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From Data to Action: How IoT-Based Systems Transform River Conservation

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Abstract:

River water quality monitoring is crucial for ensuring the health and sustainability of aquatic ecosystems and the well-being of communities that rely on these water resources. Traditional water quality monitoring methods are often time-consuming and lack real-time capabilities. In this paper, we propose an IoT-based real-time river water quality monitoring system that leverages the advancements in Internet of Things (IoT) technology to provide continuous and up-to-date information about the quality of river water.

The proposed system utilizes a network of wireless sensors deployed in the river to collect data on various water quality parameters, such as pH, dissolved oxygen, turbidity, and temperature. These sensors are equipped with communication capabilities to transmit the collected data wirelessly to a central server or cloud platform for real-time processing and analysis.

Through the integration of IoT, the system enables remote monitoring and management of river water quality. Users can access the real-time data and visualizations through a web-based dashboard or mobile application, allowing them to make informed decisions regarding water usage, pollution control, and resource management. Alerts and notifications can be generated based on predefined thresholds, providing early warnings of any significant deviations in water quality parameters.

The IoT-based real-time river water quality monitoring system offers several benefits, including improved efficiency, cost-effectiveness, and scalability compared to traditional monitoring approaches. It enables stakeholders, including environmental agencies, researchers, and policymakers, to have access to accurate and timely information for effective decision-making and proactive water quality management.

Keywords: IoT, real-time monitoring, river water quality, wireless sensors, data analysis, decision-making, environmental management.

1. INTRODUCTION

Water is a vital element for human life and the persistence of other habitats. It is crucial for drinking, domestic use, food production, and recreational purposes, and its availability in safe and clean form is essential for public health [1, 2]. Neglecting water quality can have severe consequences on human health and ecological balance. Water pollution is a global problem, leading to numerous mortalities and diseases worldwide. Lack of awareness, improper administration, and the absence of water quality monitoring systems contribute to the use of contaminated water for drinking, particularly in developing countries. This results in serious health issues [3, 4].

To address this issue, a Wireless Sensor Network (WSN) is proposed in this paper to monitor water quality. Sensors placed in water collect various parameters such as pH, dissolved oxygen, turbidity, conductivity, and temperature. WSN technology enables real-time data acquisition, transmission, and processing, allowing clients to access ongoing water quality information from remote locations [4-7].

The Internet of Things (IoT) is a rapidly growing technological phenomenon used in various fields for data collection, monitoring, and analysis. While IoT is already applied in smart cities, power grids, supply chains, and wearable's, its potential in environmental applications remains significant. It can be utilized for detecting forest fires, early earthquake warning, reducing air pollution, monitoring snow levels, preventing landslides, and controlling water quality [7-12].

Water quality monitoring has gained significant attention in the twenty-first century, with numerous projects focusing on developing efficient and cost-effective real-time monitoring systems that integrate wireless sensor networks and IoT [14]. In this study, an IoT-based sensor network is employed to monitor the physical and chemical parameters of water bodies in Chittagong city [14].

2. Related works

water quality monitoring is a critical aspect of maintaining human health and ecological balance. The traditional methods of monitoring water quality are time-consuming and less reliable. However, advancements in IoT, machine learning, and cloud computing have revolutionized the field of water quality monitoring.

Researchers such as Nikhil Kumar Koditala [15], N. Vijayakumar [16], Theofanis P. Lambrou et al. [17], Brinda Das and P.C. Jain [18], K. Saravanan et al. [19], ThinagaranPerumal et al. [20], Prasad M. Pujar et al. [21], GaganjotKaur Kang [22], O'Flynn et al. [23], ZulhaniRasin and Mohd Rizal Abdullah [24], Anuadha T [25], PrathameshVyas et al. [26], Maneesha V Ramesh et al. [27], ArivoliAppavu et al. [28], Tharam Dillon et al. [29], Umair Ahmed et al. [30], Joy Shah [31], Keyur K Patel and Sunil M Patel [32], ParneetKaur et al. [33], and Ab Rashid Dar and Dr. D. Ravindran [34] have contributed to the development and implementation of innovative systems for real-time water quality monitoring.

These studies have explored various aspects such as IoT-based sensor networks, machine learning prediction models, low-cost monitoring systems, integration with SCADA, and utilization of WSN technology. They have focused on monitoring different parameters like pH, turbidity, temperature, and chemical composition of water.

By leveraging IoT, cloud computing, and machine learning, these systems enable real-time data acquisition, transmission, and analysis. They provide remote access to water quality information, enhance the efficiency of monitoring processes, and facilitate early detection of water contamination. The integration of these technologies not only improves the accuracy and reliability of water quality monitoring but also enables effective management and control of water resources.

The application of IoT, machine learning, and cloud computing in water quality monitoring systems has revolutionized the field, making it more efficient, cost-effective, and accessible. These advancements play a crucial role in ensuring the availability of safe and clean water for human consumption and maintaining the ecological balance of aquatic ecosystems.

3. Proposed Methodology

Our proposed technique enables real-time monitoring of water quality by utilizing sensors to measure parameters such as temperature, minerals, and pH. The data collected by the sensors is sent to the cloud for processing. Using algorithms like Naive Bayes and Recurrent Neural Network, the processed data is classified and predictions are made regarding the suitability of water for various purposes. This approach improves upon manual water quality monitoring methods and provides valuable information for different water usage scenarios.

3.1 Steps of our proposed approach are:

- Start
- Step 1 : Sensors carry out the task of sensing water quality attributes such as pH, minerals, and temperature in the first stage.
- Step 2 : Data that has been sensed is forwarded to the cloud server for centralized storage.

- Step 3 : Cloud server receive the sensed data.
- Step 4 : After receiving the sensed data cloud server process or compute the received data.
- Step 5 : The processed data classified by using Naive Bayes algorithm and training data set.
- Step 6 : Classified data convert into the tested data set and predict the range of water quality by using Recurrent Neural Network.
- Step 7 : The final result aware the people or authority about the water quality by the sending them alert message.
- Stop

The primary objective of the proposed technology revolves around enhancing the consciousness of water quality. We know that 'precaution is better than cure', the WQM system aware the people about water quality in real-time situation. This technology is not a manual working process; it is completely automated for the user. The manual process of WQM system is taking much time and manual process is also expensive and inefficient process. The WQM system is really efficient and inexpensive technique.

3.2 MODEL OF PROPOSED APPROACH:

In this approach, we use sensors for sensing the water quality parameter, on the basis of the of sensed data we classify the data and predict the range of water quality that for what purpose water can be used? The NB and RNN algorithms are used in this technique for classification and categorization of use of water. The following model explains our approach.

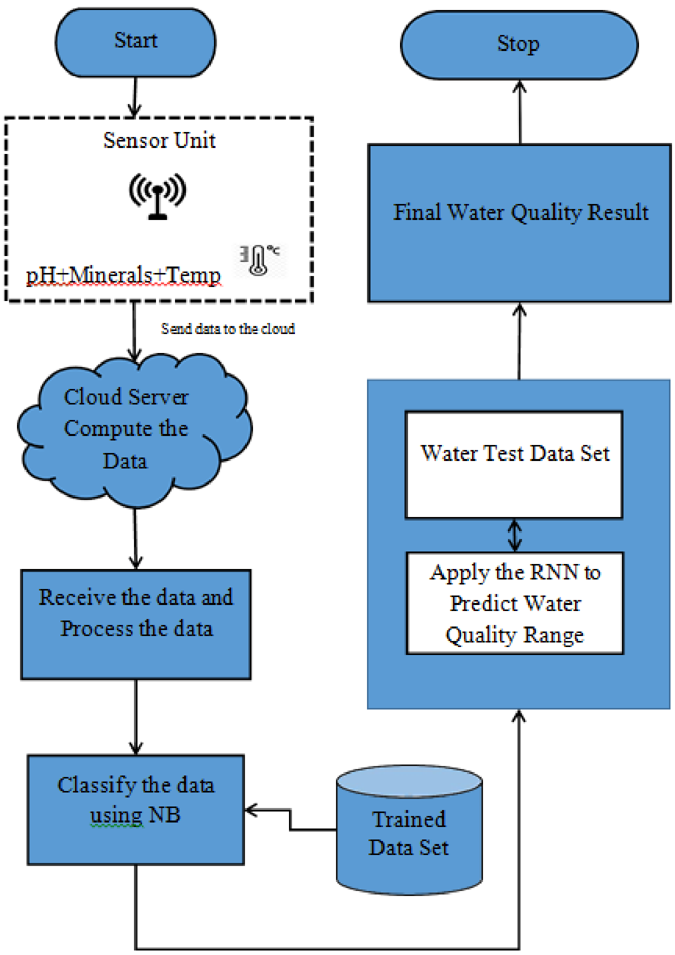


Figure 3.1 : Model of Proposed Approach

3.2.1 Naive Bayes

The Naive Bayes (NB) algorithm is a simple and efficient technique used for constructing classifiers based on Bayes' Theorem. It relies on the assumption of strong independence between features within a class. NB is a probability model that can be easily trained in supervised learning. It does not require a large dataset for learning.

The steps involved in the Naive Bayes algorithm include converting the dataset based on pH, minerals, and temperature, creating likelihoods for different water parameters, and using the algorithm to classify the datasets.

3.2.2 NB model

The NB model is particularly useful for classification tasks, providing efficient and accurate results in supervised learning. It is well-suited for processing large datasets. In our approach, Naive Bayes is employed to classify the water quality dataset based on pH, minerals, and temperature parameters.

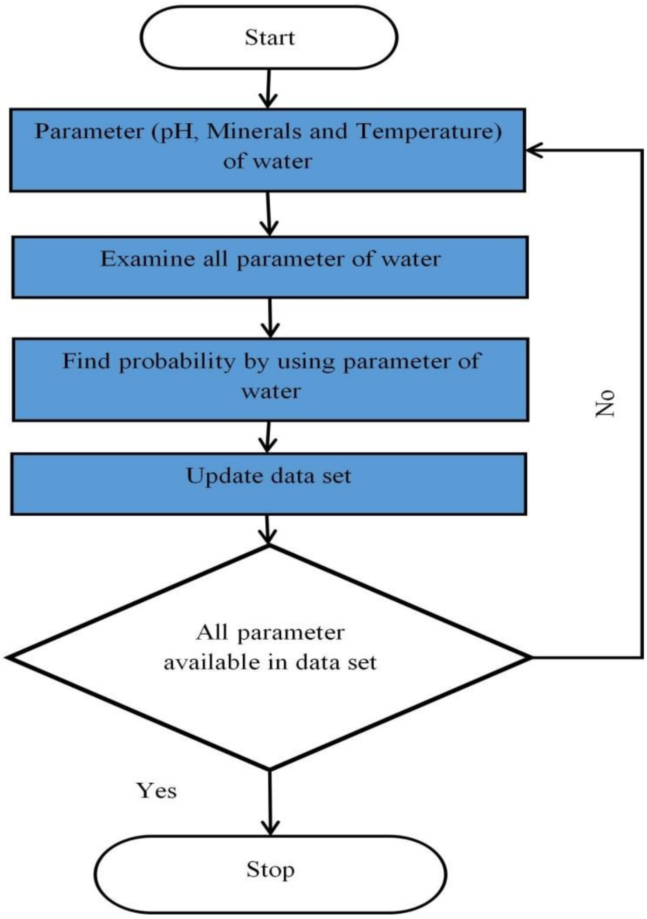


Figure 3.2 : Model of Naive Bayes

3.3 RECURRENT NEURAL NETWORK :

Recurrent Neural Network (RNN) is a type of neural network that utilizes the previous output as input in the current state. It overcomes the limitation of traditional neural networks by incorporating memory, allowing it to remember information about previous calculations. RNNs are particularly useful when dealing with sequential data, as they can effectively process input sequences by using the same parameters for each input.

The steps involved in the RNN algorithm include providing an input to the network, calculating the current state based on the current input and previous state output, repeating this process until the final current state is reached, calculating the output, and comparing it with the provided output. If the outputs match, the final output is considered correct. Otherwise, the algorithm back-propagates to update the inputs and repeats the process.

In our approach, RNN is used to calculate the final output. It takes the classified dataset as the current input and computes the final output. The output is then compared with the provided dataset. If the current output matches the provided data, the water is considered usable; otherwise, it is deemed not usable.

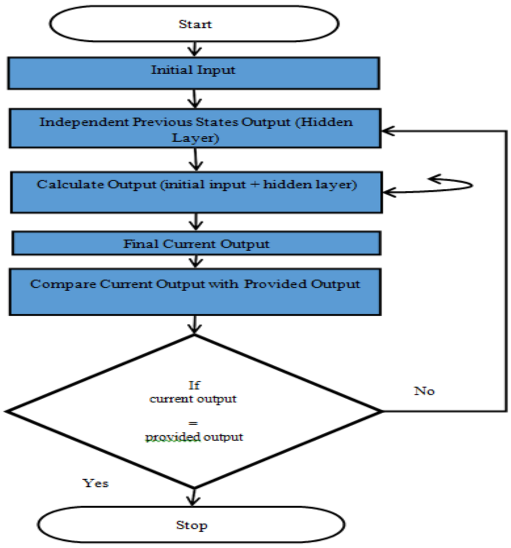
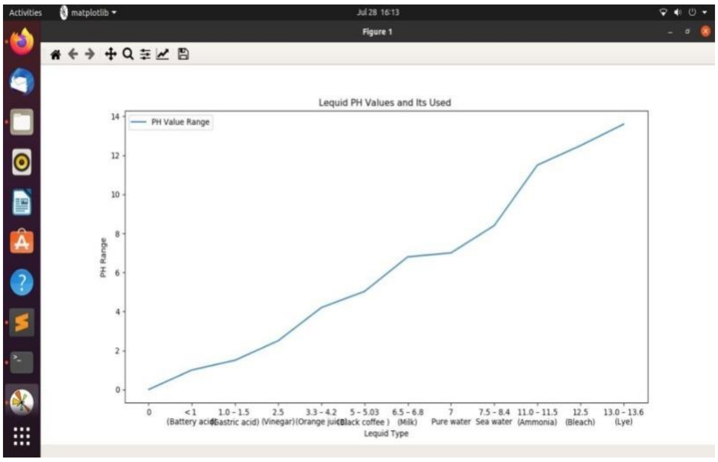


Figure 3.3 : Model of Recurrent Neural Network

4. RESULT ANALYSIS :

The IoT and WSN creates a system which monitor water quality in real-time environment, by this approach, the collected sensed data process on the cloud and aware the people by sending message or storing it on the cloud. This approach creates training data sets of minerals and pH values for prediction and analysis.

4.1.1 Result analysis for pH value :



As we can see the graph, which is a training graph of pH value, shows the taste of water on different point. Water possessing a pH value below 7 is classified as acidic, while water with a pH value exceeding 7 is categorized as basic. The pH value 7 is pure water.

The pH value lies between 6.5 - 8.5 can be use for different purpose like drinking, out-door bathing, propagation of wildlife and fisheries and Irrigation, Industrial Cooling, Controlled Waste disposal etc.

4.1.2 Result analysis for TDS (minerals) values :

The next training graph shows TDS value, it shows range of TDS by which it shows the use of water that, water is acceptable or not acceptable for different purpose.

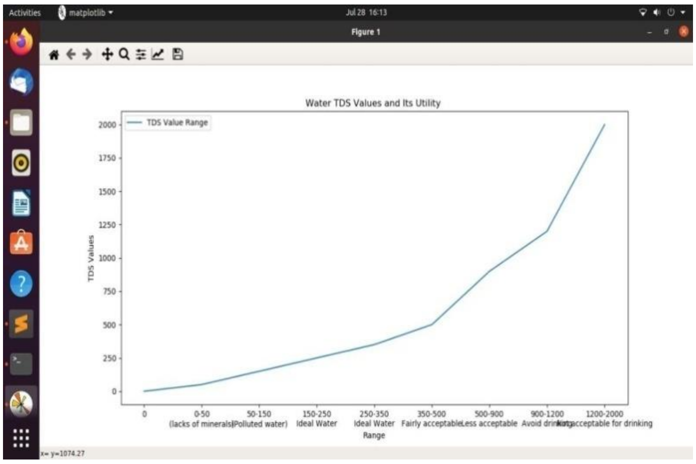


Figure 4.2 : Water TDS and its utility

TDS (total dissolve solid) is in water known as minerals, salt, metals etc., which is completely dissolve by water. The graph shows the range of TDS (range in ppm) in water, safe for drinking or not. The TDS range lies between 0-50 is unacceptable for drinking because of lake of minerals or polluted water. The TDS range lies between 50-150 is acceptable for drinking. The TDS range lies between 150-250 is ideal water and TDS range lies between 250-350 is also ideal water for drinking. The TDS range lies between 350-500 is fairly acceptable for drinking. The TDS range lies between 500-900 is less acceptable for drinking. If the TDS range lies between 900-1200 then avoid to drinking the water. If the TDS range lies between 1200-2000 or more than 2000 the water is unacceptable for drinking.

The TDS range of water other uses like irrigation, fisheries and outdoor bathing are classified as : TDS range in water for irrigation should be lies between 0-500 is acceptable for all crops. Acceptable for highly tolerant crops, the TDS range falls within 500-1500, with a TDS range surpassing 1500 being detrimental to crop cultivation. The ideal TDS range of water for outdoor bathing is should be lies 200-400 and the maximum TDS range for swimming pools are 1500. The fresh water-fishes should have TDS range 400 or less than 400 and the other side salt-water fishes needed high level TDS range which is lies between 5000 to 50,000.

4.1.3 Water Quality Accuracy and Comparison :

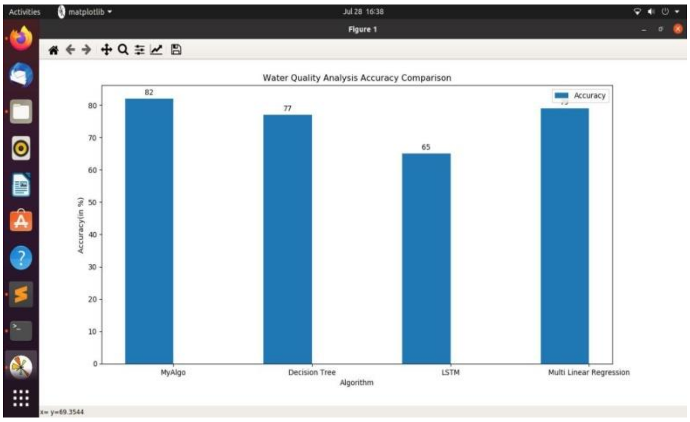


Figure 4.3 : Water Quality Accuracy and Comparison

The above graph is the accuracy comparison graph of water quality. Our approach of water quality monitoring system gives more accuracy by using NB and RNN algorithm than other algorithms. Our algorithm gives 82 % accuracy than other algorithm like LSTM gives 65% accuracy; Decision tree gives 77% accuracy and Multi Linear Regression gives 79 % accuracy comparatively.

4.1.4 : Response Time and Comparison :

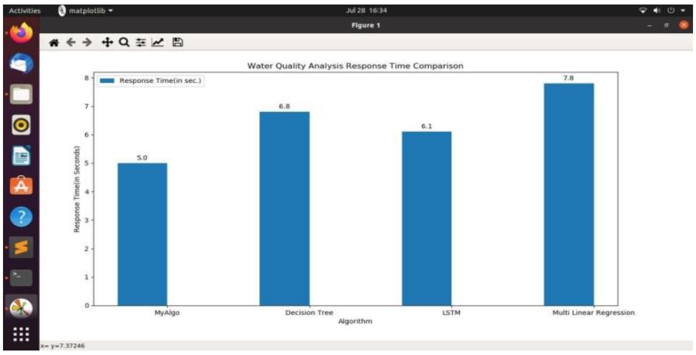


Figure 4.4 : Water Quality Response Time and Comparison

The graph displayed above depicts a comparison of response times concerning water quality. The response time of our approach is less than the other approaches. The response time means the response of our algorithm is faster than others like if there are any impurity in water occurs, our approach gives fast response that good quality water or bad quality water. Response time of our approach is 5 second which is less than other approach, like Multi Linear Regression response time is 7.8 second, Decision Tree response time is 6.8 seconds and the LSTM response time is 6.1 seconds comparatively.

5. Conclusion

This approach offers a real-time water quality monitoring system that alerts people and authorities about the current condition of water. By utilizing IoT and WSN technologies, the system continuously monitors water quality in real-time. The sensed data from the water is processed in the cloud, where it undergoes classification and comparison with trained datasets. This enables the system to predict the usability of water for various purposes, such as drinking, bathing, irrigation, industrial use, and household use. The sensors monitor important parameters like pH value, TDS value, and temperature to assess water quality. By employing Naive Bayes and Recurrent Neural Network algorithms, the system classifies and predicts water quality. The established dataset helps categorize water utility based on factors like pH value and minerals. Water within the pH range of 6.5-8.5 can be used for different purposes, while the ideal TDS range is between 150-250. This cost-effective and efficient approach ensures the implementation of a reliable water quality monitoring system that can identify impure and polluted water.

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