AquaSense: Smart IOT Solution for Water Level Monitoring

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Abstract

As a fundamental component for sustaining existence, water requires proper administration to prevent wastage. Recent innovations in Internet of Things (IoT) technology have generated novel methodologies for monitoring water levels. This manuscript introduces an intelligent water surveillance framework designed for residential settings. The system employs depth sensors to gauge water levels and compares measurements against predetermined thresholds (exceeding 20 cm). When thresholds are surpassed, the framework utilizes Arduino UNO alongside GSM modules to initiate communication and alert the user. Simultaneously, submersible pumping equipment activates, transferring excess water to storage reservoirs. The accumulated water becomes available for repurposing in applications such as irrigation networks and additional household functions, thereby ensuring minimal water wastage. This reclaimed water can subsequently serve various purposes including landscape irrigation and domestic usage, promoting conservation principles.

Index Terms—IoT, Arduino UNO, water level sensors, GSM, submersible pump, threshold, water management.

INTRODUCTION

Water represents a finite yet essential resource with critical significance across numerous domains including agricultural operations, industrial processes, and maintaining vital ecological services for all biological organisms. Nevertheless, public awareness regarding appropriate consumption quantities for daily requirements remains insufficient. Water wastage occurs through numerous sources, ranging from residential issues such as faucet leakage and tank overflow to industrial challenges including inefficient filtration mechanisms and suboptimal management practices. These circumstances necessitate efficient real-time monitoring systems capable of accurately tracking and regulating water consumption patterns. Water's value varies according to its application—whether supporting survival, enabling economic productivity, or preserving environmental integrity. Consequently, water conservation remains among humanity's most pressing existential challenges. As technological integration becomes increasingly inseparable from contemporary human experience, the introduction of Internet of Things (IoT) frameworks in 2009 transformed resource management methodologies. IoT solutions offer adaptable, expandable, and user- accessible implementations, with their integration into water management infrastructures providing dependable and economical methodologies for continuous water level monitoring

A. Motivation

When excessive precipitation accumulates intensively, water can collect in residential spaces, potentially causing significant property damage, resident inconvenience, and financial losses. Such scenarios necessitate automated water level surveillance systems capable of detecting rising water elevations and implementing immediate countermeasures without requiring manual intervention. Deployment of these monitoring frameworks can significantly minimize risks and prevent potential damages. These surveillance systems demonstrate broad applicability across numerous settings including grain storage facilities, residential complexes, and additional locations prone to frequent or intense rainfall events.

B. Contribution

This research primarily aims to develop an IoT-based water monitoring framework that effectively identifies water levels and initiates appropriate countermeasures to remove excess water through redirection to storage reservoirs. Additionally, the system must communicate notifications to users when water levels exceed predefined thresholds. This approach ensures prompt recognition and timely response implementation.

C. Organization

This manuscript's contents are structured as follows: Section II examines related research efforts. Section III elaborates on the proposed system architecture. Section IV presents hardware and software component specifications. Section V discusses experimental procedures and outcomes, while Section VI provides concluding observations.

II. RELATED WORK

Perumal et al. [1] introduced a protocol for IoT-based real-time water level monitoring during flood conditions. Their system aims to regulate water movement in flood-prone areas. Ultrasonic sensing equipment measures water elevations, with collected measurements displayed on LCD interfaces and stored on server infrastructure. When water heights surpass defined thresholds, the system updates remote monitoring dashboards and distributes information through social networking platforms including Twitter.

Gunde et al. [2] created an IoT-based water management infrastructure for extensive campus environments, functioning without human supervision. Ultrasonic sensors detect reservoir water levels, transmit measurements to Arduino components, and communicate with Raspberry Pi units to visualize water levels through web interfaces. Data remains stored in cloud repositories. The system activates submersible pumps when water reaches minimum thresholds (20%) and automatically deactivates when maximum thresholds (80%) are attained. Upon detecting maximum water levels, warning messages are transmitted.

Shah et al. [3] developed a system adaptable to existing water containment structures. An Android application enables users to establish minimum and maximum water level parameters while displaying current measurements. Data security mechanisms implement login verification procedures whenever users access the system. Furthermore, the application analyzes consumption patterns, enabling users to implement appropriate conservation measures. Remote monitoring capabilities remain accessible through smartphones or laptop computers.

Praba et al. [4] proposed an advanced water level monitoring framework developed for conventional water reservoirs, incorporating Android applications for user interaction. Their system comprises four modules: the first collects data from level sensors and forwards information to the second IoT-based module. The third module securely stores information in cloud infrastructure using Carriots platform for Android application development. The fourth module enables remote water level monitoring through web-based interfaces. Additionally, security features prevent unauthorized access to critical control functions such as pump activation by restricting access to authorized personnel. This comprehensive system facilitates efficient identification and resolution of water-related issues.

Min-Allah et al. [5] developed a prototype for monitoring KSA reservoir water levels using IoT technology through Android applications. Their system architecture incorporates three layers: physical, service, and presentation. The physical layer contains ultrasonic sensors detecting water levels, with measurements transmitted to service layers for cloud server storage. The presentation layer employs Android applications for retrieving real-time water level information.

Siddula et al. [6] introduced an automated dam management system designed for centralized operational control through single-server architecture. This system integrates IoT and cloud technologies to streamline processes. Initially, structured sensor data from ultrasonic equipment is collected and transmitted through microcontrollers to local base stations supporting both short-range and long-range communication. The second phase focuses on short-range data transmission (up to 100 meters) using technologies including Bluetooth for Arduino-based data transmission. The third phase incorporates long-range communications spanning hundreds of kilometers, enabling central station monitoring and control capabilities. Technologies including NarchBand-Networks IoT and LPWA networks are examined for long-distance communication applications, though optimal technology selection remains under consideration. This approach enhances management and control of dam systems through real-time data utilization, improving operational efficiency and security protocols.

de Paula et al. [7] examined practical implementations within intelligent buildings and residential complexes to address common water management challenges including contamination, reservoir depletion, leakage, and consumption pattern analysis. Their system identifies vulnerabilities in real-time, enabling timely interventions that prevent serious damage and reduce repair expenses. The framework provides adaptable approaches allowing automated actions such as activating or deactivating water supply to minimize waste and prevent further damage. Additionally, middleware components function as central storage and management hubs, collecting and storing measurements from diverse sensors. This information becomes available for display as required, allowing data streams to resume or redirect toward other IoT devices, ensuring seamless integration and responsiveness throughout the system. The solution's adaptability ensures customization potential for different environmental requirements, enhancing overall effectiveness in addressing real-time water management challenges.

Manoharan et al. [8] introduced LORA (long-range) wireless connectivity for comprehensive monitoring of water quality, distribution, potable consumption, and leak detection in waterways. Sensors measuring quality parameters, volume, and level integrate with KT-Lora-Mote through GPIOs positioned in water reservoirs. These sensors transmit real-time data to village administrators for informed decision-making. LORA technology provides optimal solutions for remote rural areas lacking traditional communication infrastructure by ensuring long-range transmission with minimal power requirements. This system not only improves water resource management efficiency but enables early detection of issues including leakage and contamination, preventing potential water crises.

Wadekar et al. [9] proposed an IoT-based tool for managing and optimizing water usage patterns. Sensors positioned in water containment structures continuously monitor and update level data for cloud platform upload. Users visualize real-time measurements through Android applications. The system automatically regulates pump operation based on reservoir water levels—activating when levels decrease and deactivating when reservoirs approach capacity. This automation enhances efficiency by preventing overflow conditions and minimizing water wastage.

Guppa et al. [10] introduced an intelligent IoT-based solution monitoring both water level and quality parameters. Their system employs ultrasonic sensors for measuring water heights and specialized sensors for assessing purity factors. Sensor data uploads to cloud platforms for remote accessibility. Wi-Fi modules connected to Raspberry Pi controllers enable remote pump operation through mobile applications based on measured water levels. However, the proposed monitoring system exhibits certain limitations. Primary concerns involve notification mechanisms, as many systems depend on internet-enabled alerts. When users remain offline, critical warnings may not reach appropriate personnel. Additionally, ultrasonic sensors present inherent limitations including restricted detection ranges affecting measurement accuracy.

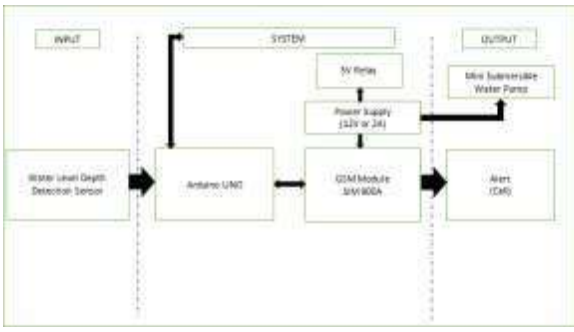

Fig. 1. Architecture of AQUA SENSE Water Level Monitoring System.

III. PROPOSED SYSTEM

The proposed framework, titled "Aqua Sense: Smart IoT Solution for Water Level Monitoring," incorporates various components for efficient water management and control. Primary elements include Arduino UNO microcontrollers, precision water depth detection sensors measuring level fluctuations, and submersible pump mechanisms transferring excess water to storage facilities. Furthermore, the system integrates notification capabilities through GSM technology, efficiently transmitting alert communications to users without requiring registration procedures or internet connectivity. Immediate responsive measures including water evacuation implement through relay components and motorized systems, reducing potential damage risks to property or agricultural products resulting from overflow conditions. The architectural design of the proposed system appears in Figure 1.

IV. HARDWARE AND SOFTWARE COMPONENTS USED IN WATER MONITORING SYSTEM

The following sections describe hardware components utilized in developing the water monitoring system.

A. Arduino UNO

This component incorporates an Atmega328p microcontroller featuring 14 digital input/output pins and 6 analog input connections. The device includes 32 kb flash memory, with 0.5 kb allocated for bootloader functions. Additional memory includes 2kb SRAM and 1kb EEPROM. Operating clock frequency maintains 16 MHz, with all processes synchronized to clock signals. As an open-source platform, both hardware boards and software remain readily accessible, allowing modification and optimization for enhanced functionality.

B. GSM Module 900

The SIM900A represents a commonly available GSM/GPRS module integrated within numerous mobile devices and PDAs. This compact wireless component finds application in IoT and embedded systems.

Operational frequencies include 900/1800 MHz bands with automatic frequency detection. Data transmission parameters configure through AT command structures.

C. Water Level Depth Detection Sensor

This sensor module incorporates parallel exposure traces for measuring droplet/water volumes to determine level conditions. Water level monitoring achieves simplicity as analog output signals maintain direct proportionality to measured water levels. Analog values read directly through converters connect to Arduino analog input pins. Water level determination occurs through resistance measurement principles—increased water immersion produces higher resistance values corresponding to elevated water levels, with reduced immersion generating opposite results.

D. Relay

A relay functions as an electrically operated switch capable of activation or deactivation. This functionality enables current flow control similar to 5V signals provided through Arduino pins.

E. Mini Submersible Pump

Submersible pumps, alternatively described as electric submersible pumps, operate while completely immersed in water. Power requirements include 3-6V supply voltage. Performance specifications include maximum lift capacity of 40-110 cm, flow rates of 80-120 L/h, and operational lifespans reaching 500 hours. Application versatility includes compatibility with various water sources such as municipal supplies, groundwater, and marine environments.

F. Miscellaneous

Additional components include USB cables, jumper wires, power adapters, and SIM cards facilitating external device connectivity.

Software requirements appear in subsequent sections.

G. Operating System

The Operating System (OS) represents system software managing computer hardware and software resources while providing common services to application programs.

H. Development Environment: Arduino IDE

Software programming Arduino devices occurs through Arduino IDE. This cross-platform application maintains compatibility with Windows, MacOS, and Linux operating systems. Arduino IDE (Integrated Development Environment) consolidates editors, compilers, and programmer functions within unified software, enhancing development efficiency. Programming language implementation for Arduino UNO utilizes C++, with IDE providing well-defined functional libraries simplifying user implementation. Arduino IDE processes written code and converts instructions into executable files with hexadecimal encoding. This file transfers to Arduino boards through loader programs available within board firmware.

V. EXPERIMENT & RESULT

Input data collection occurs through four water level detection sensors positioned at prototype model corners, as illustrated in Figure 2. Input data transmits to a system incorporating Arduino UNO and GSM module SIM900 with auto-supply functionality. Sensor data undergoes analysis through Arduino board processing. Evacuation procedures implement through relay modules and mini submersible pump mechanisms. Component interconnections and complete assembly appear in Figures 3 and 4, respectively.

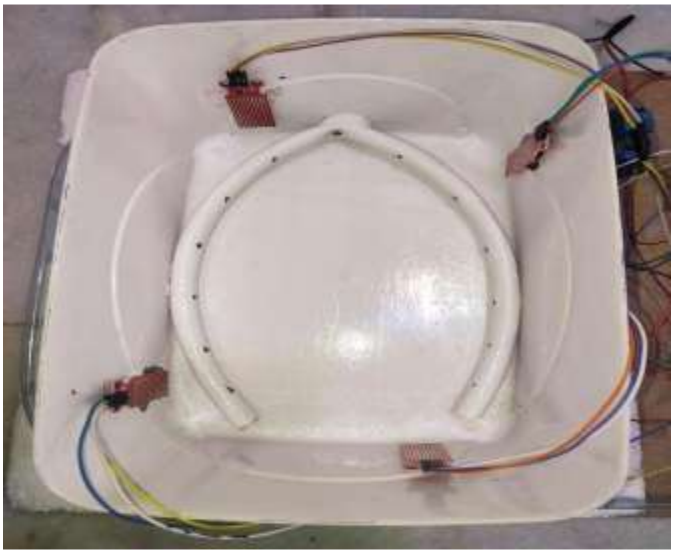

Fig. 2. Water Level Sensor Setup.

The system maintains continuous monitoring functions. When detecting moderate water levels, Arduino UNO transmits information to GSM modules for user notification while continuing level measurement processes. When threshold values exceed, the system activates submersible pumps directing water toward storage reservoirs, with automatic deactivation upon completion.

Figures 5 and 6 demonstrate system risk detection capabilities. Data analysis occurs when sensor measurements indicate deviation conditions. GSM technology facilitates user notification as shown in Figure 7.

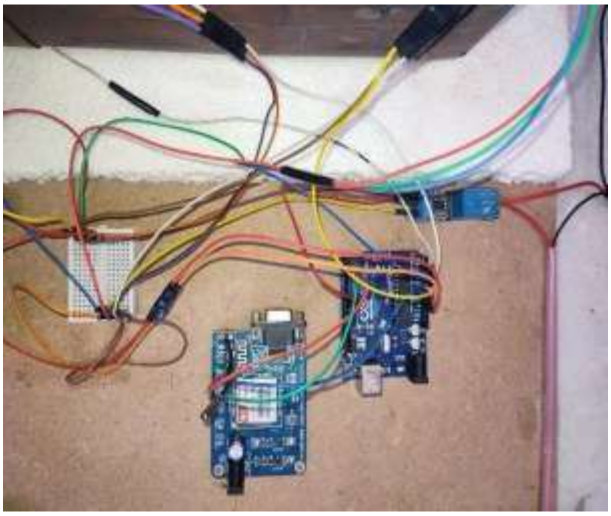

Fig. 3. Connection of Components.

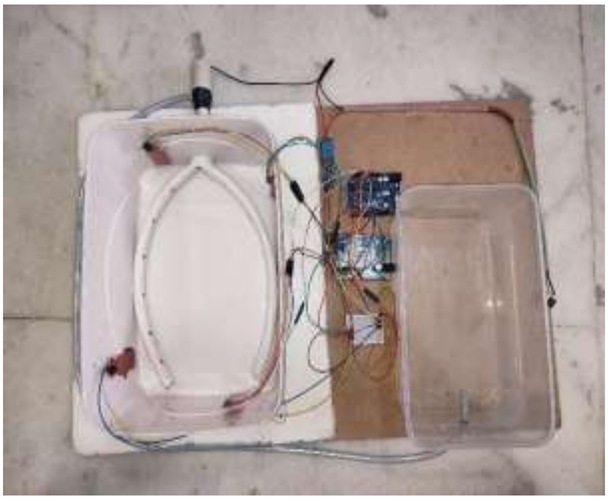

Fig. 4. Complete setup.

The system activates motorized components to drain excess water, with automatic deactivation upon complete drainage, minimizing user intervention requirements while ensuring property protection.

Advantages of the proposed system include:

a. The framework provides economical solutions by implementing straightforward water level measurement procedures requiring minimal hardware and software resources.

b. System operation maintains independence from human intervention during water level detection processes.

c. GSM module implementation enables user alert reception without requiring mobile application registration for pump control operations.

d. Installation flexibility permits deployment across various locations including private residences, bungalows, apartment complexes, grain storage facilities, and educational institutions.

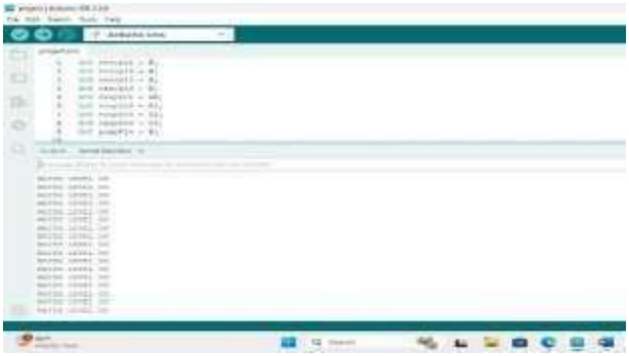

Fig. 5. Data reading on Serial Monitor

Fig. 6. Water Level Increasing on Serial Monitor.

Fig. 7. Getting a Call from GSM Module

VI. CONCLUSIONS & FUTURE ENHANCEMENTS

This module enables user warning reception without requiring mobile application registration for managing pump operations controlling excess water removal. When water levels exceed threshold parameters, users receive call notifications. System components maintain cost-effectiveness while providing extended operational lifespans compared to alternative devices. GSM module implementation facilitates notification delivery through standard telephone communications without requiring internet or Wi-Fi connectivity. This GSM functionality provides significant advantages by ensuring alert transmission reliability in locations lacking consistent internet connectivity. Future development considerations include maintenance engineer notification regarding potential leakage conditions, enabling timely corrective action implementation.

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