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Smart Irrigation Management System for Precision Agriculture

D Venkata Sarath Chandra
Computer Science and Engineering
ABV-IIITM
Gwalior, India
sarath2162002@gmail.com

Gagandeep Kaur
Computer Science and Engineering
MITS
Gwalior, India
gagan873@gmail.com

Mahua Bhattacharya
Computer Science and Engineering
ABV-IIITM
Gwalior, India
mahuabhatta@gmail.com

***Abstract*—The Internet of Things (IoT) has revolutionized every aspect of the everyday lives of the average person by making everything smart and intelligent. The Internet of Things (IoT) is a collection of interconnected devices that can self-configure. The purpose of this paper is to recommend an IoT-based smart farming system that will help farmers acquire real-time data for effective environmental monitoring that improves overall production and product quality. The major goal of this research is to propose an Internet of Things (IoT) based smart farming system to help farmers obtain live data of temperature, and soil moisture for efficient environment monitoring that enhances crop productivity.**

***Index Terms*—Sensors, Internet of Things (IoT), smart, precision agricultureSensors, Internet of Things (IoT), smart, precision agriculture**

I. Introduction

THe agriculture sector accounts for one of the most significant contributions to the Indian economy. However, agriculture production is influenced by seasonal conditions. IoT-based sensor technologies are used to achieve successful outcomes in agriculture production [1]. Systems for monitoring agriculture on a global and regional scale depend on monitoring the current real-time data on food production. An IoT-based system is required to develop agricultural field monitoring for smart farming with the aid of sensors like light, humidity, temperature, soil moisture, etc. Farmers can keep an eye on the state of their fields from remote locations. Smart farming that is IoT-based is significantly more efficient than traditional farming. In this paper, the proposed IoT-based irrigation system makes use of a DHT11 sensor and an ESP8266 NodeMCU module. In the proposed work autonomous irrigation management is achieved by sensing the physical parameters from the monitoring field such as the amount of soil moisture. Then the data is sent to the Blynk server to monitor the state of the land being monitored.

The system focuses on creating tools and devices that take advantage of wireless sensor network benefits to manage, display, and notify users. Utilizing automation and IoT technology, it seeks to make agriculture smart [2]. At the very end of the system, which may build a complete computer system from sensors to tools that view data from agricultural fields, the cloud computing devices are employed. It offers a fresh approach to smart farming by incorporating wireless communication technologies with smart sensor systems and smart irrigation systems. The installation cost of this system is low. Here, one may use a laptop, smartphone, or computer to access and manage the agricultural system [3]. The needs of contemporary agriculture, which demands high-yield, high-quality, and efficient production, cannot be met by conventional agriculture and its supporting industries. To estimate the highest potential productivity and crop suited for the very specific land, it is crucial to modernize existing methods and use information technology and data collected over a period of time. IoT has been rapidly advancing in industries including manufacturing, healthcare, and automobiles. It provides a variety of alternatives for food production, delivery, and storage that can increase India's per capita food availability. Sensors that provide data on the condition of the soil's nutrients, insect infestation, moisture levels, and other factors that may be utilized to gradually increase crop yields [4], [5]. Organic farming heavily relies on historical soil health metrics including temperature, pH, and soil moisture. IoT applications may help with irrigation pump management, opening and closing water flow gates, and data logging the state of the soil's health for both the present and the future. This paper proposes an IoT based solution to reduce the labour cost in agriculture and have a better overview of the farm time to time at the comfort of home [6], [7].

This proposed system works by establishing the connection between the user device to machine which will be implanted in the farm to give dynamic analysis and control the water flow for the crops. IoT is viewed as a critical component for smart farming since, according to experts, farmers will be able to improve food output by 70% by the year 2050 with the help of precise sensors and smart equipment. The money invested in agriculture would drastically be reduced by this continuous expert supervision would be possible, which would be almost impossible by humans to perform [8]. Less exploitation of water resources. The market for related solutions is expected to grow at a 13.47 % compound annual growth rate, or $ 7.87 billion annually, by 2022, according to research firm Markets and Markets, which notes that "the increasing focus on farm-efficiency and productivity is expected to propel the growth of the precision farming market [9], [10]. There are many problems in cultivating crops some of them being: Agriculture productivity is directly and negatively impacted by drought. In rain fed regions, severe droughts have resulted in a 20-40% reduction in agricultural output. Small and marginal farmers are particularly badly struck by drought in rain-fed areas, endangering their ability to provide for their families. Most small farmers conduct subsistence farming and can only plant one crop since they reside in locations with only monsoon rain as a source of irrigation. The excessive usage of water resources causes brackish water intrusion into aquifers, low ecosystem resilience in harsh climates, increased land vulnerability to desertification, social conflicts, and threats to the biodiversity of forested water bodies. Analyses and research on the internet of things are made in terms of technological levels and systems with an eye toward the internet of things' present state of development and based on the technology that is now accessible. Data collecting, network service, data fusion, and computation were the first three issues addressed. Based on this analysis, the technical system framework for the internet of things was developed. This framework includes technologies like RFID, ZigBee, sensors, cloud computing, and so on. In addition, study and research on the system's sensor nodes as well as debate and analysis of the many technologies involved are ongoing. In order to give objects intelligence, the Internet of Things refers to a network that connects devices like RFID, Smart Sense, GPS (Global Positioning System), etc. in objects to wireless networks via interfaces [11]. This enables communication and dialogue between humans and objects as well as objects and objects. The proposed system primary goal is to introduce contemporary technologies into necessary industries like agriculture. This technique streamlines agriculture by utilizing IoT technologies. Simple monitoring the advantages as described, such as water savings and labour efficiency are most needed in present situation in agriculture. As a result, employing the creative use of sensor networks in agricultural sectors irrigation [12], [13]. The customer receives the IoT information. As a result, any adjustments to the crop early analysis are accomplished as easily identifiable patterns may such. Fig.1 describes the connections in the proposed system.

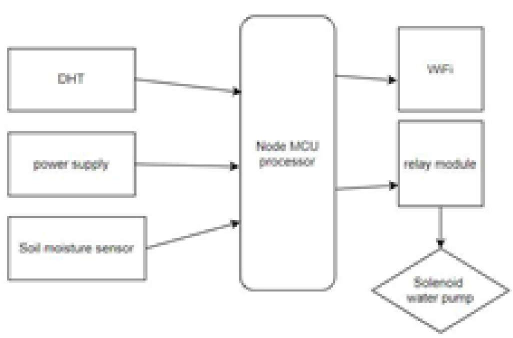

Fig. 1: Connections in the proposed system

II. Related Work

The literature review studies the various research and exploration projects that have been established for precision agriculture using IoT Technology. Madushanki et al. [3] researched on the data collection methods of currently existing IoT technologies to evaluate and have an understanding about recent developments in this field of technology to study which methods were efficient in their specific cause of usage. Puranik et al. [12] proposed to automate the whole process of agriculture through IoT devices through Arduino systems as main processor, whereas this proposed technology uses NodeMCU as the main processor. However there exist some issues as the climatic conditions of rainfall weren't taken as a key factor for rehydration. Mansoor et al. [14] proposed implementation of IoT devices to track the daily life activity using wearable sensors. However it also suffers by usability and acceptability issues. Khatri et al. [15] utilized IoT technology to keep the stray animals away and maintain the pH levels of delicate crops by using multiple processors and it will be consuming higher amounts of electricity. However, this model is developed to reduce the electricity consumption and works on a single processor, this can be highly beneficial to Fruit Crops where the farmer wants to invest lesser amounts of money and thus wants the IoT device to consume lesser amounts of electricity. However there is some vulnerability in this model too, this model depends on another server to communicate between device and user, and hence there might exist a chance of hanging issues in the functioning of the device when the server's security is breached and was made to fall in DOS and DDOS attacks. This proposed work utilises soil moisture sensor and temperature sensor to give a dynamic analysis of the farm and helps to maintain the water levels of the farm to ensure the crop stays hydrated till the yield is achieved.

III. Proposed Work

The machine works with a coordination between many devices embedded in it. The technologies embedded in the machine are as follows:

Fig. 2: Soil moisture sensor

Fig. 2 depicts a soil moisture sensor, a device that measures the amount of moisture in the sand. The module output is at a high level when the sensor detects a water scarcity in the field; otherwise, the output is at a low level. This sensor monitors the moisture level of the soil and serves as a reminder for the user to water their plants. It has been extensively utilized in farming, irrigation, and botanical gardening.

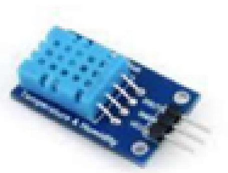

Fig. 3: Temperature sensor (DHT-11)

The temperature and humidity of the atmosphere are measured using a temperature sensor (DHT-11). The DHT-11, seen in Fig. 3, is a straightforward, inexpensive digital humidity and temperature sensor utilizing a capacitive to measure the environment, use a thermistor and a humidity sensor, and split a digital signal on the data pin from the air. A DHT-11 is measuring the electrical resistance to determine relative humidity between two electrodes resistance. Fig. 4 depicts an electrically operated switch that uses a relay. It has a set of working contact terminals and a set of input terminals for one or more control signals. The switch may include a number of contacts in various contact configurations that can make or break connections. In order to maintain the crop's moisture level, a relay is employed to activate the water pump.

Fig. 4: Relay

A cheap, compact submersible pump motor is the DC 12V Mini Micro Submersible solenoid Water Pump in Fig. 5. Power between 6 and 12 volts is required for operation. With a relatively low current usage of about 23 A, it can pump up to 120 liters per hour. It is sufficient to attach the tube pipe to the motor outlet, immerse it in water, and then power it. Fig. 6 depicts a NodeMCU (ESP8266) that is a embedded Wi-Fi module in a microcontroller. This device has 30 total pins, 17 of which are General Purpose Input Output (GPIO). There are 128 KB in the NodeMCU. Programs are stored in 4MB of flash memory and RAM data.Every time the NodeMCU gets a signal data from the sensors, it verifies the information it has received, and saves the data received. It transmits a pulse to the relay module, which then serves as a switch to turn on or off the pump, based on the data it has received. The NodeMCU's operational frequency is between 80 and 160 MHZ, and its operating voltage is between 3 and 3.6V. The NodeMCU's Wi-Fi module has a range of 46 indoors to 92 outdoors meters.

Fig. 5: Solenoid Water Valve

Fig. 6: NodeMCU Processor (ESP8266)

Fig. 7 depicts power supply's whose job is to change the voltage, current, and frequency of electric current coming from a source so that it can power a load. Power supplies are thus also known as electric power converters. While some power supplies are integrated into the appliances they power, others are independent freestanding pieces of equipment. Fig. 8 demonstrates the circuit diagram of irrigation management system. In the circuitry, one terminal from the power supply is connected to a terminal of the pump. The other terminal of the power supply is connected to the relay module. Other terminal of the pump is again connected to the relay. when the user decides to rehydrate his crop the circuit system gets the solenoid water valve to release the water to crops through relay.

Fig. 7: Power Supply

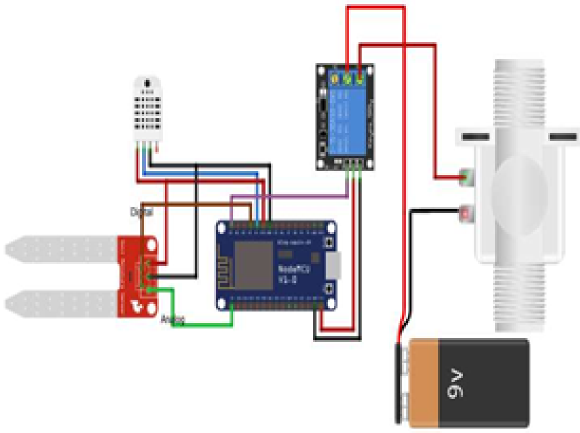

Fig. 8: Circuit Diagram

Fig.9 shows the working model of the proposed system where the NodeMCU processor gets connected to the Wi-Fi and starts acting as a communication device between the machinery and user. After installation of the machine in the farm, sensors collect the data and then send it to the Blynk server. Blynk is an open source platform that connects MCUs and boards like Arduino and Raspberry Pi over Wi-Fi. The user will then have a choice to rehydrate the farm considering parameters and climate conditions. The security feature in the proposed irrigation management system is built with help of Blynk server. All the data communicated over Blynk server is safe and encrypted.

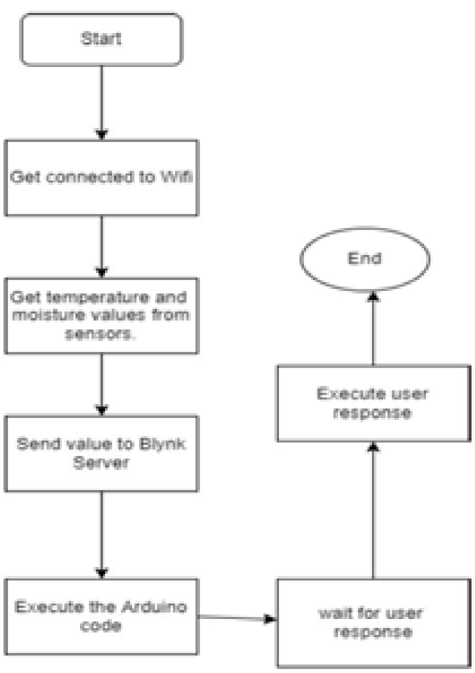

Fig. 9: Flowchart of the Proposed Work

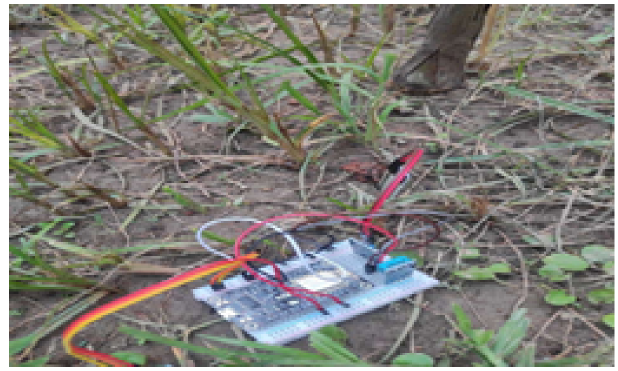

Fig. 10: Testbed

IV. RESULTS

Fig.10 shows the practical hardware testbed set up for the proposed smart irrigation management system. The water sensor was inserted into the soil to read the moisture levels while the DHT sensor remained exposed to the outer surface. It was powered with a 12V battery, which could also be replaced with a unified electric source for covering a larger area of agriculture. The interface used is created by Blynk server application, through which results are depicted in Fig. 11 and Fig. 12. The user interface is operated in a mobile in which the user gets the chance to operate power supply to the water pump connected to the machine. The real time readings of temperature, moisture level and humidity are displayed to help the user to know the right time to rehydrate crop. A timer is displayed beside the pump function button to indicate the time spent watering the crop.

Fig. 11: Results of Experiment 1

Fig.11 describes the experimental results where the device was exposed to dry soil in a humid afternoon time. As the soil was still dry low units of 642 soil moisture was shown, which indicates the farmer to rehydrate the farm to sustain the crop. Fig. 12 describes the results for moist soil. This experiment results were recorded right after the user decided to rehydrate the farm through water pump. As the soil was moist again, the moisture levels spiked to 1024 units while the temperature and humidity levels stayed stationary.

Fig. 12: Results of Experiment 2

V. Conclusion

In this paper, smart irrigation management system for precision agriculture using IoT based technology is presented that improves productivity. This smart farming technology monitors and manages the irrigation system by forecasting the humidity and soil moisture levels. The intelligent monitoring system improves time management, water management, soil management, and pesticide and insecticide control for farming. Additionally, this approach reduces the amount of labor required by humans, streamlines agricultural practices, and promotes smart farming. The expandability and scalability factor for the proposed model is very high. In future work, the proposed model will be enhanced by taking into account the security aspect and mobile sink.

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