AUTOMATIC IRRIGATION SYSTEM

Technical Report · November 2024

DOI: 10.13140/RG.2.2.17993.56169

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PROJECT REPORT

ON

AUTOMATIC IRRIGATION SYSTEM

Department of Information & Communication Technology

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CERTIFICATE

To whom it may concern,

We, the undersigned, want to say that we have read and are to recommend a project work. It's called "Automatic Irrigation System Using Microcontroller." This project was done by Md. Mejbah Uddin, Md. Imran Khan, Md. Mohiuddin, Sumi Akter, and Luni Tripura. They worked hard on it during their third year for their Bachelor of Engineering. This all took place in the academic year 2020-21.

Furthermore, we confirm that this project hasn't been submitted for any other degree, diploma, or fellowship before.

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ACKNOWLEDGEMENT

We really want to say a big thank you to Alimul Rajee, who is a Lecturer in the Department of Information and Communication Technology at Comilla University. It feels like a lucky break for us to have him as our project mentor! His support, encouragement, & guidance mean a lot to us.

Also, we can’t forget to thank all the faculty members who were so helpful and supportive during this project. Their cooperation really made a difference!

And of course, a huge shout-out to the Department of Information and Communication Technology for giving us the tools & facilities we needed to do this project. We truly appreciate everything!

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ABSTRACT

In the present situation, the density of the population experiences a swift increase on a daily basis. Due to this substantial population growth, water scarcity emerges as the most pressing and critical issue in today's global context. Furthermore, a significant volume of water is squandered each day during the irrigation processes for agricultural production. Waterlogging during the cultivation phase is the primary factor contributing to this unnecessary water loss. Due to this excessive crying, an irrigation system is crucial. This project proposes and insists on automated irrigation systems using the Arduino Uno board microcontroller, soil moisture sensor, servo motor, and other elements. In this research, the soil moisture sensor has been used to detect the level of humidity in the soil to decide whether irrigation is required or not. Accordingly, a servo motor provides the plant with an adequate amount of water. This complete system is controlled by a microcontroller. Automatic switching is done which switches on to supply water in case of low soil moisture and switches off once the soil is adequately watered and the water level drops down to a preset threshold level. This not only saves water but also provides more significant development of plants because only the amount of water needed is supplied to each plant. A servo motor is used along with a water pipe pointed towards the plant.

Keyword: Arduino Uno, Microcontroller, Soil Moisture Sensor, Servomotor.

CHAPTER 1

INTRODUCTION

1.1 Overview

Bangladesh is a land of villages, and agriculture plays a vital role in the development process. Agriculture in our country depends on monsoon and the amount of water resource in the monsoon is not adequate. Irrigation has, therefore, been used in the fields. In the irrigation system, the water supply to plants is provided according to the type of soil. In agriculture, two things are required: first, to get information about soil fertility, and second, to measure humidity content in air. Nowadays, different techniques are available for irrigation in order to reduce rain dependency. This technique is mainly driven by electrical power and on/off scheduling. In this technique, sensors for temperature and humidity are placed near the plant, and the module and gateway unit handle sensor information and transmit data to the controller, which controls the flow of water through the pump.

1.2 Motivation

With the demand for the essentials of food growing continuously and their supply continuously dwindling, there is a dire need for increasing food technology production at a rapid pace. Agriculture is the only source for this. This becomes an important factor in human societies as the demand for food production continues to grow and becomes dynamic. Agriculture is vital for the economy and prosperity in countries like India. Agriculturalists use irrigation methods due to a lack of adequate water supply and scarcity of land water, which finally reduces the volume of water on Earth. The need for water supply depends upon the type of soil and irrigation can be described as the application of artificial water to the soil or land in an orderly manner.

1.3 Economic Importance

The initiation and cessation of water flow, as well as its redirection to different areas, are facilitated by automatic irrigation, eliminating the necessity for manual effort. While farming relies significantly on irrigation, numerous benefits are derived by both farmers and other landowners through the implementation of automatic irrigation. Here’s what you need to know.

1.3.1 Save Money

Automatic irrigation saves you time. Therefore, you also save money. Money on water and power bills can be saved depending on the number of pumps you have, and the number of hours needed for watering.

1.3.2 Less Manual Labor

With an automated irrigation system, almost all aspects of irrigation can be monitored and controlled. For example, at the touch of a button, tasks such as:

- Turn pumps on and off.
- Cut off the flow from one area and direct it to a different area.
- Pivots, sprinklers, and all types of diesel and electric motors can be kept under surveillance and controlled.

1.3.3 Improved Water Efficiency

Effective design of an irrigation system is crucial to guarantee that plants and crops receive the appropriate volume of water at the optimal times. When implemented and configured by a qualified expert, concerns related to both insufficient and excessive watering are resolved, thereby enhancing the health of the crops and plants, in addition to promoting cost savings on your water expenses.

The advantages of automated irrigation include:

- Reduced labor.
- Timely irrigation plants being watered when needed.
- Administration of elevated flow rates.
- When compared to manual checking, correct cut-off of water is achieved.
- Reduced runoff of water and nutrients.
- Reduced costs for vehicles used to check irrigation are realized.

Although an intelligent irrigation system installed at a pretty costly price, it may need additional systems depending on the size of a given property. Therefore, the lower the water bills, the overall lower the costs will be. Where this system is to be used for lawn irrigation, it's advisable to have it installed underground before planting.

1.4 Objective

The primary goal is to design a system that measures soil moisture using the sensor and controls the water pump based on the moisture level. This objective aligns with the broader aim of enhancing plant care efficiency and reducing manual intervention in watering processes. Additionally, the system can be further enhanced by incorporating features such as wireless connectivity for remote monitoring and control and integrating additional sensors for environmental monitoring.

By establishing this objective, the project aims to address the need for efficient and automated plant care solutions, contributing to the advancement of agricultural and gardening technologies. This objective aligns with the principles of effective project management, emphasizing the importance of clear and measurable goals to guide the project's development and success.

The objective statement reflects the intention to create a tangible and functional system that streamlines plant watering based on real-time soil moisture data, ultimately contributing to the efficient and sustainable management of plant care

CHAPTER 2

LITERATURE REVIEW

2.1 Literature Review

A thorough examination of the literature on automated irrigation systems reveals a diverse range of research projects with the goal of improving farming methods. Remarkable research works like "A Systematic Literature Review on IoT-based Irrigation" highlights how important automated irrigation systems are for preserving water in agricultural environments [1].

Studies on the efficiency of automatic irrigation systems for rice cultivation, as shown in publications such as "Efficiency of Automatic Irrigation System for Rice Cultivation," provide insightful analyses of system functionality and water productivity, highlighting the benefits of automation in streamlining farming operations. Studies on the application of control theory principles to irrigation systems, such as "Application of Control Theory in Automatic Irrigation Systems," provide examples of investigations into automatic irrigation control. These studies highlight the potential for improved water management and increased efficiency through automation [2].

Additionally, research like "A Literature Review On Automatic Watering Of Plants" examines how smart technologies can be used to automate plant watering procedures, highlighting the importance of these systems in resolving agricultural issues and enhancing operational effectiveness [3]. The advancement of automated irrigation technologies is largely dependent on research projects that concentrate on solar-powered smart irrigation systems and the use of fuzzy logic techniques for greenhouse control, as shown in publications such as "Solar-Powered Smart Irrigation Systems: A Review" and "Fuzzy Logic Control in Greenhouse Environment: A Review," respectively [4]. Additionally, research like "A Literature Review On Automatic Watering Of Plants" examines how smart technologies can be used to automate plant watering procedures, highlighting the importance of these systems in resolving agricultural issues and enhancing operational effectiveness [5].

Smart irrigation systems' capabilities are further enhanced by the integration of IoT technology and real-time soil moisture data, opening the door to more effective and sustainable agricultural practices. All these references emphasize how crucial automatic irrigation systems are to contemporary agriculture, providing insightful information about their conception, assessment of their effectiveness, and potential to completely transform methods of managing water resources.

The paper presents an intelligent irrigation system that implements IoT technology for better usage of water at the site. It makes use of various sensors for monitoring the moisture level in the soil and the surrounding environment, hence automatically determining the irrigation schedule. In this manner, the system not only enhances the efficacy of water usage but also increases the yield of crops by proper watering relevant to the requirements of the plant. The study also identifies that IoT-based systems can contribute to reducing wastewater and offer opportunities for sustainable agriculture [6].

This research work presents an Arduino-based automatic irrigation system equipped with soil moisture sensors and a water pump. Much emphasis has been given to the simplicity and low cost of the system so that small-scale agricultural fields can be targeted. Experimental results prove that the system optimizes the use of water with no wastage, hence increasing the efficiency of irrigation [7].

The paper aims at an IoT-based system for home garden irrigation, integrating remote monitoring and control using a mobile application. This system is, therefore, intended to save water consumption in developing countries through providing an opportunity for users to manage irrigation schedules from afar hence optimizing water use in small-scale agricultural and gardening applications.[8] This project proposes the Arduino UNO-based automatic irrigation system, utilizing soil moisture sensors. Further, this paper mentions the cost-effectiveness for small-scale agriculture. Experimental results confirm that significant amounts of water can be saved by assuring higher yields in crops. Suggestions were further given to integrate more wireless modules into the system [9].

The research has focused on an intelligent irrigation system that will be enabled with IoT technology for real-time monitoring and automation. In this, the optimization of water application is done based on the analysis of soil moisture, temperature, and humidity data. Further, it discusses detailed system architecture and sensor integration for the design, pointing out that the performance will conserve much water and improve agricultural efficiency [10].

This work integrates solar power into a smart irrigation system for sustainability. The Arduino-based system operates in a fully automated mode based on the use of solar energy. Therefore, it is certainly appropriate for remote areas. Experimental data are presented showing the efficiency of the system in maintaining crop hydration without necessarily burdening the demand for non-renewable energy sources [11].

The research approach is based on machine learning integrated with IoT in developing a predictive irrigation system. It predicts the time and amount of water to be irrigated, using environmental data analysis. It helps to improve water conservation and ensures that crops will not suffer from faulty irrigation. It showed promising results toward better improvements in water efficiency and crop productivity through advanced data analysis [12].

An automated irrigation system using Arduino and IoT was presented in this article to work out the water usage of a crop in large areas. The amount of water saving and yield is very promising. It has huge scope for future improvements that can present weather-based irrigation control [13].

The following study introduces an IoT-based smart irrigation system that can automate irrigation with the help of water content and temperature sensors of the soil. A mobile application is also a part of the system, which will provide an easy user interface for its remote control. This research has been focused on its potential for savings and yield increase both at small and large-scale applications [14].

The paper presents an Arduino UNO-based automatic irrigation system that uses soil moisture sensors to regulate the need for watering, hence minimizing the use of manual intervention. Its cost-effectiveness is highlighted, which may mean a great deal in bringing positive change in water management in small-scale farming because of its practicality for efficient irrigation [15].

This research contributes to the design of IoT-enabled water management for precision agriculture, which shall apply sensors in monitoring environmental conditions to optimize irrigation. The system will employ machine learning on the forecast of irrigation requirements and create better performance in water efficiency and crop health, therefore improving the practice of precision farming [16].

This paper integrates AI with IoT in developing an intelligent irrigation system that predicts the best times and quantity of irrigation based on environmental data. The integration of AI algorithms contributes to less water wastage and increased yields due to the adjustment of irrigation according to changes in the environment, showing effectiveness in modernizing agricultural practices using advanced technologies [17].

It proposes an IoT-based automated irrigation system suitable for a wide range of agricultural applications. Due to real-time monitoring and controlling, huge quantities of water may be saved along with efficiency in the agricultural sector. The study also stipulates that this can be applied across wide ranges of farming scenarios and that this is one of the very flexible applications [18].

The paper describes the development of an efficient Arduino-based smart irrigation system using IoT technology. It would, therefore, be able to take control and monitor from a distance hence cutting down on the need for human labor. Experimental results clearly illustrate how this concept of the system saves water without affecting the health of the crops and is suitable for small-scale agriculture [19]. This research coupled IoT with machine learning in order to optimize irrigation schedules. The system analyzes environmental data to predict the best times and amounts of water to apply. The most outstanding probable potential of this capability stands at the improvement of agricultural productivity by the conservation of water while ensuring irrigation of crops at an adequate level [20].

The document discusses the application of IoT in precision farming, focusing on automated irrigation. The system monitors soil conditions and optimizes water application based on its readings, realizing high volumes of water savings. Precision farming is also practiced with increased yields while lessening adverse impacts on the environment [21]. This is a low-cost automatic irrigation system using Arduino, soil moisture sensors, and a water pump. The system covers automation in irrigation processes to minimize human labor and conserve much water. It is an effective system in boosting crop yield; hence, it is a practical solution for farmers who have the resources [22].

The research presents an IoT-based Arduino water management system, which exploits smart irrigation. Therefore, the system provides data-driven irrigation decisions, having monitored soil moisture and temperature throughout. It has been revealed that it improves crop health and decreases water use, especially in arid areas [23].

This work combines solar energy with an intelligent irrigation system. Thus, it can be installed in an area where accessibility to remote and off-grid sites is needed. An IoT- and Arduino-based system powered by solar panels focuses on sustainability at an affordable cost. The findings prove how this solution can widely be adopted in developing regions [24].

It proposes the use of the IoT-based water management system for optimal irrigation scheduling and control based on real-time data. The system makes sure not only of the high productivity of the crops but also of proper utilization of water by the crops by controlling irrigation with high accuracy. Experimental results of this proposed system are promising and highlight the effectiveness in various farming conditions [25].

The paper by Humayed et al. "Industrial Cybersecurity and the Legacy Systems Conundrum" primarily focuses on the challenge and strategies for securing ICS, especially with the presence of any legacy systems. They point out that many infrastructures still rely on older versions of legacy systems that were never designed to deal with today's cybersecurity threats. They discuss issues related to no encryption of systems, weak mechanisms for authentication, and very limited monitoring capabilities. The paper also discusses how integration of current security technologies into old systems can be a probable solution, tight access control, and the deployment of sophisticated monitoring tools that will help in the detection of anomalies. This work is very important for understanding the peculiar demands of cybersecurity an industry faces, which cannot, for one reason or another-such as high cost or operational difficulty-relatively quickly upgrade from its legacy systems [26].

Performance Analysis of Antenna Design for 5G Applications: The authors Tesma et al., in this paper, make a comparative study of a number of designs of antennas for 5G networks. It does a comparison study among various antenna configurations, considering the main constraints on the antenna gain, bandwidth, and radiation patterns. The paper discusses several challenges in the design of 5G antennas due to high-frequency bands that it operates on and the low latency the signal needs to maintain. Authors also discussed some trade-offs in antenna design regarding compact size and high performance. This research has extended the on-going development of efficient antenna solutions at the heart of 5G technology deployment [27].

Paper "Integrating Mobile Learning Technologies in Educational Settings" discusses the application of mobile learning technologies within educational institutions. The authors review several strategies related to adopting mobile learning: apps, mobile-responsive content, and cloud-based learning management systems. They outline that mobile learning offers the benefits of increased accessibility, flexibility in learning environments, and engaging students more effectively. The paper also proceeds to discuss the barriers educators face while incorporating mobile technologies including digital divide issues, resistance to change, and the need for teacher training. This work will be useful to educators and policymakers who seek to use mobile technology to improve learning outcomes [28].

Aditya, in his paper "A Novel Approach to Smart Agriculture using IoT", discusses the application of IoT in modern agriculture. It describes a system designed in such a way that different agricultural processes, like irrigation and soil monitoring, are automated using IoT devices. The authors have identified that this system can optimize water consumption, reduce labor costs, and give better yields by providing real-time soil moisture and weather data. This research is important in showing the application of IoT to mitigate traditional agriculture problems for better sustainability and efficiency in farming [29].

The article "Advances in Agricultural Automation Technologies" deals with the latest advances in automation technologies in the agricultural sector. Among others, automated systems discussed involve drones for crop monitoring, robotic harvesters, and automatic irrigation systems. The paper provides a greater analysis of the benefit level for these technologies, such as increased precision, reduced labor costs, and enhanced productivity. The high initiation costs of these technologies, as well as some skilled operators, are also discussed. This research is important with regard to understanding the future of agricultural practices and how automation plays a role in increasing efficiency and sustainability [30].

Presentation of the design and implementation of "Development of a Low-Cost Automatic Irrigation System Using Microcontroller" is presented by Diponkor Bala in the paper [31]. In this regard, the system has been devised to assist small-scale farmers by automatizing irrigation management, based on soil moisture conditions. The authors give an overview of the components to be used in building the system, which include sensors, microcontrollers, and water pumps, and describe how to build and program such a system step by step. The paper further discusses the efficiency of the system in managing water resources for increased crop yields, and it is hence an important source of information for farmers who seek to adopt low-cost agricultural technologies.

The "Design and Implementation of a Solar-Powered Irrigation System" thesis covers the design aspects of the irrigation system powered by solar energy, which aims to reduce dependency on conventional energy supply and reduce operation costs. The authors explain major components involved in such systems, which are solar panels, batteries, and water pumps, and how they interact with each other to provide a practical irrigation solution. The thesis also gives a cost-benefit analysis to prove the long-term economic viability of solar-powered irrigation systems. From this perspective, this study is quite relevant, especially in those areas where sunlight is plentiful and the conventional source of energy is scarce [32].

"An Integrated Approach to Smart Grid Security" by Shabari et al. focuses on security issues with smart grids and presents an integrated security framework for addressing these challenges. The authors have indicated that smart grids represent those complex systems that integrate subsystems: generation, distribution, and consumption of electricity, all of which might become vulnerable to cyberattacks. The proposed framework contains the use of encryption techniques, intrusion detection systems, and secure protocols for communication to protect against possible threats. This is an important paper for all stakeholders in the energy sector who look forward to improving security and ensuring reliability in smart grid systems [33].

The paper "Implementation of Machine Learning in Predictive Maintenance" discusses the implementation of machine learning techniques within the arena of predictive maintenance. Many machine learning algorithms are discussed, ranging from neural networks to decision trees, along with their potency in predicting equipment failure prior to the actual event. The paper also presents case studies on how predictive maintenance can reduce downtimes, increase equipment life, and lower maintenance costs. The conclusions derived from this study are relevant for industries interested in improving operational efficiency and reliability using advanced data analytics [34].

"Challenges and Opportunities in Deployment of 5G Networks," presents some of the technical and regulatory challenges that are about to be presented upon the deployment of 5G networks. Issues tackled in the paper that need wide support, include spectrum allocation, infrastructure building, and the need for new regulatory frameworks in order to widely support the 5G technology. The authors have also pointed out the various opportunities that may be offered by the 5G networks, such as enhanced connectivity, support for IoT devices, and better mobile broadband services. This research is important in underlining several challenges that must first be overcome before the full realization of the potential of the 5G networks [35].

A vast study has been presented in the paper "IoT-Based Smart Agriculture System Using Soil Moisture Sensor and NodeMCU," representing the development of the smart agriculture system using IoT. The system consists of a soil moisture sensor connected to a NodeMCU-an open-source IoT platform-to automate irrigation. This work identifies how effective and economically viable the establishment of such systems in agricultural operations is, while explaining that with the IoT-driven methodology, not only does the waste of water reduce, but crop yield is also enhanced due to retention of optimum levels of soil moisture. Its real-time data collection and monitoring capabilities are, thus, major reasons for its optimization in irrigation schedules hence valuable contribution to precision agriculture [36].

Diponkor Bala's research targets the design and implementation of a low-cost automatic irrigation system using a microcontroller. The work describes how various hardware and software can be integrated in order to develop a system for automating irrigation based on soil moisture. This method, based on a microcontroller, presents an economical approach toward small- and medium-sized farms, where the irrigation by manual means involves much labor and inefficiency. The fact that the system operates independently and can easily be scaled up makes it a sweet deal for farmers in ensuring irrigation efficiency at minimal financial cost [37]. The authors of this paper present the development of a real-time monitoring system that helps boost precision agriculture. The system relies on a set of sensors that provide detailed information related to soil conditions, weather, and crop health, which, after due processing, makes informed decisions on irrigation, fertilization, and other vital farm activities. With the integration of real-time data processing and machine learning algorithms, predictive analysis can be enabled, enabling substantial enhancement of farm management practices. This research also contributes to the fast-growing area of precision agriculture, where it provides a guideline toward the implementation of intelligent farming systems that could easily adapt to any change in environmental conditions [38].

This paper performs a detailed review of irrigation system automation techniques adopted. The automation techniques range from simple microcontroller-based approaches down to IoT-driven automation and sensor networks. Such a review identifies the numerous benefits of automation, which include the usage of less water, high crop yield, and irrigation management and control from remote areas. The authors discuss issues related to the implementation of these technologies, particularly in developing countries where both infrastructure and financial limitations impede the adoption of advanced irrigation systems. This paper is a goldmine of information on the status of irrigation automation and bright prospects because their development is only in its infancy [39].

The paper "Photovoltaic based automatic irrigation Systems" proposes the use of photovoltaic power to automate the irrigation system. The research carries out investigations on integrating solar energy with irrigation automation, presenting an environmentally friendly and sustainable solution for the application of water in agriculture. It is an off-grid system that can utilize solar energy, thereby being very functional in remote or off-grid areas. It shows the effectiveness of the PV-powered systems in operational cost reduction and environmental impact while providing regular irrigation with real-time soil moisture data [40].

This paper describes the design and development process for an automatic prototype model for irrigation. It aims at the development of such a system that is capable of automatically regulating the water supply in accordance with the soil moisture level so that the goal of agricultural water usage optimization is achieved. In order to make it as cost-effective as possible, its prototype is built using components that are easily available, for farmers having very meager resources. Prototype testing and iterative design have been emphasized in this research in order to come up with a reliable and efficient irrigation system. The test results, on the other hand showed that this prototype could save lots of water yet still retain an adequate amount of moisture required by the crop [41].

Another sophisticated irrigation system using IoT in an automated irrigation process is discussed in IoT-Enabled Automated Irrigation System Using Soil Moisture Sensor. The system monitors the moisture content in the soil through soil moisture sensors and switches on the irrigation system during a drop below a certain threshold. The study identifies IoT in agriculture through benefits such as real-time monitoring and remote control. This study further investigates how the system can include weather forecasting data into its system for further optimization of irrigation scheduling to save water consumption and improve crop yield [42].

Other than that, various papers have been collected in APS Proceedings Volume 14 relating to automated systems and IoT in agriculture. One of the most important papers is on the development and implementation of IoT-based smart irrigation using real-time data to optimize irrigation in agriculture, presenting a scheme that includes, in one system, sensors, microcontrollers, and communication modules-viable and efficient with the possibility of scalability in contemporary agriculture. The paper identifies the importance of such technologies in overcoming global issues such as water scarcity and food security; thus, it serves as a good contribution toward smart agriculture [38]. In "Design and Implementation of a Smart Irrigation System," an extensive study was carried out about developing an intelligent irrigation system based on the integration of IoT, sensors, and microcontrollers. It aims to monitor soil moisture and other parameters in real time, with the view of the effective regulation of water distribution. This work illustrates how integration of smart technologies could lead to improvements in water use in agriculture with only minimal losses, so as to ensure that the crops receive optimum levels of water. The research also shows that this system is scalable and can be applied in farms ranging from small to large [43].

This final paper will discuss an IoT-based monitoring framework for precision agriculture; this may involve the integration of different sensors and analytics tools to make farm management more efficient. It is thus designed to acquire and analyze information related to soil health, crop growth, and environmental parameters that provide actionable inputs to farmers for optimized practice. Thus, the research has envisioned the potentiality of IoT in transforming traditional agriculture into a more data-driven efficient industry. The paper also covers the implementation challenges of such systems, most notably with data security and scalability, and has suggested some potential solutions to overcome such obstacles [44].

CHAPTER 3

ENABLING TECHNOLOGIES

3.1 Functions of Irrigation Control System

- **User Interface:** User interfaces are primarily utilized for transmitting data to the controller from the user and vice versa, displaying information about the system to the user. This is usually done through a computer or a smartphone.
- **Devices Controlled:** Controlled devices include a wide range of equipment that this Arduino and sensor are capable of. Here in our project, it is a motor.
- **Programming Computer:** Some system controllers allow the user to program the system with the system's user interface. Other systems require a PC to program. Here we are accessing Arduino IDE with the help of a PC.
- **Controllers:** Relay controllers provide intelligent control functions in automatic irrigation control.
- **Sensing Devices:** these can report values such as temperature, humidity, etc., or states.
- **I/O Interface Devices:** They provide the logical interface between controllers and the device systems that are controlled.

3.2 Benefits of Automatic Irrigation Control

3.2.1 Mitigates Disease and Weed Spread

This happens because the automatic irrigation system, especially drip technology, precisely delivers water to the root zone of the plants without excessively exposing it in a way that the foliage is constantly getting wet. Thus, it reduces the humidity level around a plant's leaves and further reduces the growth of fungi and bacteria responsible for creating downy mildew, rust, and anthracnose diseases. In turn, the system minimizes the chance of leaf spot and other foliar diseases by minimizing excess moisture on foliage. And by distributing water in the root zone, it minimizes access to moisture that is needed for the germination of weed seeds. It means reduced weeds lessen dependence upon chemical herbicides or manual weeding to improve environmental sustainability.

3.2.2 Efficient Water Management

Saves Water and Time Automatic irrigation systems significantly conserve water by ensuring it is used only where and when it's needed. This precise water control can reduce water usage by as much as 30-50%, making it ideal for areas facing water shortages or subject to drought conditions. Smart controllers can also be interfaced with sensors for detecting soil moisture conditions and local weather-meteorological conditions that automatically adapt the watering schedule to ensure water is delivered only when needed. These not only economize water but also save gardeners or farmers from the need to manually inspect the condition of the soil. Through automation of watering tasks, users save hours of labor every week, enabling them to focus on other constructive work and thus striking a healthy work-life balance.

3.2.3 Preserving Soil Health

Maintains Soil Composition and Nutrient Content Watering large areas manually can cause soil compaction, reducing the soil's ability to absorb air and nutrients. When soil becomes compacted, plant roots struggle to grow, and nutrient exchange between the soil and roots is limited. Automated irrigation systems, especially drip or micro-sprinkler systems, apply water gently in smaller quantities, maintaining the soil's structure. The slow and steady water application ensures deep penetration without causing waterlogging or surface runoff. This practice helps retain the essential nutrients in the root zone so that they can be absorbed by plants while preventing the leaching of the main elements, namely nitrogen, phosphorus, and potassium, which are essential for plant growth.

3.2.4 Enhancing Gardening Flexibility

Gardening Flexibility Automation systems offer the gardener flexibility in that one is not bound by the strict schedule of watering the plants. The systems have pre-set cycles whereby it may water at optimal times, such as early morning or late evening when the rates of evaporation are low. Some of the advanced systems enable operation remotely using mobile applications, which enables the user to adapt or pause the watering schedules from almost any location, ensuring that the plants get adequate attention, even when the gardener is not around, for instance, on vacation or away from home. In addition, this alleviates some tasks from the gardeners or landscapers, who can attend to other parts of the garden while the irrigation system operates independently behind the scenes. Customizable zones within the system easily adapt to the various watering needs for different types of plants and sections of the garden.

3.2.5 Enhancing Plant Health and Productivity

Improving Plant Longevity and Productivity Consistency is what irrigation demands in plants, and automated irrigation systems ensure that the plants are treated to consistent and precise volumes of water. Such uniformity removes the threat of drought stress among plants, which can be highly detrimental to growth, increases susceptibility to disease, and may result in reduced productivity. Through such ideal hydration levels, plants grow more vigorously and healthily, ensuring high yields in fruit-bearing species. It has also been confirmed that automated irrigation might raise crops as much as 20% owing to the better hydration of plants and nutrients absorbed from the soil. For perennials and ornamental plants, regular watering prolongs their life by maintaining their aesthetic appeal, thus they grow stronger and healthier.

3.2.6 Improves Resource Efficiency

Besides water conservation, automatic irrigation systems improve fertilizer and other input uses. The systems that allow fertigation have nozzles that may inject fertilizers directly into the water supply lines, delivering nutrients right to the plant's roots in amounts just right for them. This ensures minimum wastage, thereby avoiding over-fertilization, which only serves to cause runoff of nutrients into local water bodies and the immediate environment. These systems contribute to the development of sustainable horticultural and agricultural methods by preventing nutrient leaching and making better use of resources. More importantly, with the use of less water and fertilizers, the negative impact on the environment due to soil degradation, aquatic pollution, and the emissions linked to the production of fertilizers will be minimized.

3.2.7 Scaling Up for Large-scale Operations

Supported For commercial farmers, landscapers, and estate managers, water management is a big headache across acres. Automatic irrigation systems have the capability of handling anything from small home gardens to big agricultural fields. Smart controllers may, therefore, run several zones, each serving the water needs of various crops or an area that has different needs. This scalability is highly suitable for areas with diverse plant species that have different watering schedules. In fact, large-scale operations, with the use of these systems reduce the number of human labor involvements and costs. Integration of soil moisture sensors and weather-based controllers ensures adjustments are made in real time in operating the system to further optimize water use over large areas.

3.2.8 Fostering Ecological Sustainability

Water scarcity is becoming a global concern, and automatic irrigation systems play an important role in the sustainable management of water. By ensuring that water is applied only when necessary, these systems help preserve freshwater resources. Also, intelligent irrigation systems using weather stations or sensors that monitor soil moisture will make real-time adjustments to watering schedules, preventing the overuse of water during rainy periods. This reduces ecological impact on local hydric resources by means of runoff reduction and prevention of water waste. In the case of agriculture, this diminishes extra irrigation and thereby minimizes the chances of soil erosion and prevents the percolation of fertilizers and pesticides into the ecosystems of its surroundings, maintaining ecological balance.

3.2.9 Saves Labor and Maintenance Costs

Manual irrigation requires continuous monitoring, readjustment, and care, especially for big gardens or agricultural fields. Automatic irrigation systems tend to minimize labor costs because there is no need to water manually and supervise at the same time. With sensors and timers inbuilt, these irrigation systems can work independently in providing the right amount of water. Advanced models may also have onboard diagnostic tools or alerts that can give notice of leaks, blockages, or system failures; this in turn can facilitate prompt repairs and lower longer-term maintenance costs. By automating routine maintenance functions, like cleaning filters and performing system checks, automated irrigation systems also reduce labor and generally minimize operating costs.

3.2.10 Improves Plant Consistency and Aesthetic Appeal

Enhances Plant Continuity and Aesthetics Irrigation by automated systems is uniform and ensures that the plants receive water in equal amounts to grow uniformly in the garden or field. The uniformity is rather vital for ornamentation and aesthetic purposes in ornamental gardens, parks, and gold courses. Even irrigation avoids unappealing dry spots or overly wet areas within the garden. By judicious use of irrigation schedules, automated systems help keep healthy, green environments that remain aesthetically appealing throughout the year. Consistent soil moisture maintains flowering ornamental plants and flowers regularly to add even more beauty to a landscape.

3.2.11 Supports Integration with Smart Technologies

Supports integration with smart technologies Present-day automatic irrigation installations can use advanced technologies such as Wi-Fi controllers, meteorological stations, and mobile applications. With such systems, users can remotely control and manage their irrigation using either a smartphone or tablet. Weather-based irrigation controllers adjust the watering schedule automatically according to weather conditions in the locality to minimize water usage on rainy days. The ability to connect such systems with home automation networks allows home automation to monitor water usage and system operation with other intelligent devices, such as thermostats or security surveillance cameras. This kind of fluid integration enhances the ease of use and effectiveness of irrigation practices that help in conserving water while offering real-time feedback about the needs of garden hydration.

3.2.12 Protects Against Drought and Water Shortages

Guards against Drought and Scarcity of Water In areas susceptible to drought or subjected to water limitations, automatic irrigation systems can offer essential assistance by meticulously regulating and conserving water resources. These systems utilize sensors to ascertain moisture levels and modify water distribution in accordance with prevailing conditions, thereby averting excessive irrigation during arid intervals. Additionally, certain systems are fitted with rain shut-off mechanisms or drought-resistant programming, guaranteeing that vegetation receives only the requisite volume of water. It minimizes the risk of crop failure in agricultural settings while maintaining the health of landscapes when water is in short supply. Moreover, using reclaimed or recycled water in such a system makes it more sustainable by tapping non-potable water resources.

3.3 Flow Chart of the System

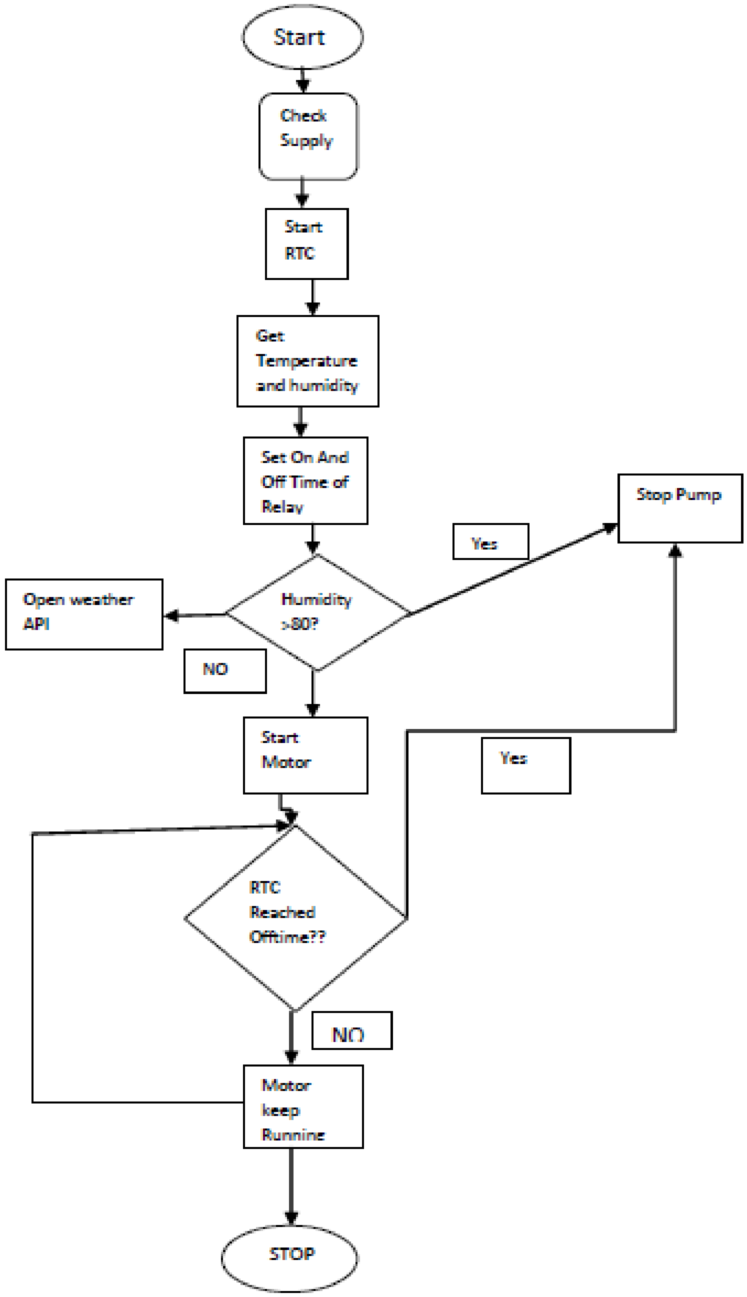


Figure 1: Flow Chart

3.4 Estimated Budget

Components Name	Unit	Price (BDT)
1. Arduino UNO R3 standard quality edition	1	785
2. Soil Moisture Sensor (YL-69 HYGROMETER)	1	120
3. 1 Channel 5V Relay Board Module	1	70
4. Submersible 3V mini-DC water pump	1	160
5. Jumper Wire 40 Pcs set 20cm	1	100
6. Pipe	1	100
7. LCD	1	250
Total Cost		**1500**

Table 1: Estimated Budget

CHAPTER 4
SYSTEM HARDWARE AND ARCHITECTURE

4.1 Component List

SL NO	NAME OF COMPONENTS	QUANTITY
1	Arduino UNO	1
2	DHT11 Temperature and Humidity Sensor	1
3	Moisture Sensor	1
4	5V Relay Module	1
5	Battery	1
6	Jumper wire	20
7	5V Water pump	1
8	LCD with I2C	1
9	Water Level Switch	1

Table 2: Component list

4.2 Arduino Uno

Arduino is an open-source physical computing platform which is a mix of a microcontroller board and a development environment that makes use of the Processing programming language. Its main purpose is to abstract the process of designing interactive systems and it employs electronics to a wider audience. The Arduino Uno, which is a version of the Arduino platform, is wildly used, and it is based on the ATmega328P microcontroller that provides diverse electronic project functions. It is actually a workhorse so one can use it as a stand-alone unit or attach to a computer system to accomplish tasks that are the most complex including automatic irrigation systems.

The fact that Arduino is open-source and user-friendly is the main reason for the wide acceptability and success of Arduino. As a low-cost tool for prototyping and experimentation in hardware &

software integration, the open source, and user-friendly nature of Arduino is the key factor to its widespread success but remains a low-cost tool for prototyping and experiments in between hardware and software. Be it various sensors or actuators, the users can involve themselves by creating projects that communicate with the environment. With the help of the Arduino Integrated Development Environment (IDE), users can write, compile, and upload code directly to the board. Both is simple, developers can use open-source coding, and both beginners and experienced developers can equally benefit.

4.2.1 Introduction to Arduino Boards

Standard hardware core, which contains microcontrollers and connections, is equipped with a simpler boot loader for embedded programming to build Arduino boards. The traditional approach of using digital and analog input/output (I/O) pins on the boards makes them able to be connected to devices such as actuators, sensors, and other electronic gadgets. Arduino is notable due to the easy environment for programming that is called the intuitive programming environment (IDE), which is the software that makes uploading and developing programs easier. The IDE also supports serial communication and debugging, allowing real-life management and control of the board through an interface that has an easy-to-use representation.

Arduino Uno, a model in this product family, is built around the ATmega328P microprocessor, which operates at 5V and whose clock speed is 16 MHz. The built-in bootloader of the board allows uploading code over the USB connection to be straightforward since there is no need for a programmer. It is also a versatile development solution with a rich library of third-party components, shields, and extensions to choose from that further increase its capability and allow for its use in robotics, automation, and the Internet of Things among others.

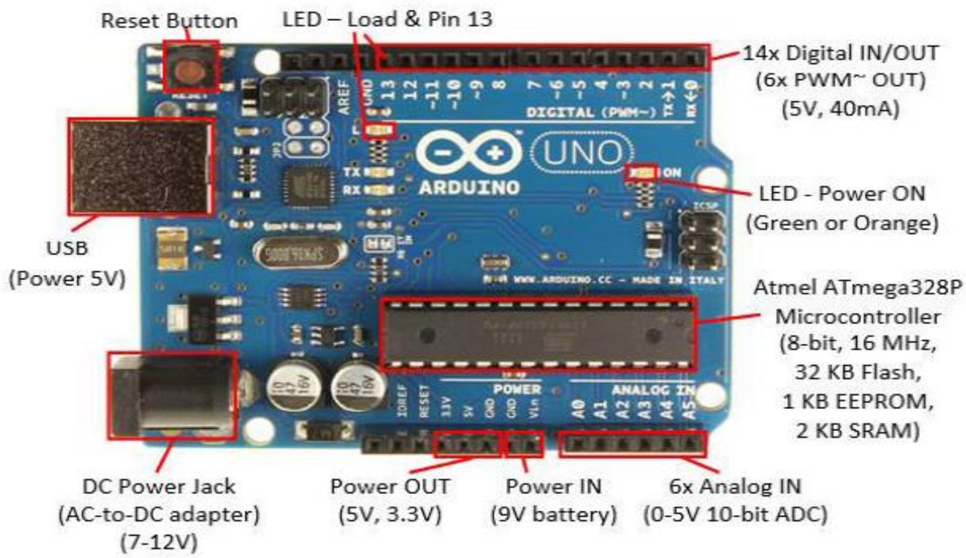


Figure 2: Arduino Uno Architecture

4.2.2 Pin Description of Arduino Uno

The Arduino Uno has a total of 14 input/output (I/O) pins and 6 analog input pins, in addition to various power-related pins. Digital pins (0-13) can be used to control devices such as LEDs, motors or sensors either as inputs or outputs with a maximum current of 40 mA. The 10-bit resolution of the analog pins (A0-A5) that measure voltages between 0-5V makes them ideal for reading sensor data. The specialized pins are those responsible for serial communication (pins 0 and 1), external interrupts (pins 2 and 3), and PWM output (pins 3, 5, 6, 9, 10, and 11) that control variable devices like motors. The SPI communication (pins 10-13) connects the Arduino to peripherals while I²C (pins A4 and A5) facilitate easy communication with several sensors at once. There are also 5V and 3.3V power pins for external components alongside VIN pin catering for external power supplies. Finally, there is ground (GND) as well as the reset pin designed for circuit grounding and resetting microcontroller respectively.

4.3 DHT11 Temperature and Humidity Sensor

The DHT11 is a popular digital sensor that measures both temperature and humidity, making it a go-to option for environmental monitoring. It provides a cost-effective and dependable solution, delivering digital signals that can be easily connected to microcontrollers like Arduino.

Figure 3: Temperature & Humidity Sensor

This sensor is frequently utilized in projects such as weather stations, home automation systems, and greenhouse monitoring due to its low price and user-friendly design The DHT11 operates with two main components: a humidity-sensing element and a Negative Temperature Coefficient (NTC) thermistor for temperature measurement. The humidity sensor features electrodes with a moisture-absorbing material that alters its electrical resistance in response to humidity changes, allowing it to provide relative humidity readings. It can measure humidity levels from 20% to 90% with a typical accuracy of ±5%. For temperature, the NTC thermistor's resistance decreases as the temperature increases, enabling the sensor to measure temperatures ranging from 0°C to 50°C with an accuracy of ±2°C.

The DHT11 provides digital output, which makes it easy to integrate with different systems, and it runs on low power, making it a great option for battery-operated applications. Its straightforward setup, dependability, and decent accuracy make it a popular sensor for various small to medium-sized projects, especially in environmental monitoring and control systems. While it does have some limitations in terms of accuracy and range, the DHT11 offers a good balance between performance and cost, making it a preferred choice for many users.

4.4 Moisture Sensor

A moisture sensor measures the amount of water in the soil, which is essential for precision agriculture, soil research, and environmental monitoring. By monitoring soil moisture levels, these sensors enable improved water management, helping to avoid over-watering or under-watering of crops and plants. They also facilitate the automation of irrigation systems by sending signals to control devices such as relays or pumps when the soil moisture drops below a certain level.

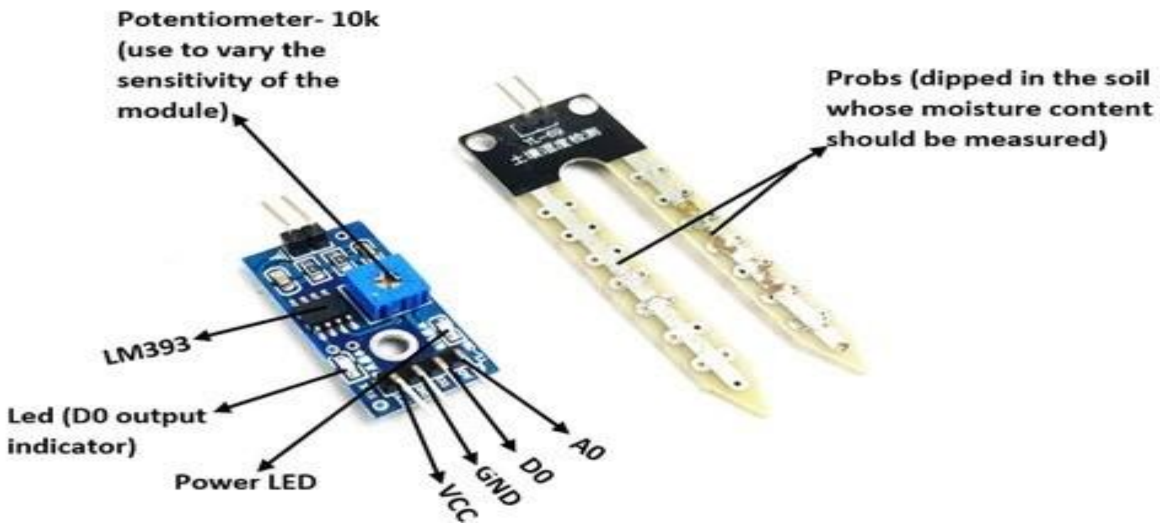


Figure 4: Moisture Sensor

4.4.1 Working Principle of Moisture Sensors

Moisture sensors work by measuring how well the soil conducts electricity. When the soil has more water, it conducts electricity better, allowing electrical currents to flow more easily. The moisture sensor picks up on this conductivity and converts it into an analog or digital signal that a microcontroller, like an Arduino, can understand.

4.4.2 Specifications and Features of a Typical Moisture Sensor

These sensors typically operate within a voltage range of 3.3V to 5V, making them compatible with microcontrollers such as Arduino. They can provide two types of output signals: an analog signal that ranges from 0 to 1023 to indicate different levels of moisture, and a digital signal that outputs either HIGH or LOW based on a set threshold. Many sensors come with a built-in potentiometer to adjust sensitivity for various soil types. More advanced models often have corrosion-resistant coatings to enhance durability, while less expensive resistive sensors may wear out over time due to exposure to moisture and soil chemicals.

4.5 5V Relay Module

The 5V Relay Module is an important component for controlling high-voltage devices using a low-voltage control system. This makes it crucial for applications such as home automation, industrial control, and automated irrigation systems. It works on the principle of electromagnetic induction, where a low-voltage signal (usually 5V from a microcontroller like Arduino) energizes a coil, creating a magnetic field that switches mechanical contactors between the normally open (NO) and normally closed (NC) states. This mechanism allows the relay to either connect or disconnect high-power loads like fans, lights, pumps, and motors, while keeping the control circuit safely isolated from the high-voltage side.

Figure 5: Relay Module

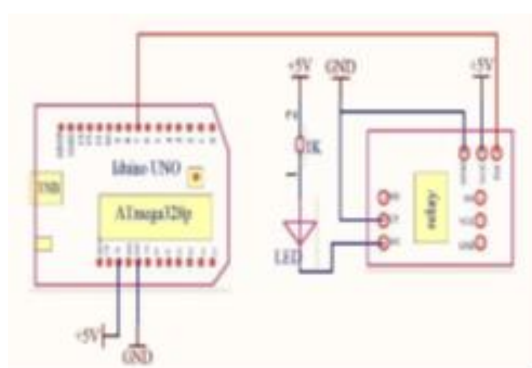


Figure 6: Connection Diagram of Relay with Arduino

One of the key features of the 5V Relay Module is its ability to connect low-voltage microcontroller outputs to high-power devices, typically rated for up to 10A at 250V AC or 30V DC. The relay consists of two sections: the input side, controlled by a small voltage, and the output side, which manages the high-power load. The module’s common (COM) terminal connects to the device's power source, and depending on whether the relay is energized, the COM connects to either the NO or NC terminal, thus powering or cutting off the load.

The 5V Relay Module is widely used in systems like automated irrigation, allowing low-power signals from sensors (such as moisture sensors) to activate pumps for watering. It is also found in other automation setups like lighting systems, HVAC, and security alarms. Often, the module includes optocoupler isolation to protect the low-voltage control circuit from high-voltage spikes or surges, enhancing safety. While mechanical relays like the 5V Relay Module are dependable for many applications, they can wear out over time due to the mechanical nature of the contactors. For quicker and more durable switching, solid-state relays (SSRs) are sometimes used as alternatives, although they tend to be more expensive.

4.6 5V Water Pump

The 5V Water Pump is a compact, submersible DC pump tailored for low-voltage applications, making it perfect for automated irrigation systems, hydroponic setups, aquariums, and water fountains. It operates within a voltage range of 3V to 5V DC, which allows for easy integration with microcontrollers like Arduino that typically provide 5V. With a current draw of 0.1 to 0.2A, this pump is designed for energy-efficient performance, and its flow rate of 1.2 to 1.6 liters per minute is adequate for small-scale water circulation and delivery tasks.

Figure 7: Water Pump

Thanks to its small size and low power usage, the 5V water pump is particularly well-suited for controlled environments such as automated plant irrigation systems. In these applications, the pump can be activated by moisture sensors through a relay module, enabling accurate water delivery based on the soil's moisture content. Its lightweight design allows for easy submersion in small tanks or containers, and the straightforward two-wire connection (red for positive, black for negative) simplifies integration with various power supplies and control circuits.

CHAPTER 5
PROPOSED ALGORITHM

5.1 Software Designing

```
#include <DHT.h>

#define DHTPIN 2  // Pin where the DHT sensor is connected
#define DHTTYPE DHT11  // DHT11 or DHT22
#define MOISTURE_PIN A0  // Analog pin for moisture sensor
#define RELAY_PIN 8  // Relay pin to control water pump

DHT dht(DHTPIN, DHTTYPE);

// Define thresholds for tomato plants
const int moistureThreshold = 60; // 60% moisture
const int temperatureMin = 18;    // Minimum temperature in °C
const int temperatureMax = 25;    // Maximum temperature in °C
const int humidityMin = 60;       // Minimum humidity in %
const int humidityMax = 80;       // Maximum humidity in %

void setup() {
  pinMode(RELAY_PIN, OUTPUT);
  digitalWrite(RELAY_PIN, HIGH);  // Start with water pump off
  dht.begin();                    // Initialize DHT sensor
  Serial.begin(9600);             // For serial monitor
}

void loop() {
  // Read temperature and humidity
```

```
float humidity = dht.readHumidity();
float temperature = dht.readTemperature();

// Read soil moisture level
int moistureValue = analogRead(MOISTURE_PIN);
int moisturePercent = map(moistureValue, 0, 1023, 0, 100);

// Print values to Serial Monitor
Serial.print("Moisture: ");
Serial.print(moisturePercent);
Serial.print("% ");
Serial.print("Temp: ");
Serial.print(temperature);
Serial.print("C ");
Serial.print("Hum: ");
Serial.print(humidity);
Serial.println("%");

// Check moisture threshold
if (moisturePercent < moistureThreshold) {
  // Consider temperature and humidity before watering
  if (temperature >= temperatureMin && temperature <= temperatureMax &&
      humidity >= humidityMin && humidity <= humidityMax) {
    waterPlants();
  }
  else if (temperature > temperatureMax || humidity < humidityMin) {
    // High temp or low humidity = higher water need
    waterPlants();
  }
  else {
    // Low temperature or high humidity, avoid watering too much
```

```
      if (moisturePercent < moistureThreshold - 10) {
        waterPlants();
      }
    }
  } else {
    // If moisture is sufficient, stop watering
    digitalWrite(RELAY_PIN, HIGH); // Turn off water pump
  }

  // Wait before checking again
  delay(10000); // Check every 10 seconds
}

// Function to water plants
void waterPlants() {
  digitalWrite(RELAY_PIN, LOW); // Turn on water pump
  Serial.println("Watering plants...");
  delay(5000);                  // Water for 5 seconds
  digitalWrite(RELAY_PIN, HIGH); // Turn off water pump
}
```

CHAPTER 6

SYSTEM IMPLEMENTATION

6.1 Block Diagram

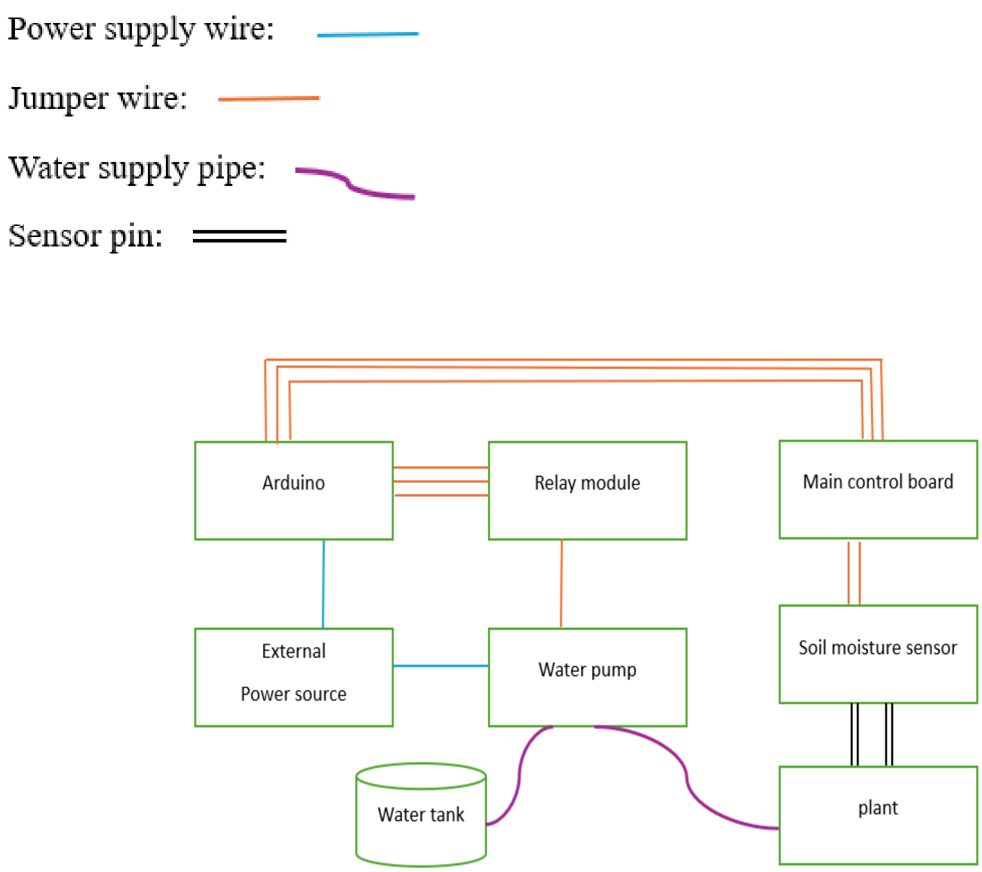


Figure 8: Block Diagram

The block diagram shown in Figure 8 offers a clear overview of the system's architecture and its components. At the heart of the system is the Arduino Uno, which serves as the microcontroller unit (MCU) and manages the entire operation. Several important components are connected to the MCU, including the DHT11 sensor that measures temperature and humidity, as well as soil moisture sensors that track the moisture levels in the soil. These sensors supply essential data to the Arduino, which processes the information and makes decisions based on set thresholds. The 5V relay module, which is controlled by the Arduino, activates the irrigation pump to ensure that water is supplied to the plants when necessary. The block diagram effectively demonstrates how these components work together and communicate, providing a clear understanding of the system's functional layout and data flow.

6.2 Circuit Diagram

The circuit diagram in Figure 9 provides a clear illustration of the electrical connections and wiring required for the system to function. It outlines the specific arrangement of the Arduino Uno along with its links to various sensors and actuators. The diagram emphasizes the wiring of the DHT11 sensor and moisture sensors to the microcontroller, detailing the connections for power, ground, and signal lines. It also describes the configuration of the relay module, showing how it connects with the Arduino to manage the irrigation pump. Furthermore, the power supply section of the circuit diagram explains how the system is powered, ensuring that all components receive the correct voltage and current for dependable operation. This diagram is essential for assembling the hardware and diagnosing any electrical problems that may occur.

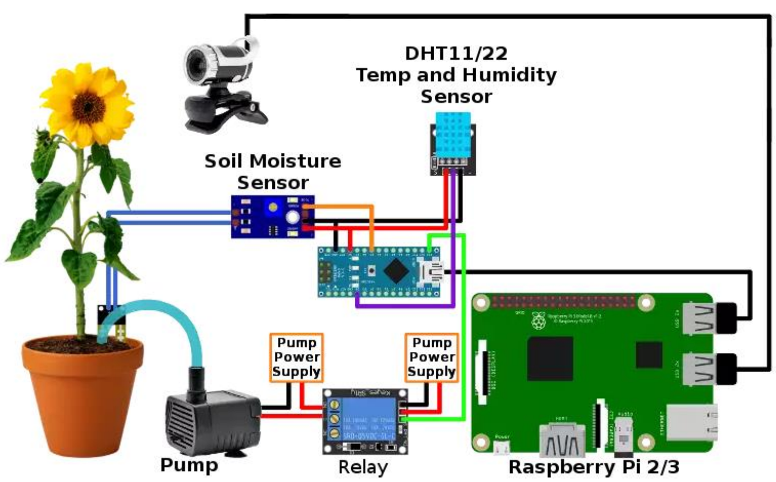
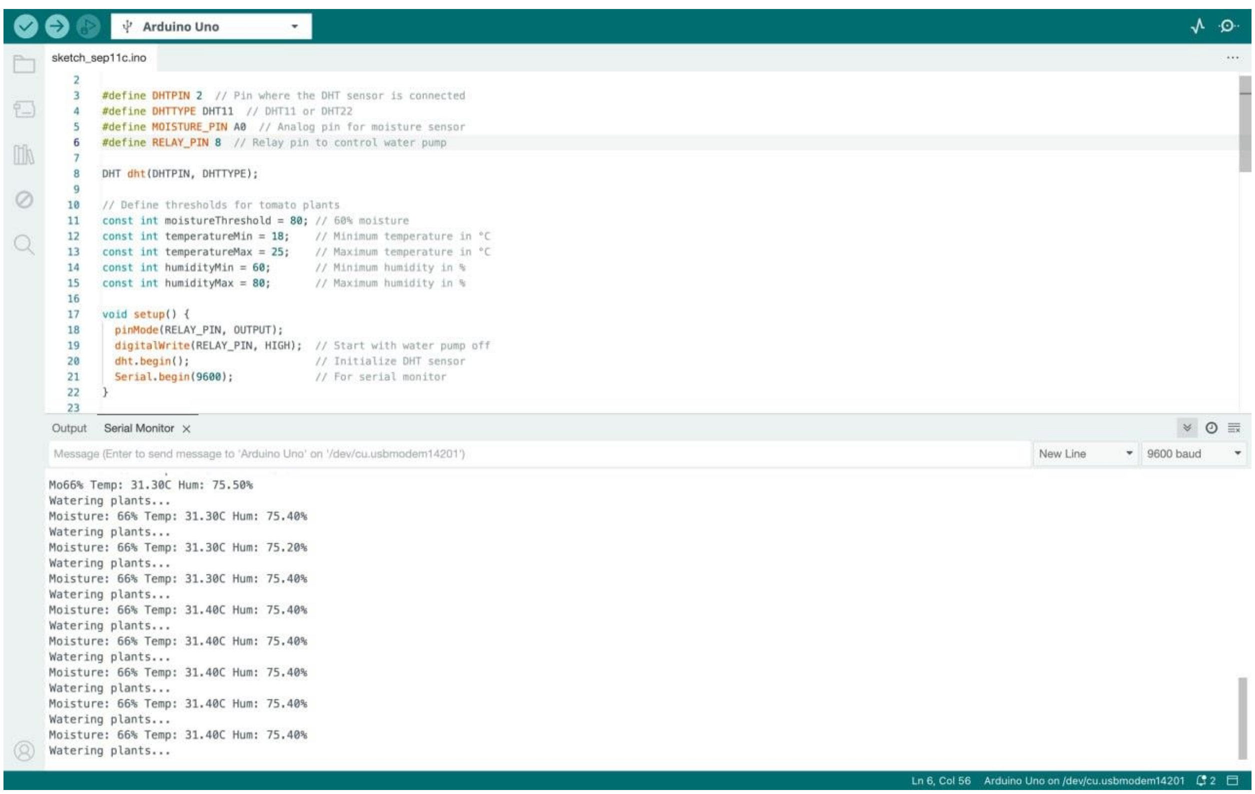


Figure 9: Circuit Diagram

6.3 Result

The results section, shown in Figure 10, outlines the outcomes from the system's implementation. The output data features measurements from the DHT11 sensor, including temperature and humidity readings, along with soil moisture levels from the moisture sensors. These readings are analyzed to assess the system's performance, demonstrating how accurately and effectively the irrigation system adapts to changing environmental conditions. Additionally, the results include an evaluation of the system's operational efficiency, highlighting any discrepancies or errors encountered during testing. If relevant, user interface feedback, such as data shown on an LCD screen, is also examined to provide insights into the system's status and settings. This section emphasizes how the system fulfills its intended purpose and identifies potential improvements for future versions.



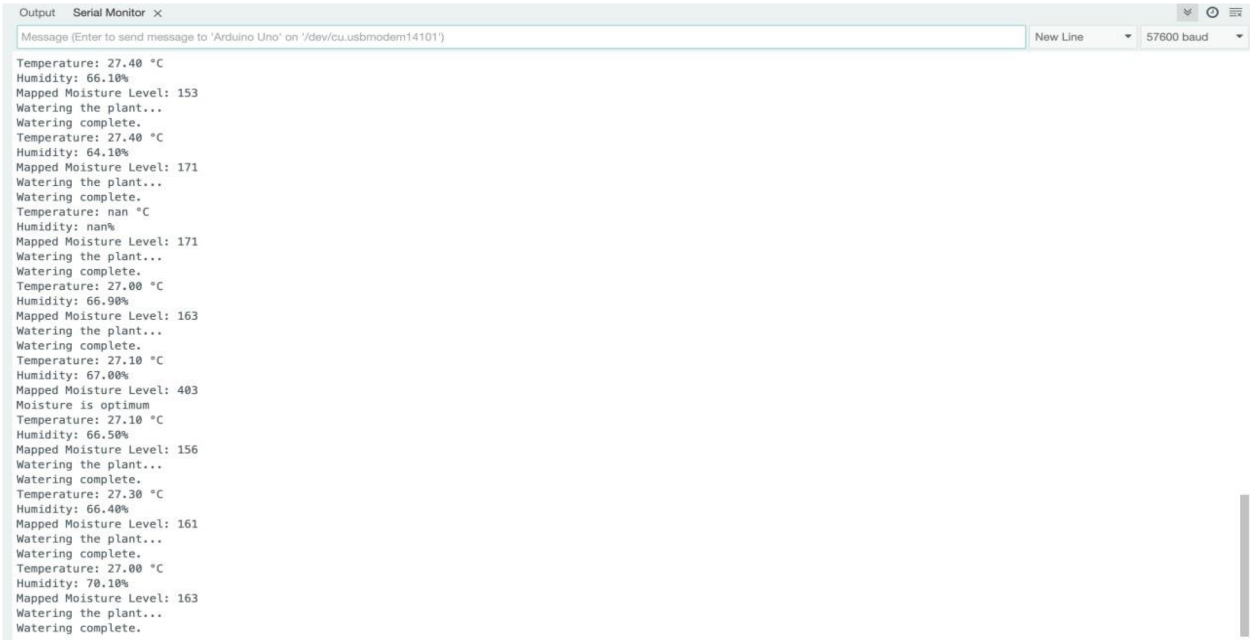


Figure 10: Output Result

CHAPTER 7
CONCLUSION AND FUTURE WORK

7.1 Conclusion

The long history of irrigation has greatly benefited from recent advancements in precise, efficient, and automated practices. An automatic irrigation system offers a new approach for storing and distributing resources when and where they are needed. The integration of sensors, controllers, actuators, and decision algorithms allows technology to precisely provide water to plants with little or no human involvement. In addition to possibly increased water conservation, it should also improve plant health.

Traditional irrigation system components installed are a microcontroller (e.g. Arduino Uno), soil moisture sensors, temperature and humidity sensors (e.g. DHT11), and 5-volt water pumps. The combined efforts of all components allow for automation and reconfiguration of the irrigation system to accommodate real-time environmental variables.

This report has discussed the underlying operations, advantages, and constraints of these systems. The advantages are reduced water usage, soil moisture management, improved plant growth, and reduced manual labor. Yet, there are limitations, such as sensor longevity, initial high setup costs, and continuous maintenance to create reliability over time. Though, at the moment these represent real limitations, automatic irrigation systems have served and will serve as a paradigm shift in both sustainable agriculture and home gardening.

7.2 Future Work

The future of automatic irrigation systems presents an opportunity that has significant potential due to the sustained course of study in this area and advancements in technology. An area in which we can see improvements is sensor technology, mainly focused on the development of moisture and environmental sensors that are more durable, accurate, and affordable while performing reliably in varying conditions. Furthermore, advancements in data analytics and machine-learning algorithms can realize even smarter irrigation systems that can make predictive decisions based on weather forecasts, soil conditions, and crop growth. Moreover, IoT devices and AI can extend the capabilities of the remote monitoring, control, and automation of irrigation systems, giving farmers and gardeners the ability to monitor and manage their irrigation systems from more places.

In addition, investigating renewable energy resources, such as solar-based pumps, might further alleviate the environmental impact of irrigation systems while also providing a solution to challenges related to energy and water shortages. Alternative water sources, such as rainwater harvesting and greywater recycling, could also frame the basis for future research to enhance sustainable irrigation technologies. In general, the evolution of automatic irrigation systems will factor in the global response to low water availability, food insecurity, and sustainable agriculture.

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