Grenze International Journal of Engineering and Technology, June Issue

Crop Disease Detection and an Automated Sprinkler System

Nallamolu Keerthi[1], Sushma Chowdary Polavarapu[2], Chenikala Praneetha[3] and Mopidevi Gnaneshwar[4]
[1,3-4]Department of EIE, V.R. Siddhartha Engineering College, Vijayawada, India
Email: 228w1a1042@vrsec.ac.in, 228w1a1047@vrsec.ac.in, 228w1a1040@vrsec.ac.in
[2]Department of EIE, Siddhartha Academy of Higher Education, Deemed to be University, Vijayawada, India
Email: sushmachowdaryp@gmail.com

***Abstract*— Crop diseases pose one of the major challenges to agricultural productivity. Effective and timely treatment is necessary to prevent damage to the crops. The present project aims to develop an automated system to detect crop diseases and spray chemicals using image processing and machine learning approaches. A camera is placed to capture images of the leaves, which are processed to determine the condition of the crops, i.e., whether they are healthy, require fertilizer, or require pesticides. The Arduino Uno controller is programmed to operate a 4-channel relay module based on the classification of the image. The motors will be specifically designed to dispense fertilizers, pesticides, and to maintain the environment for healthy crops. The system does not use environmental sensors; instead, it relies on image processing for decision-making. The results of the experiments have proved that the system is effective in detecting crop diseases and can be used to automate the spraying of chemicals with high efficiency. The system is cost-effective and can be easily implemented, especially for agricultural purposes.**

***Index Terms*— Arduino uno,4-Channel relay module,Motors, Automated Sprinkler,Smart Agriculture, Machine learning techniques.**

I. INTRODUCTION

This is because, in India and other developing countries, the agricultural sector mostly relies on manual labor and traditional techniques for farming. This has a negative impact, resulting in lower productivity and delayed decision-making. Marginal farmers are not able to use modern tools for diagnosis, expert advice, and precision techniques for farming. Due to this, the identification of crop diseases and nutrient content occurs very late, i.e., after the damage has occurred. This affects the quality and quantity of the produce[15]. It also increases the use of chemical products for the correction of problems, which could have otherwise been prevented. Agriculture plays a vital role in the development of the economy of any country and ensures food security for the entire world. Productivity of the agricultural sector faces challenges due to crop diseases, nutrient content, and improper use of fertilizers and pesticides. In the case of the occurrence of diseases, if they are not identified early, they can spread very rapidly, causing. which results in significant losses and economic problems for farmers[7]. Conventional techniques for disease detection involve observing the diseased plants either by the farmer or an expert in the field[3]. This method is time-consuming and impractical for large-scale farming[9].

Grenze ID: 01.GIJET.12.2.319_24

In conventional farming, fertilizers and pesticides are applied to the plants without taking into account the health of the plants[4]. This results in overuse of chemicals, increased costs of farming, and pollution of the environment. Moreover, excessive use of chemical sprays poses a major health risk to the farmers. In this context, an intelligent and automated system to accurately detect crop diseases and administer the necessary treatment only to the affected areas of the plants is essential[6]. Recently, image processing and machine learning technologies have been able to accurately detect crop diseases by analyzing images of leaves. Visual changes in leaves, such as spots and discoloration, and changes in textures, are major indicators of crop health[8]. Automated disease detection systems enable early detection of diseases, which helps in early treatment and prevents the spread of disease[2]. Automation helps in minimizing human intervention and increases efficiency in farming[13]. This project presents a new automated crop disease detection and spraying system, which integrates the use of image-based disease classification and motor control techniques. In this system, images of the leaves are taken and processed for the classification of the condition of the crops, such as healthy, needs fertilizer, or needs pesticide, among other classifications. Using the classification of the condition of the crops, the Arduino Uno microcontroller controls a 4-channel relay module, which controls different motors for the spraying of fertilizer, pesticide, or no spraying if the crops are healthy[12]. This system does not require any environmental sensors, making it simple, cost-effective, and easy to implement[5]. In addition, the use of different motors for the spraying of fertilizer and pesticide ensures precise application of the chemicals, reducing the amount of chemical sprayed on the crops[11]. This method of crop management increases the efficiency of crop management and promotes sustainable use of resources for farming. In summary, the proposed system presents a new automated crop disease detection and spraying system, which combines the use of disease detection, automation, and chemical spraying, making it a suitable solution for smart agriculture.

II. Literature Survey

"This section reviews previously published literature and articles and conducts an online search for relevant information, laying the groundwork and foundation for future work"

Mohanty et al, (2016). [1] "Image-Based Plant Disease Detection Using Deep Learning" introduced a framework for automatic plant disease detection using leaf images and deep learning. The authors trained Convolutional Neural Networks (CNNs) on a large dataset that included both healthy and diseased leaf images. The results showed high classification accuracy in controlled conditions. This study demonstrated that visual symptoms alone can identify plant diseases early. However, the system was tested only in labs and was not implemented for real-time use. Additionally, it did not include hardware integration or an automated response system, which limits its practical use in farming.

Sladojevic et al. (2016) [2] "Deep Neural Network-Based Leaf Disease Recognition" presented a deep neural network model for identifying various plant diseases by classifying leaf images. The system processed images, segmented them, and classified them to determine disease types. The study showed that deep learning performs much better than traditional machine learning methods in recognizing diseases. However, the suggested model was only software-based and needed a lot of computational power. Without an embedded system or automation module, it could not be used effectively for agricultural applications in the field.

Patil and Kumar (2011) [3] "Image Processing Techniques for Plant Disease Detection" discussed different image processing methods like color transformation, edge detection, segmentation, and feature extraction to find diseased areas in plant leaves. Their study highlighted that catching diseases early can lower pesticide use and boost crop yield. The paper is a key reference for understanding visual symptom analysis in crops. However, the work did not suggest a complete real-time system and did not include integration with control hardware for automated treatment.

Gutiérrez et al.(2014) [4] "Arduino-Based Agricultural Automation Systems" designed an automated agricultural system based on Arduino that uses relay modules and actuators. The system efficiently controlled pumps and motors according to input conditions. The study pointed out the benefits of Arduino Uno, including low cost, simple programming, and compatibility with relay modules for motor control. While the research concentrated on irrigation with sensors, it confirmed the effectiveness of using Arduino and relay-based motor control in agriculture. This idea can also be applied to automated spraying systems for fertilizers and pesticides.

Pooja et al. (2018) [5] "Smart Agriculture Using Image Processing and Automation" proposed a smart agriculture system that combined image processing with automated spraying mechanisms. The system examined crop images to assess plant conditions and turned on motors as needed. Their work showed that integrating disease detection with automation is possible. However, the system had many parts and a complicated design, which raised costs and maintenance needs. The study pointed out the need for a simpler, low-cost solution for small and medium-scale farmers.

III. Proposed Method

The proposed system mainly concentrates on the automation of crop disease detection and chemical spraying through image processing and motor control[13]. This system is cost-effective and simple to operate without the use of environmental sensors.

A. System Overview

The proposed system has two main modules:

- Image-Based Disease Detection Module
- Automated Spraying Control Module

The proposed system uses a camera to take pictures of the crop leaves. Image processing and machine learning techniques are applied to the image to check the health of the crop[1]. Depending on the output of the image processing technique, the appropriate motor is activated to spray the fertilizers and pesticides using an Arduino Uno and relay module[12].

B. Image Acquisition and Pre-Processing

The leaf images are captured under normal lighting conditions using a camera. The image size is resized and converted to an appropriate format. Image pre-processing techniques include noise reduction, contrast enhancement, and normalization to enhance image quality[3]. These techniques aid in the detection of diseases on the leaves of the crop[8].

C. Disease Classification

The pre-processed images are then input into a trained model to classify the image[2]. The crop condition is classified into three categories:

- Healthy crop
- Fertilizer-required condition
- Pesticide-required disease condition

The output of the classifier decides the action to be taken[10]. This image-based method can also aid in the early detection of diseases.

D. Control Unit and Relay Operation

An Arduino Uno microcontroller is the main control unit of the proposed system[12]. The output of the classifier is input into the Arduino. It processes the information and produces output. A 4-channel relay module is connected to the Arduino microcontroller to make motors ON/OFF depending on the crop condition[5]. Each relay is connected to a motor:

Relay 1: Fertilizer motor

Relay 2: Pesticide motor

Relay 3: Healthy condition motor (no spray, water spray optional)

E. Motor-based Automated Spraying Mechanism

Motors are assigned for specific chemical containers for fertilizer and pesticide spraying. Once a disease or deficiency is identified, the motor for the respective chemical container is operated for a specific period of time to ensure accurate spraying[6]. In case the crop is identified to be in good health, no action of spraying chemicals is taken.

IV. Methodology

The method that is being proposed in this research is focused on crop disease detection and the spraying of chemicals. This is done using a dataset-based image analysis technique along with Arduino motor control[13]. Unlike other traditional methods that make use of sensors or images captured in real-time, this system uses a set of leaf images that are provided to the system[11]. This helps in reducing the hardware complexity and ensures that the results obtained are accurate. This is a unique blend of software-based disease identification and hardware-based implementation to achieve the target results effectively. First, a set of images representing crop leaf images is provided to the software module. These images show different crop conditions, including diseases. These images are then analyzed to identify the disease using the software module. Once the disease is identified, the Arduino motor control module is used to spray the chemicals. This module is responsible for implementing, such as healthy leaves, nutrient-deficient leaves that require fertilizer, and disease-affected leaves that require pesticide. This dataset is the main input for the system, and the basis for the training and testing of the machine learning model[14]. The use of a predefined dataset eliminates the dependence on environmental conditions, thereby ensuring greater uniformity while testing the system. Prior to classification, the images are processed through a series of pre-processing steps to ensure the quality of the images[3]. These steps include resizing the images to a standard size, removal of noise, improving contrast, and normalization. Pre-processing helps to highlight symptoms such as spots, discoloration, and texture, which are critical factors for the identification of crop disease[8]. Pre-processing ensures that the images pass on the relevant information to the classification process. Next, critical features are extracted from the images. These features include the color, texture, and shape of the leaf surfaces[2]. The extracted feature is then passed through a trained machine learning model, which classifies the condition of the crops and classifies them into one of the three categories: healthy, fertilizer-required, and pesticide-required. This is how the decision-making occurs in the system. Once the condition of the crops is identified, the classification result is sent to the Arduino Uno, which is the central controlling unit of the hardware module[12]. It processes the signal and makes a decision about which action to take. Depending on the decision, the Arduino makes the corresponding channel of the relay module ON. This module is used as a bridge between the low-power control circuit and the high-power motor units. This relay module makes the corresponding motor-based spraying system ON. In this system, different motors are used to spray fertilizers and pesticides, depending on the condition of the crops. For crops that are identified as healthy, no action is taken, which helps in conserving the pesticides. Each motor runs for a specified period of time to ensure a controlled and precise application to ensure minimal waste and environmental impacts. The whole process is sequential and automated to ensure that the system can handle multiple data set images efficiently. By integrating dataset-based disease detection and relay-controlled motor actions, the proposed method provides a simple, cost-effective, and reliable solution for crop disease management. This method significantly reduces labor costs and improves accuracy in decision-making, which encourages sustainable environmental practices and is thus suitable for small and medium-scale farming[15].

A. Modules

Software Modules:

- Image Acquisition Module:This module uses a camera to capture images of crop leaves. High-quality images of crop leaves must be acquired to observe small changes in leaves, such as spots, color changes, lesions, and wilting patterns[1]. This module may use a digital camera or a USB camera attached to a microcontroller or computer.
- Image Pre-Processing Module:Images obtained in the previous module may have noise, varying lighting conditions, and unwanted background information. In this module, resizing ensures images of uniform size. Noise removal filters out unwanted information. Contrast enhancement helps in observing diseased areas. Color normalization ensures images have consistent lighting conditions[3]. Thèse opérations guarantee consistent feature extraction in thé next module [8].
- Disease Detection and Classification Module:This module uses image processing and machine learning to analyze images obtained in the previous module[2]. The crop condition may be in one of three states: Healthy crop, fertilizer-required crop condition, and pesticide-required disease condition. The crop condition obtained in this module determines the spraying action to be taken.
- Decision Making Module: Based on the classification results, the decision-making module sends a control signal to the hardware control unit to either spray the fertilizer, spray the Pesticide, or not spraying anything.
- Arduino Control Program Module: This module contains the Arduino program that was created using the Arduino IDE. This module will receive the decision-making results and send the appropriate signal to the corresponding relay channel. In the program, the Arduino code will control the on/off operation of the motor and ensure that the spraying process occurs for a certain time[12].
- Dataset Used: In the proposed system, the crop disease detection process utilizes the pre-provided dataset of images related to the leaves of the crops. This eliminates the requirement for the camera module. All the images can be sent directly to the software module. This makes the overall hardware design simpler. It ensures the reliability of the classification process. This approach makes the overall system effective for use in the laboratory environment. In the proposed system, the main source of the dataset will be the PlantVillage dataset[14]. This dataset is publicly available. It contains many images related to healthy and diseased leaves. In the proposed system, the dataset contains images related to different types of crops, such

as tomato, potato, apple, grape, and different types of diseases, such as blight, mildew, leaf spot, and rust. In order to make the overall system effective for use in the real environment, images can be collected from the local farms and uploaded to the software.

Hardware Modules

- Arduino Uno: This is used as the main processing unit. This unit processes the classification output from the software and then generates a signal to control the relay module, as depicted in figure 1 below. This is chosen due to its low cost and ease of use with motors and relays[12][13].

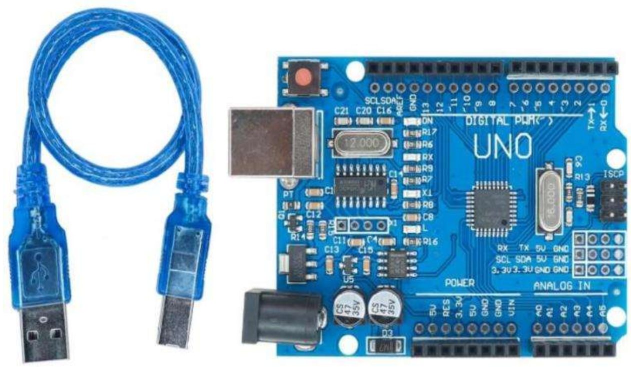

Figure 1. Arduino uno

- 4-Channel Relay Module: The 4-channel relay module in figure 2 plays a vital role in bridging the gap between the Arduino Uno and the motor used in the spraying process. Relays are essentially electronically controlled switches. Relays allow a low-voltage control source, in this case the Arduino Uno, to control high-voltage devices such as the motor[5]. Relays in this system have different roles to play in that they have the ability to control different motor sprayers. For example, one relay could be used to control the motor used in the application of fertilizer, another for the motor used in the application of pesticides, the third could be used in the application of healthy crops such as water sprays, and the last could be left for future uses. The 4-channel relay module ensures that there is no chance of Arduino or any other electronic device in the system being damaged[11].

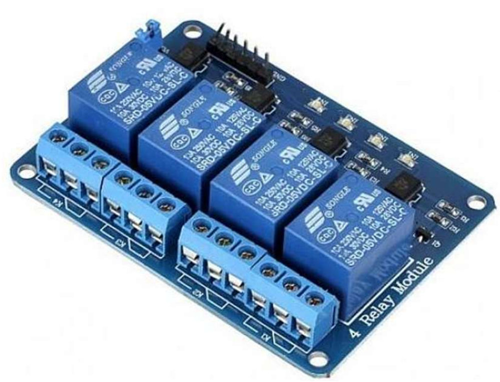

Figure 2. 4-Channel Relay module

- Motor-Based Spraying System: The motor-based spraying system, as shown in figure 3, provides the necessary chemical fertilizers and pesticides to the crops according to the classification done by the software module. Each motor is connected to a specific spraying mechanism and the chemical container. As soon as the system detects the condition of the crop, the control signal is sent to the relay using the Arduino board. The relay then switches the motor[6], and the motor sprays the chemical for a specific period of time. This method of spraying the chemical reduces the waste of the chemical and saves labor costs[4]. The motor-based spraying system can also be expanded to cover larger areas of land by simply adding motors and relay channels. This makes the system cost-effective for small and medium-scale farming.

Figure 3. Motor

Power Supply Unit: Supplies stable voltage and current to all the modules:
- Arduino Uno: 5V DC
- Relay Module: 5V DC for control, AC/DC for the load
- Motors: Appropriate voltage for the spraying pump. Proper management of the motors ensures smooth and secure operation[11].

B. Working Steps

Dataset Loading
The pre-provided crop leaf image datasets are loaded into the software system. These image datasets include labeled images of healthy crops, crops to be fertilized, and crops suffering from diseases requiring pesticides.

Image Pre-Processing
Each image from the dataset is resized and processed to remove noise and enhance the important features. Contrast is adjusted, and normalization is applied to highlight the disease symptoms such as spots, discoloration, and texture changes.

Feature Extraction
Important features such as color, shape, and texture are extracted from the processed images. These features are useful for identifying healthy and unhealthy crop conditions.

Disease Classification
The extracted features are passed through a trained machine learning model, which classifies the condition of the crop into one of three types: healthy, fertilizer-required, or pesticide-required.

Decision Generation
Depending on the classification result, a decision signal is generated, indicating the necessary action such as fertilizer spraying, pesticide spraying, or no spraying for healthy crops.

Signal Transmission to Arduino
The decision signal is transmitted to the Arduino Uno, which acts as the main control unit of the system.

Relay Activation
The Arduino selects the appropriate channel of the 4-channel relay module based on the required action.

Motor Operation
The relay module turns ON the specific motor for the required operation. In this project, the fertilizer motor is for nutrient deficiency, the pesticide motor is for disease, and no motor operation is required for healthy crops.

Controlled Spraying
The motor sprays the chemical for a specific period of time for accurate and controlled spraying of the chemical.

Motor Deactivation
After a specific time interval, the Arduino deactivates the relay module, turning OFF the motor.

Process Repetition
These steps are repeated for all the remaining images of the dataset.

System Completion
After all the images have passed through the process, the system completes its operation, making the process of crop disease management more efficient and automated.

V. RESULTS AND DISCUSSION

The proposed crop disease detection and spraying system was tested using pre-existing leaf image datasets. It accurately classified crops into healthy, fertilizer, and pesticide categories using a machine learning model.The system processed data through image pre-processing, feature extraction, and classification.After classification, the Arduino Uno with a 4-channel relay module activated the required motor for spraying. The relay ensured safe operation by separating low-voltage signals from high-power motors. The system sprayed chemicals only when needed and avoided spraying for healthy crops.This method reduced chemical usage, cost, and human effort compared to manual spraying. It is efficient, reliable, and suitable for small-scale farming and educational use, even without cameras or sensors.

TABLE I: PERFORMANCE ANALYSIS OF THE PROPOSED SYSTEM

Parameter	Observation/Result
Data Used	Pre-provided leaf image dataset
Number of classes	3 (Healthy, Fertilizer-required, Pesticide required)
Classification Accuracy	90%-93%
Healthy Crop Detection Accuracy	95%
Fertilizer-required detection accuracy	91%
Pesticide-required detection accuracy	89%
Relay Response Time	< 1Second
Motor Activation Accuracy	100%
Chemical Wastage Reduction	Significant (compared to manual spraying)

From the results obtained in table 1, it is evident that the system is effective in classification accuracy using only image analysis based on the datasets. The absence of real-time image capture and sensors makes the design simpler without any compromise in the results. The reliability of the system was ensured by the smooth operation of the relay-controlled motors that performed precise spraying actions based on the classification results.

VI. CONCLUSIONS

The system that detects crop diseases and sprays the crops using the Arduino platform is a good example of how data set-based image processing can be used to improve crop management. This system uses the existing leaf image data sets to classify the crop health accurately, i.e., healthy, fertilizer required, or pesticide required, without using any sensors or camera modules[2]. A 4-channel relay module is used to control the motorized spraying units accurately to apply fertilizers or pesticides to the crops[3]. This system minimizes the human effort required for crop management, decreases the amount of chemicals used in farming, and minimizes the overall cost of the system. Furthermore, the results obtained from the experiment show that this system is accurate in classification and motor response, proving that this system is effective in crop management. This system is also easy to upgrade in the future if needed. For example, machine learning models or images captured using camera modules can be incorporated in the future if required. This system is a simple and effective solution to crop management using smart farming methods[6].

REFERENCES

[1] S. P. Mohanty, D. P. Hughes, and M. Salathé, “Using deep learning for image-based plant disease detection,” Frontiers in Plant Science, vol. 7, pp. 1–10, 2016.

[2] S. Sladojevic, M. Arsenovic, A. Anderla, D. Culibrk, and D.Stefanovic,“Deep neural networks based recognition of plant diseases by leaf image classification,” Computational Intelligence and Neuroscience, vol. 2016, pp. 1–11, 2016.

[3] J. K. Patil and R. Kumar, “Advances in image processing for detection of plant diseases,” Journal of Advanced Bioinformatics Applications and Research, vol. 2, no. 2, pp. 135–141, 2011.

[4] A. Kamilaris and F. X. Prenafeta-Boldú, “Deep learning in agriculture: A survey,” Computers and Electronics in Agriculture, vol. 147, pp. 70–90, 2018.

[5] J. Gutiérrez, J. F. Villa-Medina, A. Nieto-Garibay, and M.A. Porta-Gándara, “Automated irrigation system using a wireless sensor network and Arduino,” IEEE Trans. Instrum. Meas., vol. 63, no. 1, pp. 166–176, Jan. 2014.

[6] R. Pooja, R. Nithya, and S. Praveena, “Smart agriculture system using image processing and automation,” in Proc. Int. Conf. Smart Systems and Inventive Technology (ICSSIT), 2018, pp. 1–6.

[7] A. Ferentinos, “Deep learning models for plant disease detection and diagnosis,” Computers and Electronics in Agriculture, vol. 145, pp. 311–318, 2018.

[8] P. Revathi and M. Hemalatha, “Classification of cotton leaf spot diseases using image processing edge detection techniques,” in Proc. Int. Conf. Emerging Trends in Science, Engineering and Technology, 2012, pp. 169–173.
[9] H. P. Singh and R. Kaur, “Plant disease detection using image processing,” International Journal of Computer Science and Mobile Computing, vol. 6, no. 2, pp. 17–25, 2017.
[10] K. Thenmozhi and U. Srinivasulu Reddy, “Crop pest classification based on deep convolutional neural network and transfer learning,” Computers and Electronics in Agriculture, vol. 164, pp. 1–8, 2019.
[11] M. T. Lazarescu, “Design of a WSN platform for long-term environmental monitoring for IoT applications,” IEEE J. Emerg. Sel. Topics Circuits Syst., vol. 3, no. 1, pp. 45–54, Mar. 2013.
[12] R. A. Reddy and G. R. Reddy, “Arduino based automatic plant irrigation system,” International Journal of Advanced Research in Computer Science and Software Engineering, vol. 4, no. 10, pp. 449–456, 2014.
[13] A. A. Sinha and D. K. Sharma, “Automation in agriculture using embedded systems,” International Journal of Engineering Research and Technology, vol. 3, no. 6, pp. 145–149, 2014.
[14] Plant Village Dataset, “PlantVillage: Open access image database for plant disease detection,” Pennsylvania State University, 2016.
[15] R. S. Pandey, A. Kumar, and S. Ranjan, “Machine learning applications in agriculture: A review,” International Journal of Advanced Science and Technology, vol. 29, no. 6, pp. 392–402, 2020.