An IoT based Energy Saving Automatic Watering System for Plants

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ABSTRACT

Any agricultural activities, be farming or gardening, require watering. Many parts of the world, due to climate change, are going through a severe crisis of water shortage. To address this issue, this project-based research is implemented using the Arduino ATmega 328p chip-based microcontroller system and Internet of Things (IoT) technology. It is programmed in such a way that it can detect the moisture level of the soil and then automatically supply water to plants only when necessary without any human intervention. The main objective of this study is to develop an automated watering system that can control the water supply, conserve water, and save energy. This system can be used for both small and large plants and people can enjoy growing plants without being worried about forgetfulness or going away for a vacation. The system has been tested to function automatically. All the sensors are working perfectly well – the moisture sensors measured the moisture level accurately, while the water level sensor detected the water level properly.

Keywords*:* Water supply; Irrigation, Moisture; Internet of Things; Arduino, Sensor; Automatic; Self-Watering

1 INTRODUCTION

AGRICULTURE is the most important sector for the socio-economic development of many countries. Farmers and gardeners are dependent on the rains and bore wells for irrigation of the land. Many urban people are growing houseplants as part of their hobbies or for health benefits. Researchers [1] have suggested to have indoor plants in offices to increase the productivity of employees. However, due to their busy schedules, they are unable to water their houseplants on time, or can't water when they go away for a vacation. Also, the unplanned use of water inadvertently results in wastage of water. Farmers, gardeners, and employees in offices all share a common problem – which is watering plants properly and keeping them alive. For watering plants, manual intervention is required to turn a manual water pump ON/OFF whenever needed. They need to pump water and wait until the soil is properly watered, which compels them to stop doing other important activities. This problem can be perfectly resolved if we use an IoT based automated watering system that will water plants only when the moisture in the soil is identified as low. This can save a lot of water, energy, and reduce the expenses in irrigation [2][3].

This project uses a microcontroller to control the flow of water by using sensors for detecting soil moisture and water level. The soil moisture sensor measures the level of moisture in the soil and sends the signal to the microcontroller. If water is required, the water motor supplies water to the plants until the desired moisture level is reached. The system has also a feature of using SMS messages to notify the owner if there is a lack of water in the main water source. This automated watering system not only will help the farmers or household gardeners to water efficiently but also will work in all climatic conditions. As the Internet of Things (IoT) has become the center of attention for most researchers, various researchers have worked on automated irrigation systems. Many researchers [4],[5],[6],[7],[8] proposed various automated irrigation systems to solve existing problems in irrigation systems or provide better services.

The researchers in [7] have studied automatic self-watering systems and security in the Internet of Things (IoT) and various flaws in the technologies used in the IoT. It has utilized Raspberry Pi 3 Model B lightweight PC, and soil moisture sensors. They concluded that paying more attention to ensure security is important.

The research in [8] has used a programmed microcontroller chip to control watering automatically based on soil moisture detected using a copper plate soil moisture sensor which works as an electrode to measure soil resistance that is converted into analog voltage and then into digital data so that it can be processed by the Arduino Uno processor. It has also used solenoid valves to reduce the use of electrical energy and helped it to be more effective compared to pumps that require greater electrical energy.

The paper [9] has provided an overview of the actual state of the existing IoT irrigation systems for agriculture. and discussed the current trends in the implementation of IoT systems for crop management and irrigation. Also, the researchers have suggested a 4-layer architecture proposal as well for the management of crop irrigation.

The research in [10] has mainly focused on improving the agricultural fields by providing a low-cost monitoring system with a wireless connection for effective and efficient usage of water resources. The system has been implemented using an Arduino Controller, a distributed sensor network built using a soil moisture sensor, temperature sensor, humidity sensor, and water level sensor. The Arduino controller reads the values from Sensors and posts the information to the cloud server.

Another irrigation system consisting of three (3) different sources namely- groundwater, pond water, and fertigation system has been proposed by Dinio, et al., [11]. It is an irrigation scheduling system along with flow control and an Arduino female header of the control system’s PCB is used as a connection hub to external wiring: to Arduino and to Solenoid Valves. The average error rate of the system is 3.86% which is quite low when considering irrigation variation in plants and compared to manual irrigation.

By studying all the above watering systems in previous studies, an IoT based automatic watering system that can overcome all the shortcomings has been proposed in this research. The objective of this study is to control the water supply automatically, and conserve water for both small and large plants. People can enjoy growing plants without being worried about forgetfulness or going away for a vacation. This system can supply water only when needed so the plants never get de-moisturized and notify the owner about water leakage in the supply system.

2 Materials and Methods

The system is designed by using IoT technology with an Arduino based microcontroller board (with ATmega 328p chip) and coded to water plants automatically. It has been integrated with the three types of sensors: water level sensor, soil moisture sensor, and photo-resistor sensor. A soil moisture sensor to measure the water content (moisture) of the soil, and a water level sensor to measure the water level of the source tank are connected with the microcontroller. The photo-resistor sensor is used to detect daylight for watering the plants. A SIM900A GSM module was connected to send SMS messages to the cell phone of the owner if there is a low water level in the source tank. The system is designed in such a way that it turns the motor ON and OFF by monitoring and detecting the moisture level of the soil through the soil moisture sensor.

The Fig. 1 shows the architecture of the system.

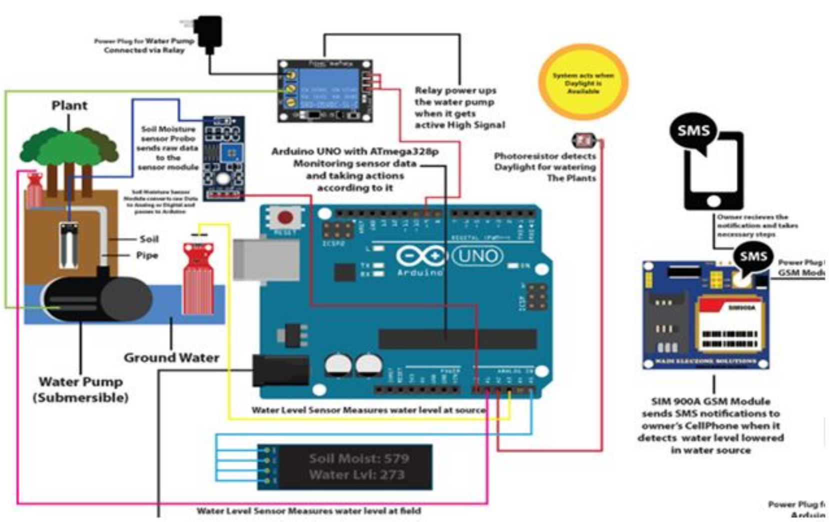

Fig. 1: System architecture

A Single Channel Relay module has been added to activate and deactivate the water pump. To show the information of current sensors values the SSD 1306 OLED Display is connected with the circuit which displays the current status of water level, soil, daylight, and water pump. A 9V DC power supply is connected to power up the circuit.

The logical flow diagram of the system is shown in Fig. 2. The threshold values of the soil moisture sensor, the water level sensor, and the photo-resistor cell sensor are set at A=850, B=150, and C=400 respectively. The system monitors and reads these values as long as it is operating. When the reading of the soil moisture sensor is above the pre-set threshold value (850), the system detects that the soil moisture level is low and it has to activate the water pump for watering. However, first, it checks the water level of the source tank and the day-light level before starting the water pump. On the other hand, if the soil moisture level is high, the water pump is not activated.

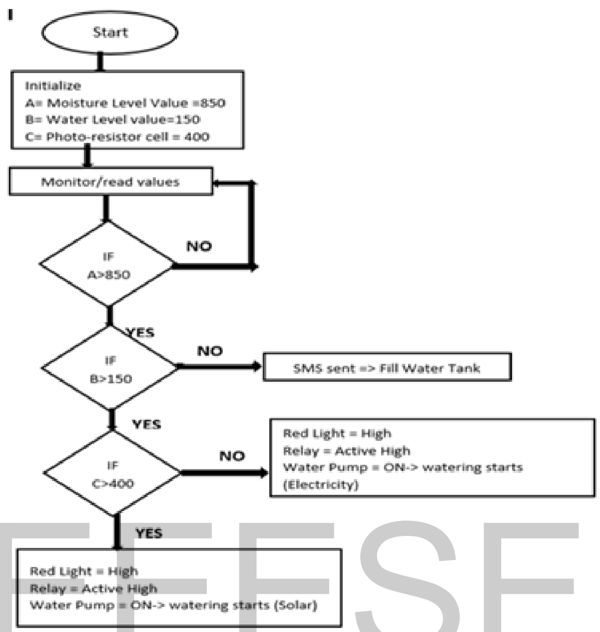

Fig. 2. System Flow diagram

Specific pins are initialized for the three sensors, relay channel, LEDs, and a serial monitor port. And then, the soil moisture sensor, photo sensor, water level sensor are initialized as analog input and relay pin, a green LED and a red LED as a digital output. The sensors' values are received by the system at a regular interval. By processing the values, the controller sends them to the RX module. When the plant needs water, the red LED turns on and the relay will be turned into active high. And when the plant doesn't need water it turns on the green LED and the relay will be turned into active low.

3. Components and Materials Used

3.1 Hardware Components

The hardware components used in this system are as follows: -

- Arduino UNO microcontroller based on an 8-bit ATmega328P chip
- 3 Sensors - soil moisture sensor, water level sensor, and photo-resistor sensor
- Water pump - A submersible water pump is employed to water
- SIM 900A GSM module - It can also be used in developing IoT and embedded applications. In this system, it is used to send an SMS notification to the mobile.
- SSD 1306 OLED display – it is used to display output.
- Single-channel relay – It is an electrically operated switch that can be turned ON or OFF, controlling a high-current circuit with a low-current signal.
- LEDs (red LED, green LED) – A red LED and a green LED are used to display signals

3.2 Software Component- Programming Environment

The Arduino IDE (Integrated Development Environment) is a cross-platform application with its programming language. However, Arduino works well in Python when the applications especially need integration with sensors and other physical devices. Here Python programming language has been used to write codes.

3.3 3.3 System Implementation

The first part of the implementation was to connect the whole circuit using the sensors and other components together – which is almost similar to [12] as in Fig. 3. shown below:

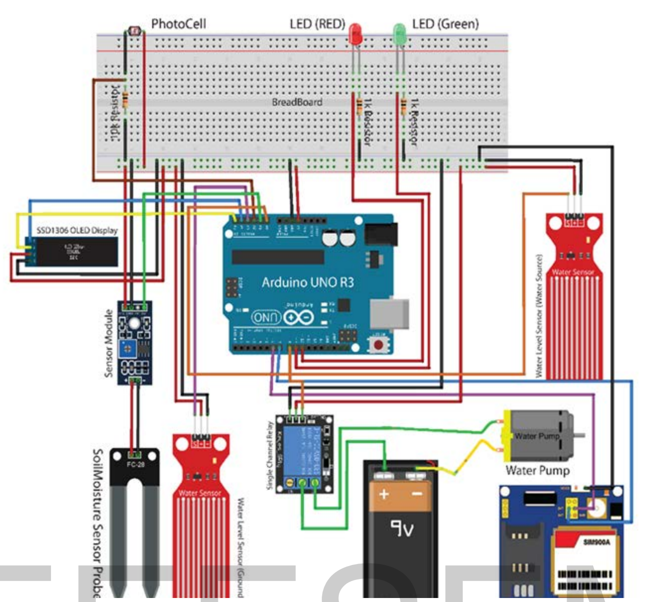

Fig. 3. Circuit diagram

The soil moisture sensor used here has two parts: a sensor module, and two small plate sensors. The four-pins module of the system has four ports: VCC. GND, A0, and D0. The soil moisture sensor uses two out ports - A0 and D0. Port A0 gives an analog output, while port D0 gives a digital output of 1 if the moisture is available, and otherwise, it gives 0. The Photo-resistor sensor uses two pins - one is connected to VCC for analog input, and the other one acts as a ground connection when it passes through a resistor greater than 1 ohm.

The Single Channel Relay module, which has three input and three output gates, is connected to change the gate by the voltage input. While the middle gate acts as a common gate, the other two gates are used to show active low and active high. To implement the system, the analog pins of the Arduino UNO microcontroller have been used as input pins from the sensors. The output pins for the relay module and other indicators are digital pins. The complete system after all the connections is shown in Fig.4.

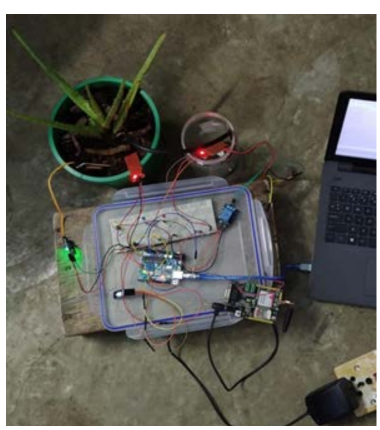

Fig. 4. The photo of the complete system after connections

4. Results and Discussion

The whole system was tested at different soil moisture conditions, and it responded appropriately. The moisture sensor measured the moisture level of the soil and depending on its value, the water supply started or stopped automatically. The GSM module also sent appropriate messages to the owner's cell phone. The system can respond appropriately by watering the soil with the exact required amount of water and then it shuts down the water supply when the required level of soil moisture is achieved. The whole system has been integrated and tested by measuring different values of different sensors. The functionality of the system is tabulated in Table -1 and Table-2. The soil Moisture Level sensor has a higher reading (>850 pre-set threshold value) when the soil is dry. However, its reading drops below the threshold value when the soil is wet.

Table-1: shows the Results based on sensors' readings

Functionalities of Sensors				
Moisture level (A=850)	***Soil Condition***	***Water Level Sensor (B=150)***	***Photo-resistor (C=400)***	***Status of the Water Pump***
1010	Dry	200	500	ON
780	Wet	170	520	OFF
1120	Dry	145	490	Water Pump = OFF, Sent Message
800	Wet	147	350	Water Pump = OFF, Sent Message

Table-2: Water Level Sensor's functionality

Water Level Sensor (B=150)	***Status of the Water Pump***
200	ON
170	OFF, No SMS sent
145	SMS Message Sent
147	SMS Message Sent Sent Message

Therefore, it can be observed that, whenever the water level in the source tank is lower than the threshold value (150), an SMS is sent to the owner's cell phone with a request to fill up the tank. Fig. 5. depicts the visualization of the system reading for different soil conditions and weather conditions. The figure also shows the colormap. The X-axis is divided into three parts: Wet, SemiDry, and Dry. The curve of moisture level, water level, and photo-resistor rises slightly with the soil/environment level changes from Wet to Dry condition. The colormap shows a higher amount of data reading (sensitivity) for the system. However, it is observed that the moisture level shows higher sensitivity (for colormap 0.6 to 0. Scale) compared to others (Photo-resistance and water level)

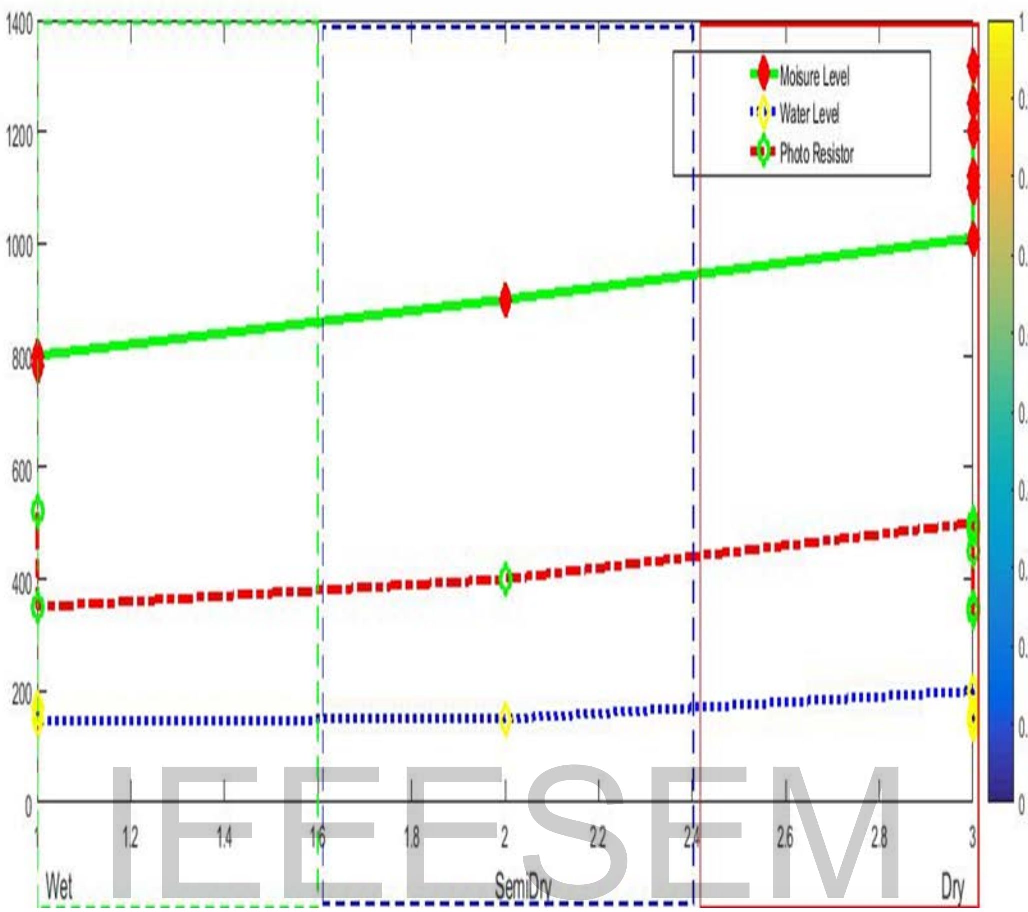

Fig. 5 Visualization of Sensor Reading to Different Environmental Condition

5. Conclusion

The system can be used for any household plants, especially for the expensive and rare plants in pots. The system can conserve water, save energy, and water the plants automatically only when needed. As the system is designed for the perfect timing of watering, it may help plants to remain healthy and grow perfectly. Thus, it can be used for gardening as well as for greenhouses. The system has been implemented, tested thoroughly, and found to be functioning successfully. The whole system has been tested at different soil moisture conditions, and it has responded appropriately. In the future, it can be extended by adding the feature for remotely monitoring and controlling sensors.

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