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Automated IoT-Based Water Level Monitoring System

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Abstract

Water is essential for domestic, agricultural, industrial, and commercial activities. Improper monitoring of water tanks can cause overflow, shortage, wastage, and unnecessary electricity consumption. This paper presents an IoT-based water-level monitoring system with automatic and manual pump control using a web dashboard or mobile application. The proposed system uses an Arduino UNO, ESP8266 Wi-Fi module, ultrasonic sensor, relay module, water pump, solar panel, and battery-charging system. The ultrasonic sensor measures the water level, while the Arduino processes the data and communicates with the ESP8266 for remote monitoring. In automatic mode, the pump turns ON when the water level falls below a predefined limit and turns OFF when the tank reaches the maximum level. In manual mode, users can remotely control the pump through the application. Water-level and pump-status data can also be stored for monitoring and analysis. The proposed system reduces human effort and water wastage, improves energy efficiency, and provides a low-cost solution for smart water management.

Keywords: IoT; Water Level Monitoring; Arduino UNO; ESP8266; Ultrasonic Sensor; Automatic Pump Control; Web Dashboard; Solar Energy

How to Cite This Article

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Introduction

Water management is important because of increasing demand, irregular water supply, and water wastage. Traditional water-tank monitoring requires manual checking, which can result in tank overflow, water shortage, and unnecessary pump operation.

The Internet of Things (IoT) enables remote monitoring and control of physical systems through internet connectivity. The proposed system uses an Arduino UNO, ESP8266 Wi-Fi module, and ultrasonic sensor to measure and monitor water levels through a web dashboard or mobile application.

The system provides two operating modes: automatic and manual. In automatic mode, the pump is switched ON when the water level falls below a predefined lower limit and switched OFF when the tank reaches the upper limit. In manual mode, users can remotely control the pump. A solar panel and battery system can also provide power support for the electronic components.

The proposed system is suitable for residential buildings, agricultural fields, industries, and commercial water storage systems. It helps reduce water wastage, human effort, and unnecessary energy consumption.

Related Work

Traditional water-level controllers generally use float switches or manual inspection. Although these methods are simple, they provide limited monitoring and do not support remote access.

IoT-based water-level systems improve conventional methods by using sensors and wireless communication. Ultrasonic sensors are suitable for non-contact water-level measurement, while ESP8266 provides an economical method for Wi-Fi connectivity. Several IoT systems have been proposed for automatic pump control; however, the proposed system combines real-time monitoring, automatic control, remote manual operation, data storage, and optional solar power in a single system.

Proposed System

The proposed system consists of an ultrasonic sensor, Arduino UNO, ESP8266 Wi-Fi module, relay module, water pump, web/mobile application, solar panel, and battery.

The ultrasonic sensor is installed at the top of the tank and measures the distance between the sensor and water surface. The Arduino processes the sensor readings and calculates the water level. The ESP8266 sends the information to the web dashboard or mobile application.

The basic system flow is:

Ultrasonic Sensor → Arduino UNO → ESP8266 → Internet → Web/Mobile Application

For pump control:

Web/Mobile Application → ESP8266 → Arduino UNO → Relay → Pump

Water-Level Measurement

The ultrasonic sensor measures the distance to the water surface using the time taken for an ultrasonic pulse to return.

The distance is calculated as:

$$d = (v \times t) / 2 \quad (1)$$

where d is the measured distance, v is the speed of sound, and t is the echo travel time.

If H represents the tank height, the water-level percentage can be calculated as:

$$\text{Water Level (\%)} = [(H - d) / H] \times 100 \quad (2)$$

Automatic Mode

In automatic mode, predefined lower and upper limits control the pump. When the water level falls below the lower threshold, the Arduino activates the relay and starts the pump. When the water level reaches the upper threshold, the relay is deactivated and the pump stops. This prevents overflow and reduces unnecessary pump operation.

Manual Mode

In manual mode, the user can operate the pump remotely through the web dashboard or mobile application. The command is transmitted through the ESP8266 to the Arduino. A maximum-level safety condition can be maintained to prevent overflow even during manual operation.

Hardware And Software Implementation

The Arduino UNO acts as the main controller and processes sensor data. The ultrasonic sensor provides non-contact water-level measurements. The ESP8266 provides Wi-Fi connectivity for communication with the remote application.

A relay module is used to control the water pump because the Arduino cannot directly handle the pump's electrical load. The pump transfers water into the storage tank.

The system can include a solar panel and rechargeable battery to provide renewable energy for the controller, sensor, and communication components. A suitable charge controller should be used to regulate battery charging.

The web dashboard can be developed using HTML, CSS, JavaScript, and ASP.NET. It can display water level, pump status, operating mode, and historical information. XML can be used for structured storage of water-level and pump-operation records.

System Operation

The system continuously measures the tank level using the ultrasonic sensor. The Arduino calculates the water-level percentage and sends the information through the ESP8266.

In automatic mode, the controller compares the measured level with predefined thresholds. If the level is low, the pump is switched ON. Once the tank reaches the maximum level, the pump is switched OFF.

In manual mode, the user selects the required pump operation through the application. The command is transmitted to the controller through the internet. The current water level and pump status are displayed on the dashboard.

The complete operation can be summarized as:

1. Initialize the sensor, Arduino, ESP8266, and relay.
2. Connect the ESP8266 to the Wi-Fi network.
3. Measure the water level.
4. Calculate the water-level percentage.
5. Send data to the web/mobile application.
6. Check the selected operating mode.
7. Automatically or manually control the pump.
8. Store water-level and pump-status information.
9. Repeat the process continuously.

Results And Discussion

The developed system successfully monitors the water level and pump status through the IoT-based dashboard. As shown in the dashboard, the current water level is 85%, and the motor is OFF at the latest recorded time. The system displays real-time water-level information along with historical data and predicted water levels.

The recorded data shows water levels of 75%, 90%, 60%, and 85% at different times. The graph provides a clear comparison between actual and predicted water levels, helping users understand the changing water conditions. The system also predicts a water level of approximately 76.9% for the next two hours.

The automatic control feature helps prevent tank overflow by switching the pump OFF when the required water level is reached. Manual mode allows users to control the pump remotely whenever required. The dashboard also provides easy access to motor status, water-level history, and prediction information.

The major advantages observed from the implemented system are:

- Real-time water-level monitoring.
- Automatic and remote pump control.
- Reduction in water overflow and wastage.
- Reduced human effort and unnecessary pump operation.
- Historical storage of water-level and motor-status data.
- Prediction of future water levels.
- Support for efficient energy and water management.
- Simple and user-friendly web dashboard.

Overall, the results demonstrate that the proposed IoT-based system can provide an efficient and convenient solution for smart water-tank management. System accuracy mainly depends on ultrasonic sensor calibration, proper sensor installation, Wi-Fi connectivity, and stable power supply.

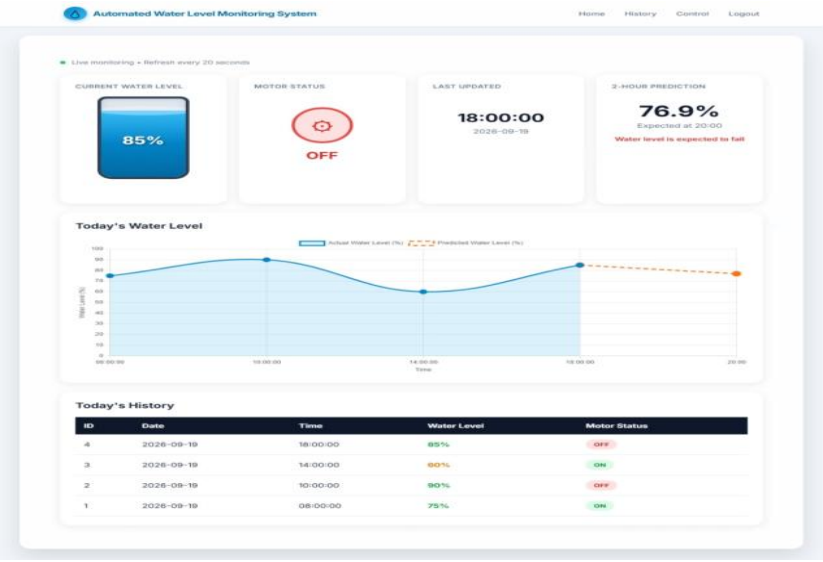

Fig. 1. *IoT-Based Water Level Monitoring and Pump Control Dashboard*

Applications And Future Scope

The system can be used in homes, apartments, farms, schools, industries, hotels, hospitals, and commercial buildings. In agriculture, additional sensors such as soil-moisture sensors can be integrated for automated irrigation.

Future improvements may include cloud-based data storage, mobile notifications, water-flow measurement, leakage detection, energy monitoring, multiple-tank management, and predictive water-demand analysis. GSM/4G communication can also be added for locations without Wi-Fi connectivity.

Conclusion

This paper presented an IoT-based water-level monitoring and pump-control system with automatic and manual operating modes. The system combines an Arduino UNO, ultrasonic sensor, ESP8266, relay, water pump, and optional solar-battery power system.

The ultrasonic sensor continuously measures the water level, while the Arduino controls the pump according to predefined conditions. The ESP8266 enables remote monitoring and manual control through a web dashboard or mobile application. The system can reduce water wastage, human effort, and unnecessary electricity consumption.

The proposed solution provides a simple, low-cost, and scalable approach to smart water management. With future integration of cloud services, leakage detection, and predictive analytics, the system can be further improved for large-scale smart water-management applications.

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