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IoT Assisted Drinkable Water Quality Analysis System using Machine Learning Techniques

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Abstract: In order to ensure the safe supply of the drinking water the quality needs to be monitor in real time. In this paper we present a design and development of a low cost system for real time monitoring of the water quality in IoT(internet of things).The system consist of several sensors is used to measuring physical and chemical parameters of the water. The parameters such as temperature, pH, turbidity can be measured. The measured values from the sensors can be processed by the core controller. The Arduino model can be used as a core controller. The other part of this system includes Machine learning algorithms which is applied on data collected by sensors for training a model and then can be used for the prediction of the new data and also evaluates some current classification algorithms to model a water quality detection system. Various algorithms are used and then only one algorithm which is best for this system is used to training the model with heights accuracy among them. And this model will allow early detection of significant changes in drinking water quality and helps water supply companies reduce in time.

Keywords: IoT(Internet of Things), water quality, Sensors, Support Vector Machine, decision tree, gradient boosting, ada boasting, Linear Discriminant Analysis, k-Nearest Neighbors.

I. INTRODUCTION

Water covers 71 percent of the surface of the Earth and is essential for living life forms. To water supply companies worldwide, drinking water safety is an important task. By using different sensors, this research tries to monitor sufficient water and environmental data regularly at different measuring points. Such measurements often include a detection system that accurately notifies water quality changes based on measured values. The use of the Internet of Things in this water quality checking system has an emphasis on various Problems such as connectivity, collection of data, analysis of data, early warnings. But to get this in the picture, the desired output is combined with technologies and protocols. The Aqua-care IoT monitoring and reporting system's water quality boundary is handled through the wireless network according to the IoT environment. Data that is collected is carried fairly and based on the ML model and the IoT interaction system. The resulting parameters are connected to the nodes for the real-time system and the device sensor data (temperature, pH, turbidity, and conductivity) are collected. The computer gathers the water feature software parameters and activates the Data Processing Server module to a controller. The system process reduces human intervention through the resources of Aqua Care-IoT and the details of the device are collected in Wi-Fi through the transceiver module the microprocessor is related to the concentration information of cable resources. It moves quality information from the sensor system and positions it in the cloud service environment [1]. Raspberry Pi acts as a microcontroller and the various sensors act as input sources for the RPi. Based on the input data from these sensors, the RPi sends signals to the valve and LCD. The valve acts as a mechanism for water control. When it is open, it makes the ow of water, and when it is closed, the supply stops. The LCD screen is used in various instances to display relevant messages [2]. The normal pH range is between 6 and 8.5. Turbidity is an indicator of water's cloudiness. Turbidity has shown the degree of loss of transparency by heat. It is considered a good water quality measure. Turbidity prevents light from reaching aquatic vegetation. As suspended particles near the surface make it easier to absorb heat from sunlight, it can also lift surface water temperatures above average. The temperature of the water indicates how hot or cold it is. The range of the DS18B20 temperature sensor is -55 to + 125 C. This sensor is a digital type that allows you to read accurately [3]. A Water Quality Index (WQI) is a way of summarizing information on water quality for reliable community reporting. It is similar to the UV index or an air quality index, and it simply tells us what the drinking water quality is from a source of drinking water. Excellent: a digital absence of disease improves water quality Quite Good: with a minor disability involvement, Water quality is protected Good: only a small degree of disease prevents water quality. Fair: The quality of the water is usually protected, but sometimes impaired. Marginal: the quality of water is often compromised [4]. The technique for problem-solving consists of classification algorithms for the classification function. When using training data, many algorithms give well accuracy, but not every algorithm gave us satisfying results in our experiment even when this research has a huge dataset, this research will see how it works.

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Drinking water Quality analysis is the system that is developed by using the approach of machine learning and IoT. In this system, the sensor network is designed by the sensors and R pi. The sensors which are used are- pH, TDS, Turbidity, TH, Chloride. The threshold values of these sensors will help to classify the water quality classes as shown in Table 1. These are the main sensors that are going to use and these are the parameters for the machine learning approach. For the machine learning approach, this system uses six algorithms to find the best-suited algorithm for the system. With the help of the following algorithms, this research is going to analyze the Drinking water quality. The Algorithms are- Decision Tree, Logistic Regression, Support Vector Machine, Linear Discriminant Analysis, Adaptive Boosting, and Gradient Boosting.

Sr.No	Sensors / Parameters	Drinking water IS 10500: 2012
1	pH	6.5 - 8.5
2	TDS	500-1000
3	Chloride (mg/l)	250-1000
4	Turbidity (NTU)	0-1
5	Hardness (as $CaCO_3$) (mg/l)	200-600

Table 1: The sensors with parameters threshold.

In This paper further sections divide as Section II explains previous research work that other had conducted in this related field. Section III represents the methodology used in developing this system. Section IV analyzes the result of the experiment with particular algorithms which are used and discusses them accordingly. Section V concludes the paper with brief of output and the future work.

II. RELATED WORK

The development of water quality control with the reporting system, which is a core technology, is carried out in this framework. However, using a sensor node, this driven and lightweight system is in the network. implementation by implies of a common monitoring system for water quality based on the rule. Sensor data collection is carried out fairly and based on the embedded system and the IoT interaction method. This system is well suited for the process in real-time, Y. Chen et al. [5]. Monitoring of Turbidity, PH & Temperature of Water makes use of a water detection sensor with a unique advantage and existing GSM network. The system can monitor water quality automatically, and it is low in cost and does not require people on duty, R. Mohammadpour et al. [6]. It is a flexible system because just by replacing the sensors and by making some changes in the software the system can be made to measure different parameters of water, A. N. Prasad et al. [7].

Smart Water quality System anticipated in this paper to address two of the major issues of water supply in the world today, namely water quality checking management and monitoring of water use. The SWMS involves of 2 components: a smart water quantity checker that guarantees water preservation by controlling water consumption by a household, notifying consumers, and authorities of water consumption. The parameters measured by this device are turbidity, temperature, PH, and conductivity, D. Sobel et al. [8]. A water checking system is used to deliver remote access to the data produced by the checking system. The data, of water quality parameter and even the water disbursed by the consumer over a given time, are regularly well-run on the web portal which can be retrieved at any time by the consumer and the authority which is concerned, R. Bajpai et al. [9].

They compared many algorithms on machine learning in this paper and compared the results for that algorithms and concluded that the poor outcomes this research obtained from Support Vector Machine and Artificial Neural Network comparison to Logistic Regression. This research may follow various models of a forecasting process; the best method is not known to be any of these systems, P. Selvaraj et al. [10]. The poor outcomes this research obtained from Support Vector Machine and Artificial Neural Network are anticipated in comparison with Logistic Regression, as this research only checked these algorithms for different values, not one specific. The dataset was huge enough to take longer to use various parameters. This research was focused on playing with the organizational regression and interaction terminology previous experimentations, both stated Support Vector Machine and ANN algorithms showed to be valuable in world related issues, but here the qualities for the Logistic Regression outcomes go to interaction, P. N. R et al. [11].

This research shows an advanced water quality monitoring system. 4 water foundations were tried over 12 hours at intervals to confirm the accuracy of the quantity of the unit. To provide the ultimate user with an alert based on the reference parameter for instantaneous action to ensure water quality, results obtained were successfully implemented in line with the expected results obtained through testing technology, N. Vijayakumar et al. [12].

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Internet of Things (IoT) and its services have become a part of our lifestyle, ways in which of operating, and business. There is an excellent deal of analysis on developing crucial building blocks and models for following generation web services supported by an inordinateness of connected things, M. S. U. Chowdury et al. [13].

To satisfy the necessities of transmission elective advances are frequently utilized like MQTT (Message Queuing estimation Transport). Rather than misuse GSM organize or the other innovation, MQTT recipe is upheld to make the framework conceivable, particular, scalar and worth practical close by this it makes Communication of data among sensors and servers simultaneously stream, S. Patil, C. V Muttinapendimath et al. [14].

The primary target was to diminish the time required for testing of water in labs, and we have had the option to accomplish it however with lesser precision. It decreases the research facility hardware that would be required for the conventional method of trying things out for its quality, S. Behmel et al. [15] Multi sensor-based air and water quality observing utilizing IoT is proposed. Writing uncovers that manual information calculation utilizing the research center strategies is tedious and existing framework are wasteful at giving precise outcomes likewise they don't give long-run correspondence yet since this task utilizes GPRS module the information can be transmitted over an extremely long range and the proposed venture is additionally practical, M. Pule et al. [16].

III. REMEDIAL APPROACH

Drinking water quality analysis is the system that uses the two main modules one is the IoT module system uses the sensors as explain early and the second module is machine learning module. There are some algorithms which system is going to use in the next Module is the Decision module in this research will need machine learning best algorithms that will give high accuracy for the classification of water is drinkable or not drinkable. There are many algorithms in Machine learning but some of them this research is going to implement such as- K-NN, SVM, LDA, etc. These are algorithm which are used in this system. These are some algorithms that show promising results in past research now, this research is going to see how these algorithms work for this system. System tends to overcome the problem for the water supply company to check water quality before distribution or for the commercial purpose also.

The idea is stored instead of a database in its networks, so data loss does not affect how it works. When a similar event happens, these networks may learn and adapt from instances, enabling them to function in real-time through actions. Uniform if a neuron does not react or a part of the material is missing, the network will sense the problem and will still yield the output. This research can achieve several responsibilities at the same time without affecting the performance of the process. In the proposed system, this research will compare all the classification algorithms given above and try to get the best-suited algorithm.

As in existing systems does not applied the Machine Learning algorithms and also very few parameters to check the water quality. This approach IoT with ML is formed to overcome the previous limitation and this includes 19 parameters for checking the quality of the water.

IV. SYSTEM ARCHITECTURE

A. IoT

Internet of things is technology is used to connect devices and exchange and share data among, in this project this research had used IoT for checking the water taking the values of the water parameters from which this research is going to check the quality of water. For this purpose, there are some parameters which used, and the source of water is also used as one of the parameters. There is a total of 19 parameters that are used in this system. In this system, this research is going to use sensors like -pH, Chloride, Turbidity, Oxidation-reduction, etc.

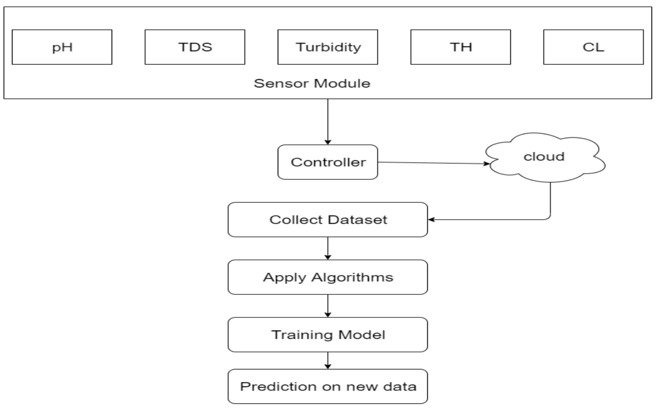

Figure 1: System Architecture

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B. Dataset

Gather dataset of water quality parameters from various sites. The water quality parameter contains 19 parameters and two classes like good and bad. For these classes, a total of 5000 data is used and 19 parameters. the following Table 2 shows how many data entry of water is good and how many data entry has bad water quality.

This dataset is from the government website from which the standard dataset is taken Source of the dataset is this website - http://iitk.ac.in/iwd/wq/drinkingwater.htm.

Water quality Classes	Total data
Good water	2561
Bad water	2439

Table 2: Water Quality Classes

C. Preprocessing

The data which this research get is having the negative factors such as noise, inconsistent & huge size in both dependent and independent variable of the dataset. This process is very important in Machine Learning approaches. In our case, this research has 519 missing values and if this research removes them, this research loses too much data. There are methods by using them this research can fill those values this research used the imputation of the mean to fill the missing values.so in our project this research continued with this approach.

D. Water Quality Index

Water quality index (WQI) is the singular measure that indicates the quality of water and it is calculated using various parameters that are truly reflective of the water's quality. To conventionally calculate the WQI, nine water quality parameters are used, but if it did not have all of them, but still estimate the water quality index with at least seven defined parameters. This dataset includes seven parameters, namely fecal coliform, pH, temperature, turbidity and total dissolved solids in dataset and also considered nitrites as the sixth parameter as the weight and relative importance of nitrites in the WQI calculation is stated to be equal to that of nitrates in multiple WQI studies. Using these parameters and their assigned weightages, this calculated the WQI of each sample as reflected in Equation (1), where q_value reflects the value of a parameter in the range of 0–100 and w_factor represents the weight of a particular parameter as listed in Table 2. WQI is fundamentally calculated by initially multiplying the q_value of each parameter by its corresponding weight, adding them all up and then dividing the result by the sum of weights of the employed parameters .

Sr.No	Weighing Factor	Weight
1	pH	0.165
2	Disolved oxygen	0.281
3	Conductivity	0.024
4	B.O,D	0.028
5	FECAL COLIFORM	0.125
6	Fluoride	0.140
7	TDS (mg/l)	0.124

Table 2 : Parameters weights for the WQI calculation

Water Qulaity Class (WQC) Once we had estimated the WQI, we defined the water quality class (WQC) of each sample using the WQI in classification algorithms as shown in Table 3.

Sr.No	Water Quality Index Range	Class
1	0–25	Poor
2	25-50	Bad
3	50-70	Medium
4	70-90	Good
5	90-100	Excellent

Table 3: Ranges

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E. Classification

Classification is the process of predicting the class of given data points. A classifier utilizes some training data to understand how given input variables relate to the class. When the classifier is trained accurately, then it gives the correct output. In this framework, 20% of data is used for the testing and 80% data for training. There are many classification algorithms available now, but it is not possible to conclude which one is superior. So, for this system, this research had applied six algorithms and chooses that algorithm which will give high accuracy. This classification is done by using the Machine learning process.

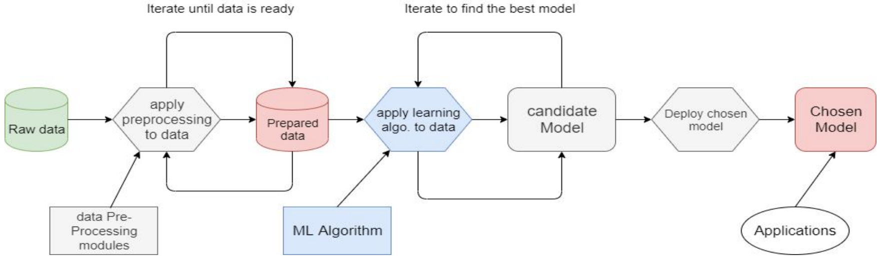

Figure 2: Machine Learning Approach

By following this above approach, this research had applied six different algorithms for this system. These are algorithms which this research is going to use- Decision Tree, Logistic Regression, Support Vector Machine, Linear Discriminant Analysis, Adaptive Boosting, and Gradient Boosting. For choosing the best-suited algorithm this research has to try an algorithm that is best for the particular system and chooses the best which gives the accuracy of the height.

V. METHODOLOGY

Water quality analysis system is best by combining the IoT and ML. following Figure 4 shows that flow chart of this system.by using the various sensors and the controllers, data collection is the most important process in this system. By applying the algorithms of the ML will be used for the classification of the data. A first examination was directed on the accessible information to clean, standardize and perform highlight choice on the water quality boundaries, and in this way, to acquire pertinent subset that permits high exactness with minimal effort. Thusly, costly lab examination with explicit Manual synthetic testing can be stayed away from in further comparative investigations. A progression of agent regulated forecast Classification calculations were tried on the dataset worked here. The total approach is proposed with regards to water quality numerical examination.
Following would be information about the ML Algorithms which used by system.

A. Decision Tree

Decision Trees are a non-parametric regulated learning strategy utilized for both grouping and relapse errands. The objective is to make a model that predicts the estimation of an objective variable by taking in straightforward choice standards surmised from the information highlights. Choice Tree Analysis is a general, prescient demonstrating device that has applications traversing various regions. All in all, choice trees are built through an algorithmic methodology that distinguishes approaches to part an informational index dependent on various conditions.

B. Logistic Regression

Logistic regression is Calculated relapse is one of the most mainstream Machine Learning calculations, which goes under the Supervised Learning method. It is utilized for anticipating the straight outward variable utilizing a given arrangement of free factors. Strategic relapse predicts the yield of a clear-cut ward variable. In this way, the result must be an all-out or discrete worth. It very well may be either Yes or No, 0 or 1, valid or False, and so forth however as opposed to giving the specific incentive as 0 and 1, it gives the probabilistic qualities which lie somewhere in the range of 0 and 1.

C. Support Vector Machine

An SVM calculation constructs an arrangement model doling out either new examples to one class, rendering it a non-probabilistic straight parallel classifier. A little change in the information doesn't extraordinarily influence the hyperplane and subsequently the SVM some will perform superior to different calculations and along these lines, the SVM configuration is steady. The model of this framework can secure without anyone else and collect yield that isn't inclined toward its creation.

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D. Linear Discriminant Analysis

Linear discriminant analysis (LDA), normal discriminant analysis (NDA), Direct discriminant examination (LDA)or discriminant work investigation is a speculation of Fisher's straight discriminant, a strategy utilized in measurements, design acknowledgment, and AI to locate a direct blend of highlights that portrays or isolates at least two classes of articles or occasions. The subsequent blend might be utilized as a direct classifier, or, all the more regularly, for dimensionality decrease before later arrangement.

E. Adaptive Boosting

Versatile Boosting strategy was planned by Yoav Freund and Robert Schapiro, who won the Gödel Prize for their work. AdaBoost deals with improving the territories where the base student fizzles. The base student is an AI calculation which is a frail student and whereupon the boosting technique is applied to transform it into a solid student. Any AI calculation that acknowledge loads on preparing information can be utilized as a base student.

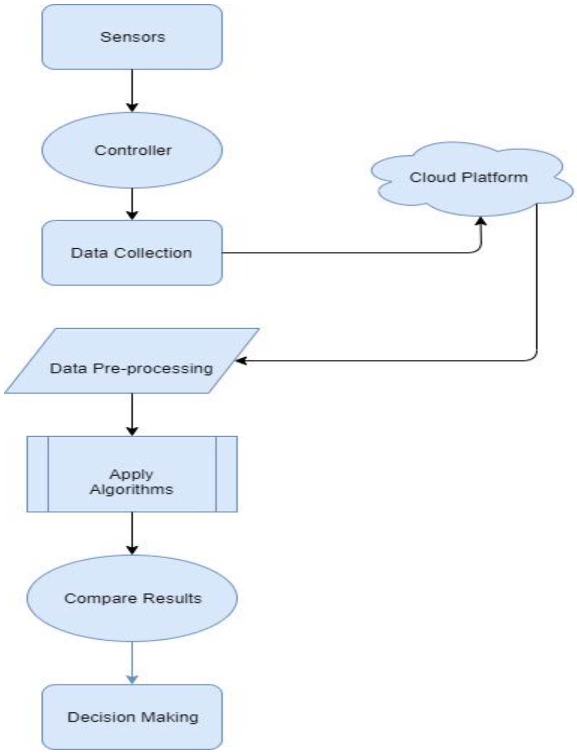

Figure 3: Flow Diagram of System

VI. COMPARISION ANALYSIS

In this project this research had used Decision Tree, Logistic Regression, Support Vector Machine, Linear Discriminant Analysis, Adaptive Boosting, and Gradient Boasting these algorithms, and this research uses the Random forest algorithm for the feature selection.

In this experiment, this research has achieved the following results. By using the python on the anaconda platform, the following Table 4 shows the accuracy of the algorithms. And Table 5 shows the accuracy of the previous results.

Sr.No	Algorithms	Accuracy
1	Decision Tree	94.3%
2	Logistic Regression	85.8%
3	Support Vector Machine	99.7%
4	Linear Discriminant Analysis	98%
5	Adaptive Boasting	94.7%
	The Winner Algorithm	Support Vector Machine

Table 4: Accuracy along with Algorithms and Winner Algorithm.

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The major difference between this and the previous or existing research is that a large number of algorithms and because of that the algorithms can get various choices to choose the best algorithm and in the existing system there are only four algorithms that used by that system.

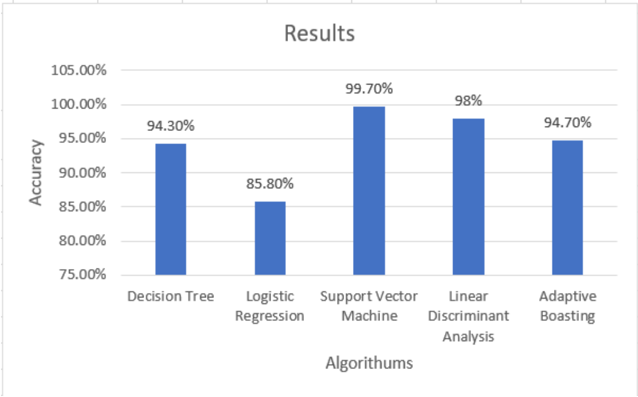

Figure 3: Graph of Accuracy of particular algorithms of current results.

Existing research had used Decision Tree, Logistic Regression, Support Vector Machine, Linear Discriminant Analysis as the algorithms for machine learning approach for this their results are shown in Table 5 and the graph for the same is shown in Figure 4.

Sr.No	Algorithms	Accuracy
1	Decision Tree	80%
2	Logistic Regression	58%
3	Support Vector Machine	71%
4	Linear Discriminant Analysis	65%

Table 5: Accuracy of Previous Results of an Existing System.

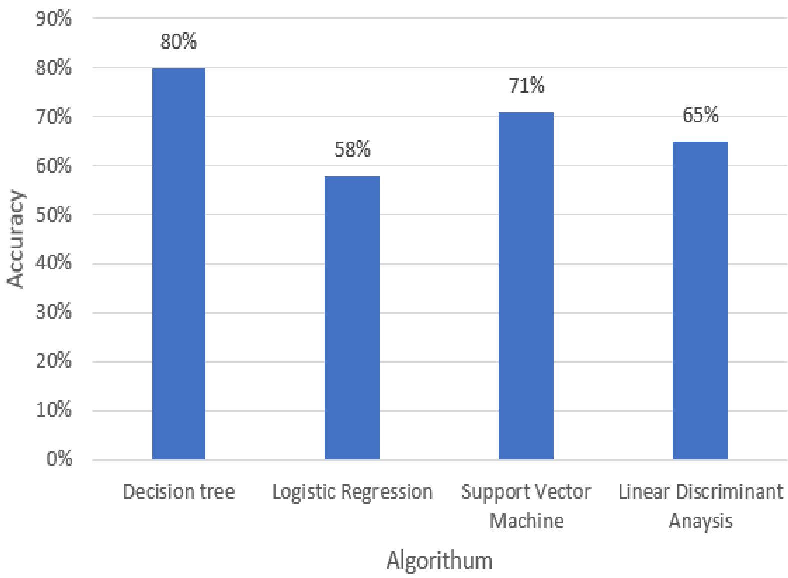

Figure 4: Graph of Accuracy of particular algorithms of the existing system.

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VII. PROTOTYPE AND EXPERIMENTS

The following figure 3 shows the class identification of the results according to the classes of the classification with yearly analysis of the water quality in India.

	year	wqi	wcls	wcls_cat	Actual	Predicted
0	2003	61.755341	medium	1	61.755341	70.564346
1	2004	61.390000	medium	1	61.390000	70.375824
2	2005	69.709076	medium	1	69.709076	74.668605
3	2006	69.716667	medium	1	69.716667	74.672522
4	2007	71.139917	good	0	71.139917	75.406943
5	2008	70.240440	good	0	70.240440	74.942798
6	2009	71.054365	good	0	71.054365	75.362797
7	2010	71.796702	good	0	71.796702	75.745855
8	2011	71.915238	good	0	71.915238	75.807022
9	2012	74.680342	good	0	74.680342	77.233862
10	2013	72.213180	good	0	72.213180	75.960765
11	2014	73.023033	good	0	73.023033	76.378662

Figure 5: Water Class Identification

In Figure 5 there is an actual prediction on the new data which is on the bases of the winner algorithm which is Gradient boosting. Below figure shows that the water quality using the parameters of the pH, TDS and Turbidity. By using this we can predict if the water quality is Good that is 0 or the water Quality is Bad that is 1.

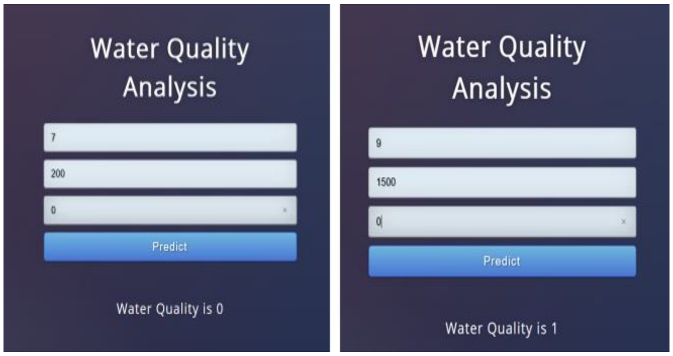

Figure 6: Water Quality Analysis with Good water and Bad water quality.

VIII.CONCLUSION AND FUTURE WORK

Drinking water quality is the main issue for humans in today's era because of various reasons water became polluted. For that problem, this research has proposed a water quality measuring system to give a solution by combining Machine Learning and IoT. The Decision Tree, Logistic Regression, Support Vector Machine, Linear Discriminant Analysis, Adaptive Boosting, and Gradient Boosting are very promising algorithms of supervised learning. In the proposed system data is analysed with the help of these algorithms and the Gradient boosting is an algorithm that gives us the highest accuracy. The parameters for measuring the quality of water: pH, turbidity, temperature, chloride, fluoride, etc, by using sensors and controllers the system has to measure the quality. The system is doing the task of collecting the real-time data and processing of that data by using the machine learning algorithm and classifying the data if that water is drinkable or not. The Smart water quality monitoring system checks quality automatically and needs less human interaction, thereby reduced the errors.

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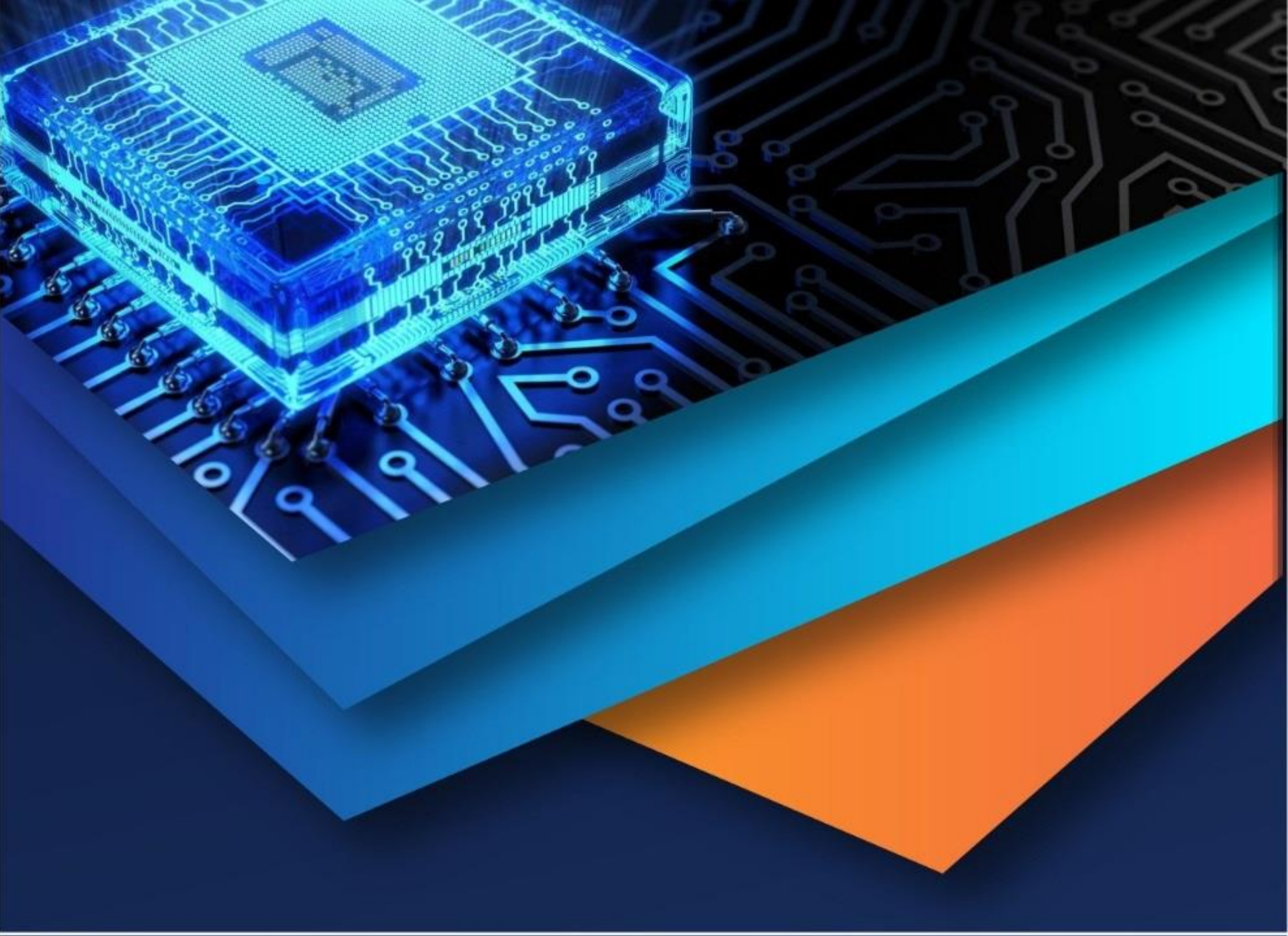

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