IoT-Enabled Smart Agriculture and Soil Quality Monitoring System

Project Report

Submitted for the partial fulfillment of the degree of

Bachelor of Technology

In

Internet of Things (IOT)

Submitted By

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UNDER THE SUPERVISION AND GUIDANCE OF

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Jul-Dec 2024

DECLARATION BY THE CANDIDATE

We hereby declare that the work entitled "**Smart Agriculture and Soil Quality Monitoring System**" is our work, conducted under the supervision of **Dr.Dhananjay Bisen, Assistant Professor**, during the session Jul-Dec 2024. The report submitted by us is a record of bonafide work carried out by us.

We further declare that the work reported in this report has not been submitted and will not be submitted, either in part or in full, for the award of any other degree or diploma in this institute or any other institute or university.

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This is to certify that the above statement made by the candidates is correct to the best of my knowledge and belief.

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PLAGIARISM CHECK CERTIFICATE

This is to certify that we, students of B.Tech. in **Internet of Things (IOT)** have checked our complete report entitled "**Smart Agriculture and Soil Quality Monitoring System**" for similarity/plagiarism using the "Duplichecker" software available in the institute.

This is to certify that the similarity in our report is found to be 11% which is within the specified limit (20%).

The full plagiarism report along with the summary is enclosed.

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ABSTRACT

Smart Agriculture and Soil Quality Monitoring System

Many who shift smart agriculture from traditional farming usually use the Internet of Things (IoT), machine learning, and data analytics. The most important advancements for this development can be noted through the advancement of systems in monitoring soils far more advanced than those currently used. The advanced soil quality monitoring system assesses all crucial soil metrics-meter temperature, pH level, moisture percentage, and nutrient concentration via an array of sensors. It gathers real-time data so that farmers can respond to decisions about crop management, fertilizing, and irrigating in the best-suited ways to reap maximum benefits from the land.

Smart soil quality monitoring systems, with integration with IoT platforms, allow for remote monitoring and smooth transfer of data. There will be wireless communication between the field-deployed sensors, transmitting data into the central platform where analyses and visualizations are undertaken. Of course, large-scale data storage and remote access through cloud-based systems enable the possibility of permitting continuous assessment by farmers as well as other agricultural specialists for adjusting their methods accordingly.

The enhancement of these systems is achieved through the analysis of both real-time and historical data, the recognition of patterns, and the forecasting of future soil behavior by machine learning algorithms. For example, predictive analytics can foresee changes in soil moisture levels or nutrient depletion, allowing for timely adjustments in fertilization or irrigation practices. This approach, which relies on data-driven methodologies, ensures optimal conditions for plant growth, thereby conserving resources, reducing environmental impact, and increasing agricultural yield.

Moreover, technologies using remote sensing and drones along with satellite imagery help in identifying variability in soil quality over large agricultural landscapes, hence providing more layers of data. It also enables practitioners to implement precision agriculture that utilizes resources according to the definite needs of the soil rather than spreading them uniformly over the entire field.

In a nutshell, therefore, the main leap towards precision agriculture is incorporation of advanced quality soil monitoring systems into agricultural operations. Apart from reducing input cost and increasing productivity, such systems will be critical tools in allowing sustainable management of soil resources in the future. Meaningful use of such smart systems will be of paramount importance in the future because this technology will grow to meet the increasing global demand for food while keeping the ecological balance intact.

ACKNOWLEDGEMENT

The full semester Project has proved to be pivotal to our career. We are thankful to our institute, **Madhav Institute of Technology & Science** to allow us to continue our disciplinary/interdisciplinary Project as a curriculum requirement, under the provisions of the Flexible Curriculum Scheme approved by the Academic Council of the institute. We extend our gratitude to the Director of the institute, **Dr. R. K. Pandit** and Dean Academics, **Dr. Manjaree Pandit** for this.

We would sincerely like to thank our department, **Centre for Internet of Things,** for allowing us to explore this project. We humbly thank **Dr. Praveen Bansal**, Assistant Professor and Coordinator, Centre for Internet of Things, for his continued support during the course of this engagement, which eased the process and formalities involved. We are sincerely thankful to our faculty mentors. We are grateful to the guidance of **Dr.Dhananjay Bisen** Assistant Professor, and Centre for Internet of Things, for his continued support and guidance throughout the project. We are also very thankful to the faculty and staff of the department.

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NOMENCLATURE

General Technology Terms:

- **ESP8266 Module:** Acts as the primary microcontroller for processing sensor data and establishing a wireless connection with cloud platforms.
- **Soil Moisture Sensor:** Measures the volumetric water content in the soil to determine its moisture level.
- **DHT11/DHT22 Sensor:** Monitors environmental parameters, including temperature and humidity.
- **Water Pump:** An actuator used for automated irrigation, controlled by the ESP8266 based on soil moisture readings.
- **Relay Module:** Interfaces the water pump with the ESP8266, enabling it to handle high-current operations.
- **Cloud Platform:** Stores and visualizes data from the sensors for remote monitoring, e.g., ThingSpeak, Blynk, or MQTT servers.
- **Power Supply:** Provides the necessary voltage and current for the operation of the entire system.

LIST OF FIGURES

- **System Architecture Diagram**
  - Overview of the entire system, showing sensors, ESP8266, relay, water pump, and cloud integration.
- **Circuit Diagram**
  - Detailed schematic of all hardware connections, including sensors, ESP8266, and actuators.
- **Block Diagram of System Functionality**
  - Illustration of data flow from sensors to ESP8266, cloud, and automated actions.
- **Hardware Components**
  - Images of individual components like ESP8266, soil moisture sensor, DHT11/DHT22, relay module, and water pump.
- **Cloud Integration Workflow**
  - Visual representation of how data is sent from ESP8266 to the cloud (e.g., ThingSpeak or Blynk).
- **Graphical Data Representation**
  - Example of a real-time graph or chart from the cloud platform, showing sensor readings.
- **Prototype Setup**
  - Photograph of the assembled hardware prototype on a breadboard or PCB.
- **Automated Irrigation Process**
  - Snapshot or flowchart showing the system activating the water pump based on soil moisture levels.

CHAPTER 1: INTRODUCTION

Agriculture happens to be one of the most significant sectors that keep humans upon the globe and are a significant contributor to the global economy. However, traditional farming often depends on manual labor and subjective decisions, making the management of water, crops, and resources very inefficient. Over the years, innovations in technology have also opened doors for smart agriculture, which teaches novel solutions to extend productivity in a sustainable manner.

It is an IoT project that pursues efficient monitoring and management of agricultural activities by means of the Smart Agriculture and Soil Monitoring System, built around ESP8266. Environmental conditions are monitored in real time through integration with sensors of soil moisture, temperature, humidity, and light intensity directly inserted into the microcontroller of the ESP8266, which then processes and transmits wirelessly to the platforms in the cloud for analysis.

The system features an automated irrigation mechanism that reduces water waste while ensuring crops get enough water. These smart systems respond to the growing need for responsible farm practices by optimizing resource use and reducing adverse environmental impacts. This program is a very real-life application of modern technology in agriculture, bringing scalability and an economically feasible solution for farmers around the world.

In the last five years, agriculture have dramatically evolved due to the fast implementation of advanced farming technologies. Innovations through the Internet of Things (IoT), artificial intelligence, and robotics fundamentally changed or upended conventional systems of agricultural practices. Agricultural practitioners or farmers have come to use sensors to continuously monitor water moisture in the soil, temperature, and nutrient content for data-informed decisions that improve the management of crop production.

Drones with high-definition cameras capture aerial shots, giving better information on crop condition and the situation of a field. AI algorithms analyze enormous amounts of data to predict weather patterns, detect diseases, or optimize the use of resources. Farmers can automate planting, weeding, and harvesting using autonomous robots and tractors and significantly increase efficiency while reducing labor costs.

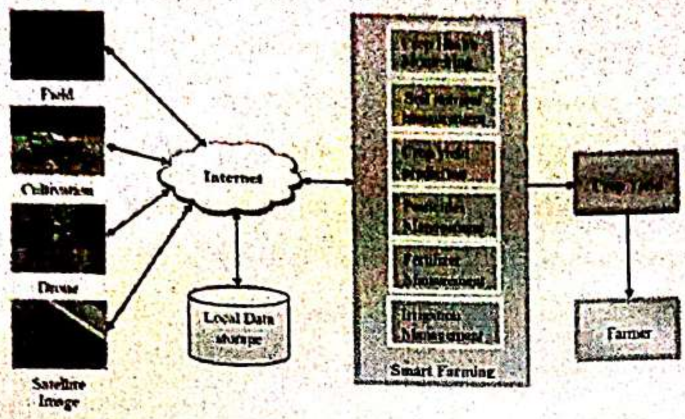

Fig 1: System Architecture Diagram

The intelligent agricultural methods show improved progress in yielding productivity and crop volume without compromising sustainable farming practices by reducing the amount of chemicals used as well as conserving water resources.

CHAPTER 2: LITERATURE SURVEY

Indeed, on analyzing the existing literature regarding Smart Agriculture and Soil Monitoring Systems, this is easy enough to give an onrush of interest concerning the technologies of IoT in the development of agricultural systems. Many studies revolved basically on the study of topics about using sensors like moisture from the soil, temperature and humidity, involved in developing real-time information able to function effectively for irrigation and crop surveillance. The setup consists of sensors with wireless communication technologies, with a configuration of having Wi-Fi systems including ESP8266. This configuration is purposefully designated to have constant transfer as in the case of cloud-based systems with the possibility of having distance monitoring and control. It mostly takes place together with automatically designed irrigation systems that respond to soil moisture levels for optimized water consumption and promotion of proper growth. Moreover, the developments in cloud computing allowed tremendous datasets produced by agricultural fields to be stored and analyzed.

ThingSpeak and Blynk are just some of the many platforms available that can enable sensor data to be visualized thereby enabling agriculturists to undertake concrete steps towards productivity enhancement. It is found that several sensors such as pH, light intensity and soil nutrients, combined together into one integral monitoring system, have proven beneficial in various studies. In this context, such innovations have contributed significantly toward precision agriculture that is characterized by decreased resource utilisation, improved crop yield, and a smaller environmental footprint. The latest studies came forward to focus on better scalable and sustainable smart agriculture systems by integrating the source of energy in remote or off-grid locations through renewable energy sources such as solar panels besides IoT devices.

Its capabilities include the incorporation of ESP8266, low power sensors, and extended functionality with no periodic maintenance. Besides this, further design of machine learning algorithms is used to achieve efficient predictions in analyses of conditions of soil, meteorological trends, and also on the health of agriculture. These innovations systematically pave the road toward more independent agricultural systems and enable farming to be made possible. Farmers control and monitor their fields with a minimum of interference, eventually being part of more conscious and sustainable farming practices.

CHAPTER 3: HARDWARE TOOLS

1. DHT11 Sensor: This is one of the cheapest digital devices that are often used for the measurement of temperature and humidity. Along with this, this DHT11 sensor provides an integrated thermistor and a capacitive type humidity sensor, which ensures the accurate measurement of environmental measurement.The sensor DHT 11 can detect temperatures ranging from 0°C to 50°C with an accuracy of ±2°C; in addition, it measures 20% to 80% relative humidity, along with an accuracy of ±5%. This sensor communicates with microcontrollers, such as the ESP8266, through a single-wire digital interface, making it easily integrated into IoT-based projects. Although it is a quite simple sensor in its capabilities, the DHT11 is perfect for non-precise applications in which cost-effectiveness and ease of use have high priority.

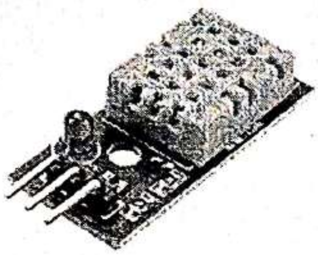

Fig.2DHT-11 Sensor

2. Relay Module: A relay module is an electrically controlled high-voltage switch, controlling the equipment - usually motors, lamps, or water pumps - by low-voltage controllers like microcontrollers or electrical pumps. Normally, the module contains an electromagnetic relay and other elements, including a flyback protection diode, a relay control transistor, and sometimes an operation indicator - a LED. In reaction to the low-voltage signal applied to the control pin of the relay, it becomes activated and opens or closes its switch to govern the work of the high-voltage device. There exist many relay modules that one can find in automation systems, like smart agriculture, due to the possibility of managing devices such as irrigation pumps according to sensor values. Modules of this type play a very important role for safe connection of low-power control systems with powerful apparatuses

Fig.3 Relay Module

3. ESP8266: It is an economically accessible microcontroller with Wi-Fi: ESP8266. It has been in high demand for applications or projects in IoT because it has a small form factor and user-friendly interface. It has an integrated module for connectivity to wireless networks, meaning that one can easily make communication with any other device through the internet. Due to well exercising simple and complex functions, the ESP8266 will be applicable in many applications from home automation, sensor networks, to smart agriculture. It has a 32-bit processor and supports different programming languages, though most take the Arduino IDE because of its ease of use and flexibility. The low power consumption and the low cost of the ESP8266 make this chip very practical for applications involving remote sensing and control, which require reliable wireless connectivity.

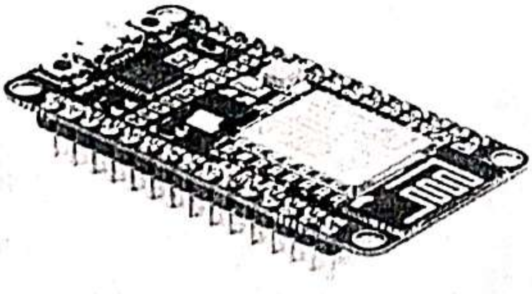

Fig.4 ESP8266

4. Water pump: An Internet of Things (IoT) water pump project uses IoT technologies to automate and remotely control water pumps with the objective of improving irrigation efficiency or managing water resources. This sort of initiative typically involves sensors measuring soil moisture, temperature, and humidity, which collect direct real-time information on environment conditions. This signal is then relayed to a microcontroller, including ESP8266 or Arduino; here, the signal is read and relays the water pump would have started once specific conditions-low soil moisture had reached the threshold. A system like this allows a cloud-based platform or mobile app to monitor and regulate remotely, letting the user track water consumption, view configurations, and provide peak irrigation without human effort. Such a system thus saves water and diminishes energy utilization while upholding crop well-being while in use in smart agriculture.

Fig.5 Water Pump

5. Jumper Wires: Jumper wires are simple electrical connectors with pins at each end and can provide interim connections between different components of a microcontroller or breadboard. They are male-to-male, female-to-female, or male-to-female, depending upon the kind of joining that needs to be done. In an Internet of Things helmet application, jumper wires enable the MQ-3 or IR sensor to connect with the NodeMCU, making it possible to send data between different componentry in a highly efficient manner.

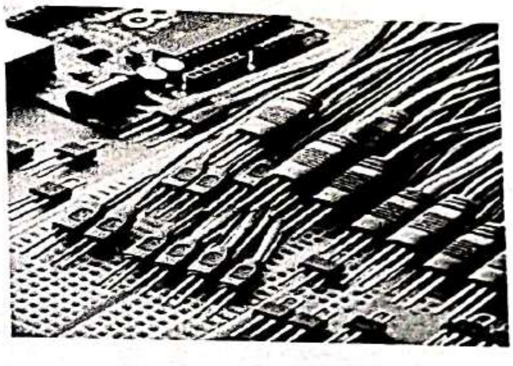

Fig :6 Jumper Wire

6. Moisture Sensor : A kind of moisture sensor is one of the tools which smart agriculture works with in the process of measuring the content of water in the soil to provide data for the real analysis with a view towards optimal control of crops. These sensors utilize the capacitive, resistive, or tensiometric techniques for the determination of the moisture content.. Moisture sensors connect directly to IoT systems and send data wirelessly, providing for automated irrigation based on soil demand, decreasing water waste, and creating healthy plants. This accurate monitoring of moisture levels helps in saving water; therefore, decreases expenses and increases crop yield, thus playing a vital role in sustainable farming methods.

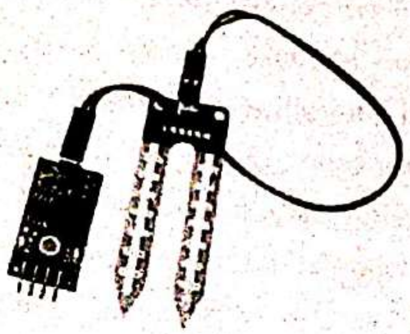

Fig:7 Moisture Sensor

CHAPTER 4: METHODOLOGY AND ALGORITHM

METHODOLOGY

The methods for IoT-based water pump system includes several key steps. The first steps include the deployment of field environmental sensors, for example soil moisture sensors, temperature, and humidity sensors. The sensors interface with the microcontroller, ESP8266, which processes the data collected from sensors. The programming in the microcontroller is done to assess sensor readings against predefined thresholds for comparison. If soil moisture falls below a certain level to signal a requirement for irrigation, the system activates a relay module that controls the water pump. The system is associated with a cloud platform where real-time data are recorded and accessed remotely via a mobile application or a web interface. This serves to enable the user to monitor and efficiently manage irrigation from a remote location and minimize manual interference. The system can use renewable sources such as energy-efficient solar panels for electricity generation.

ALGORITHM

1. System On :

ESP8266 microcontroller: Switch on the microcontroller and initiate the sensors including soil moisture, temperature, and humidity and relay module.

2. Wi-Fi: Wi-Fi Connection

Connect to Wi-Fi using SSID and password for data transfer

3. Sensor Reading :-

Monitor the soil moisture level, temperature, and humidity through the sensors attached to it.

4. Data Evaluation: .

Soil moisture reading must be compared with the required threshold value.

Water Pump Relay Activation: Switch on relay in case moisture level is less than the threshold setting to initiate pumping of water

5. Water Pump Activation:

Switch on water pump through relay in case, irrigation is in need (i.e., moisture ie less than threshold)

6. **Monitor and Adjustment:**

Monitoring the continuous sensors along with cloud data for remote adjustment of real-time basis. Once the moisture level reaches the threshold set level, stop pumping.

7. **Remote Monitoring and Control:**

Feed real time measurements data to the cloud to visualize

Let the users be in control of the system from the mobile application or the web portal if they want

8. **Loop:**

Repeat on several occasions the monitoring, evaluation, and control over the system.

Design Process:

The hardware selection stage is the first step in the design of the Smart Agriculture and Soil Monitoring System. It includes selecting the appropriate modules, as shown below: ESP8266 microcontroller; soil moisture sensor; DHT11/DHT22 sensor; light sensor; relay module. These modules can be connected, and the ESP8266 is programmed to read data from these sensors and trigger an irrigation action if the soil moisture is below a set threshold. It is programmed using the Arduino IDE to continuously monitor sensor readings and send the data to a cloud platform such as Blynk for real-time visualization. It controls the on and off of the water pump based on the soil moisture levels. Throughout the design, focus was given to ensuring that the system is energy-efficient, easy to maintain, and scalable for various agricultural settings

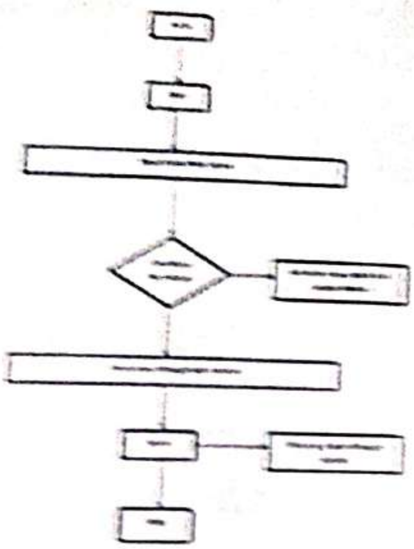

Fig.5 Design Process

CHAPTER 6: RESULTS ANALYSIS

1Effective Irrigation:

The process of irrigation is effective when the moisture level of the soil drops to a certain level, and it will utilize water only when it is necessary and therefore prevent waste.

2. Remote Access of Cloud Data:

The data transmitted by Sensor will upload into Blynk and allow farmers to view the readings in real time at a remote location, thus improving agriculture management from any side.

3. Water Savings

It utilizes water effectively, as irrigation pumping only occurs if the soil moisture is below mandatory with sustainable practices in farmed .

4. Healthy Crops

With efficient control of irrigation via proper measurements related to soil moistures, the best conditions crop prevail and this translated into healthier crops and more yields.

5. System Reliability

The system runs on continuous and faultless run concerning either the sensor measurement or pump activation.

6. Maintenance :

Modular design with off-the-shelf components allows for ease of diagnosability and maintainability by having readily available spare parts with minimal cost.

7. Scalability:

Scalability is achieved as the system can measure a number of fields or crops by the adding on more sensors or integrating it into other IoT platforms and hence versatility based on the different agricultural needs.

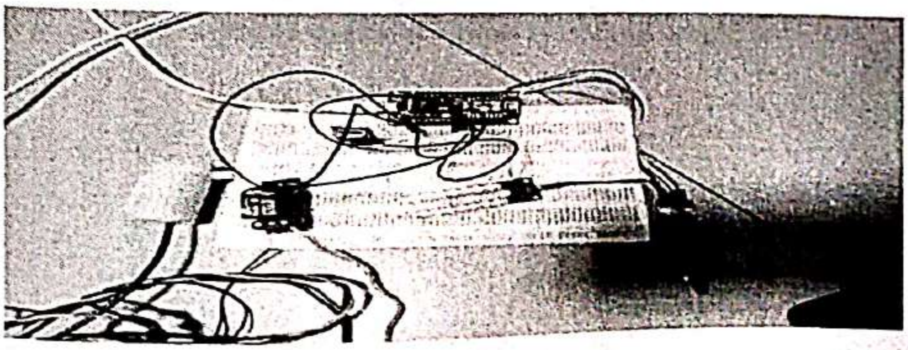

Fig-9 : Prototype Design

CHAPTER 7: CONCLUSION AND FUTURE SCOPE

Conclusion

The employment of ESP8266 in the Smart Agriculture and Soil Monitoring System permits the effective utilization of the best IoT technology in managing an irrigation system with automation, together with monitoring of soil conditions. The system uses real-time sensor data to determine soil moisture, temperature, humidity, and light intensity for optimizing irrigation, conserving water, and ensuring healthy crops. Actually, remote access of cloud-based platforms, such as Blynk, may help farmers make the right and informed decisions toward high productivity and sustainability of farms. Additionally, it relies on being energy saving and cost-effective for small and medium-sized farms.

FutureScope:

It can be improved in the near future by attaching further sensors in order to measure additional environmental factors, such as pH level, soil nutrients, and conditions of weather for optimal farming. It also allows the inclusion of algorithms developed based on machine learning that will predict analytics and predict the breakout of pests or the need for irrigation. This system can also be made highly automated by integration with other weather forecasting systems for adaptive irrigation according to the forecasted rainfall. A mobile application can be developed for a better user interface and real-time notification. The system will be scaled up to large agriculture operations with the capacity of multi-field monitoring.
In the emerging technologies, advanced sensors, drones, and satellite imagery would considerably improve the monitoring of soil health status to be significantly more accurate and real-time for comprehensive field analysis. With better machine learning models, predictive insights relating to nutrient needs, pest threats as well as from the weather, would thereby be available, enabling farmers to take proactive decisions. These shall bring resource efficiency and climate-resilient farming with greater productivity and sustainability to meet ever-growing global food demands. Innovations in wireless sensor networks and edge computing will ensure better connectivity, speedier data processing, and greater resource use efficiency even in remote areas.

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ANNEXURE

SELF-EVALUATION OF THE PROJECT

Month	Start date – End date (DD/MM/YY) - (DD/MM/YY)	Progress of Project
Month- 1	05/08/24 - 31/08/24	Topic Selection and Project planning
Month- 2	01/09/24 - 30/09/24	Hardware selection and Prototype Development
Month- 3	01/10/24 - 31/10/24	Data Analysis and Results
Month- 4	01/11/24 - 18/11/24	Documentation of the Project

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