A WIRELESSLY CONTROLLED ROBOT-BASED SMART IRRIGATION SYSTEM BY EXPLOITATION

BY

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CERTIFICATION

This is to certify that this project was carried out by **SULAIMAN TAOFEEK AYOMIDE MATRIC NUMBER; HND/23/COM/FT/0215** has part of the requirements for the award of Higher National Diploma (HND) in Computer Science.

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DEDICATION

This project is dedicated to the creator of the earth and universe, the Almighty God. It is also dedicated to my parents for their moral and financial support.

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All praise is due to the Almighty God, the Lord of the universe. I praise Him and thank Him for giving me the strength and knowledge to complete my HND programme and also for my continued existence on earth.

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ABSTRACT

Advancement of technology has led to the automation of irrigation system which has helped to solve a lot of problems encountered by the various non-automated types of irrigation system. Smart irrigation systems play a pivotal role in modern agriculture, addressing the challenges of water scarcity and the need for efficient resource utilization. This project focuses on the development and implementation of a wirelessly controlled robot-based smart irrigation system. It makes use of light, temperature, soil moisture sensors, Liquid Crystal Display, PIC microcontroller. This irrigation system consists of four different sensors which are used to measure various parameters related to the crop production. They are Light Dependent Resistor (LDR), Humidity Sensor, Soil moisture Sensor and temperature Sensor. The LDR is used to determine the intensity of light or the time of the day. This helps the system to regulate the irrigation from time to time. The Soil moisture sensor is used to determine the moisture. The smart irrigation system developed was able to automatically monitor and control the level of water available to the plants without any human intervention at the farm.

CHAPTER ONE

GENERAL INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Agriculture remains a cornerstone of global food security, yet it is increasingly challenged by issues such as water scarcity, inefficient resource utilization, and labor shortages. Traditional irrigation methods, often characterized by water wastage and uneven distribution, exacerbate these problems. As the demand for sustainable and efficient agricultural practices grows, integrating advanced technologies into irrigation systems becomes essential (Aminin, 2020).

Recent advancements in Internet of Things, robotics, and wireless communication have opened new avenues for innovation in agricultural technology. Automated irrigation systems, in particular, have demonstrated their potential to enhance water use efficiency, reduce labor dependency, and improve crop yields. By combining robotics and IoT, a wirelessly controlled smart irrigation system can provide real-time monitoring and precision water delivery based on specific crop and soil requirements (Li & He, 2019). Due to the uneven distribution of water resources and the increasing demand for fresh water resources, the shortage of fresh water resources will become a serious problem faced by all countries in the world in the near future. The proportion of agricultural water in fresh water consumption is relatively high in Nigeria. At present, water-saving irrigation in Nigeria is still in its infancy (Usman et al., 2021).

Hu, Sun, Li, He and Li (2021) claimed that irrigation is the artificial supply of water to the root of plant. Irrigation has been used to assist in the growing of agricultural crops, maintenance of landscapes, and re-vegetation of disturbed soils in dry areas and during periods of inadequate rainfall. In crop production, irrigation helps in protecting plants against frost, suppressing weed growth in grain fields and preventing soil consolidation. Irrigation systems are also used for dust suppression, disposal of sewage, and in mining. Irrigation undisputedly has evolved and it is still evolving and advancing to be a more efficient, easy and flexible process and through the course of time various methods of irrigation has been introduced, some of the most common types of irrigation include the following; Surface irrigation, Sprinkler irrigation and Drip Irrigation.

For as long as humans have grown seeds, irrigation has been around. Irrigation procedures rely mainly on the availability of water. Irrigation is essential in semi-arid and arid areas for food, pasture, and fiber production. To increase food security while saving water, irrigation methods around the world are evolving. Developed and developing countries are moving from pure supply to a system centered on a demand based model. In a nation like Nigeria, where water supplies are manually regulated and managed, and water is unevenly distributed in time and space, demand-based practices are not feasible. Due to limited sweet water supplies, an efficient and cost-effective way of irrigation has emerged as the need of the hour, especially in countries severely affected by a lack of sweat water reservoirs. Most water is lost due to insufficient plant irrigation (Bakare et al., 2022).

The efficient use of water in agriculture is one of the most important agricultural challenges that modern technologies are helping to address. Agriculture is one of the most water-intensive businesses on the planet. Due to a lack of updated technology, more than (80%) of water resources are squandered in this business. The efficient use and management of water are one of many countries' major challenges today. Irrigating (25%) of the world's crops, which provide 45 percent of the world's food, is predicted to require around 70% of the worlds' freshwater. Industrial and domestic water usage accounts for roughly 20% and 10%of total water consumption, respectively. As a result, by conserving water and managing plant development conditions at the same time, a low level of water consumption can be attained (Anjola, 2023).

The requirement of water to the soil depends on soil properties such as soil moisture and soil temperature. Effective irrigation can influence the entire growth process and automation in irrigation system using modern technology can be used to provide better irrigation. In general, most of the irrigation systems are manually operated. These traditional techniques can be replaced with automated techniques of irrigation in order to use the water efficiently and effectively (Mahzabin et al., 2016).

This project will be of great benefit to the educators and researchers since its content will contribute to the extension of the frontier of human knowledge by providing an insight into wireless controlled robotic smart irrigation system that takes advantage of scientific know-how to improve water usage in common irrigation practices.

1.2 STATEMENT OF THE PROBLEM

Conventional irrigation methods are plagued by inefficiencies, including excessive water consumption, uneven water distribution, and high labor requirements. These challenges are further compounded by the growing global demand for food production and the decreasing availability of freshwater resources. Existing automated irrigation systems, while effective, often lack the adaptability and precision required for diverse agricultural settings. This project addresses these issues by proposing a wirelessly controlled robot-based smart irrigation system that optimizes water usage and enhances agricultural productivity.

1.3 AIM AND OBJECTIVES OF THE STUDY

The aim of this project is to develop and implement a wirelessly controlled robot-based smart irrigation system that optimizes water distribution and enhances agricultural efficiency. The objectives are to:

i. design a robotic platform capable of wirelessly controlled movement and operation;
ii. integrate soil moisture sensors and environmental monitoring devices into the system;
iii. develop a control system that can interface with the sensors and the irrigation mechanism; and
iv. evaluate the performance and efficiency of the proposed system in agricultural settings.

1.4 SIGNIFICANCE OF THE STUDY

This project holds significant implications for sustainable agriculture and resource management. By demonstrating the potential of robotics and IoT in irrigation, it offers a scalable solution to the challenges of water scarcity and labor shortages in agriculture. The findings of this project could inform future innovations in precision agriculture, contributing to increased crop yields, reduced environmental impact, and improved resource efficiency. This project also contributes to the body of knowledge in agricultural technology, promoting the adoption of smart farming practices.

1.5 SCOPE OF THE STUDY

The scope of this study includes:

i. **Geographical Scope**: The design and implementation will be tested in a specific agricultural region with diverse crops and environmental conditions.
ii. **Technological Scope**: The study will focus on integrating IoT sensors, data processing algorithms, and automated control systems.
iii. **Agricultural Scope**: The system will be applicable to various types of crops with different irrigation needs, providing a versatile solution for different farming practices.
iv. **Temporal Scope**: The project will cover the design, development, implementation, and evaluation phases over a period of one agricultural cycle to assess its performance comprehensively.

1.6 ORGANIZATION OF THE REPORT

The project write-up is organized into five distinct chapters. Chapter one covers general introduction, which contains introduction to the research topic, statement of the problem, aim and objectives of the study, significance of the study, scope of the study and organization of the report. Chapter two discusses the literature review, which contains review of related past works and the review of general texts. Chapter three explains the project methodology which includes analysis of existing system, problems of the existing system, and the description of the proposed system, advantages of proposed system and design and implementation techniques used. Chapter four contains the design, implementation and documentation of the system which contain system design output design, input design, database design and procedure design, implementation of the system hardware and software support and documentation of the new system installation procedure, operating the system and system maintenance. Lastly, chapter five presents the summary of the research, recommendations and conclusion.

CHAPTER TWO

LITERATURE REVIEW

2.1 REVIEW OF RELATED WORKS

A lot of research has been done to address the traditional irrigation challenge. In this section, some past journals/articles relating to this topic of study will be reviewed.

Masaba et al; (2020) designed and implemented a smart irrigation system for improved water-energy efficiency. The paper presented a smart irrigation system that uses environmental information to determine when and where irrigation is required. The system is comprised of microcontroller, sensors and integration of water pumps with the decision-making system. A truth table is developed to help the system determine the necessity to irrigate based on the collected environment information. The sensors narrow down the location that requires irrigation and the decision-making system activates sprinklers. In this fashion, water is given to dry locations of the field, already damp locations are not irrigated and this results efficient water use. Different parameters used, i.e. temperature, humidity and moisture, makes it possible to adjust the system according to the needs of a particular location.

Hu et al;(2021) proposed an intelligent irrigation system. The intelligent irrigation system that is based on STM32 and BC95 was designed and implemented. The soil information is received through temperature sensor and humidity sensor, which is sent from the sampling node to the remote terminal serial port. The controller sends the signal to the output end for intelligent irrigation. The practice shows that the wireless communication mode of data transmission using STM32 and (NB-IoT) narrow band-internet of things technology can meet the requirements of reducing the time cost and enhancing the reliability of the system, and can meet the goal of data transmission of intelligent irrigation system and water-saving irrigation. it can be seen that the soil moisture data in the figure significantly changes. Keywords: Intelligent irrigation; STM32F103 chips; NB – IoT (narrow band-internet of things) technology; Cloud platform technology; BC95.

Bakare *et al* (2022) worked on the design and implementation of a smart irrigation system. The Research work involves applying electronics and software engineering as a means of solving the irrigation issues faced by farmers. The paper was limited to the development of Smart Irrigation System that can be controlled by software application, which also can be used to monitor irrigation in real time. It makes use of light, temperature, soil moisture sensors, liquid crystal display, PIC microcontroller and it is coded using C++ Programming language. This irrigation system consists of four different sensors which are used to measure various parameters related to the crop production. They are Light Dependent Resistor (LDR), Humidity Sensor, Soil moisture Sensor and temperature Sensor. The LDR is used to determine the intensity of light or the time of the day. This helps the system to regulate the irrigation from time to time. The Soil moisture sensor is used to determine the moisture. An app that gives the farmer information on the amount of insolation, temperature and soil moisture level was also incorporated in the system. The smart irrigation system developed was able to automatically monitor and control the level of water available to the plants without any human intervention at the farm. This intelligent system is limited to only a single plant or crop as future study could be extended to monitor a larger portion of land with two or more crops.

Mahzabin *et al* (2019) proposed a design and implementation of an automatic irrigation system. The project deals with the automatic operation of the pump to supply water in the field depending on the soil moisture. The system was operated using solar energy or even the DC voltage converted from AC. This is done by programming in ATMEGA328.

Umar (2021) implemented a performance evaluation of a wireless sensor network based irrigation system on different soil types. The research proposed an Arduino-based smart irrigation system using a wireless sensor network to overcome the problem of overwatering, underwatering, and efficient time utilization in farming. The system is implemented using Arduino IDE, Proteus Simulation Tools, and Blynk Platform. The effect of the four-mobile network: MTN, GLO, Airtel and 9mobile on response time for Gidan- Kwano area was evaluated. Testing carried out on the system resulted in a response time of 0.75 seconds for the Glo 2G network and 0.45 seconds for the Glo (4G) network. Less than 1sec in the worst-case scenario. Also, 0.72 and 6.073 seconds respectively was achieved for loamy soil average response time and average saturation time. Average response time of 0.85 seconds and 4.906 seconds for saturation time, while 0.77second and 6.366 seconds as average response time and saturation time for clay soil. This makes the system effective in terms of time response, thereby eradicating the time wasted by manual system operation to irrigation scheduling. Also, the appropriate soil moisture content is maintained, whether it rains or not. This reduces excesses and ensures healthy plant growth, increasing agricultural productivity, and cultivating crops are made possible throughout the year. The system will also help drive agricultural innovation through the use of IoT.

Odara, Khan and Ustun (2019) worked on optimizing energy use of smart farms with smart grid integration. An approach for integrating precision agriculture and smart grid technologies was presented. This aims at balancing consumption and generation in the farmland, which increases the sustainability of energy supply. The coordination with the Smart Grid operator enables farmers to save on energy costs and support grid at peak hours. Consequently, there is an urgent need to create strategies based on science and technology for sustainable use of water during irrigation processes.

Rajendran, et al; (2021) designed an architectural structure and performance evaluation of a sprinkler irrigation robot using two assemblies of ZigBee technology to enhance prototyping efficiency. ZigBee technology covered a larger communication area. The robust design could not carry more than 5litres; this may not be recommendable for a large farm. Adding an automation system would further enhance system performance. Weather forecasting was added to the authors' automated irrigation system for more efficient use of water resources (AISWP), which was an improvement over the previous system' automated irrigation system with partitioning system for efficient irrigation of small farms' (AISPF). The proposed model was able to address the (AISPF) Process issues using a weather forecast, and the water supply efficiency was increased by 20%. It isn't as efficient. The device may become more functional after the Wireless Sensor Network is established.

Kumar *et al* (2017) looked at the necessity for perfect uniformity in plant watering, which led to the development of an automated irrigation system. The irrigation system operated in a way that if one part had its requirement met and other parts were over watered or under watered, technologies that existed should indeed give the water level and detect the water required by the plant in a specific area. The proposed system provided many benefits, like operation with less workforce, due to the transfer of water directly to the root zone of plants. It had two nodes and a central node that coordinated the information provided by the sensors in each node. The resulting analysis showed that it was insufficient, and there was a need for the system to be more robust.

2.2 REVIEW OF GENERAL TEXTS

2.2.1 Overview of Automated Irrigation System

Automated irrigation systems, commonly known as smart irrigation systems, integrate advanced technologies to manage water delivery to plants efficiently and effectively. These systems utilize sensors, controllers, and communication networks to monitor environmental conditions such as soil moisture, temperature, and humidity. By leveraging real-time data, automated irrigation systems can optimize water usage, ensuring that plants receive the precise amount of water they need at the right time. This minimizes water wastage and promotes healthier plant growth. The primary goal is to enhance agricultural productivity and sustainability while conserving water resources.

A key component of automated irrigation systems is the use of soil moisture sensors, which measure the volumetric water content in the soil. These sensors provide critical data that helps determine when and how much to irrigate. Alongside soil moisture sensors, weather stations and climate sensors are often integrated to account for variables such as rainfall, wind speed, and solar radiation. This comprehensive data collection enables the system to make informed decisions, adjusting irrigation schedules and volumes automatically based on current and forecasted weather conditions.

Communication technologies play a crucial role in the functionality of automated irrigation systems. Wireless sensor networks (WSNs) and Internet of Things (IoT) devices facilitate seamless data transmission between sensors, controllers, and central management systems. These technologies enable remote monitoring and control, allowing farmers and land managers to oversee irrigation activities from anywhere using smartphones or computers. The integration of cloud computing and data analytics further enhances decision-making by providing predictive insights and trend analysis, which help in planning and optimizing irrigation strategies.

The benefits of automated irrigation systems are multifaceted. They contribute to significant water savings, reducing the demand on freshwater resources and lowering utility costs for farmers. By providing precise irrigation, these systems promote uniform crop growth and higher yields, improving agricultural efficiency and profitability. Additionally, automated irrigation reduces labor requirements, as manual monitoring and adjustment are minimized. In the context of environmental sustainability, these systems help mitigate the impacts of droughts and water scarcity, supporting more resilient agricultural practices. Overall, automated irrigation systems represent a convergence of technology and agriculture aimed at achieving sustainable water management and enhanced agricultural productivity (Li & He, 2019).

2.2.2 Automatic Farm Irrigation System

Automatic farm irrigation systems represent a significant advancement in agricultural technology, aimed at optimizing water use and enhancing crop yields. These systems employ a combination of sensors, controllers, and automation technologies to regulate the delivery of water to crops. By continuously monitoring soil moisture levels, weather conditions, and plant needs, automatic irrigation systems can make real-time adjustments to watering schedules. This precision ensures that crops receive the appropriate amount of water, reducing waste and promoting healthier plant growth. The overarching goal is to increase agricultural efficiency and sustainability while minimizing the environmental impact.

Central to the functionality of automatic irrigation systems are soil moisture sensors, which provide crucial data on the water content in the soil. These sensors are often placed at various depths and locations across the farm to gather comprehensive moisture profiles. Additionally, weather stations equipped with sensors for temperature, humidity, wind speed, and rainfall contribute to the decision-making process. The integration of this data allows the irrigation system to adapt to changing environmental conditions, ensuring optimal watering practices. By responding dynamically to both soil and atmospheric inputs, these systems can prevent over-irrigation or under-irrigation, which can lead to crop stress or water wastage.

The implementation of wireless sensor networks (WSNs) and Internet of Things (IoT) devices is crucial for the effective operation of automatic farm irrigation systems. These technologies enable seamless communication between sensors, controllers, and central management systems. Through IoT connectivity, data from the field can be transmitted to cloud-based platforms where advanced analytics and machine learning algorithms process the information. Farmers can access this data remotely via smartphones or computers, allowing them to monitor and control irrigation activities in real-time. This connectivity not only enhances the precision of irrigation but also offers convenience and flexibility in farm management.

The advantages of automatic farm irrigation systems are extensive. They significantly reduce water consumption by ensuring that water is applied only when and where it is needed, which is particularly vital in regions facing water scarcity. This precision irrigation leads to more uniform crop growth and higher yields, improving overall farm productivity and profitability. Additionally, the labor savings are considerable, as manual monitoring and adjustment of irrigation schedules are largely eliminated. The environmental benefits are equally important, as these systems help to conserve water resources and reduce the agricultural footprint on the environment. By integrating technology with traditional farming practices, automatic irrigation systems represent a forward-thinking approach to modern agriculture, aiming for sustainable and efficient food production (Li et al., 2019).

2.2.3 Smart Irrigation Management System

A Smart Irrigation Management System (SIMS) is an advanced agricultural technology solution designed to optimize the use of water resources in farming. It combines various technologies such as sensors, data analytics, Internet of Things (IoT), and automation to deliver precise irrigation tailored to the specific needs of crops. The primary aim of a SIMS is to enhance water use efficiency, improve crop yields, and promote sustainable farming practices by providing real-time data and automated control over irrigation processes.

Central to a SIMS are the sensors that monitor key environmental and soil parameters. Soil moisture sensors measure the water content in the soil at different depths, providing data on when and how much water the crops need. Weather sensors collect information on temperature, humidity, rainfall, and wind speed, which can influence irrigation requirements. These sensors transmit data wirelessly to a central control unit or cloud-based platform, where sophisticated algorithms analyze the information to determine optimal irrigation schedules. This data-driven approach ensures that water is applied only when necessary and in the appropriate quantities, preventing both over-irrigation and under-irrigation.

The integration of IoT technology plays a crucial role in the functionality of a SIMS. IoT devices enable seamless communication between the sensors, control units, and the cloud-based management system. This connectivity allows farmers to remotely monitor and control the irrigation system through mobile applications or computer interfaces. Advanced SIMS platforms often include features such as predictive analytics, which use historical data and weather forecasts to anticipate future water needs, and machine learning algorithms, which continuously improve irrigation strategies based on past performance and outcomes. This level of automation and remote accessibility significantly reduces the labor and time required for irrigation management.

The benefits of implementing a Smart Irrigation Management System are substantial. By optimizing water use, SIMS can lead to significant water savings, which is crucial in areas facing water scarcity. The precision irrigation provided by SIMS results in healthier crops and higher yields, enhancing the profitability of farming operations. Additionally, the system reduces the environmental impact of agriculture by conserving water resources and minimizing runoff and leaching of fertilizers. Moreover, the reduced need for manual intervention allows farmers to focus on other critical aspects of farm management. Overall, a SIMS is a transformative tool that supports sustainable agriculture, resource conservation, and increased farm productivity (Umar *et al*., 2021).

2.2.4 Implementation of a Smart Irrigation System in Agriculture

Implementing a Smart Irrigation System in agriculture involves a series of steps that integrate advanced technologies with traditional farming practices to optimize water use and enhance crop productivity. The process begins with a thorough assessment of the farm's specific needs, including the type of crops, soil conditions, climate, and existing irrigation infrastructure. This initial evaluation helps in designing a customized smart irrigation system that caters to the unique requirements of the farm (Liu & Zu, 2018).

The first step in implementing a Smart Irrigation System is to conduct a comprehensive assessment of the agricultural site. This involves analyzing soil types, topography, crop water requirements, and existing irrigation practices. Farmers should also consider local climate data, including temperature patterns, rainfall distribution, and evaporation rates. Based on this information, a detailed plan is developed, outlining the specific goals of the smart irrigation system, such as water conservation, improved crop yields, and reduced labor costs. The plan should also identify the types and placements of sensors, the selection of control units, and the necessary communication infrastructure.

Once the planning phase is complete, the next step is to install the necessary sensors and IoT devices across the farm. Soil moisture sensors are placed at various depths and locations to monitor soil water content accurately. Weather stations equipped with sensors for temperature, humidity, wind speed, and rainfall are also set up to provide real-time environmental data. These sensors are connected to wireless sensor networks (WSNs), enabling seamless data transmission to the central control unit. The installation process involves ensuring that all devices are properly calibrated and tested to guarantee accurate data collection.

After installing the sensors, the system is integrated with control units and cloud-based platforms. The control units process data from the sensors and make real-time decisions on irrigation scheduling and water application rates. Advanced control systems can automatically adjust irrigation based on predefined thresholds and algorithms. Additionally, the data collected by the sensors is transmitted to cloud platforms where it is analyzed using machine learning and predictive analytics. These platforms provide farmers with insights and recommendations on optimal irrigation practices. The cloud-based system also allows for remote monitoring and control via mobile apps or computer interfaces.

The final step in the implementation process involves continuous monitoring, management, and optimization of the smart irrigation system. Farmers and technicians regularly review the system's performance, making adjustments as necessary to ensure it operates efficiently. This includes recalibrating sensors, updating software, and refining irrigation schedules based on new data and changing conditions. Predictive analytics and machine learning algorithms help in continuously improving the system by learning from historical data and adjusting strategies accordingly. Regular maintenance and periodic evaluations are crucial to ensure the long-term effectiveness and reliability of the smart irrigation system (Liu & Zu, 2018).

2.2.5 Wirelessly Controlled Robot-Based Smart Irrigation

A wirelessly controlled robot-based smart irrigation system integrates advanced robotics, IoT (Internet of Things), and smart sensors to optimize agricultural water usage. The system typically consists of a mobile robotic unit equipped with sensors such as soil moisture detectors, temperature monitors, and humidity sensors, which gather real-time environmental data from the field. This data is transmitted wirelessly to a central controller or a cloud-based platform, where algorithms analyze it to determine precise irrigation needs. By using a wireless connection, such as Wi-Fi, Zigbee, or LoRa, the system ensures remote accessibility and control, enabling farmers to monitor and manage irrigation schedules from anywhere.

The robotic unit plays a dual role in this system. Besides gathering data, it physically navigates the fields to water specific areas as required. This targeted irrigation minimizes water waste by delivering the right amount of water only where it is needed, improving water efficiency significantly compared to traditional irrigation methods. Advanced systems may also integrate machine learning algorithms to predict irrigation requirements based on historical data and weather forecasts, further enhancing precision and reducing resource consumption.

This technology offers substantial benefits for sustainable agriculture, particularly in regions facing water scarcity or inconsistent rainfall. By automating the irrigation process, it reduces labor costs and human error, ensuring optimal water distribution. Moreover, its adaptability and scalability make it suitable for various farming scales, from small gardens to large agricultural operations. However, challenges such as initial setup costs, maintenance, and the need for reliable wireless connectivity may limit adoption in resource-constrained areas. With ongoing advancements, this system has the potential to revolutionize modern agriculture by making it more efficient, sustainable, and productive (Umar, et al., 2021).

CHAPTER THREE

RESEARCH METHODOLOGY AND ANALYSIS OF THE EXISTING SYSTEM

3.1 METHODOLOGY

The wireless robot smart irrigation system consists of an aggregated network of water sprinklers and sensors. To enable communication, the sprinkler is controlled by a microcontroller through the servo motor. The microcontroller sets the angles between which the servo motor should rotate, which allows the sprinkler to irrigate only within those angles. The microcontroller communicates with the sensors via Bluetooth. In this project, the integrated system of microcontroller, servomotor, sprinkler, and Bluetooth is called the Robotic Smart Irrigation System. The block diagram of the proposed system is shown in the Figure 3.1 below.

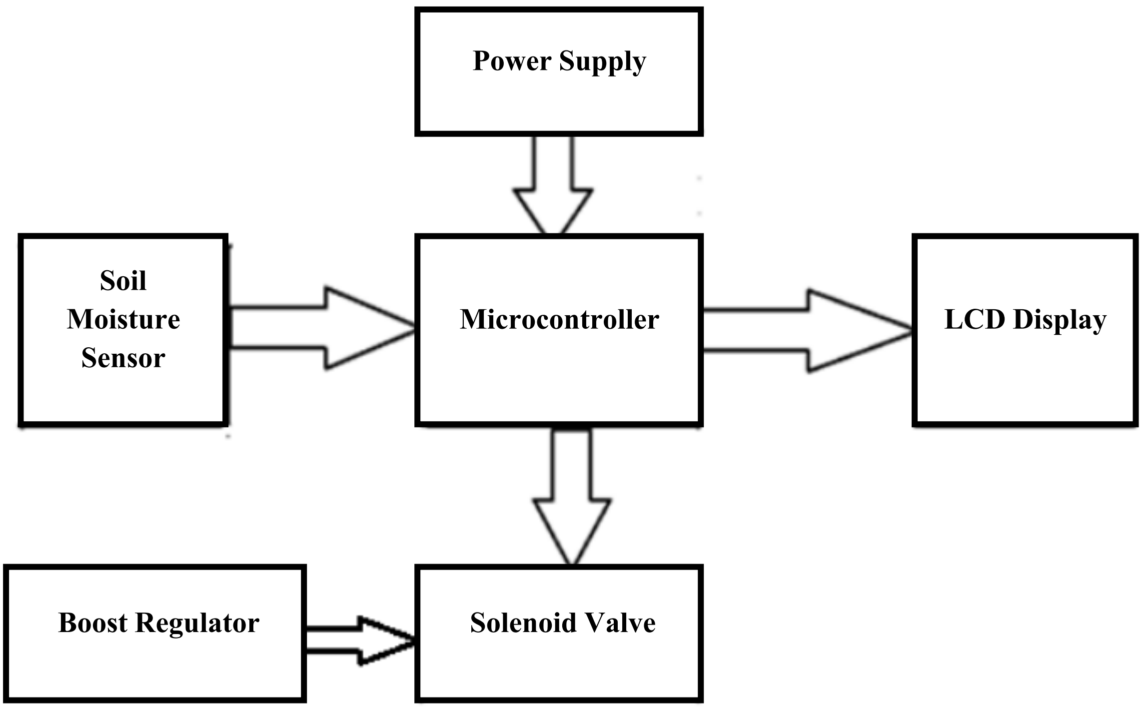

Figure 3.1: Block Diagram for the Robotic Smart Irrigation System

How the aim was achieved

Step 1: Initially, the design and implementation of a wireless robotic smart irrigation system was proposed.

Step 2: The project was designed using the microcontroller ATMEGA328. A storage tank connected to it was used to store water that can be drawn whenever the moisture level in the soil drops. It also consisted of three LEDs, which worked as indicators to indicate the level of water stored in the storage. Whenever the water would reach a low level in the storage, it would instruct the microcontroller to turn on the pump to draw water until it reaches a high level and all three LEDs glow.

Step 3: The project was developed and made more specific by cascading three different parts to it.

i. A Power Supply System

ii. An Automatic Pump controller

iii. An Automatic Irrigation System

Step 4: The power unit supply electricity which will turn the automatic pump control system on especially during the day.

Step 5: The Automatic Pump controller will ensure that there is always water in the storage and it consists of an indicator and a detector.

Step 6: In the Automatic Irrigation System, input is taken from the moisture sensor as to whether the soil moisture is less than the predefined standard. This information is fed to the microcontroller which decides whether to turn on the solenoid or not to water the field depending on whether the moisture level in the soil is below the required level.

3.2 ANALYSIS OF THE EXISTING SYSTEM

Traditional irrigation systems in agriculture often rely on manual methods or basic automated systems with preset schedules that do not account for real-time soil and weather conditions. These conventional systems generally include surface irrigation (e.g., flood irrigation), sprinkler systems, or drip irrigation methods. While they have been effective to a degree, they are limited by inefficiencies in water use and inability to respond dynamically to changing environmental conditions.

Manual irrigation requires significant labor and constant monitoring, which can be time-consuming and inconsistent. Basic automated systems may reduce labor but still apply water at fixed intervals regardless of the actual moisture levels in the soil or weather forecasts, leading to over-irrigation or under-irrigation. Such systems lack integration with modern technologies like sensors, data analytics, and IoT, making it difficult to achieve precision agriculture.

3.3 PROBLEMS OF THE EXISTING SYSTEM

The existing system has a lot of limitations, these are explained below:

i. **Water Wastage:** Traditional systems often apply more water than necessary, leading to wastage and depletion of water resources.

ii. **Inefficiency**: Fixed schedules do not adjust for real-time conditions, resulting in inefficient water use.

iii. **Labour Intensive:** Manual irrigation requires significant labor input and constant monitoring.

iv. **Crop Stress:** Inconsistent water supply can cause crop stress, affecting plant health and yields.

v. **Environmental Impact:** Over-irrigation can lead to soil erosion, nutrient leaching, and increased runoff, negatively impacting the environment.

vi. **Lack of Data Utilization:** Traditional systems do not leverage data for informed decision-making, missing opportunities for optimization.

3.4 DESCRIPTION OF THE PROPOSED SYSTEM

The proposed system's automation and integration capabilities offer significant improvements over traditional irrigation methods. By leveraging real-time data and predictive analytics, the Smart Irrigation System ensures efficient water use, reduces labor requirements, and promotes sustainable farming practices. It adapts to the unique conditions of each farm, providing a tailored irrigation solution that maximizes crop yield and minimizes environmental impact. The Smart Irrigation System represents a forward-thinking approach to modern agriculture, combining technology and data to optimize resource use and enhance agricultural productivity.

3.5 ADVANTAGES OF THE PROPOSED SYSTEM

The proposed smart irrigation system offers numerous advantages. They are:

i. **Water Conservation**: The system ensures water is applied only when and where needed, significantly reducing wastage.

ii. **Increased Efficiency**: Real-time data and automated adjustments lead to more efficient water use, enhancing overall farm productivity.

iii. **Labor Savings**: Automation reduces the need for manual intervention, freeing up labor for other tasks.

iv. **Improved Crop Health**: Precise irrigation prevents under- or over-watering, promoting healthier plant growth and higher yields.

v. **Environmental Benefits**: Reduced water usage and better control over irrigation minimize environmental impacts such as soil erosion and nutrient leaching.

vi. **Data-Driven Decisions**: Leveraging data analytics and machine learning enables informed decision-making, optimizing irrigation practices continuously.

vii. **Scalability and Flexibility**: The system can be scaled and adapted to different farm sizes and crop types, providing flexibility in agricultural management.

CHAPTER FOUR

DESIGN, IMPLEMENTATION AND DOCUMENTATION OF THE SYSTEM

4.1 DESIGN OF THE SYSTEM

The design of the smart irrigation system involves integrating soil moisture sensors, weather sensors, a microcontroller (such as an Arduino or ESP32), water pumps, valves, and communication modules (GSM or Wi-Fi) to optimize water usage. The microcontroller processes real-time data from the sensors to determine the irrigation needs, automatically controlling the water pumps and valves to adjust the water supply. A mobile app or web interface allows users to remotely monitor and control the system, providing notifications and data logging for analysis. This design ensures efficient and sustainable irrigation, conserving water while enhancing crop growth and productivity.

4.1.1 OUTPUT DESIGN

The output design of the smart irrigation system includes automated control signals from the microcontroller to manage water pumps and valves based on sensor data, user notifications for system status and alerts via SMS or app, data visualization of real-time and historical trends in soil moisture, weather, and water usage through a mobile app or web interface, and detailed system logs of irrigation events and sensor readings for review and analysis, ensuring efficient and informed water management. Things taken into consideration in determining the output are represented below:

Figure 4.1: Wireless Smart Irrigation System

This is smart Irrigation System with an Arduino Uno which will irrigate plants automatically and keep them healthy.

4.1.2 INPUT DESIGN

The input design of the wireless smart irrigation system incorporates real-time data from soil moisture sensors, weather sensors (measuring temperature, humidity, and rainfall), and user-configurable parameters via a mobile app or web interface. This data is processed by a microcontroller, which uses it to determine irrigation needs and make decisions about water distribution, ensuring efficient and responsive irrigation management.

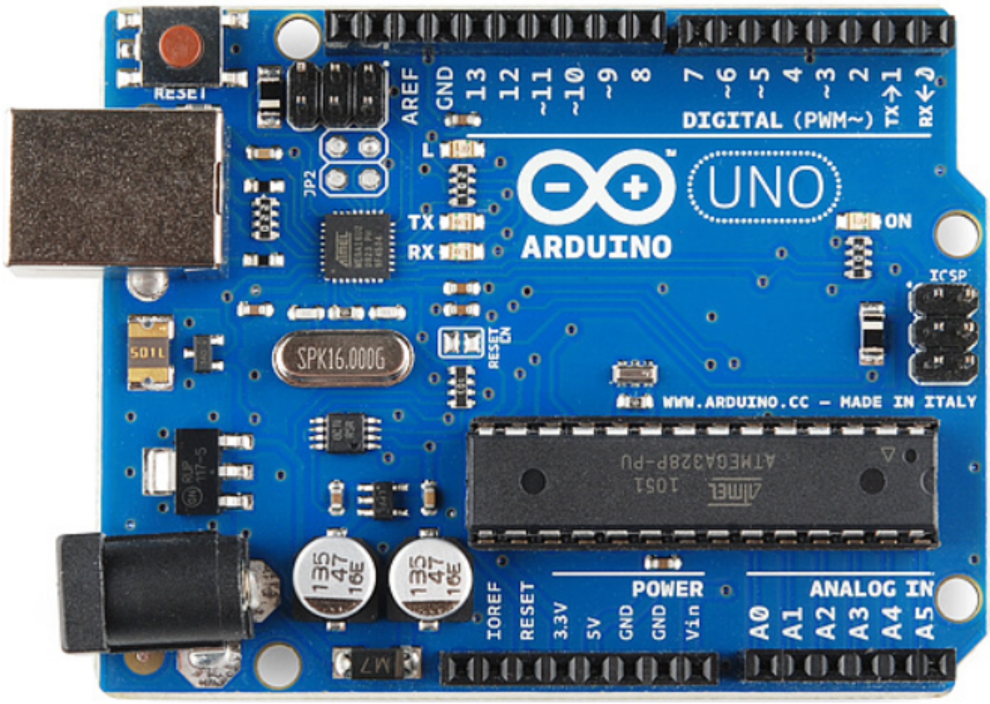

Figure 4.2:Arduino Uno

The microcontroller, such as an Arduino or ESP32, is the central processing unit of the smart irrigation system, responsible for collecting data from sensors, processing this data to determine irrigation needs, controlling water pumps and valves, and facilitating communication with remote user interfaces via built-in or external communication modules like GSM or Wi-Fi.

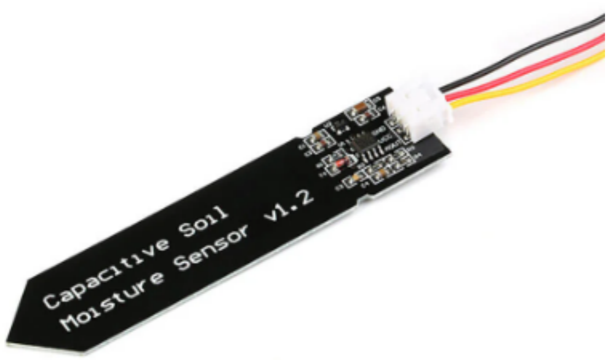

Figure 4.3: Soil Moisture Sensors.

Soil moisture sensors measure the moisture content in the soil, providing real-time data to the smart irrigation system to determine when and how much to water, ensuring efficient and precise irrigation.

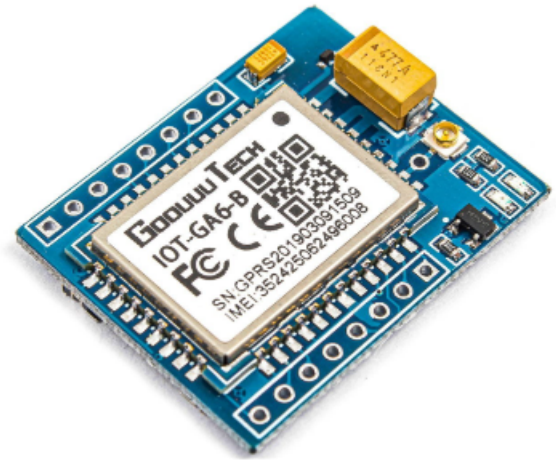

Figure 4.4: GSM or Wi-Fi Module

A GSM or Wi-Fi module enables the smart irrigation system to communicate with remote user interfaces, allowing for real-time monitoring, control, and notifications via mobile apps or web interfaces, enhancing the system's accessibility and convenience.

4.1.3 PROCEDURE DESIGN

The procedure design of the smart irrigation system involves initializing the system components, continuously monitoring real-time data from soil moisture and weather sensors, processing this data through a microcontroller to assess irrigation needs, and automatically controlling water pumps and valves. The system also includes user interaction through a mobile app or web interface for remote monitoring, configuration, and manual override, ensuring efficient and adaptive water management.

4.2 IMPLEMENTATION OF THE SYSTEM

In the implementation phase, the smart irrigation system is constructed and deployed according to the designed specifications. This involves assembling hardware components, such as soil moisture sensors, weather sensors, microcontroller, water pumps, and valves, and connecting them as per the system architecture. Software development entails writing code for the microcontroller to process sensor data, control irrigation, and interface with user applications. Thorough testing is conducted to verify system functionality and ensure reliable operation under various conditions. Once tested, the system is deployed in the field, with user interfaces configured for remote monitoring and control. Ongoing maintenance and updates are performed to sustain optimal performance and address any issues that arise, ensuring efficient and sustainable water management.

4.2.1 CHOICE OF PROGRAMMING LANGUAGE

For the smart irrigation system, the choice of programming language is pivotal to ensure efficient communication between hardware components, data processing, and user interface development. Therefore, the programming language selection plays a crucial role in the system's functionality and scalability. Commonly, a combination of languages is utilized:

In the implementation of the smart irrigation system, the primary programming language chosen is C/C++, renowned for its efficiency and suitability for embedded systems programming. C/C++ facilitates direct hardware interaction and memory management, crucial for microcontroller-based applications.

4.2.2 HARDWARE REQUIREMENT

The hardware requirements for the smart irrigation system encompass a range of components to facilitate sensor data acquisition, processing, and control of irrigation equipment. Here's an overview:

i. **Microcontroller**: A central processing unit such as Arduino or ESP32, responsible for collecting sensor data, making irrigation decisions, and controlling water pumps and valves.

ii. **Soil Moisture Sensors**: These sensors measure soil moisture levels to determine when irrigation is required. Multiple sensors may be deployed throughout the irrigation area for comprehensive coverage.

iii. **Weather Sensors**: Including temperature, humidity, and rainfall sensors to gather environmental data, enabling the system to adjust irrigation schedules based on weather conditions.

iv. **Water Pumps and Valves**: Equipment to control the flow of water from the source to the irrigation system. Valves regulate water distribution, while pumps ensure adequate water pressure.

v. **Power Supply**: Reliable power sources such as batteries, solar panels, or mains power adapters to ensure continuous operation of the system.

vi. **Communication Module**: Optional GSM or Wi-Fi module for remote monitoring and control, allowing users to access the system from a mobile app or web interface.

vii. **Enclosure**: Protective housing to shield components from environmental factors such as moisture, dust, and temperature fluctuations.

viii. **Mounting Hardware**: Brackets, screws, and other fixtures to securely install sensors, pumps, and valves in the irrigation area.

4.2.3 SOFTWARE REQUIREMENT

The software requirements for the smart irrigation system encompass various components for data processing, control logic, user interface development, and remote monitoring capabilities. Here's an overview:

i. **Microcontroller Programming**: Code written in C/C++ to run on the microcontroller (e.g., Arduino or ESP32), responsible for collecting sensor data, implementing irrigation algorithms, and controlling water pumps and valves.

ii. **User Interface Development**: Development of a user interface for remote monitoring and control. This may include web applications or mobile apps developed using languages like HTML, CSS, JavaScript for web development, or Java/Kotlin for Android apps and Swift for iOS apps.

iii. **Data Processing and Analysis**: Algorithms to process sensor data and make irrigation decisions based on predefined thresholds and environmental conditions. This may involve statistical analysis, machine learning techniques, or rule-based logic.

iv. **Communication Protocols**: Implementation of communication protocols (e.g., Wi-Fi, GSM) to enable remote access to the system from a mobile app or web interface.

v. **Database Management**: Database management system (DBMS) to store historical sensor data, irrigation schedules, and user preferences. This facilitates data logging, analysis, and reporting.

vi. **Error Handling and Logging**: Mechanisms to handle errors, log system events, and generate alerts or notifications for users in case of abnormalities or malfunctions.

vii. **Integration with External Services**: Integration with external services or APIs for weather forecasting, soil moisture monitoring, or water usage tracking to enhance system functionality and decision-making.

4.3 DOCUMENTATION OF THE SYSTEM

4.3.1 Program Documentation

Program documentation for the smart irrigation system encompasses detailed explanations and instructions to facilitate system understanding, maintenance, and further development. This documentation includes comprehensive comments within the source code, providing clarity on the purpose, functionality, and usage of each module, function, and variable. Additionally, documentation includes user manuals and guides detailing system installation, configuration, and operation, ensuring users can effectively utilize the system's features and functionalities. Technical documentation outlines system architecture, hardware specifications, software components, and communication protocols, aiding developers in troubleshooting, debugging, and extending system capabilities. Through meticulous program documentation, the smart irrigation system is equipped with the necessary resources to ensure smooth implementation, operation, and ongoing maintenance, fostering efficient water management practices and sustainable agricultural endeavors.

4.3.2 Maintaining of the System

Maintaining the smart irrigation system involves ongoing efforts to ensure its reliability, efficiency, and effectiveness in managing water resources for agricultural or landscaping purposes. This includes regular inspection and calibration of sensors to ensure accurate data collection, monitoring system performance to detect and address any issues or malfunctions promptly, and updating software and firmware to incorporate new features, optimize algorithms, and address security vulnerabilities. Additionally, routine maintenance of hardware components such as pumps, valves, and communication modules is essential to prevent breakdowns and ensure continuous operation. User training and support are provided to ensure operators understand how to use the system effectively and troubleshoot common issues. By implementing proactive maintenance practices, the smart irrigation system can sustain optimal performance, conserve water resources, and support sustainable agricultural practices over the long term.

CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATIONS
5.1 SUMMARY
This project implement a wirelessly controlled robot-based smart irrigation system designed to address the inefficiencies of traditional irrigation methods. By integrating robotics, IoT, and automation, the proposed system offers a sustainable solution for modern agriculture. The system integrate advanced technologies such as sensors, Internet of Things (IoT) devices, Microcontroller, and smart sprinkler to optimize water use in agriculture. Traditional irrigation methods, which often rely on manual or basic automated systems, are inefficient and can lead to water wastage, crop stress, and significant labor requirements. The proposed Smart Irrigation System addresses these issues by using real-time data from soil moisture sensors and weather stations to dynamically adjust irrigation schedules. The system leverages wireless communication to transmit data to control units and sprinklers where sophisticated algorithms analyze the data to make informed irrigation decisions. This approach not only conserves water and reduces labor but also promotes healthier crops and sustainable farming practices.

5.2 CONCLUSION
Implementing a wireless smart irrigation system represents a substantial improvement over traditional irrigation methods. By integrating real-time monitoring and data-driven decision-making, the system ensures precise water application tailored to the specific needs of crops and environmental conditions. This precision leads to significant water savings, enhanced crop health, and higher agricultural productivity. Moreover, the automation and remote control capabilities of the system reduce the labor burden on farmers and allow for more efficient farm management. The Smart Irrigation System offers a

sustainable, efficient, and technologically advanced solution for modern agriculture, addressing both resource conservation and economic viability. The findings of this project highlight the potential of advanced technologies in transforming irrigation practices. The proposed system demonstrates significant improvements in water use efficiency and agricultural productivity. Future research should focus on scaling the system for large-scale implementation and exploring its integration with other agricultural technologies.

5.3 RECOMMENDATIONS

Based on the findings of this project, the following were recommended:

i. Adoption of Smart Technologies**:** Farmers and agricultural stakeholders should adopt smart irrigation technologies to improve water efficiency and crop yields. Initial investment in these systems can lead to long-term cost savings and sustainability benefits.

ii. Government and Policy Support**:** Governments and agricultural agencies should support the adoption of smart irrigation systems through subsidies, incentives, and training programs. Such support can accelerate the transition to more sustainable farming practices.

iii. Continuous Monitoring and Maintenance**:** To ensure the long-term effectiveness of the Smart Irrigation System, regular monitoring and maintenance are crucial. Farmers should periodically calibrate sensors, update software, and review system performance to optimize irrigation strategies continually.

iv. Education and Training**:** Providing education and training to farmers on the benefits and operation of smart irrigation systems can enhance their adoption and effective use. Training programs should cover system installation, data interpretation, and troubleshooting.

REFERENCES

Ahmed, I. A., Mutaz, M. A, Omar, O. O. & Ahmed, I. M. (2016). *Design and Development of GSM Based Automated Spray Irrigation System Prototype.* A Thesis Submitted in Partial Fulfillment of the Requirement for the Degree of B.Sc. in Agricultural and Biological Engineering. Pp. 1-3. *Marrakesh, Morocco.*

Bakare, B. I., Ewunonu, T. C., Bruce-Allison S. A. & Eke, E. (2022). Design and Implementation of a Smart Irrigation System, *Journal of Software Engineering and Simulation*. Vol. 8, Issue: 7. Pp. 1-8. DOI: 10.1109/ICICI.2022.8365190.

Hu, X., Sun, X., Li, Q., He, Q. & Li, Y. (2021). Design and Implementation of Intelligent Irrigation System, *E3S Web of Conferences 260.* Pp. 12-13. https://doi.org/10.1051/e3sconf/202126003010

Li, J. & He, H. (2019). Design of Rice Intelligent Water-saving Irrigation System Based on Agricultural Internet of Things, *Journal of Physics: Conference Series.* Vol. 11 Issue: 5. Pp. 1121-1122. DOI: 10.33564/ijeast.2019.v03i11.005.

Liu, Z. & Xu, Q. (2018). An Automatic Irrigation Control System for Soilless Culture of Lettuce Water. *Journal of Computers and Electronics in Agriculture*. Vol. 10. Issue: 11. Pp. 689-690.

Mahzabin, A. Taziz, C., Amina, M., Gloria, M. & Zishan, R. R. (2016). Design and Implementation of an Automatic Irrigation System. *International Advanced Research Journal in Science, Engineering and Technology. DOI 10.17148/IARJSET.2016.31030*

Masaba, K., Ntakirutimana, A. & Ustun, T. S. (2020). Design and Implementation of a Smart Irrigation System for Improved Water-Energy Efficiency. *International Journal of Applied Agricultural Sciences*. Vol. 5. Issue: 3. Pp. 123-124.

Odara, Z., Khan, S. & Ustun, T. S. (2016). Integration of Precision Agriculture and Development, *IEEE International Conference Technology Innovation ICT Agric Rural Development (TIAR)*. Pp.

Rajendran, A., Kavinila, S. E., Harini, J. & Sangeethaa, V. O. (2021). Automatic Irrigation on Sensing Soil Moisture Content. *International Journal Innovation Technology Engineering*. Vol. 8. Issue: 6. Pp. 798–803.

Umar, B. U. (2021). The Design and Performance Evaluation of a Wireless Sensor Network Based Irrigation System on Different Soil Types, *Journal of Digital Food, Energy & Water Systems*. Vol. 2. Issue: 2. Pp. 121-147.

Kumar, V., Ramasamy, V. Janarthanan, S. & VasimBabu, M. (2017). Implementation of IoT in Smart Irrigation System using Arduino Processor. *International Journal of Civil Engineering Technology*. Vol. 8, Issue: 10. Pp. 1304–1314. DOI: 10.1109/TIM.2013.2276487.

Wu, J. Z., Han, S. & Liu, J. (2018). Application Progress of Agricultural Internet of Things in Major Countries. *Journal of Physics: Conference Series*. Vol. 1. Issue: 3. Pp. 3-5.