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AI-Based Smart Water Quality Monitoring System Using Multi-Sensors & IoT

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KEYWORDS

Random Forest, Support vector Machine, Machine Learning, Turbidity, Ph, Arduino Uno micro controller

ABSTRACT

Water quality monitoring is essential for safeguarding public health and ensuring environmental sustainability. This project presents an IoT and Machine Learning–based smart drinking water quality monitoring system designed for real-time, continuous, and automated assessment of water safety. The proposed system uses temperature, pH, and turbidity sensors to measure critical water quality parameters. An Arduino Uno acts as the central controller to collect sensor data and transmit it to a cloud platform through IoT connectivity for remote monitoring and analysis. Machine Learning techniques are integrated to enhance the intelligence of the system. Historical sensor data is collected and preprocessed through noise removal, normalization, and feature extraction. Classification algorithms such as Decision Tree, Random Forest, Support Vector Machine, are used to classify water as safe or unsafe and to detect anomalies and predict contamination trends. Real-time water quality information is displayed on an LCD for local monitoring, while a buzzer provides immediate alerts when parameters exceed permissible limits or when the ML model predicts unsafe conditions. The proposed system offers a cost-effective, scalable, and reliable solution that reduces manual testing and human intervention

I. INTRODUCTION

Currently drinking water is very prized for all the humans. In recent times water levels are very low and water in the lakes are going down. So its too important to find the solution for water monitoring & control system. IoT is a solution. In recent days, development in computing and electronics technologies has triggered Internet of Things technology. Internet of Things can be described as the network of electronics devices communicating among them by the help of a controller. The IoT is a collection of devices that work together in order to serve human tasks in a efficient manner. It combines computational power to send data about the environments. These devices can be in form of sensors, appliances, embedded systems, and data analysis microchips. This project presents a low cost water monitoring system, which is a solution for the water wastage and water quality. Microcontrollers and sensors are used for that system. Ultrasonic Sensor is used to measuring water level. The other parameters like pH, TDS, and Turbidity of the water can be calculated using different corresponding sensors. This system use the flow sensor which can measure the water flow and if the necessary quantity of water flow through the pipe then water flow can be stopped automatically.

Safe drinking water is a fundamental requirement for public health, yet water contamination remains a major challenge due to rapid urbanization, industrial discharge, agricultural runoff, and aging water infrastructure. Conventional water testing relies on periodic laboratory analysis, which is time-consuming, costly, and incapable of providing real-time information about water safety. As a result, contamination often goes unnoticed until it causes serious health problems. To overcome these limitations, the integration of Internet of Things (IoT) and Machine Learning (ML) offers a smart and automated approach for continuous water quality monitoring and intelligent decision making.

In this system, IoT sensors are deployed in water sources such as storage tanks, pipelines, and distribution systems to continuously measure key parameters including pH, turbidity, temperature, Total Dissolved Solids (TDS), and electrical conductivity. These sensors are connected to a microcontroller (such as Arduino which collects real-time data and transmits it to a cloud platform . The collected data is stored and visualized through dashboards or mobile applications, allowing authorities and users to monitor water quality remotely at any time.

Machine Learning enhances the system by analyzing historical and real-time sensor data to detect patterns, predict water contamination, and classify water as safe or unsafe. ML algorithms such as Decision Trees, Random Forest, Support Vector Machine, or Neural Networks can be trained to identify abnormal conditions and forecast future water quality trends. When the system detects unsafe conditions, automated alerts are sent to users via mobile notifications, email, or IoT messaging platforms, enabling quick action to prevent health risks.

1. LITERATURE SURVEY

P. Jain et al. (2021) presented an IoT-enabled smart water quality monitoring system with basic data analytics and alert mechanisms. The system monitored pH, turbidity, and temperature and displayed results locally on an LCD. The implementation enhanced real-time awareness of water conditions. Nevertheless, the system did not employ advanced machine learning models for predictive analysis or anomaly detection.

S. Anitha et al. (2022) developed an intelligent water quality monitoring system combining IoT sensing with machine learning algorithms such as Random Forest for contamination prediction. The system demonstrated improved accuracy in detecting unsafe water conditions and supported early warning mechanisms. However, the increased computational complexity required efficient data preprocessing and reliable cloud infrastructure.

R. Mehta et al. (2023) proposed a smart drinking water monitoring framework using IoT and AI-based analytics for public health applications. The system enabled continuous monitoring, real-time alerts, and predictive insights into water quality trends. While the solution enhanced decision-making capabilities, it faced challenges related to sensor calibration, data noise, and scalability for large deployment areas.

D. Chavan et al. (2024) introduced an IoT and machine learning–based water quality assessment system focused on anomaly detection and trend prediction. The system integrated sensor data preprocessing, normalization, and classification to improve reliability. Although the results showed high prediction accuracy, the system required consistent sensor maintenance and quality data to ensure long-term performance.

2. PROPOSED SYSTEM

In this project, the water quality analysis in real time is implemented using the micro controller. Which consist of Nodemcu. There are various sensors are connected in Nodemcu to analyze the water quality, and assurance of purity. The following sensors like DHT11 sensor, pH sensor, level sensors are used to analyse the water quality in various stages. A very important measurement in many liquids chemical processes (industrial, pharmaceutical, manufacturing, food production, etc.) is that of pH: the measurement of hydrogen ion concentration in a liquid solution. The pH sensor is used to find the liquid is the neutral form of acid and caustic (alkaline) approximately the water will be in the scale of 7 the common pH scale extends from 0 (strong acid) to 14 (strong caustic), with 7 in the middle representing pure water (neutral). And level sensor is used measure the water content in the tank. When the water level is reaches the threshold level it will intimates to the authorised persons. These sensor Values as 5 data are uploaded to the defined ip address connected in the Ethernet network and also the data is transmitted to a wireless sensor network say Wi-Fi.

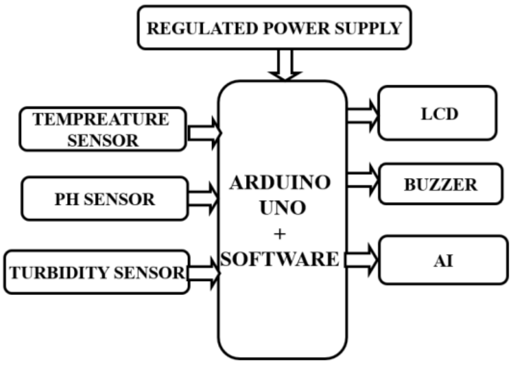

Fig 1: Block Diagram

The block diagram illustrates the architecture of the Smart Water Quality Monitoring System, which is designed to continuously evaluate water conditions using multiple sensors integrated with an Arduino Uno. At the top of the system, the regulated power supply provides stable and filtered electrical power to all components, ensuring reliable sensor operation and preventing fluctuations that may affect measurement accuracy. The Arduino Uno acts as the central processing unit of the system, responsible for acquiring, processing, and analyzing sensor data through embedded software.

The temperature sensor measures the water temperature, which is a critical parameter influencing chemical reactions, dissolved oxygen levels, and overall water quality. Variations in temperature can significantly affect aquatic life and water usability. The pH sensor monitors the acidity or alkalinity of water, an essential indicator for determining whether the water is safe for drinking, industrial use, or environmental sustainability. Abnormal pH levels may signal contamination or chemical imbalance. The turbidity sensor evaluates the clarity of water by detecting suspended particles, impurities, or contaminants. High turbidity levels often indicate the presence of pollutants, sediments, or microbial activity.

The Smart Water Quality Monitoring System operates by continuously sensing and analyzing important water quality parameters using multiple sensors integrated with the Arduino Uno. When the system is powered on through the regulated power supply, all sensors and modules receive stable electrical power for accurate operation. The temperature sensor, pH sensor, and turbidity sensor are immersed in or exposed to the water source to measure their respective parameters.

Through continuous sensing, real-time processing, visual display, and automated alerts, the system ensures efficient, reliable, and smart monitoring of water quality. All sensor readings are transmitted to the Arduino Uno, where the software processes the data and compares it with predefined threshold values. The LCD module displays real-time water quality parameters, allowing users to visually monitor system outputs. The buzzer functions as an alert mechanism, activating whenever any parameter exceeds safe limits, thereby enabling immediate attention or corrective action. Additionally, the AI module enhances the system's intelligence by analyzing sensor data patterns, predicting potential water quality issues, and improving decision-making accuracy. This integration of multi-sensor monitoring, real-time display, alert generation, and AI-based analysis makes the system efficient, reliable, and suitable for modern smart environmental monitoring applications.

3. RESULTS AND DISCUSSION

The AI-based smart water quality monitoring system effectively measured key parameters such as pH, turbidity, temperature, and conductivity using multi-sensor integration. The system provided accurate real-time analysis and reliable water quality classification through IoT connectivity. It improved water safety monitoring by enabling continuous remote tracking and early detection of contamination.

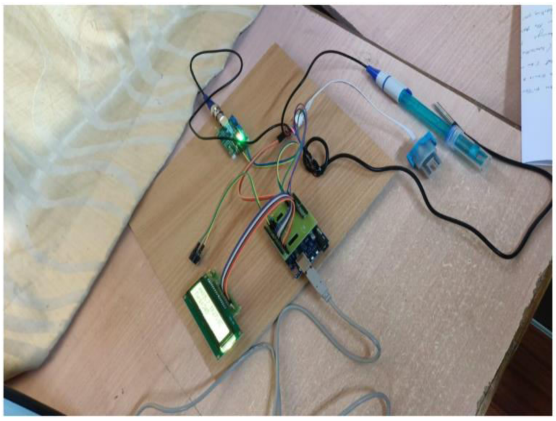

FIG 2: Hardware Implementation

The hardware implementation shows the integration of sensors, microcontroller, and display unit connected on a single platform for real-time data acquisition. It demonstrates proper interfacing of components used for monitoring and controlling the system efficiently.

Fig 3: Values Displaying In LCD

Fig 3 shows the real-time sensor values being displayed on the LCD module connected to the system.

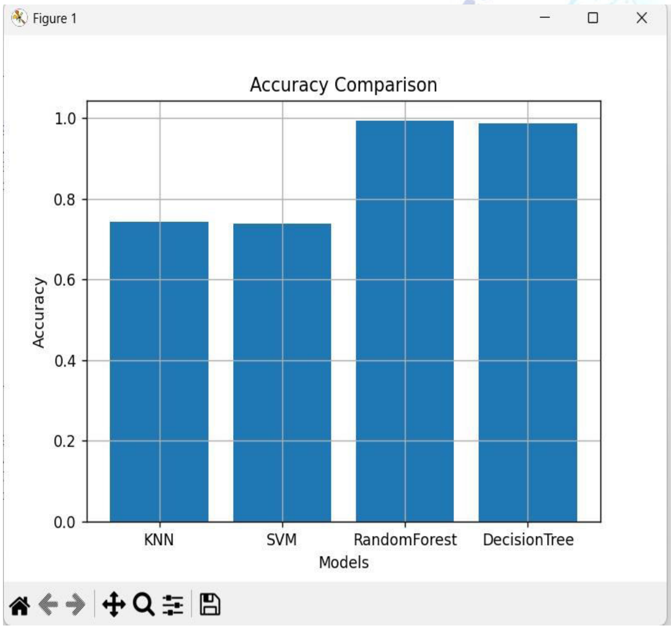

Fig 4: Accuracy Comparison Graph for Machine Learning Model

The graph compares the accuracy of different machine learning models including KNN, SVM, Random Forest, and Decision Tree. It shows that Random Forest and Decision Tree achieve higher accuracy compared to KNN and SVM, indicating better performance.

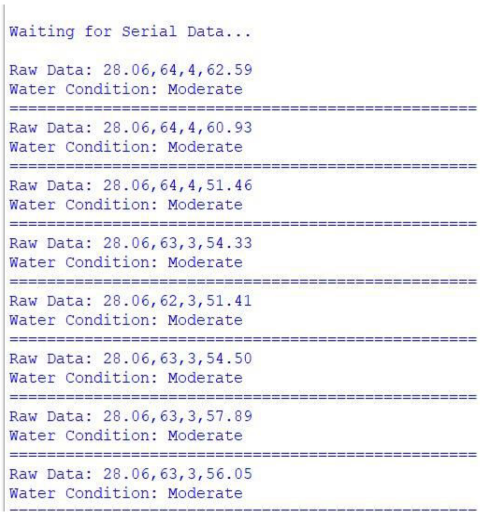

FIG 5: Final **ML Result**

The figure shows the final machine learning output displaying real-time sensor data received through serial communication. It classifies the water condition as "Moderate" based on the analyzed input values, indicating stable water quality.

4. CONCLUSION

The Smart Water Quality Monitoring System using multi-sensors provides an efficient and reliable solution for real-time water quality assessment. It successfully monitors key parameters like pH, temperature, and turbidity using Arduino Uno and displays accurate results on an LCD. The system ensures immediate alerts through a buzzer when unsafe conditions are detected, improving safety and response time. The integration of AI enhances data analysis and anomaly detection, making the system more intelligent. Overall, it reduces manual effort and improves accuracy compared to traditional methods.

FUTURE SCOPE

The system can be enhanced by integrating advanced machine learning models for more accurate predictive water quality analysis. It can also be connected with IoT cloud platforms for remote monitoring and large-scale environmental applications.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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