A novel smart irrigation framework with timing allocation using solenoid valves and Arduino microcontroller

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ABSTRACT

Irrigation in agriculture is the most common way of providing water to agricultural land or fields at normal stretches through channels and embedded platforms with the internet of things (IoT), to upgrade rural development. In this paper, the arrangement of the various types of irrigation systems and embedded platforms for agriculture was studied. The embedded platform can be designed in a suitable framework that can assist the irrigation system in growing more water-required crops. In this work, three relay switches, two solenoid valves, and one water pump source were connected to Arduino ESP32. The free version of Sinric Google Cloud was utilized significantly to control three devices namely, two solenoid valves using two relay switches and a water pump source using one relay switch. The experiment was executed in a prototype manner with timing allocation by considering two agricultural fields where water was supplied either in one field at a time and showed more prominent results to save time, replacement of manual valves, man intervention, power, and suitable quantity of water for more water-required crops namely, arecanut and coconut.

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1. INTRODUCTION

In India, around 30% of the water from streams and groundwater is utilized by enterprises and households, and the remaining around 70% is utilized for the field of agriculture. Water the board and protection in agriculture is a significant piece of guaranteeing food security and manageable agrarian creation. In an irrigation system, water is supplied from different sources through a specific arrangement to the agricultural land. The requirement of water supply in agriculture depends on the type of crops such that some types of crops need less water and some need more. Applying innovation and specialized advancements in the field of irrigation systems in agriculture has fundamentally expanded productivity and results. In this regard, a novel embedded technology with the internet of things (IoT) for irrigation systems needs to be designed by replacing manual valves and considering the specific crop growth and quantity of water that helps farmers in different parts of their cultivating tasks.

Groundwater has turned into the predominant wellspring of the irrigation system in India. Then again, there is an enormous hole between a definitive and used surface water potential. The foundation of irrigation should be further improved to collect water and increment stockpiling ability to use spillover water. The Irrigation system in the micro scheme and ideal harvest plan will assume unequivocal parts in the preservation of water assets and food security of the country. The miniature water system has scope for developing water system proficiency up to 90% [1]. The irrigation systems namely, manual and automated systems were reviewed, and concluded that irrigation with an automated system. The irrigation system with an automated system helped to save water that helpful for cultivating crops with high yields. Different types of irrigation methods namely, subsurface, surface, drip, smart, and surface irrigation were reviewed. Here, the disadvantages of the IoT namely, the requirement of labor, soil calibration, and time consumption were explained [2].

The importance of sprinkler irrigation and its effectiveness including efficiency, uniformity, types, characteristics, styles, and management skills were explained. The small irrigation, automated irrigation, periodic and self-move sprinklers, traveling boom, and smartphone or dual-tone multi-frequency sprinkler systems were reviewed. The selection of a designed system in an embedded platform for agriculture must include important key elements namely, water arrangement, control and management, season, location, type of soil, and type of crops [3].

The irrigation system framework for ideal water management was reviewed by uncovering the restrictions and benefits of customary, mechanization, and man-made reasoning-based approaches. Different irrigation systems namely, conventional, automated, and solar based on the type of application were described. That's what the audit shows the fitting model for ordinary administration and cautious activity rehearses lead to high water, saving, improvement in crop quality, expansion in yield, and decrease in agronomical expenses [4].

The management of water in agriculture and its issues and methods in India were reviewed. Normal assets have become powerless. Farming in India is in a curious circumstance of development with weakness. A critical piece of the yearly variety in India's Gross domestic product development throughout the last century is owing to yearly varieties in precipitation. The water system management is connected with three significant difficulties in the agrarian front today, to be specific raising efficiency per unit of land, diminishing neediness, and answering security of food needs [5].

The sustainable irrigation, climate changes, analysis of bibliometrics, modern technology and its innovation and technology, water efficiency, and unconventionality of water resources were explained in detail. Here, various survey articles were studied and concluded that novel alternative agriculture methodologies still designed and developed in India based on groundwater, surface, saving water schemes for high-yield crops, and their productivity. More noteworthy information on the natural effects of water system-related rehearses in different regions on plot, locale, bowl, and provincial levels is required [6].

The target of the review was to assess destructive water use and agronomic water efficiency for various harvests filled in various locales of Uttar Pradesh and to distinguish the districts for the relative benefit of yield creation in light of water efficiency and harvest yield. The estimation parameter was calculated based on region, crops, and requirement of water, and its productivity, region-wise consumption of water usage, and physical productivity of water to give proof of the need for water to grow a variety of crops [7].

The current cultivation based on the IoT empowers productive usage of water as the dirt is continually checked with the assistance of a soil moisture content sensor. The principal philosophy behind this venture is to lessen human intercession and productively utilize water and power. This is made conceivable by sending information to the Android gadget utilizing a Bluetooth Module and Arduino UNO microcontroller. The controller of the system shows the number of hours it ought to work and various times it ought to water the field and the term between each cycle, in the wake of choosing these boundaries the situation with the engine is to be chosen [8].

A novel framework based on solar power in light of dampness content in the field and saving energy and water with an ideal design motor was proposed. Here soil moisture sensors with a solar panel and a water or solenoid valve were utilized to supply necessary water from the tank. This exploration is exclusively done in structure to diminish dependence on matrix supply and utilize daylight to outfit rice crops. PVsyst programming of variant 6.3.4 gave valid information on what kind of board ought to be utilized in the area of Naushahro Feroze. By doing a similar examination, obviously, from traditional and present-day water system frameworks, similar to surface, subsurface, sprinkler, and dribble water system frameworks [9].

The smart irrigation system based on the global system for mobile communication was proposed to save consumption of water and energy. Here ARM-LPC2148, global system for mobile communication (GSM), solar panel, and battery were utilized continuously to monitor the moisture of soil and supply water to crops. The farmer will get complete information based on sensed values and make the automatic decision to supply water to crops [10].

The standard objective of the Arduino-based programmed water system framework utilizing the IoT method is to give a programmed water system framework thereby setting aside cash, time also, and force of the rancher. The humidity, soil moisture sensor, and temperature sensor were connected to Arduino UNO to sense the unique boundaries of the dirt. What's more, in light of soil dampness the agricultural field/land is naturally inundated by the ON/OFF of the motor through a relay switch to supply water and that will be shown on the client's cell phone through the ESP8266 Wi-Fi module [11].

The 8266 microcontrollers was utilized with a soil moisture or dampness sensor and DHT11 for taking the perusing of soil dampness and temperature and moistness. Every one of the information is transferred by a Wi-Fi module built into the microcontroller, to think speak cloud information base to make a smart irrigation framework. In this work, security enhancement schemes like passwords and other encoding algorithms were not included [12].

A novel framework-based horticultural field observing plan that creates and executes the utilization of various sensors implanted in an Alf and Vegard's RISC processor (AVR) microcontroller. The sensors integrated are temperature, soil moisture or dampness, and downpour locator sensors. In light of the state of the dirt detected by the dirt dampness sensor and the state of the downpour, it turns ON/OFF the siphon to supply water to the field. The liquid crystal display (LCD) was utilized to show the state of the field given by the different sensor values [13].

The embedded framework in agriculture supplies was reviewed. The utilization of artificial neural network (ANN) models in implanted frameworks with join gatherers, weed discovery in sprayers, blueberry hedge pruning, weed distinguishing proof, grain lift, and farming with precision were examined. The ANN is a powerful other option for non-straight relapse examination in fitting surfaces. Accuracy farming with the assistance of implanted frameworks turns out to be more productive, astute, and consistent [14].

The smart cultivating field perception utilizing embedded frameworks was proposed. Here different sensors are implanted into an AVR microcontroller namely, temperature, soil moisture or dampness, and downpour finder sensors. Considering the condition of the dirt identified by the dirt dampness sensor and the condition of the downpour, it turns ON/OFF the direct for deftly of water to the field, and the LCD is used to show the condition of the field given by the various sensors information [15].

Agricultural monitoring of distant regions based on the embedded system based on Arduino Mega microcontroller with various sensors namely, soil moisture, temperature, humidity, and LCD was proposed. The main goal is to make a low-power, minimal-expense, hearty information assortment to produce and accumulate an information-independent system. The framework was planned to utilize a custom working framework to completely control and streamline framework undertakings, furthermore, is demonstrated to proficiently and successfully assemble and communicate information for additional handling [16].

IoT upholds them with an electronic methodology that can capability with no person the executives and can make them aware of making a proper move in light of different sorts of issues they may experience while cultivating. The agricultural water resources, utilization of open source-based software, issues, and challenges were discussed. The IoT using embedded systems in the agriculture field to monitor using various sensors namely, potential hydrogen (PH), humidity, temperature, soil moisture, water level, Wi-Fi module, light, and drip control system was utilized with Arduino Mega microcontroller were explained in detail [17].

A smart agriculture field control and monitoring system in an embedded platform was proposed. Here sensors namely, temperature sensing, soil moisture sensing, motor on/off, and spraying systems were connected to a microcontroller to control and monitor the agriculture field without the intervention of humans. The proteus tool was utilized here to get information about sensor value for all controlling and signaling actions and act as a virtual controller [18].

A novel embedded system was proposed to monitor crops automatically. The system was created by using a microcontroller LPC214, soil dampness sensor, and motor. By knowing the level or condition continuously of moisture, carbon monoxide (CO), and temperature through LCD and GSM with the use of clamminess and temperature sensors, the water stream can be obliged essentially by conveying something explicit from a compact [19].

The aeroponic framework is the new plant development strategy for state-of-the-art cultivation. aeroponic control and monitoring system using various intelligent sensors was reviewed. The effectiveness of various sensors namely, humidity, temperature, light intensity, nutrition levels, PH, electrical conductivity (EC) value, and atomization time for flourishing plant growth were explained in detail. the rancher could screen a few paraments without utilizing lab instruments, and the rancher had some control over the whole framework from a distance [20].

Smart farming is one of the IoT's most significant purposes and the water, manure, and harvest yield squander are completely diminished by utilizing smart farming by using various sensors. The IoT in agribusiness created various advantages by decreasing the man intervention, water sources to sensors and associations, time-saving, power, and web-associated temperature checking [21].

The embedded system and remote access system-based Arduino microcontroller to monitor the environmental conditions were reviewed. Here the concept of embedded systems and their applications, the Arduino microcontroller and its specifications, various access technologies, and various environmental conditions were explained in detail [22]. In science, the implementation Arduino microcontroller board was reviewed. The Arduino microcontroller boards keep on testing analysts what's more, teachers for imagination and advancement to address normal science issues, like sensor computerization, systems administration, and information procurement [23].

The robotized fluid-filling framework was proposed by utilizing Arduino Uno alongside covering is a state-of-the-art and effective method for filling and capping fluid compartments in businesses. The framework uses an Arduino Uno board as the cerebrum of the framework and different sensors, for example, fluid stream sensors and nearness sensors to control the progression of fluid and screen the place of the holders. The framework likewise incorporates solenoid valves and peristaltic siphons to control the progression of fluid and fill the compartments [24].

The IoT and cloud computing combination creates a system that effectively coordinates and controls the area of the agriculture industry. Two sensors give information on the dirt's temperature, moistness, the measure of daylight every day, and soil temperature to the base station. The framework utilizes data from the soil moisture sensor to flood soil which assists with forestalling the water system or underwater system of soil subsequently staying away from crop harm. The ranch proprietor can screen the interaction and can assume the command of the cycle. The recommended frameworks should decide how much water is expected for the water system in light of these standards [25].

The Wi-Fi module is appropriate for IoT applications. It is modest and accessible in different structure factors, which is the best fit for various IoT-based projects. Here, we talk about various methods of correspondence that the ESP module can deal with. Utilizing the Arduino IDE, a well-known IDE, can program the ESP module rapidly [26].

The IoT smart home machine controlling framework is created that comprises a Sinric Web server, which helps the clients and managers to remotely control and screen the exercises in the home. A framework code utilizing Sinric Master interfaces this shrewd gadget and the regulator for viable working. There is additionally an equipment interface module that gives proper connection point transfers of the home robotization framework. This framework upholds an extensive variety of home mechanization gadgets like power the board and security and helps to ON and OFF control through mobile phones [27].

The framework depended on a NodeMCU or ESP8266 Web of things gadget, Sinric Master Cloud framework, and remote discourse communication utilizing Google Home application. The built gadget was tried and found to be working successfully as three lights addressing the home machines, were remotely turned ON and OFF from the Sinric Master Site, and a cell phone through voice order on the Google Home application. This gadget which can be efficiently manufactured locally is thus prescribed to homes in Nigeria as this will make life simpler from there, the sky is the limit agreeable [28].

The principal motivation behind a home computerization framework is to give straightforwardness to individuals to control different home machines with the assistance of the idea of IoT innovation. The ESP32, Relay, Wi-Fi router, Bulb, and Sinric Pro were utilized successfully to make a smart home system. This framework is fit for saving electrical energy, time, and cash. It likewise assists with watching out for homes from distant areas. This framework gives fewer actual contact gadgets because of the far-off activity highlight [29].

The arranged smart locking system frameworks comprise of android portable, Arduino Uno board, Wi-Fi module, and a hand-off circuit. Wi-Fi innovation was utilized to screen the gadget in light of its rightness, extraordinary reach, and brief network. This module controls the Lock effortlessly for fixing and it is client lovely. The framework utilizing the Sinric Assistance Cloud application has shown the guarantee as a helpful and secure answer for controlling entryway locks from a distance [30].

The coconut and arecanut plant/tree are commonly growing in the South Zone of Karnataka state of India and it requires more water from time to time. It is observed that some agricultural fields in villages at different levels from the base and different locations where water was supplied under manual controlling of valves. The problem is that, traditionally manual water valves can be adjusted with farmer intervention based on agricultural fields, and water requirements. Usually, the drip irrigation system was utilized where the water directly flows into the plant/tree compared to surface, localized, sprinkler, subsystem, centralized, and manual methods. For example, the drip irrigation system under the control of manual valves is shown in Figure 1.

The two manual valves were ON or OFF on either side to supply water from the water pump source to cultivate respective more water-required crops. If the manual valves are replaced by smart controlled valves, then the irrigation system can be automated fashion and will provide greater advantages for farmers. It is necessary to create a novel agriculture irrigation framework in an embedded platform with the help of a suitable microcontroller, IoT, and various sensors without human intervention by replacing manual valves.

Figure 1. Drip irrigation system under the control of manual valves

2. METHOD

In this work, a novel smart irrigation framework with timing allocation was proposed in a prototype manner to supply water to two agricultural fields by replacing the manual valves using two solenoid valves with two relay switches, a water pump source with a relay switch, Sinric Google Cloud and a delay program for timing allocation to save time, man intervention, water, and power for cultivating more water required crops namely, coconut and arecanut tree/plant. The proposed methodology is shown in Figure 2. The components required for the proposed methodology are as follows:

i) ESP232 Arduino: Arduino-based microcontroller module with an ESP32-S3 chip inside. This module upholds both Bluetooth and Wi-Fi modules, making it an optimal gadget for IoT improvement. ESP32 has basic common features namely, a 32-bit processor with a frequency of up to 240 MHz, a Wi-Fi module, memory of 320 KB RAM, 3.3 V to 5 V supply, Bluetooth, 2 digital to analog convector (DAC), 12 analog to digital convector (ADC), and 3 universal asynchronous receiver transmitter (UART).
ii) Solenoid valve: the solenoid valve is utilized for controlling any type of liquid flow. It acknowledges a DC voltage of 24 V and additionally deals with 12 V DC.
iii) Power supply: 5 V DC supply for ESP32 Arduino microcontroller and 12 V DC supply for relay switch.
iv) Water pump source: A 5 V DC water pump submersible source was utilized to supply water from pond/lake/tank/borewell/ any other readily available water resources.
v) Relay switch: it is a switch that works electrically and it can be can be turned off or on permitting the flow stream of current to go through or not, and can be controlled with low voltages, like the 5 V given by the pins of Arduino.
vi) Sinric Google Cloud: is a stage that helped to interface IoT gadgets to Google Home, IFTTT, Amazon Alexa, Hub-RED, SmartThings, and different stages. It is a paid help; however, you can utilize a free record with up to 3 gadgets or devices.

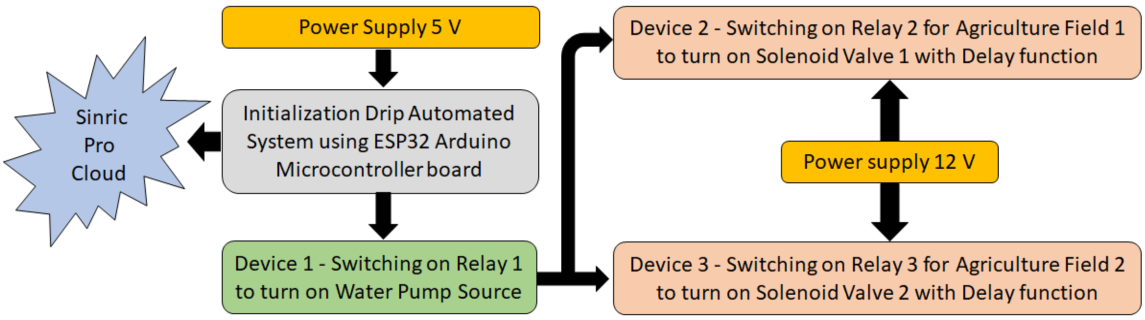

Figure 2. The proposed methodology

3. RESULTS AND DISCUSSION

The proposed methodology layout and Sinric Google Cloud demonstration are shown in Figure 3. The proposed work was developed in terms of providing a timing allocation. The timing allocation setup helped to control the 3 devices to Turn ON/Turn OFF and the procedure for the same is as:

i) Initialize the power supply of 5 V DC to ESP32 Arduino system.
ii) Sinric Google Cloud platform was connected 3 devices via ESP 32 Arduino namely, Device 1–relay 1 switch for water supply pump source, Device 2–relay 2 switch for solenoid valve 1, and Device 3-relay 3 switch for solenoid valve 2.
iii) An additional single power supply of 12 V was connected to two Solenoid valves through 2 relay switches.
iv) Device 1 and Device 2 were activated (Turn ON) such that the water supply pump source through relay 1 switch and solenoid valve 1 through relay 2 switch were activated for 20 seconds (Timing allocation or delay) and then Device 1 and Device 2 were deactivated (Turn OFF).
v) Device 1 and Device 3 were activated (Turn ON) such that the water supply pump source through relay 1 switch and solenoid valve 2 through relay 3 switch were activated for 20 seconds (Timing allocation or delay) and then Device 1 and Device 2 were deactivated (Turn OFF).
vi) Even if Device 1 was in active and Device 2 or 3 were not in active status then the smart system will be restarted again into the initial state and waiting to activate Devices 1 and 2 or 1, and 3 for the operation.
vii) The operation proceeded again with the same procedure from step 2 if required such that the whole system can be worked in an automated or smart fashion through mobile phone by the switch on 3 relay switches whenever needed.

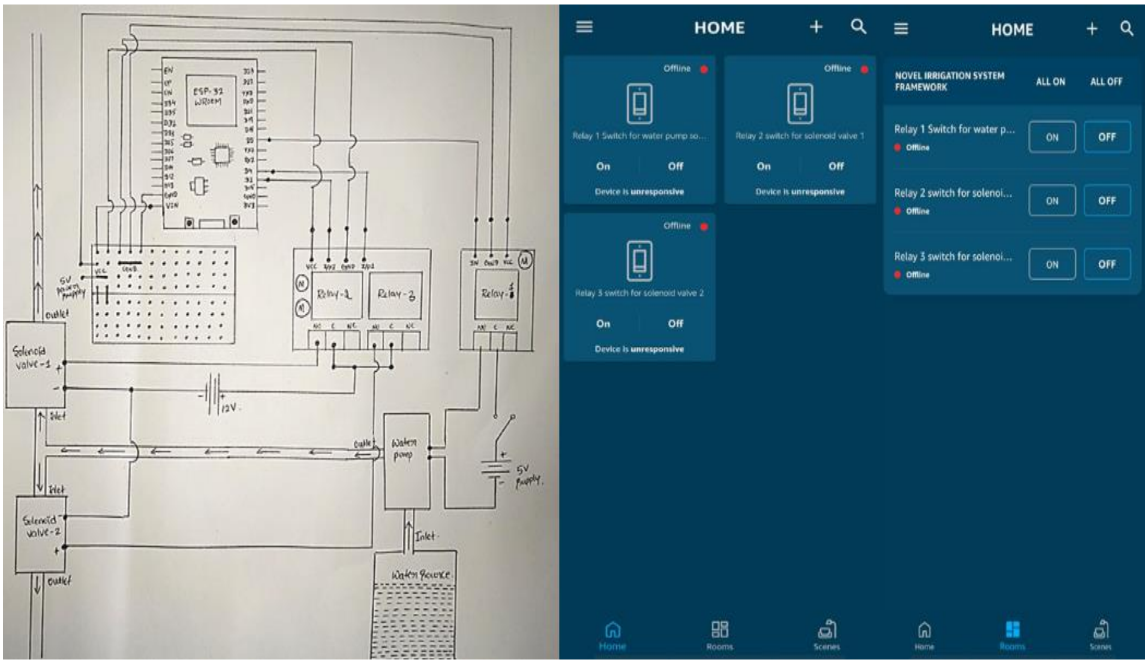

Figure 3. The proposed methodology layout (left) and Sinric Google Cloud demonstration (right)

4. CONCLUSION

In this work, a novel smart irrigation framework with timing allocation using solenoid valves and an Arduino microcontroller was designed and developed in a prototype manner. Here components namely, three relay switches, two solenoid valves, and one water pump source were connected to Arduino ESP32. The free version Sinric Google Cloud system successfully connected 3 devices in terms of 3 relay switches to turn on or off the solenoid valve to supply water using a water supply pump source from available water to either agricultural field 1 or agricultural field 2. Since only one solenoid valve was activated at a time and hence here single 12 V power supply was connected to two solenoid valves instead of an extra power supply connection. In the experiment, the time allocation was set up for a 20 seconds delay only, such that activating Device 1 to supply water for up to 20 seconds through activated Device 2 or 3 for agriculture field 1 or 2. After the delay completion Devices 1, 2, and 3 are deactivated automatically. The experiment was executed successfully and showed more prominent results in replacing manual valves, saving time, man intervention, water, and power that helped for growing more water-required crops namely, arecanut, coconut plant/tree, and so on. In the future, need to make Sinric Google Cloud that connects more devices and also make use of solar panels, sensors, and data analysis methods to include more features for smart agriculture irrigation systems.

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