Research Article

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Solar power based automatic irrigation system

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Abstract
In recent days, the scarcity of power and water has become a major challenge in the field of agriculture. The traditional techniques used in agriculture are still needed major improvements in the direction of multitasking on many concerns like observing the water level periodically, natural resource utilization, and soil health analysis. In this paper, an automatic irrigation system based on the Internet of Things (IoT), solar power, sensors, and the embedded controller is implemented. The smart irrigation system proposed here is to support people who are involved in agriculture in terms of effective utilization of natural resources like solar energy and water resource. By using smart irrigation systems people can overcome the problems of scarcity of electricity and water wastage. The proposed design is found to be effective and efficient for the small irrigation areas.

Keywords
IoT, Moisture sensor, Rain sensor, Microcontroller, LDR, Irrigation system.

1.Introduction
In India, agriculture is the major sector in terms of water consumption. As the population increases water consumption and water wastage also increase. In order to avoid this problem, an efficient automated irrigation system is required which is based on the Internet of Things (IoT) [1]. In rural areas there is a scarcity of electricity, this can be overcome by using solar energy. Solar energy is used to generate electrical energy using a solar panel. A solar panel produces Direct Current (DC) electricity. Solar panel contains Photovoltaic (PV) cells, which convert light energy into electric energy [2]. It is important to measure the moisture content in the soil to help farmers to manage the irrigation system more effectively. The soil moisture is measured using a sensor by dipping into the soil. When the water level is low in the field, the motor starts automatically to pump and vice versa [3]. The system can also be automated using a Microcontroller which accepts the signals from the sensors and provides the commands to do the respective work [4].

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2.Literature review
2.1Solar Powered based irrigation system
The scarcity of electricity is one of the big issues in the agricultural field. This problem can be overcome by making use of solar energy which is renewable energy and abundant in nature. The electric energy is generated by solar energy using solar panels. This electrical energy is used to power the submersible pump to pump and store the water. The system is driven by using a sufficient amount of power generated by solar energy. The Solar tracker system in such a way that it tracks the movement of the sun in a bi-directional pattern. Output power received from the solar panel by tracking the sun movement is usually higher than the power received from the panel without tracking [5]. Due to the scarcity of electricity, fossil fuel-based water pumping system is used for irrigation purpose. The alternative to the fossil fuel, water pumping system is the automatic solar energy water pumping system. The converted energy from the solar cells can be stored in an external battery [6].

2.2Sensor based irrigation system
The temperature sensor and soil moisture sensors are used in the irrigation system to avoid water wastage. The moisture content in the soil is detected by using a soil moisture sensor. When the temperature and the moisture are high and low respectively, then the water

flow will be high and vice versa [1]. The moisture sensor and Potential of Hydrogen (pH) sensor are used in the irrigation system where the moisture level is measured by using a moisture sensor and the pH value is measured by the pH sensor in the soil [2]. The Moisture sensor, Humidity, Temperature sensor, and ultrasonic sensor are used to sense the data like Moisture content, humidity, and temperature level in the soil and water level of the reservoir [4].

2.3Microcontroller based irrigation system

The Microcontrollers are used to automate the irrigation system. The whole system can be controlled by the microcontroller. The main heart of the irrigation system is the microcontroller. The sensors send the signals to the microcontroller Based on these signal's microcontroller gives the commands to do the particular function. A Programmable Interface Controllers (PIC) Microcontroller is used to control the whole system moisture sensor detects the level of moisture in the soil if the moisture level is decreased PIC microcontroller sends a command to switch ON the pump. A PIC Microcontroller accepts the signals from the sensors and gives the commands to the submersible pump which is used to pump and store the water. The water will be supplied to the crops by a drip irrigation technique using a microcontroller [2]. The complete operation is automated using an embedded controller. The KL25Z embedded microcontroller is used. When the soil moisture sensor level, which is placed in the field is low, then the controller gives the signal to display and also which makes the motor to switch ON. The ON/OFF status of the motor is indicated using LED. This ON/OFF message is displayed by using a Liquid-Crystal Display (LCD) display. Because of this system, the overflow of water is reduced in the field [3, 7]. Atmega328p microcontroller is used to automate the system. The soil moisture is maintained using the motor within the range of moisture threshold value [8].

2.4IoT based irrigation system

An IoT based irrigation system is driven by fuzzy logic. MATLAB platform is used to implement the designed system based on the Mamdani fuzzy controller. The fuzzy rules are applied to control the flow of water from the motor which helps the irrigation for the proper growth. The ZigBee based wireless network is applied widely in the system for real-time applications [1]. A smart irrigation system monitoring and control features are designed and implemented by using the Internet of Things. The ESP8266 is the main controller of the system. Then it will cut off the pumping. ESP8266 is used to connect the system to the internet it supports a WIFI connection and the cloud is integrated so that it can connect to an Android phone [7]. All the real-time values can be fetched and displayed on the application. SSIS is the Android app developed in this system. The SSIS is an efficient and cost-effective alternative to the manual irrigation system [9].

3.Proposed methodology

Figure 1 shows the diagram of the proposed system. The Arduino Mega microcontroller is employed to automate the operation which has Wi-Fi enable ESP8266 chip on it. A soil moisture sensor is employed to measure the extent of moisture present within the soil. The rainfall is detected using the raindrop detection module and this sensor is also used to measure the intensity of rainfall. Even this sensor can be used for monitoring the weather condition. The water level of the tank can be measured using the water level sensor and based on the output of the water sensor the controller may actuates either the pump, an indicator, an alarm, or any other device. A submersible pump is used to pump the water to the land. The pump is activated based on the output of the moisture sensor. The Light Dependent Resistor (LDR) is used to detect the intensity of the light. This is useful to maintain the intensity of the light in the form which helps in maintaining the proper growth of the crop. To utilize the natural resource, the solar panel is used to provide the sufficient power to drive the motor.

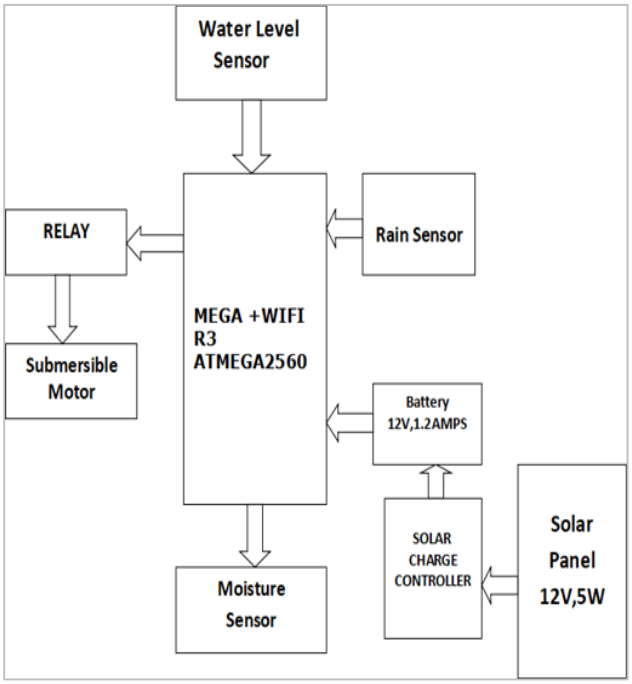

Figure 1 Block diagram of the proposed system

4.Results and discussions

Figure 2 illustrates the flow of the proposed system. When the moisture sensor value drops below the threshold value, then it sends an alert to the controller. Then the controller turns on the motor which intern pump the water to the farm. Once the water level reaches the threshold level, then the controller turns off the motor to stop the pumping. Whenever there is rainfall, rain sensors will detect it and sends the notification through the Blynk app. The solar panel is used to power the motor. A 12V 7AH rechargeable battery is being charged by the 10 Watt 12V solar panel and the same battery is used to start the motor. The stored energy can be used during night time.

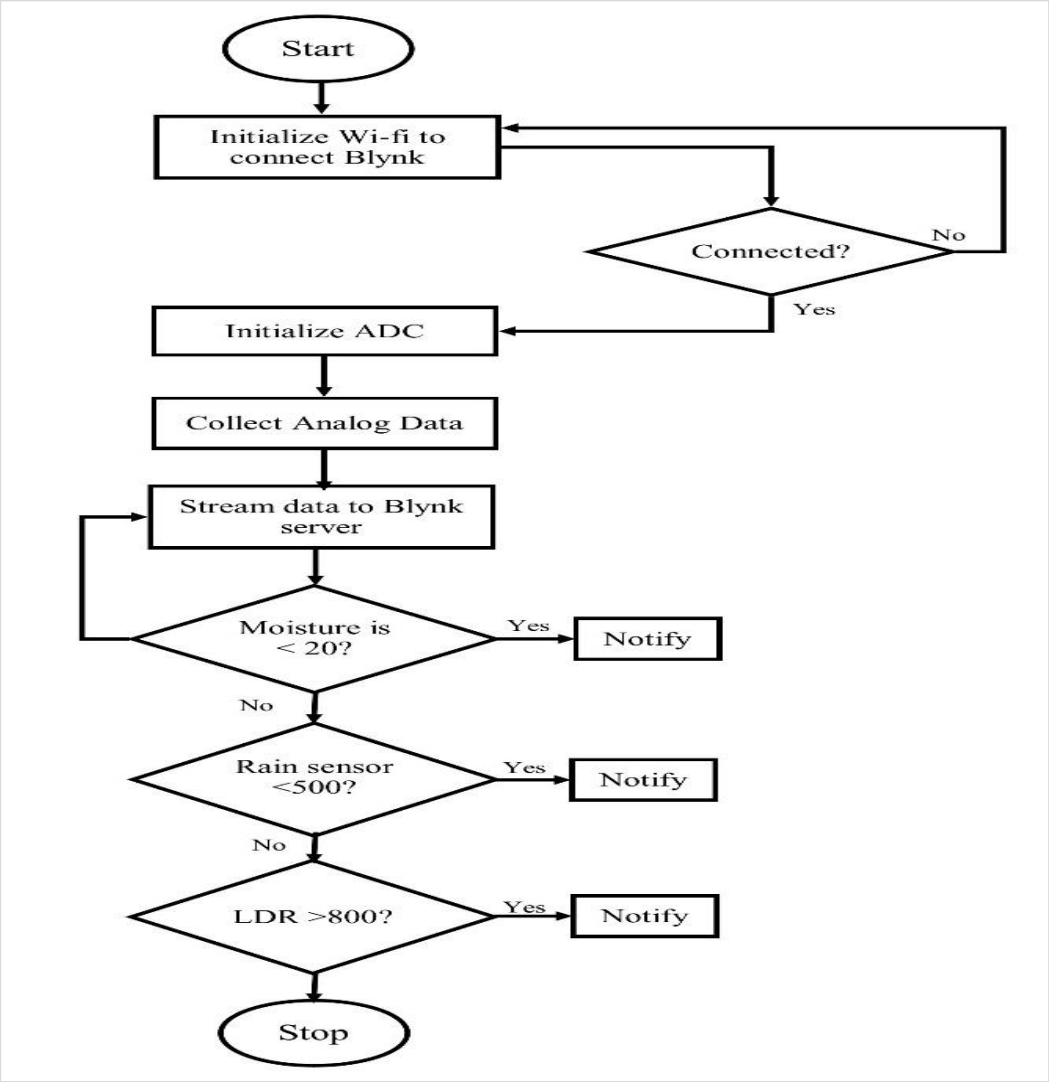

Figure 2 Flow diagram

The water level is measured by the water level sensor whenever it drops below-set the value it will send an alert to the microcontroller. LDR is used to detect the intensity of light and it will help to provide artificial light for the development of plant growth. ESP8266 is used to connect the system to the internet. It also supports WIFI connection and the cloud is integrated so that it can connect to an Android phone via the Blynk app. All the real-time values can be fetched and displayed in the Blynk app. Even module's control is possible if the user requires it. Rain is detected by using a Rain sensor. If the rain is detected it will appear in the Blynk app as Raining. The intensity of light is detected using LDR. If the intensity of light is low it will appear in the Blynk app as Low light.

The *Table 1* shows the moisture results recorded on different time lines and a threshold are used to turn-on or turn-off the motor for watering the crop. If the sensor value is less than the threshold the motor will be continued to be off and the motor turns on when the sensor value becomes greater than the threshold value.

Figure 3 shows the implementation of solar powered irrigation system. *Figure 4* shows the soil moisture sensor and moisture content detected. *Figure 5* shows the rain sensor and its detection mechanism. *Figure 6* shows the water level sensor detected the tank water level.

Figure 3 The implementation of solar powered irrigation system

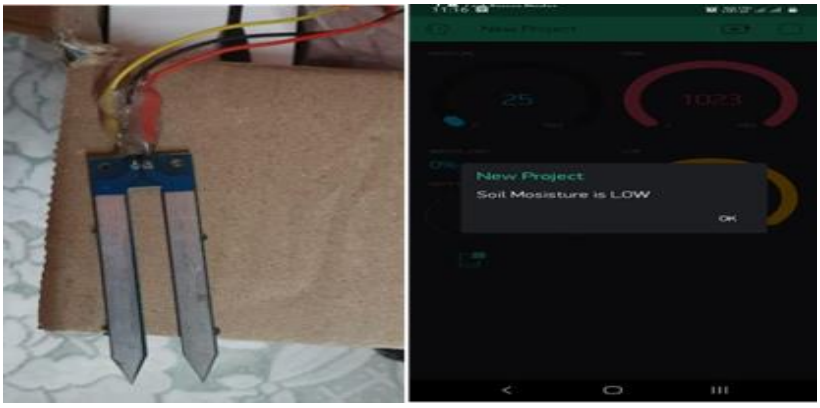

Figure 4 Soil moisture sensor and moisture content detected

Table 1 The moisture test results

Time	Moisture
08:00AM	22.3
10:30AM	25.5
11:30AM	30.8
12:30PM	32.4
1:30PM	31.3
2:30PM	30.2
3:30PM	29.9
4:30PM	30.1
5:30PM	26.3

The *Table 2* shows the rain sensor test values recorded in different time lines for one week. The threshold for rain sensor is 500. The rainfall is detected when the sensor value is less than the threshold and no rainfall is shown when the value is greater than the threshold.

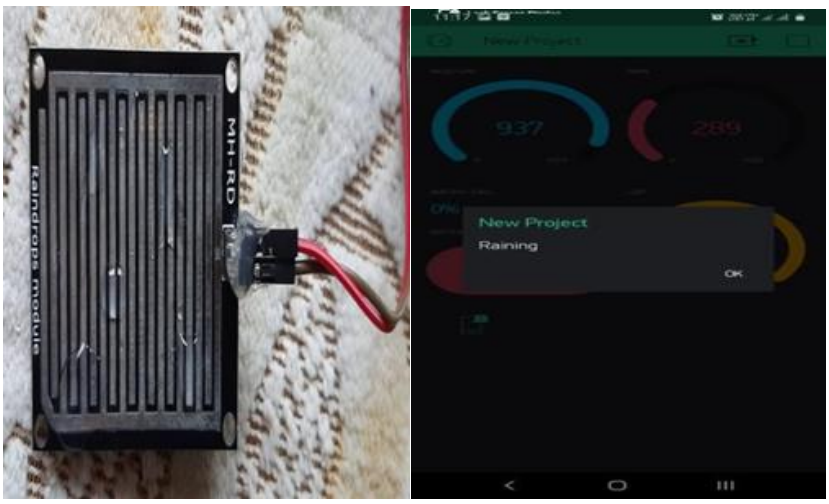

Figure 5 Rain sensor and its detection

Table 2 Rain sensor results in one week

Time	Rain sensor output
Day 1	1024
Day 2	1020
Day 3	870
Day 4	890
Day 5	560
Day 6	900
Day 7	1020

A water level sensor is used to measure the water level in the tank. If the water level is below the threshold value it sends signals to the controller to pump the water. IoT is implemented and notifications are sent to the user through the Blynk app. A solar grid is utilized to supply the power to the system.

Limitations

The proposed system can be used in small irrigation systems like small crop area where the drip system is used. Though the system has many advantages, for large irrigation systems the initial cost would be high. And to maintain the supply power during the night it may require an extra power storage system.

Figure 6 Water level sensor detected the tank water level

5.Conclusion and future work

The proposed system helps the farmers to use solar power to drive the system and it reduces the dependency of power supply from the grid. It saves electrical power by using solar energy. Because, the system is completely automated and there will be no wastage of water. This is a user-friendly irrigation system that provides real-time information to the user by using IoT technology. Automating the process of agriculture is still a challenging task because of the difficulty in its implementation and also imparting the technical knowledge of the system to the farmers.

Acknowledgment

None.

Conflicts of interest

The authors have no conflicts of interest to declare.

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