Development of Trash Aggregating and Water Quality Monitoring System for Aquatic Habitat Using Machine Learning

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Abstract— **Floating trash/waste present in the water bodies emerge as a major environmental problem that endangers the lives of its inhabitants and makes the water unsuitable for drinking by altering its properties. The existing method for monitoring and collecting trash relies on the manual inspection by dispatching inspectors to the field, periodically. This process is time consuming and involves a lot of human intervention. The system proposed in here uses Unmanned Robotic Boats (URBs) mainly used for many real-time monitoring applications. In here, we propose an automated river trash aggregator system, also being able to check the quality of water, consisting of a remote processing unit, Arduino UNO, Wi-Fi module, temperature, pH and Conductivity Sensor. The values from these sensors are sent to Linode cloud, where machine learning algorithm is applied to analyze the aquatic habitat. The robot includes a MQTT architecture and machine learning model to predict whether the conditions of water is Good or Bad. A data set is generated for training and testing the machine learning network, specifically for floating trash detection application. The system finally enables the URB to communicate wirelessly with a remote computer in a real-time manner using IoT.**

*Keywords—**Unmanned Robotic Boats (URBs), Linode Clouds, MQTT Architecture***

I. INTRODUCTION

Water is an elixir of life. Water being a natural resource, is a vital need for mankind and finds its use in almost all fields which include agricultural, industrial, household, recreational and environmental activities. However, its abundant presence has led to its exploitation by various means of pollution caused by mankind. Eliminating these kinds of exploitation and protecting the water resources has become a major necessity.

In recent times, we see an increase in population with limited resources. As most of the diseases these days spread through water, there is a need for online real time water quality monitoring system. The methods used for water quality assessment at present involve collection of random samples of water at various locations weekly or monthly and analyzing them in the laboratories, which is not much efficient as they have various limitations including long-time consumption and a need for laboratory to predict the quality of water samples periodically. In order to overcome these drawbacks, we need a real time system which monitors water quality through sensors such as temperature, pH, conductivity and updates those values in Cloud service [4].

The system proposed in here consists of sensors which measure the chemical composition of water. These sensor values are then passed to Linode cloud via Wi-Fi. This system also uses MQTT architecture to transmit data from micro controller to external MQTT broker service [5]. Temperature sensors measure the temperature of water. Conductivity sensor measures the conductivity of water that is invisible. Apart from temperature and Conductivity, pH is also an important measure that checks the acidic level of drinking water. This part of Project uses machine learning, where the system predicts the weather conditions using previous labelled dataset and informed about quality of water. This makes the system automatic with comparatively fewer manual interventions. Whenever the sensor value exceeds the predefined threshold, an SMS alert will be sent to the supervisors, informing the situation and thereby forcing them to take immediate action [6-7].

In addition to this, any trash like that of dried leaves or other forms of plastic wastes will be collected as we are implementing the trash aggregator system using the URBs. This therefore helps to prevent the quality of water, thereby protecting the water resources from its extinction. The rest of the sections are organized as literature review in section II, followed by methodology, result and discussion, conclusion and lastly, future work.

II. RELATED RESEARCH

Protecting water from its Pollution and exploitation has been a major concern to look into in the existing present-day world. Different approaches have been proposed by various authors for real time water quality monitoring. The detailed analysis from various sources has been studied and understood.

According to the author in [1] a system using wireless sensing technology can be used. A Mobile water quality monitoring system based on autonomous bionic robot fish, measures the concentration of pollutants at fixed times, fixed points, and fixed depths, thereby solving the problem of different concentrations at different depths.

The author in paper [2] proposed a system, that monitors the quality of water relentlessly with the help of IoT devices, such as, Node MCU. The water quality is analyzed using the live feed of data, indicating the status as normal, warning and abnormal value, when compared against the threshold.

The author in paper [3] described the use and involvement of network analysis performed between the base station and sensor nodes spanning an aquaculture farm, in an efficient manner. The adopted methods were questionnaires, personal interviews and field visits. The main observations from the end user interaction were the basis of remote water quality monitoring system which provides a warning in the form of alerts through SMS in order to take precautions in time.

According to the author in [4] a system using the Internet of Things (IoT) together with properly Design-Based Learning (DBL) activities, is presented to enquiry aquatic environments. This describes the automated system that gets the data from installed sensors in lakes and rivers to record environmental parameters. System involves STEM educational practices.

The author in [5] proposed a system that gathers the data such as the water pH level, temperature and it executes suitable variations in the water habitat at appropriate times in the absence of human mediation. This system will inform the supervisor as pH of water exceeds maximum or minimum with threshold.

The different approaches provided by various authors, forms the basis of information to implement this particular research work

III. METHODOLOGY

The research work is to develop a cleaning system that aggregates trash and monitors the quality of water in aquatic habitat. This research work consists of two major units namely the trash aggregating unit and the monitoring unit which will be explained below.

A) BLOCK DIAGRAM

The evaluation of the robot and mechanism in manual mode is based on the block diagram shown in Figure 1. This consists of Microcontroller, Wi-Fi, temperature sensor, pH sensor, conductivity sensor, Bluetooth, LCD, propellers, motors and a control room to send the message in case of any attention required for monitoring changes. All the sensors and communication devices are connected to the microcontroller. The operation of robot is completely based on Atmega328p microcontroller. The power supply given to the controller from the battery is 12V.

The Sensors are used to monitor the water quality and send these data to cloud where machine learning algorithms are applied to analyze the aquatic habitat. This Robot includes a MQTT architecture, machine learning model to predict whether the condition of water is Good or Bad. The robot will be able to inform the supervisor regarding the same, when the value of temperature, pH and conductivity keeps changing above the threshold value. The LCD is used to display the sensed values i.e., temperature, pH and conductivity.

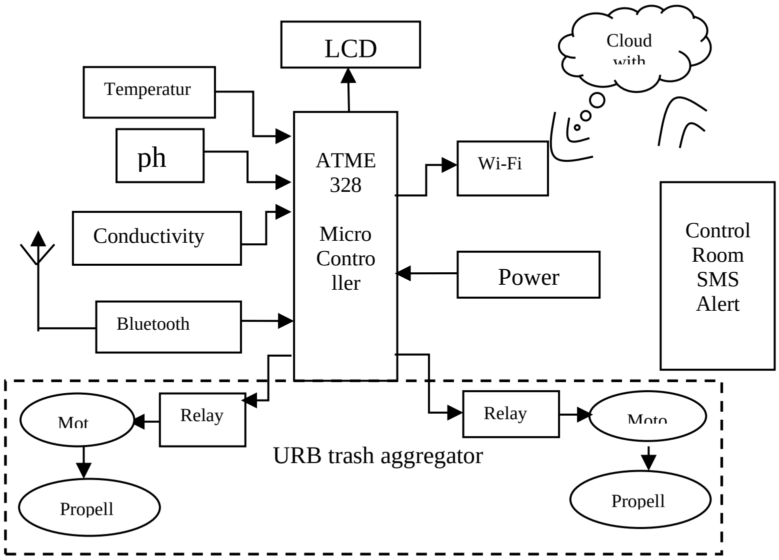

Figure 1: Block diagram

The sensed values are monitored by controller and send these values to cloud via ESP8266 Wi-Fi module. Once data received from the hardware to cloud there, we can apply machine learning algorithms like naïve bayes to predict whether the water is good or bad. Motion of the boat is controlled remotely using Bluetooth terminal app through which the trash is aggregated to one place by cleaning the waterbody.

B) FLOWCHART

The flowchart is in two ways i.e., for hardware and Software (AI PREDICTION) are as shown below: -

1. Trash aggregating and sensing takes place in the steps as shown below and the flowchart for the same is represented in figure 2. The steps are as described below.

STEP 1: The Robot is ready to take over and the system and the power is turned on.

STEP 2: Initializing the microcontroller input output pin, timer UART, Wi-Fi, LCD, Bluetooth.

STEP 3: The values are read by the respective sensors.

STEP 4: Display the values on the LCD and send data

to cloud.

STEP 5: The robot moves forward, backward, left, right and stops as per the data given.

STEP 6: After completion of all the action, the robot power supply is turned off.

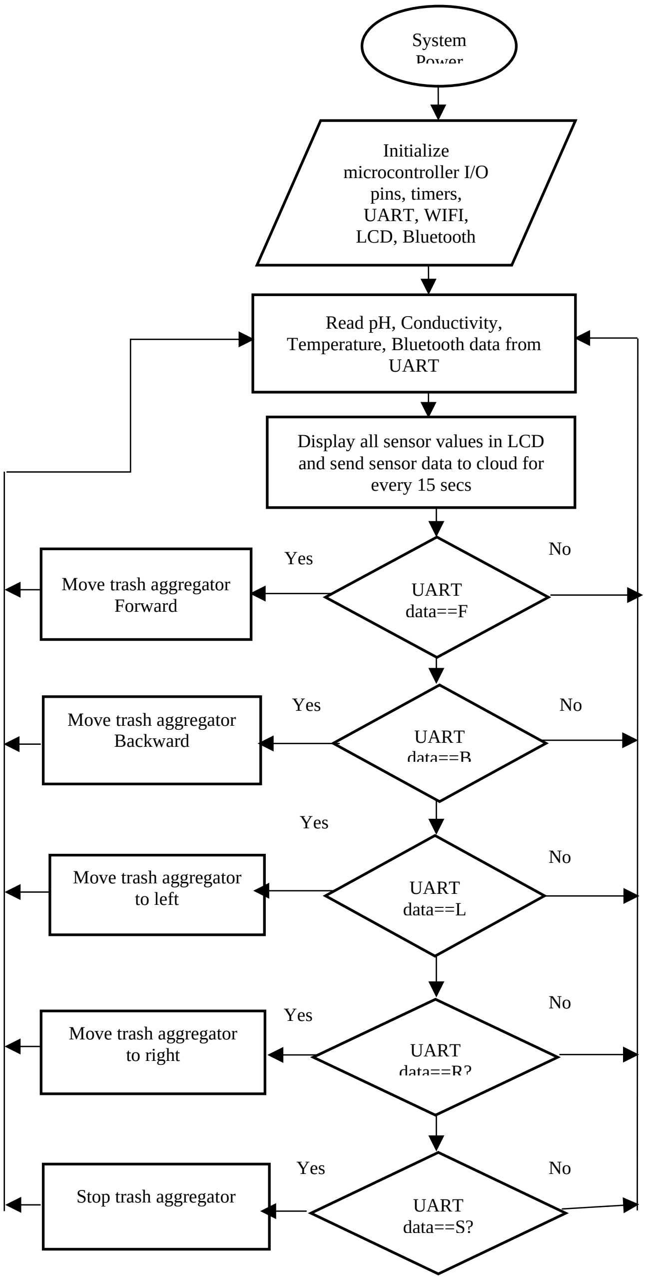

Figure 2: Flowchart of hardware

2. AI Prediction steps and flowchart for the same is represented in figure 3. The steps are as described below.

STEP 1: Receives data from hardware.

STEP 2: Reprocessing and testing of data takes place.

STEP 3: Applying Machine Learning algorithm.

STEP 4: Predict the quality of water and send SMS to the control room.

STEP 5: This process takes place continuously until the trash is aggregated

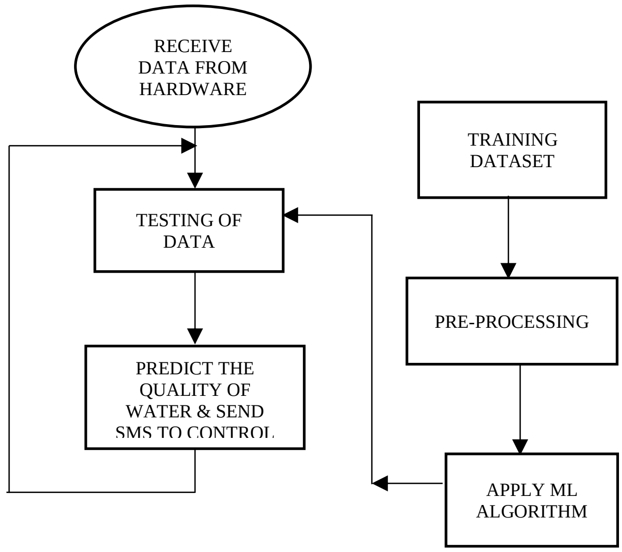

Figure 3: Flowchart of cloud software

IV. ALGORITHM USED

The Naive Bayes method is a supervised learning algorithm for addressing classification issues that is based on the Bayes theorem. It is mostly utilized in text classification tasks that require a large training dataset. The Naive Bayes Classifier is a simple and effective classification method that aids in the development of fast machine learning models capable of making quick predictions. It's a probabilistic classifier, which means it makes predictions based on an object's probability. Bayes' theorem is a conditional probability whose formula is as follows:

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)} \quad (1)$$

Where, **P(A|B)** denotes the probability of hypothesis A on the observed event B, and P(A|B) denotes the probability of hypothesis A on the observed event B**. P(B|A)** stands for Likelihood Likelihood, which is the probability of the evidence provided that a hypothesis' probability is true. Prior Probability **P(A)** is the probability of a hypothesis before seeing the evidence. **P(B)** stands for Probability of Evidence Marginal Probability.

V. RESULTS

The following results have been obtained on the performance of robot. The Trash aggregator was allowed to move over a distance of 60-80 meters and took around close to 2-4 minutes to aggregate the trash and could also monitor any changes in the values of Temperature, Conductivity and pH , send the same to the cloud and predict the status as Good or Bad and therefore send them in an SMS format to the supervisor. The final model is as shown below: -

Figure 4: Robot View

The snapshots of final predictions in cloud and the SMS alert are as shown below: -

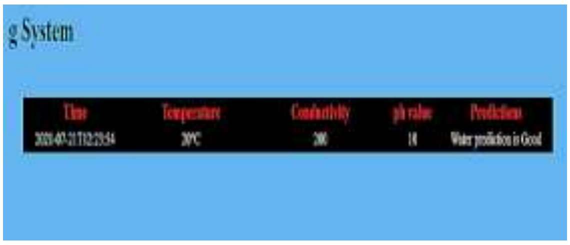

Figure 5: Snapshots of predictions in cloud indicating a good prediction

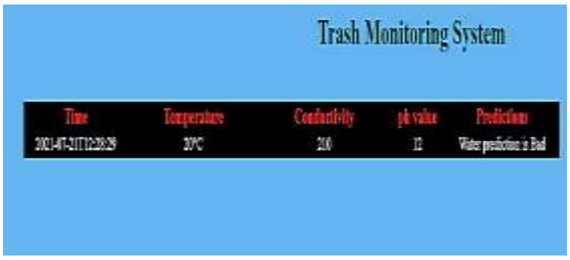

Figure 6: Snapshots of predictions in cloud indicating a bad prediction

Figure 7: - Snapshot of the message received

The accuracy of Predicted values of temperature, Conductivity & pH verses its expected value is as shown below in Figure 8, 9 and 10 respectively: -

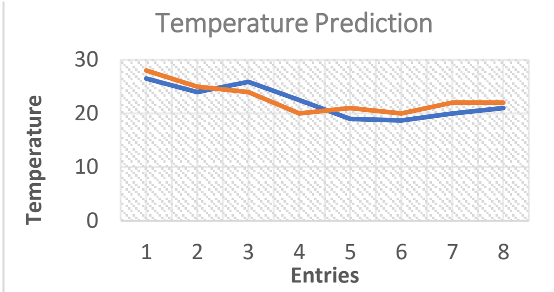

Figure 8: - Temperature prediction

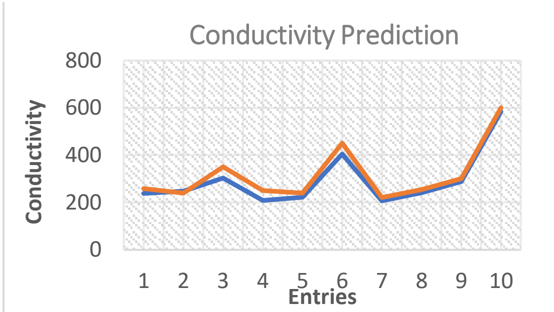

Figure 9: Conductivity prediction

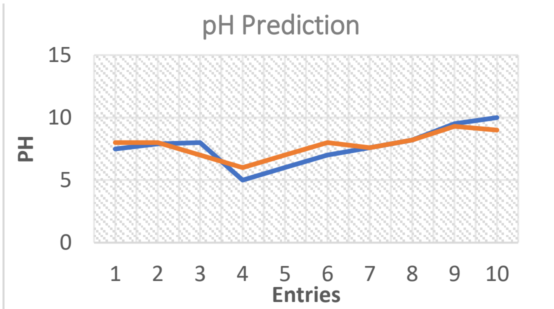

Figure 10: - pH prediction

The Efficiency of trash aggregation was calculated using the traditional formula and it was found that the efficiency is directly proportional to the amount of trash present in the waterbody i.e., more the number of trash, more will be the efficiency. It is difficult to collect when there's a small bit or piece of paper is what, the data shown in Table 1 indicates. The corresponding graph is shown in Figure 11.

Table 1: - Efficiency

SAMPLES	EFFICIENCY
0-10	15-25%
10-30	30- 45%
30-50	55-60%
50-70	70-95%
70-100	98-100%

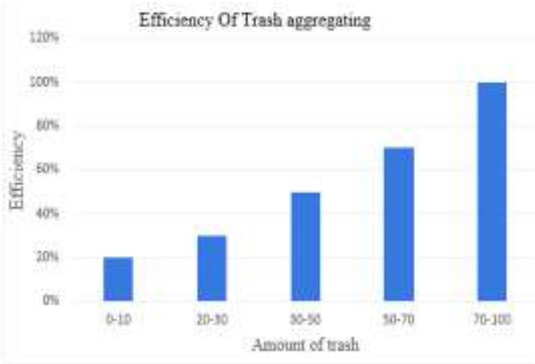

Figure 11: - Efficiency of trash aggregator

The four orientation speed analysis is shown in Figure 12. We have established before that the robot can function in all the four directions. The speed in the forward direction is more as compared to the other directions speed. Backwards is comparatively slower. The right and left are moderate. All the directions almost have the same speed, it varies very slightly. Hence, is the representation of all the speeds in all directions of motion of the robot.

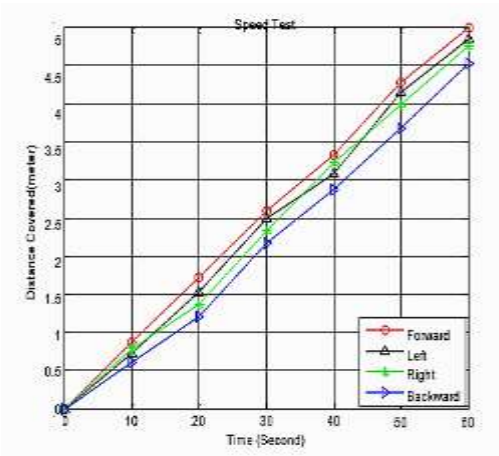

Figure 12: - Speed analysis in four directions

VI. CONCLUSION

The Trash monitoring system based on the robot is designed by combining the advantages of checking water quality and providing the safe space for the aquatic life. The main advantage of the system is that we can identify and analyze any change in pH, temperature & conductivity with respect to its normal values and notify the supervisor. We conclude that this research presents a practical and economical solution to maintain the quality of water especially in rural areas without any human intervention. Various contemporary technologies such as Internet of Things, Robotics, Cloud computing & Machine Learning is being used in the project. On combining these technologies, we are able to solve one of the basic and emerging problem of human survival and resource exploitation to a certain extent.

VII. FUTURE SCOPE

The system designed in here could be advanced into a completely automatic system by removing the feature of human intervention for supervision purposes. It can also be trained to respond to tentative changes in seasons and decide the normal conditions or values according to that particular season. In addition to this, we can develop this model to do a separation or segregation of trash that is collected. The Bluetooth can be replaced with a GSM module to make the tracking of the system easier from far distances and several other features of this system can be enhanced by using various other components.

VIII. REFERENCES

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