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DESIGN AND IMPLEMENTATION OF AN ARDUINO-BASED AUTOMATIC IRRIGATION SYSTEM USING SOIL MOISTURE SENSOR, LCD AND WATER PUMP

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ABSTRACT

This project focuses on addressing the need to automate irrigation systems for efficient and sustainable agriculture practices. The use of soil moisture sensors helps to detect the moisture content of the soil and control the pumping motor to turn on or off accordingly. This reduces the time and effort required for manual irrigation and promotes better water conservation practices. The optimized design with low power consumption makes it a cost-effective solution for small and largescale agriculture applications. The implementation of this system was significantly reduced human effort and resources required for manual irrigation. The accurate measurement of soil moisture content ensures that water is only used when necessary, reducing water wastage and promoting better environmental practices. The use of an Arduino microcontroller and a 12V DC power supply ensures that the system runs efficiently with minimal power consumption. The system design is focused on better resource management and cost-effectiveness, making it a suitable solution for farmers seeking an efficient and affordable way to automate their irrigation system. The system's ability to control the pumping motor based on soil moisture content makes it a reliable and efficient solution for agriculture applications. In summary, this project presents an efficient and cost-effective solution for converting manual irrigation into an automated irrigation system using soil moisture sensors. The implementation of this system can promote sustainable agriculture practices while reducing human effort and resources

required for irrigation. The optimized design with low power consumption makes it a suitable solution for small and large-scale agricultural applications.

KEYWORDS: Arduino, automatic irrigation, soil moisture sensor, LCD display, water pump, microcontroller, water conservation, smart agriculture, real-time monitoring, circuit design, programming.

I. INTRODUCTION

A lot of research has been done to address the traditional irrigation challenge. In[3], an approach for integrating precision agriculture and smart grid technologies was presented. This aims at balancing consumption and generation in the farmland, which increases the sustainability of energy supply. The coordination with the Smart Grid operator enables farmers to save on energy costs and support grid at peak hours.[4] Consequently, there is an urgent need to create strategies based on science and technology for sustainable use of water during irrigation processes.

The requirement of water to the soil depends on soil properties such as soil moisture and soil temperature. Effective irrigation can influence the entire growth process and automation in irrigation system using modern technology can be used to provide better irrigation. In general, most of the irrigation systems are manually operated. These traditional techniques can be replaced with automated techniques of irrigation in order to use the water efficiently and effectively. The rise in energy demand has outpaced power generation capacity due to the high increase in population and industries. This calls for management of energy demand to optimize the usage of the limited generated power. One of the areas where power is so essential is irrigation.

A lot of research has been done to address the traditional irrigation challenge. In[3], an approach for integrating precision agriculture and smart grid technologies was presented. This aims at balancing consumption and generation in the farmland, which increases the sustainability of energy supply. The coordination with the Smart Grid operator enables farmers to save on energy costs and support grid at peak hours.[4] Consequently, there is an urgent need to create strategies based on science and technology for sustainable use of water during irrigation processes.

Automated irrigation system using solar power in Bangladesh

The gadget specializes in rice fields in nations depending on agriculture within the economy, such as Bangladesh. The sensor sends a message from the field to the person approximately the extent of water within the area if it will increase or decreases then the operator controls the pump to regulate or flip off the irrigation process. The blessings of this machine are that it depends on the sun energy to get hold of electricity. The dangers of this system are that it centred on one sort of sensor, the water stage sensor, no matter whether the plant desires water or not.[5] The short-coming of this gadget is taken care of by smart irrigation system using additional sensors the likes of the temperature and light sensors which gives the micro-controller more parameters for its decision making so in the case where the temperature is high and there is high level of insolation the system decides to stop irrigating due to the fact that water supplied to the soil will get easily get evaporated and at the same saving water.

2.2 Arduino Based Automatic Plant Irrigation System with Message Alert

In this System, soil moisture checks the moisture level of the soil and if the moisture level is low then the Arduino switches ON a water pump to provide water to the plan. Water pump gets automatically switched OFF when the soil moisture level gets to the required threshold, when-ever the system is switched ON or OFF, a message is sent to the user/farmer via GSM module, the system is very useful in gardens and homes and the whole irrigation process is fully automated.[6] But one of the downsides of this system is that the microcontroller decides to carry out irrigation based on only one parameter gotten from the in-field sensor which is the soil-moisture sensor and this can affect the efficiency of the system and there isn' t any means for the farmer to control the system remotely. This limitation was solved by introducing more in-field sensors, which helps the micro-controller make more efficient irrigation decisions and an app was developed that gives the farmer the ability to monitor and control the irrigation process remotely in the project (smart Irrigation System) being developed.

2.3 GSM based Automatic Irrigation Control System for Efficient Use of Resources and Crop Planning by Using an Android Mobile in India

This device works by using Bluetooth or GSM. This device is placed in the agricultural land. The idea of this device is to monitor the humidity and temperature in the agricultural land in addition to monitoring the state of the climate through the temperature of the weather and humidity and dew drops after which the device sends a text message to the user's phone using wireless communication.[7] One of the dis-merits of this system relates to the inability to control the working process of the system remotely, the farmer gets just information relating to the irrigation process without been able to control the system. This short-coming was solved in the project being developed through the development of an app that is able to give the farmer real data o the irrigation process and also a feature was provided to enable the farmer start and end an irrigation process irrespective of whether irrigation requirement that was encoded into the micro-controller was met.

MATERIALS

To achieve the exact project objectives, we decided to use PIC18F4620 as the operating system in this project (after considering several micro-controllers) because of some of its beneficial features like speed and its low power consumption and high reliability. The first step of this process of building the prototype of the smart irrigation system was the choice of materials to be used for the project, research was undertaken to select materials. Some of the major materials used in the developing the Smart irrigation system include the following; Switch/Button, LCD (liquid crystal display), Temperature sensor, Light Sensor Light Dependent Resistor (LDR), Soil moisture sensor, PIC 18F4620 Micro-controller, Valve, Pump and Bluetooth module.

II. METHODOLOGY

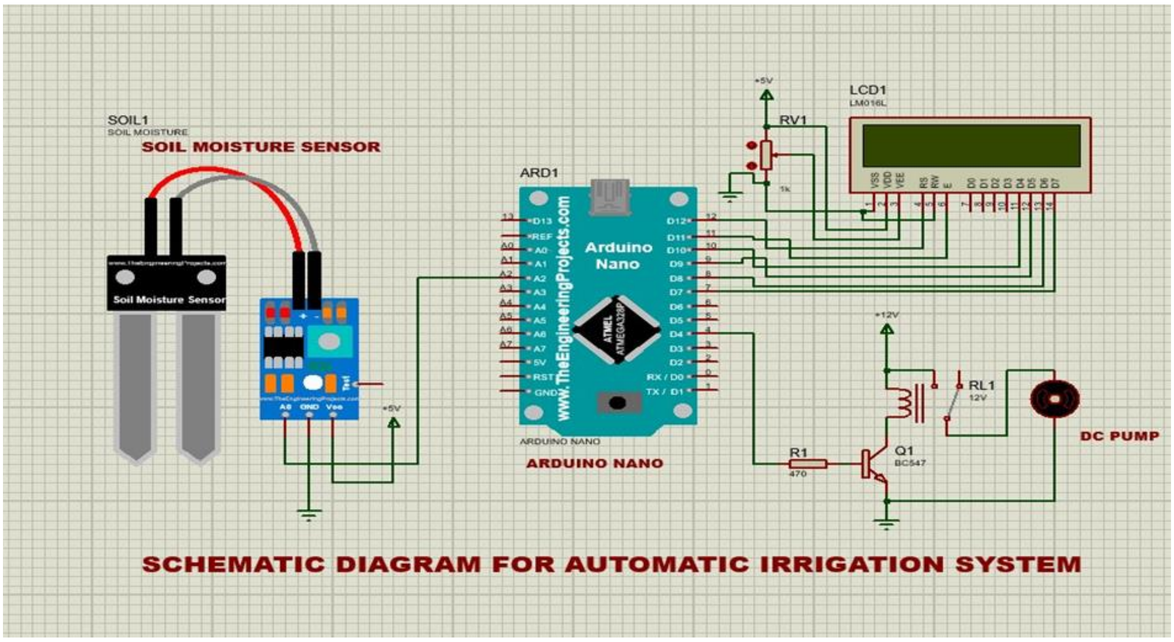
This research was carried out using the ESP32 module interfaced with the R307 fingerprint sensor and the 16×2 LCD display. The ESP32 module has embedded within it, a WIFI module which enables the module transmit data to the internet when engaged to do so without having to secure a separate WIFI device to carry out the task.

The R307 fingerprint module is responsible for capturing voters' fingerprint data and disseminating to the ESP32 module for both accreditation and voting. The accreditation is done by both capturing the voters' data and storing them in the database for the purpose of voting without which the candidate won't be granted access to participate in the voting exercise when the time comes.

The ESP32 module is programmed through the Arduino IDE platform using both the C and C++ programming languages. Consistent with the programming, as soon as the voting exercise commences, live results will be transmitted to the internet in matter of seconds to enable voters have a up-to-date access to the electoral collation process.

The ThingSpeak platform is used as the internet platform for the transmission and reception of voting results which would be accessible by voters. During the programming, to enable the ESP32 module communicate with the internet, the module is synchronized with a router whose SSID is imputed within the program. The router helps the module connect to the internet this, transmit the results as expected. Without the router the accreditation would be done and voting exercise will still go on, but the results would not be transmitted online for voters to have access to. A mobile hotspot can serve as a reliable alternative to the router.

III. RESULTS AND DISCUSSION



All the components required for the project were put together following the system block diagram and circuit diagram. Fig 8 shows the system control box consisting of the PIC-18F4620, capacitors and connection of the system. There are three farms, each farm comprises of a soil moisture sensor, a light level sensor (LDR) and a temperature sensor. These sensors measure farm parameters and send it to the microcontroller for processing. The signals from the sensors are analogue and are converted to digital quantities using the microcontroller Analogue to Digital Converter ADC; after which values are derived from the sensor reading. These values are analyzed and used to decide whether to irrigate the farm or not. Fig 8 also shows the LCD displaying the parameters being measured by the sensors situated in the farm.

Figure 8: The Smart Irrigation Test bed.

The measured parameters at the farm is equally being sent by Bluetooth interface to the host computer for logging and monitoring. When the conditions for irrigation are met as shown in table 1, the microcontroller puts a signal to the valve in the farm and it opens, then the pump starts to pump water thus irrigating the farm. As irrigation is on-going, the information is being displayed on the LCD screen as well as on the app in the host computer.

Table 1: Irrigation condition.

S/No	Irrigation status	Sunlight/insolation	Moisture level	Temperature
1	Yes, irrigation	Low	Low	Low
2	Yes, irrigation	Low	Low	High
3	No irrigation	Low	High	Low
4	No irrigation	Low	High	High
5	No irrigation	High	Low	Low
6	No irrigation	High	Low	High
7	No irrigation	High	High	Low
8	No irrigation	High	High	High

System Implementation

Before live implementation, testing of the developed technique is required. Most of the time, testing and evaluating the protocols or theories proposed is not practically feasible through real experiments as it would be more complex, time consuming and even costly. So, to overcome this problem, “SIMULATORS and TESTBEDS are effective tools to test and analyze the performance of protocols and algorithms proposed.[8] In accomplishing this project, certain technologies were applied from start to finish. And some of them are categorized under the following.

i. Electronic Engineering: Basic electronics (light emitting diodes LEDs, resistors, diodes) components mounted on the interfaced with the PIC microcontroller, light, temperature and soil moisture sensors.

ii. Programming: C++ was used to feed commands to the microcontroller. It was written in the MPLAB IDE. The written program was then compiled and burned into the microcontroller using a PICKIT2 programmer and the app for the smart irrigation system was written in VB.NET language using the visual studio IDE. The app was developed to run on computers having the windows OS. iii. Carpentry: For the construction the board for the design layout.

3.2 Design Considerations

During the design of the entire system, a lot of factors were put into consideration to ensure we develop a reliable and effective system. Below are the design considerations we made during the design of this process; i App Development and Implementation.

The app for the smart irrigation system, was written in VB.NET language using the visual studio IDE. The app developed runs computers having the windows OS. Fig 5 shows the app flowchart which is a pictorial representation of the functionalities depicting the connectivity in the functionalities as the app executes it command process.

3.3

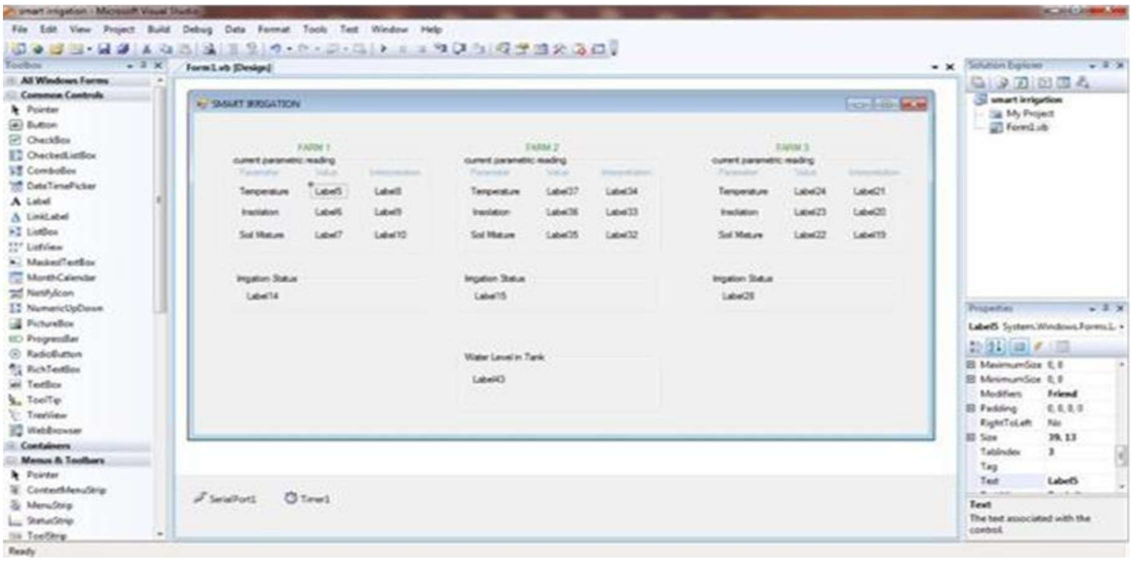


Figure: App interface.

The app follows algorithm meant for it to implement its specifications. The app algorithm is shown thus.

1. Connect to the serial port
2. Connect to the particular Bluetooth device
3. Start timer

4. Check for new data on serial receive buffer
5. Transform the received data to useful format
6. Display the information accordingly

The next step was to assemble all parts together to finalize the project construction and to gather all codes in one single program and run it in a large-scale project to make sure that everything working well.

Figure 3.10 shows the circuit design of the whole system, which was developed and simulated using proteus (which is an IDE for developing, testing and simulating proposed circuit designs virtually) and based on this circuit design the smart irrigation system was built.

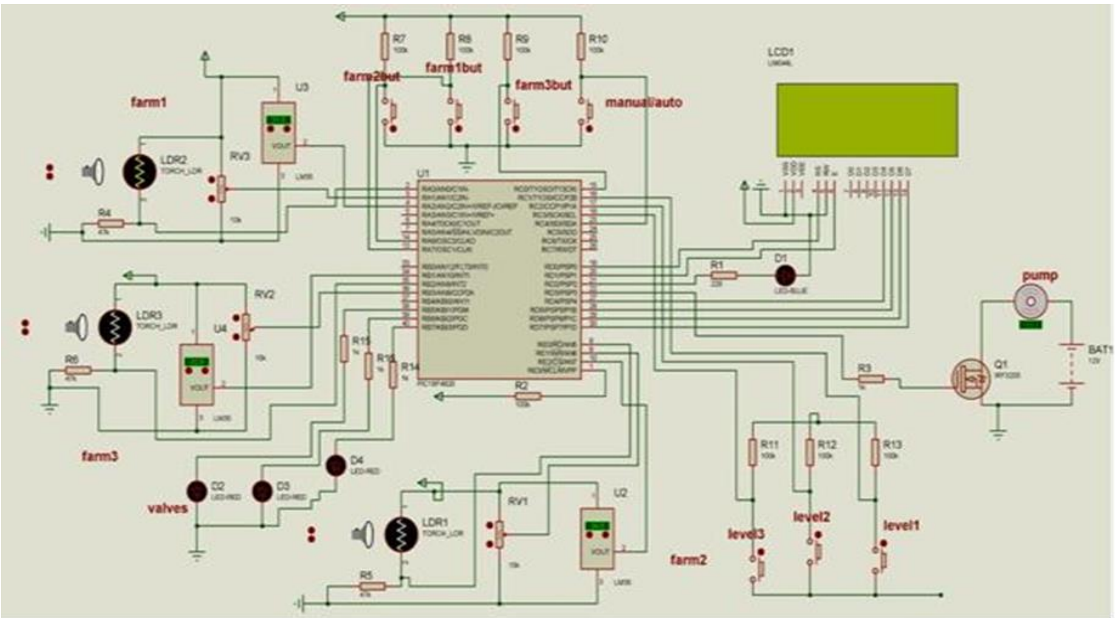


Figure: Circuit Design of the prototype Smart Irrigation system.

For the system programming, a program written in C++ language was used to program the microcontroller. It was written in the MPLAB IDE. The written program was then compiled and burned into the PIC18F4620 microcontroller using a PICKIT2 programmer.

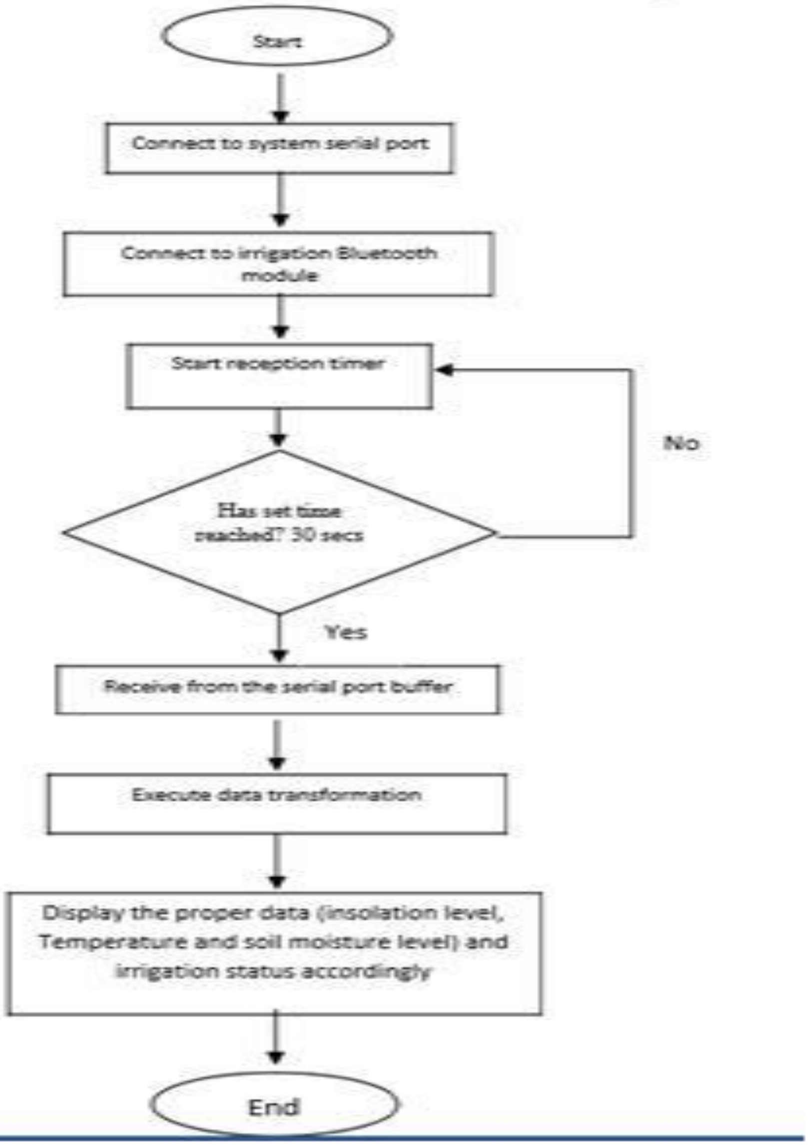


Fig: App flowchart.

The efficient and economical way to deploy live implementation is to perform adequate testing of the developed technique. But the environment to carry out the required test for wired/wireless network is not always readily available especially for live experimental study which could be very challenging, costly and time wasting. Hence, the solution is to use "SIMULATORS, EMULATORS and MODELERS which is a helpful tool to adequately analyze and test the performance of algorithms and protocols.[9] In the main screen of the app, the user gets real time data on the level of soil moisture, temperature and amount of insolation and available in each farm (farm1, farm2, and farm3 respectively) and also the irrigation status. Moreover, the farmer is able to control the system irrigation process through the start and end irrigation button provided in the software application for each farm (i.e. the farmer can decide to turn ON/OFF irrigation process for each farm irrespective of the data gotten from the system). The laptop pairs up with the smart irrigation system via the Bluetooth module with the app as shown in figure 6. The app interface consists of labels representing each farm, each parameter been measure by the light, temperature and soil moisture level sensors, water level and irrigation status for each farm.

4.1 DISCUSSION

The system will not work until the irrigation requirements are met and these requirements include that the soil moisture level must be below the required threshold and that the amount of insolation and temperature is within the acceptable range. So, if the parameters being measured by the soil moisture, light and temperature sensors meet this criterion, then the PIC micro-controllers will send a command to the relay of that specific valve linked to a farm to open the valve and a command is also sent to the relay of the pump to irrigate the farm that needs to be irrigated. Also, for the purpose of demonstration the system assigns an irrigation time of thirty second to irrigates each farm (farm1, farm2 and farm3).

IV. CONCLUSION

This paper makes a noteworthy contribution to the field of efficient irrigation system in agriculture which cannot be over emphasized. To solve some of the irrigation problems faced by farmers, an advanced system such as this prototype smart Irrigation system is needed. The field application of this technology will lead to better growth of plants as irrigation is applied as at when needed without over or under irrigation of plants. This would not only increase yield but would also conserve water which is a scarce product and most importantly to reduce labourers stress of going to monitor their plant all the time and perhaps wrong application of water to their plant. The smart Irrigation System have been successfully implemented at the laboratory scale. The next step is to implement the project in real life scenario for first hand results, before implementing it on the commercial scale.

The following recommendations were made for further studies: Zig Bee module can be used to offer wireless connection between the components interfaced with the microcontroller instead of wire connection. A Wi-Fi module could also be used in place of the Bluetooth module to increase receptive range. Creating user friendly mobile application in place of the desktop app will also help in making the system easier to which have more controlled data. Also, we can develop this system by using renewable energy which is solar power instead of batteries using solar energy will help to reduce future cost and study could be extended to monitor a larger portion of land with two or more crops.

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