Smart Irrigation System Using I.O.T

Shudhanshu Ranjan
Department of Electrical Engineering
Kalinga University
Raipur, India

Shreyansh Maurya
Department of Electrical Engineering
Kalinga University
Raipur, India

Sumit Chaudhary
Department of Electrical Engineering
Kalinga University
Raipur, India

Manoj Kumar Das
Department of Electrical Engineering
Kalinga University
Raipur, India *Kalinga University*

Dr. Vijayalaxmi biradar
Department of Electrical Engineering
Raipur, India

Abstract— **Smart irrigation systems using IoT technology are gaining significant attention as an efficient solution to the water scarcity challenge in agriculture. These systems consist of sensors, controllers, and a cloud-based platform that collects real-time data about soil moisture content, weather conditions, and plant water requirements. The data is analyzed and used to regulate water supply to the crops, resulting in reduced water consumption and significant savings in water resources. Field experiments have shown that smart irrigation systems can increase crop yields by 25% and reduce water consumption by 40%. This system is designed to be automated and allows users to monitor and control the irrigation process remotely through a smartphone app or a web interface, making it easy for farmers or gardeners to manage their irrigation systems from anywhere, at any time. The smart irrigation system helps to conserve water by using only the required amount of water and preventing over-watering, leading to a significant reduction in the cost of irrigation. The system has the potential for large-scale deployment and can benefit farmers worldwide, making it a powerful tool to optimize irrigation processes, conserve water, and improve crop yields.**

Keywords— *Smart irrigation systems, IoT technology, water scarcity, agriculture, sensors, controllers, cloud-based platform, soil moisture content, water consumption, crop yields*

I. INTRODUCTION (*HEADING 1*)

The demand for water is increasing rapidly due to population growth and industrialization, and agriculture is the largest consumer, accounting for about 70% of total water consumption worldwide. To address this issue, smart irrigation systems using Internet of Things (IoT) technology have gained significant attention in recent years. These systems consist of sensors, controllers, and a cloud-based platform that collects real-time data about soil moisture content, weather conditions, and plant water requirements. Based on this data, the system can be automatically controlled to optimize water usage and improve crop yield.

This thesis report aims to provide an overview of the smart irrigation system using IoT and its benefits in agriculture. The system uses sensors, weather data, and machine learning algorithms to optimize water usage based on the current needs of plants. These sensors measure the soil moisture level, temperature, humidity [1], and other environmental factors that affect plant growth. The system is connected to the internet, allowing for remote monitoring and control. Users can access the system from their smartphones or computers to check the status of their plants and adjust the settings if needed.

The benefits of a smart irrigation system using IoT are increased water efficiency, reduced costs, and improved crop yields. By reducing water wastage and optimizing irrigation, the system helps to conserve water resources and minimize water bills. The system also enables farmers and landscapers to better manage their irrigation schedules, reducing the risk of over or under-watering, which can damage crops and plants. Additionally, the smart irrigation system can be remotely controlled through a smartphone app or web-based interface, providing convenience and flexibility to users.

The smart irrigation system using IoT technology is an effective solution to address water management challenges in agriculture and landscaping. With its ability to optimize irrigation, conserve water, and improve crop yields, the system can help to promote sustainable farming practices and enhance the quality of life for communities.

II. LITERATURE REVIEW

Agriculture is a crucial sector for providing food and livelihoods for people around the world. However, traditional irrigation systems have proven to be inefficient, resulting in excessive water usage, crop loss, and environmental degradation. With the increasing demand for food production and the need for sustainable water management in agriculture, there is a growing need for more efficient irrigation systems. The solution lies in smart irrigation systems powered by the Internet of Things (IoT).

Smart irrigation systems offer several advantages over traditional irrigation systems. One of the main challenges with traditional irrigation systems is that they often over-water or under-water plants, leading to crop loss and environmental degradation. Smart irrigation systems can address these issues by automating the irrigation process and using sensors to collect data on soil moisture and other environmental conditions. This data can then be analyzed to determine the optimal amount of water needed for each plant or crop. By using IoT-enabled smart irrigation systems, farmers can conserve water, increase agricultural productivity, and reduce labor costs.

In recent years, there has been a significant increase in research on smart irrigation systems that use IoT technology. A study by S. S. Saranya et al. (2021) suggested a smart

irrigation system that uses IoT to monitor soil moisture levels, meteorological conditions, and water flow rates. The method managed to maintain crop output while cutting water use by up to 40%. Another study by S. Chatterjee et al. (2020) suggested a smart irrigation system that combines IoT and machine learning approaches to optimize water use for various crops. By using soil moisture and temperature sensors, as well as weather data, the system estimates crop water needs and controls irrigation accordingly, resulting in water savings of up to 30%.

Commercial IoT-based smart irrigation systems are also available on the market, such as Rachio, Weathermatic, and Netafim. These systems use sensors and weather information to optimize water use for agriculture. A study by Sundaravadivelu et al. (2021) highlighted the potential benefits of smart irrigation systems, including water conservation, improved crop yields, and reduced labor costs. The authors suggested that IoT-based systems can help farmers make informed decisions about irrigation, such as when and how much water to apply based on real-time data.

Kaur and Singh (2021) proposed a smart irrigation system that maximizes water utilization in agriculture by combining sensors, actuators, and controls. The system can be remotely managed using a smartphone app or online interface and is intended [2] to function independently. Zhang et al. (2021) reviewed the various technologies and agricultural uses of smart irrigation systems. The authors emphasized the importance of utilizing accurate sensors to gather information on soil moisture, temperature, humidity, and other variables, as well as the need for effective communication protocols and data processing algorithms to optimize water use.
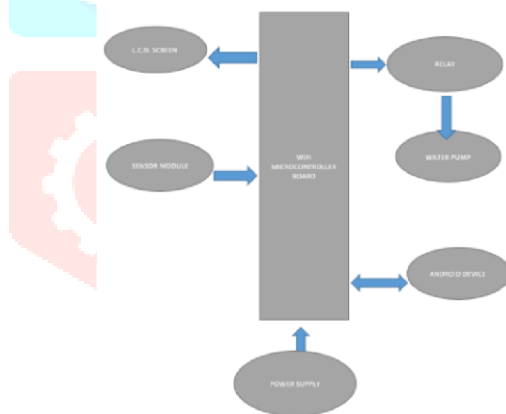

Figure 1: Flow chart

III. SYSTEM ARCHITECTURE

A smart irrigation system using IoT typically consists of a network of sensors and devices that gather data on soil moisture levels, weather conditions, and other environmental factors, and use this data to automate the watering of crops or other plants. These devices communicate with a cloud server, which stores and processes the data and sends commands back to the devices to control the irrigation system.

The system architecture of a smart irrigation system includes three primary components: a cloud server, an IoT gateway [4], and sensors/actuators. The cloud server is the main element of the system and is responsible for storing and interpreting the data gathered by the sensors, as well as issuing commands to the actuators to regulate the irrigation system. The IoT gateway is an essential component of the system as it provides connectivity and interoperability between various devices and cloud platforms. It serves as a connection point between the sensors and the cloud platform.

The sensors are the devices that are used to measure various environmental parameters like soil moisture, temperature, humidity, and light intensity. These sensors are usually placed at strategic locations in the field, and they collect data periodically. The actuators are the devices that regulate the irrigation system, based on the data received from the sensors.

A. Actuators

Actuators are the devices used to control the irrigation system based on the data collected by the sensors. There are several types of actuators used in smart irritation system.

B. Electric valves

Electric valves are used to control the flow of water through the irrigation system. They are connected to the water supply and can be opened or closed to regulate the amount of water delivered to the plants. Electric valves can be controlled remotely using a mobile app or other interface, based on data collected by the sensors.

C. Pumps

Pumps are used to move water from a water source to the irrigation system. They can be used to provide water pressure or to lift water to a higher elevation. Pumps can be controlled using a variety of methods, including manual switches, timers, or sensors.

D. Controllers

Controllers are used to manage the overall operation of the irrigation system. They receive data from the sensors and use it to control the electric valves, pumps, and other devices in the system. Controllers can be programmed to adjust irrigation schedules based on changing environmental conditions, such as rain or temperature.

E. Communication Protocols

Communication protocols are used to ensure that the different components of the smart irrigation system can communicate with [3] each other. There are several communication protocols used in IoT-based smart irrigation systems.

F. MQTT

MQTT (Message Queuing Telemetry Transport) is a lightweight messaging protocol that is used to send data between devices. It is often used in IoT applications because it is simple to use and requires minimal bandwidth.

G. HTTP

HTTP (Hypertext Transfer Protocol) is a protocol used to transfer data over the internet. It is commonly used to access web pages but can also be used to transfer data between devices.

H. CoAP

CoAP (Constrained Application Protocol) is a lightweight protocol designed for use in constrained networks, such as those used in IoT applications. It is similar to HTTP but uses less bandwidth and is more suited to low-power devices.

I. LoRaWAN

LoRaWAN (Long Range Wide Area Network) is a wireless protocol used for long-range communication between devices.

IV. IoT Gateway

The IoT Gateway serves as a vital component in a smart irrigation system, facilitating connectivity and interoperability between various devices and cloud platforms. Its role is illustrated in the diagram, where sensors responsible for assessing [5] environmental factors like temperature, humidity, soil moisture, and light intensity are connected to the IoT gateway.
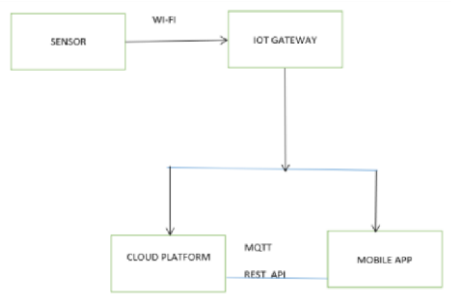

Figure 2: Data flow through network

Equipped with a WiFi module, the IoT gateway joins nearby wireless networks, while its software utilizes protocols like Bluetooth, LoRaWAN, and Zigbee to establish connections with the sensors. The gathered data from the sensors is transmitted to the IoT gateway, which processes and forwards it to the cloud platform using the MQTT (Message Queuing Telemetry Transport) protocol. This enables the cloud platform to store and make the data available for analysis and visualization through a mobile application.

The mobile application interacts with the cloud platform via a REST (Representational State Transfer) API, enabling users to remotely monitor and control the smart irrigation system. Users can set watering schedules, adjust irrigation levels, and receive alerts based on specific conditions.

Within the ecosystem of the smart irrigation system, sensors play a crucial role in collecting data on environmental parameters. For instance, the soil moisture sensor measures moisture content by utilizing two metal probes inserted into the soil, assessing electrical resistance changes as moisture levels fluctuate. These sensors are widely employed in agriculture, landscaping, and gardening to ensure optimal water usage for plants. However, it's important to consider factors such as soil type, calibration, and potential influences on accuracy, such as temperature and soil salinity.

Another vital component is the humidity sensor, also known as a hygrometer. It measures moisture or water vapor levels in the air or other gases using different techniques, including capacitive, resistive, and thermal conductivity sensors. Humidity sensors find applications in weather monitoring, HVAC systems, food storage, and industrial processes. They are commonly incorporated into home appliances like dehumidifiers and air conditioners to regulate humidity levels effectively.

Temperature sensors, available in various types such as thermocouples, thermistors, RTDs, and IC sensors, detect and convert surrounding temperature into electrical signals. These sensors play crucial roles in applications such as thermostats, industrial process control, medical devices, and environmental monitoring systems. Devices like refrigerators, ovens, and HVAC systems rely on temperature sensors for precise temperature control.

Rainfall sensors are utilized to measure precipitation levels, including rain, snow, sleet, or hail, at specific locations over a given period. Tipping bucket sensors, weighing sensors, and optical sensors are among the common types used. Precipitation data collected by rainfall sensors is vital for weather monitoring and forecasting, agriculture, hydrology, and other applications. It aids in predicting weather patterns, monitoring flood risks, and managing irrigation systems.

The user interface of the smart irrigation system provides a platform for users to interact with the system. This interface can be in the form of a web or mobile application, offering real-time data on environmental parameters and the irrigation schedule. The control system of the smart irrigation system manages the [6] irrigation activities based on data collected from the sensors. It incorporates actuators and valves responsible for controlling the flow of water to the plants.

Effective communication between the system components is facilitated by a specified communication protocol, determining the structure and format of the transmitted data. Well-known IoT protocols like CoAP (Constrained Application Protocol) or MQTT may be employed to ensure seamless and standardized communication within the smart irrigation system.

V. Sensors

The Sensors play a crucial role in measuring and monitoring environmental parameters such as soil moisture, temperature, humidity, and rainfall. These devices are strategically placed in fields to collect periodic data, enabling efficient management of resources and improved decisionmaking in various domains.

Soil moisture sensors are electronic devices used to measure the moisture content in soil. Typically composed of two metal probes inserted into the soil, they measure the electrical resistance between the probes. As soil moisture increases, the resistance decreases, allowing the sensor to estimate the soil moisture level. These sensors find widespread use in agriculture to monitor soil moisture levels and determine the need for irrigation. They are also valuable in landscaping and gardening, ensuring appropriate water supply for plants. Some sensors are designed for continuous monitoring, while others are portable for spot-checking soil moisture in different areas. However, it's important to consider soil types, calibrate sensors, and account for factors like temperature and soil salinity that may affect accuracy.

Figure 3: Soil Moisture sensor

Humidity sensors, also known as hygrometers, measure the amount of moisture or water vapor in the air or gases. They come in various types, including capacitive, resistive, and thermal conductivity sensors. Capacitive humidity sensors, the most commonly used type, measure the capacitance of a material that changes with humidity. Resistive humidity sensors detect resistance changes, while thermal conductivity sensors measure changes in thermal conductivity. Humidity sensors find application in weather monitoring, HVAC systems, food storage, industrial processes, and home appliances such as dehumidifiers, humidifiers, and air conditioners. They play a vital role in maintaining optimal humidity levels for comfort, preservation, and process control.
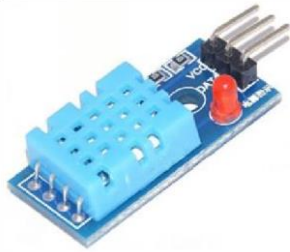
Figure 4: DHT11 – Temperature & Humidity Sensor

Temperature sensors are electronic devices that measure the temperature of their surroundings and convert it into an electrical signal. Different types of temperature sensors include thermocouples, thermistors, RTDs (Resistance Temperature Detectors), and IC (Integrated Circuit) sensors. Thermocouples generate [7] a voltage proportional to the temperature difference between two junctions made from different metals. Thermistors are resistive elements that change resistance with temperature, while RTDs exhibit linear resistance changes. IC sensors utilize integrated circuit technology and offer high accuracy, small size, and low power consumption. Temperature sensors are widely used in thermostats, industrial process control, medical devices, and environmental monitoring systems as well as refrigerators, ovens, and HVAC systems.

Rainfall sensors are essential in measuring precipitation, including rain, snow, sleet, or hail, over a specific period at a particular location. Different types of rainfall sensors include tipping bucket, weighing, and optical sensors. Tipping bucket sensors use a small bucket that tips over when a specific amount of precipitation accumulates, triggering a sensor to record the rainfall. Weighing sensors measure the weight of precipitation on a sensor plate, while optical sensors detect the presence and intensity of precipitation using light. Rainfall sensors find applications in weather monitoring, agriculture, hydrology, and other domains requiring accurate precipitation data. They provide insights into total precipitation, rainfall intensity, and duration, contributing to weather prediction, flood monitoring, irrigation management, and more.

Figure 5: Rainfall sensor

VI. Results

Through the utilization of IoT (Internet of Things) technology, a smart irrigation system presents an exceptionally efficient and productive approach to watering plants and crops. By employing sensors, controllers, and connectivity devices, this advanced system is capable of gathering and analyzing real-time data pertaining to soil moisture, weather conditions, and other factors that significantly impact plant growth.

Subsequently, based on the insights derived from the collected data, the smart irrigation system can make necessary adjustments to watering schedules, thereby optimizing water usage and preventing the issues associated with both overwatering and underwatering. This dual benefit of conserving water resources and reducing expenses is accompanied by the assurance that plants receive the appropriate amount of water at precisely the right time, consequently fostering healthier and more fruitful growth.

The integration of IoT technology empowers the smart irrigation system with remote monitoring and management capabilities accessible through a user-friendly mobile app or web interface. This convenient feature grants farmers and gardeners the ability to oversee and control their irrigation systems from any location, proving particularly advantageous for individuals who frequently find themselves away from their properties or managing multiple fields and gardens simultaneously.

In essence, the advent of an IoT-based smart irrigation system holds the potential to revolutionize the approach to watering plants and crops, ushering in a new era of heightened effectiveness and sustainability in agricultural practices.

VII. Conclusion

Through In conclusion, the implementation of an IoTenabled smart irrigation system brings numerous benefits to farmers, gardeners, and the environment alike. By leveraging real-time data and automation, these systems optimize water usage, mitigate the risks of over- and under-watering, and enhance crop yields and overall plant health.

The convenience of remotely monitoring and controlling irrigation systems through user-friendly mobile apps or web interfaces is particularly advantageous for individuals managing multiple fields or gardens. This capability not only simplifies the management process but also saves time and money, ultimately fostering more efficient and sustainable agricultural practices.

Furthermore, the adoption of smart irrigation systems integrated with IoT technology plays a crucial role in water conservation and reducing the environmental impact of agricultural activities, which is increasingly significant in the face of global water scarcity concerns. By maximizing water efficiency and minimizing wastage, these systems contribute to sustainable water resource management and help address the pressing challenges associated with water shortage.

The utilization of IoT-enabled smart irrigation systems holds immense potential to revolutionize crop cultivation practices and promote the responsible use of water resources. By embracing this technology, we pave the way for a more sustainable and resilient future, where agriculture can thrive while minimizing its ecological footprint.

VIII. Future Scope

The potential for further advancements in smart irrigation systems using IoT technology is extensive and diverse, opening up numerous areas for research and development.

One promising avenue is the integration of smart irrigation systems with other IoT technologies, such as soil moisture sensors, weather stations, and crop sensors, to gather more precise data and enhance the accuracy of system forecasts and recommendations.

Another area of exploration is the incorporation of machine learning and artificial intelligence algorithms into smart irrigation systems. By leveraging historical data, weather patterns, and other variables, these systems can optimize watering schedules and improve water efficiency.

Integrating smart irrigation systems with crop management systems is another avenue for development. This integration would provide farmers and gardeners with a comprehensive overview of their crops, including insights into soil health, pest and disease management, and more.

Water quality monitoring is another potential area of focus. By considering factors like salinity and pH levels, the integration of water quality sensors can aid in optimizing water usage and ensure optimal conditions for plant growth.

Furthermore, cloud-based data analysis can play a significant role in smart irrigation systems by gathering and

analyzing data from multiple farms or gardens. This approach can reveal insights into local water usage patterns and guide targeted conservation efforts.

The scope for further advancements in smart irrigation systems using IoT technology is vast, offering ample opportunities for innovation and improvement. As water scarcity becomes an increasingly pressing issue, the development of more efficient and sustainable agricultural practices is crucial, and smart irrigation systems using IoT technology are poised to play a vital role in addressing this challenge.

REFERENCES

[1] Singh, N., & Malhotra, J. (2018). Smart Irrigation System Using IoT. International Journal of Scientific Research in Computer Science, Engineering and Information Technology, 3(5), 880-885. [2] Manikandan, V., & Hemalatha, N. (2019). IoT-Based Smart Irrigation System Using Raspberry Pi. International Journal of Innovative Technology and Exploring Engineering, 8(6), 1970-1973. [3] Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., & Ayyash, M. (2015). Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications. IEEE Communications Surveys & Tutorials, 17(4), 2347-2376.

[4]   Sevugarajan, M., & Sivaraj, M. (2018). IoT-Based Smart Irrigation System Using Arduino. In 2018 IEEE International Conference on Innovative Research in Engineering and Technology (ICIRET) (pp. 1-5). IEEE.

[5]   Goyal, S., & Kaur, R. (2020). Smart Irrigation System Using IoT: A Review. In 2020 11th International Conference on Computing, Communication and Networking Technologies (ICCCNT) (pp. 1-6). IEEE.

[6]   Li, X., Jiang, C., Fu, M., & Wu, J. (2019). IoT-Based Smart Irrigation System Using Wireless Sensor Network and Embedded Systems. IEEE Access, 7, 11695-11709.

[7]   Xu, L., Hu, J., & Xu, C. (2020). An Intelligent IoT-Based Smart Irrigation System for Efficient Water Management in Agriculture. IEEE Internet of Things Journal, 7(2), 1141-1152.