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An IoT Application for Effective Management of Agriculture Resources

Vaibhav R. Chavan
Department of Computer Science and Information Technology, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad, Maharashtra, India

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ABSTRACT

Several issues related to traditional agriculture have hindered the growth of nation. Thus, solution to this mode of agriculture is adoption of smart agriculture. Therefore, the aim of this research is to make the agriculture smart by adopting innovative and advanced technologies such as Internet of things (IoT) and Wireless Sensor Network (WSN) enabled automation in agriculture. In recent times, IoT and WSN based technologies can be applied in several research fields. IoT enables various applications employed in crop growth monitoring and selection of irrigation decision support system. The technology like Raspberry Pi used recently in irrigation system of agriculture for improvement of crop productivity. This research paper focuses on various parameters of IoT related to agriculture such as soil moisture sensor, floodwater detector, temperature tracking sensor, humidity and light intensity sensor, etc. The sensors are associated to web server through raspberry pi controller. It detects the each activity of field and transfer the information to web server. The result outcomes assist the former to know about the actual scenario of field in real time through buzzer and can smartly do watering and showering fertilizer to the field in very efficient manner without trying too hard and quality of the crops will be get improved.

Keywords : Internet of Things (IOT), Raspberry Pi, microcontroller, Sensors, Soil Moisture, Smart Agriculture

I. INTRODUCTION

The nation India is having huge cultivable land, but the output produced does not justice to the potential of nation. It has been observe that, around 60-65% of the land is under cultivation (The World Bank Report). In the era of globalization, adoption of digital technologies has diffused in agricultural to improve the productivity of agricultural sector; however, some portion of agriculture, especially irrigation remains a manual exercise so far. It has been seen that several factors has affects the plant productivity. The availability of adequate amount of water is necessary for overall growth of plants in agricultural sector.

Several researchers have done research in the field of agriculture. Few of them used WSN for collection of data from various sensors. These sensors deployed at various nodes of WSN through wireless protocol. The gathered data provides the information related to different ecological factors. However, the examining only the environmental factors is not complete solution for yielding of crops in agriculture. There are numerous factors hinder the productivity to a large extent. Thus, there is need to implement automation in agricultural sector to conquer the generated issues or problems. Therefore, to develop the integrated system that will take care of all factors that harms the productivity of crops. However, it is difficult to adopt complete automation in agriculture due to numerous issues. However, it implemented at research level but that could not give valuable benefits to the former in real life. Hence, this research develops the smart agricultural system using IoT and WSN technologies [1].

WSN monitor the physical and environmental conditions through various interconnected sensors. WSN is a powerful and less expensive network that collects and process information in the various domains of agriculture. It sends the data in automatic manner through the application of multi-hop communication. WSN offers a high spatial and temporal resolution to observe the crops conditions using different sensors nodes deployed in the field of agricultural [2]. The proposed method plans the system to adopt microcontroller-based module that receives its instructions or orders from mobile application through internet and the same time microcontroller complete the issued commands. The main aim of this paper is to design the wireless mobile device based on IoT and adopt it in various operations of agricultural field. The proposed device measures the diverse ecological conditions of agricultural through sensors. This device consists of Raspberry Pi 3 hardware to execute the whole system. The main characteristic of this system is to execute the tasks such as measurement of temperature, moisture content, humidity measures, intensity of light, and switching ON / OFF electric motor. It can also connect other equipment's like sprinkler light, fan, etc. for automation purpose. The proposed system tested in the domain of agriculture, as it monitors the desired resultsThe said system is very much useful to the smart agricultural systems.

This paper organized as below: Section 2 presents the literature review. Components used in designing the system presented in Section 3. The system architecture is presented in Section 4. Section 5 presents the list of hardware and software adoption. Section 6 described the method used in this study. Results and discussion of findings presented in Section 7.A conclusion is the last part and this study concluded in Section 8.

II. LITERATURE REVIEW

This project comprises GPS-based remote moisture, monitoring and temperature sensing, intruder scaring, security, leaf wetness, and correct drainage facilities, among other characteristics. It uses wireless sensor networks that continually monitor the soil characteristics and environmental conditions. Sensor nodes placed across the farm in various areas. Temperature, humidity, moisture, and PIR sensors used to show the threshold value, whereas the water level sensor only used to show the amount of water within a tank or a water resource [1].

The majority of WSN-based applications in agriculture aimed at varied purposes; this article looked at the different types of WSNs and their potential for agricultural application development. They emphasized the most important agricultural and farming applications and discussed how WSNs might help increase performance and production. The network architecture, node architecture, and communication technology standards utilized in agricultural applications are also have been categorized. This study also lists real-world wireless sensor nodes with numerous sensors such as soil, environment, pH, and plant health [4].

This paper aim is to use automation and IoT technology to make agriculture smart. This paper's standout characteristics include a smart GPS-based remote controlled robot that can execute duties like as weeding, spraying, moisture detecting, animal & bird scaring, and maintaining vigilance, among others. Second, it incorporates smart irrigation with intelligent control based on real-time field data. Finally, smart warehouse management comprises temperature control, humidity control, and theft detection in the warehouse. All of these actions will be control by any remote smart device or computer linked to the Internet, and will carried out by connecting sensors, Wi-Fi or ZigBee modules, cameras, and actuators with a microcontroller and a Raspberry Pi [5].

The direction of the water and its supervision techniques as discussed in Chandan Kumar et al. They also connected to the DHTT11 soil moisture sensor, which allows them to manage the flow of water. This variant has a single-click switch control for the motor pump on the mobile app. This article discusses a cost-effective irrigation method for green fields. It also analyses energy savings as result of modernized agriculture, although access confined to mobile applications [6].

The design and execution of a unique wireless mobile robot discussed in this paper. It integrated with a variety of sensors that monitor a variety of environmental elements that are conducive to crop output. Wireless crop monitoring reduces labour expenses while also allowing for reliable tracking of changes that occur in real time at the field. The suggested system has the ability to regulate the critical factors for plant growth. As a result, the suggested smart agricultural system is both user-friendly and extremely durable [7].

III. COMPONENTS USED IN DESIGNING

We will be providing the detailed description of every component used in designing this password protected smart agriculture application system:

A. Raspberry Pi 3:

The Raspberry Pi 3 is a PI series developer board. It is may be regarded of as a single-board computer that runs on the LINUX operating system. The board not only offers many functions, but it also has a lot of computing power, so it is good for sophisticated applications [8]. Raspberry Pi is a compact computer that can execute all of the functions that a computer can accomplish. For input and output connections, it has 40 GPIO pins. In ARM CPU/GPU, the CPU is responsible for taking input, conducting computations, and providing output, while the GPU is responsible for graphical output. HDMI uses a cable to function as a connection. RCA jack for connecting to an analogue TV and other output devices. A USB port used to connect a mouse and keyboard. For power, a 5-voltmicro USB power connection may put in. To boot the gadget, you will need an SD card slot containing an operating system. There is no audio in here, but there is a 3.55 mm connector for audio output such as headphones or speakers. The LED provided to serve as a light indicator.

The Raspberry Pi 3 Model B has an improved ARMv7 multi core CPU and Gigabytes of RAM, making it a pocket computer that can transition from a "toy computer" to a true desktop PC. The circuit board diagram of the Raspberry Pi shown in Figure 1. The major update is from the BCM2836 (single core ARMv6) to the BCM2837 (dual core ARMv6) (quad core ARMv7). When compared to multi-core CPUs, the processing speed rises by two times. The speed of a system may increase by 4 to 7.5 times by effectively utilizing architecture. This processor boosts the speed with which you can browse the web and play games. All additional daughter boards will run at 99 percent efficiency on the Pi 3 [3].

Fig. 1: Raspberry Pi 3

B. Arduino Nano:

The Arduino Nano is a compact, comprehensive, versatile, and breadboard-friendly Microcontroller board based on the ATmega328p. It was created by Arduino.cc in Italy in 2008 and features 30 male I/O connectors set in the DIP30 manner. There are 14 digital pins, 8 analogue pins, 2 reset pins, and 6 power pins on the Arduino Nano. The Arduino Nano is a smaller version of the Arduino UNO, and the two boards have almost identical functionality. It has a 5V operational voltage, however the input voltage may be anywhere between 7 and 12V. The maximum current rating of the Arduino Nano is 40mA, thus the load connected to its pins should not drain more than that. Each of these Digital & Analog Pins has numerous roles assigned to it, but their primary use is to be set as Input / Output. When you link Arduino Pins with sensors, they work as Input Pins, but if you are driving a load, you will need to utilize them as Output Pins [9].

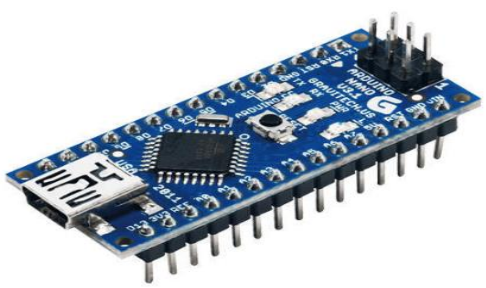


Fig. 2: Arduino Nano

C. Soil Moisture Sensor:

A soil moisture sensor is a device that detects the moisture content of the soil. Both analogue and digital outputs are available from the sensor. The analogue output threshold can changed, but the digital output is fixed. It operates on the open and short circuit principles. The LED indicates if the output is high or low. When the soil is dry, no current can flow through it, resulting in an open circuit. As a result, the production considered to be at its maximum. When the soil is moist, current flows from one terminal to the other, indicating that the circuit is short and the output is zero. To increase efficiency, the sensor is platinum plated. It is anti-rust, which means the sensor will last a long time, saving the farmer money [1].

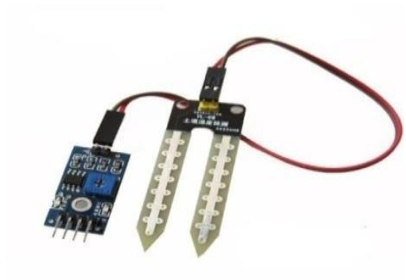


Fig. 3: Soil Moisture Sensor

D. ULN2803 IC:

The ULN2803 is a high-voltage, high-current Darlington transistor array that mostly used as a relay driver. It can handle up to eight relays at once. The collector-emitter voltage is roughly 50 V, whereas the input voltage is around 30 V. The Darlington pairs coupled in a parallel manner to provide better current capabilities. Eight NPN Darlington pairs are included in the component, which have high-voltage outputs with common-cathode clamp diodes that directly connected to switching inductive loads. Each Darlington pair has a good collector-current rating, usually about 500 mA [10].

Fig. 4: ULN2803 IC

E. LCD:

The LCD (Liquid Crystal Display) [11] screen is an electronic display module that has several uses. A 16x2 LCD display is a relatively simple module that may found in a variety of devices and circuits. There are 16 columns and 2 rows in this arrangement. The library that is used is <liquidcrystal.h>.

Fig. 5: 16*2 LCD

F. DHT11 Sensor:

The DHT11 is a simple digital temperature and humidity sensor with a modest price tag. It outputs a digital value, thus there is no need to employ a conversion procedure at the microcontroller's ADC, and we can send its output straight to the data pin instead of using the ADC. It has a humidity sensor that is capacitive. The only significant flaw with this sensor is that you can only collect new data from it every two seconds [5].

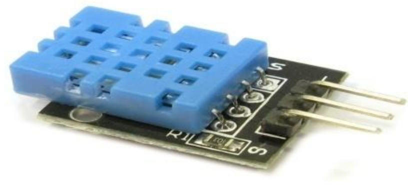


Fig. 6: DHT11 Sensor

G. Ultra-sonic sensor:

The ultrasonic sensor works on the concept of sound waves and their ability to reflect them. It is a made up of two parts: an ultrasonic transmitter and a receiver. The transmitter delivers a 40 KHz sound wave to the receiver, which receives the reflected 40 KHz wave and provides an electrical signal to the microcontroller. The speed of sound in air has previously established. The ultrasonic sensor allows the robot to identify and avoid obstacles while also measuring the distance between them [5].

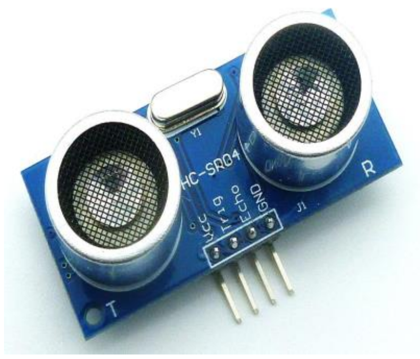


Fig. 7: Ultra-sonic Sensor

H. Relay:

The regulated DC signal utilized to control the A.C motors through a relay. It has the ability to separate one electrical circuit from another. The electromagnet closes and opens the circuit using the principle of electromagnetism. Wide-area electronics circuits, such as industrial control circuits, high-power amplifiers, telephone exchanges, and so on, use relays [3].

I. Buzzer:

Buzzers divided into two types: passive and active. Active buzzers are easy to operate and can be used on their own, even when just supplied with constant DC power [12]. Only the active buzzer may produce a specified frequency of sound. The passive buzzer, on the other hand, necessitates the use of an external circuit. A buzzer or beeper is a mechanical, electromechanical, or electronic auditory signalling device. There are several different sorts of buzzers accessible today, including alarms, timers, mouse clicks, and keystrokes [3].

J. Software Used in Designing

a. Python:

Python is one of the most popular programming languages for Raspberry Pi. The key advantage is that a programmer may create a small amount of codes compared to other programming languages.

b. Proteus 8 Simulator:

Proteus 8 is one of the finest simulation software for diverse microcontroller circuit designs. Because it has practically all microcontrollers and electronic components, it is an extensively used simulator. It may used to evaluate electrical programmes and embedded designs before they put to the test on actual hardware. Proteus may also used to simulate the programming of a microcontroller. Simulation reduces the probability of hardware failure due to poor design.

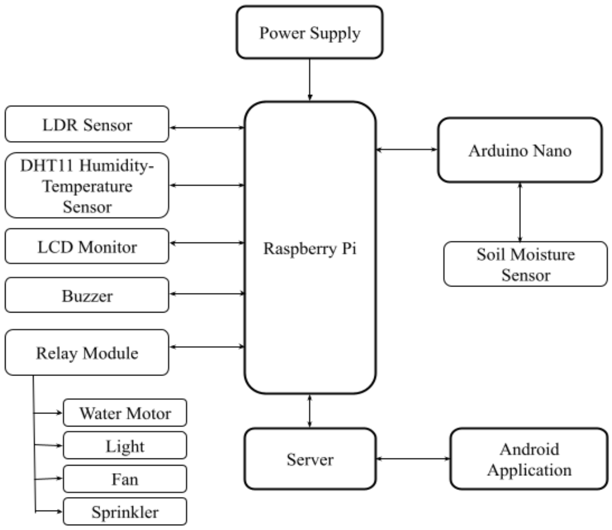
c. *Raspbian Operating System:*

The Raspbian operating system is a free and open source operating system based on Debian and designed specifically for Raspberry Pi. It comes with a minimal set of apps and tools to get your Raspberry Pi up and running. It comes with roughly 35,000 packages, which are pre-compiled software packages packaged in a convenient style for easy installation on the Raspberry Pi. It has a strong developer community that manages the discussion forums and offers answers to a variety of difficulties. Raspbian OS, on the other hand, is still in constant development, with the goal of enhancing the performance and reliability of as many Debian packages as possible [5].

IV. SYSTEM ARCHITECTURE

The Embedded Control Unit (ECU) and the Remote Control Unit (RCU) are two components of smart agriculture system where ECU is a part of Smart farming where the system implemented, while the RCU is a framework implemented on the user's smart phone. ECU is an efficient, low-power embedded access control solution for smart agriculture that allows users to monitor and control their equipment remotely. ECU made up of a Raspberry Pi with the Raspbian operating system, which installed on an SD card. On the user's smart phone, the Android application serves as a remote control unit. Using Android Studio, RCU implemented on the Android platform. Android is the world's first fully functional, open, and free mobile operating system. Android Studio is a tool for implementing Android apps.

Figure 8 shows the system architecture of smart agriculture. The entire smart system to be put at the needed location consists of a Raspberry Pi, Arduino Nano, DHT11 Humidity and Temperature sensor, soil moisture sensor, relays, light dependent register, and power supply. The soil moisture sensor connected to the Raspberry Pi 3's GPIO ports through an Arduino nano microcontroller. The Raspberry Pi 3's GPIO pins are connected to an LDR light intensity sensor, a DHT11 humidity-temperature sensor, a 16x2 LCD monitor, a buzzer sensor, and relays. The drivers for multiple relays Circuits containing ULN2803 IC used to control the water motor, light, fan, and sprinkler using the Raspberry Pi's GPIO pins. On the Raspberry Pi3, all of the sensor data saved on an SD card.



Fig, 8: Block Diagram of IoT Based Smart Agriculture

The soil moisture sensor in this block diagram measures the amount of moisture in the soil. The temperature sensor measures the crop's ambient temperature. The water level sensor measures the crop's water level. The sensor values sent to the remote server over a Wi-Fi connection using IOT protocols using the Wi-Fi module. The Raspberry Pi connected to an Arduino controller, which collects data from the sensors and operates the output devices. To manage the temperature and moisture level of the crop, relays utilized to turn on the fan and the water pump. When any of the sensor data reaches a certain threshold, the buzzer sounds.

V. HARDWARE IMPLEMENTATION

Sensors such as moisture sensors, DHT11, Ultrasonic, Arduino mini, ULN2803 IC, and buzzer are linked up with the Raspberry Pi3 board GPIO pins, which also contain the power supply. The overall project design is initially simulated in Proteus, as shown in Figure 9.

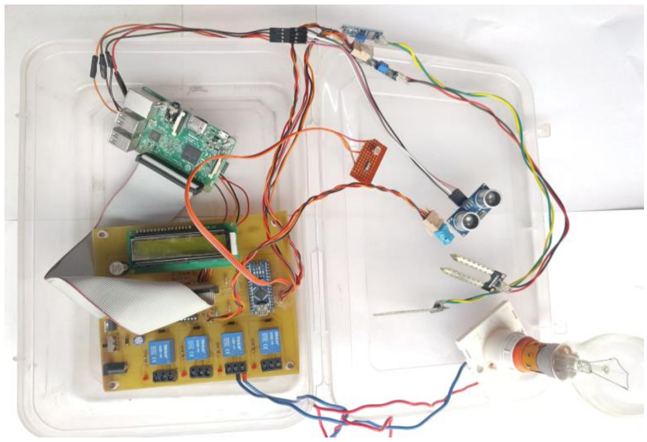


Fig. 9 : Hardware Implementation of system

a. *Circuit Description*

The Raspberry Pi 3 model, Arduino nano microcontroller, IC ULN2803, LCD 16*2, power supply for the system, and other sensors make up the circuit of this Agriculture System, that based on IoT. The Raspberry Pi 3 is in charge of the entire processing process where we can operate the system as well as use it as a server system for data storage and application connectivity. The Raspberry Pi system has a 12V to 3.3V power supply with a system ON/OFF switch. The GPIO pins used to connect sensors to the Raspberry Pi, as well as to acquire sensor data readings and store them in the database. The result readings displayed to the user via an LCD display attached to the Raspberry Pi GPIO5, 6, 13, 19, 26 pins. To determine the wetness of soil, the soil moisture sensor coupled to the Arduino nano microcontroller. The Arduino nano converts analogue data from attached sensors to digital data and sends it to the Raspberry Pi's GPIO14 (Tx) and 15(Rx) pins through the Arduino D0 and D1 pins, while DHT11 is connected to GPIO4. To obtain trig and echo information, the ultrasonic sensor connected to GPIO17 and GPIO27. Multiple GPIO pins used to link multiple ICs in order to execute relay automation. Some of the GPIO 23, 24,25,8 pins on the ULN2803 are connected to relays that are connected to the Water Motor, Fan, Sprinkler, Light/Bulb with power supply. To show when the relay action begins and ends, a buzzer connected to the GPIO21 pin.

VI. SOFTWARE IMPLEMENTATION

The client application, the server and database, and the application on the device are the three components of software implementation. The overall communication flow between the components depicts in the diagram. This part will explain how the various components communicate with one another, how the components built, the database structure, and how the application appears.

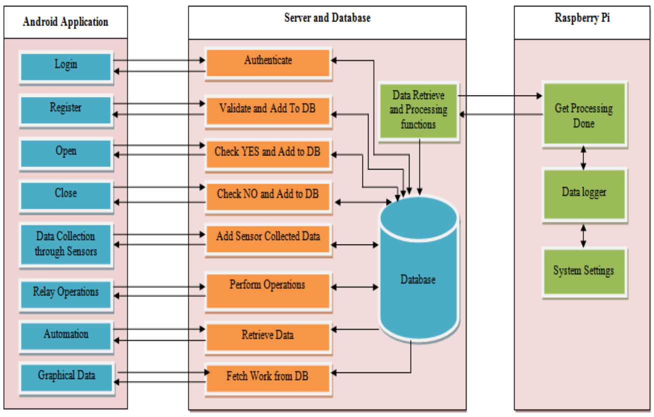


Fig. 10: The communication flow between components

In the smart agriculture system, the Raspberry Pi reads real-time data from the field using several sensors. The information gathered will be forward to the server. The information will be saving in the server's database. An android application with an internet connection can retrieve data from the server (fig. 11). The android studio used to create an android application. The system is a low-cost, portable Smart agricultural system that enables for data collection, storage, and transfer.

Fig. 11: Login Page

Fig. 12: Home Page

VII. METHODOLOGY

This project's operation is straightforward. We have placed our soil moisture sensor in the field when working in the field section so that we may get the wetness of the soil in an analogue format value. The soil moisture sensor connected to an Arduino nano microcontroller, which converts the analogue value to a digital value that may sent to the Raspberry Pi. Other sensors attached to the Raspberry Pi include a DHT11 sensor for obtaining information on the field's temperature and humidity, as well as an LDR sensor for determining the field's light intensity. We utilise an ultrasonic sensor to measure the level of water in the field such that we may automate or notify farmers or users about the condition. We can manage the monitoring of field issues or greenhouse monitoring using all sensor data through analysis. The relay operation may used to automate or manually the process by connecting various essential equipment's such as a water motor, fan, sprinkler, lamp, and so on. One click is all it takes to automate manual procedures using an application or a webpage.

The data collected from the sensors kept in the database server and viewed by the user via his mobile or PC, allowing us to automate the relay operation by defining the exact value to use. As the user information recorded in the system, once the action is completed, the value applied to the given data. The buzzer also signals if the procedure is about to start or end. The LCD 16*2 component is also utilized to show the live monitoring of sensors such as the soil moisture sensor, DHT11, which displays temperature and humidity readings, LDR, which displays light intensity, and Ultrasonic, which displays the depth of water level in the tank.

Flow Chart:

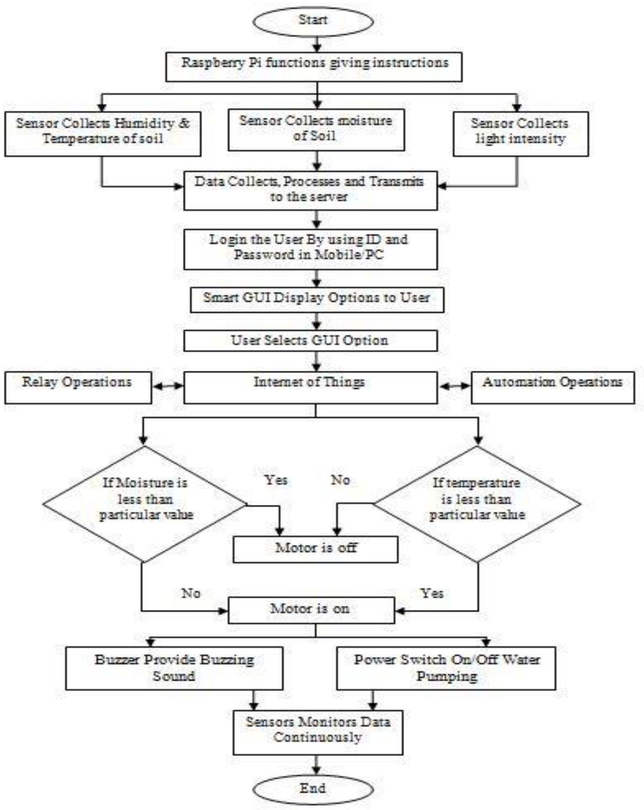


Fig. 13: Flowchart of System

VIII. RESULT AND DISCUSSION

The Smart Agriculture System project primarily intended to deliver an IoT-based Agriculture Monitoring System. The embedded control unit, which includes soil moisture, humidity, temperature, sensor, relays, and an Arduino nano that interfaced with a Raspberry Pi, installed in the Agriculture Field. When we start the execution, the name appears on the LCD as shown in fig.14.

Fig. 14: LCD Display with System Name

The below fig.15 shows It will be useful to maintain the weather condition in the field or in the greenhouse by showing the temperature and humidity at various spots on the field. The DHT11 sensor used to assess the surrounding surroundings, and water then delivered to the plant based on the results. When there was a particular degree of humidity, the pump switched 'OFF,' whereas when there was less humidity, the pump turned 'ON'.

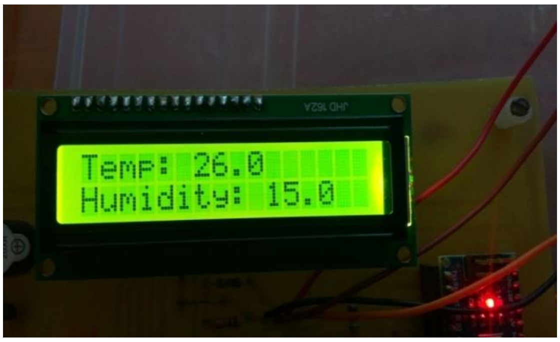


Fig. 15: Temperature and Humidity in LCD Display

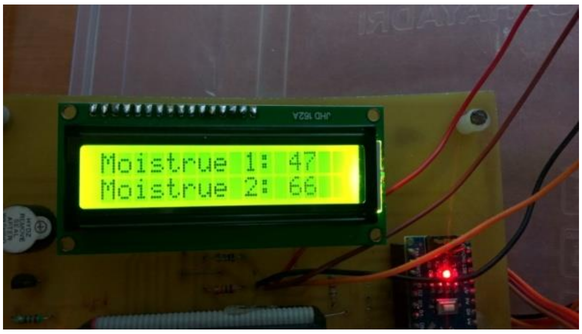


Fig. 16: Two Soil Moistures in LCD Display

These two soil moisture sensors used to determine the moisture content of the soil depicted in fig. If the moisture level falls below the acceptable level, the moisture sensor sends a signal to the Raspberry Pi, which performs the automation operation, turns on the water pump, and supplies water to the plant using the mobile app illustrated in Figure 16. The light intensity in the field shown in fig.17, and the Level indicates the level of water in the tank.

Fig. 17: Light and water Level in LCD Display

The fig. 18 shows registration page for a new user sign up

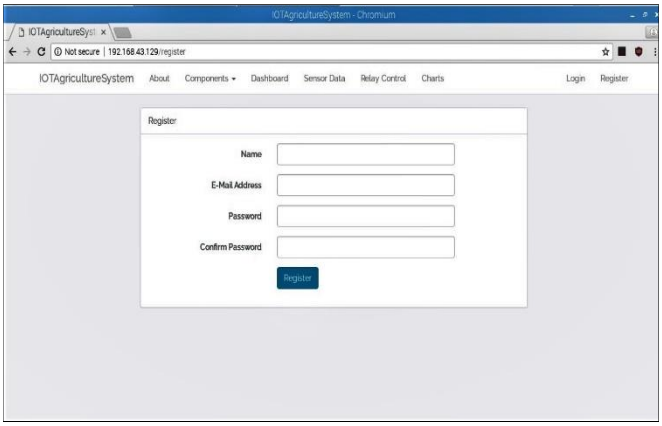
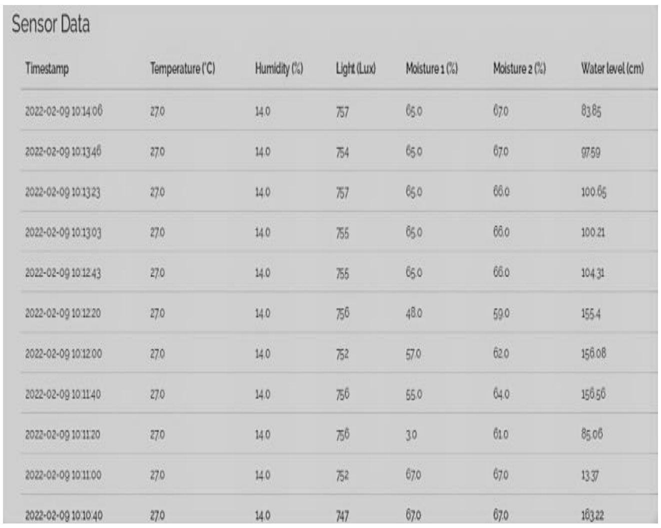


Fig. 18: Sign Up Webpage

Fig. 19: The Proposed System

As we can see, the practical implementation of this project given in above fig 19,



Sensor Data

Timestamp	Temperature (°C)	Humidity (%)	Light (Lux)	Moisture 1 (%)	Moisture 2 (%)	Water level (cm)
2022-02-09 10:14:06	27.0	14.0	757	65.0	67.0	83.85
2022-02-09 10:13:46	27.0	14.0	754	65.0	67.0	97.59
2022-02-09 10:13:23	27.0	14.0	757	65.0	66.0	100.65
2022-02-09 10:13:03	27.0	14.0	755	65.0	66.0	100.21
2022-02-09 10:12:43	27.0	14.0	755	65.0	66.0	104.31
2022-02-09 10:12:20	27.0	14.0	756	48.0	59.0	155.4
2022-02-09 10:12:00	27.0	14.0	752	57.0	62.0	156.08
2022-02-09 10:11:40	27.0	14.0	756	55.0	64.0	156.56
2022-02-09 10:11:20	27.0	14.0	756	3.0	61.0	85.06
2022-02-09 10:11:00	27.0	14.0	752	67.0	67.0	13.37
2022-02-09 10:10:40	27.0	14.0	747	67.0	67.0	163.22

Fig. 20: Sensor Readings Monitored from the Field

The above fig. 20 displays many essential sensor readings monitored from the agricultural field at various time intervals, as well as the continuous measurement of moisture content from the sensor.

IX.CONCLUSION

For all intents and purpose, this work has successfully implemented the Raspberry Pi wireless sensor network in the Agriculture Field for measuring temperature, humidity, and moisture utilizing sensors. The proposed technique can reduce farmers' efforts while providing a high return. By monitoring environmental conditions and giving the relevant information to farmers remotely, an IoT-based agricultural monitoring system deployed to enhance agricultural production. This method is effective for field management because it analyses multiple parameters. To regulate and monitor the field's status, an Android application created. Furthermore, sensors will use IoT to provide the current condition of the system, enhancing smart agriculture and removing the need for human monitoring near the system.

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XI.REFERENCES

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