IOT-Based Water Valve Actuator For Agriculture Applications

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ABSTRACT

Traditional irrigation methods such as ditch irrigation, sprinkler system, and drip irrigation have been used for decades. However, these methods have several drawbacks, including uncontrolled irrigation practices, waterlogging, soil deterioration, water waste, and the need for continuous human intervention. This can lead to higher electricity usage, uneven plant growth and sometimes even breaking of pipes due to closing of all the valves. IoT solutions can help to address these challenges by enabling precise crop watering. This results in increased productivity, low maintenance, optimal use of resources, and the ability to predict future damage. A new, sophisticated approach to irrigation minimizes these problems by connecting one feeder pipe to multiple pipes with the valves in between them. This covers the entire area that needs to be watered. IoT-enabled control valve boxes are mounted over a range of the field.

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

It is of interest to know that there are numerous researches and developments within the agriculture field, and it is increasing at a greater speed. The necessity of accelerating yield directly depends on pH, temperature of soil, and various other factors which has become the most area of interest for the researchers. Wastage of water seems to be a common problem in all the available traditional methods because of uncontrolled or flood irrigation practices.

A. Srivastava proposed the improved quality and quantity of agriculture products, many new technologies are being developed to practice smart agriculture which can adapt to the changing climatic condition and irrigation system in their paper [1]. The system measures soil parameters such as moisture, humidity, and temperature, and then turns the motor pump on or off depending on the level of moisture in the soil. This ensures that the soil is always kept at an optimal moisture level, which can lead to higher crop yields. However, the system does not currently inform the farmer about the current field status, which could be a limitation.

A. U. Rehman, proposed an automated irrigation system using microcontrollers and global system for mobile communication (GSM) in their paper [2]. The system measures soil moisture, temperature, and humidity, and sends a message to the farmer via GSM if any of these parameters exceed the threshold value set in the program. However, the system consumes high power and is not economical.

Joaquin Gutierrez et al. proposed a gateway unit that handles information from sensors, triggers actuators, and transmits data to a web application in their paper [3]. The unit is powered by photovoltaic panels and has a duplex communication link that is based on a cellular internet interface. This allows farmers to inspect data and schedule irrigation through a web page. However, the system still consumes high power and does not provide real-time data to farmers. The system proposed in this paper is cost-effective and entirely solar-powered. It uses Long Range Wide Area (LoRa) technology to transmit data over long distances instantaneously. This makes it a significant improvement over the existing systems.

III. SYSTEM DETAILS

A. System Overview

The developed system mainly focuses on controlling the quantity of water from the mother pipe through the control valve. The controller is triggered by the signal received by the Wifi module from the control station which will be controlled by mobile application. The input can be either from the mobile application or from the website specifying the exact quantity of the water to be controlled.

B. Components Description

The components used in this project are an Arduino Uno, a servo motor, and an ESP32. The Arduino Uno will be used to control the servo motor, which will in turn actuate the valve. The command to open or close the valve will be sent from the ESP32 to the Arduino Uno. The Arduino Uno is a popular microcontroller board that can be used to control a variety of electronic devices. It has a built-in 5V regulator, which can be used to power the servo motor and other components. A servo motor is a type of motor that can be rotated to a specific angle. This makes 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 be used to connect to the internet and send and receive data. This makes 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. IMPLEMENTATION

The system receives command from the mobile application The water supplied to the crops is controlled by IoT using LoRa technology. ESP 32 module is a revolutionary IoT solution that enables data to be transferred with a bidirectional communication network over an extremely long-range. This module is well suited for low data rate, wireless control, and monitoring. The proposed system is built for low-power consumption thus, the flowmeter is best suited as it does not require any external power supply and is easy to install with low maintenance cost.

A. Long Range Wide Area (LoRa)

LoRa (Long Range) is the physical layer with a wireless protocol designed specifically to create long-range and low power communication links. Compared to Wifi and Bluetooth, LoRa transmits small data packets with the help of the low power sensors over an incredibly long-range distance. Each LoRa gateway enables it to handle millions of nodes, thus enabling the connection of several applications running on the same network. The ESP 32 module is well suited for a broad range of low-data-rate wireless monitoring and control designs because of its scalability, reliability, mobility, and ability to operate in harsh outdoor environments. For the communication technology that deals with numerous connecting nodes, security must be robust, end-to-end encrypted and future-proof. LoRa WAN security is achieved 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.

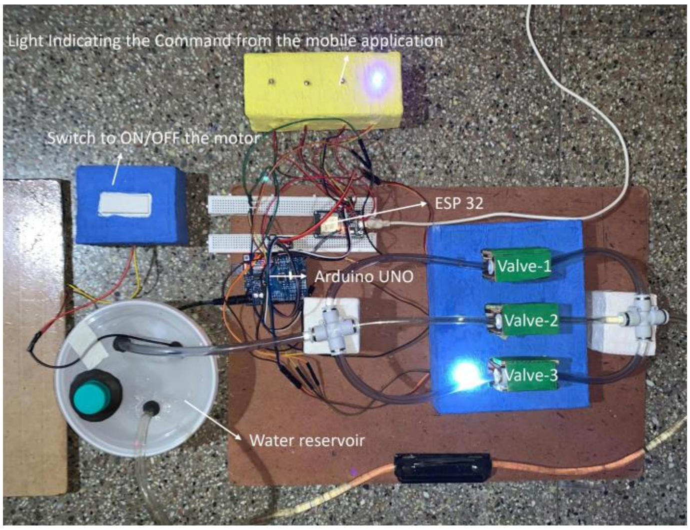

Figure 1: Assembled parts of valve actuator

V. METHODOLOGY

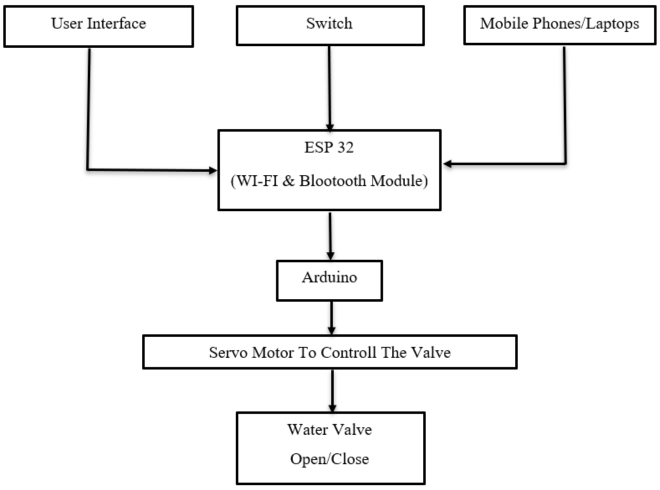

Figure 2: Block schematic of the system

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, black, and orange. The red wire is the power wire, which should be connected to the 5V pin on the Arduino. The black wire is the ground wire, which should be connected to a ground pin on the Arduino. The orange wire is the signal wire, which should be connected to a PWM pin on the Arduino.

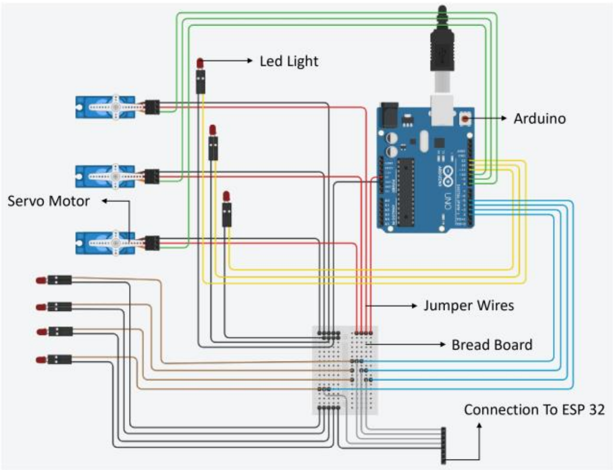

Figure 3: Circuit diagram showing connections between the different components

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.

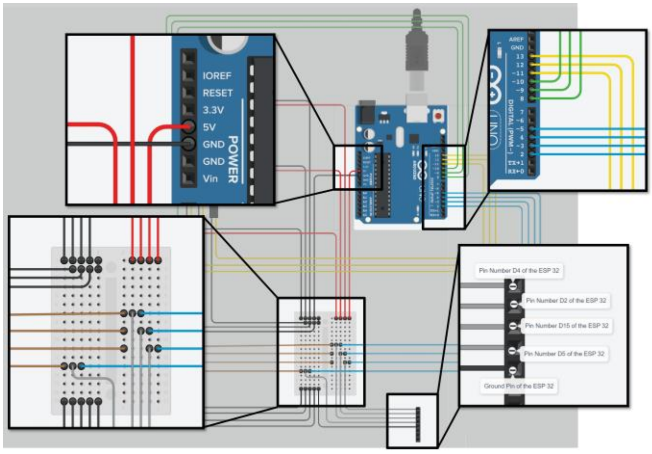

Figure 4: Circuit diagram showing enlarged connections between the different components

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 WiFi 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 control of irrigation system is done for precision agriculture. The major application of this project is for the farmers, who want to water their crops during their absence in the field. It was found that this system is cost effective and feasible. It can be used in the areas where there is water scarcity thereby improving the water sustainability. In future, this prototype can be extended to various purposes such as feeding the animals without any human intrusion 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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