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Research Paper

Design and Implementation of a Smart Irrigation System

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ABSTRACT: *Advancement of technology has led to the automation of Irrigation system which has helped to solve a lot of problems encountered by the various non-automated types of irrigation syatem. The use of electronics has made irrigation easier, more efficient and flexible, various automatic irrigation systems has been developed to help the farmer carry out irrigation. This Research work involves applying electronics and software engineering as a means of solving the irrigation issues faced by farmers. This paper is limited to the development of Smart Irrigation System that can be controlled by software application, which also can be used to monitor irrigation in real time. It makes use of light, temperature, soil moisture sensors, LCD, PIC microcontroller and it is coded using C++ Programming language. This irrigation system consists of four different sensors which are used to measure various parameters related to the crop production. They are Light Dependent Resistor (LDR), Humidity Sensor, Soil moisture Sensor and temperature Sensor. The LDR is used to determine the intensity of light or the time of the day. This helps the system to regulate the irrigation from time to time. The Soil moisture sensor is used to determine the moisture. An app that gives the farmer information on the amount of insolation, temperature and soil moisture level was also incorporated in the system.The smart irrigation system developed was able to automatically monitor and control the level of water available to the plants without any human intervention at the farm. This intelligent system is limited to only a single plant or crop as future study could be extended to monitor a larger portion of land with two or more crops.*

KEYWORDS: *Bluetooth; Humidity Sensor; Irrigation; Light Dependent Resistor (LDR); Microcontroller,*

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I. INTRODUCTION

Irrigation, is the artificial supply of water to the root of plant. Irrigation has been used to assist in the growing of agricultural crops, maintenance of landscapes, and re-vegetation of disturbed soils in dry areas and during periods of inadequate rainfall. In crop production, irrigation helps in protecting plants against frost, suppressing weed growth in grain fields and preventing soil consolidation. Irrigation systems are also used for dust suppression, disposal of sewage, and in mining [1]. Irrigation undisputedly has evolved and it is still evolving and advancing to be a more efficient, easy and flexible process and through the course of time various methods of irrigation has been introduced, some of the most common types of irrigation include the following; Surface irrigation, Sprinkler irrigation and Drip Irrigation as shown in Figure 1, Figure 2 and Figure 3 respectively.

Figure 1: Surface Irrigation system

Figure 2. Example of Sprinkler Irrigation system

Figure 3: Drip irrigation system.

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. There is always need to pump water to the water tanks and operate the irrigation system such as sprinklers. However, two scarce and valuable resources of irrigation, i.e. water and energy, are not efficiently utilized by the traditional irrigation systems. They do not have the means to determine where and when irrigation is required. Consequently, irrigation is sometimes performed when it is not necessary or delayed when required. This leads to water/energy waste and low-crop yield, respectively. These challenges can be mitigated if the irrigation system was able to determine precisely when and where to irrigate.

Good operation of any irrigation system includes matching the irrigation duration with the rate of application and the intake rate of the soil to maximize the fraction of water stored in the root zone. Operation of surface irrigation requires being there to " tend" the water, i.e. to move the water to successive application points as it reaches the end of the run [2]. The research will be of great benefit to the educators and researchers since its content contributed to the extension of the frontier of human knowledge by providing an insight into affordable irrigation system that take advantage of scientific know-how to improve water usage in common irrigation practices

II. REVIEW OF RELATED WORKS

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.

2.1 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 centered 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 micro-controller 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.

III. MATERIALS AND METHOD

3.1 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.

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3.2 Method

This project is about the design of a smart irrigation system that helps in ensuring that the farm land is properly irrigated. In this system sensors such as light, temperature and soil moisture sensor were used to measure the level of insolation, temperature and soil moisture in the farm where the system is installed. The system is able to carry out irrigation when the soil moisture level is below the optimum level for proper plant growth and when the farm is fully irrigated the system stops the irrigation process and operation is decided by the PIC micro-controller, which is the core of the system. The PIC microcontroller is able to communicate with other components that makes up the system and based on the parameter gotten from the sensors, the micro controller decides if the farm needs to be irrigated. Fig 4 shows the block diagram of the smart irrigation system where each block/sub unit of the block diagram is analyzed/designed for interoperability with other connected blocks so as to ensure the project objectives were met.

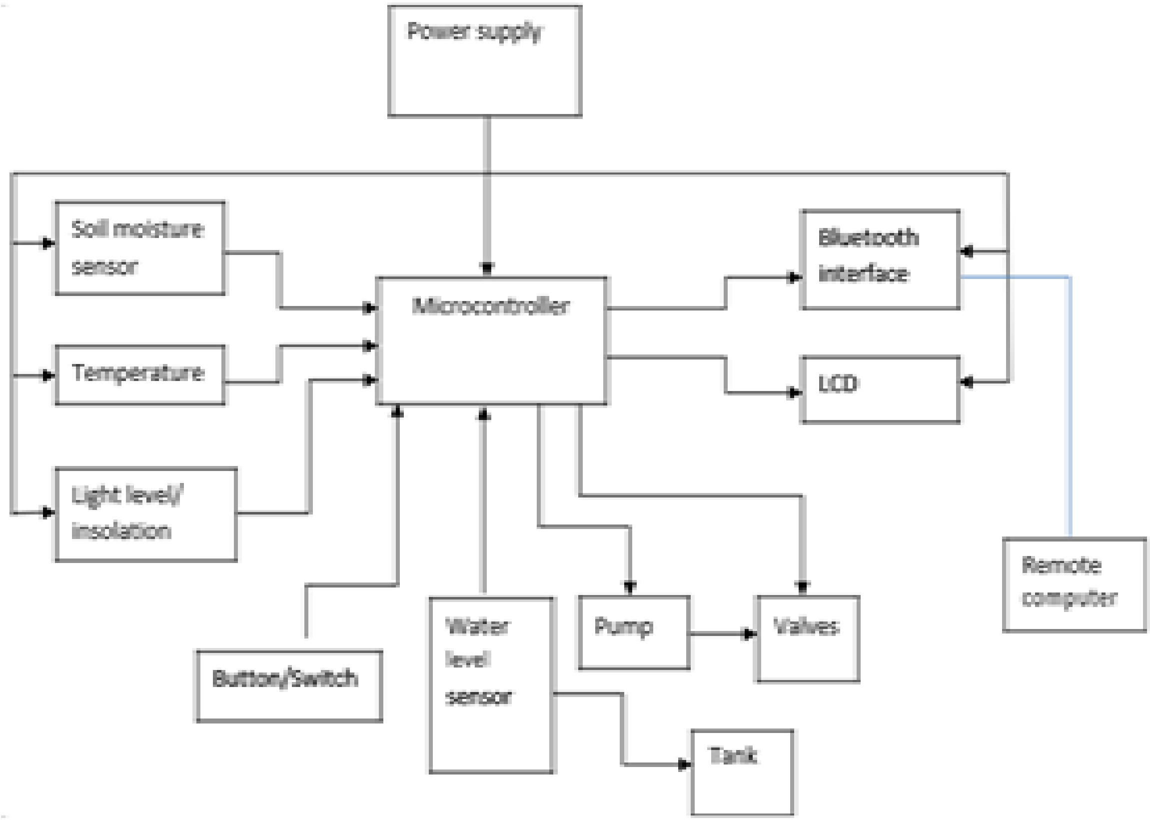

Figure 4.The Irrigation system block diagram

3.2.1 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.

3.2.2 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.

Fig 5. 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.

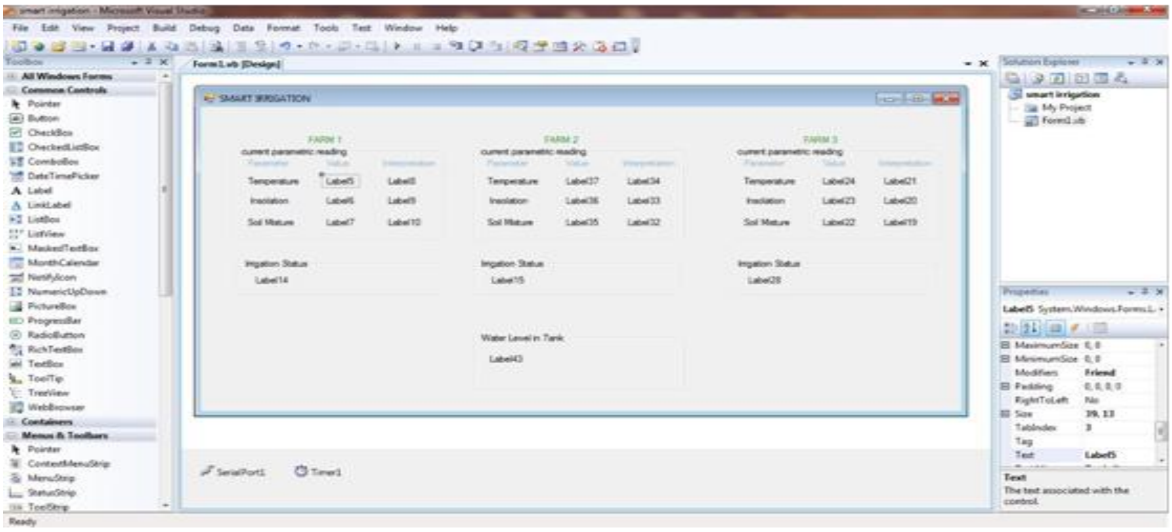

Figure 6: App interface

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

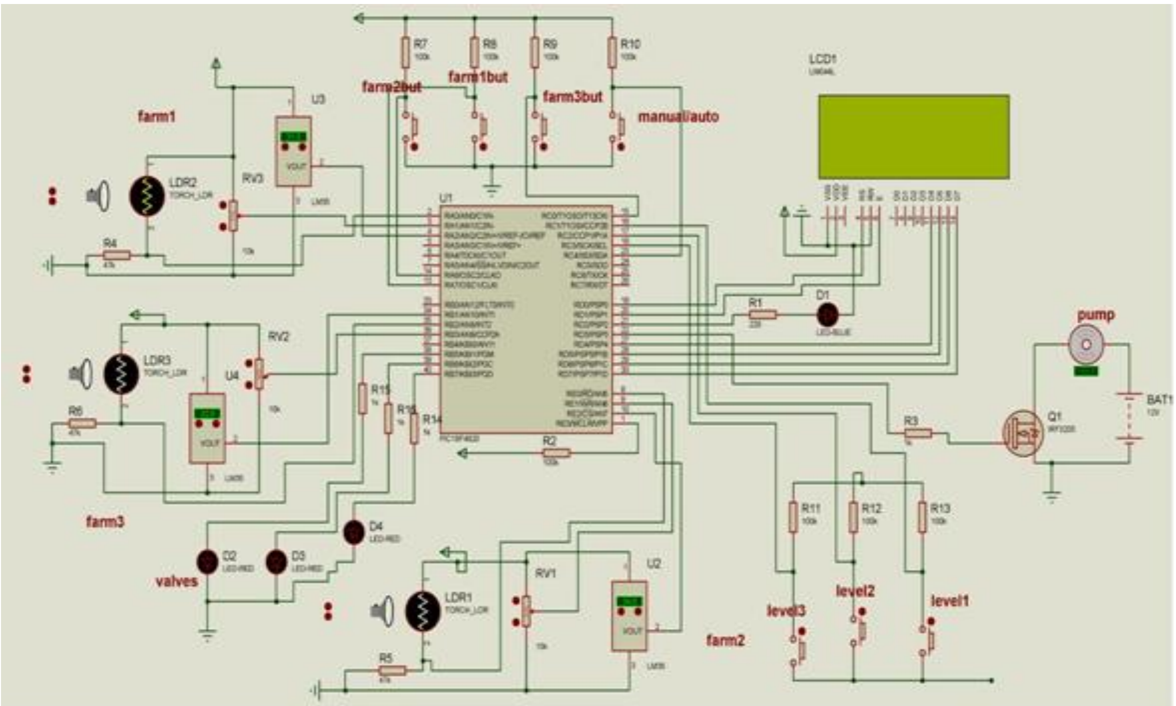

Figure 7: Circuit Design of the prototype Smart Irrigation system

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

IV RESULTS AND DISCUSSION

4.1 Results

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

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 criteria, 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).

V. CONCLUSION

The need for efficient irrigation system in agriculture 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 leads 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 being 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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