IoT-Enabled Smart Irrigation System for Precision Farming using Microcontroller

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The modern era is rapidly progressing in all sectors, including agriculture. Irrigation is a crucial aspect of agriculture, and in India sprinkler and drip irrigation techniques are used. But these processes are manually operated, which is time-consuming and results in low productivity. The objective of this project is to design and develop a Microcontroller based Smart Irrigation System for Farms. The automation in the irrigation process of farms will minimize the costs and time consumption while promoting sustainable development with the help of IoT. This system can precisely utilize the water on the farm without any wastage. The System is designed to operate in Automatic and Manual mode. In automatic mode all the control of the system is handed to the AT89c51 Microcontroller, Soil moisture sensor connected to the AT89c51 MCU is used to sense the moisture in the soil and the motor is actuated accordingly. If the rain is detected by the Rain sensor which is also connected to the AT89c51 MCU, the motor is automatically turned off to avoid the access water in the farm. In manual mode, the motor can be turned on and off with the help of an Android app that is connected to the ThingSpeak IoT cloud. The temperature and humidity values from the Dht11 sensor in the farm area are also shown on the app interface. The system sends and reads the data from the cloud with the help of ESP8266 MCU which is connected through the Wi-Fi. As the System is connected to the Internet through Wi-Fi we can monitor and control the system from any remote area. We have used two controllers so that if any one microcontroller fails the other microcontroller runs the system smoothly.

Keywords: Smart Irrigation, AT89c51 MCU, Android App, ESP8266, ThingSpeak IoT Cloud, remote monitoring, IOT (Internet of Things).

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1. Introduction

A smart irrigation system using a microcontroller is an automated method of irrigating crops that involves the smart IoT devices and real time data monitoring. This system uses a microcontroller, such as an AT89c51 MCU or, to control the amount of water provided to plants based on different factors like soil moisture levels, weather conditions. The smart irrigation system using a microcontroller typically includes sensors to monitor the soil moisture levels and other environmental factors like temperature and humidity. The microcontroller receives information form sensors and compare with pre-set values, which determines the amount of water required by the plants and adjusts the water flow accordingly to ensuring optimal water usage and minimizing waste. The system also provides real time data monitoring on an App which provides user friendly interface to users over the internet through ThingSpeak IoT Cloud.

The primary benefit of a smart irrigation system using a microcontroller is that it helps reduce water consumption while increasing crop yield. By monitoring moisture level in soil and actuating water pump motor accordingly, the system can avoid over-watering and under-watering, both of which can harm plants and decrease crop yields. Furthermore, the system helps to minimize water waste, which is particularly crucial in areas where water is scarce or expensive.

The smart irrigation system is also flexible and customizable, allowing it to be tailored to the specific requirements of different crops and plant species. This ensures that each plant receives the optimal amount of water for its growth and development. Additionally, the system can be integrated with other smart farming technologies like remote monitoring systems and automated fertilization systems, further increasing crop yield and reducing labor costs.

2. Literature Review

Ananthi et al.'s (2017) study delves into an IoT-based smart soil monitoring system for agricultural enhancement. Centered on ICT innovations, it deploys IoT technologies to monitor real-time soil conditions, providing vital data for enhanced productivity. Integrating smart sensing, data communication, and analytics, the system empowers farmers with timely insights, fostering informed decisions, improved crop yields, and sustainable agricultural practices. The research underscores IoT's transformative role in modernizing agriculture and advancing precision farming [1].

Math, Ali, and Pruthviraj (2018) present a smart drip irrigation system using IoT, featured in the IEEE DISCOVER conference. The study explores IoT's application in enhancing drip irrigation for efficient water management. By integrating sensors and communication technologies, the system monitors soil moisture levels, allowing precise irrigation control. The research contributes to the development of sustainable agricultural practices through the implementation of smart technologies in irrigation systems [2].

Saraf and Gawali (2017) present an IoT-based smart irrigation monitoring and controlling system, showcased in the IEEE RTEICT conference. The research focuses on leveraging IoT for efficient irrigation management. By integrating monitoring and control features, the system enables real-time assessment of soil conditions, optimizing irrigation practices. The study contributes to the realm of smart agriculture by implementing IoT technologies to enhance precision and control in irrigation systems, promoting sustainable water usage in agriculture [3].

Sushanth and Sujatha (2018) present an IoT-based smart agriculture system, featured in the IEEE WiSPNET conference. The study explores the integration of IoT in agriculture to enhance productivity. The proposed system incorporates sensor technologies and communication networks to monitor various parameters affecting crop growth. By providing real-time data and control mechanisms, the research contributes to the evolution of precision farming, showcasing the potential of IoT applications in optimizing agricultural processes for sustainable and efficient practices [4].

Kumar, Pramod, and Sravani (2013) present an Intelligent Irrigation System the study focuses on incorporating intelligence into irrigation systems to optimize water usage in agriculture. Through sensor technologies and smart control mechanisms, the proposed system aims to enhance crop yield while conserving water resources. This research contributes to the development of precision agriculture by leveraging intelligent irrigation strategies for sustainable and efficient farming practices [5].

Shiraz Pasha and Yogesha (2014) present a Microcontroller-based Automated Irrigation System, the research focuses on leveraging microcontroller technology for automating irrigation processes. By integrating sensors and control mechanisms, the system optimizes water distribution, enhancing crop irrigation efficiency. This study contributes to the field of precision agriculture by introducing an automated approach to irrigation, aiming to improve water resource utilization in farming practices [6].

Pernapati (2018) explores an IoT-based Low-Cost Smart Irrigation System in the context of the Second International Conference on Inventive Communication and Computational Technologies (ICICCT). The research focuses on implementing an affordable IoT solution for efficient irrigation. By incorporating smart sensing and communication technologies, the system aims to optimize water usage in agriculture. This study contributes to the development of cost-effective and technologically advanced solutions for precision irrigation in the realm of smart agriculture [7].

Atayero and Alatishe (2015) present research on the Design and Construction of a Microcontroller-Based Automatic Irrigation System, featured in the Proceedings of the World Congress on Engineering and Computer Science. The study focuses on the development of an automatic irrigation system using microcontroller technology. This research contributes to the advancement of automated irrigation solutions, offering insights into the design and implementation of efficient systems for improved water management in agriculture [8].

Ghodake and Mulani (2018) contribute to the field of irrigation systems with their research on a Microcontroller-Based Automatic Drip Irrigation System, presented in the Proceedings of the International Conference on Advanced Technologies for Societal Applications. The study focuses on the development of an automatic drip irrigation system using microcontroller technology. This research adds valuable insights into the design and implementation of efficient irrigation systems, emphasizing technological advancements for societal applications [9].

Choudhary et al. (2020) contribute to agriculture automation in their paper titled "Agriculture Automation System," published in the Journal of Physics: Conference Series. Their research likely explores advancements in automation technology for agricultural practices, addressing the evolving needs of the agricultural sector. This work adds to the growing literature on integrating automation systems into agriculture, potentially offering innovative solutions for improved efficiency and productivity in farming processes [10].

Bwambale et al. (2022) contribute to precision agriculture with their paper, "Smart Irrigation Monitoring and Control Strategies for Improving Water Use Efficiency in Precision Agriculture: A Review," published in Agricultural Water Management. The review likely provides insights into smart irrigation methods, focusing on enhancing water use efficiency in precision agriculture. This work adds valuable information to the literature, potentially offering strategies and insights for optimizing irrigation practices in agriculture [11].

Abba et al. (2019) present "Design and Performance Evaluation of a Low-Cost Autonomous Sensor Interface for a Smart IoT-Based Irrigation Monitoring and Control System" in Sensors. The research likely involves the design and assessment of an economical autonomous sensor interface tailored for an IoT-based irrigation monitoring and control system. This work contributes to the literature, potentially providing insights into cost-effective solutions for enhancing irrigation monitoring and control in smart agricultural systems [12].

Dasgupta et al. (2019) contribute to smart irrigation with their paper "Smart Irrigation: IoT-Based Irrigation Monitoring System" in the Proceedings of the International Ethical Hacking Conference 2018. The research likely explores an IoT-based irrigation monitoring system, showcasing advancements in technology to enhance irrigation practices. This work adds to the literature, providing potential insights into the implementation of IoT for efficient irrigation monitoring and management [13].

Vaishali et al. (2017) contribute to smart irrigation with their paper "Mobile Integrated Smart Irrigation Management and Monitoring System Using IoT" in the 2017 International Conference on Communication and Signal Processing (ICCSP). The research likely explores a mobile-integrated IoT-based system for smart irrigation management and monitoring. This work adds to the literature, providing potential insights into the implementation of IoT for efficient irrigation practices with mobile integration [14].

The paper by Kurundkar et al. (2023) explores a smart pumping system, titled "Smart Pumping System - A Smart Solution to Automize the Manual Pumping Process," this work likely delves into the development and implementation of a smart solution for automating manual pumping processes. The study contributes to the literature on innovative technologies applied to enhance efficiency in pumping systems [15].

3. Method

This project aims to monitor environmental factures which can impact crops growth and yield and automating farming processes. For this, project consists of 3 types of system namely (1) soil moisture control system, (2) Rain detection system and (3) DHT11 Temperature and Humidity monitoring system, to automate this system an AT89c51 Microcontroller is used which programed in Embedded C language and also ESP8266 microcontroller is used (see Figure 1).

1. Soil Moisture Control System: This system allows automating water distribution in farm which saves 20% to 40% water than normal irrigation techniques. It utilizes a soil moisture sensor which is capable of measuring moisture level in soil and coverts this in to form of data, this sensor relays this information to microcontroller which analyzes this information and based on pre-set values sends signal to relay for actuation of water pump motor. When moisture level is above pre-set value water pump motor will be OFF and when moisture level is below than pre-set value water pump motor will ON with help of relay.
2. Rain System: When system is already watering to crops and at that time sudden rains starts it may lead to overwatering to crops which can negatively impacts the crops. To prevent this, system uses a rain sensor which is interfaced with microcontroller, sensor detects the rain and sends this information to microcontroller based on the data water pump motor is will get OFF.
3. DHT11 Temperature & Humidity system: Parameters like Temperature and Relative Humidity is sent over the ThingSpeak IoT cloud with help of ESP8266 microcontroller and it is also connected to App which allows farmers to monitor this data from any remote area through internet. For this, system uses DHT11 sensor which senses the temperature and humidity and the data from the sensor is displayed on the mobile app through ESP8266 connected over the cloud.

The App also allows the farmers to set the System in Automatic or Manual mode, when the system is set in Automatic mode the control of the system is handed to the At899c51 Microcontroller and in

Manual mode the control is handed over the ESP8266 Microcontroller which allows to turn motor ON or OFF through App interface from any remote area. The user interface of mobile app is shown (see Figure 3). The system uses two Microcontrollers so that if any controller fails the system may runs without any interrupt. The complete Hardware is implemented for the proposed system (see Figure 2)

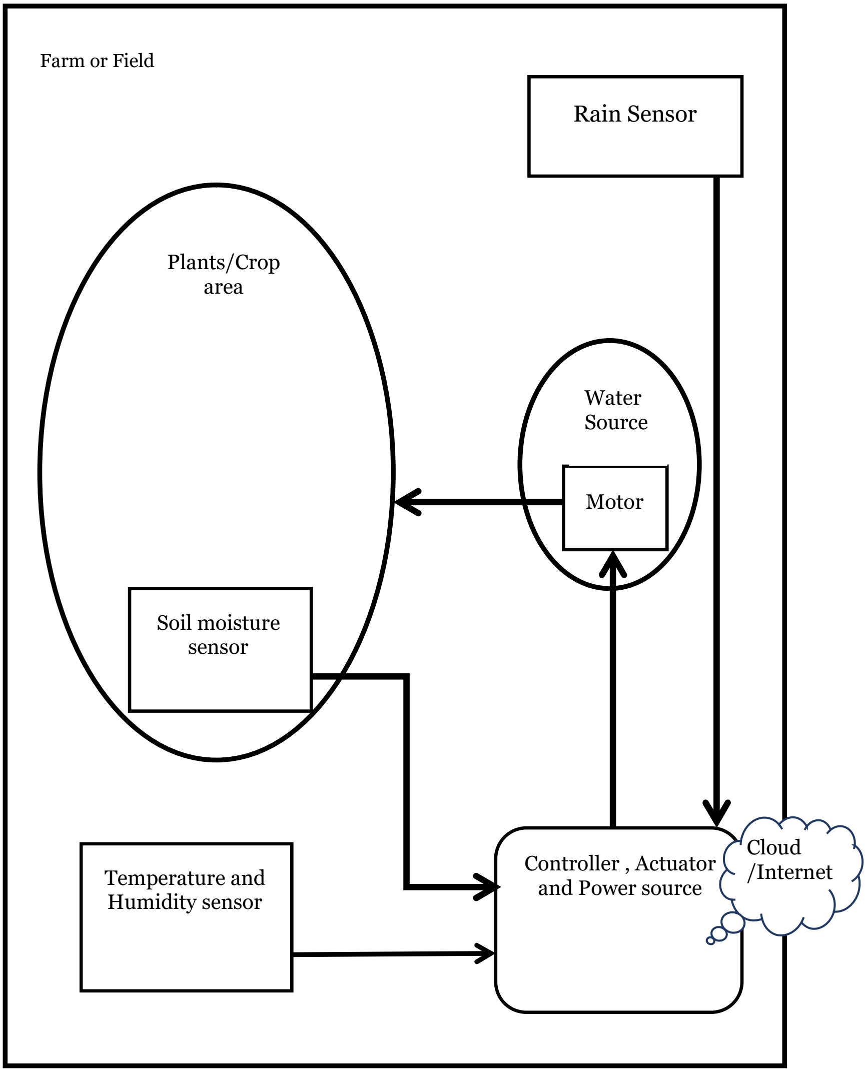

Figure 1. Block Diagram explaining working of project

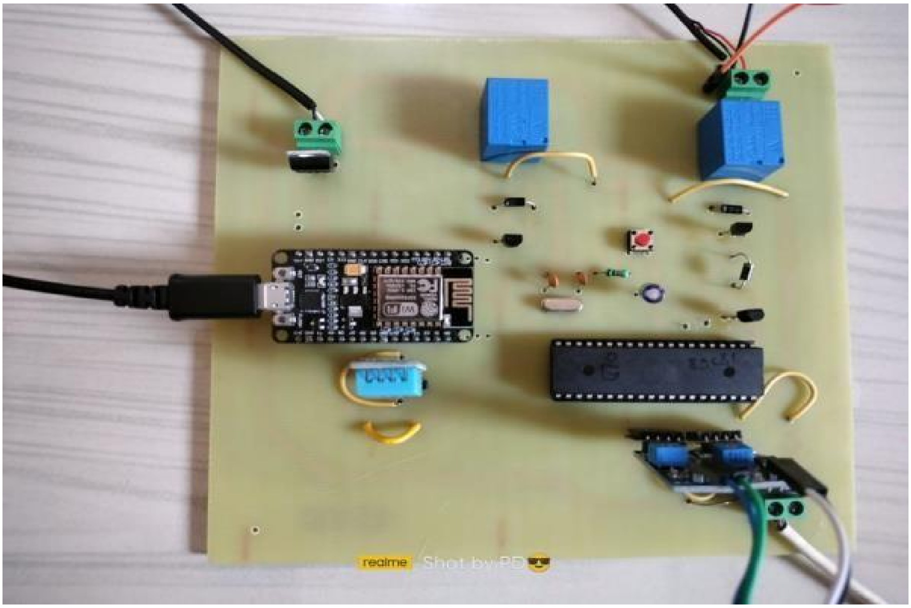

Figure 2. Hardware Implementation

Figure 3. User Interface of APP

Hardware requirements for this project are as follows:

1 AT89c51 Microcontroller
2 Node MCU (ESP8266)
3 DHT11 Temperature and Humidity sensor
4 Soil Moisture sensor
5 Rain sensor

6 IC 7805 ,5V Voltage Regulator IC
7 5V Relay
8 9V Water pump
9 9V DC Battery
10 22 pico farad Capacitor
11 12 MHz Crystal
12 40 pin IC base
13 40x1 female to male header pins (Berg)
14 PB2 connector
15 Resistors
16 Push buttons
17 Single side Copper clad PCB

Software requirements for this project are as follows:

1 Arduino IDE
2 ThingSpeak IoT Cloud
3 MIT App Inventor

4. Results

However, in general, smart farming using sensors and actuators can offer several benefits, such as improved plant growth and reduced energy consumption. The use of an At89c51 and ESP8266 microcontroller can provide a cost- effective and versatile platform for controlling the sensors and actuators. By implementing DHT11, soil moisture sensor and Rain sensor in this smart farming system we are able to monitor the important environmental parameters such as Rainfall, water level of soil and temperature and humidity in surrounding. Same data was displayed on ThinkSpeaks IoT cloud and App for user. The parameters recorded during the testing of the system are shown (see Table 1).

The Temperature and Humidity of the surrounding and the moisture level in soil is recorded and On/Off action of the motor is noted for the particular Soil Moisture level.

Table 1. Parameters recorded during testing.

Temperature	Humidity	Soil Moisture	Water Pump Motor	
			ON	OFF
31.20	72%	491	✔	✘
31.27	72%	621	✔	✘
31.30	72%	789	✔	✘
31.31	71%	875	✘	✔

Monitoring this parameter will help farmers in making better decision or to set farming system automatic based on pre-determined values. Efficient use water is adapted through this system.

5. Discussion

The proposed Microcontroller based Smart Irrigation System for Farms is a potential solution for improving the productivity of agriculture by automating the irrigation process. The system is designed to minimize costs and time consumption while promoting sustainable development with the help of IoT. The system operates in both automatic and manual modes, with the control of the system handed to the AT89c51 Microcontroller in automatic mode and in manual mode the control is handed to the

ESP8266 Microcontroller. The system uses soil moisture sensors to precisely utilize water on the farm without any wastage. The rain sensor is used to detect an accidental rain, and of the motor if rain is detected. The system is also connected to an Android app that can be used to control the motor and view temperature and humidity values from the farm area. The system can be remotely monitored and controlled from any location, making it convenient for farmers. The use of two controllers ensures the smooth operation of the system, even if one microcontroller fails. Overall, the proposed system can be an effective solution for optimizing the irrigation process and improving the overall productivity of agriculture.

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