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Enhancing Crop Growth Efficiency through IoT-enabled Smart Farming System

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Abstract

The agricultural sector is facing significant challenges in meeting the increasing demands for food production while ensuring sustainability and resource efficiency. To address these challenges, the integration of Internet of Things (IoT) technology into farming practices has gained attention as a promising solution. This research focuses on the development and implementation of an IoT-enabled smart farming system aimed at enhancing crop growth efficiency. The proposed system leverages IoT sensors and devices to monitor and collect real-time data on various parameters such as environmental conditions, soil moisture levels, and crop health. The collected data is then analyzed using advanced analytics techniques to gain valuable insights and make informed decisions regarding irrigation, fertilization, and pest control. By utilizing IoT technology, farmers can optimize their resource utilization, reduce waste, and maximize crop productivity. This research aims to investigate the potential benefits and challenges associated with implementing the IoT-enabled smart farming system. In this paper, a cutting-edge Internet of Things (IoT) technology is explored for monitoring weather and soil conditions for efficient crop development. The system was built to monitor temperature, humidity, and soil moisture using Node MCU and several linked sensors. Additionally, a Wi-Fi connection is used to send a notification through SMS to the farmer's phone about the field's environmental state. The results will help in developing strategies and guidelines for the widespread adoption of IoT-enabled smart farming practices, ultimately leading to sustainable and efficient crop production to meet the demands of a growing population.

Keywords: IoT, Node MCU, agriculture, sensors

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1. Introduction

The global population is projected to reach 9.7 billion by 2050, necessitating a substantial increase in agricultural productivity to meet the growing demands for food. However, the traditional farming methods face challenges such as limited resources, environmental constraints, and unpredictable weather patterns. To address these challenges and enhance crop growth efficiency, the integration of Internet of Things (IoT) technology into farming practices has emerged as a transformative solution. The primary industry and the foundation of the Indian economy is agriculture. Domesticated animals are raised in order to generate food, fibre, and a variety of other desirable goods. About 58% of Indians rely mostly on agriculture for their income. Agriculture will be significantly impacted by climate change, which will result in higher water demands and lower agricultural output in regions that need irrigation the most. To effectively utilized water, an intelligent system is being created. The technology automatically and effectively flows water into the fields and the farmer does not need to do this. People's

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use of traditional methods results in water waste. As a result, the idea of automating agriculture using an IoT mix has been created. It became a dependable system as a result of technological advancements, which considerably increased crop yield efficiency. The decision to manage the water supply intelligently will be aided by knowledge of the soil's characteristics. Increased knowledge of soil and temperature conditions results from smart farming. Water waste is reduced as a result of the development of smart agriculture using IoT-based solutions.

For continually monitoring soil and ambient conditions, the Soil Moisture Sensor is a used that provides real- time data to a smartphone through a cloud service. When it starts to rain, a raindrop detection sensor alerts the controller, which then limits or stops the water flow depending on the moisture content. In this study, the system makes use of sensors to measure temperature, humidity, and soil moisture content as well as a rain-detection sensor to assess the crop's suitability for cultivation. Along with the node MCU, all of these sensors are linked to the internet and smart phones.

IoT-enabled smart farming systems offer a paradigm shift in agriculture by leveraging sensors, devices, and data analytics to optimize resource utilization, monitor crop health, and automate farming operations. These systems enable real-time monitoring of environmental parameters such as soil moisture, temperature, humidity, and light intensity, providing farmers with valuable insights for informed decision-making. The objective of this research is to explore the potential of an IoT-enabled smart farming system in enhancing crop growth efficiency. By harnessing the power of IoT technology, this research aims to revolutionize traditional farming practices and promote sustainable and efficient agriculture. The proposed smart farming system utilizes IoT devices and sensors deployed in agricultural fields to collect continuous data on environmental conditions. This real-time data is transmitted to a centralized system for analysis.

By implementing precise and targeted interventions based on real-time data, farmers can optimize their resource utilization, reduce waste, and maximize crop productivity. For example, the system can automatically adjust irrigation schedules based on soil moisture data, ensuring optimal water supply while minimizing water wastage. This research involves field trials in collaboration with local farmers to assess the effectiveness and practicality of the IoT-enabled smart farming system. Key performance metrics, including crop yield, water usage and economic viability, will be evaluated to determine the impact of the system on crop growth efficiency. The findings of this research will contribute to the existing body of knowledge on smart farming systems and provide valuable insights for farmers, researchers, and policymakers. The adoption of IoT-enabled smart farming practices can lead to sustainable and efficient crop production, addressing the challenges of food security and resource scarcity in the face of a growing global population.

2. Related Work

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A literature survey on enhancing crop growth efficiency through IoT-enabled smart farming systems reveals the significant potential and advancements in this field. Various studies highlight the benefits of real-time monitoring, precise resource management, early detection of crop stress and disease, automation, data-driven decision making, and scalability. For example, Zhang et al. discuss methodologies, challenges, and opportunities in smart farming, emphasizing the role of IoT [1]. Mishra et al. review IoT-based smart farming [2], while Khan et al. [3] proposes an IoT-based intelligent system for crop protection and monitoring. Yadav and Jaiswal provide a comprehensive review of IoT-enabled smart farming [4], and Islam et al. focus on sustainable agricultural practices [5]. These studies collectively demonstrate how IoT technologies facilitate improved crop growth efficiency, optimizing farming practices, reducing costs, and contributing to sustainable agriculture. However, further research is needed to explore the full potential of IoT-enabled smart farming systems in different farming environments and crop types.

Anushree Math, Layak Ali, Pruthviraj developed a smart irrigation system [6] which focus on giving plants a certain quantity of water at a given time is the process of irrigation. An open-source system serves as the system's main controller. An array of sensors continually provides the most recent data on the variables impacting plant health. Based on data from the RTC module, the solenoid valve is set up to water the plants regularly [7]. It is possible to manage and keep an eye on the complete irrigation system online. A Raspberry Pi camera is used to send live footage to a website to track the health of the plants. Through a wireless network, the controller gets information about water flow from the water flow sensor [8-10]. This data is examined by the controller to check for line leaks. To improve the effectiveness and predictability of water distribution, weather forecasting is also utilized to determine water allocation restrictions [11].
Ghosh et al. (2023) embarked on a comprehensive study to assess water quality through predictive machine learning. Their research underscored the potential of machine learning models in effectively assessing and classifying water quality. The dataset used for this purpose included parameters like pH, dissolved oxygen, BOD, and TDS. Among the various models they employed, the Random Forest model emerged as the most accurate, achieving a commendable accuracy rate of 78.96%. In contrast, the

SVM model lagged behind, registering the lowest accuracy of 68.29% [15].
Alenezi et al. (2021) developed a novel Convolutional Neural Network (CNN) integrated with a block-greedy algorithm to enhance underwater image dehazing. The method addresses color channel attenuation and optimizes local and global pixel values. By employing a unique Markov random field, the approach refines image edges. Performance evaluations, using metrics like UCIQE and UIQM, demonstrated the superiority of this method over existing techniques, resulting in sharper, clearer, and more colorful underwater images [16].
Sharma et al. (2020) presented a comprehensive study on the impact of COVID-19 on global financial indicators, emphasizing its swift and significant disruption. The research highlighted the massive economic downturn, with global markets losing over US $6 trillion in a week in February 2020. Their multivariate analysis provided insights into the influence of containment policies on various financial metrics. The study underscores the profound effects of the pandemic on economic activities and the potential of using advanced algorithms for detection and analysis [17].

3. Proposed Smart Farming System

The suggested setup makes use of a Node MCU microcontroller on which is installed an ESP8266 Wi- Fi module. Blink serves as the user| interface on a smartphone. The system makes use of a deck robot, a DC motor, a humidity and temperature sensor (D HT11), a rain detection sensor, and a soil moisture sensor. When turned on, a water pump coupled to a DC motor sprays water over the plants. Soil| moisture is measured using a sensor. The NodeMCU determines whether or not to water the plants based on the humidity. The NodeMCU begins watering the crop by turning on the DC motor when the moisture level is below the threshold and shutting it off when the soil has an adequate moisture level by ap plying the necessary functions and conditional statements in the code| for the NodeMCU function. A humidity and temperature sensor records the air's humidity and temperature to evaluate if the culture is conducive to development. While some plants only produce well in a certain range of temperatures, others nee d a certain environment to grow. The amount of rain that has fallen is determined using a raindrop sensor. The plants won't get water if there isn't enough rain to provide the soil the moisture it requires. Even after it rains, if the plants still don't receive enough water, the DC motor has to be switched on and more water should be applied. The NodeMCU Wi-Fi module transmits data to the NodeMCU Blink Cloud through Wi-Fi [12]. The user may observe humidity, temperature, soil moisture, and get notifications if it rains while the DC motor is operating by downloading the Blinkapp to their smartphone. The farmer may use a range of buttons and switches to operate the DC motor with the aid of this programme. After doing the necessary analysis, the NodeMCU starts the DC motor in response to a signal from the application. Once again, a similar WLAN data routing method issued. Fig. 1 depicts the smart farming system's process.

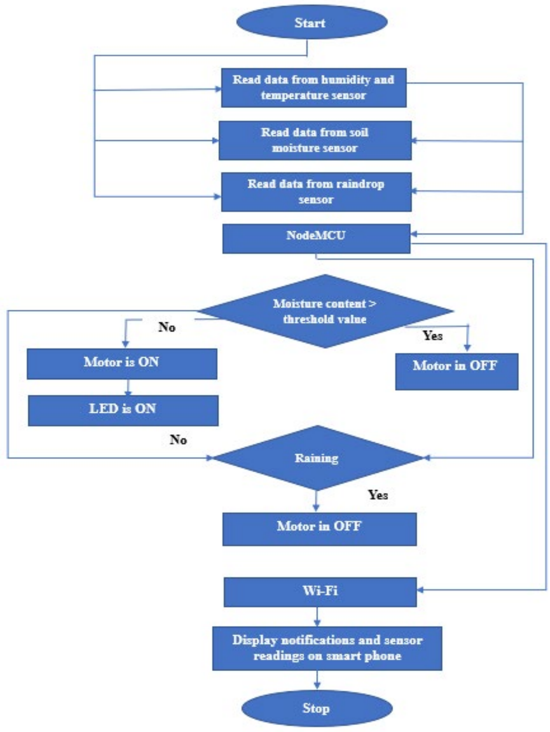

Fig1. Flow of the Smart Farming system.

4. Implementations

For farmers in the agriculture industry, creating a successful IoT based intelligent irrigation system is a crucial prerequisite. An economical, weather- based intelligent irrigation system was necessary [13-14]. The first step is to create an effective drip irrigation system that can regulate the water flow to the plants according to the soil's moisture level. With the addition of an IoT-based communication component, this irrigation system is more effective while using less water. This feature allows a remote user to manually change the waterflow and examine the soil moisture values. The system also incorporates updated sensors for temperature, humidity, and precipitation in order to allow online remote monitoring of these factors. A distant database continually stores this field weather information. Based on the weather at the time, a weather prediction algorithm is utilized to manage water distribution. The suggested intelligent water system would enable farmers to irrigate their crops more effectively. Fig. 2 displays the block diagram of the proposed IoT-based smart farming system:

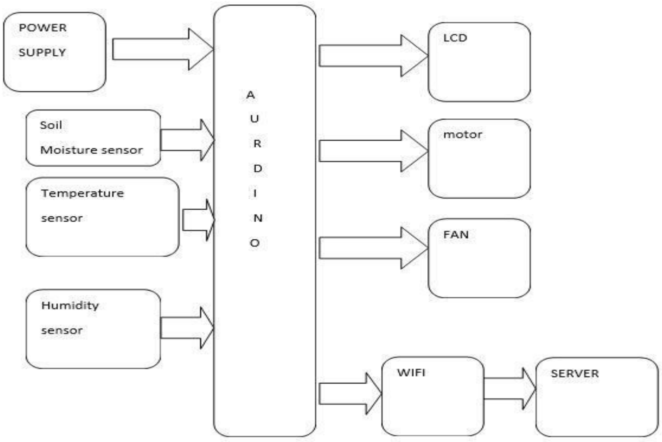

Fig. 2. Block diagram of the Smart Farming system.

The detailed description of the components used in the above figure is mentioned below.

Arduino

A microcontroller board called Arduino Uno is based on the ATmega328 (datasheet). It has a 16MHz ceramic resonator, a USB connection, a power jack, an ICSP header, a reset button, 14 digital I/O pins, six of which may be used as PWM outputs. It is equipped with all the parts required to support the micro controller; to use it, power it is using an AC/DC converter or a battery, then connect it to a computer using a USB cable.

Soil Moisture Sensor

The dielectric permittivity is averaged over the length of the soil moisture sensor. The dielectric constant here depends on the presence of water. This sensor's operating temperature range is between 10 and 30 degrees Celsius, and the applied voltage is 5 volts. The Soil moisture sensor is shown in the figure 3.

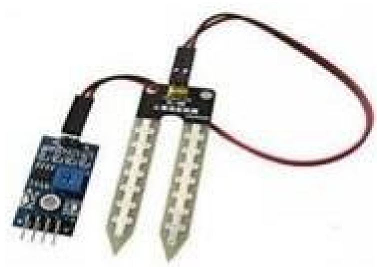

Fig. 3. Soil moisture sensor.

Humidity and Temperature

The Digital Humidity and Temperature Sensor (D HT11primary)'s function is to gauge the temperature and humidity of the surrounding air. The relative electrical resistance of the ambient air in the growth region is measured by this sensor, which in this system combines a capacitive humidity sensor with a thermistor to monitor temperature and humidity. This information is used to forecast what crops should be planted on fields this year. To optimize agriculture, this sensor offers exact weather changes. It offers a seasonal crop cycle technique and utilizes an Android app to forecast weather changes to warn farmers. The IC analyses and calculates the change in resistance before reporting the humidity measurement to the NodeMCU. The voltage range in which this sensor functions is 3.3V to 5V. the range of| humidity is 20 to 90% RH, and the temperature range is 0 to 50°C.

LCD

A liquid crystal display, often known as an LCD, is especially helpful for user interface and troubleshooting. The Hitachi HD44780 controller or other HD4580-compatible hardware serves as the brains of the majority of character-based LCDs. Currently, 80 characters may be handled by 1-, 2-, or 4-line LCDs using a single HD44780 controller. Additional drawing capable LCDs need twoHD44780 controllers.

DC Motor

A sort of electrical machine that transforms electrical energy into mechanical energy is a direct current (DC) motor. Electricity is transformed into mechanical rotation by direct current (DC) motors. The figure 4 represents a DC Motor.

Fig 4. DC Motor

The Internet of Things (IoT) is being utilized more often to link things and gathers data. Therefore, using the Internet of Things in agriculture is essential. The goal of this paper is to create an Internet of Things- connected intelligent agricultural system. The sensor data is sent via Wi-Fi to the field manager, and a harvest prediction is generated using the mobile app. The usage of an automated irrigation system is done when the temperature is high. The following figure 5 illustrates how IOT is used in smart farming.

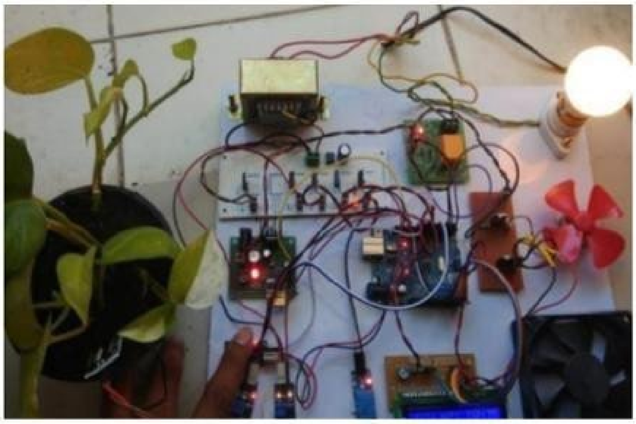

Fig.5. IoT Implementation for Smart Farming

5. Conclusion

Using Internet of Things technology, in this paper temperature, humidity, soil moisture, and rain status are all measured and reported. These values are all sent to the smartphone through Wi-Fi. Farmers who frequently pump water and monitor the state of each crop can greatly benefit from this method. Farmers can monitor soil moisture, temperature and humidity from anywhere in the world by using the Blink app on their smartphone. In conclusion, the integration of IoT-enabled smart farming systems has the potential to revolutionize crop growth efficiency. By enabling real-time monitoring, precise resource management, automation, data-driven decision making, and scalability, these systems empower farmers to optimize their farming practices and achieve higher productivity while reducing costs and environmental impact. With further advancements and research in this field, IoT-enabled smart farming systems hold immense promise in transforming agriculture and ensuring sustainable food production for the future.

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