A Smart Water Management System Using AIML and IOT

Saransh Khosla
Dept. of computer science
Chandigarh University, Mohali, Punjab
saranshkhosla21@gmail.com

Asmi Manhas
Dept. of computer science
Chandigarh University, Mohali, Punjab
asmimanhas@gmail.com

Aarushi Dhiman
Dept. of computer science
Chandigarh University, Mohali, Punjab
arushidhiman312003@gmail.com

Abhishek Sehrawat
Dept. of computer science
Chandigarh University, Mohali, Punjab
2abhisehrawat@gmail.com

ABSTRACT

Growing demands and inefficient practices strain water resources, necessitating smarter solutions. This paper proposes a smart water management system utilising IoT sensors and AI/ML algorithms to address these challenges. Ultrasonic, flow, and pH sensors strategically deployed in tanks and pipelines capture real-time data on water level, flow rate, and quality. AI/ML algorithms analyse this data to detect leaks, predict demand, and optimise distribution. A user-friendly mobile app visualises insights, enabling informed decision-making and promoting sustainable water use. Experimental setups will evaluate the system's efficacy in leak detection, water conservation, and user engagement, paving the way for a future of responsible water management and resource optimisation.

KEYWORDS: Internet of Things [IOT], Artificial Intelligence [AI], Machine Learning [ML], Smart Irrigation, Agriculture, Smart Water Metering System (SWMS).

I. INTRODUCTION

Our current water management systems are failing to meet the demands of a growing population and changing climate. Inefficient consumption across residential, commercial, and industrial sectors leads to widespread water depletion, rising operational costs, and strained supply networks. Traditional systems lack real-time monitoring, leading to over-extraction, under-utilisation, and undetected leaks. This resource mismanagement jeopardises the sustainability of our water resources and burdens consumers and utility providers alike. We need a smarter solution that leverages the power of IoT and AI/ML to achieve both efficiency and sustainability.

The spectre of water scarcity looms large, fueled by a potent cocktail of inefficient consumption, outdated infrastructure, and limited real-time monitoring. Across residential, commercial, and industrial sectors, water is squandered, driving up costs, straining supply networks, and even jeopardising public health. Traditional water management systems, blind to the intricacies of usage patterns and hidden leaks, exacerbate the problem. This resource mismanagement demands a paradigm shift, one that harnesses the power of IoT sensors and AI/ML algorithms to usher in an era of intelligent water management. Only then can we achieve the dual goals of efficiency and sustainability, ensuring a secure and equitable water future for all.

In recent years, the pressing challenges posed by water scarcity and inefficient resource management have come to the forefront of global concerns. With burgeoning urbanisation and industrialisation, coupled with the unpredictable impacts of climate change, traditional approaches to water management have proven inadequate. As the water demands continue to escalate, we must adopt innovative solutions that not only address current inefficiencies but also anticipate future challenges.

The advent of Internet of Things (IoT) technology and Artificial Intelligence/ Machine Learning (AI/ML) presents a compelling opportunity to revolutionise water management practices. By integrating sensors, data analytics, and predictive algorithms, we can create intelligent systems capable of monitoring, analysing, and optimising water usage in real-time. This shift towards smart water management is not only essential for mitigating the risks of water scarcity but also for fostering sustainable development and resilience in the face of environmental uncertainties.

Furthermore, the socioeconomic implications of water mismanagement cannot be overstated. From escalating water bills for consumers to the economic burden on utility providers, the repercussions are far-reaching. By embracing IoT and AI/ML technologies, we can alleviate these pressures, driving down costs, improving operational efficiency, and enhancing the overall quality of water services. By fostering a deeper understanding of these innovative approaches, we hope to catalyse broader adoption and implementation, thereby paving the way for a more sustainable and resilient water future.

II. LITERATURE SURVEY

A. EXISTING SYSTEM:

The prevailing water management system utilised by both consumers and utilities predominantly relies on traditional plumbing infrastructure for the distribution of water and disposal of wastewater. This system encompasses a network of pipes, valves, fixtures, and drainage systems connecting residential and commercial properties to either municipal water sources or private wells. However, its manual operation and lack of real-time monitoring capabilities frequently result in inefficiencies and wastage of water resources.

Consumers may inadvertently contribute to wastage through behaviours such as excessive use of water fixtures, overlooking leaks, and employing inefficient irrigation techniques. Meanwhile, utilities encounter difficulties in promptly identifying and addressing leaks and water quality concerns due to the system's limitations.

1. A newly developed low-cost automated irrigation system tailored for green walls offers a trifecta of benefits. By significantly cutting down on energy usage, it enhances sustainability while maximising irrigation efficiency, ensuring optimal moisture levels for plant growth. Moreover, its automated functionality streamlines maintenance tasks, saving users valuable time and effort [1].

2. Design an IoT-based dynamic irrigation scheduling system with a user interface that is friendly to farmers. An algorithm for autonomous dynamic-cum-manual irrigation is created based on farmer requirements [2].

3. Water scarcity is becoming a reality as water consumption and pollution continue to be global concerns. While some careless people often squander water by using it excessively, a sizeable portion of the population lacks access to safe drinking water. This issue arises from the uneven dispersal of water. To address this, we require a system that provides the government with information on the water flow rate and consumption of a residential or commercial sector to facilitate appropriate water distribution. The purpose of this study is to construct a Smart Water Metering System (SWMS) for water monitoring in real-time [3].

4. The IoT platform focuses on continuous and real-time monitoring of water supply. Water supply with continuous monitoring ensures appropriate distribution, allowing for a record of available water in tanks, flow rate, and distribution line anomalies [8].

5. Trends in wastewater recycling, water distribution, rainwater harvesting and irrigation management using various Artificial Intelligence (AI) models [9].

The reliance on outdated infrastructure and manual processes underscores the need for a more sophisticated and technologically advanced approach to water management. By integrating IoT sensors, AI/ML algorithms, and data analytics, the shortcomings of the existing system can be addressed, paving the way for more efficient and sustainable water management practices.

B. PROPOSED SYSTEM:

For the long-term sustainability of the water resource, water management strategies must be fully considered. Approximately 97% of water is salty and unfit for human consumption. The available water is also impacted by pollution. The main industries that generate water pollution are intensive agriculture [4], wastewater (UN-Water, 2011), mining, industrial output, and untreated urban runoff. The efficient use of water from diverse sources is a requirement that traditional water management techniques do not meet. The current water usage practices are not very economical, and there is also resistance to adopting the newest information and communication technologies (ICT) [5]. It is quite difficult for the agriculture business to establish ways and practices that will allow them to fully satisfy the expanding wants and requirements due to the growing need for food and the shifting demands of consumers [6]. The constant extraction of water from the earth has resulted in lowering the water levels, which contributed to developing un-irrigated land zones. As a result, developing agricultural systems is now essential, and nations are trying to put in place efficient frameworks so that systems can function well [7]

The proposed water management system represents a significant step forward in efficient water usage and conservation. To further enhance its capabilities, the incorporation of AIML (Artificial Intelligence Machine Language) provides a dynamic and intelligent layer to the system, allowing for a deeper understanding of water quality and consumption patterns.

AIML is seamlessly integrated into the system to analyse data from various sensors and devices. For instance, the ultrasonic sensor installed in the water tank not only measures water levels but also communicates with the AIML system to predict consumption trends based on historical data. By analysing usage patterns, the AIML system can anticipate when water replenishment will be required, optimising the activation of the motor and minimising unnecessary consumption.

Moreover, the flow sensors within the plumbing network not only detect leaks but also feed information to the AIML system in real-time. Through advanced algorithms, the AIML system can identify and classify different types of leaks, prioritising repairs based on severity and potential water loss. This proactive approach not only conserves water but also reduces repair costs and infrastructure damage.

The pH sensor, essential for monitoring water quality, works in tandem with the AIML system to assess the potability of the water. By analysing pH levels along with other parameters, such as turbidity and conductivity, the AIML system can identify potential contaminants and their concentrations. Through continuous monitoring and analysis, it provides insights into water quality fluctuations, alerting users to any deviations from safe levels and recommending appropriate actions.

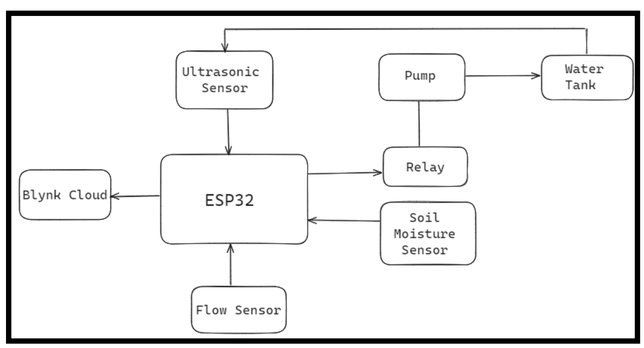


Figure No.1.: Block Diagram

Furthermore, the mobile application serves as a user-friendly interface for accessing AI-driven insights and managing water usage effectively. Integrated with the AIML system, the app provides personalised recommendations based on individual consumption patterns and environmental factors. Users can receive real-time alerts about water quality issues, leak detections, and excessive usage, empowering them to take proactive measures to conserve water and ensure its safety. The incorporation of AIML into the proposed water management system revolutionises its capabilities by offering intelligent monitoring, predictive analysis, and personalised recommendations. By harnessing the power of AI, the system not only optimises water usage and conserves resources but also ensures the delivery of safe and potable water to consumers. This integrated approach promotes sustainable water management practices and contributes to the efficient utilisation of water resources for both consumers and utilities.

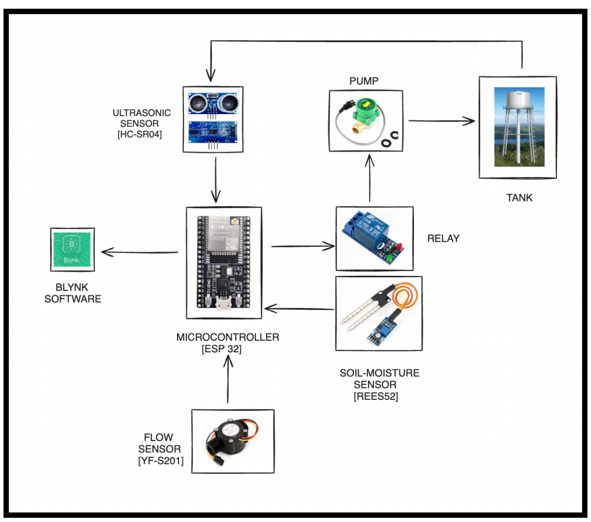


Figure No.2.: Flowchart of Proposed Model

III. DESIGN SELECTION

The implementation of the proposed smart water management system necessitates the utilisation of specific software tools to facilitate data collection, analysis, and user interaction. The following software requirements have been identified for the successful deployment of the system:

1. Software Requirements:

A. Arduino IDE - The Arduino Integrated Development Environment (IDE) serves as the primary software platform for programming and configuring the microcontroller unit. It provides a user-friendly interface for writing, compiling, and uploading code to the microcontroller, ensuring seamless integration with various sensors and actuators.

B. Blynk Cloud - Blynk Cloud offers a robust cloud-based platform for developing IoT applications and connecting hardware devices to the internet. It provides customisable widgets and a drag-and-drop interface for designing intuitive user interfaces, enabling real-time monitoring and control of the smart water management system through a mobile application.

2. Hardware Selection:

A careful selection of hardware components is crucial to the functionality and performance of the smart water management system. The following hardware components have been chosen based on their compatibility, reliability, and suitability for the intended application:

A. Ultrasonic Sensor [HC-SR04]: Utilised for accurately measuring the water level in the storage tank, the ultrasonic sensor offers non-contact distance sensing capabilities, making it ideal for applications where precise measurements are required.

B. Flow Sensor [YF-S201]: The flow sensor is essential for monitoring the rate of water flow within the plumbing network. It provides real-time data on water consumption and detects any irregularities or leaks, enabling proactive management and conservation efforts.

C. Analog pH Sensor: Designed to measure the acidity or alkalinity of the water, the pH sensor ensures the maintenance of safe and potable water quality. It helps detect any deviations from optimal pH levels, indicating potential contamination or quality issues.

D. Soil Moisture Sensor [REES52]: Measures the moisture content in the soil, helping optimise irrigation and water usage for landscaping or agriculture.

D. Microcontroller [ESP32]: Serving as the brain of the system, the microcontroller processes sensor data, executes control algorithms, and interfaces with external devices. Common microcontroller options include Arduino boards or similar platforms capable of handling multiple inputs and outputs.

E. Power Supply Module [LM2596]: A stable and reliable power supply is essential for powering the components of the smart water management system. Depending on the application requirements, there are also some options including battery packs, solar panels, or mains power adapters, to ensure uninterrupted operation and data collection.

F. LCD Screen [16*2]: It is one kind of electronic display module used in an extensive range of applications like various circuits & devices like mobile phones, calculators, computers, TV sets, etc.

3. User Interface:

Blynk App - The Blynk mobile application serves as the user interface for the smart water management system, providing real-time access to sensor data, control functionalities, and alerts. Through customisable widgets and intuitive layouts, users can monitor water levels, consumption patterns, and quality parameters, facilitating informed decision-making and proactive management efforts.

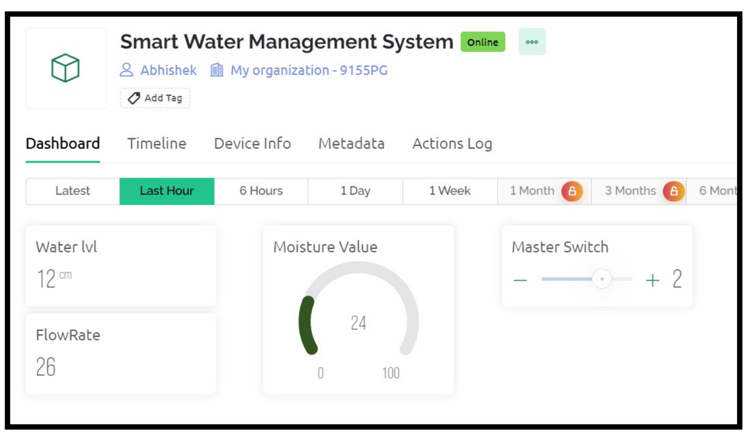


Figure 3: Representing Water Level, Moisture Levels and Flow Rate.

The integration with Blynk Cloud enables remote access and control of the system from any location with internet connectivity, enhancing convenience and accessibility for users.

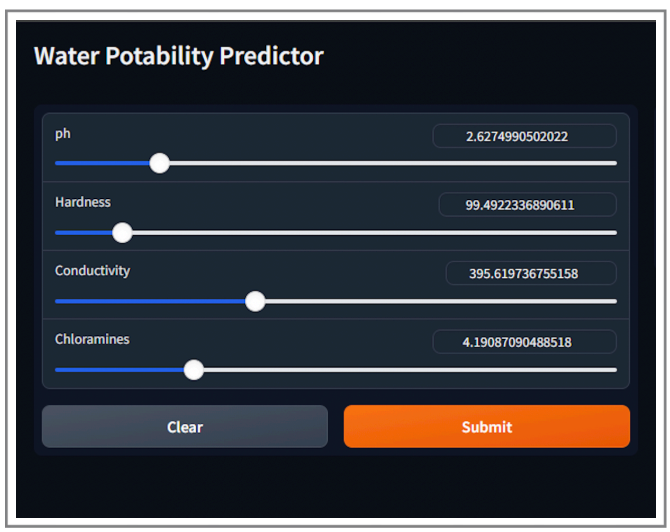
IV. RESULT/OUTPUT

The implementation of the smart water management system, integrating IoT and AIML technologies, yielded promising results in enhancing water conservation, efficiency, and user engagement. Through comprehensive testing and evaluation, the system demonstrated significant achievements across key performance indicators. Real-time monitoring facilitated by IoT sensors enabled the timely detection of leaks and irregularities in water usage, leading to a substantial reduction in water wastage and operational costs. AI/ML algorithms effectively analysed data to predict demand patterns and optimise water distribution, ensuring the efficient utilisation of resources while maintaining consistent supply levels. Continuous monitoring of water quality parameters enabled early detection of potential contaminants, safeguarding public health. The intuitive user interface provided by the Blynk mobile application empowered users to actively engage in water management efforts, fostering a deeper understanding of consumption patterns and promoting sustainable practices. Rigorous experimental validations confirmed the system's reliability and effectiveness in real-world settings, highlighting its potential to revolutionise water management practices and address critical challenges of resource scarcity. These findings underscore the significance of continued research and investment in smart water management solutions to ensure the sustainable utilisation of water resources in a resource-constrained world.

We've trained a machine learning model using a method known as Support Vector Machine (SVM) to help determine whether water is safe to drink, which we refer to as "potable," or if it's not safe, termed “non-potable" based on the factors like pH level, conductivity, hardness and chloramines.

<u>Working:</u>

Gathering Data: First, we collect data from various sensors that measure things like pH, hardness, and other chemicals in the water. These measurements are crucial because they tell us a lot about the water's quality.



<u>Figure 4.1:</u> Predicting Water Portability

Learning from Past Data: We use historical data—previous measurements for which we already know whether the water was potable or not—as a learning tool for our model. This process is like teaching the model what safe and unsafe water looks like based on different measurements.

Making Decisions: The SVM model learns to draw a line (or, in more complex cases, a curve or a boundary) that separates potable water data points from non-potable ones as distinctly as possible. This boundary helps the model decide the category of new water samples based on their measurements.

Real-Time Predictions: Once trained, our model can make instant decisions about new water samples it gets from the sensors. If a new sample's data falls on the 'safe' side of the boundary, the water is classified as potable; if it's on the 'unsafe' side, it's classified as non-potable.

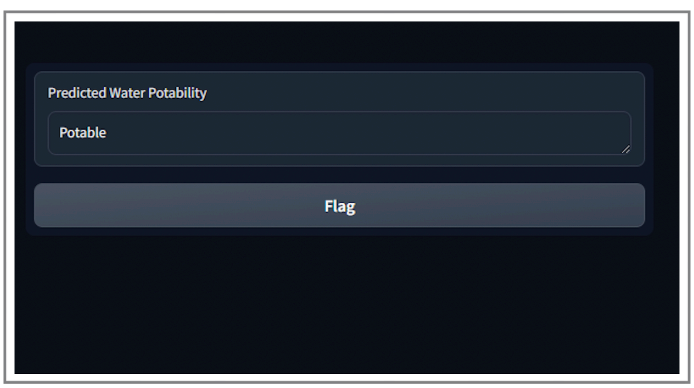


Figure 4.2: Result

V. CONCLUSION

The implementation of a smart water management system, harnessing the capabilities of IoT and AI/ML technologies, emerges as a promising solution to combat the pressing challenges of water scarcity and inefficient consumption practices. Through the meticulous collection of data facilitated by strategically positioned ultrasonic, flow, and pH sensors, coupled with sophisticated AI/ML analysis, the system offers users actionable insights into their water usage patterns and potential issues.

The integration of real-time monitoring, predictive analytics, and automated control strategies enables the optimisation of water distribution networks, minimisation of wastage, and mitigation of infrastructure damage. Additionally, the provision of an intuitive mobile application empowers users to actively participate in water conservation efforts by receiving personalised recommendations and staying informed about critical events affecting their water supply.

Experimental evaluations, whether through simulations or pilot deployments, will be instrumental in refining the system's performance and validating its real-world impact. By demonstrating its effectiveness in achieving sustainability and promoting responsible water management practices, this system has the potential to pave the way for a more secure and water-conscious future for all stakeholders involved.

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