A COGNIFICATION APPROACH TO MEASURE CONTAMINATION IN LAKES

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Abstract - The paper mainly focuses on determining the amount of pollutants on a periodic basis. This helps to monitor and control the contamination. Any individual who needs to learn about the water purity is benefitted by this application. The method which exists in the industry for measuring the pollutants are laboratories. The existing methods are static. Hence people have to travel with the test sample to the laboratories. But the advantage of the proposed system is that it is portable. The device is portable to any place and the results will be available in the mobile application. This reduces the time taken to obtain results as well as the time taken for travelling. The proposed system is easier to use. It is cheaper and smaller in size. Hence portable and cost effective.

Keywords- *Machine learning algorithm, Water conditions, Classification, Analyzing.*

I. INTRODUCTION

For more than a decade, online water quality monitoring has been a serious topic since it is a serious issue related to environmental pollution. In the 21st century, there were lots of inventions, but at the same time were pollutions, global warming and so on are being formed. All life is dependent on water and exists in nature in many forms like ocean, river, lake, clouds, rain, snow and fog etc. Every single day, more than 2 million tons of agricultural, industrial sewage are let into water bodies which are causing water pollution. In real time, water quality monitoring faces challenges and some of the reasons include global warming, scarcity of water etc . Therefore, better methodologies have to be implemented for measuring parameters in water quality monitoring . One of the main parameter is pH which measures the concentration of hydrogen ions.. It shows the water is acidic or alkaline.

Water purity can be measured using characteristics like pH and turbidity. The pH value for pure water is 7pH. Less than 7pH indicates that water is acidic and more than 7pH indicates water is alkaline. So the range lies between 0-14 pH. Drinking water should have a pH value of 6.5-8.5. The measure of suspended partilces also determine the quality of water. This is known as measuring turbidity.

After determining turbidity, the value can be used to identify disease causing factors. If the turbidity value of water is high, then the chances of being affected by water borne diseases are high. Different sensors are used to measure different criterial. To measure if the water is hot or cold, we use temperatures sensors. To measure the flow of water, we use flow sensors.

Many natural process happening in the environment affect water bodies. These natural process sometimes cause water contamination. But the major reason for water contamination involves human intervention in natural process. Water from sewage, industrial waste are all let into water bodies. These have high nutritional and chemical contents. This will damage the aquatic ecosystem and results in the death of aquatic living beings.

The water contamination is measured dynamically using IoT. The different lake parameters like pH, Temperature and Turbidity are measured using sensors. The collected sensor data is then moved onto the Arduino uno board for processing and then moved onto the cloud platform, through a iot module. Finally, the lake parameters are presented and displayed to the end-user in a graphical representation along with the current location of the module through a mobile application. The user can view the current data instantly by refreshing the application and the history of the previous data is also available in the application. When a water body is tested, it should be maintained on a regular basis to reduce the contamination level.

The benefit of monitoring the water body qualities involves controlling the nature's pollution and finding solution for pollution.

Water is the elixir of life. Out of 0.3% of usage water on the earth, more than half has already being contaminated. Water is contaminated by discharging sewage, garbage and liquid wastes of household, agricultural lands and factories into lakes and rivers. The usage of contaminated water in the daily life results in health hazardous. Water must be made available and contamination free for any household usage or for personal purposes. Water pollution control not only helps individual but also contributes for country's economy. Here the big need is to increase the quality of water and alert immediately as soon as the pollution is detected, in order to prevent further damage. So this system shall help in preventing the large quantum of damage of water body.

This project aims at developing a control system, in order to provide a technical solution for the above problem. The control system will be deployed in the water resources which sense various parameters and sends the data onto the cloud platform through a server. Then real-time data analytics are applied to the data on the cloud platform. Finally the results are presented to the user in the form of graphs on daily or weekly basis, through a mobile application. The challenges faced while developing the module include understanding of concepts moving data onto the cloud platform, applying real-time data analytics on data and presenting the dynamic results to the end-user.

II. LITERATURE SURVEY

1.AUTHORS: Nazleeni Samiha Haron, Mohd Khuzaimi Mahamad, Izzatdin Abdul Aziz, Mazlina Mehat.

Abstract: This paper proposes an architecture of water quality monitoring system. This system has a GSM module which helps in monitoring the water quality remotely. The traditional methods used for testing involves the staff to visit the water bodies, collect the samples and then return to laboratory. Hence, this method is time consuming. This GSM system also has features to send alerts or messages, when the quality of water decreases [1].

2. AUTHORS: Fiona Regan, AntóinLawlor and Audrey McCarthy.

Abstract: The project of the SmartCoast Project (a partnership between Dublin City University (DCU), the Marine Institute, Tyndall National Institute (TNI), The National Microelectronics Applications Centre (MAC), the South West Regional Authority (SWRA) and Marine Informatics (MaInf)) was done to build a system which collects data innovatively and autonomously. This system was built to meet the requirements of WFD because it didn't have such facility before [2].

3. AUTHORS: ZulhaniRasin and Mohd Rizal Abdullah.

Abstract: This project uses wireless sensor network(WSN). Hence the system uses several sensor nodes with wireless networking for continuous purposes. Basic parameters of water quality like temperature, pH and turbidity are sensed from the respective sensors and are sent to the storage device or system. This project also concentrates on low cost, easy handling and maintenance of the built model. Since the wireless system is used, it makes the model easy to install and cost effective. The WSN also provides flexibility to the system. The system uses Zigbee based technology with IEEE 802.15.4 compatible transceiver [3].

4. AUTHORS: Dong He, Li-Xin Zhang.

Abstract: The particular project uses Wireless Sensor Networks(WSN) and consists of a remote data center. The hardware platform uses wireless microprocessor CC2430as the core. The network uses Zigbee wireless transmission. The model collects the data and sends it to internet using GPRS DTU. This GPRS DTU has built in TCP/IP protocol. From the internet, the remote data center gets real time data of water quality, then analyzes it, processes it and keeps a record of the data. This helps the work to me more efficient and cost effective [4].

5. AUTHORS: Jayti Bhatt, Jignesh Patoliya.

Abstract: To make sure that the water being supplied is safe, we need to monitor the water on a daily basis. For this IOT(Internet Of Things) approach is very effective. In the particular project, system contain sensors to measure basic parameters of water like pH, turbidity, conductivity, dissolved oxygen, temperature. These values from sensors are processed my microcontroller and sent to raspberry pi using Zigbee protocol. The result can be viewed on browser application [5].

III. OBJECTIVES

While finding solution to water contamination problem, it is necessary to first know the correct information regarding the cause of problem, how is it happening, where and why are the causes to this problem. Then it is easier to propose solution which lasts longer and also costs less.

The project aims at providing a feasible and flexible solution to measure quality of the water. The main goal is to provide a complete view of the current state of contamination in water and create awareness regarding the importance of water safety. The water contamination measuring system aims to fulfill the following goals:

- To identify the nature and amount of pollutants in the water bodies.
- To identify pattern of pollution over a time period.
- To identify the capacity of absorbing of the water body, in order to reduce the cost of pollution control.

IV.EXISTING SYSTEM

The existing water testing techniques are difficult and time consuming. In order to attend to the problems of manual testing, a remote monitoring of the water body system was proposed. The system works on Wireless Sensor which determines the features or parameters of the water, and the result is obtained. Three main parameters which are important for the aquatic life(pH, temperature and turbidity) are considered. The system design details and implementation are presented in the paper.

V. PROPOSED SYSTEM

Using IOT modules and required Machine language concept we build the essential project were the IOT hardware helps out in getting all the required data and then later it will be turned to required processing data sets from the cloud where IOT deploys. Then it will be fetched to Machine language Algorithms for the further processing so that we get the complete result whether the taken water sample of the lake is fit or not. .

Later, for the user friendly and commonly accessible to end user a website is developed and daily monitoring of the lake is made possible.

VI. COMPONENTS

1. Arduino Uno Rev3

FIGURE 1: ARDUINO UNO R3

1. Features of Arduino UNO

- Microcontroller: ATmega328
- Operating Voltage: 5V
- Input Voltage (recommended): 7-12V
- Input Voltage (limits): 6-20V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 40 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328)
- EEPROM: 1 KB (ATmega328)
- Clock Speed: 16 MHz

2. pH Sensor

2. **FIGURE 2: PH METER SKU:SEN0161**

Features of PH METER SKU: SEN0161

- Module Power : 5.00V
- Module Size : 43mm×32mm
- Measuring Range:0-14PH
- Measuring Temperature :0-60 ℃
- Accuracy : ± 0.1pH (25 ℃)
- Response Time : ≤ 1min
- pH Sensor with BNC Connector
- PH2.0 Interface (3 foot patch)
- Gain Adjustment Potentiometer
- Power Indicator LED
- Cable Length from sensor to BNC connector:660mm

3. Turbidity Sensor

FIGURE 3: TURBIDITY METER SKU:SEN0189

Features of Turbidity Sensor SKU: SEN0189

- Operating Voltage: 5V DC
- Operating Current: 40mA (MAX)
- Response Time : <500ms
- Insulation Resistance: 100M (Min)
- Output Method:
    - Analog output: 0-4.5V
    - Digital Output: High/Low level signal (you can adjust the threshold value by adjusting the potentiometer)
- Operating Temperature: 5℃~90℃
- Storage Temperature: -10℃~90℃
- Weight: 30g
- Adapter Dimensions: 38mm*28mm*10mm/1.5inches *1.1inches*0.4inches

3.

4.

4. Temperature Sensor

FIGURE 4: TEMPERATURE SENSOR DS18B20

Features of Temperature Sensor Ds18b20

- Unique 1-Wire Interface Requires Only One Port Pin for Communication
- Reduce Component Count with Integrated Temperature Sensor and EEPROM
- Measures Temperatures from -55°C to +125°C (-67°F to +257°F)
- ±0.5°C Accuracy from -10°C to +85°C
- Programmable Resolution from 9 Bits to 12 Bits
- No External Components Required
- Parasitic Power Mode Requires Only 2 Pins for Operation (DQ and GND)
- Simplifies Distributed Temperature-Sensing Applications with Multidrop Capability
- Each Device Has a Unique 64-Bit Serial Code Stored in On-Board ROM
- Flexible User-Definable Nonvolatile (NV) Alarm Settings with Alarm Search Command
  Identifies Devices with Temperatures Outside Programmed Limits
- Available in 8-Pin SO (150 mils), 8-Pin µSOP, and 3-Pin TO-92 Packages

VII. CIRCUIT CONNECTION

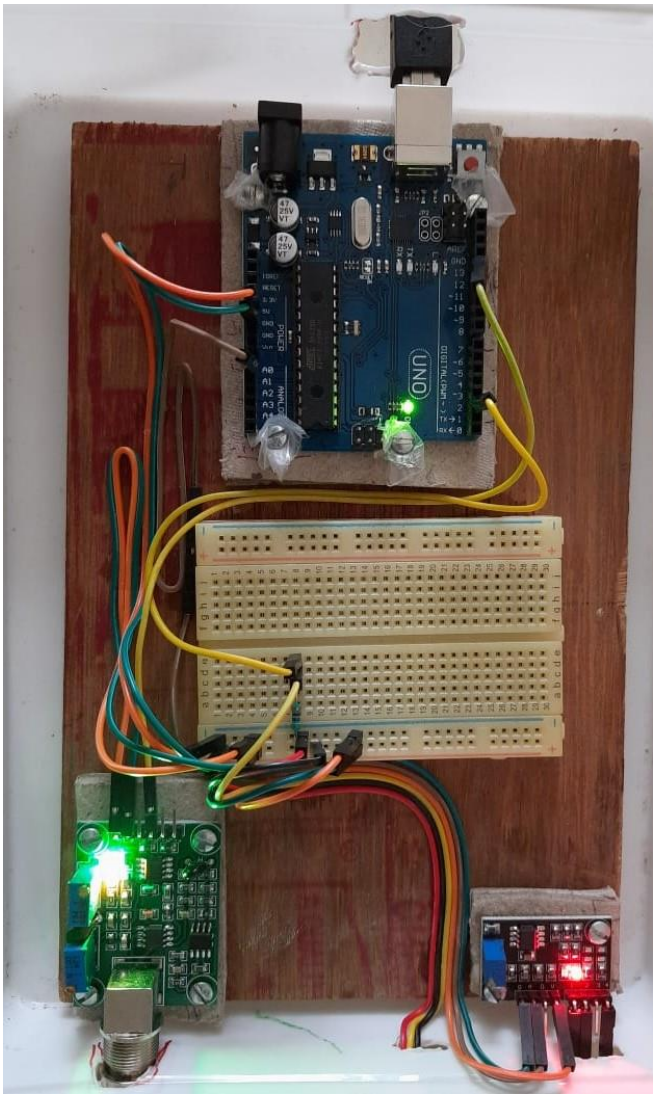

FIGURE 5: CIRCUIT CONNECTION OF ALL SENSORS

- Arduino board is powered using the system. The board can also be powered using a battery for more efficient performance.
- The voltage pin and ground pin are made common on the bread board, this helps in connecting pH board and turbidity board.
- Temperature sensor is directly connected to the common pins on bread board. In the circuit, red wires are connected to voltage pins and black wires are connected to ground pins. Yellow wire is connected to digital input pin 2 which will provide us the sensor output. To provide accurate outputs a resistor of 4.7k ohm is used in this connection.
- The pH sensor is connected to the pH board. The pH board has pins voltage, ground and inputs. The voltage and ground pins are connected to the common voltage and ground pins on the bread board. The input pin (P0) is connected to the digital pin 12 which provides us the output of the pH sensor.
- The turbidity sensor has a triple pinned wire (red, blue, yellow). It has a board which has pins for voltage, ground, inputs and pins 1,2,3 and 4. The voltage and ground pins are connected to the common voltage and ground pins on the bread board. The input pin is connected to the analog input (A0). The triple pinned wires are connected to the board pins 1,2 and 4 with the wires red, blue and yellow respectively.
- The sensors are dipped in the water, and the values are read using Arduino ide. These values are saved as a csv file to the local system using a third party service called tera term. This csv file is then fed into the machine learning algorithm to predict the values.

VIII. MODULES

1. Logistic Regression:

Logistic regression is one of the supervised classification algorithms.

Generally, in a classification problem, the output value 'y', also known as target variable can take only discrete values for given input 'X', which is also known as set of features.

Opposite to general opinion, Logistic Regression is a regression model. The model builds a regression model to predict the probability that a given data entry belongs to the particular category.

Hypothesis function for Logistic Regression:

$$\frac{p}{1-p} = \exp(b_0 + b_1 x)$$

While training the model we are given:

x: input training data

p: probability

b0: constant

b1: coefficient of x and defines the steepness of the curve

Logistic regression plots graph to predict the probability value p for given input x. The best fit for the curve is obtained by finding bo and b1 values. When the model is finally built and used for prediction, it predicts output value(y) for a given input(x).

2. K-Nearest Neighbor:

One of the very common supervised Machine Learning algorithm is K-Nearest Neighbor(KNN) algorithm. This algorithm can be used for both regression prediction and classification problems. But, in the industry KNN is mainly used for classification prediction problems.

K-nearest neighbors(KNN) algorithm classifies the data points based on features. It checks every data point with all the available features and classifies the data point based on its similarity with the feature.

The following steps indicate KNN's working:

Step 1 − Algorithms works on data sets. Hence we must first load the data sets. These data sets are divided into training set and test set.

Step 2 – In the next step, we choose the number of neighbors (K). This can be any integer.

Step 3 − For each point in the test data do the following −

3.1 – We need to calculate the distance between each data point and its neighbors. For calculating distance we use any one of the following methods namely: Euclidean, Manhattan or Hamming. But most commonly we use Euclidean distance.

3.2 − Now, based on the distance value, sort them in ascending order.

3.3 – In the ascending ordered list, it will choose the top K rows.

3.4 – It identifies the most frequent class and assigns the data points to the respective class.

Step 4 – End.

3. Support Vector Classifier:

Another supervised learning methods include Support Vector Machine(SVM). The support vector machines can be used for outliers detection, classification as well as regression.

The advantages of support vector machines are:

•SVMs are highly effective in high dimension spaces.

•But it is also effective in situations where in the number of samples is less than the number of dimensions.

•From the training points, a subset is created and is used in the decision function. These are called support vectors. Hence it also becomes memory efficient.

• For the decision functions different kernels can be specified. Hence, it is versatile. By default, common kernels are provided. But user can use custom kernels.

The disadvantages of support vector machines include:

• If the number of samples are very much lesser than number of features, we need to avoid over-fitting in choosing Kernel functions and regularization term is also crucial.

• The probability estimates are not directly provided by SVMs instead these are calculated. They are calculated using a five-fold cross- validation.

The support vector machines in scikit-learn support both dense and sparse sample vectors as input. However, to use an SVM to make predictions for sparse data, it must have been fit on such data.

4. Gaussian Naïve Bayes:

The Naïve Bayes can be applied on to real-valued data attributes, but before applying we must assume a Gaussian distribution.

Extending Naïve Bayes in this format is known as Gaussian Naive Bayes. Estimation of data can also be done using other functions, but this Gaussian (or Normal distribution) is the simplest way to work on because when using this distribution only standard deviation and mean of the training data has to be estimated.

It is similar in calculating the standard deviation and mean values of all the input variable i.e., x for all the class values.

mean(x) = 1/n * sum(x)

Where n denotes the instance number and x are the input values from training data.

Standard Deviation is calculated using the equation:

standard deviation(x) = sqrt(1/n * sum(xi-mean(x)^2))

The above equation the square root value of average squared difference. Here n denotes the number of instances, sqrt() returns the square root, sum() return the sum of the values, xi is the value of x at a specific instance i, mean(x) returns average value of all x instances and ^2 is nothing but the square.

5. Decision Tree Classifier:

Decision Trees (DTs) are a non-parametric supervised learning method used for classification and regression. The main aim of decision tree is to build a model which predicts values based on simple rules.

Some advantages of decision trees are:

• Decision tree is visualized. Hence provides a clear understanding.

• Before using data on decision tree the data has to be prepared. If there are missing values, this method does not support it.

•The cost of using the tree (i.e.., predicting data) is logarithmic in the number of data points used to train the tree.

•Decision tree supports all types of data. It can use both categorical and numerical data unlike other algorithms. It can also handle problems that produce multiple-outputs.

•The methods and results in the decision tree are observable. It uses Boolean logic to explain the conditions of the algorithm. Where as in Artificial neural networks, it is difficult to analyze the condition.

•Possible to validate a model using statistical tests. That makes it possible to account for the reliability of the model.

•Performs well even if its assumptions are somewhat violated by the true model from which the data were generated.

6. Random Forest Classifier:

Random Forest Classifier is formed by randomly selecting data from training set and building decision trees to it. To obtain the final result, it combines the output of all the decision trees.

Types of Random Forest models:

1. Random Forest Prediction for a classification problem:

f(x) = majority vote of all predicted classes over B trees .

2. Random Forest Prediction for a regression problem:

f(x) = sum of all sub-tree predictions divided over B trees

Advantages Of Random Forest:

1. Random forest is one of the most accurate algorithms. It provides very efficient and precise results for models with large data set.

2. It provides accurate results for models with thousands of inputs without deleting any of the variable

3. It estimates the importance of variables and based on the estimation uses only the important variables for prediction.

4. As the building of the forest progresses, it generates an unbiased result.

6. If the data in the database is missing, then it has effective measures to estimate this data and also maintains accuracy of such large data.

7. K-means Clustering:

K-means clustering, is one of the simplest and popular unsupervised machine learning algorithms. The unsupervised learning always uses only input vectors and does not refer to outcomes or results.

K-Means method is based on clusters. Hence, a cluster is nothing but a group of points with similar features. In K-Means we have to first determine the value of k, which refers to number of centroids in the respective dataset. Centroid is the imaginary center of a cluster. And every data point is allocated to clusters by reducing the cluster sum of squares. In K-Means, 'K' refers to number of clusters to which data points are assigned to and 'means' refers to average of the data.

When the dataset is loaded into the model, the algorithm first randomly selects a group of centroids. To these centroids it assigns the initial data point. Then the algorithm performs iterative(repeated) steps to optimize the centroids.

The iterative step stops when either of these occur:

- When the centroid is stabilized.
- When the defined number of iteration are finished.

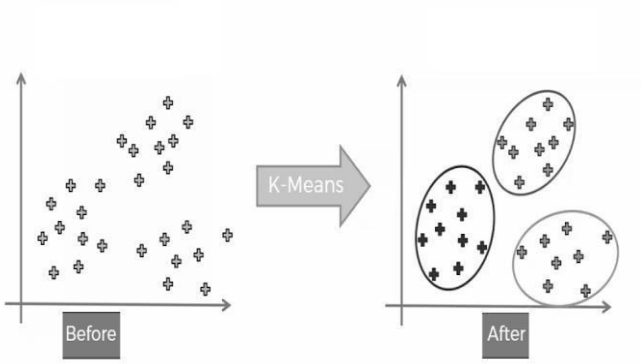

FIGURE 6- K-means Clustering

8. Hierarchical Clustering:

Hierarchical clustering, also known as *hierarchical cluster analysis*, is an algorithm that groups similar objects into groups called *clusters*. All the objects in a cluster have similar properties where as objects in different clusters have variable characteristics. To distinguish between two clusters, we look the cluster of endpoints.

Hierarchical clustering is usually performed with distance matrix. But the user can also provide raw data. This raw data is further converted into distance matrix.

In Hierarchical clustering, initially all the data is considered as separate clusters.

Then the following two steps are executed continuously:

(1) determines the closest cluster and check for the similarity

(2) if two similar clusters are found, then merge the two clusters.

This process ends when all the clusters are merged together.

The main output of Hierarchical Clustering is a *dendrogram,* which shows the hierarchical relationship between the clusters.

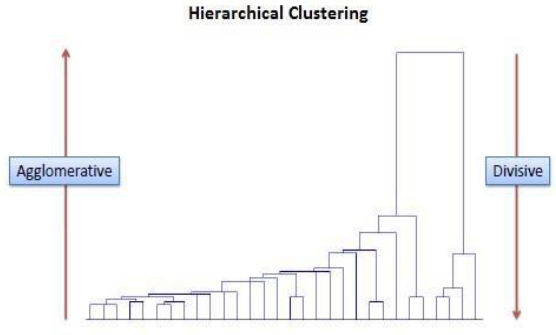

FIGURE 7 - Hierarchical Clustering

IX. SYSTEM ARCHITECTURE

Data flow diagram is a representation of the data is used in the system. It is used as a basic step to view the working of the built model. The DFD's can be used for visualizing data processing since it shows what data is given as input and what is obtained as output.

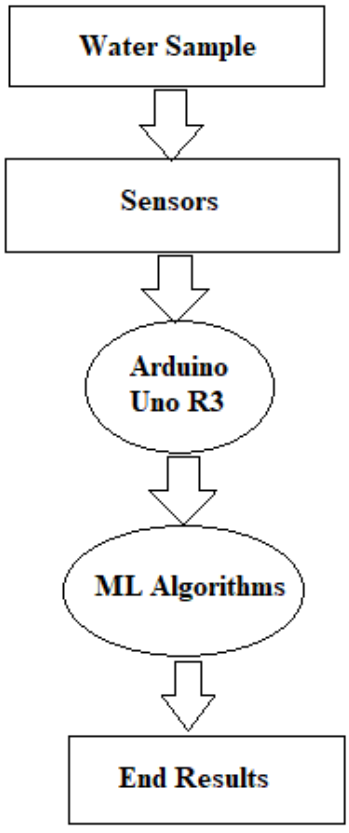

FIGURE 8 - Data Flow Diagram

X. RESULTS

1. Logistic Regression result:

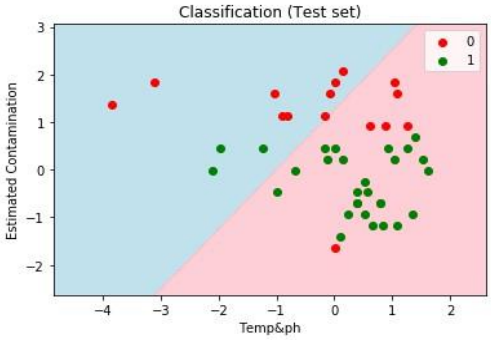

FIGURE 9 – Logistic Regression Result

Inputs: -all X-axis is independent variables of dataset , Y -axis is dependent variable of dataset.

Output:-red dot indicates contaminated, green dot indicates not contaminated

Result:-According to trained model the given sample is determined as not contaminated with overall data.

2. K-Nearest Neighbor result:

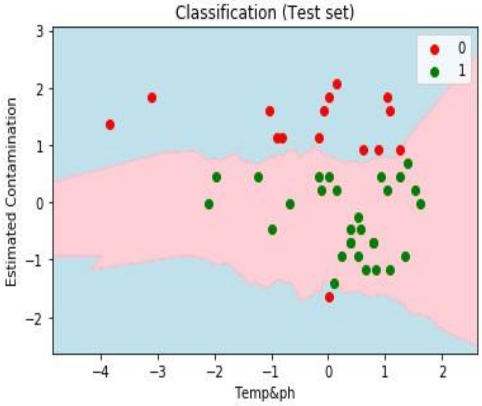

FIGURE 10 – K-Nearest Neighbor Result

Inputs:-all X-axis is independent variables of dataset , Y -axis is dependent variable of dataset.

Output:-red dot indicates contaminated, green dot indicates not contaminated.

Result:-According to trained model the given sample is determined as not contaminated with overall data.

3. Support Vector Machine result:

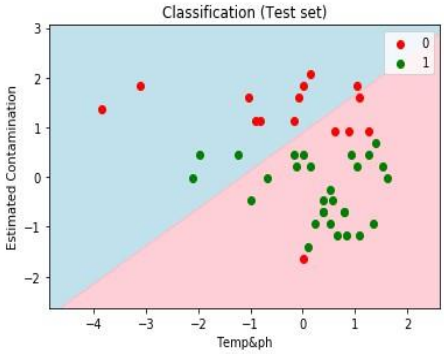

FIGURE 11 – Support Vector Machine Result

Inputs:-all X-axis is independent variables of dataset , Y -axis is dependent variable of dataset.

Output:-red dot indicates contaminated, green dot indicates not contaminated.

Result:-According to trained model the given sample is determined as not contaminated with overall data.

4. Gaussian Naïve Bayes Result:

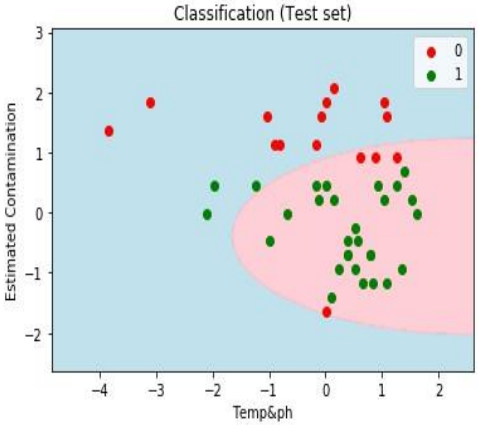

FIGURE 12 – Gaussian Naïve Bayes Result

Inputs:-all X-axis is independent variables of dataset , Y -axis is dependent variable of dataset.

Output:-red dot indicates contaminated, green dot indicates not contaminated

Result:-According to trained model the given sample is determined as not contaminated with overall data

5. Decision Tree Result:

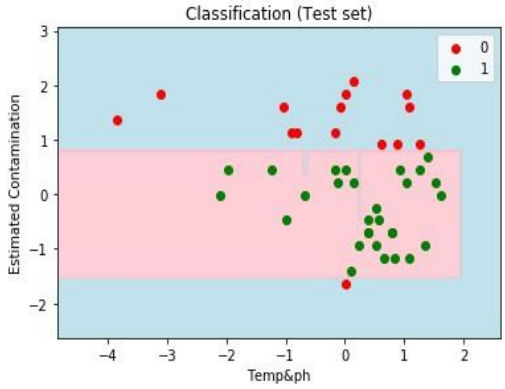

FIGURE 13 – Decision Tree Result

Inputs:-all X-axis is independent variables of dataset , Y -axis is dependent variable of dataset.

Output:-red dot indicates contaminated, green dot indicates not contaminated

Result:-According to trained model the given sample is determined as not contaminated with overall data

6. Random Forest result:

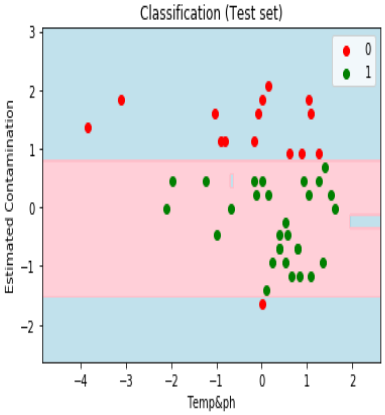

FIGURE 14 – Random Forest Result

Inputs:-all X-axis is independent variables of dataset , Y -axis is dependent variable of dataset.

Output:-red dot indicates contaminated, green dot indicates not contaminated

Result:-According to trained model the given sample is determined as not contaminated with overall data.

7. K-Means Clustering result:

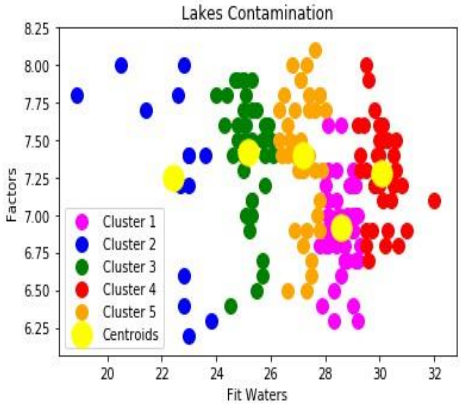

FIGURE 15 – K-Means Clustering Result

Inputs:-all X-axis is independent variables of dataset , Y -axis is dependent variable of dataset.

Output:-We obtain required cluster of similar sample

Result:- cluster 1: good, cluster 2: better, cluster 3: best, cluster 4: caution, cluster 5: Alert(contaminated)

8. Hierarchical Clustering result:

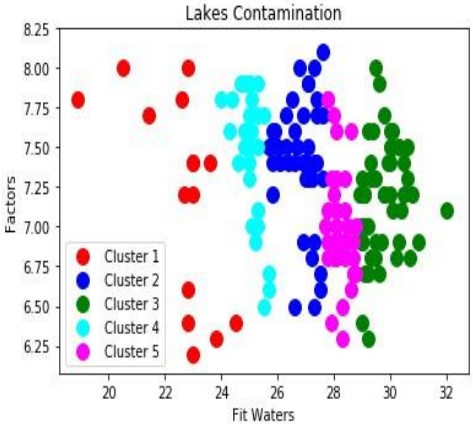

FIGURE 16 – Hierarchical Clustering Result

Inputs:-all X-axis is independent variables of dataset , Y -axis is dependent variable of dataset.

Output:-We obtain required cluster of similar sample

Result:- cluster 1: good, cluster 2: better, cluster 3: best, cluster 4: caution, cluster 5: Alert(contaminated).

XI. CONCLUSION

Real time water quality monitoring system has been developed in this project. The model is very versatile and economical. The model finds different basic parameters of water and sends it to the central storing device. From the device the data is analyzed, processed and the result is sent to the user. The system is economical and low cost. It is portable hence has more advantage than the existing methods.

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