Autonomous Irrigation System

M. Murali, Akshay Kumar, Mohit Khare

***Abstract*: India is an agriculture based country and it needs a smart and efficient way of irrigation to prevent wastage of water as water table in many regions of the country are already depleting at a serious level. In this paper, implementation of a system which has multiple sensors connected to a control module to regulate outflow of water in an irrigation system is shown. The paper shows a Raspberry Pi based system which takes input from sensors like humidity sensor, soil moisture sensor, barometer etc. to regulate the water output to the irrigation field. Multiple sensors are scattered over the field. The sensors in the field sense the moisture of the soil and signals it back to the microcontroller. The control module then irrigates the field according to the water requirement based on the sensor data. The model of an autonomous irrigation system also implementing machine learning is presented for rural areas. The aim of the autonomous irrigation system and its implementation is to effectively irrigate agricultural fields preventing water wastage.**

***Index Terms*: irrigation, soil moisture, sensor, agriculture, farming**

I. INTRODUCTION

India is an agricultural country where a large percentage of population is dependent on agriculture for their livelihoods. By incorporating more technical and cost effective methods maximum yield can be produced by utilizing water efficiently i.e. by minimizing the volume of water wasted. Current systems that exists or are in implementation that use a machine learning approach either use a cloud based system or contain a network access for data. These systems rely on network connectivity to transfer data for analysis on a cloud server. This approach of cloud computing may yield better and more accurate results but are not feasible to implement in agriculture fields throughout the country. Hence, the cloud based system is ineffective for irrigation for the Indian agriculture system. Our proposed system is to create an autonomous irrigation system having a relay which will regulate the water outflow from the pump mainly depending upon the soil moisture. In this paper minimization of water usage by integrating automatic irrigation based on soil moisture and other variables such as humidity, rain and ground orientation is proposed. It not only reduces water consumption but also reduces the energy consumption and increases the efficiency of entire agriculture process.

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This automated irrigation system brings in a localised machine learning approach over the collected data from the different sensors, which analysed overtime to comprehend the changes in climate conditions and weather patterns. A localised machine learning approach would be beneficial because of the unavailability of internet connectivity in multiple regions across the country. The reliability of a cloud based system also comes into consideration because a network may have downfall which will affect the efficiency of the entire process. A closed system will be independent of any network issues.

II. LITERATURE SURVEY

Current techniques follow low level analysis and a fewer sensors, which makes the entire process less reliable and allows error in weather predictions. In Automatic Irrigation System on Sensing Soil Moisture Content [4], the system uses soil moisture sensor, temperature sensor and humidity sensor which doesn't account for various other parameters like topology of land which done by gyroscope. It also uses cloud integration as shown in Fig. 1 which depends on network stability but network connection in rural areas is unstable.

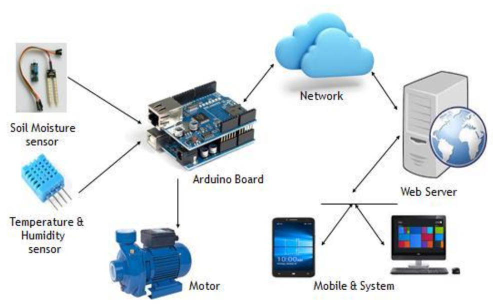

Fig 1. Architecture for automatic soil sensing system [4]

In design and implementation of automatic irrigation system using ARM7 [3], the system uses soil moisture sensor, humidity sensor and temperature sensor for input. These values are shown on the LCD display and the values are also sent to the user using wireless network technology like GSM and ZigBee as stated in [3]. The architecture for the system is shown in Fig 2. This system is not standalone and is network oriented and that is not feasible to set up in most rural areas of India unlike the proposed system.

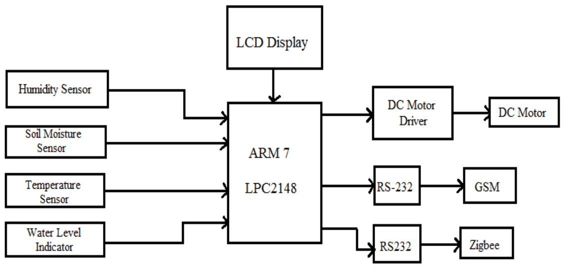

Fig 2. Architecture of automatic irrigation system using ARM7 [3]

Automatic Irrigation System Using Soil Moisture Sensor [2] uses a single sensor (soil moisture sensor) and regulates water outflow based on the soil moisture reading only as shown in Fig. 3. Multiple methods of flooding for irrigation is also reported in [2] but only soil moisture sensor based system is less than capable of getting all the parameter values to control irrigation system and thus, the irrigation system is not as effective.

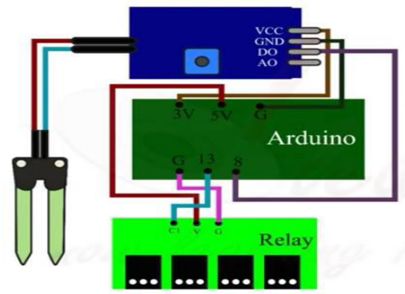

Fig 3. Architecture of Automatic Irrigation System using conventional flooding method [2]

III. PROPOSED WORK

The proposed system requires designing a system where soil moisture sensor and rainwater sensor is primarily used to determine the amount of water content in the field. Other sensors like humidity sensor, temperature sensor, barometer are used to predict weather conditions. The basic architecture of all the modules are shown in Fig. 4. By determining weather of a particular area patterns can be drawn out for rain, temperature and wind in the area. Predicting rain, temperature and wind will help in efficiently using the system as the system can be stopped if probability of rain is very high on a day. All the controller and sensors are divided into 4 modules:

A. Control Module

This module consists of Raspberry Pi and Relay as the Raspberry Pi is used to control the output of water using relay as shown in Fig 4. Raspberry Pi takes input from the different sensors and based on the moisture content of the soil and the weather prediction, it turns the relay which is connected to the water pump ON or OFF. Control module in other existing systems have older microcontrollers like PIC 16F877A [7] , AT89S52 [5] etc.

B. Ground Module

This module consists of Soil Moisture sensor and Rainwater sensor as shown in Fig 4. The moisture content in the soil is read by measuring the flow of current between two pins of the soil moisture sensor. The value comes out in mA. If the value comes to be more than 10 mA that shows that the water content is high in the soil. This value is sent back to the control module a shown in Fig 5.

C. Weather Module

This module consists of humidity and temperature sensor as shown in Fig 1. The values from these sensors are used in predicting weather. Humidity sensor has a substrate between two rods and the resistance of the substrate changes with humidity. This is reflected as output in terms of relative humidity (RH). Temperature sensor uses a thermistor which has a negative temperature coefficient. The resistance and temperature are inversely proportional. The output values are in degree Celsius. This module is also present in [3].

D. Terrain Module

This modules consists of gyroscope, barometer and wind sensor which can be seen in Fig 4. Gyroscope has 6 axes gyro sensor and it gives out reading for inclination angles of three axes namely X Y Z. This will help in determining the terrain of the field. Barometer uses capacitive circuit and outputs voltage which is dependent on the calibration of the circuit. Wind sensor gives wind speed as output. This will help in determining weather conditions as changing wind speed affects humidity in the area and also it will help in predicting rain which is shown in Fig 5.

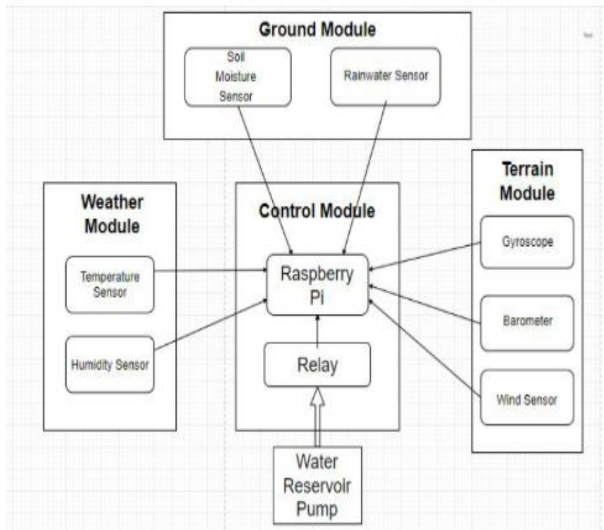

Fig 4. Block diagram for irrigation system

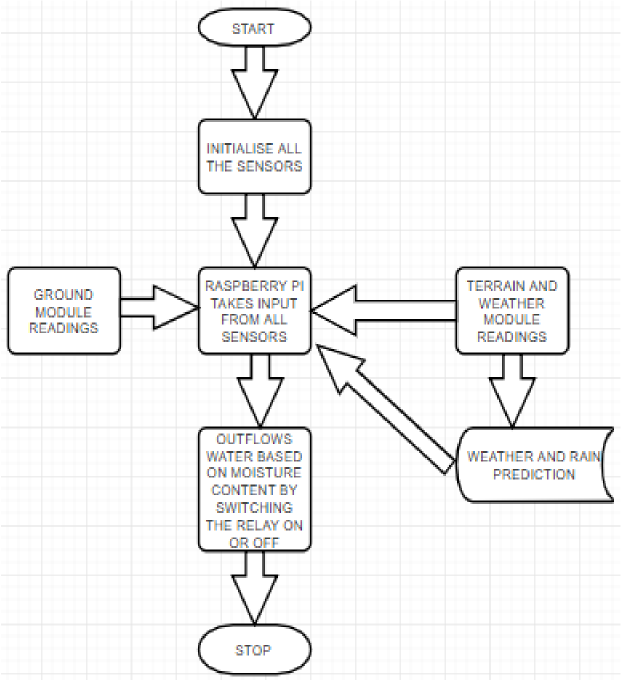

Fig 5. Flowchart showing working of irrigation system

IV. USE OF MACHINE LEARNING

The proposed system will also implement machine learning algorithms for rainfall prediction for both short term and long term periods. LSTM (Long Short Term Memory) neural network is implemented for rainfall prediction as it performs better than other models as stated in [10] and the predicted output is shown in Fig. 7 with comparison to real time rainfall dataset [10]. The input parameters used are atmospheric pressure, humidity, amount of rainfall, wind speed and temperature. These parameters are read by the sensors and tested against the real time downloaded dataset for training. Fig. 6 shows how the temperature value predicted is similar to the realtime downloaded temperature data [10]. For result analysis, two parameters are used. One is Mean Absolute Error (MEA) and the second one is Root Mean Square Error (RMSE) as shown in [10].

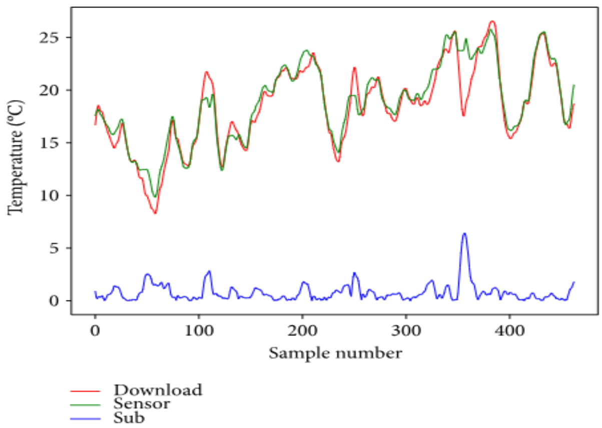

Fig 6. Comparison of predicted temperature [10]

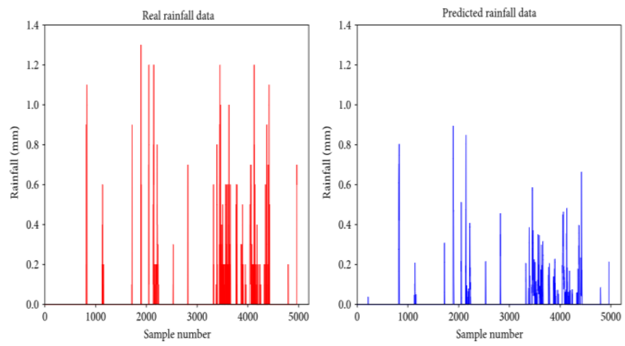

Fig 7. Predicted rainfall comparison [10]

V. SENSORS

A. *Soil moisture Sensor*

Soil moisture sensor measures the volume of water present in the soil. It measures the dielectric permittivity of the soil, which depends on the water content of the soil as more water in soil will lead to high permittivity. The dielectric permittivity is checked between the two sensor electrodes which are shown in Fig 8. This sensor will provide the current water content of the soil which will play an important role deciding the irrigation output for the pump. This sensor has been used in most of the existing automatic irrigation systems as shown in [1],[8] and [9].

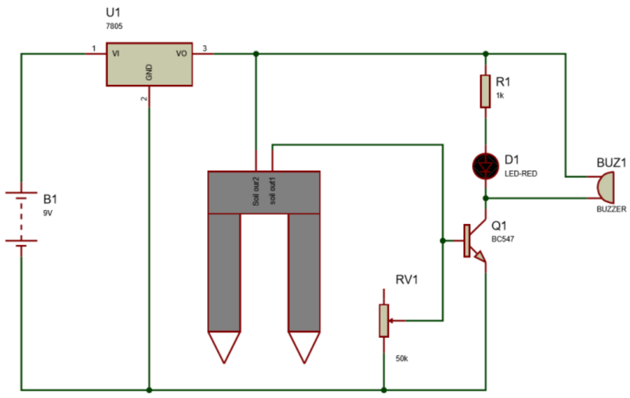

Fig 8. Circuit Diagram of Soil Moisture Sensor

B. *Rainwater Sensor*

This sensor will be used to measure the rainwater. It has a plate which collects data about raindrops falling on it and measures the precipitation by measuring the drops falling per mm^2 on the sensor plate. Rainwater is a factor in irrigation as it reduces the need of explicitly irrigating the field as it is a natural source of irrigation. Determining how much rainfall has been there would also help in determining whether how much further irrigation is required exactly or no further irrigation is required at all.

C. *Temperature Sensor*

It is a sensor which measures temperature. It uses only one wire for data signal. Thermistors are used in these temperature sensors. They have a negative temperature coefficient in which resistance is inversely proportional to temperature. It is extremely accurate and takes measurements quickly.

It has a 64-bit ROM which has its unique code stored on it. This unique code acts as an identifier for the microcontroller to know that the data is coming from this temperature sensor. It has a working range of -55 degree Celsius to +125 degree Celsius. Temperature sensing plays an important part in irrigation as higher the temperature would lead to faster drying of the soil needing more frequent irrigation.

D. *Humidity Sensor*

This sensor measures air humidity in the region. The result is given in relative humidity units. It has two electrode plates between which one moisture holding substrate is present. The moisture content of this substrate is proportional to voltage drop across the electrodes. This data is passed to the microcontroller. Humidity is also a crucial part of irrigation as the rate of transpiration in plants depend on the humidity of the region they are grown in. A dry region would lead to an increased rate of transpiration resulting in loss of water in plants and a humid region would lead to less intake of water from the ground which may lead to improper growth. This sensor will give us the data on the humidity of the region and that can be used to properly regulate the irrigation needs of the field.

E. *Gyroscope*

Gyro sensors are used in all kinds of gadgets like smartphones, smartwatches, controllers, etc. The gyroscope sensor used has 6 pins.

The values are usually the angles of different axes and combining these values we get its altitude. Thus, they are going to be used in the field to detect its orientation.

F. *Wind Sensor*

Wind sensor uses a linear potentiometer which can be seen in Fig. 9 to sense wind speed and direction. This potentiometer is attached to wind vane. This helps in predicting rain as shown in Fig. 5 and high wind speed will change the moisture content of the air which will lead to re-evaluation of the other parameters.

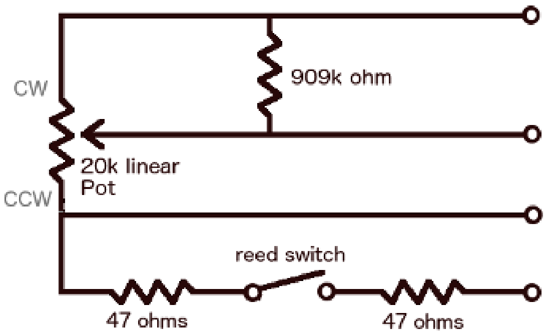

Fig 9. Circuit Diagram of Wind Sensor

G. *Barometer*

This sensor is of great use as a low cost sensing device. It has a 1.5 Pa resolution. Easy to use altitude meter with no calculations required. It has a temperature sensor with +/-1 degree accuracy. It is compatible with Arduino, Raspberry Pi or any controller with I2C interface.

VI. CONTROL MODULE

A. Raspberry Pi 3

This is the microcontroller which will control and analyse all the data coming in from the sensors. It will be used as the main controller and computation board. All the sensor data will be sent to it where different machine learning algorithms will analyse and produce the necessary action for the irrigation system.The Pi has a quad-core processor, WLAN, Bluetooth support and 1GB RAM with support for multiple sensors as shown in Fig. 10.

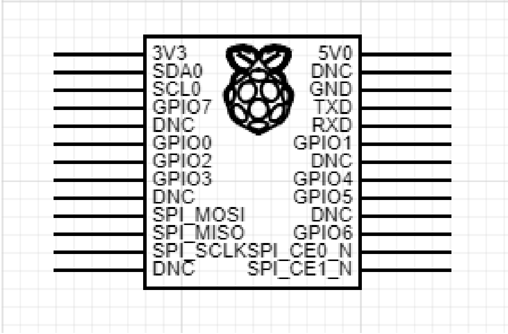

Fig 10. Circuit Diagram of Raspberry Pi

B. Relay

Relays are electrically operated switches that are controlled by a microcontroller as shown in Fig. 11. These device contains a electromagnet that is controlled by the providing a current. A relay will be used to control the water pump in the irrigation system. The system will send a signal to the relay which will turn the pump on or off.

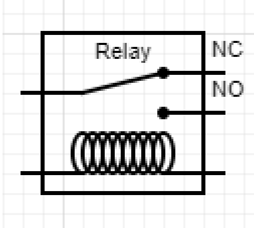

Fig 11. Circuit Diagram of Relay

VII. ADVANTAGES

The proposed system introduces several enhancements over traditional irrigation systems and recent automatic irrigation systems. These enhancements include standalone operability, hassle free installation, lesser manual labour, better performance and multiple modules to enhance quality of the crop production. This system is also cost efficient and doesn't require as much upgradation over a given period of time as other existing systems may require. Hence, the proposed autonomous irrigation system is better than the existing systems for irrigation in agricultural fields and many other areas like playgrounds, golf courses etc for water dissipation. The proposed system improves the efficiency of irrigation by implementing modules mentioned, which gives information about the type of field, its slope and also includes weather parameters to control water usage for irrigation.

VIII. CONCLUSION

This paper focuses on implementing standalone offline system for providing an autonomous system for irrigation. There are multiple areas of improvement which include finding out an efficient method to upgrade the system as an offline system poses the problem of lack of self-learning and robustness after a period of time.Some kind of arrangement can be done to make a hybrid system which periodically upgrades the system code on the control module via cloud but the inclusion of any such module in the proposed system will add to the cost and the cost effectiveness of the proposed system may decrease. Further, multiple modules can be added to make it a whole smart agriculture system rather than just focusing on irrigation system.

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1. M.Murali and Dr. R. Srinivasan, "Bandwidth Reservation in Mobile Ad hoc Network using Real-Time MAC Protocol", 563-566, ICFCC 2009, Malaysia. (available in IEEE explore)
2. M.Murali and Dr. R. Srinivasan, "Multi-Agent System for Distributed Data Retrieval using PQR Approach", International Journal of Computer Applications, ISSN: 0975 – 8887, Volume 29– No.3, September 2011

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