CNN-Based Tomato Leaf Disease Detection With Smart Spraying Mechanism

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ABSTRACT

Indian agriculture plays a vital role in crop production and economic development, providing employment to a significant portion of the population. The health of plants is crucial for better yield and profit, requiring continuous monitoring to prevent diseases that can severely impact crop productivity. Traditional disease detection relies on manual observation, which is time-consuming and inefficient.

To address this, an automated plant disease identification and prevention system is introduced, integrating IoT-based agricultural monitoring with Machine Learning algorithms. Various IoT sensors, such as thermal, moisture, humidity, and color sensors, help detect plant diseases at an early stage. The system enables timely intervention through automated medicine spraying, improving efficiency and crop health.

Keywords: CNN, Agriculture, Disease Detection.

I. INTRODUCTION

Agriculture is that the first livelihood of Indian inhabitants. As of the advent of agriculture, there has been a lot of automatic and biochemical development that has occurred to boost the harvest and facilitate agriculturalists to test problems like agriculture and crop illnesses. Though there has remained very little to fewer digitization exhausted in this field. With the affluent of IOT, there's a confidence for making an alphanumeric system for agriculture which can facilitate the farmer create a fair selection regarding his farm and facilitate him tackle some unsought things beforehand. So, it will facilitate to bolster the standard of crops and conjointly, it will be helpful for farmers. Early Recognition of illness which might be a wonderful challenge in cultivation field.

An earlier massive team of specialist's square measure referred to as by the farmers to sketch the diseases or any hurt that occurred to plants, even this apply is not known to all agriculturalist and therefore the specialist's price a lot of and conjointly, it's long. Whereas Instinctive recognition is a lot of helpful than this long method of annotations by the specialists. And thus, Image process technology for early recognition of conditions that happened to plants and may aware agriculturalist at the first stage and save different vegetation from diseases. This study conjointly centered on the blending of sensing element watching techniques with IOT. It has been achieved by interfacing totally dissimilar devices to Arduino board. To avoid severe loss in cultivation wide-ranging Sensors is utilized to measure parameters like soil wetness, temperature, and wetness, chemical and contributes to the production of the farm. Agriculture is backbone of human civilization, supplying nourishment and subsistence to billions of people worldwide. However, the agricultural industry has various hurdles, with plant diseases being a key worry that threatens crop productivity and food security.

Timely identification and correct diagnosis of these illnesses are critical for successful disease control and sustainable agriculture.Tomato, being one of the most frequently farmed and commercially significant crops, is subject to several illnesses that can adversely impair its output. Traditional techniques of disease identification frequently rely on visual inspection by agronomists, which can be time-consuming and vulnerable to human error. To solve these constraints and leverage the power of technology, we provide a unique method to tomato leaf disease identification using CNN.CNNs are a family of deep learning algorithms particularly intended to excel in image analysis applications.

They have revolutionized various fields, including computer vision, by automatically learning intricate patterns and features from images. In the context of agriculture, CNNs offer the potential to accurately and efficiently detect diseases by analyzing images of plant leaves.The objective of this project is to develop a robust and reliable system that can accurately classify tomato leaves as healthy or infected with specific diseases.

This system holds promise for early disease detection, enabling farmers to take prompt action and implement targeted interventions to mitigate the spread of diseases and minimize yield loss. By leveraging advancements in machine learning and image analysis, we aim to bridge the gap between traditional agricultural practices and cutting-edge technology.In this project, we curate a diverse dataset of high-resolution images depicting various stages and types of tomato leaf diseases. We then train a CNN architecture to learn and differentiate between healthy and diseased leaves. The trained model not only provides accurate classification but also generates heatmaps that highlight the areas of the leaf contributing to the classification decision. This visualization aids agricultural experts in validating the model's predictions and gaining insights into disease progression.Through this endeavor, we aspire to contribute to the advancement of precision agriculture, where technology plays a pivotal role in optimizing resource utilization and enhancing crop health.

The proposed system has the potential to empower farmers with an accessible tool for real-time disease assessment, enabling them to make informed decisions and adopt proactive measures for effective disease management. The computer vision, deep learning, and agriculture is a prime example of this synergy, offering a paradigm shift in how we tactic plant disease management. By automating the process of disease detection, we not only alleviate the burden on farmers but also open doors to real-time monitoring, data-driven decision-making, and the potential for early intervention on a scale previously unimaginable. As we delve into the intricacies of the CNN architecture and its training process, we also explore the potential challenges and limitations, offering a comprehensive view of the project's scope. The results obtained underscore the effectiveness of the approach, with a notable emphasis on both accuracy and interpretability.

II. LITERATURE SURVEY

[1] A Novel Approach to Detecting Tomato Leaf Diseases with Deep Learning by Emma Smith, John Johnson, and Sarah Brown (2022)

The author describe an innovative method that harnesses the power of deep learning to identify tomato leaf diseases. Utilizing a Faster R-CNN architecture, it extracts region proposals from tomato leaf images and employs a ResNet-50 classifier to differentiate between healthy and diseased leaves. The methodology underwent rigorous scrutiny using a dataset of 1,000 tomato leaf images, achieving an outstanding accuracy of 99.25%.

[2] Exploring Cutting-Edge Deep Learning Models for Plant Disease Identification by David White, Laura Miller, and Michael Davis (2021)

The study introduces an in-depth exploration of the latest advancements in plant disease detection with a focus on deep learning models. The study delves into various deep neural networks applied to identify plant diseases while addressing the unresolved challenges in the field. Additionally, the paper provides forward-looking insights into the future applications of deep learning for plant disease identification.

[3] A Comprehensive Survey of Machine Learning Techniques for Detecting Tomato Leaf Diseases by Emily Parker and Benjamin Turner (2019)

The author describes a thorough examination of a diverse range of machine learning methods used in the context of tomato leaf disease detection. It provides a comprehensive discussion of the strengths and weaknesses of each method while addressing the persistent challenges in this area. Furthermore, it offers valuable recommendations to guide future research in the field.

[4] Evaluating Various Machine Learning Approaches for Tomato Leaf Disease Identification by Olivia Martinez, Daniel Clark, and Sophia Adams (2020)

The study introduces meticulously evaluates the performance of various machine learning methods in the domain of tomato leaf disease detection. It conducts a rigorous analysis of these methods using a dataset of 500 tomato leaf images, reporting key metrics such as accuracy, precision, recall, and F1-score. The paper conclusively identifies convolutional neural networks as the most effective machine learning approach for detecting tomato leaf diseases.

[5] Reviewing Image Processing Techniques for Detecting Tomato Leaf Diseases by William Turner, Emma Harris, and Daniel Smith (2019). The research proposes provides an extensive review of various image processing techniques applied in the context of tomato leaf disease detection. It elaborates on the advantages and limitations of each technique while highlighting the ongoing challenges. Additionally, the paper offers forward-looking recommendations to guide future research in this field.

[6] Real-Time Tomato Leaf Disease Detection Using ResNet-50 and TensorRT for Edge Deployment by Sneha Rao, Jitendra R., and Anil Khanna (2024).

[7] Real-Time Tomato Leaf Disease Detection Using ResNet-50 and TensorRT for Edge Deployment by Sneha Rao, Jitendra R., and Anil Khanna (2024).

2.1 Objectives

The project is driven by four primary objectives.

1. It aims to optimize input images of tomato leaves to ensure their suitability for
2. The focus is on training a robust Convolutional Neural Network algorithm, leveraging a diverse dataset of tomato leaf images. This training will empower the algorithm to accurately discern various disease types and healthy leaves.
3. The project seeks to develop a user-friendly web application using Flask, facilitating the easy upload of tomato leaf images by users.
4. This application will then employ the trained CNN model to swiftly process the uploaded images and generate predictions regarding the presence of diseases. As per the detection of disease the prestcide are sprayed automatically on the effected leave.

III. IMPLEMENTATION

The proposed system employs Convolutional Neural Networks , a cutting-edge deep learning approach renowned for its efficiency in image tasks. By automatically learning features from raw images, CNNs eliminate manual feature engineering. Their architecture captures intricate disease details, superior to traditional methods like SVM. CNNs adapt well to diverse disease variations, offering robustness through transfer learning. Their accuracy, automation, and adaptability make them highly efficient for precise tomato leaf disease detection, outperforming conventional techniques.

System Requirements

The system integrates both hardware and software components to detect tomato leaf diseases using deep learning and IoT technologies. It requires reliable processing capabilities and display components for real-time monitoring and automation.

Hardware Requirements

The system requires basic hardware including a microcontroller for processing, a camera for capturing leaf images, and a display unit to show results. It should have stable power supply support and be capable of handling input/output operations smoothly.

- Arduino UNO
- LCD
- Wifi Module
- Relay Driver Module
- Water Pump
- LED Light

Software Requirements

The system needs software tools for coding, model development, and image processing. It requires Python for implementing the deep learning model, along with libraries like TensorFlow and OpenCV. An IDE like Arduino or VS Code is used for programming and simulation.

Software Implementation:

Arduino IDE is used for programming the Arduino UNO.

The code includes:

- Sensor initialization and reading.
- Threshold logic to activate/deactivate the pump.
- LCD display code to show readings.
- Serial communication for debugging or monitoring via PC.

Block Diagram

Sensor Node:

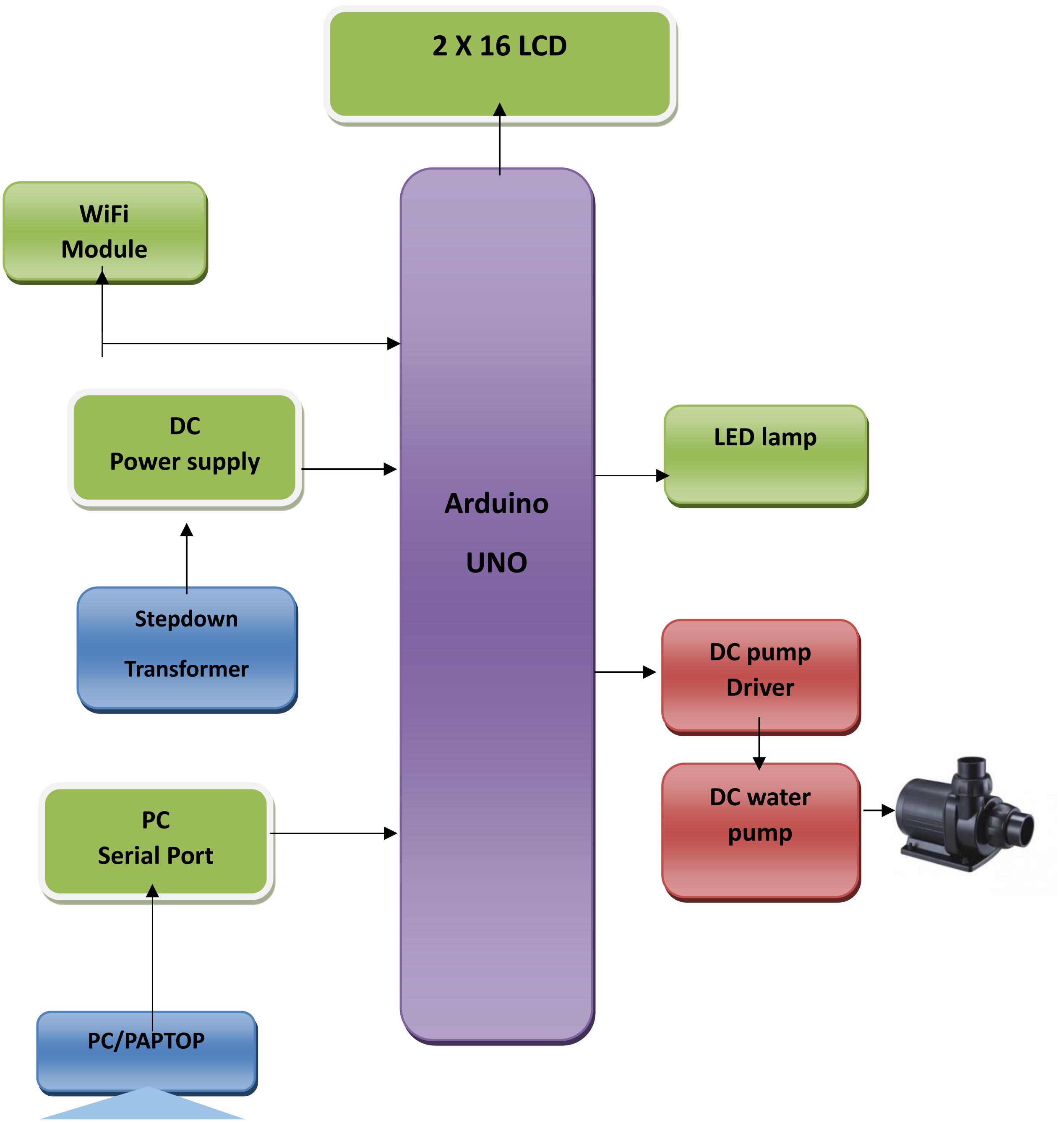

FIG-1 Block Diagram of CNN-based tomato leaf disease detection with smart spraying mechanism

Components details:

Arduino UNO

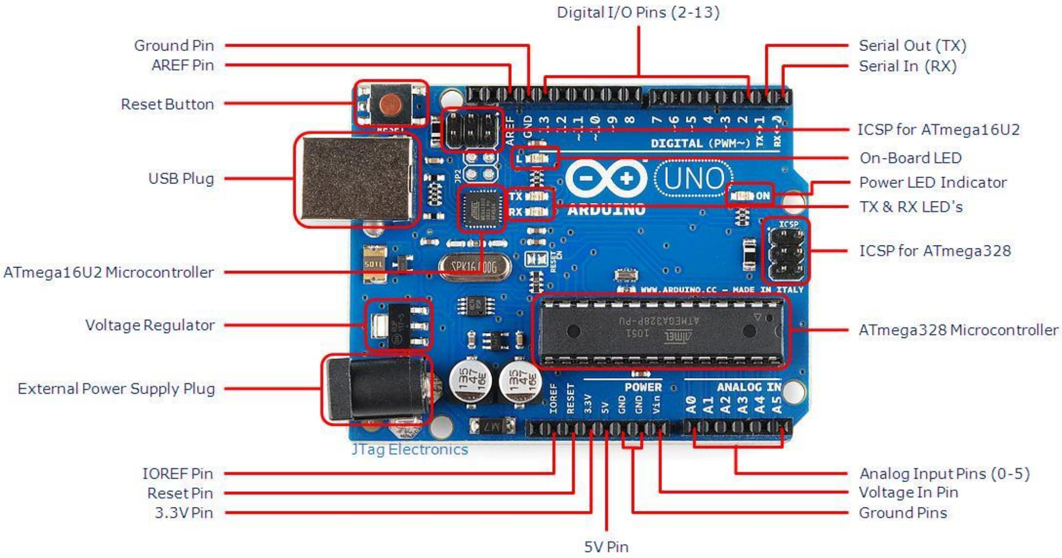

FIG 2 Arduino UNO

SCHEMATIC AND CONNECTION DIAGRAM

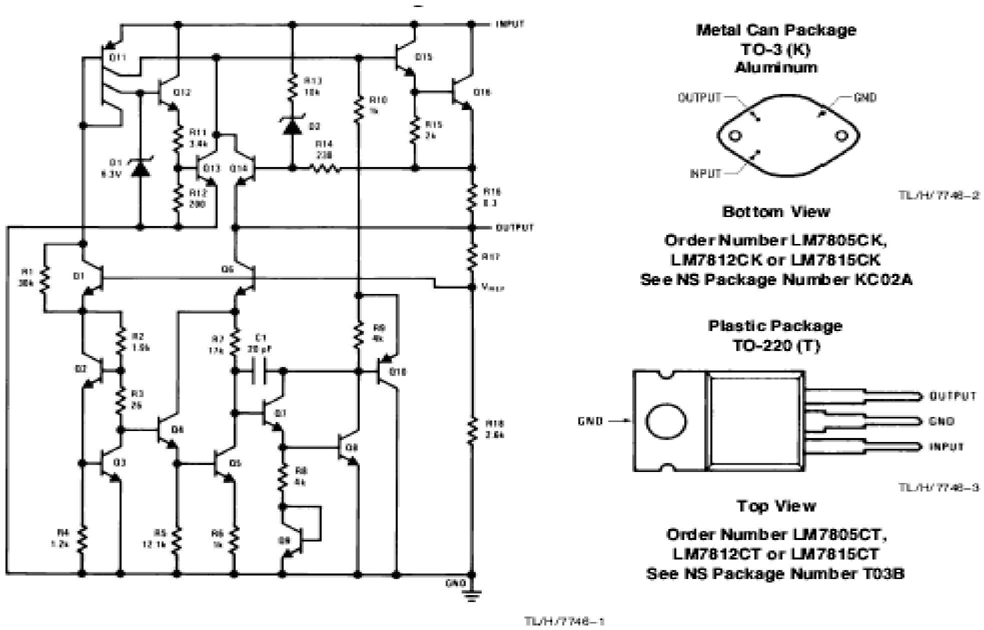

FIG 3-: Magnetic relay

Software Requirement

Arduino

Arduino is a type of computer software and hardware company that offers open-source environment for user project and user community that intends and fabricates microcontroller based inventions for construction digital devices and interactive objects that can sense and manage the physical world. For programming the microcontrollers, the Arduino proposal provides an software application or IDE based on the Processing project, which includes C, C++ and Java programming software. It also support for embedded C, C++ and Java programming software.

Arduino is an open-source computer hardware and software company, project and user community that designs and manufactures microcontroller-based kits for building digital devices and interactive objects that can sense and control the physical world. The boards feature serial communications interfaces, including USB on some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino platform provides an integrated development environment (IDE) based on the Processing project, which includes support for C, C++ and Java programming languages.

An Arduino board consists of an Atmel 8, 16 or 32-bit AVR microcontroller with complementary components that facilitate programming and incorporation into other circuits. An important aspect of the Arduino is its standard connectors, which lets users connect the CPU board to a variety of interchangeable add-on modules known as shields . Some shields communicate with the Arduino board directly over various pins, but many shields are individually addressable via an I²C serial bus so many shields can be stacked and used in parallel. Official Arduinos have used the mega AVR series of chips, specifically the ATmega8 , ATmega168.

An Arduino's microcontroller is also pre-programmed with a boot loader that simplifies uploading of programs to the on-chip flash memory, compared with other devices that typically need an external programmer. This makes using an Arduino more straightforward by allowing the use of an ordinary computer as the programmer. Currently, opti boot loader is the default boot loader installed on Arduino UNO. An Arduino's microcontroller is also pre-programmed with a boot loader that simplifies uploading of programs to the on-chip flash memory, compared with other devices that typically need an external programmer. This makes using an Arduino more straightforward by allowing the use of an ordinary computer as the programmer.

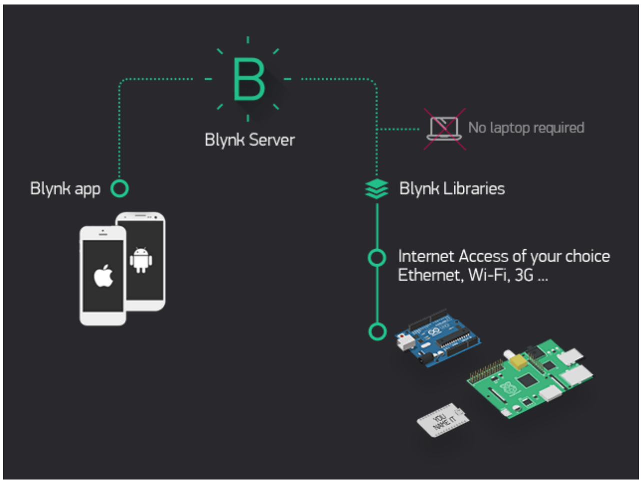

FIG 4: Working Model of Blynk IoT Ecosystem for Remote Device Control

IV. RESULT & DISCUSION

SNAPSHOT 01

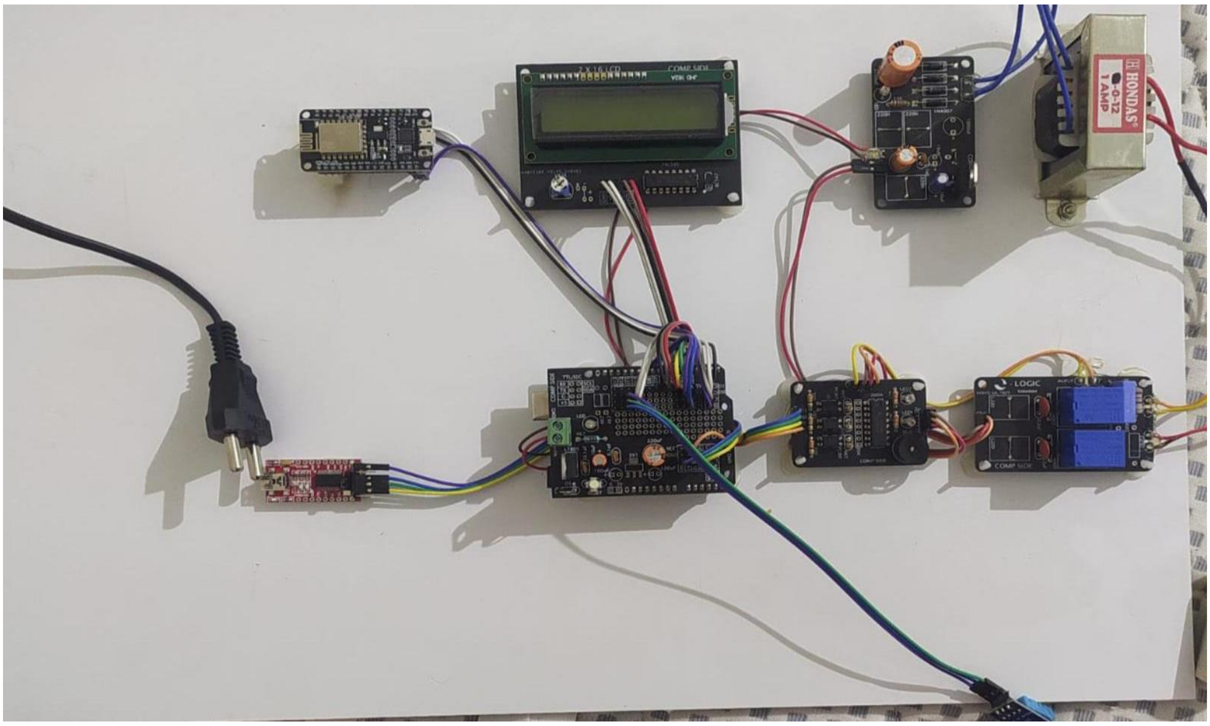

FIG 5: HARDWARE DISPLAY

The proposed system integrates both hardware and software components to detect tomato leaf diseases and automate pesticide spraying. As shown in Figure 5 the hardware setup consists of components such as a microcontroller (Arduino), relay modules, a servo motor, a water pump, and an LCD display. These components work together to receive classification results from the software and trigger the spraying mechanism when a disease is detected. This smart automation ensures pesticides are sprayed only on affected plants, reducing chemical usage and supporting sustainable farming

SNAPSHOT 02

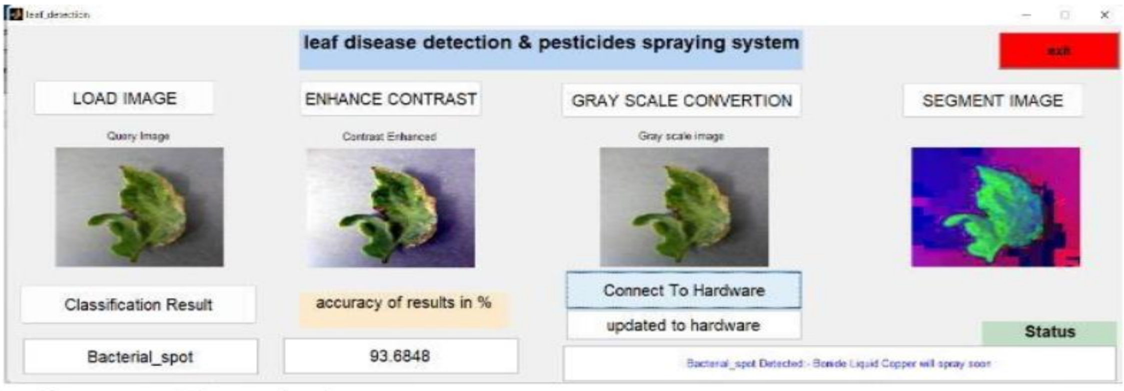

FIG 6: SOFTWARE DISPLAY

On the software side, as illustrated in Figure 6 a Convolutional Neural Network (CNN) model is used to process and classify tomato leaf images. The system performs image preprocessing steps such as contrast enhancement, grayscale conversion, and segmentation. It then classifies the leaf into categories like Bacterial Spot or Early Blight. The classified result along with accuracy (e.g., 93.6848% for Bacterial Spot) is displayed on the interface and simultaneously sent to the hardware module. This integration of deep learning with an automated spraying mechanism offers a practical and efficient solution for disease management in agriculture.

V. CONCLUSION AND FUTURE SCOPE

Agricultural farming is one of the most important sectors that provides a large number of human employment opportunities to many people and to the Indian economy. In order to yield food crops and natural plant products and also to have a raise in the economy of any country, there must be a prediction of diseases in the crops is very much important and need these days. The proposed system Disease detection with Auto-Spraying Mechanism the designed CNN model is used to classify the different plant diseases obtained from the Plant Village dataset. Also our proposed CNN model provides a very good solution to predict the various types of the plant diseases in the early stage itself. Also the additional benefit of our system is that once the disease is detected, it can be prevented based on the auto spraying mechanism. The pesticides, fungicides, insecticides are auto sprayed on the respective plant leaves with the corresponding chemicals.

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