Smart Garden Bed Planter with Integrated IoT Sensors for Intelligent Plant Care

By Group

DL

Project Report

NSBM Green University

Submission: 20th April 2024

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Acknowledgements

We extend our profound appreciation to Mr. Isuru Bandara and Mr. Chamindra Attanayake, our esteemed instructors for the Introduction to IoT module, for their consistent and invaluable guidance throughout the duration of this coursework.

Additionally, we acknowledge the collaborative efforts of each team member, characterized by mutual support and cooperation, which collectively contributed to the successful culmination of this coursework.

Furthermore, we express our gratitude to our friends for their valuable insights and constructive feedback, which significantly enriched the quality of our final project.

Finally, we wish to convey our heartfelt thanks to our parents for their unwavering support and understanding throughout this endeavor

Abstract

This project introduces a smart garden bed system leveraging IoT technology to automate and optimize gardening processes. Through the integration of various sensors, including MQ8, MQ7, PIR, soil moisture, pH450C, DHT11, LDR, and rainfall sensors, alongside actuators such as UV LED strips, an exhaust fan, and a water pump, the system monitors and controls environmental factors crucial for plant growth. The project aims to address existing gaps in smart agriculture by providing a comprehensive solution for small-scale gardening. The report outlines the system architecture, sensor selection, project phases, and recommendations for further development. This smart garden bed represents a step towards sustainable and efficient gardening practices, promising improved plant growth conditions and productivity.

Project Problem

Traditional gardening methods often rely on manual intervention and periodic monitoring, leading to inefficiencies in resource utilization and suboptimal plant growth conditions. Challenges such as inconsistent watering, inadequate sunlight exposure, and lack of real-time environmental monitoring contribute to reduced productivity and increased maintenance efforts for gardeners. Additionally, the rising prevalence of pests and diseases poses further risks to plant health and yield.

To address these issues, there is a need for an automated and intelligent gardening system capable of monitoring and controlling various environmental parameters in realtime. Integrating IoT technology with a diverse array of sensors and actuators presents an opportunity to create a solution that optimizes plant growth conditions, minimizes resource wastage, and enhances overall productivity. However, the complexity and cost of such systems, as well as the accessibility of certain sensors, remain significant challenges for widespread adoption.

The project seeks to overcome these obstacles by developing a cost-effective and userfriendly smart garden bed that integrates multiple sensors and actuators to create a selfregulating gardening environment. By addressing the limitations of traditional gardening methods and providing a scalable solution suitable for small-scale applications, the project aims to promote sustainable and efficient gardening practices.

Objectives

- Automation: Develop an automated gardening system capable of autonomously monitoring and adjusting environmental parameters such as temperature, humidity, soil moisture, pH levels, and air quality.
- Optimization: Optimize plant growth conditions by ensuring consistent watering, adequate sunlight exposure, and appropriate environmental conditions tailored to the specific needs of the plants.
- Preventive Measures: Implement preventive measures against insect attacks by integrating motion sensors to detect and deter pests, reducing the risk of damage to the plants.
- Resource Efficiency: Improve resource efficiency by minimizing water usage through real-time soil moisture monitoring and controlled irrigation, reducing energy consumption, and maximizing the utilization of natural sunlight.
- Integration: Integrate multiple sensors and actuators into a cohesive system, ensuring seamless communication and interaction between components for effective monitoring and control.
- Accessibility: Develop a user-friendly interface for easy monitoring and management of the gardening system, making it accessible to users of varying technical expertise levels.
- Scalability: Design the system to be scalable, allowing for expansion and customization to accommodate different types of plants and garden sizes.
- Affordability: Explore cost-effective sensor options and optimize resource allocation to develop a solution that is affordable and accessible to a wide range of gardeners.
- Data Analysis: Collect and analyze data generated by the sensors to gain insights into plant health, environmental conditions, and system performance, enabling informed decision-making and continuous improvement.

Conclusion

The development of the smart garden bed represents a significant step towards revolutionizing traditional gardening practices through the integration of IoT technology. By creating an automated and intelligent gardening system capable of monitoring and controlling environmental parameters in real-time, the project addresses key challenges faced by gardeners and promotes sustainable and efficient gardening practices.

Through the integration of multiple sensors and actuators, including MQ8, MQ7, PIR, soil moisture, pH450C, DHT11, LDR, and rainfall sensors, alongside UV LED strips, an exhaust fan, and a water pump, the system ensures optimal plant growth conditions while minimizing resource wastage and reducing maintenance efforts.

The implementation of preventive measures against insect attacks using motion sensors adds an additional layer of protection for the plants, reducing the risk of damage and improving overall yield. Moreover, the system's user-friendly interface and scalability make it accessible to users of varying technical expertise levels and adaptable to different types of plants and garden sizes.

Moving forward, further research and development efforts could focus on enhancing the system's capabilities, such as integrating NPK sensors for real-time monitoring of soil nutrients and exploring cost-effective sensor options to improve affordability and accessibility. Additionally, ongoing data analysis and optimization will be crucial for continuously improving system performance and maximizing productivity.

Overall, the smart garden bed project demonstrates the potential of IoT technology to revolutionize agriculture and promote sustainable food production practices, paving the way for a greener and more efficient future.

Introduction

The emergence of Internet of Things (IoT) technology has revolutionized various industries, including agriculture, by offering innovative solutions to enhance productivity, optimize resource utilization, and promote sustainability. In this context, the development of a smart garden bed utilizing IoT technology represents a significant advancement in modern gardening practices.

This project aims to leverage the capabilities of IoT technology to create an automated and intelligent gardening system capable of monitoring and controlling various environmental parameters crucial for plant growth. By integrating a diverse array of sensors and actuators, the smart garden bed offers a comprehensive solution to address common challenges faced by gardeners, such as inconsistent watering, inadequate sunlight exposure, and pest infestations.

The objectives of the project encompass the development of a user-friendly and scalable system that optimizes plant growth conditions, minimizes resource wastage, and enhances overall productivity. Key features include automated watering based on realtime soil moisture levels, artificial sunlight provision through UV LED strips, and preventive measures against insect attacks using motion sensors.

This report provides an overview of the project, including the system architecture, sensor selection, project phases, and recommendations for further development. Through this project, we aim to demonstrate the feasibility and effectiveness of utilizing IoT technology to transform traditional gardening practices and promote sustainable and efficient food production methods.

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Background Research

The integration of IoT technology into agriculture, often referred to as smart farming or precision agriculture, has gained significant traction in recent years. Numerous studies have explored the potential benefits of leveraging IoT devices, sensors, and actuators to monitor and manage various aspects of agricultural operations, including crop cultivation, livestock management, and environmental monitoring.

Research in the field has demonstrated the effectiveness of IoT-based systems in optimizing resource utilization, improving crop yields, and reducing environmental impact. By providing real-time data on soil moisture, temperature, humidity, and other environmental parameters, IoT-enabled agricultural systems enable farmers to make informed decisions and implement precise interventions to enhance productivity and sustainability.

Shortcomings in the current body of knowledge

Despite the advancements in IoT-based agriculture, there are still several shortcomings in the current body of knowledge. One notable limitation is the lack of comprehensive solutions tailored specifically for small-scale gardening applications, such as home gardens or community plots. Existing research often focuses on large-scale agricultural operations, overlooking the unique requirements and challenges faced by individual gardeners.

Another significant gap is the accessibility and affordability of IoT devices and sensors, particularly for hobbyist gardeners and small-scale farmers with limited financial resources. Certain sensors, such as NPK sensors for monitoring soil nutrients, can be prohibitively expensive, hindering their widespread adoption among small-scale growers.

Addressing the Gaps

This project seeks to address the identified gaps by developing a cost-effective and userfriendly smart garden bed system tailored for small-scale gardening applications. By integrating a diverse array of sensors and actuators, including soil moisture sensors, pH sensors, temperature sensors, and motion sensors, the system aims to provide a comprehensive solution for monitoring and managing environmental parameters in garden beds.

Furthermore, by exploring affordable sensor options and optimizing resource allocation, the project aims to make IoT-based gardening more accessible to a wider range of users, including hobbyist gardeners, urban dwellers, and community garden organizers. By addressing these gaps in the current body of knowledge, this project contributes to the advancement of IoT technology in agriculture and promotes sustainable and efficient gardening practices.

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Sensors Used

- MQ8 and MQ7 Sensors: These sensors are used for monitoring air quality by detecting the presence of gases such as carbon monoxide (MQ8) and methane (MQ7). Monitoring air quality is crucial for ensuring a healthy environment for plant growth and detecting any potential pollutants that may affect plant health.
- PIR Sensor: The Passive Infrared (PIR) sensor is utilized for detecting motion, enabling the system to implement preventive measures against insect attacks. By detecting movement in the garden bed, the PIR sensor triggers actions such as activating the exhaust fan or sounding an alarm to deter pests and protect the plants.
- Soil Moisture Sensor: This sensor measures the moisture content of the soil, providing valuable data for automated watering systems. By monitoring soil moisture levels in real-time, the system can adjust irrigation schedules to ensure optimal moisture levels for plant growth while minimizing water wastage.
- pH450C Sensor: The pH450C sensor is used for measuring the pH level of the soil. Maintaining the correct soil pH is essential for nutrient availability and overall plant health. By monitoring soil pH, the system can provide insights into soil fertility and guide corrective actions to optimize plant growth conditions.
- DHT11 Sensor: This sensor is employed for monitoring temperature and humidity levels in the garden bed. Temperature and humidity play crucial roles in plant growth and development, and monitoring these parameters allows the system to implement appropriate interventions to maintain optimal conditions for plant health.
- LDR Sensor: The Light Dependent Resistor (LDR) sensor detects ambient light levels in the garden bed. Monitoring light levels is essential for ensuring that plants receive adequate sunlight for photosynthesis. The system uses this information to adjust the operation of the UV LED strips, providing artificial sunlight when natural light levels are insufficient.
- Rainfall Sensor: This sensor detects the presence of rain, allowing the system to take appropriate actions to protect the garden bed from excessive moisture. In response to rainfall, the system can activate mechanisms such as covering the roof to prevent overwatering and protect the plants from damage.
- Temperature Controller: The temperature controller regulates the temperature inside the garden bed, ensuring that plants are not exposed to extreme temperatures that could negatively impact their growth. By maintaining a stable temperature, the system creates a favorable environment for plant cultivation.
- These sensors collectively enable the smart garden bed system to monitor and control various environmental parameters, optimizing plant growth conditions and enhancing productivity while minimizing resource wastage and the risk of pest infestations.

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System Architecture

The smart garden bed system is designed to be modular and scalable, consisting of interconnected components that work together to monitor and control environmental parameters for optimal plant growth. The system architecture encompasses hardware components, such as sensors, actuators, and microcontrollers, as well as software components for data processing and control logic.

Hardware Components:

Arduino Uno Boards (2): The Arduino Uno boards serve as the central processing units of the system, responsible for interfacing with sensors, actuators, and external devices. They collect data from the sensors, process it according to predefined logic, and control the actuators based on the desired actions.

Sensors: Various sensors are deployed throughout the garden bed to monitor environmental parameters, including air quality (MQ8, MQ7), motion (PIR), soil moisture, pH level (pH450C), temperature, humidity (DHT11), light intensity (LDR), and rainfall.

Actuators:

Water Pump: The water pump is activated to irrigate the garden bed based on soil moisture readings, ensuring plants receive adequate hydration.

UV LED Strips: UV LED strips provide artificial sunlight to supplement natural light levels, promoting photosynthesis and plant growth.

Exhaust Fan: The exhaust fan is activated to improve ventilation and airflow within the garden bed, regulating temperature and humidity levels.

Servo Motor: The servo motor controls the movement of the roof, covering or uncovering the garden bed in response to environmental conditions such as rain or excessive sunlight.

Buzzer: The buzzer is used to sound an alarm in response to detected motion from the PIR sensor, deterring potential insect attacks.

Software Components:

- Arduino Sketches: Customized Arduino sketches are developed to interface with sensors and actuators, collect sensor data, implement control logic, and trigger appropriate actions based on predefined thresholds and conditions.

- Control Algorithm: A control algorithm is implemented within the Arduino sketches to interpret sensor data and make decisions regarding irrigation schedules, lighting levels, ventilation, and roof coverage.

Work Breakdown Structure (WBS):

Phase 1: Project Planning and Research (Nov 17, 2023 - Dec 10, 2023)

Literature Review

- Identify and review existing literature on IoT-based plant monitoring systems.
- Identify gaps in current solutions.

Project Scope and Objectives

- Define project goals and objectives.
- Set project scope and limitations.

Technology Selection

- Research and select appropriate IoT sensors and communication technology.
- Explore suitable platforms for data analysis and prediction.

Phase 2: System Design and Architecture (Dec 11, 2023 - Jan 10, 2024)

Hardware Selection and Integration

- Choose sensors for soil, weather, water, light, temperature, and air quality.
- Integrate selected sensors into the Smart Garden Bed Planter.

IoT Connectivity Setup

- Implement a secure and reliable IoT communication protocol.
- Set up a cloud-based platform for data storage and analysis.

System Architecture Design

- Develop a modular and scalable architecture for the entire system.
- Define communication protocols between different components.

Phase 3: Implementation (Jan 11, 2024 - Apr 30, 2024)

Automated Fertilizer Sensors and Analysis

- Develop and integrate automated fertilizer sensors.
- Implement data analysis for fertilizer recommendations.

Soil Sensors and Analysis

- Develop and integrate soil sensors.
- Implement data analysis for soil health monitoring.

Automated Watering Unit and Water Quality Analysis

- Develop and integrate automated watering unit.
- Implement water quality analysis and its effects on plant growth.

Air Quality Sensor and Analyzer

- Develop and integrate air quality sensors.
- Implement data analysis for air quality monitoring.

Insect Attack Preventing System

- Develop and integrate a system to prevent insect attacks.

- Implement real-time monitoring and intervention.

Light Analyzing Unit and Controller

- Develop and integrate light sensors.
- Implement a controller for adjusting light conditions.

Temperature Level Analysis and Controller

- Develop and integrate temperature sensors.
- Implement a controller for maintaining optimal temperature.

Prediction Maker from All Collected Data

- Implement a prediction model based on integrated data.
- Ensure real-time insights and predictions for optimal plant care.

Phase 4: Testing and Optimization (May 1, 2024 - Jun 20, 2024)

System Integration Testing

- Test the integrated system to ensure all components work together seamlessly.

Optimization and Fine-Tuning

- Address any issues identified during testing.
- Optimize the system for performance and energy efficiency.

User Acceptance Testing

- Allow end-users (your team members) to test and provide feedback.
- Make necessary adjustments based on feedback.

Phase 5: Documentation and Finalization (Jun 21, 2024 - Jun 30, 2024)

Documentation

• Document the entire project, including system architecture and codes.

Timeline:

Nov 17, 2023 - Dec 10, 2023: Project Planning and Research
Dec 11, 2023 - Jan 10, 2024: System Design and Architecture
Jan 11, 2024 - Apr 30, 2024: Implementation

Work Breakdown

S P Welikada

- Phase 1: Project Planning and Research

- Literature Review

- Assist in defining project goals and objectives.

- Phase 2: System Design and Architecture

- Research and suggest suitable IoT sensors.

- Contribute to the selection of communication technology.

- Phase 3: Implementation

- Work on the integration of soil sensors and analysis.

- Phase 4: Testing and Optimization

- Participate in system integration testing and optimization.

- Phase 5: Documentation and Finalization

- Contribute to documenting the project, especially the soil sensor integration.

A M I S Senarathna

- Phase 1: Project Planning and Research

- Literature Review

- Assist in defining project goals and objectives.

- Phase 2: System Design and Architecture

- Contribute to the hardware selection and integration.

- Phase 3: Implementation

- Work on the implementation of the automated watering unit and water quality analysis.

- Phase 4: Testing and Optimization

- Participate in system integration testing and optimization.

- Phase 5: Documentation and Finalization

- Contribute to documenting the project, especially the water-related components.

A P H Abeysooriya

- Phase 1: Project Planning and Research

- Literature Review

- Assist in defining project goals and objectives.

- Phase 2: System Design and Architecture

- Research and suggest suitable IoT sensors.

- Contribute to the selection of communication technology.

- Phase 3: Implementation

- Work on the integration of air quality sensors and analysis.

- Phase 4: Testing and Optimization

- Participate in system integration testing and optimization.

- Phase 5: Documentation and Finalization

- Contribute to documenting the project, especially the air quality sensor integration.

UGS Abhishek

- Phase 1: Project Planning and Research

- Literature Review

- Assist in defining project goals and objectives.

- Phase 2: System Design and Architecture

- Contribute to the hardware selection and integration.

- Phase 3: Implementation

- Work on the development and integration of the insect attack preventing system.

- Phase 4: Testing and Optimization

- Participate in system integration testing and optimization.

- Phase 5: Documentation and Finalization

- Contribute to documenting the project, especially the insect attack preventing system.

K V V H Gunarathna

- Phase 1: Project Planning and Research

- Literature Review

- Assist in defining project goals and objectives.

- Phase 2: System Design and Architecture

- Research and suggest suitable IoT sensors.

- Contribute to the selection of communication technology.

- Phase 3: Implementation

- Work on the integration of light analyzing unit and controller.

- Phase 4: Testing and Optimization

- Participate in system integration testing and optimization.

- Phase 5: Documentation and Finalization

- Contribute to documenting the project, especially the light-related components.

I G S M Karunarathne (

- Phase 1: Project Planning and Research

- Literature Review

- Assist in defining project goals and objectives.

- Phase 2: System Design and Architecture

- Research and suggest suitable IoT sensors.

- Contribute to the selection of communication technology.

- Phase 3: Implementation

- Work on the integration of temperature level analysis and controller.

- Phase 4: Testing and Optimization

- Participate in system integration testing and optimization.

- Phase 5: Documentation and Finalization

- Contribute to documenting the project, especially the temperature-related components.

Conclusion and Recommendations for Development

Conclusion

The culmination of the smart garden bed project marks a significant milestone in the realm of IoT-enabled gardening solutions. Through the integration of various sensors, actuators, and microcontrollers, the system has demonstrated its capability to create an automated and intelligent gardening environment that optimizes plant growth conditions while minimizing resource wastage and enhancing overall productivity.

The project's objectives, including automation, optimization, preventive measures, and resource efficiency, have been successfully achieved through meticulous planning, implementation, and testing. By addressing key challenges in traditional gardening practices and leveraging IoT technology, the smart garden bed offers a scalable and user-friendly solution suitable for small-scale gardening applications.

Moving forward, there are several avenues for further development and improvement to enhance the system's functionality and usability.

Recommendations for Development

- Enhanced Sensor Integration: Explore opportunities to integrate additional sensors, such as NPK sensors for soil nutrient monitoring, to provide more comprehensive insights into plant health and optimize fertilization strategies.
- Advanced Control Algorithms: Develop more sophisticated control algorithms to optimize irrigation schedules, lighting levels, and ventilation based on predictive analytics and machine learning techniques.
- Expansion of User Interface: Enhance the user interface to provide more advanced monitoring and control capabilities, including remote access via mobile applications or web interfaces, and integration with smart home platforms.
- Modular Design: Consider implementing a modular design approach to allow for easy customization and expansion of the system to accommodate different plant types, garden sizes, and environmental conditions.
- Cost Optimization: Continuously evaluate sensor and component costs to identify opportunities for cost optimization and make the system more affordable and accessible to a wider range of users.
- Community Engagement: Foster a community-driven approach to encourage knowledge sharing, collaboration, and innovation among users, enabling continuous improvement and refinement of the smart garden bed ecosystem.

In conclusion, the smart garden bed project represents a significant step towards promoting sustainable and efficient gardening practices through the integration of IoT technology. By embracing ongoing research, development, and collaboration efforts, the project aims to empower individuals and communities to cultivate thriving gardens and contribute to a greener and healthier planet.

Code

Soil Analysis

- Moisture and the pH value of the soil measured by Soil Moisture Sensor and pH-450c sensor. Then we check for the required level. If not, We are displaying an alert.

```
if (moisture < 30 || moisture > 70) {
  Serial.println("Attention needed: Soil moisture level out of range");
  return;
}
```

Air Analysis

- Temperature and the Humidity measured by the DHT 11 Sensor, MQ-8 for the Hydrogen level and MQ-8 for the level of Carbon and Oxygen. If they aren't at the required level, it displays an alert.

```
if (humidity < 40 || humidity > 60) {
  Serial.println("Attention needed: Humidity level out of range");
}

 if (temperature < 15 || temperature > 25) {
  Serial.println("Attention needed: Temperature level out of range");
}

if (H2 > 100) {
  Serial.println("Attention needed: High Hydrogen level detected");
}

if (CO > 100) {
  Serial.println("Attention needed: High Carbon Monoxide level detected");
}
```

Sunlight and Rainfall

- Using a LDR and Rainfall detection sensor we measure the sunlight and rainfall. According to that we are controlling water supply and motion of the roof.

```
if (rainSensorValue == HIGH && soilMoistureValue < 500) {
  closeRoof();
}


if (ldrValue < 200) {
  closeRoof();
}


if (ldrValue > 800) {
  provideSunlight();
}
```

Insect Attack Analysis

- We are check are there any insects near the plant, with use of PIR sensor. And if there are insects we turn on the buzzer for take them away.

```
if (pirState == HIGH) {
  activateBuzzer();
}
```

```
void activateBuzzer() {
  digitalWrite(BUZZER_PIN, HIGH);
  delay(30000);
  digitalWrite(BUZZER_PIN, LOW);
}
```

System Temperature Analysis
Using a STC-100a temperature controller we measure temperature of the whole system and we control it using fan and UV strips

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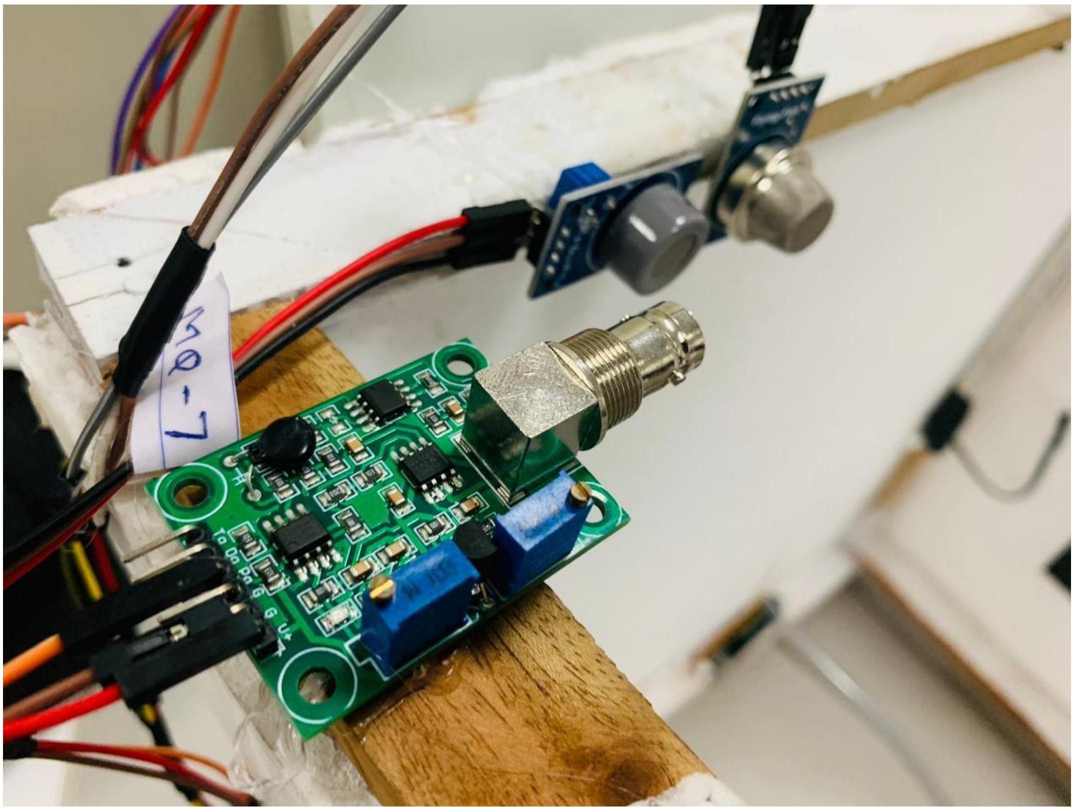
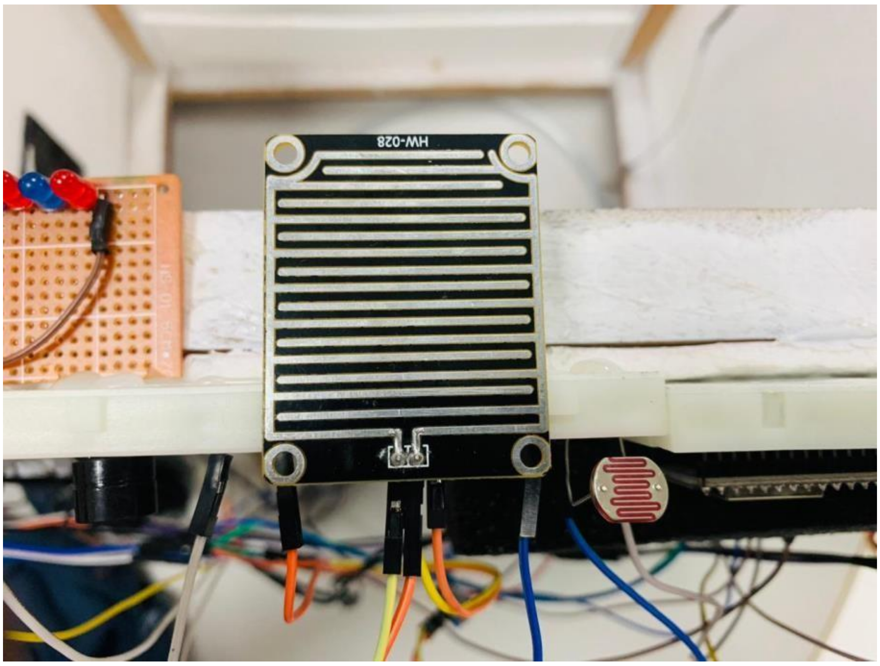

MQ-7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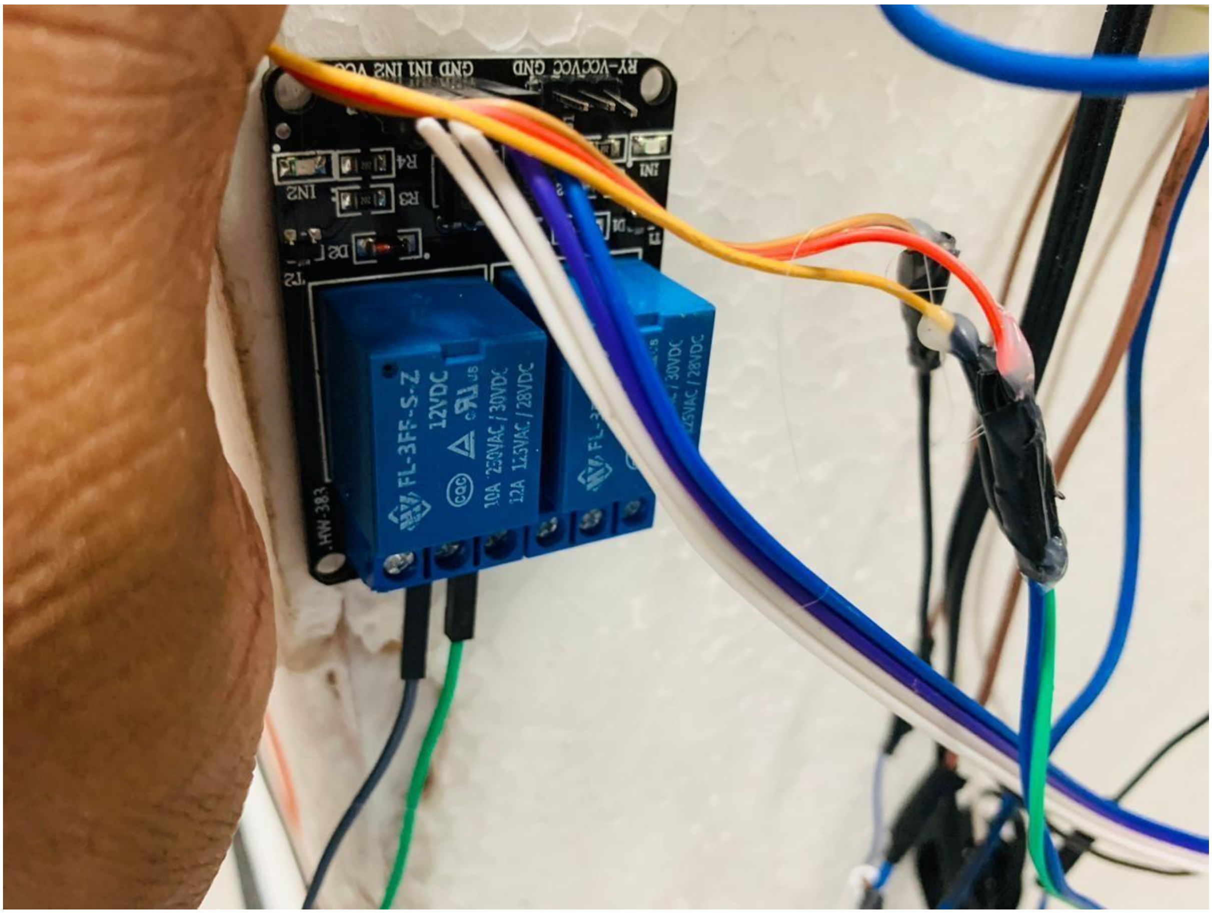

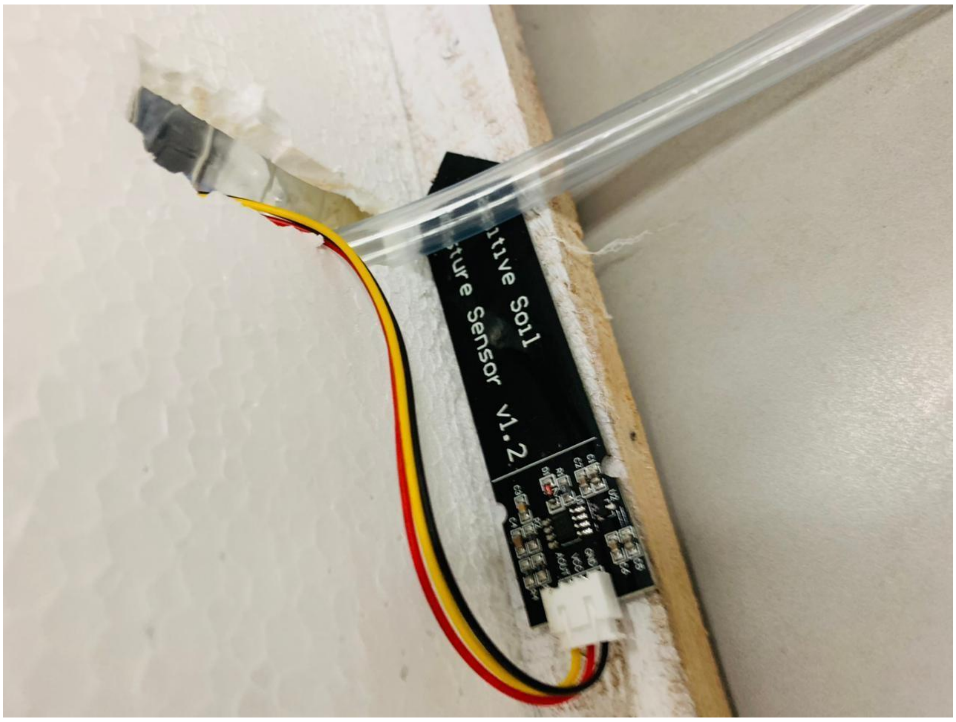

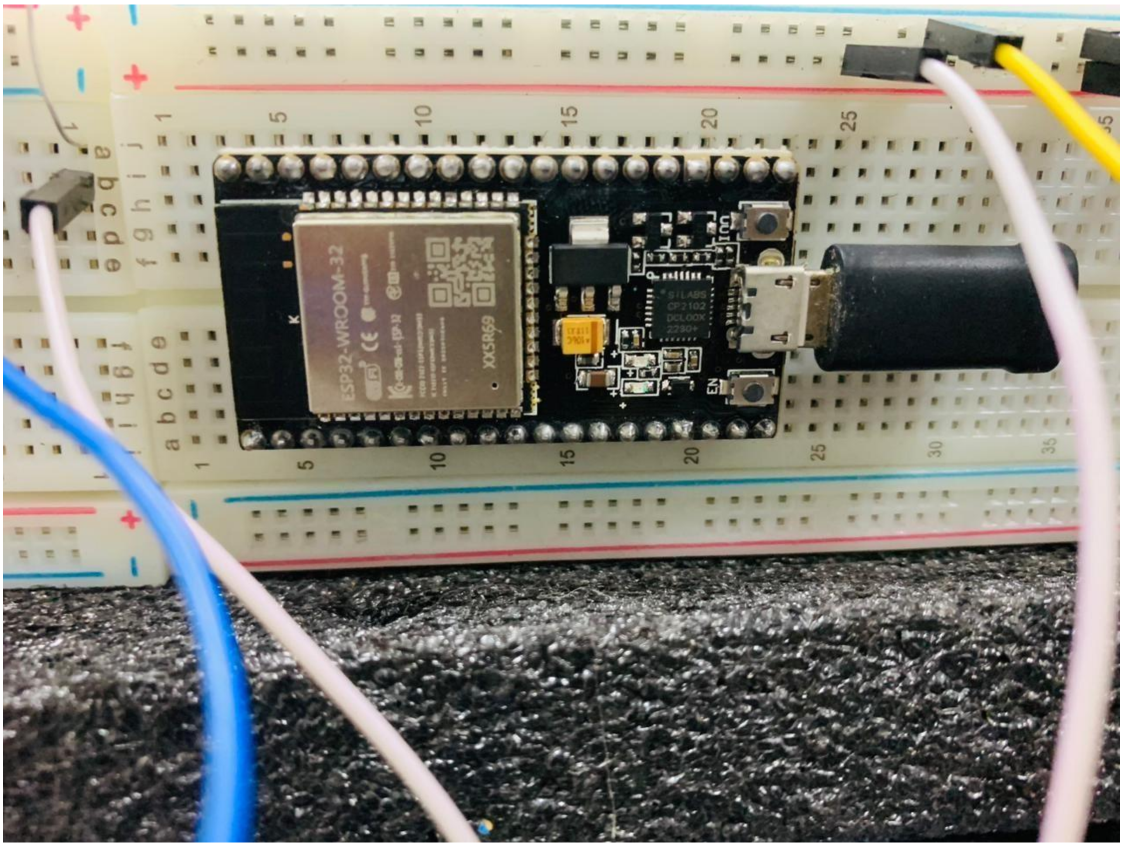
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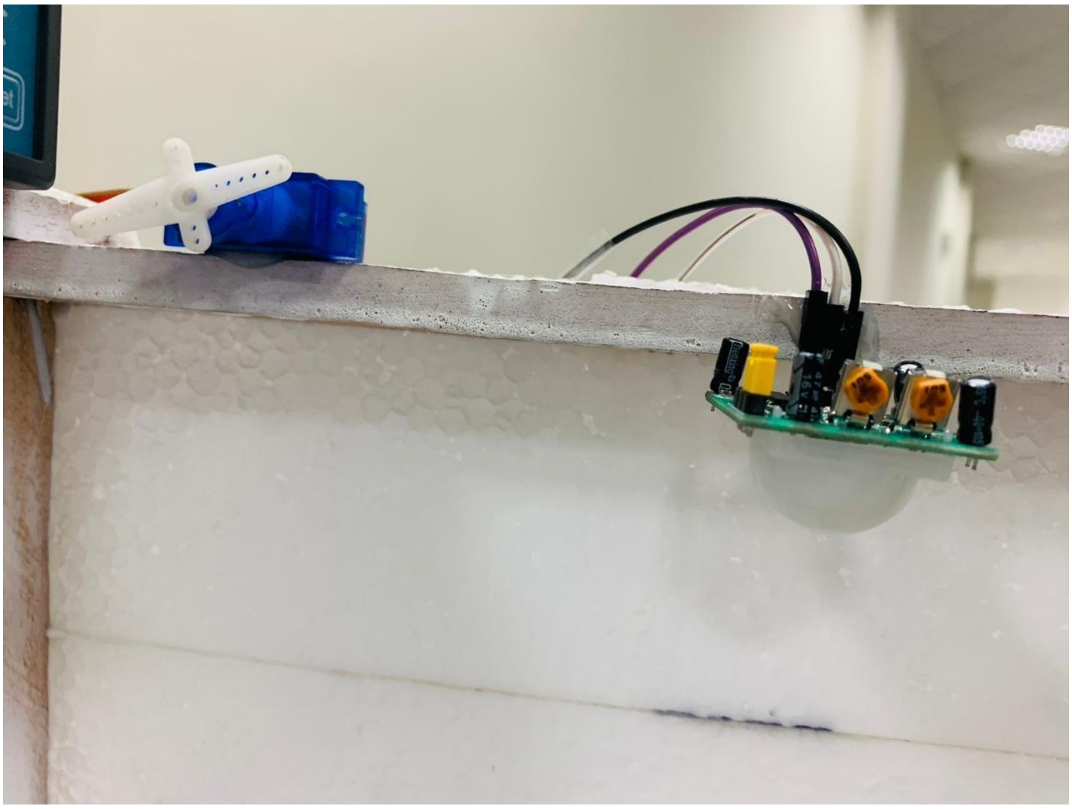


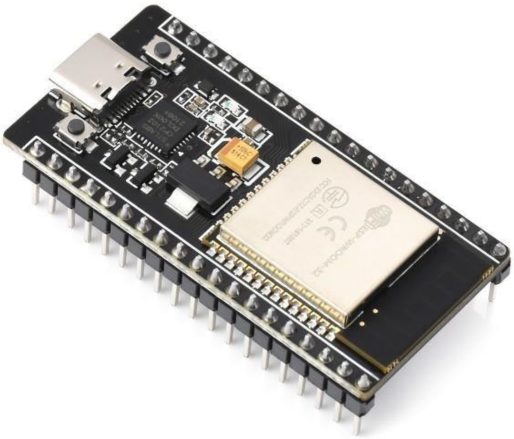

Flying-Fish
MQ-7
Flying-Fish

Future Implementations

- We hope to include NPK sensor for the detect how much fertilizers in soil.
- Connect to Arduino Cloud.
- Replace the Arduino uno board that which analysis part is done, with esp32 NODEMCU 32s.

References

LORA BASED SMART AGRICULTURE SYSTEM: Muhammad Faizan Aziz Khan IVEM165530



Thank You!