IOT Based Monitoring and Controlling System of Hydroponic Vertical Farming

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***Abstract-* The project aims to develop a smart hydroponics vertical farming system using sensor technology and IoT for automated monitoring and control. The system integrates various sensors, including soil moisture, temperature, humidity, fire, and gas sensors, to optimize resource utilization and ensure safety.**

The ESP8266 Wi-Fi module collects data and transmits it to a cloud platform for remote monitoring. This system improves efficiency, reduces resource waste, and promotes sustainable agricultural practices in urban environments. It optimizes crop yields, reduces water consumption, and minimizes labor requirements, making it a viable solution for food security.

***Keywords-* vertical farming, hydroponic, agriculture, data acquisition, IOT.**

I. INTRODUCTION

Hydroponics is a soilless growing system in which nutrient is supplied by water form, meeting the food requirements of the world, particularly urban where there is no space. The objective of this project is to provide an intelligent, automated vertical growing system using technology to optimize plant growth as well as the use of resources. Conventional farming is beset with problems such as unpredictable weather, drought, and pests that hydroponics can address by giving the plants an environment for maximum productivity. The vertical farming aspect optimizes space by piling hydroponic units on top of each other, perfect for urban areas. The project entails the development of a self-sustaining automated unit that promotes localized food production and eco-agriculture. It has a few sensors and ESP8266 microcontroller that track the soil moisture, temperature, and humidity levels and give the plants appropriate care and conditions for optimal growth. The accurate regulation is necessary to prevent conditions such as root rot caused by overwatering and dwarfing caused by underwatering.

The system not only keeps track of the environment but also includes safety features. It has a fire sensor that can detect risks of fire inside the vertical farm. Catching a fire early is crucial because the space is small and closed. This allows quick action to stop a fire from spreading and helps protect the plants and equipment. The system also has a gas sensor to detect dangerous gases like methane or carbon monoxide. These gases can be released if there are leaks or system failures, putting both plants and people at risk. The gas sensor sends an early warning if harmful gases are present. The system uses a water pump to move nutrient-rich water through the hydroponic setup. A relay controls the pump, and it is operated by the ESP8266 microcontroller. This setup allows automated watering and precise delivery of nutrients. The relay acts as a switch, turning the pump on or off depending on soil moisture levels and other system data.

The main controller is the ESP8266 microcontroller. It gathers data from all sensors, processes that information, and makes decisions based on preset rules. It manages the water pump, ventilation, and other parts based on sensor signals. It also connects to the internet, giving users the ability to check and control the system remotely via a web page or mobile app. This remote control is very useful because it lets users manage the farm even when they are not on site. Additionally, the system includes an alarm buzzer. The buzzer sounds if there’s a fire, gas leak, or other emergency. This alert helps users respond quickly to problems. Adding sensors, actuators, and the ESP8266 microcontroller makes this farm system more advanced and automatic. It helps grow plants better, uses resources carefully, and enhances safety. This project shows how technology can change farming for the better, especially in facing new global challenges. Building these smart farming systems is a key step toward food security and eco-friendly farming. It also helps people learn how hardware and software work together to create a useful modern farming system.

II. PROPOSED SYSTEM

The hydroponic vertical farming system aims to mechanize and optimize plant growth through environmental condition management. It implements several sensors, actuators, and a microcontroller to simulate a controlled environment for plants. The ESP8266 Wi-Fi module is the central controller that receives data from sensors and controls actuators depending on defined parameters. It further provides remote monitoring and control through a web dashboard or mobile application.

The setup has a soil moisture sensor to monitor water content in the growing medium. It is important for watering the plants. When the moisture falls below a predetermined value, the ESP8266 switches on a water pump via a relay to provide nutrient water.

The system measures soil moisture, ambient temperature, and humidity via a DHT11 sensor, which is vital for plant development. The ESP8266 reads this information and compares it with optimal values for the plants. If temperature or humidity levels are too high or low, it triggers systems such as ventilation or humidifiers to provide a perfect environment.

Safety is paramount, and the hydroponics system has a fire sensor and a gas sensor. The fire sensor monitors for smoke or heat and alerts the ESP8266, which can initiate alarms and cut power or initiate fire suppression. The gas sensor monitors for toxic gases and can initiate alarms and cut off gas supplies. These safety features improve safety against fire and gas hazards.

The ESP8266 is responsible for reading and processing sensor data and managing the operations of the system. The ESP8266 drives relays to power devices such as pumps, fans, and alarms. The ESP8266 provides alerts in the form of a buzzer for critical conditions detected by sensors. Users can control and monitor the system via Wi-Fi. The vertical farm system optimizes space and enhances environmental control of the plants.

III. METHODOLOGY

This method explains how to build a vertical farm system that uses hydroponics. It employs different sensors, actuators, and an ESP8266 microcontroller for automatic monitoring and control. The goal is to help the plants grow better by carefully managing the environment. The system can control soil moisture, temperature, humidity, and detect hazards like fire and gas leaks.

Component choice and system design come first. This step involves planning how the vertical farm will look and work. It includes deciding how many tiers will be built, how far apart they will be, and what materials to use. The physical layout is important for effective operation.

The main parts of the system include:
ESP8266 Microcontroller: The brain that gathers data and manages controls.
Soil Moisture Sensor: Measures how wet or dry the soil is.
DHTU Sensor: Tracks temperature and humidity levels.
MQ-2 Gas Sensor: Detects gases that can catch fire.
Fire Sensor: Senses the presence of fire.
Water Pump: Moves nutrient-rich water to the plants.
Relay Modules: Control the water pump and other parts.
Buzzer: Emits a sound to alert you of serious issues.
Power Supply: Provides energy to all devices.
Growing Medium: Provides a clean base for the plants and helps support them.
Nutrient Solution: Supplies the necessary nutrients for healthy plant growth.
Water Reservoir: Stores the nutrient solution.
The system needs to meet some key requirements. It should be easy to understand while explaining how the system works. It must keep the same level of formality as the original. The description should accurately describe each component and its role. The language should be simple and flow naturally. Proper paragraphs and punctuation are important to improve readability.

Circuit Design and Implementation:
A schematic diagram is first made, showing how all parts connect. The connections are tested on a breadboard to ensure they work correctly. Once confirmed, the circuit can be moved to a printed circuit board (PCB) for a more permanent setup. The ESP8266 is linked to several sensors and components:
The soil moisture sensor has an Analog output that connects to an Analog input pin on the ESP8266. The DHT11 sensor's data pin connects to a digital pin on

the ESP8266. The MQ-2 gas sensor's Analog output also connects to an Analog input pin. The fire sensor has a digital output connected to a digital pin. A relay module is connected to a digital pin for controlling a water pump. The relay's control pin connects to the ESP8266 through a resistor, and its negative terminal goes to ground.

Software Development:
The code for the ESP8266 is written using the Arduino IDE. It is designed to perform key tasks. The device reads sensor data at set intervals. The raw data is processed to make it meaningful. For example, soil moisture is shown as a percentage, temperature in degrees Celsius, and gas levels in parts per million (PPM).

The program also uses the sensor readings to control devices. If the soil is dry, it turns on a water pump. If high levels of gas or a fire are detected, it activates a buzzer. It can also send alerts over Wi-Fi for remote monitoring.

The ESP8266 is set up for Wi-Fi communication. It allows remote control, viewing data on web or mobile apps, and saving data to the cloud. Sensors are calibrated by comparing their readings with known standards. Adjustments are made in the code for better accuracy.

System integration and testing: This step involves several important tasks: First, connect all parts, including sensors, actuators, and other components, to the ESP8266 microcontroller by following the circuit diagram. Next, upload the code that has been developed to the ESP8266. Then, check if the sensors give accurate readings. It is also necessary to test the alarm system by ensuring the buzzer sounds when the gas sensor detects high gas levels or the flame sensor detects fire. Monitor how well the system works over time and make any needed changes to improve performance.

Deployment and maintenance: Once testing is complete, set up the system in the field, plant the crops, and configure it to grow plants effectively. Regularly inspect the plants for signs of disease or nutrient problems. Keep the software updated to improve its performance or add new features. The main focus is on caring for the plants consistently and maintaining the software to keep everything running smoothly.

Improvements and future plans: Future work includes upgrading the system for hydroponics. This could mean adding automatic nutrient dosing, controlling environmental factors like light, temperature, and humidity, and allowing remote monitoring and control through web or mobile apps. Collecting data. it can help improve plant growth. The system can also work with other farming programs to make better use of resources and support better farming methods.

IV. IMPLEMENTATION

The design and implementation of a hydroponic vertical farm system using an ESP8266 microcontroller, sensors, actuators, and a buzzer. The architecture of this system includes a sensing unit for acquiring environmental data, a control unit for processing the data and making decisions, and an actuator unit to execute tasks like watering plants and sending out notifications.

The parts and interfaces of a low-cost, wi-fi capable microcontroller system, possibly for environmental monitoring or control. The system uses an ESP8266 microcontroller system, possibly for environmental monitoring as the central part, communicating with other sensors, a water pump, a relay, and a buzzer.
ESP8266: Serves as the system's "brain," controlling the connections and operations of the other parts.
Soil moisture sensor: Records the water in soil and provides an Analog voltage output.
DHT11 Sensor: Records temperature and humidity and gives digital output.
Fire sensor: Sensing fire or high heat and gives a digital output.
Gas sensor: Sensing gases such as LPG, propane, and methane and provides an Analog voltage output
Water pump: Submersible pump to circulate the hydroponic nutrient solution and needs a different power supply.
Relay: Controls the on/off state of the water pump, controlled by the ESP8266'
Buzzer: Produces audible signals, connected to a digital pin on the ESP8266.

SOFTWARE IMPLEMENTATION
Software implementation for a project that uses an ESP8266 micro controller for data acquisition, processing, and remote monitoring of a sensor. It explains the procedures from the initial setup of the Arduino IDE and including required libraries to

applying control logic, wi-fi, and an alert mechanism.

Key features are the reading of sensor data, conversion to meaningful units, driving external devices by sensor readings, and remote access and Notifications through a web interface or mobile app.

The steps outlined are:

Arduino IDE: Utilize the ESP8266 with the proper board support package installed.

Library inclusion: Include necessary libraries for sensors (e.g., DHT sensor) and wi-fi capabilities of the ESP8266.

Sensor data reading: Utilize Analog Read () for Analog sensors and digital read () for digital sensors.

Data processing: Convert raw sensor data to useful units such as Celsius, percentage, or level of soil moisture.

Control logic implementation: Drive external devices (e.g. water pump) or issue alerts on the basis of sensor readings (e.g., low soil moisture, high temperature, or gas detection).

Web interface/mobile application development: Develop a platform to show sensor data and remotely control the system Using HTML, CSS, and JavaScript, or an appropriate framework. The ESP8266 can support a basic web server for this application.

Alert system integration: Implement local alerts using a buzzer and provide email or SMS alerts through the wi-fi connectivity of the ESP8266 for emergency events

V. RESULT

Figure 1: Hydroponic vertical farming

The findings using an IoT-based monitoring and controlling system for hydroponic vertical farming, employing Thing Speak App for data visualization. show the effective implementation of an IoT system for monitoring and controlling environmental conditions in a hydroponic vertical farm. The plots, named fig IOT Thing speak, are probably plots of real-time streams of data related to the hydroponic system, i.e., temperature, humidity, pH levels, or concentration of the nutrient solution. These graphs show how the system can gather and display information, offering useful information on the developing environment.

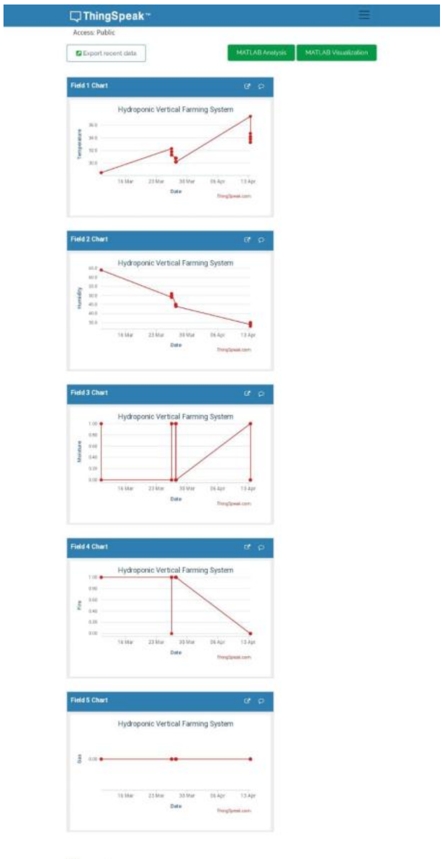

Figure 2: Thing speak

VI. CONCLUSION

The development of a hydroponic vertical farming system with integrated environmental monitoring and control. The system effectively utilizes an ESP8266 microcontroller to manage various aspects of the growing environment. The soil moisture sensor provided real-time data on the hydration levels of the growing medium, enabling automated watering through the pump and relay system, thus optimizing water usage and preventing over or under-watering. The DHT11 sensor accurately monitored temperature and humidity, crucial factors for plant growth, allowing for potential adjustments to the environment. The inclusion of a fire sensor and gas sensor significantly enhances the safety of the system, providing alerts through the buzzer and potential remote notifications via the ESP8266 in case of hazardous conditions. This integrated approach allows for efficient resource management, optimized growing conditions, and enhanced safety, demonstrating the potential of IoT-based solutions for modern agriculture. This project lays a foundation for further advancements in automated hydroponic systems, potentially incorporating features like automated nutrient delivery, light control, and remote monitoring through a user interface, ultimately leading to higher yields and more sustainable agricultural practices. Future work could also explore the use of more advanced sensors for nutrient levels and pH, as well as the implementation of machine learning algorithms for predictive analysis and optimized control

In conclusion, use of an IoT-based vertical hydroponic system has numerous benefits like higher yield in crops, effective resource utilization, remote monitoring, and automatic execution of vital operations.

By integrating sensors, actuators, and data analysis, this new approach converts traditional farming into a more efficient, sustainable, and climate-resilient practice.

Given the potential to solve food security challenges and facilitate urban farming initiatives IoT-based vertical hydroponics is one of the potential solutions for agriculture in the future

This project successfully demonstrated the feasibility of a smart, automated hydroponic vertical farming system leveraging an ESP8266 microcontroller and a suite of sensors. The integration of soil moisture sensors ensured optimal hydration, while the DHT11 sensors maintained precise temperature and humidity levels, crucial for plant health. The inclusion of fire and gas sensors provided a safety layer, mitigating potential hazards within the controlled environment. The automated pump, regulated by relays, efficiently delivered nutrient-rich water, minimizing manual intervention. The ESP8266 facilitated real-time data monitoring and control via a network connection, enabling remote management and data logging. The buzzer system acted as a real-time alarm for critical events. The system's modular design allows for scalability and adaptation to various plant types and growth requirements. By automating essential environmental parameters and providing alerts, this system significantly reduces resource consumption, enhances crop yield, and promotes sustainable urban agriculture. The data collected can be further for optimizing growth parameters. This project paves the way for efficient and reliable indoor farming solutions, contributing to food security and resource conservation in urban settings. The integration of IoT technology creates a robust and user-friendly platform, empowering individuals and communities to embrace sustainable agriculture practices. The system’s ability to monitor and regulate multiple environmental variables in real-time provides a significant advantage over traditional farming methods. The consistent environmental control leads to predictable and potentially higher yields. The implementation of this system marks a step towards more efficient and environmentally conscious agricultural practices.

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