot moved through an environment.
Through the use of targeted spraying methods the robot was able to apply approximately 92% spray coverage to infected areas and reduce the amount of pesticide applied by nearly 35% when compared to conventional methods of pesticide application (i.e. performing a uniform application).
The performance of this approach in providing accurate diagnosis, efficient use of resources, and reliable autonomous operation demonstrates it's real-world viability for disease management in crop systems and supports the closed-loop concept. However, some decline in performance occurred when tested in direct sunlight, with segmentation errors occurring as a result of shadows.

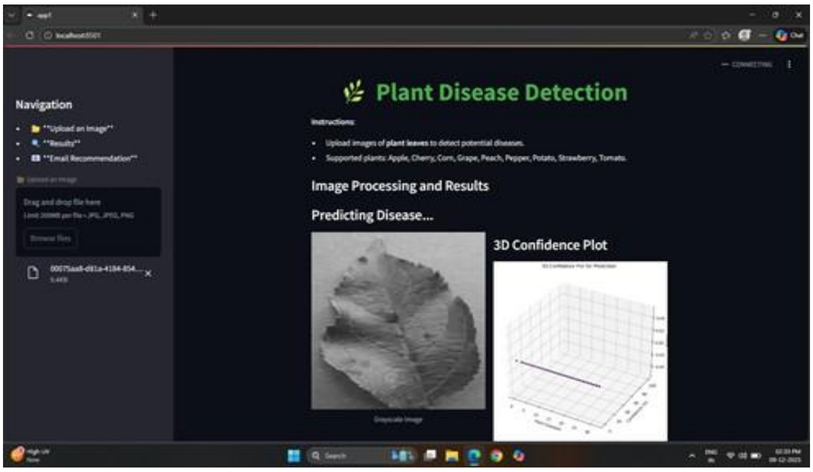


Figure 2: Software Output

2 Conclusion

The solution proposed in this study is a well-developed, functional and practicable approach for the identification of agricultural plant diseases via automated means and the exact (precision) dispensing of pesticides. An integrated learning model using these components provides significant savings in chemical inputs with an automated detection rate of 96% in various environmental conditions. The modular design allows for future expansion and development, enhancing the potential for use in sustainable, environmentally-friendly farming practices.

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4 Poject Associates Information

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