AUTOMATED WATER SYSTEM BASED ON IoT

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ABSTRACT: The Automated Water System has been developed to monitor water consumption and reduce the water wastage. The Automated Water System is potentially designed for live monitoring of the water consumption and limiting the water wastage when water consumption crosses the designed threshold level. Specifically, the water system designed is smart enough to continuously monitor the water level in the overhead tank; also, the automated water system monitors the amount of water used and restricts further water usage once the consumption reaches the pre-designed water level. The water level is continuously updated to the cloud and can be regularly monitored by the user. The Automated Water System is implemented using Arduino UNO, a low-cost controller. The system is pre-designed with specific threshold values; based on these values, the water system monitors and controls the water level and water usage simultaneously. Features like low-cost and automated water monitoring make it advantageous to commercial applications.

General Terms: Water Management, Smart Water System, Embedded systems.

Keywords: Automation, Cloud Data, IoT, Ultrasonic sensor, Wi-Fi, Arduino, Water Saving.

1. INTRODUCTION

Water is the essence of life. Globalization has created the need for dependency on natural resources. The continuous expansion of the urban dwellings and the population growth has created an imbalance in the neighboring water resources available. According to the study conducted in the articles [3] and [4], "A survey of household domestic water consumption patterns in the rural semi-arid village, India", results of the study revealed that the daily average water consumption for the village was found to be 117.0 liters per person per capita per day (based on questionnaires and interview surveys of 763 households of a local community). Washing clothes consumes the highest amount of water, whereas 85% of households use government water supplies with very safe water quality. According to the EPA, the average U.S. household uses more than 300 gallons of water per day. In a typical residential dwelling, 70 percent of this usage occurs indoors, primarily in the washroom. Water availability has created water use and development patterns around the country (for example, we build power plants at the intersection of power needs and water sources). As we continue to progress, water demand shifts, i.e., we may be creating an imbalance between the need and the availability. To preserve water, we need to think about ways to be more strategic about tapping our water resources to the most appropriate use.

This work aims to provide a feasible solution to water consumption problems; we can prevent the wastage or overuse of the water for particular applications by monitoring and limiting the consumption. The water consumption can be monitored by the user live, continuously updating him/her about the water level and thus preventing the overuse of water.

Several related works have been done for different applications. In one of the researches, the author focused on Water Level Monitoring, i.e., detecting and indicating the water level in an overhead tank or any other water container. The investigation aims to design a water level sensor device using Arduino UNO to detect the water level in a water storage system. [2]. Another similar research was proposed to develop a low-cost automatic water level monitoring system (WLMS) [1]. The major components used for developing the WLMS were the Arduino board, ultrasonic sensor, Xbee transceiver, and personal computer. The automatic water level monitoring system was designed using an Ultrasonic sensor attached to an Arduino UNO to decode the analog signal coming from the sensor into a useable digital value of distance. In all these researches, the water level monitoring is designed using different aspects. In this paper, we will monitor the water level. Additionally, we will restrict the overuse of water.

A stage involved in the design is: The paper is organized as follows: Section 2 deals with hardware implementation. Section 3 describes the software and algorithm implementation. Section 4 deals with experiment results and Section 5 concludes with the experiment.

2. HARDWARE IMPLEMENTATION

2.1 Circuit Diagram

The Automated Water System based on IoT is designed using threshold values. The threshold values can be designed concerning time and water quantity. In this paper, the threshold values are based on the time parameter. Considering time as a threshold parameter, the hardware and software system of the smart water system is designed accordingly.

The circuit representation of the Automated Water System is shown in Figure 1. There are two tanks: ground tank and overhead tank. The ground tank supplies water to the overhead tank. Water for household use is supplied from the overhead tank. The water flowing from a household tap is measured to time. There are two ultrasonic sensors: to measure the water level in the overhead tank and the water level used from the household tap. Two water pumps pump the water based on the input signal from the ultrasonic sensors. A servo motor is installed to check and control the water flow to the household tap. A Wi-Fi module is used to transmit data to the cloud to monitor the system continuously.

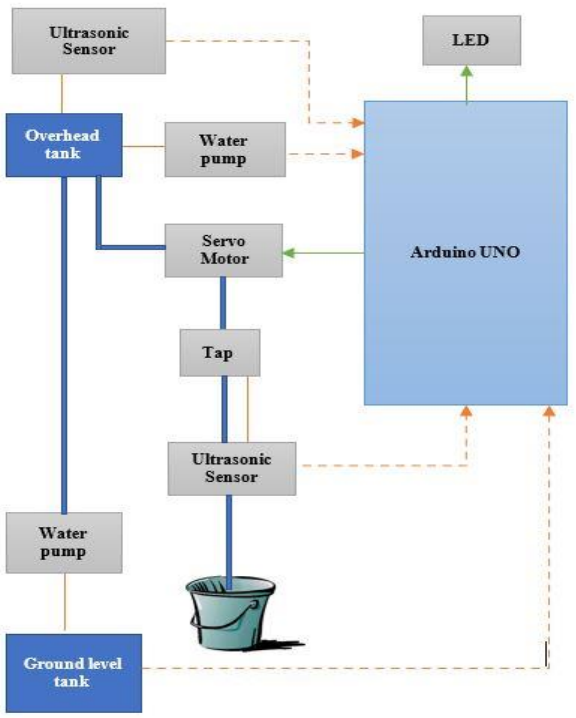

Figure 1: Circuit representation of the Automated Water System

2.2 Ultrasonic Sensor - HC-SR04

The ultrasonic sensor calculates the distance of a target by emitting ultrasonic sound waves and transforming the reflected sound into an electrical signal. Distance is estimated by calculating the time for the sound waves to travel from source to target and back to the source, as shown in Figure 2. The distance is estimated using the formula :

$$D = \frac{1}{2} T \times C \quad (1)$$

(where D - distance, T - time, and C is the speed of sound ~343 meters/second).

There are two HC-SR04 ultrasonic sensors in the circuit. One sensor is connected to the overhead tank and the other ultrasonic sensor is connected to the household tap. The ultrasonic sensor in the overhead tank measures the tank's water level; if the water level is less than the designed range, the microcontroller automatically pumps water from the ground tank. Therefore, the overhead water tank remains filled. The second ultrasonic sensor is fixed to the household tap. It measures the water level from the bucked to be filled. If the water level is less than the designed range, then the microcontroller monitors the flow of the water concerning time. Based on the water level in the overhead tank and the bucket, the ultrasonic sensor triggers the microcontroller, which controls the water consumption.

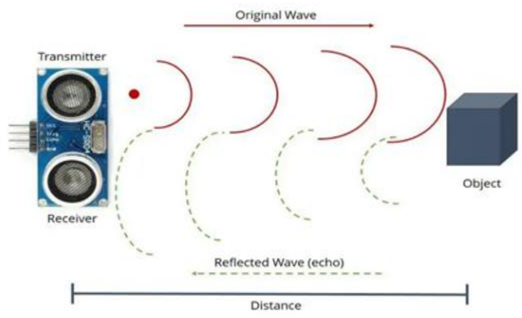

Figure 2: Representation of Distance measurement by the ultrasonic sensor

2.3 Water Pumps and Pump Driver

A Micro DC 3 Volts-6 Volts Submersible Pump, as shown in Figure 3, is a low-cost, small-size motor that can be operated from a 3 Volts ~ 6 Volts power supply. If the water level in the overhead is less than the desired value, the ultrasonic sensor signals the microcontroller indicating a low water level in the overhead tank. The microcontroller resolves the issue by triggering the water pump to pump water from the ground level to the overhead tank. As the water level keeps rising and reaches the desired maximum level, the microcontroller automatically triggers the pump to stop the water supply to the water tank. Therefore, the level of the water in the overhead tank will always be at the maximum level. The other water pump is connected to the overhead tank. If the water level in the bucket is less than the desired value, the ultrasonic sensor fixed to the tap triggers the microcontroller. The microcontroller activates the pump in the overhead tank to pump water. Once the water is consumed to the maximum level, the microcontroller automatically halts the water flow from the pump. The submersible pumps are connected to the L293D, a 16-Pin Motor Driver IC. A single L293D IC can run two DC motors at the same time.

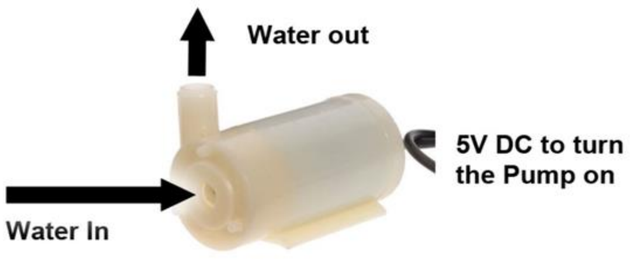

Figure 3: Micro DC 3-6V Submersible Water Pump

2.4 Wi-Fi Module

The ESP8266 is a user-friendly and low-cost device to provide internet connectivity. The module can work both as a station (can connect to Wi-Fi) and an access point (can create hotspot); hence it can easily fetch data and upload it to the internet, making the Internet of Things as easy as possible. It can also fetch data from the internet using API's hence the application could access any information that is available on the internet, thus making it more intelligent. The ESP8266 continuously uploads the sensor data to the cloud, and the user can monitor the water consumption. Based on this data, water usage can be regularly analyzed.

2.5 Microcontroller

Arduino UNO is a microcontroller based on the ATmega328P. It has 14 digital output/input pins, of which six can be used as PWM outputs, six analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a power jack, a USB connection, a reset button, and an ICSP header. It can be connected to a computer with a USB cable or power with an AC-to-DC adapter or battery to get started.

2.6 Servo Motor

A Micro Servo Motor SG90 is used to control the tap, in turn controlling the water flow. The servo can rotate ~180 degrees (90 in each direction). The microcontroller rotates the servo motor, controlling the amount of water flowing to the household tap based on the amount of water used. The microcontroller controls the motor based on the designed threshold values. For example., initially, water flows from the household tap for 60 min-threshold value 1. Once the system reaches threshold value 1, the microcontroller automatically rotates the motor say 90 degrees. The flow of the water is reduced by half. If the water is used for another 50 min – threshold value 2, the microcontroller turns the motor another 90 degrees and the flow of the water ceases. Based on the threshold values, the microcontroller controls the amount of water consumed using a servo motor. Arduino UNO is a microcontroller.

2.7 LCD and LEDs

A 16×2 LCD (16 Columns and 2 Rows) indicates the water level and threshold timings. Three LEDs indicate the threshold values of the system. Flow for the initial flow of the water green LED is on, as the water flow reaches the second threshold level say the water has flown for 60 min then a yellow LED is high and further if the flow the continues for another 60 min crossing the threshold value two then a RED LED is high.

3. SOFTWARE IMPLEMENTATION AND ALGORITHM DESIGN

3.1 ThingsSpeak

It is an Internet of Things analytics platform that allows you to visualize, aggregate, and analyze live data streams in the cloud. By using the provided API keys in the Arduino IDE, the WI-FI module directs the data to the cloud and the user can access the data. The data for the date and water level is uploaded and is represented as shown in Figure 4.

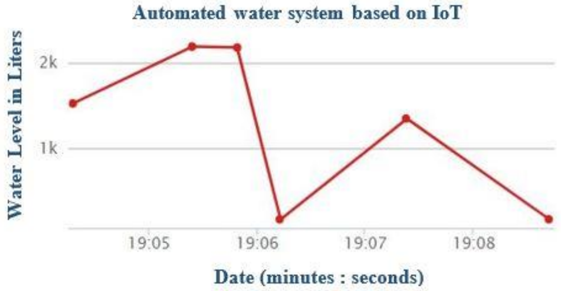

Figure 4: The water level in liters concerning the time

3.2 Algorithm Design

The Circuit of the Automated Smart Water System is shown in Figure 5. On turning on the water system, the ultrasonic sensor placed in the overhead tank checks for the water level. If the water level in the overhead tank is less than the desired value, then the microcontroller pumps water from the ground tank to the overhead tank. If the water level is greater or equal to the desired value, the microcontroller enters the next phase. In the next phase, the ultrasonic sensor fixed to the household tap measures the water level in the bucket. If the water is greater or equal to the desired value indicating the bucket is full. If the bucket is full, the ultrasonic sensor keeps monitoring the water level continuously. Once the water level in the bucket is less than the desired value, the microcontroller pumps water from the overhead tank to the bucket for, say, 60 min and a green LED is high, indicating the initial flow of water. If the user continues to use water for more than 60 minutes, the yellow LED is turned high, indicating the user has crossed the safe level of water usage. The microcontroller controls the rotates of the motor 90 degrees which reduces the water flow by half, saving 50% of water. If the user continues to use the water for another 60 minutes, then a red LED is turned on, indicating that the user has reached the safe limit of water usage for the given day. The microcontroller rotates the motor by another 90 degrees and a total of 180 degrees, ceasing the water flow to the bucket. Simultaneously, the water level in the overhead tank is measured every 20 min and if the water level is less than the desired value, the water is pumped from the ground tank. The water level data in the overhead tank is uploaded to the cloud continuously and can be accessed by the user. The circuit diagram and flowchart of the Automated Water System Based on IoT are shown in Figure 5 and Figure 6. respectively.

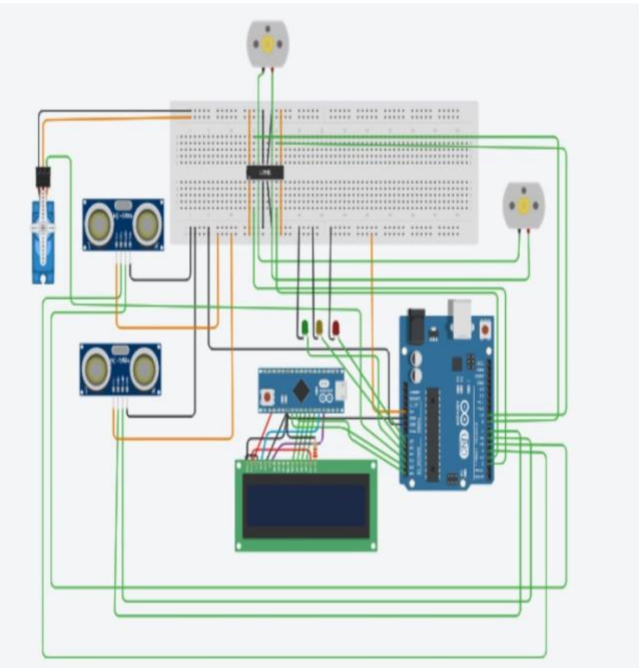

Figure 5: Simulation representation of Automated Water System Based on IoT

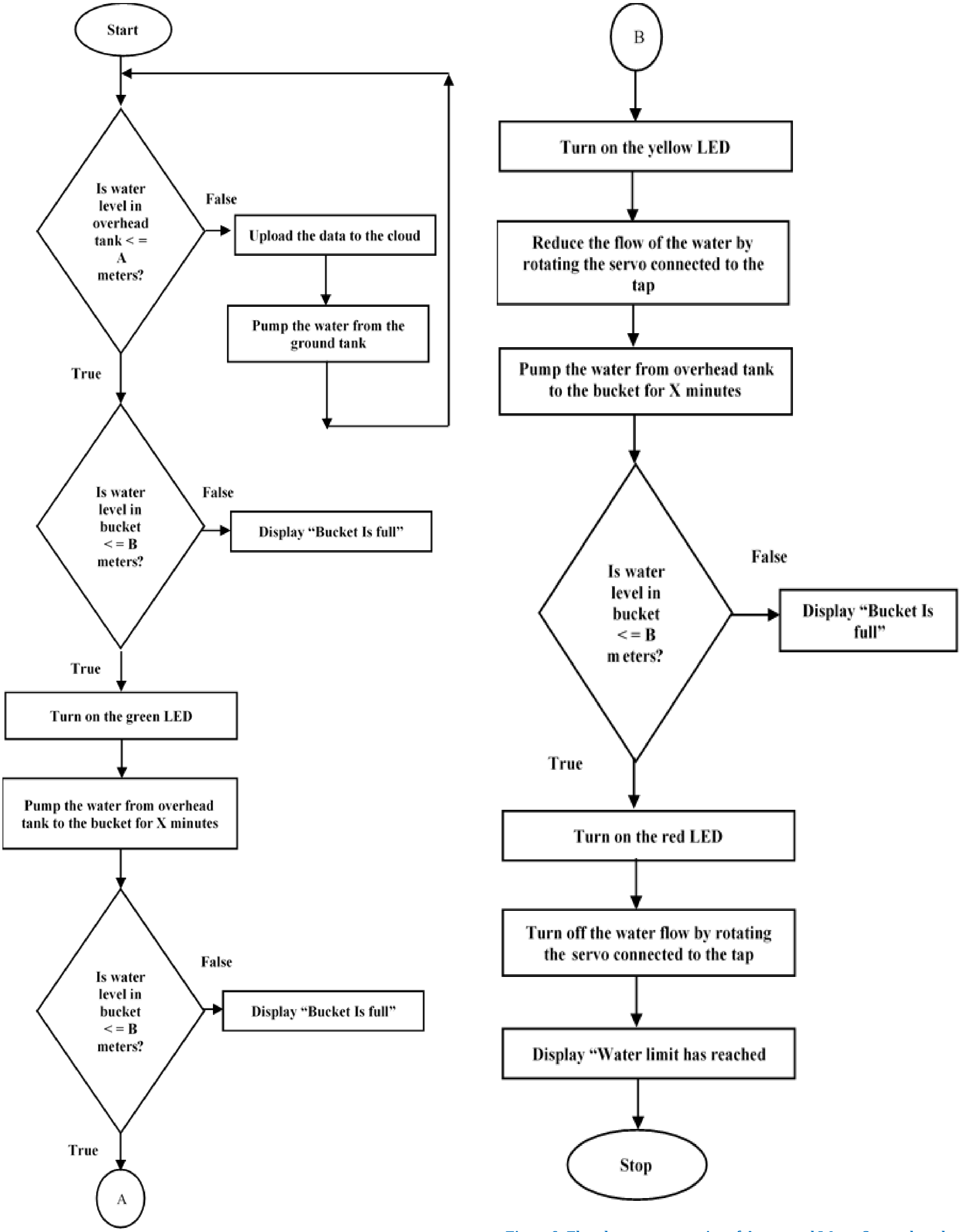

Figure 6: Flowchart representation of Automated Water System based on IoT

4. EXPERIMENT RESULTS

Considering a bathroom will normally use about 8 - 10 liters per minute. If the water flows for, say 90 min. Consider X = 45 min and Y = 45 min.

Table 1. Experiment results for a pre-designed time

Parameter	Without Automated Water System	With Automated Water System
Water Flow	For 90 min: 720 - 900 liters	For the first (X=45 min) : 360 - 450 liters For the next (Y=45min) : 180 - 225 liters **<u>For the total of 90 min: 540 - 675 liters</u>**

5. CONCLUSIONS

The given 90 min water saved is around 180 - 250 liters when an Automated Water System, as shown in Figure 7, is used. Without an automated water system, if there is no time limit on the water flow, water wastage is difficult to account for. In the other case, with the Automated water system, if the water flow remains unchecked or if the time remains unchecked, the system is intelligent to control the water flow and shut it off after the designed time.

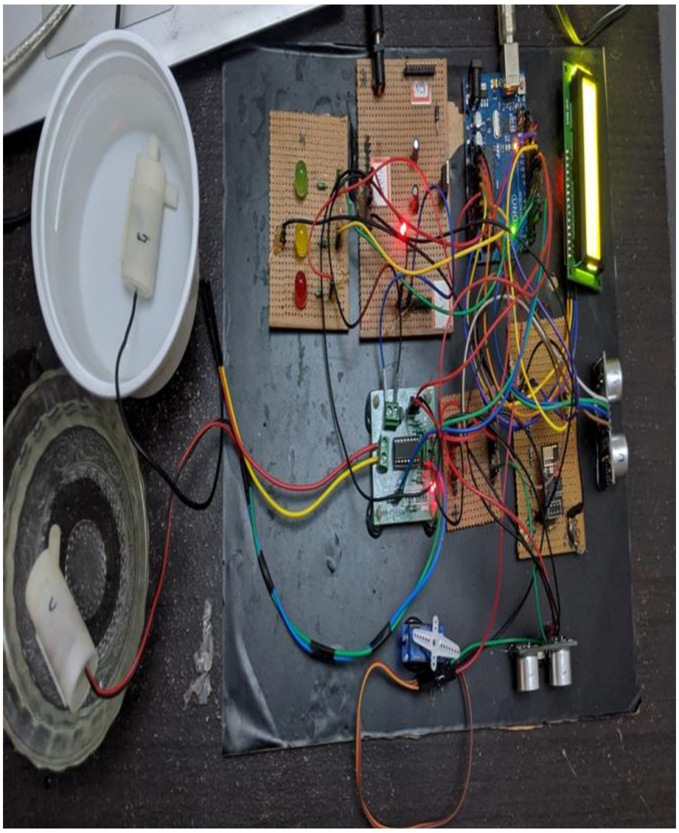

Figure 7: Working model of Automated Water System based on IoT

Figure 8: LCD indication that Automated Water System is connected to the Wi-Fi

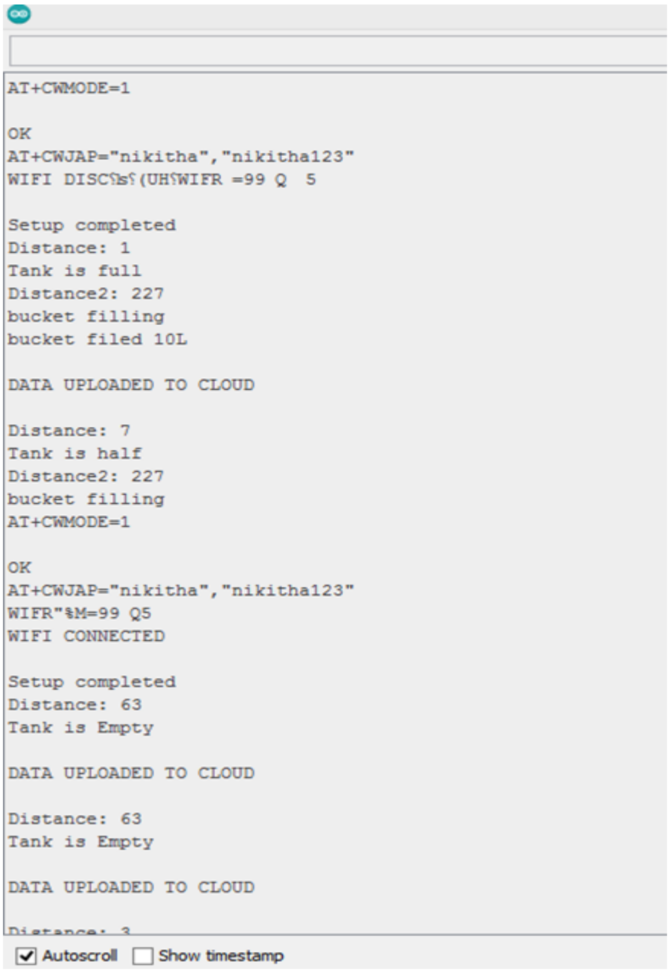

Figure 9: Serial mode communication of Automated Water System – Part 1

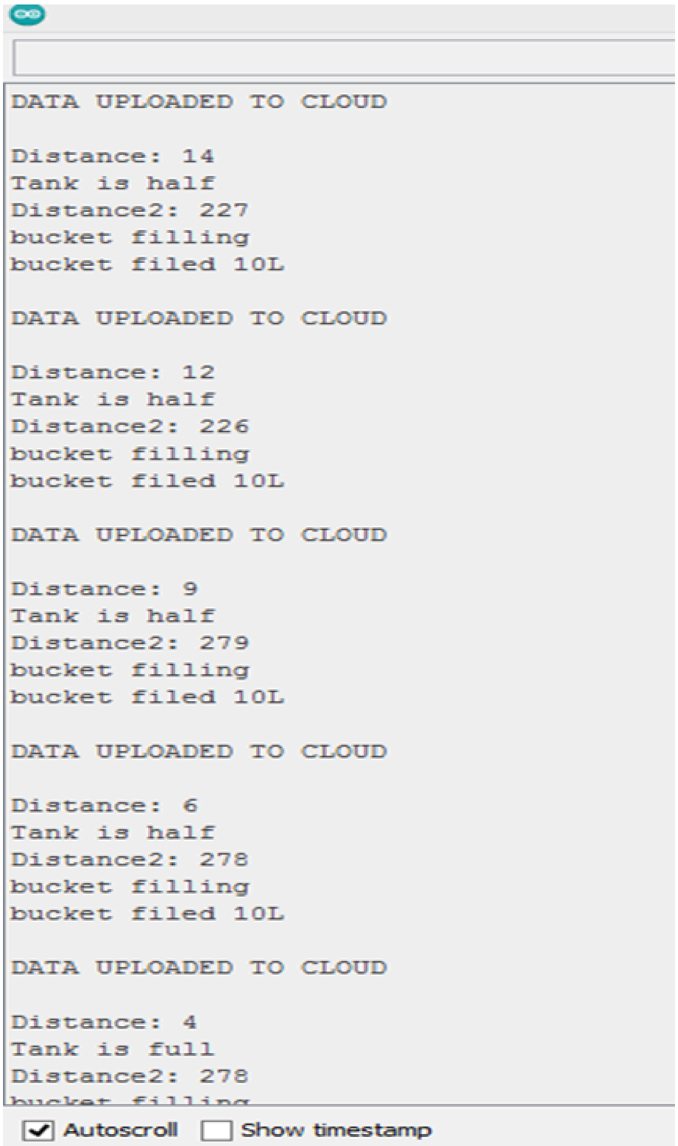

Figure 10: Serial mode communication of Automated Water System – Part 2

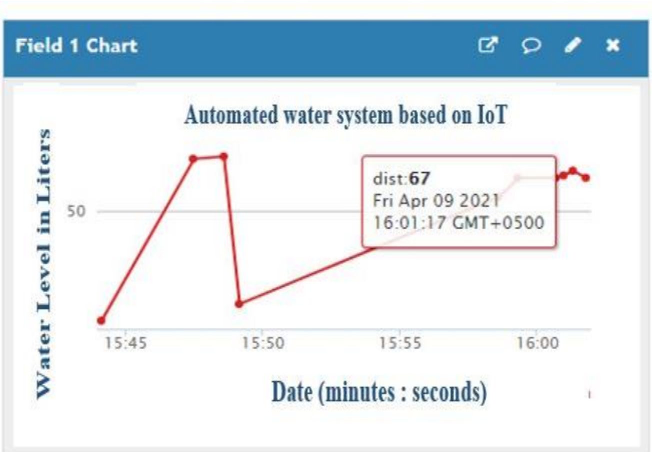

Figure 11: Data transmission indicating water level use

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