HEIGHT BASED WATER LEVEL INDICATOR AND PUMP CONTROL IOT SYSTEM WITH ANDROID APP

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ABSTRACT

In General, homeowners need to fill their overhead water tanks by manually operating water pump motor to ensure a consistent water supply. However, it throws challenges at odd hours like in cold nights etc. in turning the water pump on and off in manual mode. Which even Sometimes results in non-turning on the water pump leading to an empty tank and inconvenience. Similarly, sometimes non-turning off the water pump after the tank is filled leads to water overflow and wastage. To address these issues, an automated system is required that provides accurate water level indication and controls the pump operation. The development such automated systems using IOT provides mobile app based real time operability & flexibility to the user.

This paper presents a Height Based Water Level Indicator and Pump Control IoT System. The proposed IOT based system uses ultrasonic sensor to measures water distance from top of tank which allows calculation of the water level as a percentage of height instead of percentage of volume as in traditional systems thus allowing any type or shape of water tank to be managed efficiently.

Further, the android app developed indigenously which facilitate operating the proposed system in both manual and automatic mode. The android app is developed with features which can provide automatic on/off functionality based on pre-specified water level thresholds, pre-setting on/off timer and auto off in case no water supply by pump motor.

This is a completely indigenously developed and practically tested, on real time installations, novel IOT system for management of overhead water tank system

KEYWORDS

IoT, Water Level Indicator, Water Pump, Android App, Node MCU, Arduino, Alarm Manager, Firebase.

1. INTRODUCTION

The rapid advancement of technology has revolutionized various aspects of our daily lives, including the way we manage and control essential resources such as water. In this context, the Internet of Things (IoT) has emerged as a powerful framework that connects physical devices and enables them to communicate and interact with each other over the internet. One of the significant applications of IoT is in the domain of water management, where it has the potential to enhance efficiency, conservation, and automation.

But all the currently developed IOT based systems for overhead water tank level measurement and pump control are volume-based calculation requiring entering the multiple parameters like height, radius etc. based on shape of water tank in the system thus restricting the system to become universally utilizable for all types of water tanks. Further, all the currently developed

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systems are using third party android apps like Blynk which further restricts the versatility of these systems.

This paper focuses on developing an IoT-based water level indicator and automatic pump control system with an accompanying Android application, free from all the above restrictions thus making it a truly universally usable versatile IOT system. The deployment of IoT technology in the proposed system enables water level monitoring on real-time basisand allows users to remotely control the pump from their smartphones.

With the aim of enhancing water management efficiency and conservation, the system offers automated control, customizable threshold levels, and convenient remote access. By combining IoT and mobile technology, this paper presents a practical solution for effective water level monitoring and pump control.

The novelty of this work is as below-

- The paper focuses on providing water level data based on the container's height rather than its volume. This approach allows for universal applicability across containers of various shapes. By calculating the percentage based on the height, the model can be utilized for tanks or containers with different shapes, as height serves as a common factor for all. This flexibility enables the system to accurately determine the water level regardless of the container's specific dimensions or geometry.
- It uses an indigenously developed Android App instead of any party application like Blynk IoT for displaying the real time water level percentage and controlling the water pump.
- Instead of relying on user input or measurements, it uses a seamless process within the Android app. With just a single button press, the app triggers the sensor to measure the actual height of the container accurately. Based on this measured height, the system automatically calculates and displays the precise water level percentage on the Android app. This novel thought rules out the need for manual calculation of water volumebased on the manual inputs from the user leading to higher accuracy and ease of operation while measuring water levels.
- An Alarm Manager functionality is added in Android App, which lets users easily schedule when the water pump should turn on and offby pre-setting a Start-Time and an End-Time using the Android app. This feature automates the operation of the water pump, so it starts and stops according to the user's chosen schedule. It's a convenient way to control the pump without needing to manually do it every time.
- A robust mechanism to monitor the filling status of the tank in implemented in the proposed system. If it detected that the tank is not being filled with water as expected, the system automatically shuts off the motor pump. Additionally, notifications are promptly sent to all mobile devices with the Android app installed, alerting users about the situation. By incorporating this mechanism, it ensures proactive monitoring and timely response to any issues related to the tank's fillingthus preventing wastage of resources and real-time redressal of issues. The notifications serve as valuable alerts, keeping users informed and allowing them to promptly investigate and resolve any potential concerns with the water supply.

2. Related Work

The IoT Based Water Level Control System [1], proposed a solution utilizing the Internet of Things (IoT) employing an ESP8266 controller to autonomously regulates the pump or valve, preventing water overflow and wastage but using a third-party application “Blynk” to facilitate water level monitoring and control. They conducted tests on a 64 cm water container, and the system exhibited a 2 cm error in water level control.

In IOT Based Water Level Monitoring System [2], specifically focused on liquid level sensors and logic controllers. It compared manual systems with IoT-based systems in terms of power consumption and water wastage. This system utilizes a controller-based approach to indicate thewater level in the tank to an agent, while employing sensor-based water level detection using water level sensors.

In IOT Based Water Level Monitoring & Controlling System [3], they developed an IoT-based water level monitoring and control system by utilizing an Ultrasonic Sensor, the water level monitoring system senses the liquid level and compared it with the tank's depth. The system incorporated components such as Arduino Uno, a Buzzer, and an LCD screen to display the water level in the tank and the motor's operational state but not using any mobile app.

In Water Level Monitoring System Using IOT [4], the system utilized water containers with ultrasonic sensors placed on top to detect and compare the liquid level with the container's depth. To facilitate its functionality, the system employed an AVR family microcontroller, Raspberry Pi, LCD screen, Wi-Fi modem for data transmission, a buzzerand 12V transformer-basedPower supply for the system.

In IoT Based Water Level Indicator Using Node MCU [5][6]presented a volume-based water monitoring system based on IoT by utilizing an ultrasonic distance sensor.The IOT based water level meter [7]make utilization of a hub MCU with water sensor to foresee surge and caution particular specialists regarding surges utilizing IoT. In Automatic Water Level Control System[8] used Arduino to automate the process of water pumping in a tank. In Microcontroller Based Automated Water Level Sensing and Controlling: Design and Implementation Issue[9] introduce the notion of water level monitoring and management within the context of electrical conductivity of the water using microcontroller-based water level sensing and controlling in a wired and wireless environment. A Node-MCU based water pump control systems for irrigation was presented in [10]. Android app development for automation systems using Bluetooth presented in [11].

But all the above IOT based systems developed for overhead water tank level measurement and pump control are volume-based calculation requiring entering the multiple parameters like height, radius etc. based on shape of water tank in the system thus restricting the system to become universally utilizable for all types of water tanks. Further, all the currently developed systems are using third party android apps like Blynk which further restricts the versatility of these systems. The proposed systems are free from all the above restrictions thus making it a truly universally usable versatile IOT system.

3. PROPOSED WORK

As per the existing relevant literature, many researchers have utilized Blynk IoT app as third-party solutions or LCD screens to display the water level percentage and control the water pump. However, the proposed approach deviates significantly from these methods. It does not rely on any third-party applications like Blynk, and does not utilize LCD screens. Instead, the authors have developed its own customized Android application to cater the various functionalities. This application enables users to conveniently monitor the water level percentage and control the water pump remotely from anywhere via internet connectivity.

The proposed solution offers effortless manual control of the water pump through the dedicated Android App. Users can easily activate or deactivate the pump with a simple tap on the App's "On" or "Off" buttons.

To enhance user convenience and automate pump control, the concept of water level thresholds has been implemented. Accordingly, if the water level drops below 25%, the pump motor turns on automatically to ensure a steady water supply. Similarly, when the water level exceeds 90%, the pump automatically shuts off to prevent overflow. These thresholds optimize water levels and promote efficient usage.

Furthermore, users can schedule automatic pump control by setting specific start and end times by using a time picker in the Android App. This functionality is implemented using Alarm Manager features of Android. This feature enables precise control over pump operation, aligning it with users' preferred timings.

The proposed system also incorporated a mechanism to detect if the tank is not being filled with water. In such cases, the motor pump is automatically turned off to conserve power, and immediate notifications are sent to users with the App installed. This improvement ensures effective water management and enables prompt responses to potential water supply issues.

The authors have implemented these functionalities in the proposed solution as below:

3.1. Register and Login to the Android App

The authors have integrated secure Login and Registration features into the proposed Android app, ensuring that only authorized individuals can register and access the app's functionalities. To maintain strict control over user registration, a secret passcode system has been implementedwhich ensures that only duly authenticated user can register on the app and gain access to proposed system.This stringent approach prevents any unauthorized individuals from registering on the app.

The registered users can easily log in to the proposed Android app using their designated email and password, which they created during the registration process. These features are implemented using Firebase Authentication. With these robust security measures in place, we prioritize user privacy and limit access to authorized individuals, ensuring a safe and secure experience.

3.2. Measuring Water Tank's Height/Depth in Android App

To accurately calculate the water level percentage and to eliminates the need for users to manually input the tank's height, the ultrasonic sensor is used to determine the tank's height. When the tank is empty, users can conveniently tap the "Press" button on the Android app screen. This action triggers the system to measure the tank's exact height/depth using the ultrasonic sensor. The obtained data is then displayed on the app and simultaneously updated in the Firebase database for subsequent calculations. This approach ensures precise calculations and eliminates the reliance on user-entered tank height, enhancing the overall accuracy and convenience of the system.

3.3. Displaying Water Level Percentage (using a visual representation) on Real Time Update

The proposed system employs a straightforward method to calculate the water level percentage by utilizing the tank's height as explained below in section 5. This calculated percentage of water level is stored in the Firebase Database for easy access and retrieval. It displays the water level percentage in an appealing visual representation or animation form within the app. This visual representation not only adds attractiveness to the interface but also provides real-time updates. As water fills up the tank, the percentage data is promptly updated in the app, allowing users to see the progress in real-time. This dynamic display ensures an engaging user experience and keeps users always informed about the current water level.

3.4. Automatically Controlling the Water Pump

A smart feature that automatically controls the water pump based on specific thresholds has been implemented. When the water level in the tank falls below 25%, the pump turns on automatically, ensuring that the tank starts filling up. This helps to maintain a continuous water supply without requiring manual intervention. On the other hand, if the water level in the tank exceeds 90%, the system automatically turns off the water pump. This prevents any overflowing of water and conserves resources by effectively managing the tank's capacity. By setting these thresholds, the proposed system takes care of controlling the water pump, so users don't have to constantly monitor or manually operate it. This feature ensures that the water level remains optimal and promotes efficient water usage, providing users with a convenient and hassle-free experience.

3.5. Manually controlling the Water Pump using Android App

Through the Android app, users can manually control the water pump also. The app incorporates intuitive buttons, allowing users to easily activate or deactivate the pump as desired. By tapping the "ON" button, users can activate the water pump, initiating water flow. Similarly, tapping the "OFF" button instantly turns off the pump, halting water circulation. This straightforward and user-friendly interface empowers users to have direct control over the water pump, facilitating efficient management of water supply.

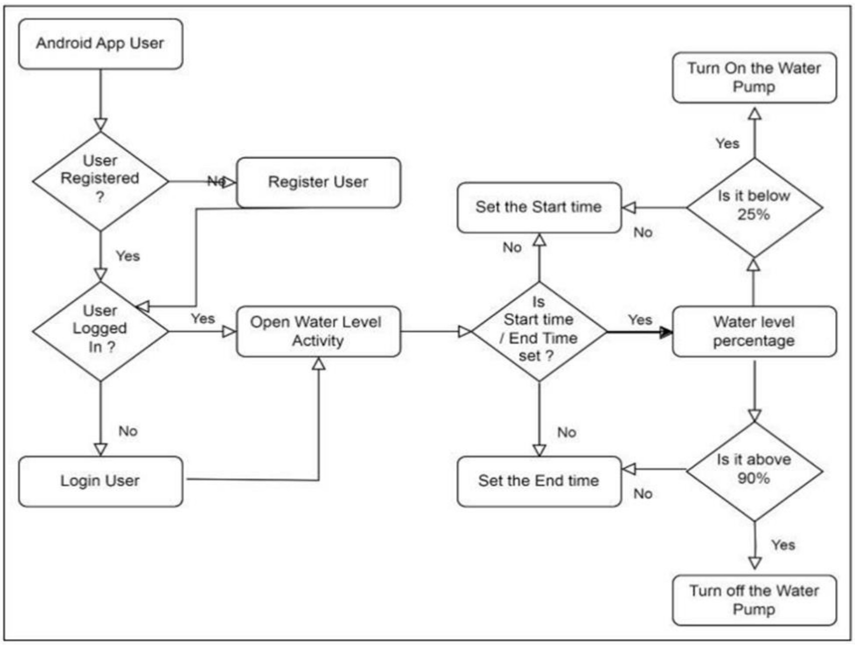

Figure.1: User flow diagram for the proposed model

3.6. Implemented Schedule Based Pump Control functionality

A schedule-based pump control functionality in implemented in the Android app, allowing users to conveniently set the start and end times using a time picker. By utilizing the powerful Alarm Manager feature of Android, our app ensures that the pump will automatically activate precisely at the specified start time and deactivate at the designated stop time, all according to the user's preferences. This seamless integration of scheduling capabilities enhances the user experience by eliminating the need for manual intervention and ensuring reliable and accurate pump control.

3.7. Efficient Power Management and Alert System for Optimal Water Usage:

The proposed system also introduced a mechanism to detect if the tank is not being filled with water even when the pump is on. In such cases, the motor pump is automatically turned off, preventing unnecessary power consumption. Furthermore, notifications are sent to all mobile phones with the Android app installed, promptly notifying users about the issue. This improvement ensures effective water management and enables quick responses to any potential water supply problems.

The whole work flow can be understood with the flowchartshown in figure.1

4. METHODOLOGY / IMPLEMENTATION

4.1. Basic UI and screens for Android App

Initially, a user-friendly interface is created for Android app by designing various screens and activities. These include the Login and Register activities, the Water Level screen, the Navigation Drawer for easy navigation, and the Contact Developer and Dashboard fragments. These screens allow users to interact with the app's features effectively, and the underlying Kotlin logic ensures seamless input and output.

4.2. Firebase Integration for Android App

Next, the Android app is seamlessly integrated with the Firebase Database, utilizing Firebase Authentication for secure user authentication and Firebase Realtime Database for efficient data storage and retrieval. This integration provides a reliable and secure access system for app features and keeps user information up-to-date. With Firebase Authentication and the Realtime Database, our app offers robust user authentication and seamless data management, enhancing functionality and user experience. This integration also sets a strong foundation for future development and expansion. The integration of Water Levels Details, User Details and Authentication Details is shown in Figure 2,3,& 4 respectively.

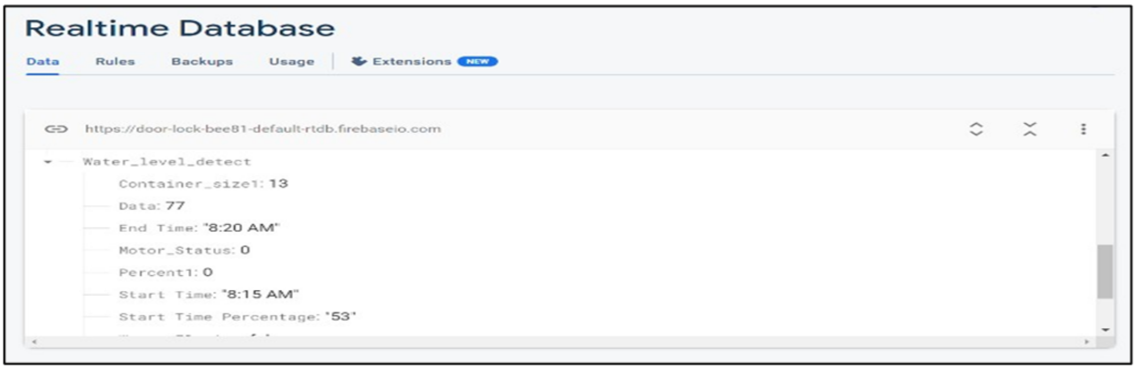

Figure2: Firebase Realtime Database Screenshot (Water Level Details)

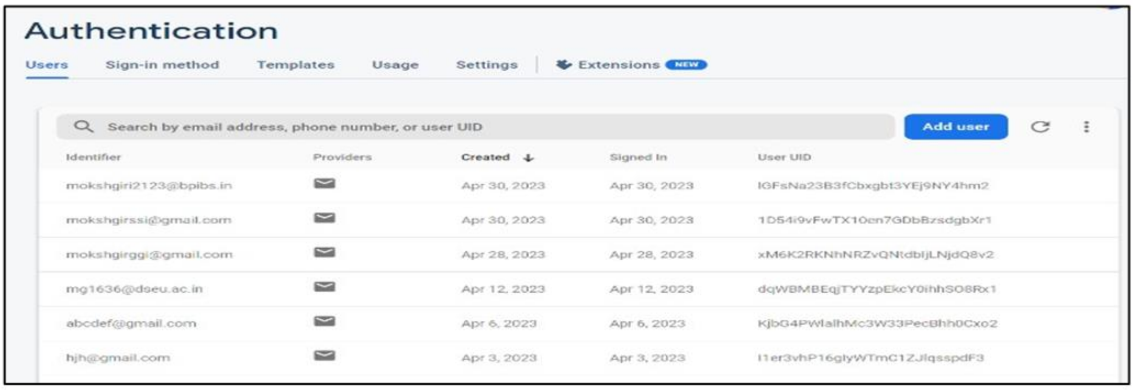

Figure3: Firebase Realtime Database Screenshot (User Details)

Figure4: Firebase Authentication Screenshot

4.3. Hardware Integration and Circuit Setup

The hardware setup is designed as shown in Figure5 using the hardware components such as the Node MCU, Ultrasonic Sensor, and Buzzer.

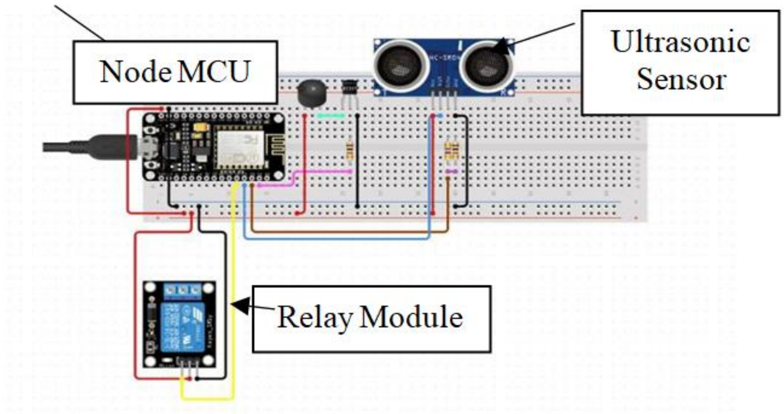

Figure5: Circuit Diagram (Node MCU, Ultrasonic sensor, Relay Module)

4.4. Arduino IDE Configuration and collecting Data from Ultrasonic Sensor

This involved configuring the sensors, writing code to retrieve distance measurements, and establishing a secure connection with Firebase to store the data. Initially, system focused on calculating and storing the distance of the top-most water level from the sensor in the Firebase Realtime Database. The proposed water level indicator system (Physical setup) is shown in Fig.6

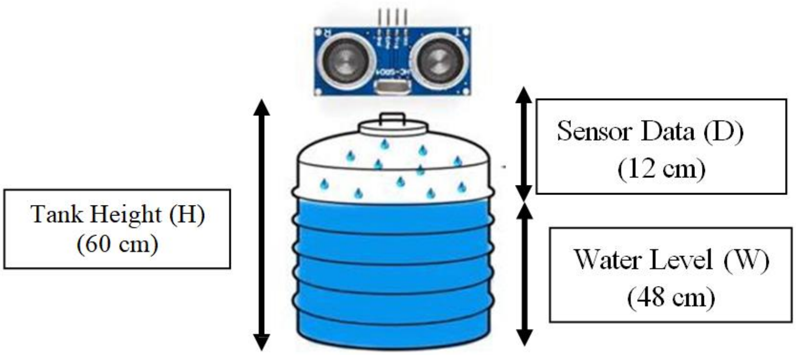

Figure6: Proposed water level indicator system

4.5. Water Level Measurement and Conversion Logic

The nest important task was to implement logic that converts the sensor data into accurate water level measurements in centimetres. A conversion process is developed that represents the water level as a percentage. This information can be displayed not only on the Android app but also on the serial monitor of the Arduino IDE and the web server. The water level display at android app is shown in Figure7.

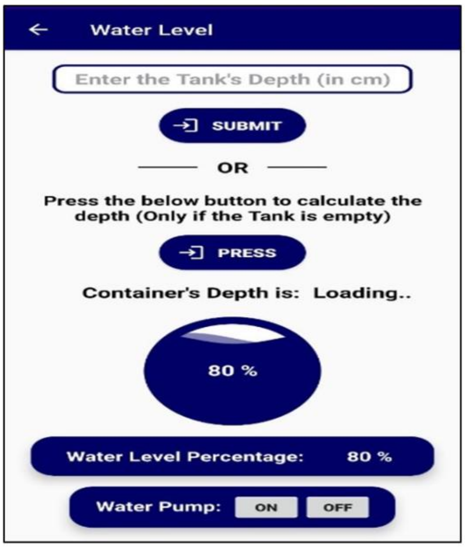

Figure 7: Water Level Display at Android App

Then the Water Level in cm and the water level percentage will be calculated as:

- **Water Level Calculation:** The water level in centi-meters (W) can be calculated as the difference between the Tank Height (H) and the Sensor Data (D):
  W = H – D
- **Water Level Percentage**

= (Water Level * 100) / Tank Height

This mathematical description demonstrates how this system calculates the water level and express it as a percentage based on height measurements using an ultrasonic sensor.

4.6. Automated Water Pump Control with Time Picker Integration using Alarm Manager

We focused on incorporating the necessary functionality and logic into the Arduino code to control the water pump based on specific water level percentages. Our aim was to automate the water pump's operation, activating it when the water level falls below 25% and turning it off when the level exceeds 90%. By implementing this logic, we ensure efficient management of water levels and promote automated pump operation. Additionally, we included a Time Picker functionality in the Android app, allowing users to set the desired start and end times for the water pump. The pump will turn on exactly at the start time and turn off at the end time. This Android App functionality is shown in Figure8 &Figure9.

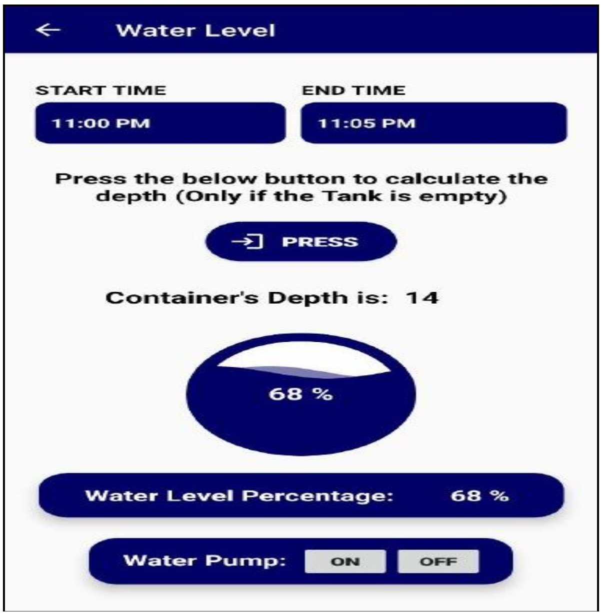

Figure8: Water Level with Set Time (Android App)

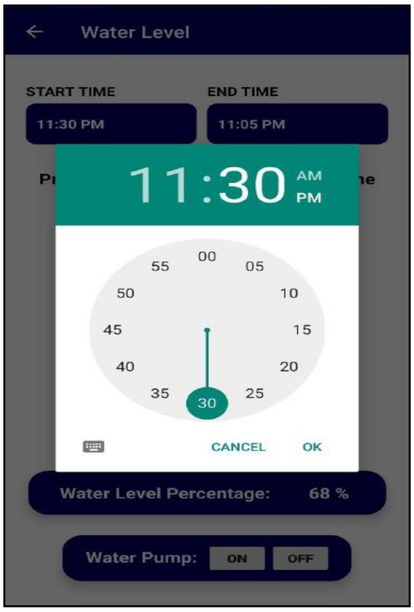

Figure 9:Water Level with Time Picker (Android App)

4.7. Automated Water Pump Control with Notification System

Lastly, we aimed to monitor the water level in the tank while the water pump is active. A mechanism is developed to detect if the tank is not filling up with water. When this occurs, the motor pump is automatically turned off, preventing unnecessary operation. Furthermore, notifications are sent to all Android app users, promptly notifying them about the issue. These improvements ensure efficient water management and enable quick responses to potential water supply problems. The display of proposed notification in Android App is shown in Figure 10 &Figure11.

Figure10: Notification 1- Water Tank is getting filled with the water

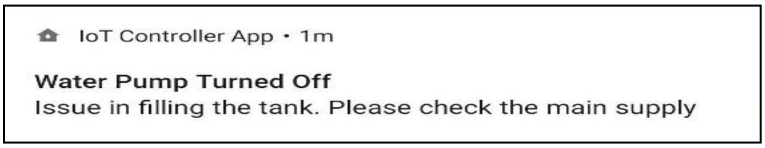

Figure11: Notification 2- Water Tank is not getting filled with the water

5. PRACTICAL IMPLEMENTATONS

5.1. Experimental Setup

The IoT-based Height-Based Water Level Indicator and Pump Control System was implemented in a real-world residential setting with a standard overhead water tank. An ultrasonic sensor was installed at the top of the tank, connected to a microcontroller and an IoT module. A custom Android app was developed to provide real-time monitoring and control of the pump via Wi-Fi. The hardware setup and its connectivity with android app for practical implementation is shown in Figure12 &Figure13

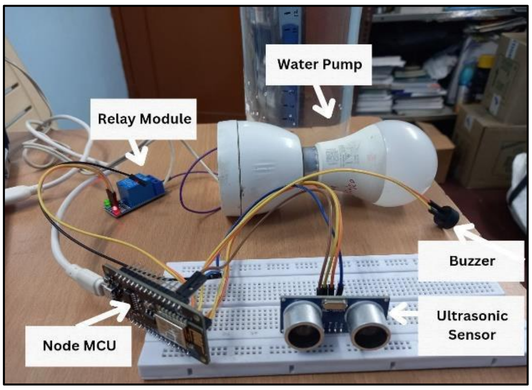

Figure12: Hardware Prototype Model

Figure13: Water Level Indication

Testing was conducted over a period of two weeks with various starting water levels, capturing the system's performance in both automatic and manual modes.

5.2. System Training

The system is trained to determine optimal water level thresholds for pump activation and deactivation, as per below setting:

- Pump ON: When water level drops below 35%.
- Pump OFF: When water level exceeds 85%.

The sensor readings were calibrated to ensure accurate water level percentages, and baseline data was recorded.

6. RESULT ANALYSIS

The proposed water level indicator IoT system was tested for the following parameters-

- **Accuracy**: The ultrasonic sensor consistently provided precise water level readings, with no false activations or deactivations noted.
- **Pump Control**: The system effectively adhered to the set thresholds, with automatic pump operation demonstrating high reliability. Overflow prevention was triggered at full capacity, with the pump turning off accurately.
- **App Functionality**: The Android app provided real-time notifications and allowed for remote pump control, including scheduled timer settings for added convenience.
- **Environmental Conditions**: The sensor performed reliably even with slight fluctuations in environmental temperature and humidity.
- **Latency:** Minimal latency was observed between the Android app command and pump operation, maintaining a user-friendly experience.

The real-time testing confirms the system's effectiveness in managing overhead water tank levels autonomously. The accurate water level measurement, combined with reliable pump control, significantly reduces water wastage due to overflow and ensures an uninterrupted water supply. The proposed system allows users to monitor and adjust the system remotely making it more convenient and efficient.
The data observed from the real time testing is tabulated in the Table-1.

The paper resulted in a Water Level Indicator with Motor Control system integrated with an Android App. It uses a Node MCU board, Ultrasonic Sensor, relay module, and buzzer. The Android app displays the water level percentage and allows manual pump control. Automatic mode activates the pump based on predefined thresholds (25% and 90%) and includes a Time Picker for scheduled pump control. The system detects tank filling issues and sends notifications to app users.

7. CONCLUSION

In conclusion, the development of this Height Based Water Level Indicator and Pump Control IoT System with Android App, offers a robust and user-friendly solution for monitoring and managing water levels in tanks. The integration of advanced features, such as visual animations, percentage display, manual pump control, automated thresholds, and scheduled operation, enhances the convenience and efficiency of water management.

Table1:Real-Time Testing Data

Test No.	Day & Time	Initial Water Level (%)	Measured Sensor Distance (cm)	Thresholds	Expected Pump Action	Actual Pump Action	Outcome
1	Day 1 - 08:00 AM	10%	90	ON < 35%	ON	ON	Successful; pump started as expected at low level.
2	Day 1 - 09:45 AM	88%	7	OFF > 85%	OFF	OFF	Successful; pump stopped upon reaching threshold.
3	Day 2 - 05:30 AM	30%	65	ON < 35%	ON	ON	Successful; pump activated at low level.
4	Day 3 - 12:00 PM	95%	5	OFF > 85%	OFF	OFF	Successful; overflow prevention active.
5	Day 5 - 07:15 AM	50%	50	Maintain 35-85%	-	-	No action needed; water level stable.
6	Day 7 - 10:00 PM	100%	0	OFF at 85%	OFF	OFF	Successful; overflow avoided at full capacity.
7	Day 10 - 04:00 PM	5%	95	ON < 35%	ON	ON	Immediate activation; pump engaged promptly.

The additional mechanism for detecting if the tank is not being filled and promptly notifying users through the Android App ensures proactive response to potential water supply issues. This feature enhances the overall efficiency of the system and promotes responsible water management.

In summary, the Water Level Indicator with Motor Control system integrated with an Android App offers a comprehensive and user-centric solution for managing water levels, enhancing convenience, promoting responsible usage, and ensuring effective water management in both residential and commercial settings.

8. FUTURE SCOPE

In future, a mechanism to measure the time it takes to fill the tank accurately may be implemented. Further, by expanding compatibility to iOS devices, we aim to make this solution accessible to a broader user base, ensuring that more individuals can benefit from the convenient water level monitoring and motor control functionalities.

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