A WIRELESSLY CONTROLLED ROBOT-BASED SMART IRRIGATIO N SYSTEM BY EXPLOITATION

BY

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CERTIFICATION

This is to certify that this project was carried out by SHUAIB ABDULWAHAB ABIOLA matric number **HND/23/COM/FT/0416** 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 Almig hty God. It is also dedicated to my parents for their moral and financial sup port.

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TABLE OF CONTENTS

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 pivot al role in modern agriculture, addressing the challenges of water scarcity a nd the need for efficient resource utilization. This project focuses on the de velopment and implementation of a wirelessly controlled robot-based smar t irrigation system. It makes use of light, temperature, soil moisture sensor s, Liquid Crystal Display, PIC microcontroller. This irrigation system consist s of four different sensors which are used to measure various parameters r elated to the crop production. They are Light Dependent Resistor (LDR), Hu midity Sensor, Soil moisture Sensor and temperature Sensor. The LDR is us ed to determine the intensity of light or the time of the day. This helps the s ystem 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 t o 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 increasin gly challenged by issues such as water scarcity, inefficient resource utilizati on, 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, integr ating advanced technologies into irrigation systems becomes essential (A minin, 2020).

Recent advancements in Internet of Things, robotics, and wireless commun ication have opened new avenues for innovation in agricultural technology. Automated irrigation systems, in particular, have demonstrated their potent ial to enhance water use efficiency, reduce labor dependency, and improve crop yields. By combining robotics and IoT, a wirelessly controlled smart irri gation system can provide real-time monitoring and precision water deliver y based on specific crop and soil requirements (Li & He, 2019). Due to the u neven distribution of water resources and the increasing demand for fresh water resources, the shortage of fresh water resources will become a serio us problem faced by all countries in the world in the near future. The propor tion of agricultural water in fresh water consumption is relatively high in Nig eria. At present, water-saving irrigation in Nigeria is still in its infancy (Usma n 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 distu rbed soils in dry areas and during periods of inadequate rainfall. In crop pro duction, irrigation helps in protecting plants against frost, suppressing weed growth in grain fields and preventing soil consolidation. Irrigation systems a re also used for dust suppression, disposal of sewage, and in mining. Irrigat ion undisputedly has evolved and it is still evolving and advancing to be a m ore efficient, easy and flexible process and through the course of time vario us methods of irrigation has been introduced, some of the most common ty pes of irrigation include the following; Surface irrigation, Sprinkler irrigation and Drip Irrigation.

For as long as humans have grown seeds, irrigation has been around. Irriga tion procedures rely mainly on the availability of water. Irrigation is essentia l in semi-arid and arid areas for food, pasture, and fiber production. To incre ase food security while saving water, irrigation methods around the world a re evolving. Developed and developing countries are moving from pure sup ply to a system centered on a demand based model. In a nation like Nigeri a, where water supplies are manually regulated and managed, and water is unevenly distributed in time and space, demand-based practices are not fe asible. Due to limited sweet water supplies, an efficient and cost-effective way of irrigation has emerged as the need of the hour, especially in countri es 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 agricul tural challenges that modern technologies are helping to address. Agricultu re 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 exc essive 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.

1.4SIGNIFICANCE 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 dis cusses 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 challen ge. 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 irrigatio n system that uses environmental information to determine when and whe re irrigation is required. The system is comprised of microcontroller, sensor s and integration of water pumps with the decision-making system. A truth table is developed to help the system determine the necessity to irrigate ba sed on the collected environment information. The sensors narrow down th e 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. Differe nt parameters used, i.e. temperature, humidity and moisture, makes it poss ible to adjust the system according to the needs of a particular location.

Hu et al;(2021) proposed an intelligent irrigation system. The intelligent irrig ation system that is based on STM32 and BC95 was designed and implem ented. The soil information is received through temperature sensor and hu midity 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 ir rigation. The practice shows that the wireless communication mode of dat a 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 sin gle plant or crop as future study could be extended to monitor a larger porti on of land with two or more crops.

Mahzabin *et al* (2019) proposed a design and implementation of an automa tic irrigation system. The project deals with the automatic operation of the pump to supply water in the field depending on the soil moisture. The syste m 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 n etwork based irrigation system on different soil types. The research propos ed an Arduino-based smart irrigation system using a wireless sensor netwo rk to overcome the problem of overwatering, underwatering, and efficient ti me utilization in farming. The system is implemented using Arduino IDE, Pr oteus Simulation Tools, and Blynk Platform. The effect of the four-mobile n etwork: MTN, GLO, Airtel and 9mobile on response time for Gidan- Kwano a rea was evaluated. Testing carried out on the system resulted in a respons e 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 6.0 73 seconds respectively was achieved for loamy soil average response tim e 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 sys tem effective in terms of time response, thereby eradicating the time wast ed by manual system operation to irrigation scheduling. Also, the appropria te soil moisture content is maintained, whether it rains or not. This reduces excesses and ensures healthy plant growth, increasing agricultural producti vity, 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. Th e 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 irri gate. 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 ir rigation 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 man agement.

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 p hysically 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).