IOT-Based Water Valve Actuator For Agriculture Applications

Gowrav M P Kannar
Student, Department of Mechanical Engineering
R V College of Engineering
Bengaluru, India
gowravmpkannar.me20@rvce.edu.in

Mallappa
Student, Department of Mechanical Engineering
R V College of Engineering
Bengaluru, India
mallappa.me20@rvce.edu.in

Jaiprakash I P
Student, Department of Mechanical Engineering
R V College of Engineering
Bengaluru, India
jaiprakaship.me20@rvce.edu.in

Shivaraj B.W
Assistant Professor, Department of Mechanical Engineering
R V College of Engineering
Bengaluru, India
shivrajwali@rvce.edu.in

K A Sucheth Moudgalya
Student, Department of Mechanical Engineering
R V College of Engineering
Bengaluru, India
kasuchethm.me20@rvce.edu.in

ABSTRACT

Traditional irrigation methods, such as ditch irrigation, sprinkler systems, and drip irrigation, have been used for decades but have several drawbacks, including unregulated irrigation practices, waterlogging, soil degradation, inefficient water utilization, and the need for constant human intervention. These issues can lead to increased electricity consumption, uneven plant growth, and even pipe damage due to valve closures. IoT solutions offer a viable remedy to address these challenges, enabling precise crop watering. This approach yields enhanced productivity, reduced maintenance, optimal resource utilization, and the ability to anticipate potential damage. A new and sophisticated irrigation strategy mitigates these problems by interconnecting a single feeder pipe with multiple pipes, strategically incorporating valves. This configuration effectively covers the entire targeted irrigation area. Moreover, strategically positioned IoT-enabled control valve boxes across the field further enhance precision and control in irrigation management.

Keywords*—ESP 32, Control of the Valves, Mobile operated**, **Microcontroller, Internet of Things*

I. INTRODUCTION

The IoT-based valve actuator for crop irrigation is an innovative technology that combines the Internet of Things (IoT) with precision agriculture techniques. This system enables automated and precise control of water supply to crops in a particular area based on specific timing requirements. The valve actuator is the central component of this system. It is a device that controls the flow of water through irrigation pipelines. By integrating this actuator with IoT technology, it becomes possible to control the irrigation process using a web-based application or a dedicated mobile app. The IoT-based valve actuator system typically consists of several interconnected components. Based on the analyzed data, the system can automatically open or close the valve actuator, adjusting the water flow to the crops.

This IoT-based solution offers several benefits for farming operations. It provides water conservation by providing precise and targeted irrigation, reducing the risk of over-watering and water wastage. Additionally, it optimizes crop growth and yield by ensuring crops receive water at the right time, which is crucial for their development. The system also reduces the manual labor requirements and enables mobile app and switch control, allowing farmers to efficiently manage their irrigation processes from anywhere at any time.

In the world of farming, technology continues to play a crucial role in optimizing agricultural processes and maximizing crop yields. One such technological advancement is the implementation of Internet of Things (IoT) solutions. In this case, we will explore how IoT, specifically in combination with a valve actuator, can be utilized to efficiently supply water to crops in a particular area at specified timings. Traditionally, irrigation systems in farming relied on manual intervention or basic timers. However, with the advent of IoT, automation and remote control have become possible, enabling farmers to streamline their irrigation processes and enhance water management.

II. LITERATURE SURVEY

Researchers are making remarkable strides in developing innovative agricultural technologies at an unprecedented pace. Among the critical areas of research, smart irrigation systems stand out as they possess the capability to adapt to changing climatic conditions while concurrently curbing water wastage.

A notable contribution comes from A. Srivastava, who introduced a smart irrigation system designed to gauge soil moisture, humidity, and temperature levels. This system, while showing promise in enhancing the quality and quantity of agricultural yields, lacks the feature of providing real-time field status updates.

A. U. Rehman, on the other hand, proposed an automated irrigation system employing microcontrollers and GSM technology. This system effectively monitors soil moisture, temperature, and humidity, and it promptly notifies farmers via GSM messaging if any of these parameters surpass predefined thresholds. However, it is important to note that this system is associated with higher costs and consumes a substantial amount of power.

Joaquin Gutierrez and his team put forth a gateway unit designed to manage data from sensors, activate actuators, and transmit information to a web application. Powered by photovoltaic panels and equipped with a duplex communication link relying on cellular internet connectivity, this unit empowers farmers to access data and schedule irrigation activities via a web interface. Nevertheless, like the previous systems, it also grapples with power consumption issues and fails to provide farmers with real-time data.

The system proposed in this paper effectively addresses the limitations observed in existing systems. It distinguishes itself by being cost-effective, fully reliant on solar power, and utilizing LoRa technology for instantaneous long-distance data transmission. These improvements mark a significant advancement over current systems.

III. SYSTEM DETAILS

A. System Overview

The core functionality of the developed system is to regulate the water flow from the main supply pipe using a control valve. This control valve is activated by signals from the Wi-Fi module, which is controlled by a mobile app-based control station. Input commands can come from either the mobile app or the system's dedicated website, allowing users to precisely specify the desired amount of water to be dispensed.

B. Components Description

This project uses an Arduino Uno, a servo motor, and an ESP32 microcontroller. The Arduino Uno controls the servo motor, which actuates the valve. The ESP32 sends commands to the Arduino Uno to open or close the valve. The Arduino Uno is a popular microcontroller board that can power and control electronic devices. It has a built-in 5V regulator, which is convenient for powering the servo motor and other components. A servo motor is a type of motor that can rotate to a specific angle, making it ideal for controlling valves, which often need to be opened and closed to a precise degree. The ESP32 is a powerful microcontroller that can connect to the internet and send and receive data, making it ideal for controlling the Arduino Uno remotely.

Table 1: Name of the components used

Sl no.	Name	Quantity
1	Water pump	1
2	Arduino UNO	1
3	Servo Motors	3
4	Jumper Wires	3
5	ESP 32	1
6	Valves	3
7	Bread-Board	1

IV. OPERATION

The system receives commands from the mobile application to control the water supply to the crops using LoRa technology. ESP32 is a revolutionary IoT solution that enables bidirectional data communication over extremely long ranges. This module is well-suited for low data rate, wireless control, and monitoring. The proposed system is designed for low power consumption, so a flowmeter is the best sensor for this application, as it does not require an external power supply and is easy to install and maintain.

A. Long Range Wide Area (LoRa)

LoRa (Long Range) is a wireless protocol designed specifically for long-range, low-power communication. Compared to Wi-Fi and Bluetooth, LoRa can transmit small data packets over incredibly long distances using low-power sensors. Each LoRa gateway can handle millions of nodes, enabling the connection of multiple applications on the same network. The ESP32 module is well-suited for a wide range of low-data-rate wireless monitoring and control designs due to its scalability, reliability, mobility, and ability to operate in harsh outdoor environments. For communication technologies that deal with numerous connecting nodes, security must be robust, end-to-end encrypted, and future-proof. Lora WAN security achieves this by using standard protocols and well-studied algorithms. Lora WAN security design provides low implementation complexity, low power consumption, low cost, and high scalability. The ESP32 LoRa is a development board that combines the ESP32 microcontroller with a LoRa radio module. The ESP32 is a powerful microcontroller that can be used to run a variety of applications, while the LoRa radio module provides long-range, low-power communication.

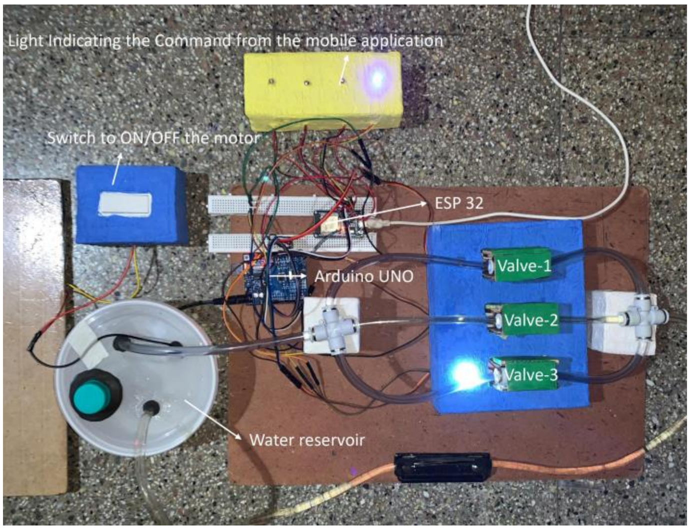

Figure 1: Assembled parts of valve actuator

V. METHODOLOGY

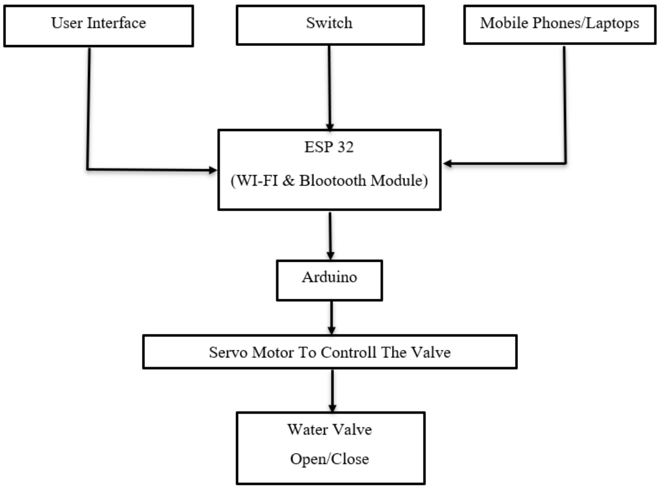

Figure 2: Block schematic of the system

Figure 2 shows the connect the servo motor to the Arduino, the required program code is uploaded to the Arduino to enable its operation. The Arduino is then linked to the ESP32 Wi-Fi module. By inserting the program on the Arduino using a laptop, the entire system can be controlled. The servo motor is connected to the globe valve, allowing for precise control over its opening and closing. Mobile Application or The User Interface Switch Arduino Servo Motor to Control the Valve ESP 32 (WI-FI & Bluetooth Module) Mobile Phones/Laptops Water Valve Open/Close. The globe valve's function is essential for flow control in agricultural fields.

The Arduino receives the command from the farmer through the mobile application and determines if the water valve should be opened or closed. The Arduino sends a signal to the servo motor to open or close the water valve. The mobile phone or laptop can be used to monitor the system and send commands to the Arduino. This system is an example of an IoT-based water valve actuator. IoT-based water valve actuators are becoming increasingly popular in agricultural applications, as they can help to conserve water and improve crop yields and decrease the dependence of the farmer on the labor to irrigate their fields

A. Circuit Diagram

The servo motor has three wires: red (power), black (ground), and orange (signal). Connect the red wire to the 5V pin on the Arduino, the black wire to a ground pin on the Arduino, and the orange wire to a PWM pin on the Arduino.

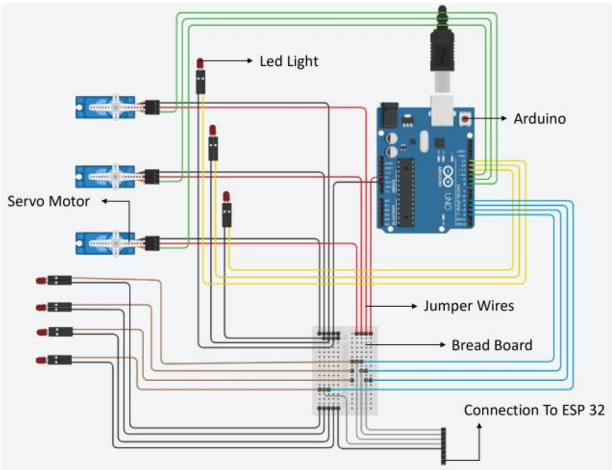

Figure 3: Circuit diagram showing connections between the different components

Figure 3 shows the power wire from the servo motor is connected to the 5V rail on the breadboard. This provides power to the servo motor. The ground wire from the servo motor is connected to the GND rail on the breadboard. This grounds the servo motor. The signal wire from the servo motor is connected to the respective pin on the Arduino. This is a PWM pin, which means that it can output a signal with a variable duty cycle. The duty cycle of the signal controls the position of the servo motor. The positive wire from the LED light is connected to the 5V rail on the breadboard. This provides power to the LED light. The negative wire from the LED light is connected to the GND rail on the breadboard. This grounds the LED light. When the Arduino outputs a PWM signal on the respective pin, the servo motor will rotate to the corresponding angle. The angle of rotation is determined by the duty cycle of the signal. A duty cycle of 100% corresponds to a 180-degree rotation, while a duty cycle of 0% corresponds to a 0-degree rotation.

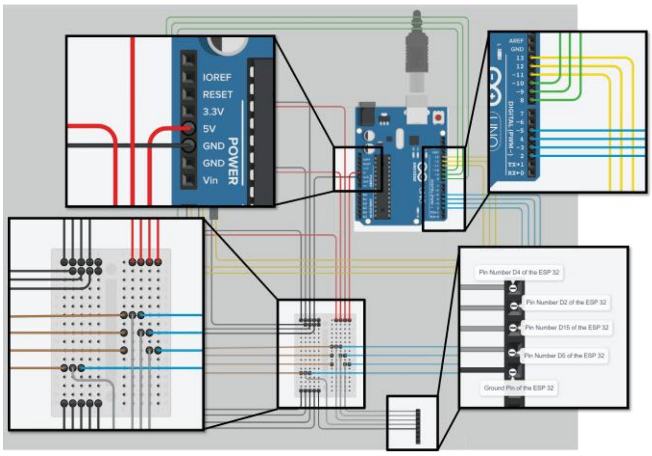

Figure 4: Circuit diagram showing enlarged connections between the different components

Figure 4 shows The LED light will turn on when the Arduino outputs a high signal on the 5th pin. The LED light will turn off when the Arduino outputs a low signal on the 5th pin.
The connection of the Arduino to the servo motor and ESP 32

- Signal pin of the Servo Motor (Orange Wire) connected to Arduino UNO Pin No. 8,9 & 10
- ESP 32 Pin No. D15, D2, D4 & D5 connected to Arduino UNO pin No. 2, 3, 4 & 5

VI. RESULTS

The utilization of an Arduino UNO board, along with relay and globe valve automation, facilitated by the Blynk Application on an Android device, and connected through an ESP32 Wi-Fi module, monitors and controls parameters such as servo motors using ON/OFF switch buttons on the Blynk interface. In agriculture, IoT revolutionizes irrigation by automating systems. Traditionally, manual control of valves led to time-consuming tasks and errors. Leveraging IoT, sensors measuring soil moisture and actuators adjusting valves based on these readings enable precise watering, potentially increasing yields by up to 30% and reducing water wastage by 20-50%. Furthermore, IoT-managed irrigation mitigates waterlogging and salinization risks. Excessive water saturation can damage crops, but IoT systems prevent this with tailored water flow. Additionally, salinization risks, which affect about 20% of irrigated lands globally, can be reduced by optimizing water delivery through IoT-based systems. The reduction of the labor to an extent of 50%, to minimize the time by 65% - 70%. Increasing the productivity and the crop yield by irrigating the crop at right time and conserve the water which will be wasted during the Irrigation.

VII. CONCLUSIONS

Wireless irrigation systems are used for precision agriculture, allowing farmers to water their crops remotely. This system is cost-effective, feasible, and can be used in water-scarce areas to improve water sustainability. In the future, this prototype could be extended to various purposes, such as feeding animals without human intervention from anywhere. One of the key advantages of this IoT-based system is the ability to automate the irrigation process based on specific timing requirements. Farmers can set schedules for water supply, ensuring that crops receive water at the appropriate times for optimal growth. This eliminates the need for manual intervention and reduces the risk of over- or under-irrigation.

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