An Experimental Design Approach to IoT Enabled Smart Parallel Irrigation System Using Embedded Microcontrollers

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Abstract

The mode of irrigation used in agriculture plays a very important role in the yield. There are many existing advanced technologies for irrigation systems in agriculture, but many farmers still follow the traditional irrigation techniques such as furrow irrigation. This involves high maintenance and is exorbitant because it includes labor work. The main objective is to develop an automated irrigation system based on sensors which are interfaced to the Microcontroller unit. It helps to gain command on monitoring and controlling the system using multiple sensors whose output data can be processed by the Arduino to make suitable decisions. The entire farm can be divided into parallel rows for effortless observation. Moisture and rain sensors are being used which assist the water flow in a row and act when it starts to rain respectively. The activities of the Arduino completely depend on the output of the moisture sensors and the weather predictions by the rain sensors. This idea of parallel irrigation makes the agricultural technology modernized by using programmed components and building the necessary module for the system. On the other hand, it also helps to reduce human intervention and provides an adequate method of irrigation.

Keywords 1

Internet of Things, Arduino Uno, Irrigation, Moisture Sensor, Rain Sensor.

1. Introduction

We all need food in order to live and it is obvious that food production depends on agriculture and the quality of the crop. Watering the plants plays a major role in providing a good yield of the crop. The type of irrigation method used depends on the type of the soil and the plant to be grown and it varies from place to place. The idea for the proposed work has been obtained from real time problems of a farmer. They are explained, along with the proposed idea to overcome the problems to a great extent.

Since the area of agriculture is generally very large, it is very difficult, time consuming and exhausting to water the entire field manually. The whole area is divided into sections (usually rows), through which the water flows. It is not possible for one person to check if the water is reaching till the end of the row or not. Hence, people are hired to do this monitoring job. A person needs to stand there to constantly check or monitor, whether the soil is moist enough or not. So, the people doing this extra work are paid approximately ₹1800 - ₹2400 per month, by the farmers.

Many farmers in India are still following traditional methods of agriculture such as furrow irrigation. Furrow irrigation is widely used technique for irrigation because of its simple and economical pricing [1]. When the pace of the water is intemperate, it might also lead to erosion of the soil. It has been observed that the performance of furrow irrigation can be improved if the flow rate and time of suspension are kept under control. Many techniques have been developed to upgrade

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furrow technique and one of them is surge irrigation method. Surge irrigation is a technique in which water is supplied in an irregular fashion with on and off series of operations. This has proved to show great results in the fields. Surge irrigation has shown a good amount of reduction in water supplied for the process by 22%. The efficiency of the irrigation has been enhanced by 29% [2]. Still manual irrigation will not give better results because it is very time-consuming process and every time farmer needs to check the soil moisture. So, it is better to add some automation to this surge irrigation.

Smart irrigation systems may be used to achieve efficient irrigation of agricultural land [3]. The primary aim of smart irrigation systems is to reduce water usage while increasing the quantity and quality of crops. Wireless sensor networks aid advanced systems in the emerging digital world. Internet of Things (IoT) in agriculture and farming is to automate all aspects of farming and agricultural methods in order to make the process more productive and competitive [4]. Traditional livestock management methods (such as cattle detection) are not completely automated and have numerous inefficiencies, including increased human activity, labor costs, power consumption, and water consumption [5][6][7].

Actuators and sensors are used in smart irrigation systems to monitor the ground moisture of agricultural land. The data obtained by the sensors could be sent to data servers via the IoT for statistical analysis and processing [8]. For example, soil moisture sensor is used to estimate the moisture content of the soil. So, this sensor continuously monitors the moisture and the data is processed through the controllers. Based on given conditions, the controller will decide how much water is needed for the crop. If moisture is enough for a row, then the system will automatically stop the water supply for that row. This is how we can increase the efficiency of irrigation with the help of automation. Integrating cutting-edge technology such as IoT and Machine Learning into the agricultural sector will assist farmers in increasing crop yield. It will also ensure that the crop produced is adequate to meet the food needs of the country's entire population, which is rapidly increasing [9][10][11].

The proposed system is described in Section 2, which gives a brief idea about the working procedure of the prototype. The experimental setup and hardware specifications are explained in detail in the sections 3 and 4 respectively. The functions and processes taking place in the model are the methods linked to the respective sensors and actuators. The details about each component functionality are elucidated in the above sections. The prototype behaves differently according to the conditions of the soil moisture content and the raining status. The actions taken by the system are captured for analysis from Arduino IDE. The results and observations are provided in Section 5. The next section consists of a comparative study between the existing techniques and the proposed methodology followed by a conclusion.

2. Proposed System

The intention is to reduce manual participation and automate the process of irrigation to provide better monitoring and control over the agricultural field. The entire field can be divided into parallel rows and a single source such as a reservoir for water supply. The moisture level at the end of every row can be checked to decide if the water supply to that row must be continued or not. If the moisture present is sufficient, the water to that row can be terminated. Otherwise, as shown in the Fig 1, the supply can continue until the moisture is enough. If it starts to rain suddenly, the system should stop providing water to the field to avoid two sources of water. After the rain stops, the moisture can be checked again to decide whether water can be retained to the rows. The experimental setup of this parallel irrigation system is explained in detail in the following section.

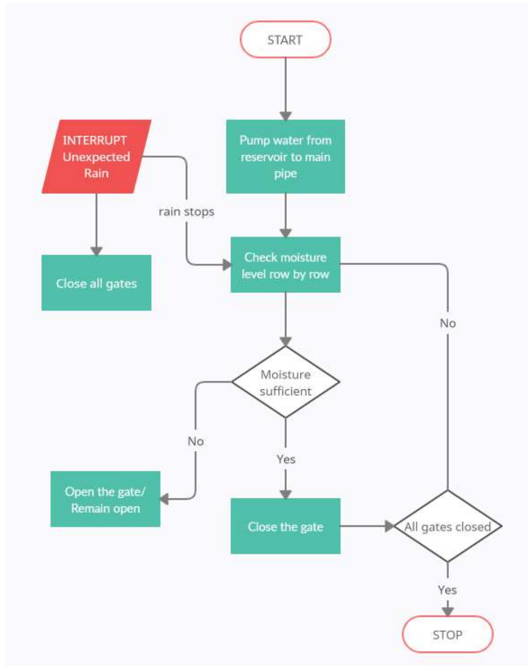

Figure 1: Block diagram of proposed system

3. Experimental Setup

The farm is divided into parallel rows and a water pipeline is placed perpendicular to all the rows, at one side of the field. The pipe is closed on one end and the other end is connected to the water reservoir. The pipe consists of several holes (equal to the number of rows) that are placed in line with the beginning of the rows as shown in Fig 2.

From these holes, small pipes are placed for water to flow from the tube to the plants. Beside the holes present on the tube, motors (equal to number of rows) are placed. A small piece of thick plastic sheet is attached to the shaft of all motors. This piece of rectangular plastic sheet acts as a gate. Moisture sensors which are used to indicate the moisture level of a particular substance/substrate are placed at the end of the rows. The output of this sensor is used by the Arduino to control the motors (which are by default) present in the pipe which stops the water flow, if the required moisture level is reached. This is controlled by the Arduino as the optimum moisture level is already provided.

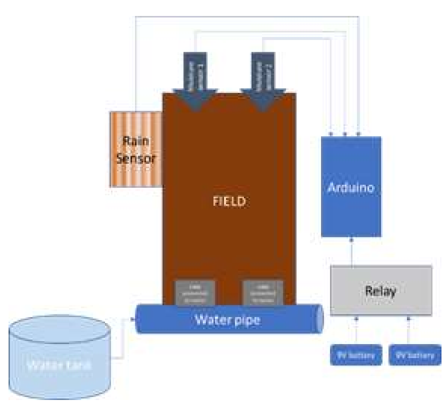

Figure 2: Setup model of the system

The optimum moisture value varies for different soil and crop types. When moisture level of the soil is reached, the plants no longer need water so the gates attached to motor will automatically close to resist the flow of water (based on the optimum moisture level given in Arduino code).

A rain sensor can also be placed as shown in Fig 3, in the farm to detect rain and stop the irrigation process temporarily. That is, the gates will be automatically closed when it is raining. If the moisture level of the soil is not enough even after the rain, the water flow from the pipes will start again automatically until it reaches the optimum level. Otherwise, it will be turned off.

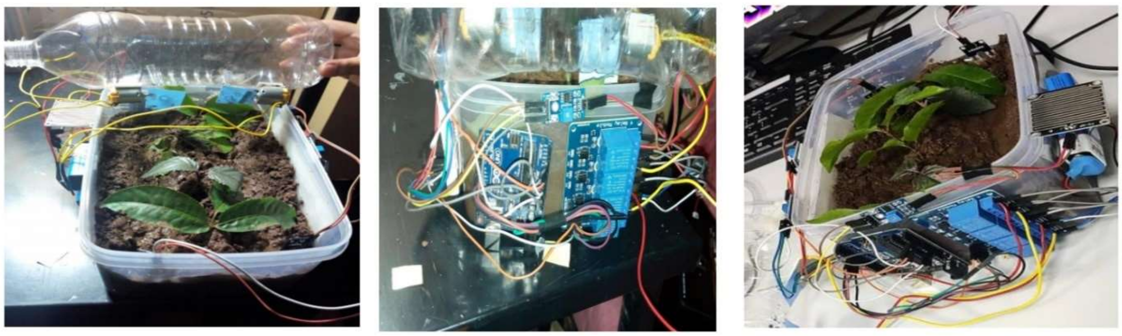

Figure 3: Prototype Setup

4. Hardware Specifications

A plastic container has been used as a field for the prototype development. An Arduino Uno is used for communication between the sensors and the system. Moisture sensors are placed at the ends of each row to get the moisture level from that line. Rain sensors are used for collecting data about the weather conditions. Plastic flaps have been used as the gates. Furthermore, motors are present to open and close the gates. To control the movement and power supply to the motors, a relay has been used. Arduino IDE is used to write the code, analyze and observe the results obtained.

5. Results and Discussion

The computerized and programmed solution will help the farmer to save a lot of amount of water compared to Furrow irrigation System. A lot of manual work can be avoided using this implementation. As it is automatically controlled system in which moisture sensors can detect whether water reached the end of the row or not it saves a lot of work and time for the farmer. In the Arduino IDE we can see the moisture level of the sensors displayed in the serial monitor. If it rains it shows “RAINING” in the serial monitor. If it drizzles, then “RAIN WARNING” is displayed. If it stops raining, then the sensor outputs are displayed as usual. The outputs observed in Arduino IDE are attached.

When both the moisture sensors are in wet soil, the results are as shown in Fig 4. The reading of the sensors displaying in the serial monitor is inversely proportional to the moisture level. This means if the value of the sensor reading is very high then the soil moisture is low. The values displaying are low hence moisture level is high as they are placed in wet soil. This means that both the gates will be closed in such a case.

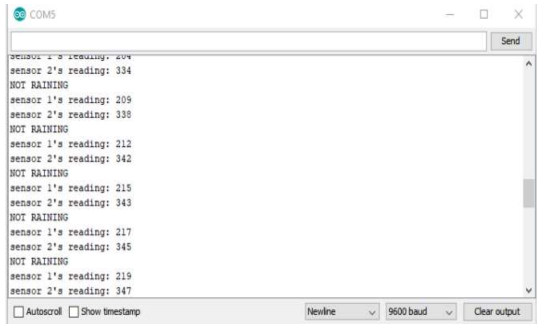

Figure 4: Both sensors in wet soil

When sensor 2 is in dry soil at an instant as shown in Fig 5, the reading of sensor 2 is very high which indicates that the moisture level is very low as the sensor is placed in dry soil. The reading of sensor 1 is low as it is placed in wet soil that means that the moisture level is optimum. In this case, the gate corresponding to sensor 2 will be open and the other one will be closed.

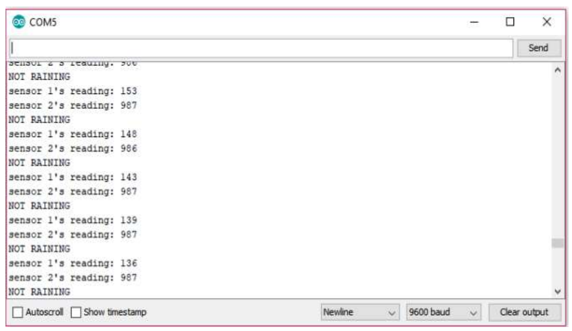

Figure 5: Sensor 2 in dry soil

When sensor 1 is in dry soil at an instant as shown in Fig 6, the reading of sensor 1 is very high which indicates that the moisture level is very low as the sensor is placed in dry soil. The reading of sensor 2 is low as it is placed in wet soil that means that the moisture level is optimum. In this case, the gate corresponding to sensor 1 will be open and the other one will be closed.

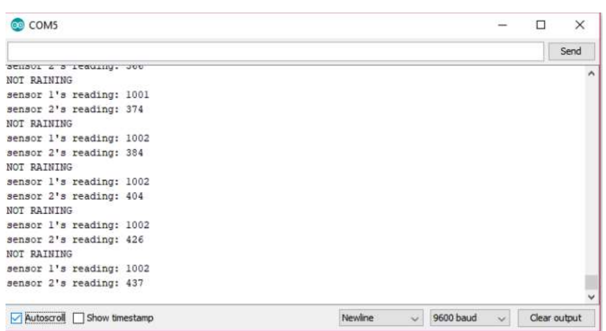

Figure 6: Sensor 1 in dry soil

When both the sensors are in dry soil, the results are as shown in Fig 7. Both the readings are quite high which means that the moisture level is not sufficient. Both the gates will remain open in such a case since the moisture level requirements are not satisfied.

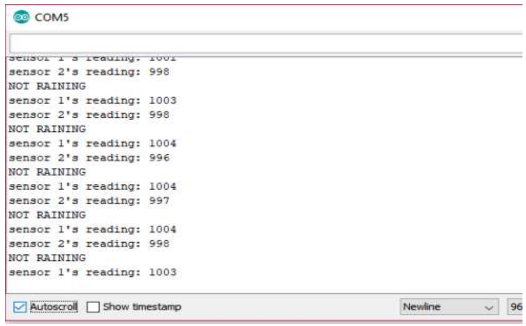

Figure 7: Both sensors in dry soil

When it is drizzling/ very less rain, the result is as shown in Fig 8. The system triggers a warning that it is raining lightly. When the rain stops, the warning is disabled, and the system continues to provide the sensor readings and act according to it.

Figure 8: When it's slightly raining

When it rains heavily, the results are as shown in Fig 9. All the gates of the system be closed and remain closed until it stops raining. After it stops raining, again moisture level is checked which means the sensor readings are displayed. When the moisture level is optimum gates remain closed.

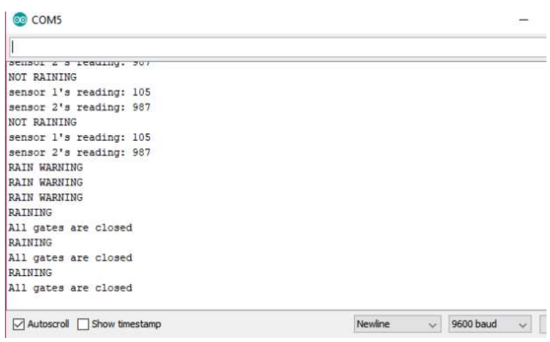

Figure 9: When it is raining heavily

6. Comparative Study of the Proposed Model with Existing Literature

S.No	Title	Result	Comparison
1	Effect of Surge Flow on some Irrigation Indices of Furrow Irrigation System [1]	Evaluated the performance of the surge irrigation technique and furrow irrigation technique. Surge flow irrigation was found to perform better than furrow irrigation.	Added IoT techniques to surge irrigation which makes this method automatic rather than manual irrigation system.
2	A Smart IoT Fuzzy Irrigation System [3]	A fuzzy computational algorithm with IoT, sensors and microcontrollers for processing. Humidity and soil moisture sensors are used.	A rain sensor is used for taking immediate action while raining in order to avoid two sources of water.
3	Smart Irrigation Integrated with IoT [5]	Implemented a smart Surge irrigation technique integrated with internet of things which included soil moisture sensor.	Included a rain sensor to stop the water flow at the time of raining and then again check the moisture level which can be an advantage.
4	Design of a Low-Cost Sensor-Based IoT System for Smart Irrigation [10]	Implemented low-cost sensor and IoT system for smart irrigation system. This soil moisture sensor data is continuously on memory card only which was integrated with the system and based on the data and crop requirements feedback is sent to the different sensors	The data from the sensors is sent to Arduino for processing with conditions already given for each soil type. Moisture and rain sensors are used for better results based on weather conditions.

7. Conclusion

The implementation of the smart parallel irrigation system has been accomplished by achieving the main objectives using the sensors and actuators to monitor and control the system. Moisture sensors make sure that the right amount of water is reached to the rows and rain sensors assure that the weather conditions are also taken into consideration. This system can be implemented in fields to avoid wastage of water. As this is an automated version of the irrigation process, the work is reduced for the farmer. It is more durable. We need not change any components as they have long lifetime. When it rains automatic flow of water from the tank stops and this is a huge advantage for the farmer as the farm doesn't need two sources of water at the same time. This execution can also be utilized in large fields. Manpower is reduced considerably with the proposed idea and this can be a huge advantage to the farmer. In this model, the right amount of water is delivered to the plants in the farms at the right time.

8. References

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