Design of a Low-Cost Sensor-Based IOT System for Smart Irrigation

Kunal Singh and Raman Kumar

1 Introduction

Water is the most precious resource in agriculture. As agriculture is fundamentally the most important sector of Indian economy, an appropriate measure to control and regulate constant supply of clean water at different intervals of time in a year is our utmost priority. It has been observed [1] through studies that the impact of climate change on the availability of water throughout the year is appreciable and has received much attention from scientific community in recent years. With ever-increasing population of India, the crop requirement would undoubtedly increase every year to feed this growing population, while the resources would remain limited. With the advent of new technologies and emerging sciences combined with recent researches, it is now possible to estimate the optimal resources required for a particular crop production, whether it is moisture, nutrients, or temperature of the field. It may be noted that in this world of competition, emerging technologies in the field of communication, artificial Intelligence, robotics, and actuation have flourished [2] beautifully and proved to be beneficial for the people of India and other developing countries. It is now possible to buy powerful computing devices inexpensively in these countries, and high cost is no longer a factor preventing the implementation of these technologies in smart irrigation systems. It may be noted that some of the Indian scientific communities, under ignorance and lack of

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adaptation to these emerging technologies, still perceive an advancement of technology with high cost and disregard the effective application of these smart irrigation systems in India. Such communities take for granted the availability of precious resource like water and neglect its scarcity in the near future. It may be noted that not only is the scarcity of water a threat for our crops, but also in a country like India where weather conditions turn around violently and storms and heavy rainfalls are prominent, an unregulated supply of water throughout the year has only proved to be a disaster for high-yield agriculture. It may be observed [3] that according to the United Nations (UN) Food and Agricultural Organization (FAO), our mother nature needs to produce around 70% more food by 2050, compared with its production in 2006 to not just satisfy but to barely feed our growing population. To achieve these goals, farmers as well as agricultural companies are diverting their attention to the Internet of Things [4] for analyzing the effective use of resources and achieving high production capabilities, so precision farming or smart agriculture is our only choice to flourish our future generation with adequate food. This chapter discusses a prototype of a smart irrigation system elegantly designed, considering the low purchasing capability of Indian farmers. A rope and pulley system has been designed to cover the crops with inexpensive canvases in case of storms or heavy rainfall. This canvas shed is controlled by an IOT-based control system, the design of which has been explained in detail in this chapter. The canvas shed can respond to different environmental conditions based on the analysis of the control system which takes decision depending on the data sent by different sensors situated in the field. This combination of low-cost mechanical actuation and sensory feedback control system in general can provide a sound platform for Indian farmers to begin their journey in precision farming and adapting IOT as a means for conserving precious natural resources, which may not be adequately available in the near future. The following sections explain the design and construction of the complete system in detail.

2 Literature Review

It may be noted that a framework [5] has already been set which utilizes the Internet of Things for smart irrigation. Such systems use heterogeneous devices, which are an integral part of the smart irrigation system and help monitor the system in real time. Also, the actuation of the mechanism is automated, based on the outputs of the sensors. There are also such systems [6] which aim toward autonomous monitoring of the irrigation for both large- and small-scale plantations using IOT. Such systems monitor the temperature and moisture content of the soil along with the detection of pollutants like $PM_{2.5}$ (particulate matter 2.5), PM_{10} (particulate matter 10), carbon monoxide, and NO_x (nitric oxide) in the air. Such an analysis helps in the estimation of a proper amount of fertilizer required by the crop and prevents unwanted toxicity to the soil. In another system [7], a process of autonomous irrigation in the urban gardens has been developed. It consists of multiple sensors and actuators in conjunction with Zigbee (A Wi-Fi shield for

Arduino microcontroller) for monitoring and controlling the system through a web portal in real time. The system can be automated, such that it prevents the watering of garden if there is a forecast of precipitation and the humidity of soil has not fallen below a critical value. In another system [8], a simple smart irrigation system has been proposed, which utilizes the solar energy for its operation and irrigation is automated using microcontroller. The status of irrigation is notified to the user's mobile using a Global System for Mobile Communications (GSM). It may be noted that such a system is simple and efficient in operation and does not require IOT technology. Another system [9], which utilizes a combination of GSM and IOT technology, proposes a design in which the temperature, moisture, and water level in the irrigation tank will be measured and sent to the user via GSM. The water pump is automated through messages on user mobile and an android application. The data of sensors are also being stored in cloud for analysis. In another system [10], a low-power consumption and long-distance transmission smart irrigation system has been proposed, which makes use of 6LOWPAN (Internet Protocol version 6 over Low-Power Wireless Personal Area Networks) to implement very low power transmission and networking. Another system [11] proposes a smart irrigation project, which is not only capable of monitoring the irrigation of a field but also checks the amount of the three major macronutrients, such as nitrogen (N), phosphorus (P), and potassium (K), of the soil. An ARM 7 Processor is used to control the system and all the sensors are connected to this controller. In this system, the user will be notified via an e-mail about the status of temperature, humidity, and macronutrient content of the soil.

In another system [12], a simple system is designed, consisting of Arduino UNO microcontroller board and ThingSpeak (open-source cloud platform) to sense the moisture content of the garden and to update regularly on the cloud in the form of a graphical representation. Such a simple system is effective and helps prevent the degradation of plants and helps maintain soil fertility for longer periods of time. Another author [13] proposes different models to supervise the moisture of soil to help Indian farmers in the irrigation of fields. Such models make use of several sensors and Raspberry Pi (a mini computer) to build intelligent systems for irrigation. In another system [14], open-source technologies are utilized to sense the soil parameters such as soil temperature and moisture to automate the irrigation of fields. This system also utilizes the data of weather forecast obtained through internet. The sensors involved also sense the amount of ultraviolet (UV) light radiation on the field. The system is based on the smart algorithm that utilizes the sensor data along with the data of weather forecast to decide and predict the requirement and level of irrigation in the field.

3 Design of a Smart Irrigation System

An IOT-based smart irrigation system must not only be capable of taking logical decisions based on sensory data, but must also be able to transfer these data reliably and wirelessly through cloud servers to any device connected to internet. The beauty of cloud computing lies in the fact that the data can be stored virtually on these servers and can be assessed by the user at any time or in real time. Figure 1 depicts the overall view of an IOT-based smart irrigation system. The system consists of three sensors, which are temperature sensor, moisture sensor, and rain sensor, out of which the temperature and moisture sensors gather information on the condition of soil while the rain sensor collects the information on rain.

The sensory data are sent to the IOT-based control system that wirelessly updates these data as well as the logical states of actuators to a mobile application connected to internet. It can be observed through Fig. 1 that the board is capable of taking smart decisions to protect the crop and can actuate the shed actuator and the water pump. The function of a shed actuator is to cover the crop with a shed in case of heavy rainfall or to cover the crop to prevent any unwanted evaporation from soil in case of dry and hot environmental conditions. It may be noted that all the logical conditions, which actuate the shed, have been fully illustrated in Fig. 2 representing the flowchart of the complete system. In Fig. 2, the middle portion of the flowchart represents the logical conditions under which the shed will actuate. As there are three sensors determining the condition of soil, the decision taken by the control system will depend on various combinations of these sensors' output. Therefore, the middle section of the flowchart can be divided into three parts. According to the program, one of the decisions is that the shed will be actuated when the moisture of the soil exceeds the preset defined value and it is heavily raining, in this case, the shed will get closed. It may be noted that this condition is independent of the temperature data. The idea behind this condition is to prevent the drowning of crops under heavy rainfall. The other condition is based on the temperature sensor data alone, that is when the temperature of the soil exceeds a defined value then the

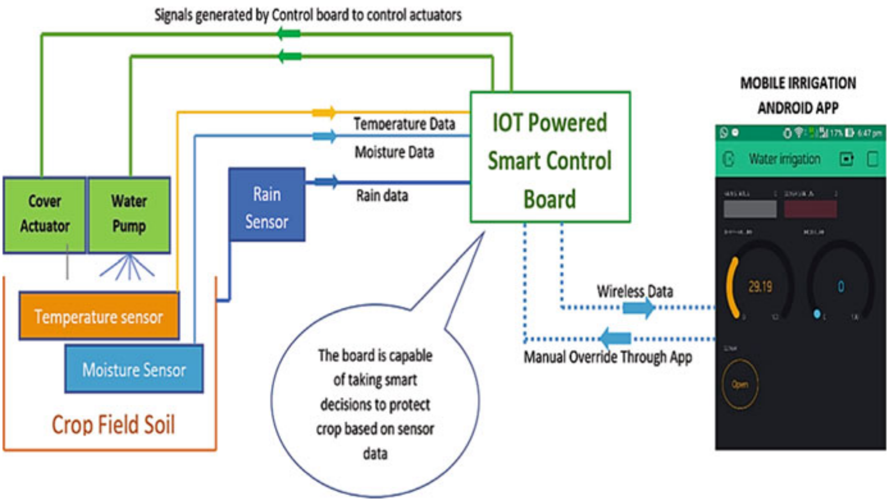

Fig. 1 Block diagram of IOT-powered smart irrigation system

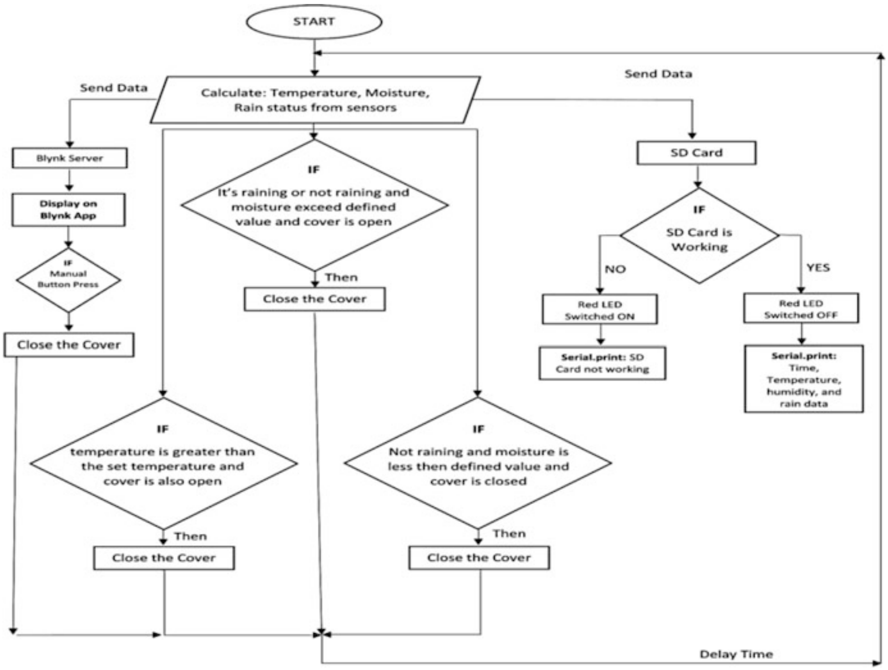

Fig. 2 Flowchart of IOT-powered smart irrigation system

shed will be actuated and get closed. This decision prevents the evaporation of soil under excessive heat of the sun. The other condition prevents the evaporation of moisture under minimum rain condition. In this case, the shed will be closed when it is not raining and the moisture is below the set value. It may be noted that the three decisions defined above represent the conditions which can be programmed in the control board based on the requirements of the farmer, depending on the environmental factors required by the crop. These conditions represent an intelligent attempt at the creation of an unmonitored smart irrigation system and can be expanded or deleted based on the personal preference of the farmer. As no change in hardware of the system is required to change these conditions, the system itself can be customized at very low cost. This feature makes this smart control board adaptive to a variety of different regions in India and also compatible with the crops grown in different seasons requiring different environmental conditions. It can be observed from Fig. 2 that the sensory data as well as the status of field actuators can be monitored on mobile application connected to internet. This is the core IOT feature of the smart control board, as the system can not only be monitored from any part of the world but the crop shed can be closed or opened by the farmer using the manual override button in the mobile application based on the visual indications of the sensory data. The application also helps the farmer to keep a check on the functionality of this smart irrigation system.

From Fig. 2, we can observe that sensory data are being stored in a memory card integrated in the control board. This feature allows the researchers to analyze the effect of environmental conditions on the production of crops; therefore, this system cannot only help improve crop production but also determine the factors that need to be controlled for better crop production.

4 Hardware Arrangement of a Smart Irrigation Control System

Figure 3 represents the block diagram of the smart control board. The board receives the data from the sensors and stores them simultaneously on a Secure Digital (SD) card. The control board also controls the outputs of the relay board and motor driver board, which controls the water pump and shed situated in the field. It may be observed that the relay board and motor driver boards are not integrated within the control board itself. The main reason to keep them separate is to enhance the adaptive capabilities of the control board. The power required by the water pump and field shed actuators depends on the wattage of the motor used, which, in turn, is different for different farmers. A small farmer growing medicinal plants might have preinstalled or preferred a small wattage motor for pumping water which will definitely save his money, while a farmer with large crop fields requires a high-wattage motor for irrigation. Therefore, the relay board can be replaced easily with high- or low-wattage relay board or even solid-state relays or Mosfets (metal–oxide–semiconductor field-effect transistors), etc., without affecting the working or design of the control board. Figure 4 represents the actual circuits of this smart irrigation control board in operation.

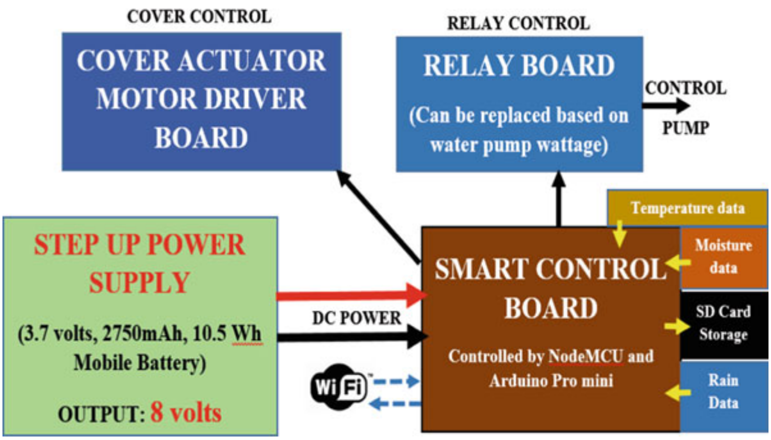

Fig. 3 Block diagram of smart irrigation control board

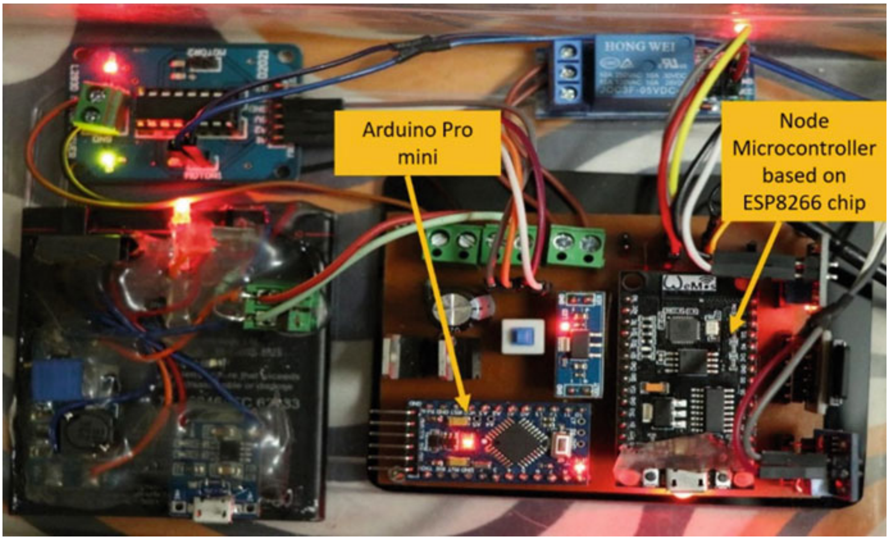

Fig. 4 Actual smart irrigation control board

The memory unit of the control board is a combination of two microcontroller boards of different architecture working in harmony with each other. The following two control boards are used:

- NodeMCU
- Arduino Pro Mini

The following sections describe the operation and working of these two micro-controller boards in this smart irrigation control board.

4.1 NodeMCU Microcontroller Board

The main control unit of this smart irrigation control board, which is equipped with inbuilt IOT capabilities, is NodeMCU [15]. It is an open-source IOT platform that contains a firmware running on an ESP8266 Wi-Fi system on a chip made by Espressif Systems [16]. The hardware of NodeMCU is based on the ESP-12 module. Originally, the microcontroller unit (MCU) needed to be programmed in Lua script. It may be noted that Arduino, which is an open-source software and hardware community which is popular for designing control boards based on the Atmel series of microcontrollers, has recently made changes in its IDE (Integrated Development Environment), so that its IDE can program NodeMCU. It may be observed that as DIY (Do It Yourself) community as well as researchers, hobbyists and electronic enthusiasts are more familiar with Arduino IDE for the development of embedded systems than the Lua script. With the capability of Arduino IDE to program ESP8266 controllers in its native Arduino C language, new doors were opened for the DIY community to explore this controller to its depth. The NodeMCU, used in this smart irrigation control board, has been programmed in Arduino C, which makes the programming much more adaptable and easier to understand for debugging purpose. NodeMCU and all the ESP8266-based microcontrollers work on 3.3-volt power supply; therefore, the sensors, such as temperature, moisture, and rain sensors connected to MCU, work on this 3.3-volt power supply.

4.2 Arduino Pro Mini Microcontroller Board

It may be noted that it is possible to connect a sensor pin to different microcontrollers and it does not affect the quality of data output from the sensor. This little trick expands the multitasking capabilities of an embedded system, that is, different operations can be performed based on the sensor data at the same time without indulging in interrupts. Considering the above advantages, the sensory pin of the moisture sensor, apart from being connected to NodeMCU, is also connected to Arduino Pro mini microcontroller board. A program fed in the Arduino Pro mini microcontroller board operates the water pump motor in real time by turning it on or off based on the moisture content of the soil, while the same moisture sensor simultaneously sends the data to NodeMCU which transmits it via Wi-Fi to an IOT application for display purposes. Also, as stated previously, both NodeMCU and Arduino Pro mini must work at the same voltage level, which is 3.3 volts in this case for the moisture sensor to deliver the exact readings to both these microcontrollers. Therefore, a 3.3-volt input supply is required for Arduino Pro mini. It is not advisable to use this 3.3-volt supply from NodeMCU itself as Arduino Pro mini is also connected to a relay board and any voltage surge, even for a millisecond, can disrupt the operation of NodeMCU. Therefore, a separate 3.3-volt power module (ASM1117) is used to supply this power, the input to this module is 5 volts and is supplied by a separate 7805 voltage regulator (5-volt step-down regulator) dedicated for this purpose only.

5 Detailed Overview of Sensors and Other Components

It may be noted that the most important components of the designed control board are the sensors, from which all the data of the soil are being transferred to the control board itself. The board consists of the following three sensors that transmit the sensory data to the NodeMCU and Arduino Pro mini.

- 3.3–5 volt raindrop (waterdrop) detection sensor
- 3.3–5 volt soil moisture detection sensor
- DS18B20 digital temperature sensor

5.1 Raindrop Sensor

It is a resistive sensor and is basically an easy way to detect the rain. It works on the principle of change in resistance between two metal wires when in contact with a common conductive liquid medium. This sensor consists of two parts, one is the base plate with a mesh of closely placed copper traces with little gap between them. The other part of this sensor is the operational amplifier board which has two outputs: one analog and other digital. As the resistance of the base plate changes when in contact with conductive medium such as rainwater, the output resistance from this plate is fed to the operation amplifier board which gives an output high or output low from the digital pin of the board. The board also consists of an LED (light-emitting diode) to give visual indication of the sensor output. When rain falls on the base plate, the resistance between the copper traces decreases and the output of the digital pin of the control board goes low which was initially high during no rain. The analog output of the amplifier board gives a relative measure of the amount of rain on the base plate. The sensitivity of the digital output can be adjusted using an on-board potentiometer. Figure 5 depicts the base plate and control board of the rain sensor. While the base plate is situated in the field, the board is connected to the base plate via wires which in turn is situated inside the smart irrigation control board, as shown in Figs. 3 and 4. The working voltage of this sensor is 3.3–5 volts depending on the control board type. If this sensor is attached to Arduino, then the base voltage provided by Arduino is 5 volts, but in this case, it is being connected to NodeMCU, whose base voltage is 3.3 volts.

5.2 Soil Moisture Detection Sensor

The control board of this sensor is exactly similar to that of the raindrop sensor, except the base plate whose shape is a bit different. The working principle of this

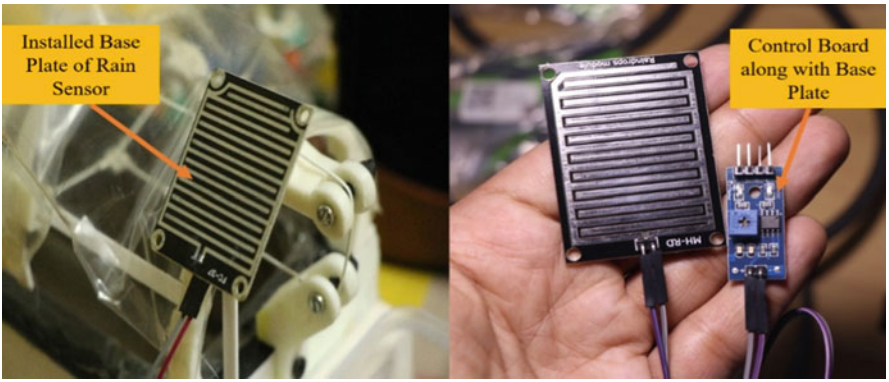

Fig. 5 Base plate and control board of rain sensor. Note that the control board is an electronic device and is needed to be kept separate from rain or water

sensor is also based on the change in resistance. It may be noted that the working current of both rain sensor and soil moisture sensor is less than 20 mA, so they consume less amount of power. This sensor comes in two flavors: one resistive and other capacitive. The accuracy of capacitive sensor is more as compared to resistive sensor, but this system is constructed using a resistive sensor, as it is quite inexpensive and serves the purpose of this system well. The resistive soil moisture sensor consists of two probes, which can be used to estimate the content of water in terms of its volume. The current is passed from one probe to another using soil as its medium. When the soil is wet, the resistance decreases and it indicates more water content in soil. It may be noted that the dry soil is a poor conductor of electricity therefore the resistance will be more. The main drawback of the resistive soil moisture sensor is the corrosion of probes. This drawback is solved using capacitive sensor which is made of a corrosion-resistant material. Figure 6 depicts the soil moisture detection sensor used in this system.

5.3 DS18B20 Digital Temperature Sensor

This is a digital temperature sensor [17] which is the waterproof version of the original sensor. It has an inbuilt 12-bit analog to digital converter. It can be easily connected to an Arduino digital input. It communicates with the microcontroller

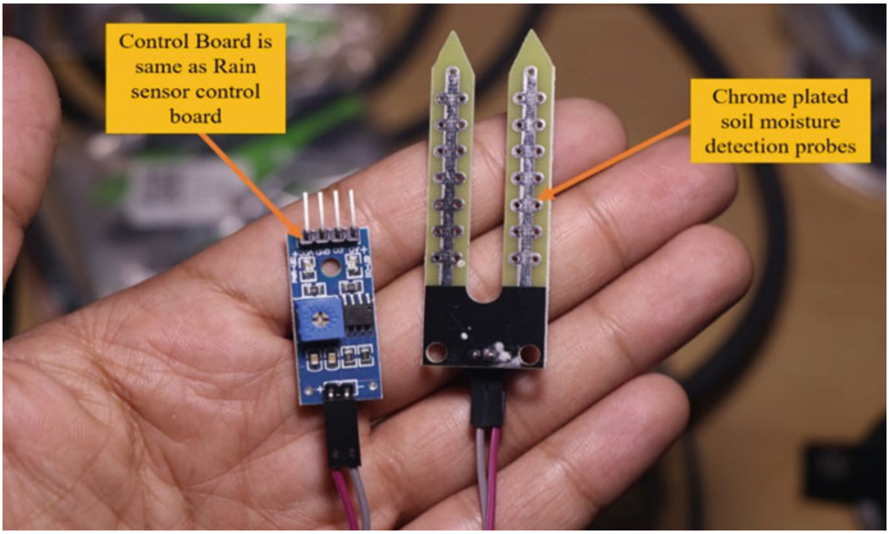

Fig. 6 Soil moisture detection sensor; note that the control board is the same as the rain sensor control board

Fig. 7 Waterproof digital temperature sensor used for temperature sensing of soil. (Image downloaded from https://components101.com/sensors/ds18b20-temperature-sensor on May 29, 2019)

using a single wire. It consists of three wires: ground wire (GND), input voltage wire (VCC), and data wire. It can work within a voltage range of 3.3–5 volts and has a temperature measuring range of −50 °C to +125 °C. The accuracy of this sensor is 0.5 °C. This temperature sensor has a wide range of applications and is usually used to measure the temperature in adverse environments. The waterproof version of this sensor is robust in nature and is appropriate to measure soil temperature in the field. Figure 7 depicts the temperature sensor used in this system.

It may be noted that the relay board, to drive water pump, is kept separate from the control board to make the system adaptable to the requirement of the farmer. The specifications of the relay board, shed actuator motor, and its driver as well as the mini water pump used are as follows:

5.4 Five-Volt Relay Board

This type of low-end relay board is mostly used to build prototypes and test the circuit. The relay module used here can switch AC (alternating current) as well as DC (direct current) power. Output AC rating of this board is 250 volt AC, 10A and the DC rating is 30 volt DC, 10A. It may be noted that such power rating is sufficient to run most of the lightweight pumps, but is not appropriate for heavy-duty pumps. The input to this module is simply connected to the data pin of the microcontroller. Figure 8 depicts the relay module used in this system.

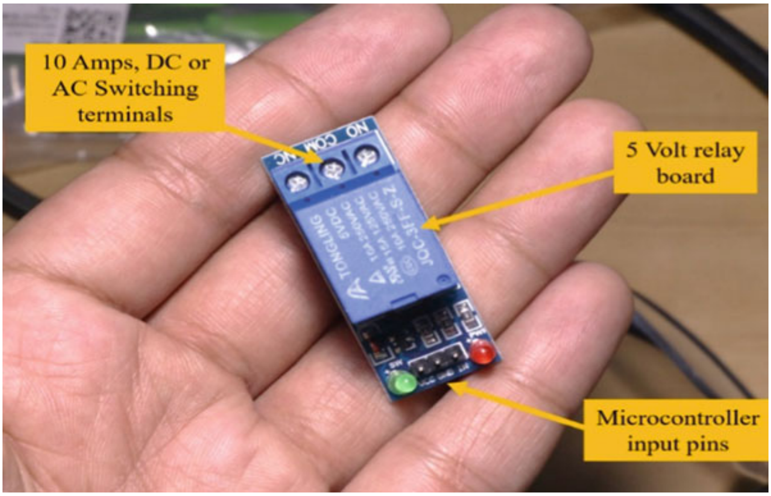

Fig. 8 The term 5-volt relay implies that it can be triggered directly via microcontroller pins working at the base voltage of 5 volts

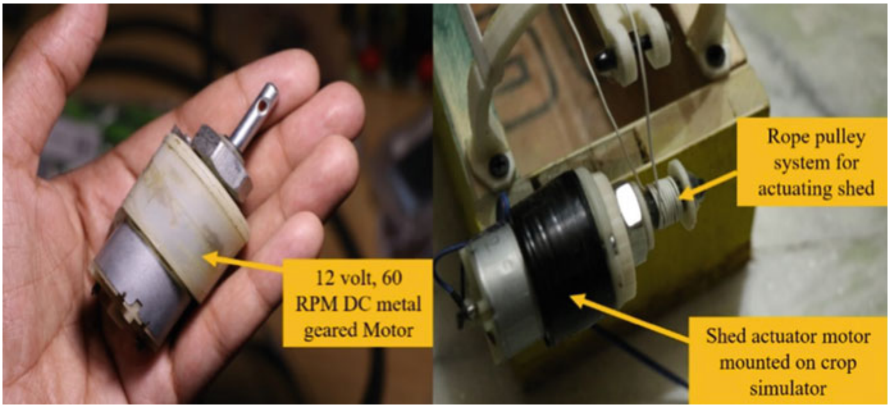

Fig. 9 Shed actuator motor (DC 12 volt, 60 RPM-geared motor) used for the crop simulator

5.5 *Twelve-Volt 60 RPM Direct Current Motor*

This type of DC motor is inexpensive and is used for testing and prototyping a control system. Figure 9 depicts the motor which is used to actuate the crop simulator. It is a geared motor with nylon or metal gears. The motor used in this system consists of metal gears.

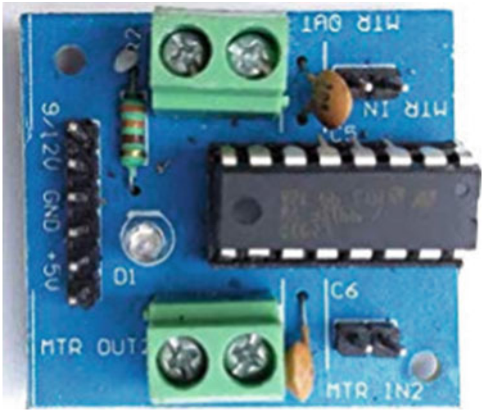

Fig. 10 L293 motor driver board. (Image downloaded from https://images-na.ssl-images-amazon.com/images/I/51wtGN3-mfL._SX522_.jpg, courtesy of Amazon.com)

5.6 L293D Motor Driver Board

This module is used to run medium power motors and is suitable for driving stepper motors or DC motors, as used here in this system. The integrated circuit (IC) used in this board is L293D which is an H-bridge driver. The board requires four data lines from the microcontroller which, in this case, is NodeMCU. It also requires a ground and 5-volt power connection from the microcontroller. The power to run the motor is separate from the power to drive the IC from microcontroller. This board can supply at most 12 volts with a DC current limit of 0.6A, which is sufficient to run the actuator motor used in this system. Figure 10 depicts the motor driver board used in this system. It may be noted that this H-bridge driver board can drive two DC motors simultaneously and has the capability to change the direction of motors.

5.7 Mini Submersible Water Pump

The mini submersible water pump is mostly used in small projects to simulate irrigation. Here, it is used to test the control of the smart irrigation control board. It may be noted that the voltage rating of this pump is 3–6 volt DC and the working current is around 130–220 mA. It consumes little power, ranging from 0.4 to 1.5 watts and is suitable for such simulation and testing of this smart irrigation system. The flow rate of this pump is around 80–120 liters per hour. Figure 11 displays this motor used for the simulation of irrigation.

As discussed, all the sensor data are being stored on an SD card. An SD card reader module holds the SD card that stores the data. The specifications of the module are as follows:

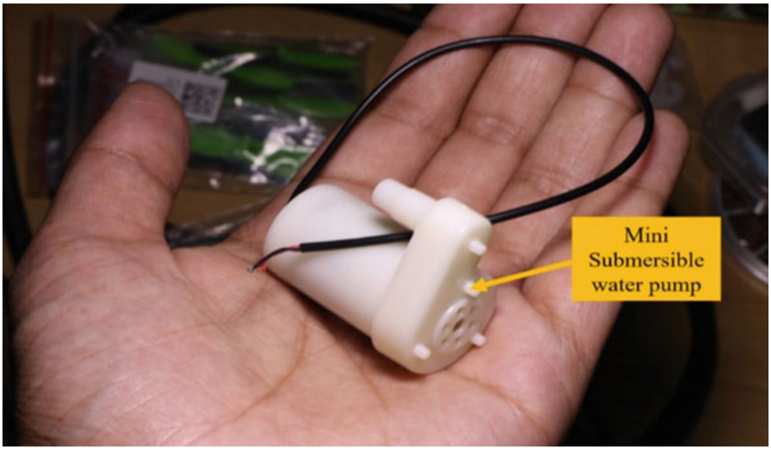

Fig. 11 Mini submersible water pump used for pumping water in the plants of the simulator to maintain the moisture level

5.8 SD Card Module

This module is interfaced with microcontroller via serial peripheral interface [18]. It consists of data pins like MOSI, MISO, SCK, CS and power pins like VCC and GND. The data from the sensors are being transferred through synchronous serial communication, which is suitable for short-distance communication, especially in embedded systems. This module works on a 3.3-volt power supply, which is being supplied directly from NodeMCU. Figure 12 depicts the SD card module used for this system. The control board is programmed, such that the sensor data are stored in the excel file in the form of a table. The control board is programmed, such that the time interval between sensor data readings, which are being stored in the SD card, can be stored in a text file within the SD card itself. The program stored in the control board reads the time interval from this text file itself.

Another important part of the system is the power supply for the control board. Complete specifications of this control board are discussed below:

5.9 Power Supply

The complete system, that is, the control board, sensors, relay board, water pump, shed actuator, and motor driver, is being powered by step-up power supply developed from a mobile lithium-ion battery whose specifications are 3.7 volts, 2750 mAh, which is around 10.5 Wh. The voltage is stepped up using a step-up

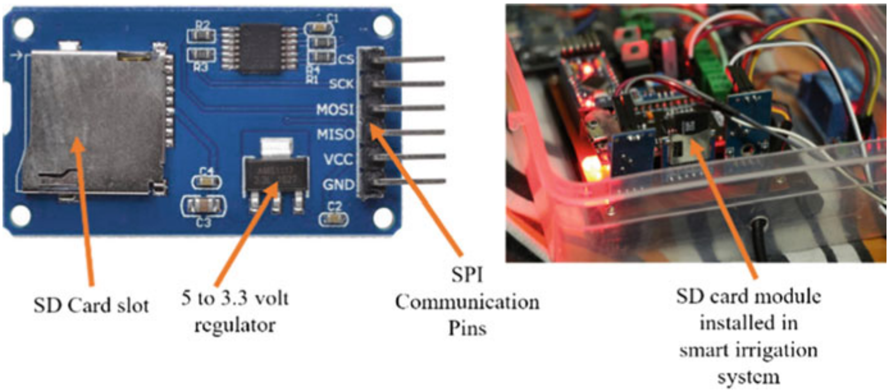

Fig. 12 SD card module used in smart irrigation systems

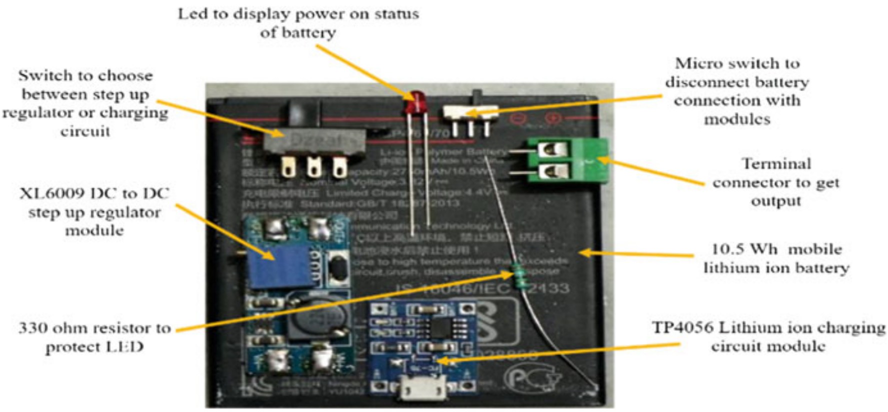

Fig. 13 Components of power supply system

regulator (XL6009 DC to DC step-up module), also a lithium-ion charging circuit based on IC TP4056, which is being used to charge the battery when discharged. This power supply system is specifically developed for this smart irrigation system, to serve the power requirement of the system for long hours. It may be noted that in actual conditions the power supply for water pump and shed actuator and its driver has to be different due to high-wattage requirement. Figure 13 depicts the disassembled view of the power supply system developed for this smart irrigation system.

This system is designed and developed in EagleCAD software [19]. It is a well-known reputed printed circuit board (PCB) designing software from AutoDesk, which is an American multinational software corporation. Figure 14 displays the schematic of this system in detail. Figure 15 depicts the single-sided PCB board layout of the smart irrigation system.

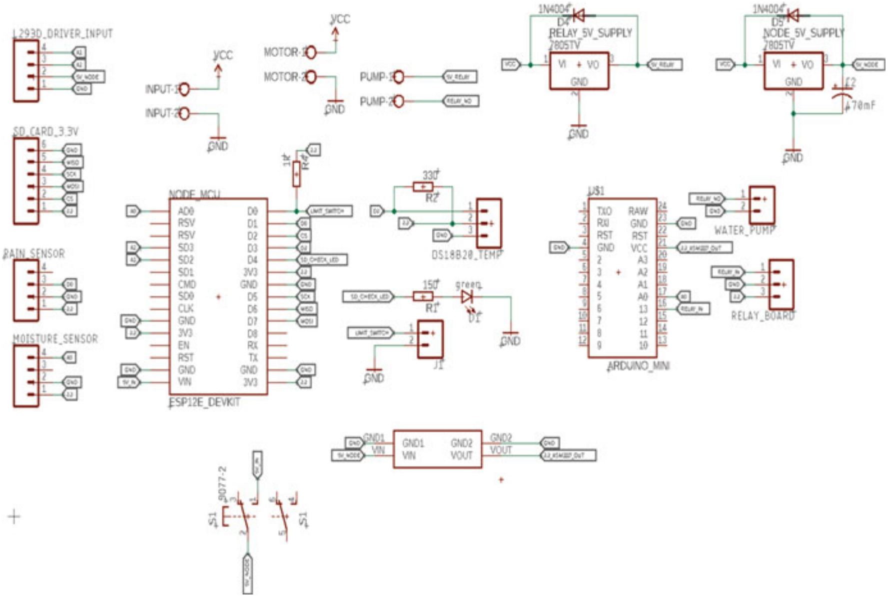

Fig. 14 Actual schematic diagram of IOT-based smart irrigation control board developed in EagleCAD software

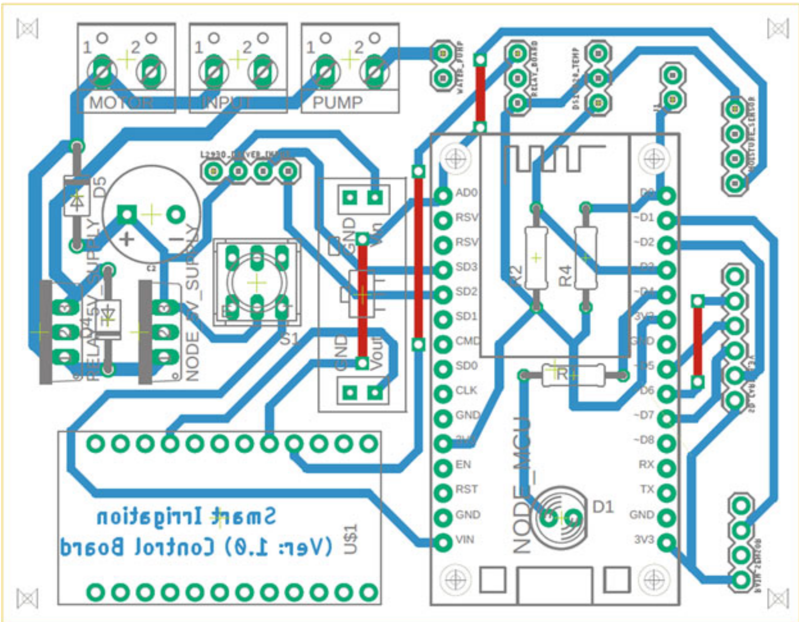

Fig. 15 PCB layout of IOT-based Smart irrigation system developed in EagleCAD software

6 Mechanical Components of the Crop Simulator

Figure 16 depicts the computer-aided design (CAD) model of the crop simulator. The idea is to develop a mechanical system that is inexpensive and effective. It should also be a system that can cover the crop rapidly and is reliable. A miniature prototype of the actual mechanical system has been developed to mimic the system, which can be applied in the field itself. It may be observed that the rope and pulley mechanism, which can drive a canvas rapidly, that is, open or close it, is quite effective as well as inexpensive. In the CAD model, railings or smooth rods as shown serve the purpose of guide rails for the canvas. An angle slide helps move the canvas on the guide rails and motor mounted on the shed actuator motor mount helps move the angle slide bidirectionally. As one end of the canvas is fixed to the mounting and the other is fixed to the angle slide, a bidirectional movement of the angle slide causes the canvas to open and close rapidly with the movement of angle. It may be noted that this mechanism is not only inexpensive but also easy to install as well in medical fields or other plantation areas where high-value crops or plantation is grown and it is very important to protect the field from natural disasters.

The parts of this miniature crop simulator, such as rope pulley brackets, motor mount, and mountings, etc., are three-dimensionally (3D) printed from acrylonitrile butadiene styrene (ABS)-based filament using the fused deposition modeling technology. The infill [20] (amount of plastic within the part) of these parts is kept to 100% for maximum strength, as these parts have to bear the tension of ropes during the motion of angle slide and canvas shed. It may be noted that in reality these parts will be constructed from wood or metal for large fields for optimum strength and reliability. However, the future is not far ahead when such large and complex

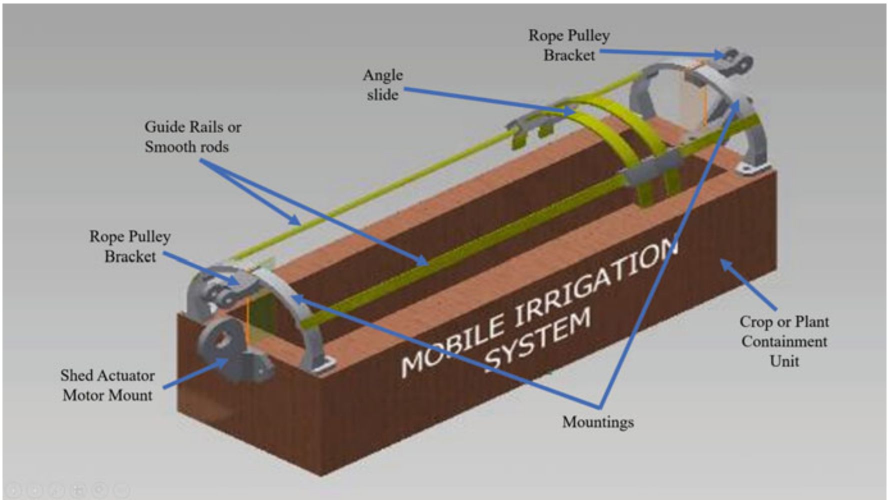

Fig. 16 Crop simulator mechanism developed in Autodesk Inventor Professional software

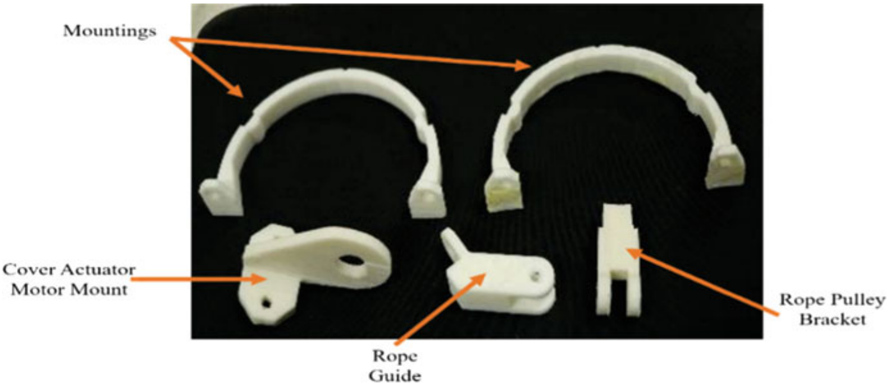

Fig. 17 3D printed crop simulator parts printed using 100% infill

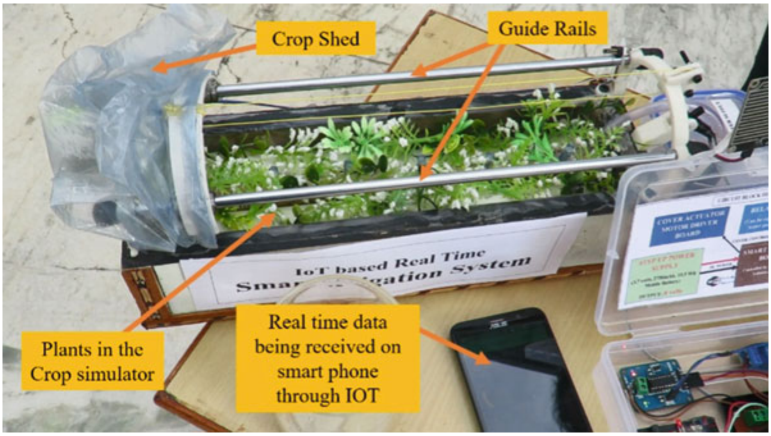

Fig. 18 Actual simulator with plants

structures can be printed using 3D print technology. The 3D printed parts, printed for the miniature crop simulator, are shown in Fig. 17.

Figure 18 depicts the actual simulator developed to test the working of a smart irrigation control system. It may be noted that for this miniature simulator, the shed is composed of a thin plastic sheet and an angle slide, as discussed in Fig. 16, is made out of cuttings of a polyvinyl chloride (PVC) pipe. The environmental conditions are being controlled for the plants grown in this miniature simulator, as shown in Fig. 18.

7 Cost Estimation and Implementation of Design

The cost associated with this system can be broadly classified into two parts. One being the cost of control board and the other being the cost of mechanical system required to implement the design. It may be noted that the cost of control board and sensors is fixed and may be minutely increased, based on the requirement of few additional sensors depending on the field area. However, the cost of a mechanical system employed in the field can vary drastically depending on the field size. For medicinal or experimental plantation, the mechanical system cost is quite low. However, for large fields a robust and low-maintenance mechanical system to control the shed needs to be employed. Such systems may require a high-torque Synchronous or AC induction motors as an actuator to run the shed mechanism. Also for large systems, relays are required, instead of motor drivers. It may be noted that simple smart irrigation systems are already available in the Indian market as well as globally. However, the technology of irrigation involving IOT has not yet reached its market potential in India and is still a topic of research and analysis. The total cost of the smart control system, as proposed in this chapter, is around 1500/− rupees which can be further scaled down under mass production. Comparing the cost with that of a similar system such as "SMARTDRIP" [21], available in the Indian market with an MRP of 4399/− rupees, it may be observed that the proposed system is cost-effective.

8 Pros and Cons of the System

Every innovative system when first designed for practical implementation in the market faces some difficulties and objections. Such systems surely have some advantages as well as disadvantages. The system as proposed is IOT based and is designed to make use of cloud servers to send and receive control signals to control the system. Such a control system requires Internet connection at both ends for operation. It may be noted that in a country like India, the Internet connection may not be available always in the fields, especially during heavy rainfall or storms. However, it is expected that in a growing economy like India, this problem will be totally eliminated in the near future. The advantage of having IOT as a means of communication is that the system can be operated from anywhere around the globe. The disadvantage, however, is the nonavailability of Internet connection, as discussed above. Looking at the cost, the system has an advantage of being inexpensive, considering the technology involved. It may be noted that the current system, as proposed, is not IP66 certified and needs to be encased in IP66 standard encasing for weather- and waterproofing. Such casings are easily available in the market and are inexpensive. Also, the circuits and components involved need to be of Industrial grade for additional reliability and long life. Such implementations need to be considered before actual mass production of the system.

9 Conclusion

In this chapter, we discussed the design and construction of a smart irrigation system which is IOT based and inexpensive in nature. In the upcoming future, where resources will not be plentiful, such systems can act as a good choice for an Indian farmer to understand and farm in a scientific way. As the technology is becoming inexpensive day by day and India is the leading customer of mobile phones, it is not only good in terms of effective use of technology but is also inexpensive for an Indian farmer to save the destruction of crops using this advanced technology. It may be concluded that with the advancements in virtual and sensor technology, it is fairly easy to build such smart irrigation devices and even easier to use these devices. It may be concluded that the IOT can play an important role in the design and development of such systems. With the help of IOT devices, it is possible for a farmer to not only monitor the status of his crops but also control and prevent the crops from unwanted destruction from anywhere in the world. It may be observed that unleashing the true potential of IOT in the field of agriculture is not only one of the best ways to save precious resources like water in the upcoming future but also to regulate the proper supply of these resources in accordance with the requirement of crops. With more advancements in such a smart irrigation system, it may also help farmers to grow crops in adverse conditions. Such a development may require the use of artificial intelligence in combination with IOT and is the subject of future research.

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