Smart Irrigation system for Marigold

A Project Report

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in partial fulfilment of requirements for the completion of the project work of DS3001-prototyping and testing course

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CERTIFICATE

This is to certify that the report titled “Smart irrigation system for marigold” of Project Report, submitted by student Team no: 24(Thursday Batch), Sk Arian Islam(CS21B1023), Basab Ghosh (CS21B1068), E. Saileswara Reddy (CS21B1078), Devanjaan Sarkar (ME21B1068), to the Indian Institute of Information Technology, Design and Manufacturing Kancheepuram, for the completion of project work for course titled ‘DS3001 – Prototyping and Testing’ is a bona fide record of the work done by the student team under my supervision and the work is satisfactory for the completion of the course. The contents of this report, in full or in parts, have not been submitted to any other Institute or University for the award of any degree or diploma.

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ABSTRACT

Keyword: Smart Agriculture, IoT, Machine Learning

The project aims to tackle issues with smart irrigation systems in marigold cultivation by presenting a comprehensive framework for precision agriculture utilizing IoT and machine learning methodologies. It comprises two main elements: The hardware and The web application designed to detect diseases in marigold flowers.

In the hardware segment, data is collected from the field and analyzed to determine watering requirements, subsequently triggering the water pump and notifying the user accordingly. Additionally, users are furnished with a dashboard to monitor field variables.

The web application offers an intuitive interface enabling users to upload photos of marigold flowers for disease identification, facilitating appropriate treatment measures.

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1. Introduction

The country has exported 21024.41 MT of floriculture products to the world for the worth of Rs. 707.81 Crores/ 88.38 Million USD in 2022-23. Major Export Destinations (2022-23): The U.S.A, Netherlands, United Arab Emirates, U.K. Germany, and Malaysia were major importing countries of Indian floriculture during the same period. Due to rising disposable income, lifestyle changes, and Government initiatives India's Flower market is on the rise. Still, the flower market has more potential and the introduction of technologies will certainly help lift per hectare growth of flowers. The problem statement is "SMART IRRIGATION SYSTEM FOR MARIGOLD ''. From the name we can see that we are specifically targeting the Marigold market in India. Our product aims to increase the productivity of marigolds by leveraging IoT and Artificial Intelligence. Our system takes key measurements(temperature, moisture), and based on that it waters plants to mitigate any disruption in production. It also makes sure that the pH remains between 6.5 to 7 which is optimal for marigold agriculture. Studies have also figured out that disease and lack of its treatment is one of the contributing factors in reducing productivity, so it comes with an app that can detect 9 common diseases namely(Alternaria Leaf Spot, Aster Yellows, Bacterial Leaf Spot, Botrytis Blight, Fusarium Wilt, Root Rot, Septoria Leaf Spot, Tomato Spotted Wilt Virus, Verticillium Wilt) in a marigold flower/leaf.

2. Literature Review

The need for IoT-based solutions has gotten attention due to the scarcity of water. It has led to the development of various open-source solutions (Dr. S. Velmurugan et. al [1]). Addressing challenges in Indonesia's horticulture sector, Kaburan et. al [2] proposes an IoT-based micro-climate monitoring system integrated with automated intelligence. By collecting and analyzing data on soil, water, air, and plant conditions, this system aims to optimize productivity and quality while mitigating the impact of climate variability on crop yields. Integration with Indonesia's weather agency enhances the system’s effectiveness in providing actionable insights for farmers. Sustainable agriculture, crucial for preserving natural resources and reducing greenhouse gas emissions, faces challenges in India, where despite increased agronomic output, the number of farmers is dwindling due to various factors. The advent of digital connectivity offers opportunities to bridge this gap and enhance agricultural productivity. However, challenges such as limited arable land availability, fragmented land use, and heterogeneous crop characteristics necessitate innovative technology-driven solutions like wireless sensor networks. These technologies enable precise monitoring and remote management of crops, optimizing yield production while minimizing ecological impact [3] [4] [5]. In a comprehensive meta-analysis conducted by Goldstein et. al [6] spanning 81 studies and 836 paired observations, the response of various crop types’ water use efficiency (WUE) to drought was assessed. Findings indicate a nuanced relationship, with cotton showing promise for cultivation in hyper-arid or arid regions, while legume crops may not be suitable for drylands without irrigation infrastructure. This analysis provides valuable insights into crop selection strategies tailored to different dryland environments, laying the groundwork for effective agricultural management amidst changing climatic conditions. The study paved the way for the proposed product to find its customers and is important for the success of the product. Machine Learning (ML) has revolutionized the capabilities of IoT systems, particularly in empowering agriculture systems. Classical ML algorithms like Random Forest, KMeans clustering, Decision Tree, and Regression techniques have been integrated into IoT frameworks to enhance their effectiveness. These algorithms enable IoT systems to analyze vast amounts of data collected from various sensors deployed in agricultural fields, providing valuable insights into crop health, soil conditions, weather patterns, and pest infestations. For instance, Random Forest algorithms can predict crop yields based on historical data and environmental factors, while Decision Trees can classify crops based on their health status. KMeans clustering helps in identifying patterns and grouping similar data points, aiding in precision agriculture practices such as targeted irrigation and fertilization. Regression techniques allow for the prediction of future trends and optimization of resource utilization. By leveraging the power of ML, IoT systems in agriculture can optimize decision-making processes, improve productivity, and ensure sustainable agricultural practices [7] [8].

3. Gaps in existing Solution

The burgeoning field of IoT in smart agriculture has seen a proliferation of research papers, yet a critical gap exists in explicitly modeling the intricate relationship between soil temperature, moisture levels, and water requirements, particularly concerning specific crops such as marigold flowers. Despite the wealth of literature, there remains a conspicuous absence of standardized datasets and algorithms tailored to detecting diseases in crops. Previous studies often focus on isolated aspects of agricultural IoT, offering piecemeal solutions rather than comprehensive frameworks. Moreover, the discourse largely neglects discussions on system vulnerabilities, leaving potentially catastrophic circumstances unaddressed. In response to these deficiencies, our proposed product endeavors to bridge these gaps by offering a holistic approach that integrates advanced modeling techniques to elucidate the pH-moisture-water nexus introduces novel datasets and algorithms for disease detection in marigold flowers, and underscores the importance of addressing systemic vulnerabilities to ensure the robustness and resilience of agricultural IoT systems. Our research underscores the imperative for a more nuanced and comprehensive approach to IoT implementation in smart agriculture, one that moves beyond the confines of simplistic solutions and embraces the complexities inherent in agricultural ecosystems. By explicitly addressing the interplay between soil parameters and water requirements, particularly in the context of specific crops like marigold flowers, our proposed framework aims to enhance precision agriculture practices and optimize resource utilization. Furthermore, by introducing novel methodologies for disease detection and emphasizing the identification and mitigation of system vulnerabilities, our research seeks to bolster the resilience of agricultural IoT systems against potential disruptions. Through this multifaceted approach, we endeavor to contribute to the advancement of agricultural IoT research and pave the way for more robust and sustainable farming practices in the face of evolving environmental and technological challenges

4. Methodology and Solution

4.1 Part -1

This project is an intricate IoT (Internet of Things) setup aimed at automating irrigation and environmental monitoring using LoRa (Long Range) communication technology and the Blynk IoT platform. Let’s break down the components and functionalities:

4.1.1 Hardware Part

Transmitter side:

- Arduino Nano: Microcontroller board serving as the brains of the operation.
- SX1278 LoRa Transceiver Module: Facilitating long-range wireless communication.
- Capacitive Soil Moisture Sensor v1.2: Measures soil moisture.
- DS18B20 Waterproof Temperature Sensor: Measures soil temperature.
- DHT11/DHT22 Temperature & Humidity Sensor: Monitors ambient temperature and humidity.
- 5V Single Channel Relay Module: Controls the water pump for irrigation.
- DCWater Pump: Provides water for irrigation.

Receiver Side:

• NodeMCU ESP8266 Board: Equipped with a built-in Wi-Fi chip for internet connectivity.

• SX1278 LoRa Module: Receives data from the transmitter.

• 0.96-inch OLED Display: Displays soil and air parameters.

• 5V Single Channel Relay Module: Controls the water pump.

• Various sensors for environmental monitoring.

4.1.2 Functionality

Transmitter

• Collects data from sensors including soil moisture, soil temperature, ambient temperature, and humidity.

• Utilizes LoRa technology to wirelessly transmit collected data to the receiver node.

• Controls the water pump through the relay module based on predefined conditions such as soil moisture levels. Receiver

• Receives data transmitted by the transmitter node via LoRa communication.

• Displays soil and air parameters on the OLED display.

• Uploads collected data to the Blynk IoT platform using the NodeMCU ESP8266 board and Wi-Fi connectivity.

• Provides remote monitoring and control capabilities through the Blynk mobile application and web dashboard.

4.1.3 LoRa Technology

• Utilizes SX1278 LoRa modules for long-range communication with a transmission distance of up to 5km.

• Provides reliable communication with a high sensitivity of-148 dBm and a power output of +20 dBm.

• Frequency hopping technique enhances signal transmission quality within the frequency range of 420 450 MHz.

4.1.4 Blynk Platform

• Offers a user-friendly interface for IoT device management and data visualization.

• Enables remote monitoring and control of connected devices via web dashboards and mobile applications.

• Allows customization of data streams and virtual pins for efficient data transmission and organization.

4.1.5 Project Configuration & Setup

Hardware Assembly

• Connects various sensors and modules to Arduino Nano and NodeMCU ESP8266 boards according to the project requirements.

• Ensures proper wiring and power supply for seamless operation

Software Configuration

• Programs Arduino Nano and NodeMCU ESP8266 boards with appropriate code for data acquisition, transmission, and reception.

• Configures Blynk IoT platform for device integration and data visualization.

• Sets up virtual pins and data streams for efficient data management and communication.

4.1.6 Data Monitoring & Real time Visualization

• Real-time data transmitted and received through LoRa communication can be monitored using the serial monitor.

• Soil moisture, temperature, and ambient parameters are displayed on the OLED display at the receiver node.

• Blynk IoT platform provides comprehensive data visualization and remote monitoring capabilities through web dashboards and mobile applications.

Conclusion: The integration of Arduino-based sensor nodes, LoRa communication technology, and the Blynk IoT platform enables efficient environmental monitoring and automated irrigation in agricultural applications. By leveraging wireless connectivity and cloud-based data management, the project offers scalability and remote accessibility for users to monitor and control agricultural parameters from anywhere in the world.

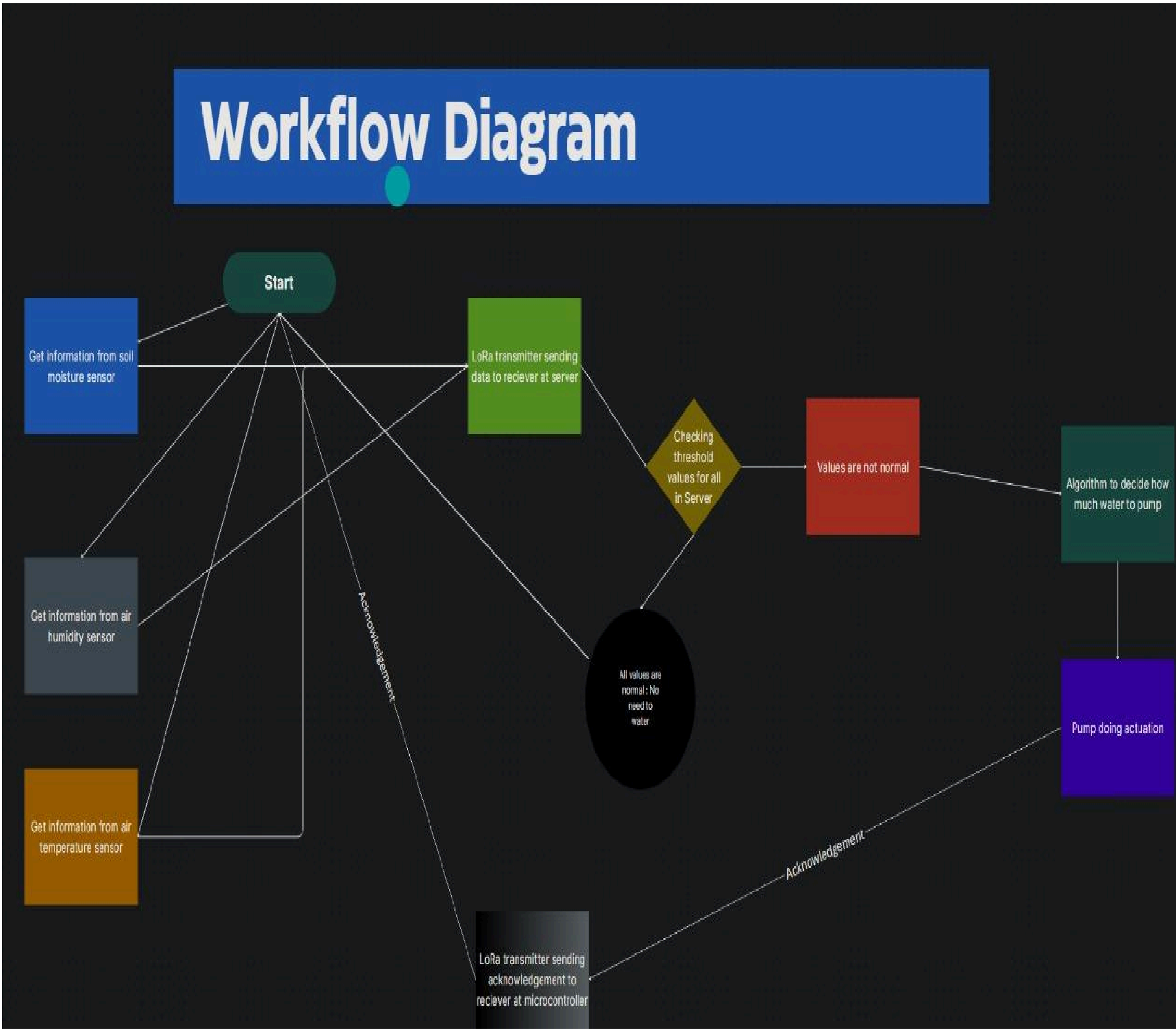


FIG: WORKFLOW DIAGRAM

4.2 Leveraging TinyVGG for Marigold Disease Detection: A Novel Approach with High Accuracy

In recent years, advancements in deep learning and image recognition have revolutionized various fields, including agriculture. Recognizing the critical role of disease detection in agricultural productivity, our team embarked on a project aimed at leveraging state-of-the-art technology to develop a robust solution for identifying diseases in marigold plants. Through the implementation of TinyVGG, a lightweight convolutional neural network (CNN), and the creation of a custom dataset, we have achieved remarkable success, achieving an accuracy rate of approximately 75 % with just 109 data points.

4.2.1 Introduction

Marigold, a popular ornamental plant, is susceptible to various diseases that can significantly impact its growth and yield. Identifying these diseases early on is crucial for implementing timely interventions and preventing widespread damage. However, manual disease detection methods are often labor-intensive and prone to errors. Hence, there is a pressing need for automated, accurate, and efficient disease detection systems in agriculture

4.2.2 Dataset Creation

To train our disease detection model, we compiled a comprehensive dataset comprising images of marigold leaves and flowers affected by various common diseases, collected from open-source. Each image was meticulously labeled with its corresponding disease category, including **Alternaria Leaf Spot, Aster Yellows, Bacterial Leaf Spot, Botrytis Blight, Fusarium Wilt, Root Rot, Septoria Leaf Spot, Tomato Spotted Wilt Virus, and Verticillium Wilt.**

Fig: Verticillium Wilt

Fig: Tomato Spotted Wilt Virus

Fig: Septoria Leaf Spot

Fig: Fusarium Wilt

4.2.3 Model Selection

For our disease detection framework, we opted to use TinyVGG, a variant of the VGG (Visual Geometry Group) architecture that is optimized for resource-constrained environments. TinyVGG strikes a balance between model complexity and computational efficiency, making it suitable for deployment on devices with limited computational resources, such as mobile phones or embedded systems

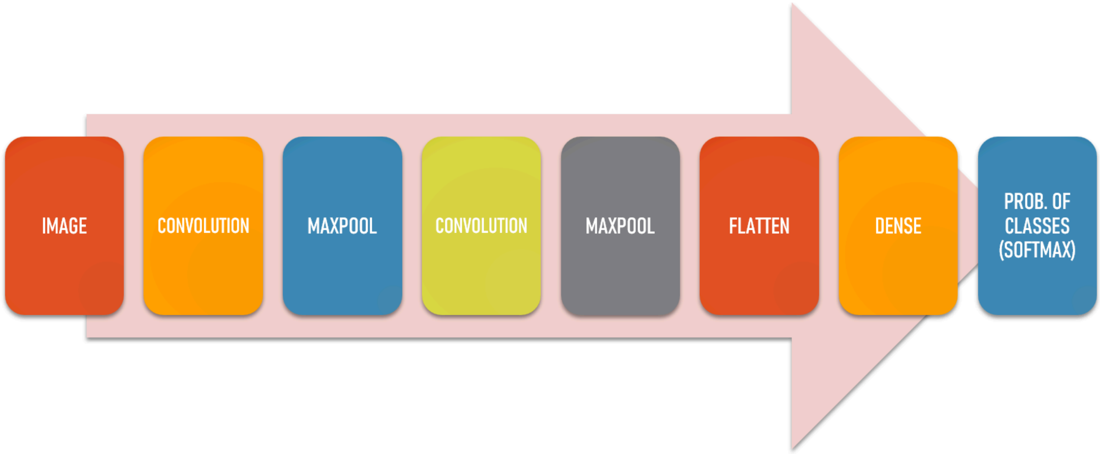


Fig: Tiny VGG Architecture

4.2.4 Training Process

We trained the TinyVGG model on our custom dataset using transfer learning, a technique that leverages pre-trained models to accelerate the training process and improve performance. By fine-tuning the pre-trained TinyVGG model on our dataset, we were able to adapt it to the specific task of marigold disease detection while benefiting from the features learned from a large-scale dataset.

4.2.5 Evaluation & Performance

After training the model, we conducted rigorous evaluation tests to assess its performance in detecting marigold diseases. We used standard metrics such as accuracy, precision, recall, and F1 score to quantify the model's performance across different disease categories. Our experiments revealed that the TinyVGG-based model consistently achieved an accuracy rate of approximately 75%, demonstrating its effectiveness in accurately identifying various diseases in marigold plants.

4.2.6 App Development

In addition to the disease detection model, we will develop a user-friendly mobile application that integrates seamlessly with the model. The app will allow users to capture images of marigold leaves or flowers using their smartphone cameras and instantly receive feedback on the presence of any of the nine common diseases. Leveraging the power of deep learning and computer vision, the app will empower farmers and agricultural practitioners to make informed decisions about disease management and treatment strategies.

Conclusion: Our project represents a significant advancement in the field of agricultural technology, offering a reliable and efficient solution for disease detection in marigold plants. By harnessing the capabilities of TinyVGG and developing a custom dataset tailored to the specific domain of marigold diseases, we have achieved remarkable accuracy rates, paving the way for improved productivity and sustainability in agriculture. Moving forward, we envision further enhancements to our model and app, as well as broader applications in other crop species and agricultural contexts. In summary, our work underscores the transformative potential of deep learning and AI-driven solutions in addressing pressing challenges in agriculture and underscores the importance of technological innovation in advancing food security and agricultural sustainability

5. Bill Of Materials

Sl. No.	Product	Quantity (pc)	Rate (Rs.)	Cost (Rs.)
1	SSX1278 LoRa Module Ra- 02 433MHZ Wireless Spread Spectrum Transmission	2	501	1002
2	Songle Single-channel 5V 30A Relay Module Power Failure Relay	1	162	162
3	Horizontal Mute Sounds Mini Submersible Pump DC 3V-5V	1	99	99
4	NodeMcu ESP8266 V3 Lua CH340 Wifi Dev. Board	1	175	175
5	Robotbanao DS18B20 Waterproof Digital Temperature Sensor Probe	1	202	202
6	Xcluma DTH22 AM2302 Digital Temperature and Humidity Sensor Module	1	337	337
7	Scriptronics Capacititive Soil Moisture Sensor Module	1	199	199
8	Maison Up Nano board CH340/ATmega328P	1	499	499
9	ApTechDealsBreadboard 840 points with jumper wires set(10+10+10)	2	268	536
10	Maison Up 0.96” I2C/IIC 4-Pin OLED Display Module	1	448	448
11	Soldering Equipment	1	459	459
#	**Total**	**13**		**4118**

6. Roles & Responsibilities of Each Team Members

6.1 Basab Ghosh(CS21B1068)

• Basab Is The brains behind the machine learning models implemented on our project.

• He has Been working on creating the CNN model to classify diseases present in marigolds, using the picture which will be provided by the customer.

• He has also been working on a statistical ML model, using Linear regression and random forest and Xg boost to determine the optimal requirements for the Marigold at that instance, they are soil temperature, moisture, amount of water, etc.

• Training Our Model with The current Dataset, We Have been able to correctly classify the disease with 75% Accuracy and building apps for the same.

• All the team members have gathered all the information, and researched how we would calculate these parameters using the given data, which Basab has implemented with the ML model.

6.2 E. Saileswara Reddy(CS21B1078)

• Sailesh has been impactful In co-ordinating the 3 sub-problems present in the project, that each person was assigned, i.e. ML, Assembly (Circuit integration), and IOT (LoRa Module), with each other.

• Sailesh has also been involved in researching the diseases present in marigolds, gathering info on the diseases and their traits, along collecting the dataset.

• He has thoroughly reviewed what products we need and chose the materials.

• He also chips in to help Basab in preparing the ML model, and Arian for implementing the IOT system.

• He has also helped document our progress, which in turn helped our reviews while we met.

6.3 SK Arian Islam(CS21B1023)

• Arian Spearheads The IOT system we have implemented to monitor the parameters Like soil moisture, soil temperature, and temperature for implementing the best requirements.

• Here He has used the LoRa Module to transmit the data we get from the fields to the device (Mobile), which in turn we will be sending it through the internet to a common server where we will be implementing the ML models,

• He has thoroughly reviewed what products we need and chose the materials.

• He has also been working on a website, i.e. a working user interface which the customer will use, to see the performance of the product we have made.

• He has been working to integrate all the manipulations we do to the input to get the desired output, through the website, and make the physical product work.

• He has also been researching how the data collected from the sensors, will yield actionable outputs, and increase the efficiency of our product

6.4 Devanjaan Sarkar (ME21B1068)

• Devanjan has been influential in designing the circuits for our project, especially the LoRa module. Where

he has been able to get together the parameters like, soil moisture sensor, soil temperature level sensor, and Temperature sensor, to the module, along with actionable output, that is the irrigation system

• Hehasalso been helping out to collect the dataset for the ML model and documenting the working of the IOT system.

• He has also worked with Arian, and came up with viable options to implement the Io module efficiently, by creating a compact circuit design that is required for tough terrain like the marigold fields.

7. <u>Deliverables</u>

7.1 Smart marigold Agriculture monitoring system

7.1.1 Project Plan Document:

• Outline project objectives, scope, and stakeholders.

• Define roles and responsibilities of team members.

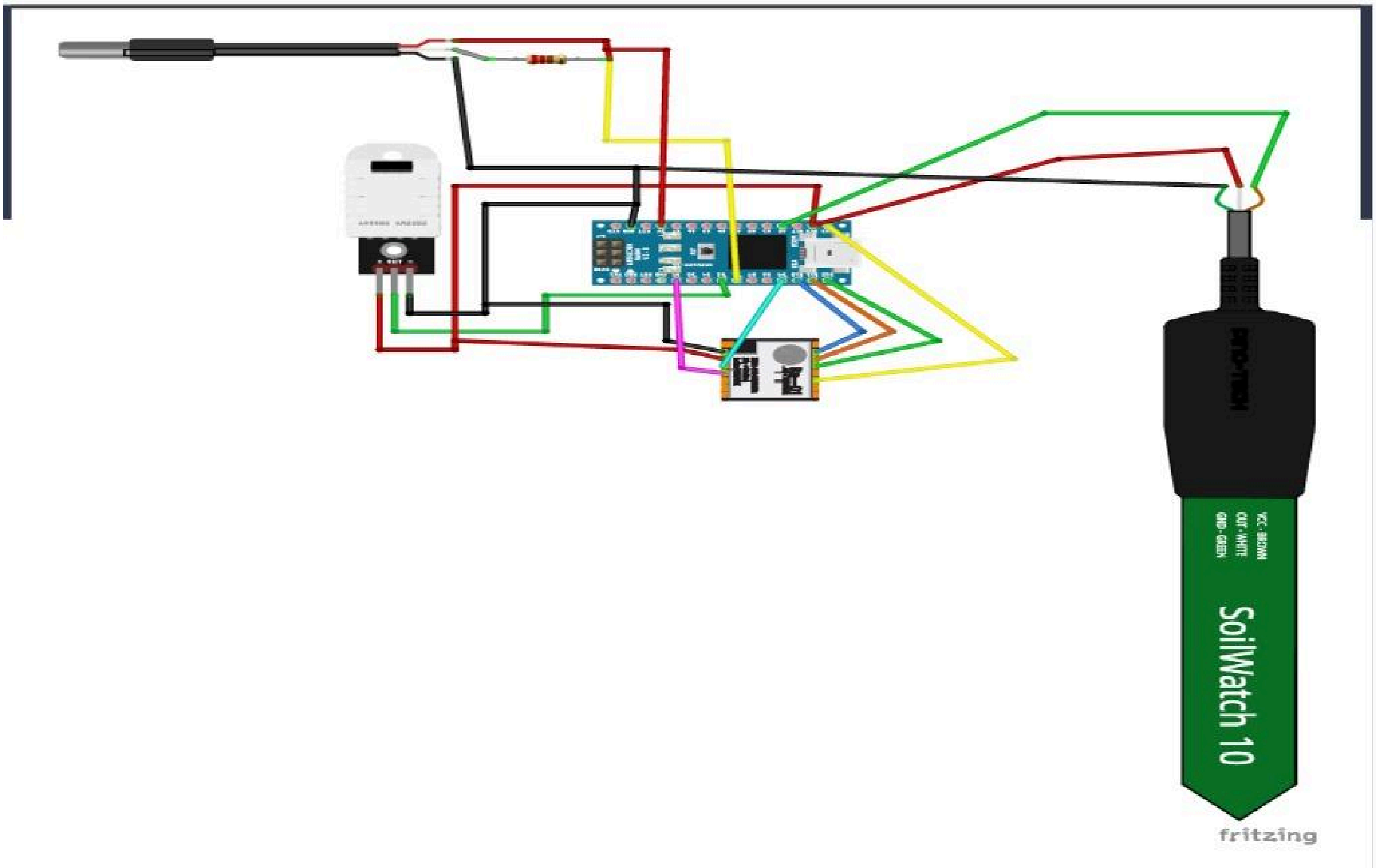
• Establish a timeline with milestones and deadlines for the development and deployment of the IoT system.

7.1.2 Hardware setup and Configuration

• Document the hardware components required for the LoRa-based IoT system, including sensors, LoRa modules, and microcontrollers.

• Provide instructions for assembling and configuring the hardware components.

• Ensure compatibility and connectivity between sensors and LoRa modules


SoilWatch 10
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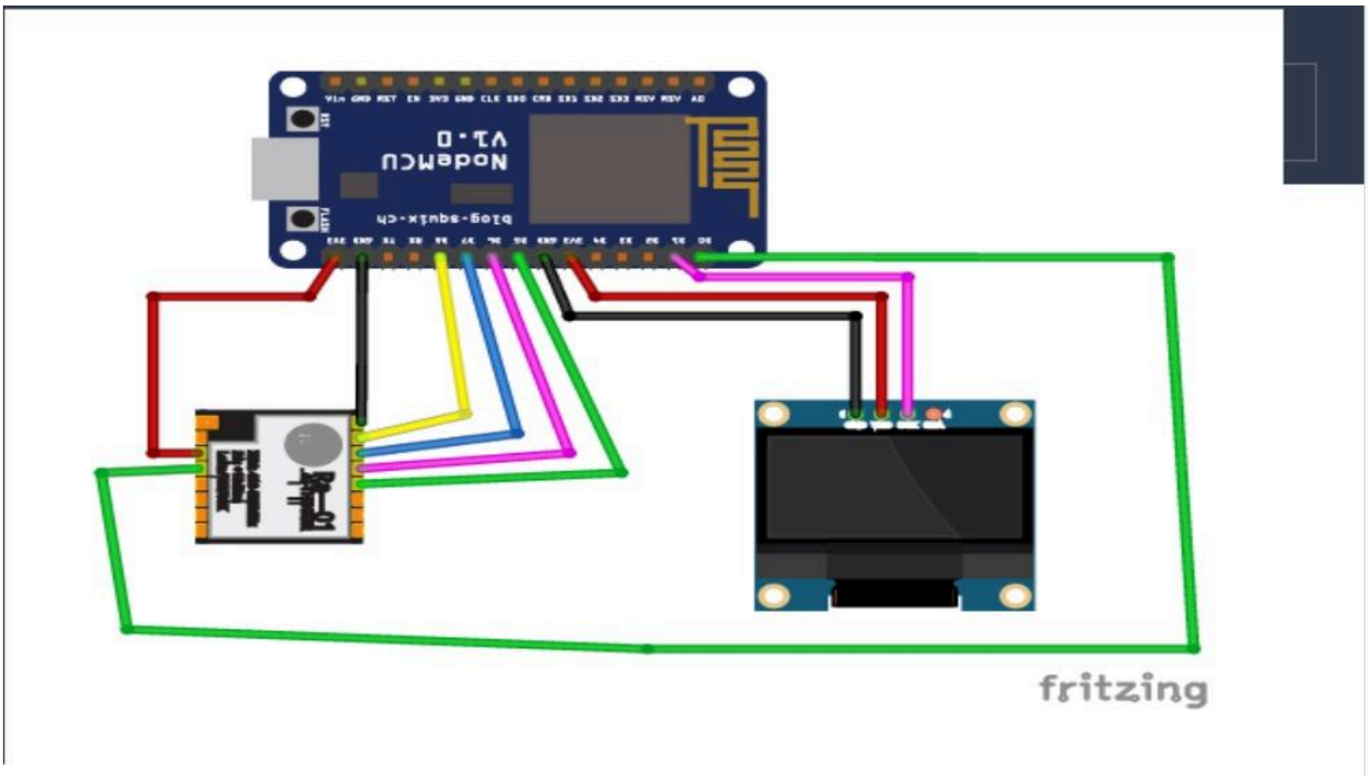
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7.1.3 Deployment and Maintenance:

• Deploy the LoRa-based IoT system in agricultural fields or greenhouses.

• Provide guidelines for maintenance, troubleshooting, and firmware updates.

• Establish protocols for data backup and security to protect against data loss or unauthorized access.

7.2 Machine Learning Model for Analyzing Anomalies in Marigold Plants

7.2.1 Project Plan Document

• Define project objectives and scope for developing a machine-learning model for anomaly detection in marigold plants.

• Identify stakeholders and their roles in the project.

• Establish a timeline with milestones and deadlines for model development, training, and evaluation.

7.2.2 Data Collection & Preprocessing

• Gather a dataset of images containing healthy and anomalous marigold plants.

• Preprocess the images by resizing, augmenting, and normalizing them for model training.

• Split the dataset into training and validation sets to evaluate model performance.

6.2.3 Model Deployment

• Design a convolutional neural network (CNN) architecture suitable for image classification tasks.

• Implement the CNN model using a deep learning framework such as PyTorch or TensorFlow.

• Fine-tune the model architecture and hyperparameters to optimize performance for anomaly detection.

7.2.4 Model Training & Evaluation

- Train the CNN model using the preprocessed dataset of marigold plant images.
- Evaluate the model's performance on the validation set using metrics such as accuracy, precision, recall, and F1-score.
- Conduct cross-validation to assess the robustness and generalization of the model.

7.2.5 Deployment and Integration

- Deploy the trained model for inference on new marigold plant images.
- Integrate the model with the IoT smart agriculture monitoring system to enable real-time anomaly detection.
- Ensure compatibility and interoperability between the model inference module and the data visualization dashboard

8. Future work & conclusion

Nowadays it's a challenge to improve the development of marigold plants in respect of its growth and to reduce costs which leads to an innovative idea of using an automated irrigation system which will further help in better management of water and human resources. An automated irrigation system is developed which is effective enough to optimize the utilization of water and other resources. This system helps in irrigation in areas with low water levels and leads to sustainability. This system is very volatile and low maintenance and could be adjusted not only to marigolds but according to various types of crops without much human effort. Other than cost reduction this project helps to save the vital element of life that is water. This project needs the hour to convert manual irrigation into an automated irrigation which with the help of a soil moisture sensor will detect dankness content of soil leading to the turn on or off of the pumping motor. Human Efforts can be reduced using this technique and increase the saving of water by efficiently irrigating the plants. The design has been made with better resource management and low power consumption. The advancement of farming technology exemplified by our project represents a significant leap forward in agricultural efficiency and sustainability. By leveraging deep learning techniques such as TinyVGG and curating a specialized dataset focused solely on marigold diseases, we have achieved remarkable accuracy in disease detection. This breakthrough empowers farmers with a reliable tool to swiftly identify and address plant ailments, enabling them to optimize production and minimize crop loss. Moreover, our success in this endeavor underscores the potential of smart technologies, such as artificial intelligence, to tackle substantial challenges in farming. As we continue to refine our model and expand its applicability to diverse crops and farming scenarios, we pave the way for a future where precision agriculture becomes the norm, bolstering global food security and promoting sustainable agricultural practices. Looking ahead, our aspirations extend beyond the realm of marigold disease detection. We envision our model and accompanying application evolving into versatile tools capable of addressing a myriad of agricultural challenges across various crops and environments. By harnessing the power of AI-driven insights, we aim to equip farmers worldwide with the knowledge and resources needed to mitigate risks, optimize resource utilization, and enhance overall productivity. Our journey exemplifies the critical role of innovation in fostering resilience within the agricultural sector, highlighting the imperative of continued advancements in technology to meet the ever-growing demands of a rapidly changing world. As we forge ahead, we remain committed to pioneering solutions that not only bolster food security but also contribute to the broader goal of sustainable farming practices, safeguarding the well-being of both present and future generation

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