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IoT-Driven Crop Monitoring for Enhanced Agricultural Analysis and Precision Farming

Mayuri Gawade, Vedant Sanap, Purva Salunke, Samay Kumar, Samyak Lokhande, Sanika Luktuke, Sanskar Zine

Department of Engineering, Sciences and Humanities (DESH)
Vishwakarma Institute of Technology, Pune, Maharashtra, India

Abstract-
India is mostly an agricultural nation. Agriculture is the primary source of income for the majority of Indian families. The Internet of Things (IoT) plays a vital role in improving cultivation methods for green houses and providing farmers/landowners with the relevant information to make decisions for optimal yields. The core objective is to automate the irrigation process based on real-time soil moisture data. The systememploysanESP8266 module to facilitate the seamless exchange of data between various sensors and Firebase, a real-time cloud database. In this system using DHT11 sensor, Touch sensor, soil moisture to monitor and collecting data. The ESP8266 module serves as the central hub for collecting data from the sensors and transmitting it to the Firebase database. The data stored in Firebase is accessible through a web application built using React.js and Node.js. This web interface provides users with a graphical representation of the gathered data, allowing them to monitor the agricultural conditions in real-time.

Keywords — Crop Monitoring, Internet of Things (IoT), Soil Moisture Sensors, Touch Sensors, Web Interface.

I. INTRODUCTION

In our fast-paced life, we ignore many things that we need to take care of, but ignoring of something living might result in the death of that, so are the plants, if we, because of any reason, forget to take care of the plant or even forget to water the plant, might result as the end of life of that plant. The need for the efficient utilization of resources in agriculture is critical in order to achieve increased production. As a result, various technologies are being integrated into the agricultural industry, such as cloud computing, wireless sensor networks, the Internet of Things (IoT), big data, machine learning, and fog computing, play an important role, especially in regard to the use of energy and water, to improve the yield of crops or maintain the good health of plants. One of these is IOT- Internet of Things is a technology that allows a mobile device to monitor the operation of a device. The "IoT-Based Agriculture Management System with ESP8266 and Firebase Integration" project emerges as a groundbreaking solution to enhance agricultural productivity and resource management. This project focuses on harnessing the power of the Internet of Things (IoT) to create a smart and efficient agricultural ecosystem [1]. The ESP8266 module serves as the central hub for collecting data from the sensors and transmitting it to the Firebase database. The plant's health deteriorates due to environmental conditions, i.e., high temperatures, abnormal humidity factors, and bad soil conditions. When the IoT-based agricultural monitoring system is activated, it checks the water level, soil moisture, temperature and humidity. All data collected by the sensors is transmitted in real-time to the Firebase database, which serves as the central repository for agricultural information. This data is then made accessible through a web application developed using React.js and Node.js. By continuously monitoring such key environmental parameters the system enables precision agriculture practices. This includes automated irrigation control, real-time alerts for adverse conditions, and the ability to take immediate corrective actions. The web application features an intuitive and easy-to-use graphical interface, allowing users to effortlessly visualize and analyze data. By presenting information in a clear and accessible way, it helps users make informed decisions and take proactive steps for better management.

II.LITERATURE REVIEW

The newer scenario of decreasing water tables, drying up of the rivers and tanks, and unpredictable environment present an urgent need for proper utilization of water. In India about 35% of land was under reliably irrigated. And the 2/3rd part of land is depending on monsoon for the water. Irrigation reduces dependency on monsoon, improves food security and improves productivity of agriculture and it offers more opportunities for jobs in rural areas. The implementation of wireless sensor network technology in precision agriculture has significantly contributed to the development of plant monitoring systems. These systems are designed to provide real- time monitoring and automation of agricultural processes, leading to improved crop production and efficient resource management [2].

Mancuso and Franco [16], have done a similar research work in a tomato greenhouse in the South of Italy. The Sensicast device is used for air temperature, humidity and soil temperature with wireless sensor network and a web-based plant monitoring system is developed. User can read the measurements over the Internet, and an alert message is sent to his mobile phone through SMS if there are any deviations from normal measurements. Sensor node will transmit the data of temperature and relative humidity in one minute interval to the Bridge node.

Abhishek Gupta [15] et al. explain that the system consists of a soil moisture sensor, a water pump, and a microcontroller that controls the watering process. The article also discusses the advantages of using an automated system over manual watering, such as improved plant growth and reduced water waste. Overall, the article presents a useful solution to maintain healthy plants while minimizing their water usage.

T.Thamaraimanalan [17] et al. They explain that the system collects data on parameters such as temperature, humidity, soil moisture, and light intensity using sensors and sends the data to a cloud-based server for storage and analysis. The article also describes how the system can be accessed remotely through a mobile application. The authors highlight the benefits of such a system, including improved plant growth and reduced water usage, as well as potential applications for large-scale farming. Overall, the article provides a useful resource for implementing an IoT- based garden monitoring system.

III.METHODOLOGY/EXPERIMENTAL

I. COMPONENTS

A. DHT 11

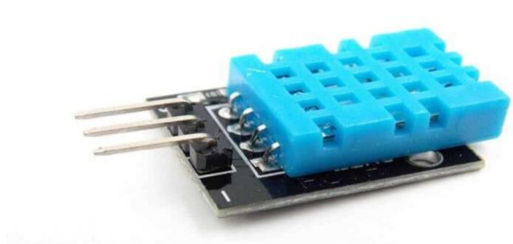

Fig.3.1 DHT11 humidity and temperature

The DHT11 sensor is for temperature and humidity. It reads through a digital process and relies on sensing special materials. There is a resistance-changing component within that senses humidity and another resistance-changing component that senses temperature. These components are connected to a small, efficient computer chip that interprets the information. The DHT11 is characterized as being accurate, fast responding, and energy conserving. It's also low-cost, which makes it an ideal option for IOT-based projects.

B. Node MCU (ESP8266) wifi module

Through the addition of a Wi-Fi modem, a smart agricultural monitoring system is able to access the internet. This internet access opens up a number of important advantages, most significantly remote access and control. Farmers or other parties are then able to view real-time information from their farms, including temperature, humidity, soil moisture, and other important measures, from any location with internet access. In addition, they are able to manage many of the system's aspects remotely, including turning on irrigation systems, regulating ventilation, or even managing lighting in greenhouses, without having to be physically located at the farm. So we are basically using Node MSU(ESP8266) wifi module.

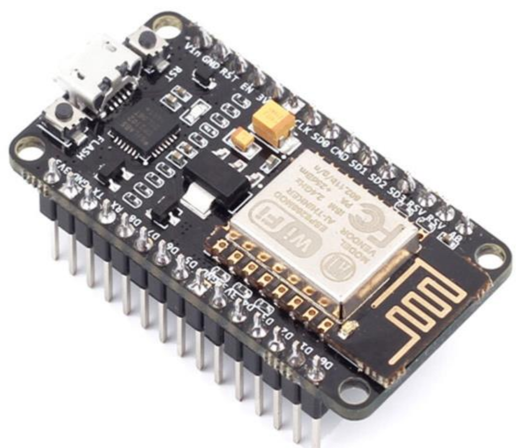

Fig.3.2. Node MCU (ESP8266) wifi

Node MCU is a device that simplifies the process of making devices that are internet-connected. It's like Arduino but with a more advanced programming language, which is Lua. Node MCU is open-source, and its design is made available to the public, and it's built on the ESP8266 Wi-Fi chip. This chip provides Node MCU with its internet connectivity. You can connect multiple sensors and other peripherals to a single Node MCU board using 16 pins. The ESP8266 processor inside Node MCU has an internet of things-optimized processor. Although the term "Node MCU" generally applies to the software (firmware) used in the ESP8266, sometimes it also refers to the development board itself. The ESP8266 chip is also directly usable as a simple Wi-Fi module for any other project

C. Soil moisture sensor

A soil moisture sensor gauges the quantity of water in the ground. It has two components: an electronic circuit board and a probe with two pads. The probe is placed in the ground, and the pads engage with the moisture of the ground. The sensor then converts the level of moisture to a readable measure that tells whether or not the soil is wet, dry, or in between. This can be read from a webpage, providing remote access to information on soil moisture.

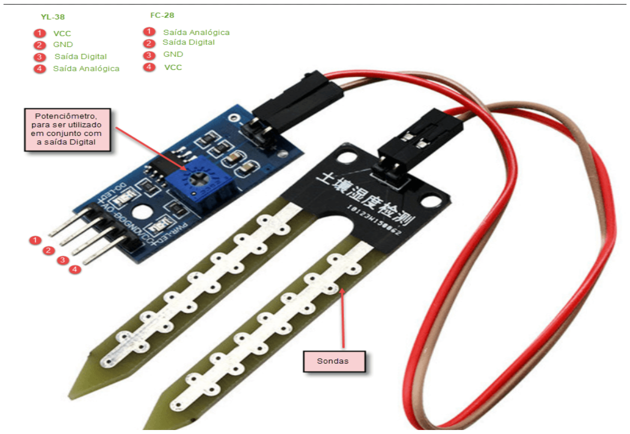

Fig.3.3 Soil moisture sensor

B. METHOD

In this IOT-based crop monitoring system, the ESP8266 module is used as a central point for gathering data from sensors. The sensors attached to the ESP8266 are used to measure key factors such as soil moisture, temperature, and humidity. The ESP8266 then sends the gathered data to a Firebase database. Prior to this data being able to be appropriately visualized, it goes through an important preprocessing step to have it in the proper format and prepared for analysis. The system has access to real-time data, which means that it is working with constantly updated data. This makes it so the data within the Firebase database, from the ESP module, is indicative of the current environment being sensed by the sensors. Additionally Crop Feedback web page is an advisory tool that processes real-time crop health parameters and gives actionable suggestions to farmers. The Crop Feedback page, which enables users to choose a crop and get AI-driven insights for more informed farming decisions It retrieves temperature, humidity, and soil moisture levels from IoT sensors in the field and checks if corrective action is required.

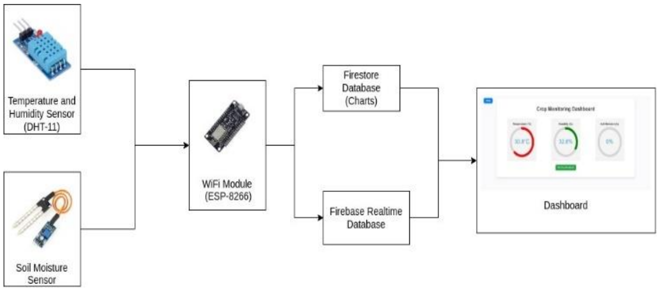

Fig.3.4 Flow chart of working model

This working model aim to achieve better accuracy of data visualization and therefore opted for Chartjs library, a type of library commonly used in data visualization tasks. One of the key features of Chartjs is that it can give a fully functional dynamic data visualization [1]. JavaScript package called Chart.js is used to create HTML based charts. Among the most basic JavaScript visualization libraries, it includes all types of pre-built chart. A selection of commonly used chart types, plugins, and customization options are offered by Chart.js. A mixed chart can also be created by combining other chart types. HTML & CSS provides dynamic web page where all data can be integrated. The farm owner can monitor the process online through a web application.

IV. Results and Discussions

Working and results of our system is displayed here. Several screenshots with their explanation and how they will work is shown here.

Fig.4.1 Image 01

The Fig 4.1 homepage of the Crop Monitoring System showcases real-time monitoring designed for more efficient farming. The navigation bar provides easy access to features, contact information, and sign-in options.

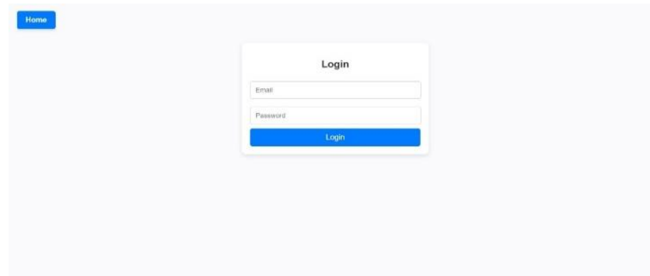

Fig.4.2 Image 02

These is the login page provides safe entry into the IoT-based agricultural website to enable authorized individuals to track real-time farming data. It comprises email and password fields, an authentication button for login, and a "Home" button for convenient navigation. The system boosts data security against unauthorized access of vital sensor readings. Integrating features such as password encryption and two-factor authentication can enhance security and user privacy further.

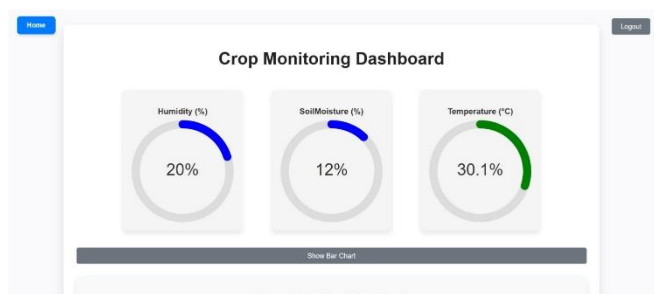

Fig.4.3 Image 04

Fig.4.4 Image 05

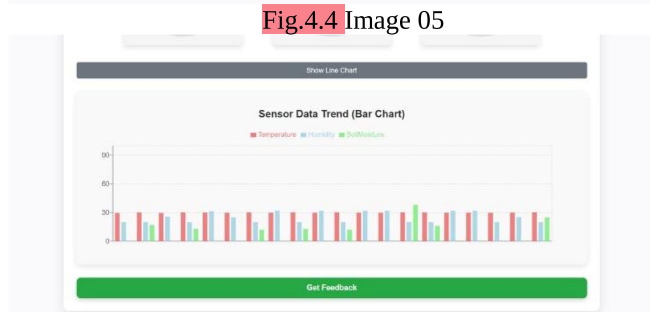

Fig.4.5 Image 06

The graphs in Fig 4.3, Fig 4.4, Fig 4.5 depict the most important characteristics of the agricultural website based on IoT, created to improve the efficiency of farming by monitoring and visualizing data in real time. The dashboard for crop monitoring offers immediate measurements of critical environmental parameters such as soil moisture, temperature, and humidity, visualized using circular progress indicators. Apart from that, the site also features interactive data visualization tools, including line and bar charts, to enable farmers to monitor trends in these parameters over time. The provision of toggling between different chart types makes it more user-friendly and enables improved trend analysis for informed decision-making. Moreover, the system features a "Get Feedback" function, which allows users to obtain data-driven recommendations for optimizing agricultural practices. These features together help in precision farming by allowing farmers to respond in a timely manner, conserve resources, and optimize productivity.

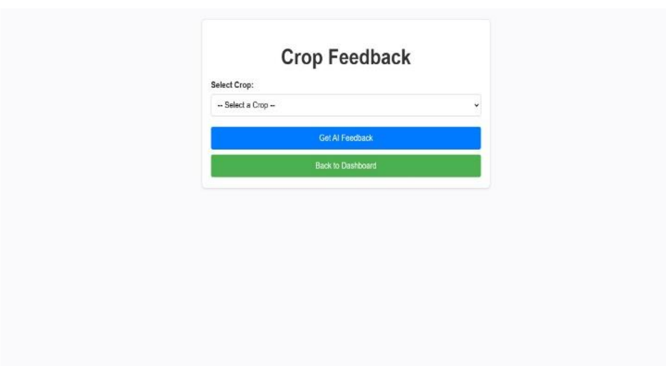

Fig.4.5 Image 07

One of the most valuable features of our website is the Crop Feedback page, which enables users to choose a crop and get AI-driven insights for more informed farming decisions. It has a dropdown list for choosing a crop, a "Get AI Feedback" button for customized advice, and a "Back to Dashboard" option for quick navigation. This is a potent tool for precision farming, offering data-based advice, and enabling farmers to optimize crop health and maximize output.

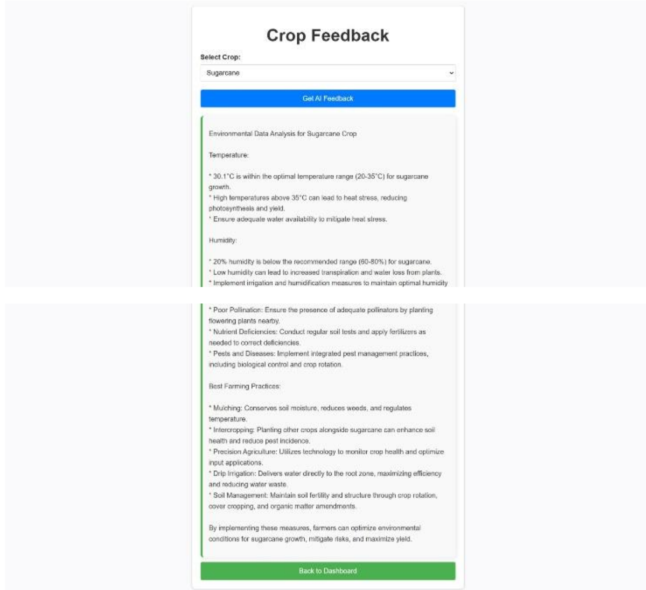

Fig.4.6 Image 08

The Crop Feedback feature offers in-depth environmental analysis and best agricultural practices for chosen crops. The feedback also addresses best agricultural practices such as mulching, intercropping, precision farming, and drip irrigation to improve soil quality and increase yield. Natural fertilization methods and integrated pest management are also suggested to ensure crop health. The "Back to Dashboard" button makes it easy to navigate, and users can easily toggle between monitoring and feedback.

V. Conclusion

Conclusion An IoT-based crop management system with a website, data visualization capabilities, and language change support offers a comprehensive solution for farmers to monitor, analyze, and optimize agricultural practices. Farmers can access real time data on soil moisture levels, environmental conditions, and crop health through intuitive data visualization interfaces. By leveraging IoT sensors and data visualization tools, farmers can closely monitor crop conditions and implement targeted interventions to maximize yield and quality. This results in higher profitability and competitiveness in the agricultural market. In summary, an IoT-based crop management system with website integration, data visualization capabilities, and language change support represents a transformative approach to modern agriculture. By harnessing the power of IoT technologies and data analytics, farmers can overcome challenges, optimize productivity, and cultivate a more resilient and sustainable agricultural sector.

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