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Automated Water Level Monitoring System using Arduino and GSM Module

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Abstract

This paper aims to represent an Internet of Things (IoT)-based Smart Water Level Monitoring (SWLM) system to provide continuous measurement of water levels in the Nilgiris district water ATMs. Multiple IoT devices (microcontrollers and sensors) are connected with each other to detect the water levels. The extracted data from the sensors are transmitted to a mobile application developed using flutter and the data is stored in a cloud platform called ThingSpeak. According to the obtained results, the proposed SWLM system will be able to analyse the water levels and display the ATMs category wise according to the water level percentage in the application built with flutter framework. This paper clearly explains how the hardware components are connected with each other and sends real time data to the cloud application (ThingSpeak). The paper also explains the methodology of flow of data from the cloud application and retrieval by using the flutter application. Furthermore, this paper also describes a working prototype that, when expanded, will ensure real time and quick redressal of tourist needs for clean drinking water while avoiding the use of plastic bottles in such an exquisitely beautiful and sensitive biosphere reserve like, the Nilgiris in Tamil Nadu, India. An application has also been developed for the same.

Keywords: Automation, Arduino, GSM Module, Ultrasonic Sensor, Internet of Things (IoT), ThingSpeak, Sensors

1. Introduction

The Nilgiris is a breath-takingly scenic but sensitive biosphere with flora and fauna, which calls for sustainability. Strict regulations by the district administration are in place to ensure the safety of the biodiversity while tourists explore the fragile ecosystem. One such regulation is ban on the use of plastic water bottles as it adversely affects wildlife as well as the soil quality, water retention and regeneration capabilities.

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As an alternative to packaged water bottles, water ATMs are in place to enable refilling of tourist's water bottles. These water ATMs are basic in design, checking and refilling is done manually, with no technology in place currently. As a natural consequence, there is a time lag in refilling ATMs leading to tourist discontent. This is leading to plastic water bottles getting smuggled into the district, with the ecology bearing the brunt of the situation.

1.1 Purpose

The purpose of this paper is to introduce a system that increases the availability and accessibility of water, without jeopardizing the ecosystem of the Nilgiris. The proposed IoT system employs sensors to detect the volume of water present in the water ATMs, and using the combined architecture of microcontrollers, GSM modules, and other tools, the user is able to view the level of water present in the ATM(s) (using a unique ID for each ATM). The Internet of Things, or IoT, is the method of in which sensors and microcontroller boards are connected to objects, machines or even humans to sense or collection data/information [14]. The information is then sent to the system (or an application) without the help of human interference.

Subsequently, the application categorizes the ATMs present into four zones depending on the amount of water present, and sends alerts to the person in-charge (technician) if the amount of water present in a particular ATM falls below the threshold value. In this manner, the technician is able to replenish the water in the ATMs as and when required. Sensor data can be uploaded to the cloud using the IoT platform ThingSpeak [15]. With the help of the platform, data can be stored, visualised and examined online without the need of any local storage. Thus, the parameters received are stored in ThingSpeak. The changes in the water levels are updated in the database through cloud computing. ThingSpeak also provides a feature to create a public channel to analyze and estimate the water level present. It also has an inbuilt feature to visualize real-time data [11]. Furthermore, an Android application is created for the direct access of the measured parameters.

2. Literature Survey

[1] Proposes an automated way to check the quality of water. The quality of water, being optimal is very much needed. In recent times, due to industrial pollution, pesticide waste from farm lands, and household waste being dissolved in water bodies, the quality of

water has drastically become worse. Hence this paper provides a system to check the quality of water to decide whether or not the water is contaminated. Through this paper, the unique concepts such as real-time data sharing were incorporated into our proposed model. Only a selected set of parameters are used to determine the water quality. The parameters vary vastly with the geographic and the demographic of the water body. The degree of importance of each parameter in water-quality measurement fluctuates with time. The above-mentioned factors reduce the accuracy of measurement. The selection of locales to place the sensors is important, placing the sensors in fixed locations as suggested by the paper can prove to be inefficient. A concrete logging solution is not suggested by the paper. The paper fails to describe the construction of a neural network to consolidate the various parameters.

The next method [2] also proposes a model that tests water quality with the help of wireless technology. The proposed model uses an Arduino UNO microcontroller board and multiple sensors such as the temperature sensor, the PH sensor and the turbidity sensor to test the quality of water. The paper focuses mainly on how wireless technology is being used in the above-mentioned use case. The paper fails to elaborate on the accuracy results produced by the proposed model.

[3] also proposes a model to test the quality in water bodies. The proposed model uses ThingSpeak. It uses the same sensors to check if water the water quality is optimal. The data collected by these sensors are then sent to the microcontroller with the help of a ZigBee module. The proposed model uses ThingSpeak cloud platform. It gives an elaborate discussion on how the ThingSpeak cloud platform is used. The proposed system relies on the GSM-module for SMS communication which might be unreliable depending on the mobile-signal strength. The system makes use of GSM and Zigbee for wireless communication which increases latency and adds to the points of failure. Only selected parameters are taken into account for calculations; crucial features like oxidation-reduction potential and micro particle density have been omitted which reduces the accuracy of measurement. The proposed proximity sensor integration fails to differentiate the public who pollute and bystanders which makes the system inefficient.

[4] aims to detect water levels in a water body using a AVR microcontroller. This paper also uses an ultrasonic sensor that detects continuous water levels. The paper aims at avoiding excess water distribution during transmission which is a similar problem statement to ours. It requires WiFi and raspberry Pi to detect water levels. This paper gives a detailed approach on how the hardware components are connected together and a whole run-through

on how water levels are detected. The same model has been implemented by [6] but instead of using raspberry Pi, it uses nodeMCU as their microcontroller. The proposed system relies on continuous internet connectivity for its functioning. Water level can be measured more efficiently using conductivity-based methods. The use of infrared sensors makes the system prone to failure and inconsistency.

In order to avoid wastage of water from the overhead tanks, [5] proposes an automatic water controller. The paper gives a detailed explanation on how wireless technology is used in an automatic water controller system. The proposed model uses microcontrollers, light emitting diodes, Bluetooth and relay modules to avoid wastage of water in these water tanks. It also uses ultrasonic sensor to detect water levels continuously and check if there is a possible overflow of water. The wired implementation of the water level controller uses exposed cables over long lengths. This makes the system prone to failure due to wire damage. The wireless implementation uses a Bluetooth module. This limits the wireless range of the system; coupling the system with a GSM module adds true wifelessness to the proposed system. Any delay in transmission or loss of signals may result in the relay not responding which causes the system to fail.

[7] also focuses on measuring water levels in a container. It makes use of LED lights to indicate the level of water in the container. Hence when the water level is not optimal, the user will be alerted by the LED lights present in the hardware. In the proposed system, there is a problem of burning due to a lack of short circuit protection in the water level controller. The system fails if the sensor takes damage due to the flow of water. The water level controller is attached to the sensor by a wire to the water tank, the breakage of these wires can result in system failure.

3. Energy Efficient HEMS

The proposed model automates the process of checking water level via IoT sensors as shown in Fig.1.

3.1 System Architecture

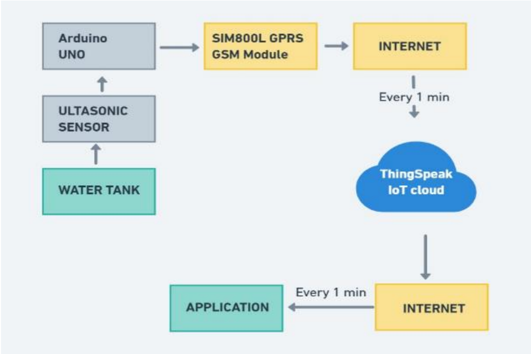

Figure 1. Block diagram of system architecture

The water ATM system architecture functions by receiving data from the ultrasonic sensor. The data about the level of water in the water tank is captured through Arduino, which is then sent to the SIM800L GPRS GSM Module, which in turn uses Attention (AT) commands to connect to the internet as shown in Fig.1. This further feeds the given data of the water level to the ThingSpeak API. The data written to the ThingSpeak API is obtained as a JSON document and is deployed in the flutter code. At the end, the data will be displayed in the application.

As Nilgiris is a natural habitat and home to many endangered wildlife species, it is imperative to follow environment friendly and sustainable measures. Hence to minimise power usage, ultra-low power systems are used. The TPS62740 is used for the power supply. It has an input range from 2.2V to 5.5V which is optimal for the microcontroller and results in effective power management.

3.2 Components

The following components are used in the hardware setup. Other than the below mentioned components certain basic components like jumper wire, 5V power supply and breadboards were used.

3.2.1 Arduino UNO

The Arduino UNO is the microcontroller used for the hardware setup. These boards are not very expensive, which makes it cost efficient [9]. These microcontrollers are attached to the top of every water ATM. This microcontroller is connected to all the other components such as the power supply, the GSM module, the ultrasonic sensor. The Arduino UNO microcontroller board contains multiple input and output pins. The Arduino UNO microcontroller board was selected as an alternative to the nodeMCU. The nodeMCU would be feasible and efficient if there is a Wi-Fi connection around the area. This microcontroller board is works very efficiently at adverse weather conditions.

3.2.2 SIM800L GPRS GSM Module

Initially the NodeMCU was used as the microcontroller development board instead of the Arduino UNO. The problem with the NodeMCU board was that, these microcontrollers needed Wi-Fi to function. They use Wi-Fi to connect to the internet and send results to the cloud platform. In a hilly terrain it is unfeasible to provide internet for all the water ATMs present. Hence an Arduino UNO board was selected. The GSM module uses a sim to connect to the cloud. Hence the prerequisite for this setup to work is just a sim signal. The GSM module contains a sim card that uses signal to send a SMS or connect to the cloud [10]. The GSM Module is connected to the microcontroller (Arduino UNO) which is then connected to the power supply [8]. Using this module, the GPRS location of the particular water ATM can be found.

3.2.3 Ultrasonic Sensor

Ultrasonic sensors are sensors used to generally detect the distance between a particular target object and the sensor itself [12]. The target object can be either solid or liquid. This sensor uses high frequency ultrasonic waves (echo waves) to send signal and based on the amount of time taken to receive a signal back, the distance between the target object and the sensor is calculated. In our hardware setup the ultrasonic sensor is placed on the lid of the water ATM. This allows the sensor to detect continuous water levels. The ultrasonic sensor will continuously detect the water levels and send it to the microcontroller (Arduino UNO). These sensors have a detector and an emitter. The emitter emits the high frequency ultrasonic waves and the detector detects any signal that is reflected back from the target surface. The ultrasonic sensor has been chosen for this hardware setup as they are easy to install and are comparatively accurate. The ultrasonic sensor is connected to the microcontroller. This sensor has four pins: the Vcc pin, the trig pin, the echo pin and the ground pin. And these pins are connected to the 5V, 8, -9, GRND pins in the microcontroller respectively. The ultrasonic sensor is kept in such a way that the water inside the water ATM does not come into contact with the sensor. As doing so might cause the ultrasonic sensor to cause inaccurate results.

3.3 System Implementation

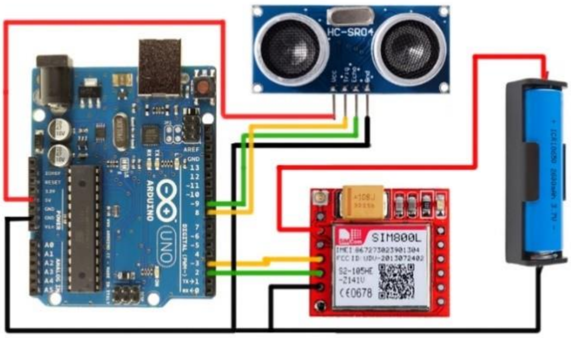

Figure 2. Circuit diagram of the connected components

Step 1: The hardware components were connected - the Arduino with both an ultrasonic sensor and SIM800L GPRS GSM module. It was practically implemented as shown in Fig.3, the water mug is analogous to the water tank.

Step 2: The data obtained from the sensors is given to the ThingSpeak cloud platform using the WriteKey as mentioned.

Step 3: The data is deployed to the Flutter application using the ThingSpeak API key.

Step 4: Data is categorized into different zones depending on the level of water present.

A system of colour code is employed to categorize the water level:

1. **Red** – water level less than 25% - An alert will be sent if the water level falls in the Red Zone.
2. **Orange** – water level between 25% to 50%
3. **Yellow** – water level between 50% to 75%
4. **Blue** – water level above 75%

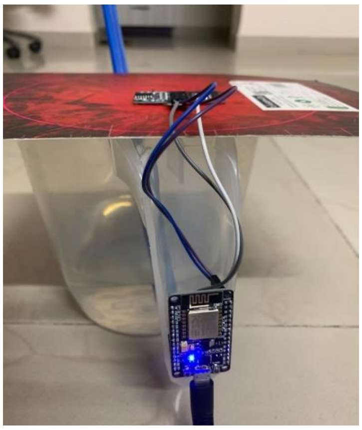

Figure 3. Entire Hardware Setup

Fig. 3 depicts the hardware setup of the proposed model. Where the ultrasonic sensor is connected to the Arduino board and monitors water levels continuously and sends data updates to the cloud platform ThingSpeak.

4. Results and Discussion

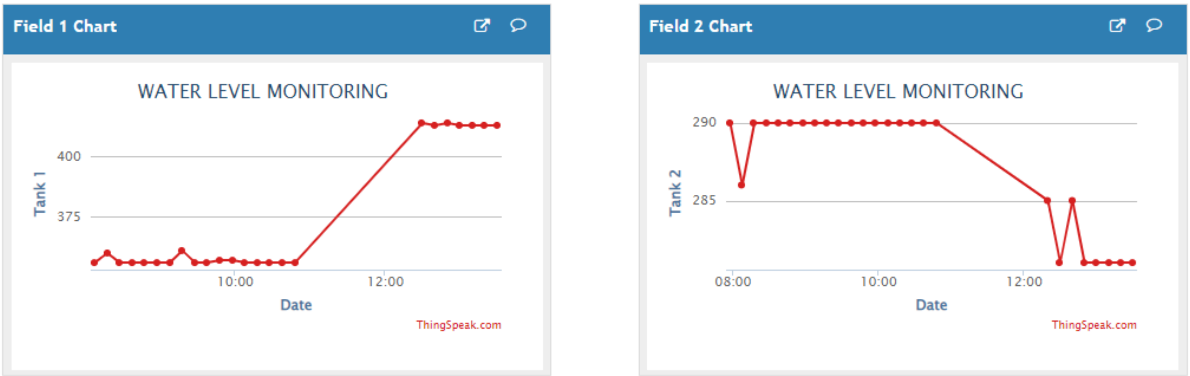

Figure 4. Results from ThingSpeak

The ThingSpeak cloud platform acts as a link between the hardware setup (water tank) and the application by storing the water level data in the cloud. Fig.4 shows how the data is stored in the API and also how it can be visualized as a graph, the graph plot the percentage of water in a particular tank on multiple instances of a day.

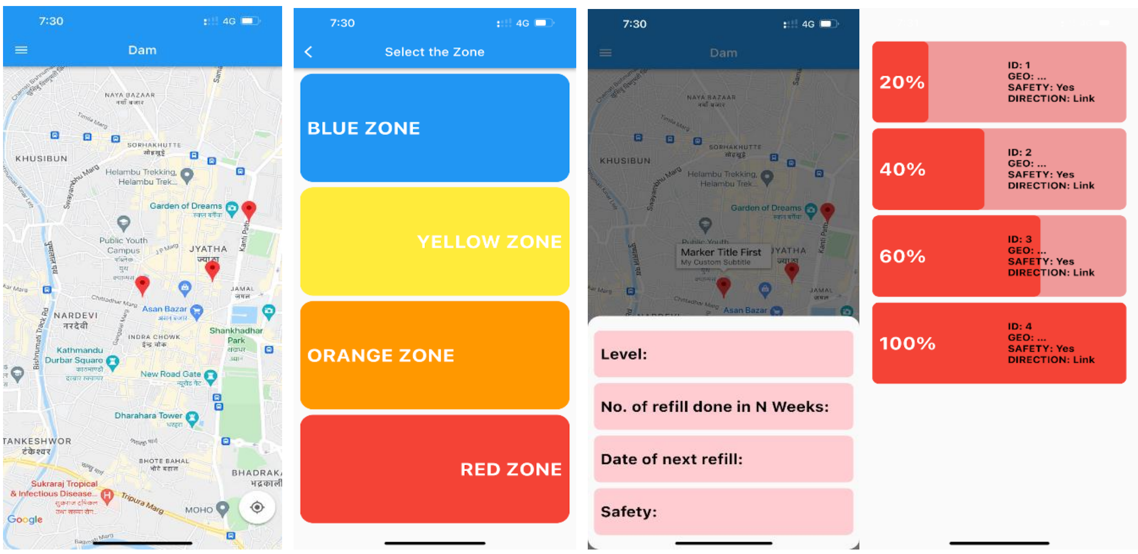

Figure 5. User Interface of the application developed

The desired results are produced and showed to the user in an easy-to-use application depicting the tanks that need to be filled and what zone each water tank comes in as shown in Fig. 5.

5. Conclusion

The well-connected architecture of the microcontroller, sensors, and the software application was integrated to create a model of the Automated Water Level Sensing system displays efficient functionality. The developed system has been integral to removing labour intensive, time consuming, and expensive ways of filling water, and furthermore developed an optimal and easier way of refilling water ATMs. This has, in turn, has increased availability of water, and subsequently, improved the living conditions of people. Additionally, the proposed methodology of this paper plays a pivotal role in increasing accessibility, because hilly regions struggle with getting unrestricted and continuous supply of water. This paper also has the scope to benefit drinking water facilities at many government institutions, places of worship, and even on city roads and national highways by tweaking the same technology to suit the geographical needs. The paper offers expansion in not only the department of tourism, but also in homes, educational institutions, and every other utility space where a drinking water tank needs refilling. It is of special interest to the tourism departments with fragile ecosystems and minimal infrastructure, where laying of pipes can be difficult.

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