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A Review of Control Automatically Water Irrigation Canal Using Multi Controllers and Sensors

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ABSTRACT

Automatic irrigation refers to the utilization of a mechanism to activate irrigation systems, facilitating the alteration of water flow from bays even in the absence of the irrigator. The implementation of automation encompasses various approaches, such as initiating and ceasing irrigation via supply canal outlets. The objective of this study was to review the majority of control water automatic irrigation canal problems and their solutions, utilizing several controllers and suitability sensors based on requirements, this review in order to assist researchers in selecting the right hardware and software for their respective studies. By employing controllers like Arduino, programmable logic controller (PLC), Raspberry Pi, and an assortment of sensors such as the soil moisture sensor, ultrasonic sensor and rain sensor. Control system can be constructed for the automation of water irrigation canals. This system's specifications are contingent upon the condition of the land necessitating irrigation as well as the requirements set forth by the farmer. Moreover, it takes into consideration the challenges that arise during the process and offers suitable solutions based on latest studies.

1. INTRODUCTION

Automation refers to a concept that has significantly facilitated the existence of individuals. It diminishes the exertion exerted by human beings, as well as the inaccuracies committed by them. It establishes a connection between society and technology, thereby enhancing the level of advancement and progress within society [1]. In developing countries, irrigation stands as the foremost consumer of water, accounting for up to 85% of the water supply [2]. Early automation of canals, prior to the 1950s, exhibited the distinctive feature of employing hydraulic gates. The examination of flap gates was undertaken by Vlugter in the Netherlands in the year 1940 [3]. In the 1960s and 1970s, the emergence of computers enabled a select group of researchers to formulate models for simulating unsteady open canal flow. This advancement not only facilitated the exploration of alternative approaches to canal automation, but also expanded the scope for studying such methods [4]. In the latter segment of the 1980s and early phase of the 1990s, there was a shift in focus towards interventions of a physical and technical nature, such as enhancing water level and controlling flow. Consequently, in the early 2000s, the emphasis almost entirely reverted back to the establishment of associations comprised of water users. This emphasis on modernizing social institutions continues to endure in the present era. However, the success of a social institution created to manage and allocate water resources is heavily dependent on the feasibility of effectively overseeing the water supply in the initial stages [5]. In recent times, there has been a substantial decline in the water levels of the Tigris River in Baghdad City, resulting in a notable impact on the functionality of twelve water supply initiatives situated on the river banks in the city. This occurrence can be attributed to significant alterations in climatic patterns and the expansion of hydraulic infrastructures, namely dams, as well as the implementation of novel irrigation schemes in Turkey. These factors have collectively contributed to a substantial reduction in the river's water flow rates, amounting to approximately 46% [6]. The heightened interest in the accessibility of water sources, specifically groundwater, can be attributed to the surge in global water demand resulting from population growth. Furthermore, the depletion of water resources is exacerbated by the effects of climate change [7]. Forecasting aquifer depletion is crucial for managing groundwater systems, especially in arid and semi-arid areas where groundwater is the main source for home and agricultural needs [8]. In recent years, water has emerged as the foremost concern in the diplomatic ties among Middle Eastern nations. This issue has assumed a significant position on the itinerary of various global institutions. The management of water resources and the mitigation of water wastage pose formidable obstacles in the development of novel irrigation initiatives [9]. The escalating desire for water is diminishing the innate water reserves on a global scale. The agricultural sector stands as a significant water user. Conventional methods of irrigation lead to substantial water loss, thereby necessitating the introduction of precision irrigation through the use of embedded devices [10]. Climate change, the increase in population, the absence of agreement among provincial governments regarding the construction of new dams, and the accumulation of sediment in the two primary reservoirs all contribute significantly to the issue of water scarcity in the country [11]. Traditionally, the canals are operated through manual means, employing the local upstream control, and the discharge of water is executed in accordance with a predetermined schedule prior to the commencement of a crop season, a period that is typically unchanging [12]. The process of manually operating dams is intricate, requires a significant amount of time, and involves risks. In addition, the efficiency of irrigation systems that are operated manually is relatively low [13]. Automatic regulation of irrigation canals represents a potential avenue for enhancing water resource governance by facilitating a reduction of up to 33% in water volume consumption [14]. Water supply automation tools are not commonly employed on antiquated irrigation systems, resulting in substantial quantities of surplus water being discharged and a corresponding rise in the value of crops cultivated on irrigated land [15]. People have initiated the examination of remote measurement and control systems of agricultural facilities. To a certain degree, the emergence of the remote intelligent irrigation system has aimed to accomplish remote intelligent irrigation. The working principle of intelligent irrigation as illustrated in Figure 1 [16].

The majority of earlier reviews only examined one kind of controller, which limits the researcher's ability to identify suitable solutions for irrigation canal operation issues or in situations where the researcher is unable to make a final decision regarding the type of controller to be used in a project or other tools and devices used to build control systems for irrigation projects. This review paper presents a variety of controller types as well as the issues they raise. Three controllers: PLC, Arduino, Raspberry Pi, the chosen depending on the size of the irrigation canal, local economic, climatic conditions and the conditions surrounding the project implementation. The type of controller is also chosen by the researcher according to the problem that each controller can deal with, as explained in Literature Review section, because it contains extensive details for the researcher.

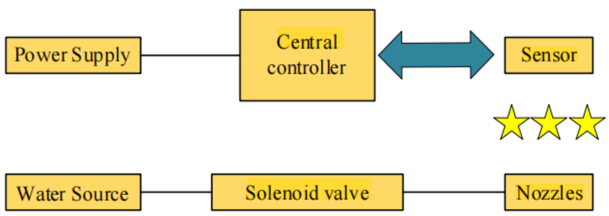

Figure 1. Intelligent irrigation working principle diagram [16]

2. LITERATURE REVIEW

Below represent the comprehensive understanding of the tools and techniques that employed in the process of automating irrigation canals, as well as an in-depth exploration of the outcomes achieved by researchers in addressing the challenges they faced in various scenarios and projects.

The creation of an economical smart irrigation system, based on Arduino and incorporating the Internet of Things (IoT), aims to optimize water usage. Furthermore, the integration of solar energy in the implementation of this smart irrigation system contributes to its efficiency. The primary objective of this system is to enhance farmers' productivity by reducing labor costs and promoting judicious water consumption through the utilization of appropriate quantities. A sophisticated irrigation system incorporates the utilization of Arduino, LCD, SIM900 A, moisture sensors, an ultrasonic sensor, a solenoid valve, and a submersible pump. The control system's program is developed to exhibit the moisture content on a liquid crystal display (LCD) and transmit a Short Message Service (SMS). Sy et al. [17] reached that the automatic irrigation system detect the moisture level in the soil as well as the presence of water in the reservoir. The documentation for this system includes photographs of the constructed and tested prototype, a schematic diagram illustrating the control system and a flowchart outlining the development of the Arduino script. From another point of view , there exists a research objective of utilizing the principles and concepts of control engineering in order to deliver an automated irrigation system tailored for clay, loamy, and sandy soil. The Arduino micro-controller programmed to transmit an interrupt signal to the irrigation system based on the moisture level present in the soil. The moisture content of the soil is assessed by means of the soil moisture sensor. Whenever there is a modification in the soil moisture, the moisture sensor dispatches an interrupt signal to the micro-controller, which in turn examines the water level within the overhead tank water storage by employing a water level sensor. Consequently, the micro-controller proceeds to activate or deactivate the watering system accordingly. Okoye et al. [18] used Arduino UNO, which is equipped with an ATmega328P microcontroller, facilitates the continual observation of the level of moisture in the soil for regulation of water supply in accordance with the moisture level detected in the soil. Moreover, the reference level of soil moisture content can be customized to cater to the varying types of soil. The system prototype underwent testing with the utilization of three distinct soil variations. The duration of irrigation does not remain constant among all three soil variations. Clay soil necessitates a greater amount of irrigation time in comparison to loamy soil. Sandy soil possesses the minimal duration of irrigation. To enhance the efficacy of irrigation and economize the invaluable resources of time and energy for farmers, the creation and execution of an automated irrigation system utilizing a microcontroller circuit undertaken. Although assessed on a limited scale, additional investigations are essential to ascertain its applicability in large-scale agricultural operations. Akter et al. [19] used direct current (DC) motor with a voltage 12V to facilitate the process of water pumping, the incorporation of a relay and battery within the electrical circuit, examination of soil dryness data on a computer system to regulate and manage the irrigation process, implementation of soil moisture sensors to assess the irrigation requirements and the results was that the system operated automatically sans the requirement for human involvement and necessitated lesser amounts of water and time in contrast to manual irrigation. The research was carried out on a limited scope and additional investigations are requisite for extensive-scale agriculture. Recently, the foremost components of any irrigation network are the gates that regulate water levels and control flow. An endeavor was made to devise and build a gate that utilizes contemporary technologies, enabling it to be operated intelligently and efficiently pass the intended discharge. The PLC carries out all the calculations for the gate-opening rate, subsequently relaying instructions to the electromotor. Zahiri and Jafari [20] used bubble rubber effectively served the purpose of sealing the gate, thereby minimizing any potential water loss. The mechanization of the gate was achieved through the utilization of various components, namely the electromotor, encoder, ultrasonic sensor, inverter, and PLC. In order to accurately gauge the water level, an ultrasonic sensor was employed. Multiple experiments were conducted in order to calibrate the constructed sluice gate in accordance with the derived equation. The TIA Portal served as the means of facilitating communication between the PLC and the mechanical components. This system results are: The correction coefficient was derived as the coefficient of 0.625. The calibrated equation was utilized to calculate the coefficient of determination and root mean square error, resulting in values of 0.97 and 0.66, respectively. These findings indicate the proficient functionality of the automatic gate, which is based on the aforementioned calibrated equation. The utilization of PLC and motorized vertical gates employed to facilitate the real-time control of water levels in irrigation canals downstream. This innovative approach allows for the regulation of water flow and downstream level. It has been discovered that the appropriate management of these gates ensures the maintenance of desired water levels downstream. Kamel and Kamel [21] coordinated the interconnected organization sites for PLC, created diagrams illustrating the logic operations for the purpose of documentation and implementation of ladder programming, and demonstrated the practical application of Siemens S7-1200 and Allen Bradley SLC500 PLC devices. The division of the canal into seven distinct sections, each equipped with its own PLC regulators, has been effectively put into practice in the delta irrigation branch originating from the Nile River. It is imperative to establish coordination among the interconnected PLCs to ensure efficient regulation. There exists a conspicuous necessity for an Intelligent irrigation system of substantial importance for the advancement of agriculture. This will be achieved through the establishment of a PLC-based intelligent irrigation control system that facilitates the examination of system functionalities in relation to the precision of sensors and the testing of system functions. Li et al. [16] created intelligent irrigation control system based on (PLC), is characterized by its ability to acquire data and provide web services. It employs a fuzzy control process that involves querying and transforming control tables, solenoid valve control for irrigation purposes and the testing of sensor accuracy, analysis on the accuracy of temperature and air humidity predictions. The findings were the accuracy and stability of the sensor in monitoring the value of the system is commendable. The relative error of the soil water content falls within an acceptable range of 3%. Additionally, the relative error of the soil temperature is limited to 0.5. The utilization of the Smart drip irrigation system in agricultural practices serves as a solution to the matter of irrigation management, as it effectively mitigates water wastage and enhances the productivity of crops. This system is not only cost-effective and dependable but also expedites the process. Moreover, the prospective developments in this field encompass the integration of Internet of Things (IoT), the incorporation of pre-programmed canals, and the facilitation of fertilizer provision. Thote et al. [22] regulated the execution network of sensors and actuators by (PLC). Various methods used for example employment of a humidity sensor for the purpose of gauging the levels of humidity, activation and deactivation of a solenoid valve contingent upon predetermined threshold values, utilization of a soil moisture sensor to ascertain the moisture content present within the soil. The substitution of a sprinkler system with drip irrigation leads to a decrease in water consumption. This method involves providing plants with a precise quantity of water based on their moisture levels. Moreover, the availability of water supply becomes independent of the electricity schedule. Dams are considered to be one of the key locations where the regulation of irrigation water holds immense significance. In order to enhance efficiency and ensure safety, it is imperative to employ automated systems. The utilization of Raspberry Pi assumes pivotal importance in this regard. This system effectively identifies the water level and instantaneously governs the operation of gates. Joshi et al. [13] explored the employment of Raspberry Pi for the management and functioning of a canal system. The traditional approach to water distribution and the rotation mechanism are examined. The utilization of a DC motor, motor driver, and Node MCU for controlling the gates is investigated. Additionally, a level sensor is employed to identify the water level and ascertain the extent of gate opening. A successful creation of a prototype for canal automation achieved through the utilization of acrylic sheets. To facilitate the control of motors and enable communication over long distances, a Node MCU integrated with a Raspberry Pi. Through this integration, the optimization of water usage was accomplished. A model of a monitoring and control device, based on the Internet of Things (IoT), can be utilized in agricultural settings. Furthermore, the implementation of the IoT concept has facilitated the connection of devices via the Internet, granting users access to valuable information. By employing this device, individuals are able to reduce expenses related to supplies, decrease overall costs, and oversee the production process taking place in the field. Hassan [23] facilitated the transmission of data from a Raspberry Pi to a monitoring system by the MQTT protocol. To ensure reliable delivery of messages, a Quality of Service (QoS) level 2 is employed. To minimize power usage, a smart filtering algorithm is implemented. Furthermore, an Internet of Things (IoT) based device is utilized for remote tracking and control purposes. The SFA protocol eradicated the perpetual perusal of analogous information and discards said information prior to its dissemination to the MQTT broker. The suggested algorithm diminished energy consumption by 65% in contrast to the non-SFA function.

3. AUTOMATIC IRRIGATION CANAL: WEAKNESS AND OBSTACLES

The majority of control water automatic irrigation canal issues are listed below:

- One of the primary challenges with surface irrigation networks is the low efficiency in the flow rate delivered to agricultural plots, which can be considerably boosted by applying current mechanized techniques [24].
- One of the drawbacks associated with automated gates is the presence of mobile metallic components and sensors, which in turn decrease the overall dependability of the structures [15].
- The fact that the off takes may be positioned anywhere along the canal is ignored by the majority of research on

the automatic control of open canal irrigation systems, which solely concentrate on the distant downstream water level [25].
- Canal inflow is not entirely under the operator's control; supply mistakes are carried downstream [26].
- Canal inflow-imposed restrictions on the water supply [27].
- Water quality can be impacted by anthropogenic activities such as fertilizer use and untreated sewage discharge [28].
- It was discovered that during times of high spring tides, the banks of several rivers in the southern region, like the Shatt Al Arb river, were susceptible to flooding [29].
- The most prevalent issue with irrigation projects is, finally, the extremely expensive automation of the canal irrigation system [30].

4. BENEFITS OF AUTOMATION IRRIGATION CANAL

The following is a list of the most typical advantages of an automated irrigation canal:
- Adaptable and automated control mechanisms for irrigation management in paddy rice fields present a viable solution that can be applied to: improve the water-use efficiency of rice production; and reduce labor costs associated with field and farm-level irrigation flow rate regulation while maintaining irrigation flooding customs [31].
- Automation in canal irrigation systems enables the implementation of effective control and monitoring mechanisms to ensure the efficient distribution of water. This technology not only prevents the unnecessary wastage of water but also mitigates the risk of flooding, thereby conserving valuable water resources [30].
- Command temperature and humidity-based crop irrigation system with a sensor, controller, and regulating valve for accurate irrigation management [32].
- The information can either be immediately connected to wireless communication or acquired from the official source and then entered into the billing system [5].
- Examine the issue that arises when the irrigation main canal pools are controlled due to model uncertainty [33].
- Groundwater level monitoring in real-time and groundwater mineral and substance analysis [34].
- Outlining plans for managing the river's water quality [35].
- Established a water quality index that provides useful information for decision makers [36].
- Efficiency calculations for application, transportation, distribution, storage, water productivity, and water use [37].
- Precision irrigation applications are employed in order to enhance the utilization of water resources, by managing the water needs of plants through the implementation of diverse systems based on soil moisture and plant growth stages [38].

5. PARTS OF IRRIGATION CANAL AUTOMATION PROSSES

Any irrigation scheme, regardless of whether it pertains to direct irrigation utilizing a weir or involves barrage and storage irrigation employing dams or reservoirs, necessitates an intricate web of irrigation canals characterized by diverse capacities and diameters [39]. Consequently, the canal system comprises a fundamental component: controller irrigation canal, Canal Gates, Water Flow Control, Sensors, Software, Power Supply, Motor Driver and Limit Switch.

5.1 Controller irrigation canal

The three most commonly used controllers, whose uses and importance we will focus on in our research paper, are:

- Arduino is a microcontroller as showed in Figure 2 utilized for the construction of computers that possess the ability to detect and regulate various devices. It is an open source framework that relies on an ATmega328 microcontroller board, as well as a development environment that facilitates the creation of software for said board. Arduino projects are autonomous and can be activated on displaying devices that possess the appropriate software. The option to acquire preassembled devices exists, but they may also be assembled to meet specific requirements. The Arduino programming language operates on wires, a comparable physical computing platform, which derives its foundation from the Processing multimedia programming environment [40]. The following are some advantages of utilizing Arduino: 1. Low-cost and affordable platform; 2. Easy-to-use, unambiguous programming environment, 3. Quick prototyping process; 4. Energy efficiency. In addition, using Arduino has the following limitations:1. Minimal memory and storage capacity, 2. Restricted processing power [41-43].

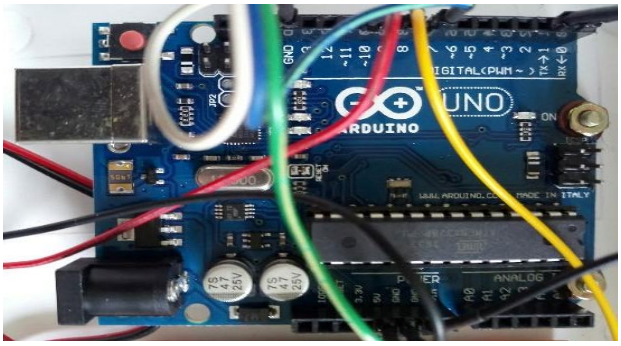

Figure 2. Arduino UNO board [44]

- PLC: The overall configuration of automated irrigation relies on a PLC. The primary objective of the PLC is to receive input signals from sensors and generate corresponding output signals based on the logical operations specified in the program. It is a convenient process to incorporate additional input/output modules or communication modules without requiring any alterations to the hardware. Figure 3 illustrates one of the types of PLCs [22]. PLCs have numerous advantages including: 1. Flexibility and reliability: PLCs are essential for applications such as safety systems and high-speed operations that call for quick decisions, 2. Proficiency in communication, 3. User-friendly, particularly in contrast to other kinds of industrial control systems, 4. Safety elements that aid in preserving the safety of personnel and equipment can be programmed into PLCs. The PLCs have many drawbacks as well, namely 1. Limited processing power, 2. Programming and maintaining PLCs can be challenging, particularly for individuals who are unfamiliar with the specific programming language used for this purpose, 3. Limited capacity to expand [45-48].

Figure 3. SIEMENS LOGO 230 RC controller [22]

- The Raspberry Pi : a single board PC as showed in Figure 4 that estimated by the Raspberry Pi Foundation and developed in the United Kingdom, serves the purpose of promoting the education of fundamental software engineering in academic institutions. It serves as the central component of the entire system. The utilization of the Raspberry Pi within this system involves the management of substantial quantities of data, as well as the maintenance of vital aspects pertaining to the vehicles incorporated within the system. The Raspberry Pi is an optimal choice for serving as a web server that is not subjected to excessive traffic, while simultaneously consuming a mere 5 Watts of power [49]. Among the advantages of the Raspberry Pi are: 1. Huge processing capacity in a small board, 2. Excellent connectivity (Bluetooth, Ethernet, USB, HDMI), 3. Operates as a complete desktop and headless, 4. Because of its compact size, it is very portable and simple to deploy. The Raspberry Pi has many drawbacks as well, namely 1. Not as powerful as a conventional PC, 2. No integrated digital-to-analog converter, 3. No sleep mode or power button [50].

Figure 4. Raspberry Pi [51]

5.2 Canal gates

These gates possess the ability to manipulate and regulate the movement of water in rivers, streams, and reservoirs. Consequently, they function as a form of obstruction to facilitate the storage of surplus water. Furthermore, they facilitate the safe and regulated passage of water around, over, and through a dam during periods of water surplus [52]. These gates include:

- High pressure vertical lift gates: These are gates that are capable of vertical movement along a groove that is incised between two piers. The primary purpose of these vertical lift gates is to regulate the flow of water over the crest of a hydraulic structure, and as such, they are typically equipped with wheels. While this particular type of gate is commonly employed in barrages, it is currently infrequently utilized in dam spillways. Various composite materials have been subjected to rigorous testing in order to evaluate their capacity to withstand shocks and provide sufficient structural strength for vertical lift gates in dams and reservoirs [52, 53].
- Sluice gates: A hydraulic construction called an underpass gate allows water to flow beneath it. Utilizing FLOW-3D software, various gate position models were examined numerically. These models included vertical, deflection to the upstream and downstream of the channel with respect to the vertical axis, as well as oblique position with regard to the transverse axis at angles of 10°, 20°, and 30° [54].
- Radial or tainter: Principle-wise, gates are similar, but to better withstand water pressure, the vertical sections are curved. When tilted, tilting gates allow water to flow over the top of their flaps, which are supported by hinges along their lower borders. At the summit of the spillway crest are often located radial gates and vertical lift [55].
- Floodgates, also called stop gates: is utilized to either obstruct or allow the passage of water over spillways, as part of the functioning of a dam. In the context of numerous dam structures, floodgates and spillways serve as crucial safety measures by diverting surplus water away from the dam and its underlying base, thereby averting erosion that holds the potential to culminate in a disastrous failure of the dam [56].

5.3 Water flow control

The primary component of the irrigation process, which requires manual labor in the traditional approach, is exemplified in Figure 5. Within this system, water flow is regulated by means of solenoid valves. These valves serve as switches that can either open or close the flow of water within the pipe. Solenoid valves are categorized into two types: normally open and normally closed. In the former type, the coil is typically in a closed state, but changes its state upon the arrival of a signal. Furthermore, this type is further classified based on the direction of current. In our system, we have utilized a 230V AC solenoid valve. In each field, solenoid valves are positioned. The matching solenoid valve is switched by the PLC when it receives the signal from the sensor. The water then moves on to the next field via the solenoid valve. The PLC will open the next solenoid valve after closing the previous one in the event that the subsequent field sensor is detected [57]. Currently, a variety of measuring instruments are presently under development with the aim of quantifying water flow in open canals and unpressurized pipelines. Diverse technological procedures may impose distinct demands on these flow gauges. Therefore, It was delineated the universal technical prerequisites essential for the enhancement of such flow gauges. The subsequent criteria have been established for contemporary flow gauges: -optimal dependability; -precision in measurement; -minimal deviation in response to alterations in liquid density; -heightened sensitivity in measurement; -expansive measurement span; -adaptable calibration; -streamlined design; -economical cost [58].

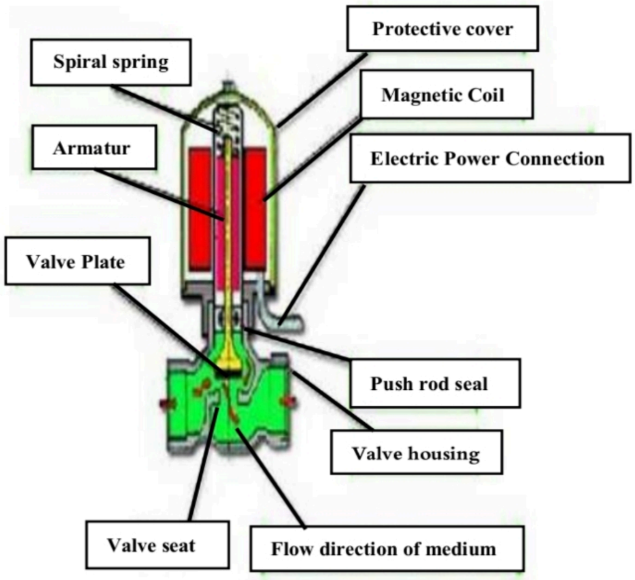

Figure 5. Water flow control [57]

5.4 Sensors

Different sensors are used as one of the main inputs in irrigation system designs based on the appropriate requirements and features. These sensors include:

- Ultrasonic sensors: As showed in Figure 6 the analog signal, which represents the duration in seconds, is acquired by the ultrasonic sensor that detects the water level. This analog signal is then transformed into a digital signal that provides the distance in centimeters. The task of computing the distance is carried out by the NI myRIO [59, 60]. The NI myRIO system comprises a Real Time Processor that encompasses deterministic processing and control. Additionally, it includes a User interface, data logging, and communication capabilities [60]. High frequency ultrasonic waves are used by ultrasonic sensors to measure the water level in irrigation canals. This sensor/transmitter is pointed downward and installed at the top of the irrigation gate.It sends out waves and calculate how long it takes for the sensor to get the return signal [61].

Figure 6. Ultrasonic sensor [60]

- Rain sensors: The concept of rain sensors is like to that of level sensors. In comparison to level sensors, rain sensors exhibit a higher level of intelligence. The transmission of rain sensor signals can be accomplished through the same channels that are outlined for level sensors. Within the rain sensor, two contacts are positioned in close proximity to each other. Should a rainwater droplet bridge the small gap between these contacts, the sensor circuit will be closed and the resulting signal will be conveyed to the PLC control unit [57]. Rain sensors are employed as a mechanism for conserving water, being linked to the irrigation system to automatically deactivate it when precipitation occurs [62].
- Soil moisture sensor: That showed in Figure 7 is employed for the purpose of quantifying the moisture level present within the soil. This sensor is connected to PLC, wherein two probes are introduced into the soil. These probes are utilized to facilitate the transmission of current throughout the soil. In the event that the soil contains moisture, the resistance value will be comparatively low, thus allowing for a greater flow of current. Conversely, if the soil is devoid of moisture, the resistance value will increase, subsequently reducing the flow of current. Consequently, the resistance value serves as a means to ascertain the moisture content within the soil. The specific module employed for this purpose is the YL-69 [22]. Various applications that commonly require the use of soil moisture sensors include watershed characterization, irrigation scheduling, greenhouse management, fertigation management, plant ecology, water balance studies, microbial ecology, plant disease forecasting, soil respiration, hydrology, and soil health monitoring [63-65].

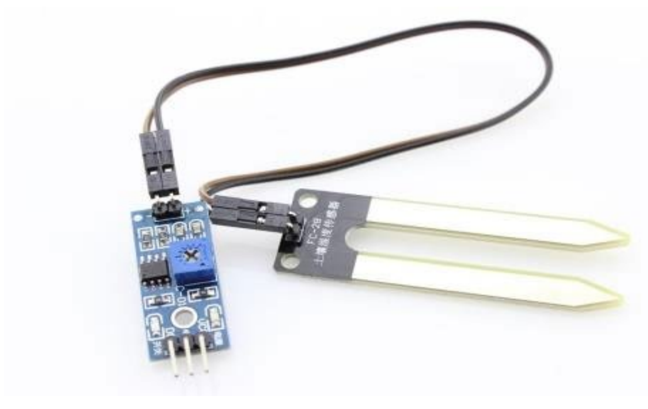

Figure 7. Soil moisture sensor [51]

5.5 Software

The followings are collection of programs that employed for the purpose of operating computers and carrying out designated functions. It can be conceptualized as the modifiable component of a computer, whereas hardware represents the unalterable component.

- Ladder logic: Programming languages such as ladder logic use graphical diagrams based on relay logic hardware circuit diagrams to express programs. Its main purpose is to create software for PLCs found in industrial settings. Since the ladder code is continuously and repeatedly scanned, the precise ordering of the implemented subroutine is insignificant. However, certain functional blocks may need to be ordered precisely for critical activities [21].

- Matlab: For the analytical solution of these equations, the MATLAB environment was utilized. The gate's design called for the usage of a motor, gearbox, inverter, encoder, and PLC, among other parts. In this investigation, the PLC and other mechanical parts communicated with each other via the TIA Portal. One of the most potent programming languages for automation is the programming environment. Furthermore, certain strategies were offered to improve gate performance in real-world scenarios for sensor sensitivity [20].
- SCADA-MATLAB platform: new platform combining the SCADA supervisory system and the MATLAB program to give the standard Supervisory Control and Data Acquisition SCADA systems with the capacity to handle complicated control algorithms. Through the newly established SCADA-MATLAB platform, the developed MPC-model offers a revolutionary approach to irrigation canal control by enabling the use of industrial PLCs to implement very complicated controllers. The DDE protocol (dynamic data exchange) is used to facilitate communication between MATLAB and SCADA. Data interchange between two separate, independently operating software programs (Client and Server) is made possible by this communication protocol. In the developed application the MATLAB software is the Client, as it begins the communication, and the SCADA software is the Server, as it answers to Client's requests [66]. The advantage of Matlab over SCADA lies in its capability to execute intricate computations and present received data in both graphical and numerical formats, while also enabling complex calculations to be performed based on this data. SCADA, on the other hand, allows for data archiving. Nevertheless, the key distinction with Matlab is its ability to conduct additional processing on the gathered data [67].
- LabVIEW: Laboratory Virtual Instrument Engineering Workbench is essentially a graphical programming language (although, technically it's more of a development environment, and the language is just "G," but for practical purposes we just call it a language). Place and connect visual objects around your screen, as opposed to typing words as in text-based languages like C++, Python, and others. An NI MyRIO can be utilized in instead of a PC running LabVIEW [59].

5.6 Power supply

The subsequent elements are the primary sources of energy for the flow control mechanism:

- Solar Power System: A solar power system is suggested to supply electricity for the flow control system at the gate locations. A solar power system is made up of. Battery is charged with the proper current by the solar charge controller. Battery charging automatically stops with an indicator when the voltage reaches 13.6V. The controller signals a low battery voltage if it falls below 10.5V. Nevertheless, the battery voltage falls much lower below the 10.25V solar charge controller cut output load. The battery's lifespan is extended by this charging and draining procedure [68]. Another framework consists of Photovoltaic modules are an array of solar cells used in photovoltaic plants to produce and supply solar power. Every module has been categorized according to standard test output current (STC) parameters; these circumstances are usually in the range of 100 to 365 watts (W). A 230W module with an efficiency of 8% will have twice the size of a 230W module with a yield of 16%. This is because module efficiency determines the area of a module with the same nominal power. Some commercially available solar modules have efficiency of more than 22%, and some are even expected to surpass 24% [44].
- The DC Power Supply, operating at a potential difference volts equipped with the SIEMENS SITOP PSU8200 within its system as shown in Figure 8 [22].

Figure 8. DC power supply [22]

5.7 Motor driver

There exist two primary classifications of motor drive:

- The gate is powered by DC motor that is equipped with a gearbox in order to generate the necessary torque needed for its operation. The motor has the ability to move in both the forward and reverse directions based on the command given by the operator through a push button or remotely through a command sent by a Remote Terminal Unit (RTU) via a communication link [68].
- An AC motor refers to an electrical motor propelled by alternating current (AC). The AC motor generally comprises two fundamental elements: an exterior stationary stator coil equipped with AC coils to generate a rotating flux, and an internal rotor linked to the output shaft, thereby producing a secondary rotating flux. The rotor flux can be generated through permanent magnets, reluctance striking, or DC or AC electrical windings [69].

Due to their ability to produce greater torque with a larger current, AC motors are typically regarded as being more powerful than DC motors. But DC motors usually use their input energy more efficiently and more effectively. Both AC and DC motors are available in a range of sizes and strengths to satisfy the power needs of any industry.

The selection of the motor type is contingent upon the specifications of the irrigation canal, the dimensions of the canal, and the components integrated into the control mechanism. It is commonly understood that direct current (DC) exhibits higher efficiency compared to alternating current (AC) as required in reference [68], but AC provide more torque as required in reference [69]. However, it has been noted that the bulk of irrigation projects tend to provide efficiency and better use of energy, which is why direct current motors are utilized in most irrigation canals.

5.8 Limit switch

Basic switches have been affixed in order to safeguard against external forces, water, oil, and dirt. These switches are activated either by the motion of an object or by the presence of an object. They are utilized to regulate machinery within a control system as safety interlocks. Moreover, they are employed to tally the number of objects passing a specific point. A limit switch is an electromechanical apparatus comprised of an actuator connected to a set of contacts. When an object makes contact with the actuator, it triggers the contacts to establish and interrupt an electrical connection. Limit switches are utilized in a wide range of applications and settings due to their durability. Their installation is effortless, and their operation is dependable. They are capable of identifying the existence or nonexistence of an object, as well as the passage, positioning, and termination of an object's movement [70].

6. CONCLUSIONS

The purpose of this study was to review the majority of control water automatic irrigation canal problems and their solutions, utilizing several controllers and suitability sensors based on needs. The literature review can lead to the following conclusions:

(1) Few components made the micro controller circuit, which has a high level of reliability. It used information from soil moisture sensors to enable soil irrigation, which tries to conserve water by irrigating only the precise amount required. Additionally, data regarding the water level in the container was obtained from the ultrasonic sensor.

(2) Using automated irrigation systems on sandy, loamy, and clay soils reduces water waste and enables crops to withstand the hard dry season assists in controlling both excessive and insufficient irrigation Depending on the kind of soil, different irrigation times apply.

(3) A micro controller-based intelligent irrigation system created. In order to prevent over-or under-irrigation, the system made use of soil moisture sensors.

(4) To improve the precision of the flow rate going under the gate without requiring human intervention, an automatic gate employed. Complex equations for determining gate opening are solved using MATLAB.

(5) Software that provides insight into PLC programming for industrial process automation, such as RSLogix 500 and SIMATIC STEP 7, was used for implementation. LogixPro 500 simulation software can be used for testing process control.

(6) Optimizing genetic algorithms for agricultural irrigation and an irrigation controller based on neural networks that uses the RHC algorithm to control the amount of water and fertilizer applied as well as soil moisture.

(7) Water requirements of individual plants are being technically analyzed. It lessens issues like water logging and waste by using systems that run on solar power can function when the power is off. It has the ability to create databases for irrigation forecasts and analysis.

(8) The effective management of irrigation greatly depends on canal automation. A Raspberry Pi is utilized to operate and control canal systems in situations where conventional methods are inadequate and result in water imbalances.

(9) When it comes to networking computers and gathering data, the "Internet of Things" is, for the most part, a castoff. This farm monitoring system is dependable and efficient, enabling the use of smart filtering algorithms to reduce redundant data and take appropriate action based on sensor data, which may need the use of electricity.

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