International Journal of Emerging Technology and Computer Science
ISSN: 2455-9954

WATER QUALITY MONITORING AND PREDICTION SYSTEM USING MULTI SENSOR NETWORK

Abhay Awale, Prof. Dr. Vinayak Kottawar, Bhivraj Shelke, Rushikesh Tayde, Rushikesh Shirsate
Department of Computer Engineering
D. Y. Patil College of Engineering, Akurdi, Pune – 44. Maharashtra, India

ABSTRACT

Water quality has been a major issue for many decades causing 5 to 10 million deaths worldwide. Many of the existing water quality management techniques are not enough to promise the cleanliness of water. Existing methods consist of taking samples from various points in a distributed network and then testing them in a laboratory. This method is time consuming and is laborious and require great extent of man power and also it is not effective as it is a proactive measures of water quality monitoring. Thus a multi sensor network using wsn can take care of all the needs which are required for efficient and non-laborious water quality monitoring system. This system are relatively affordable and allow measurements to be taken from remote location, in real time and with minimal human intervention. There are various WSN based paper of water quality monitoring method suggested by others authors.

Keywords - multi sensor network, ANN, SVM, and GMDH.

I. INTRODUCTION

Nowadays drinking water is the most precious and valuable for all the human beings, drinking water utilities faces new challenges in real-time operation. This challenge occurred because of limited water resources growing population, ageing infrastructure etc. Hence therefore there is a need of better methodologies for monitoring the water quality. Most of the water laboratories and public health engineering departments are highly dependent on manual data collection and storage process, which is time-consuming and highly prone toward human error. Wireless sensor networks (WSNs) have gained popularity within research community because they provide a promising infrastructure for numerous control and monitoring applications. These simple low-cost networks allow monitoring processes to be conducted remotely, in real-time and with minimal human intervention. A typical WSN network consists of two main components namely node and base-station. A node is a device that is normally equipped with sensing, processing and communication capabilities, and is responsible for measuring the parameters associated with a particular application. A base station is responsible for capturing and providing access to all measurement data from the nodes, and can sometimes provide gateway services to allow the data to be managed remotely. The main aim is to measure the, pH and turbidity of drinking water as well as water that may be used for agriculture and industrial processes. The remote access of water quality measurement parameters using wireless communication facilitates quality control, record keeping and analysis using simulation software at base station.pH and turbidity level are the parameters that are analyzed and control to improve water quality.

II. FACTORS LEADING TO NEW SYSTEMS REQUIREMENTS

- Limitations of existing water treating systems.
- Drinking too much chlorinated water leads to Cancer and other diseases.
- No single instrument is available that can detect many possible water parameters. Thus, it is necessary to deduce a single instrument which can detect large number of possible water parameters such as pH, turbidity and conductivity.
- Predicting the water quality by analyzing the passed sensed data of two- or three-weeks using pattern lines analyzed by sensor

2.1. Different goals of water quality monitoring

3 sub goals in this project:

- First: 1st goal of this project is to design and manage a Wireless Sensor Network (WSN) for water quality monitoring.
- Second: Next goal is the Prediction of water quality change pattern using artificial intelligence (AI) techniques including ANN, SVM, and GMDH.
- Third: Finally last one is the graphical user interface (GUI) in the form of android application for the monitoring purpose.

2.2. Water Quality Tests on three parameters

- Ph
- Turbidity
- Temperature

2.3. Sensors

Fig.1 Turbidity sensor

Fig.2 Temperature sensor

Fig.3 PH sensor

COMPONENT DESCRIPTION

2.3.1 Ph sensor

- Measures the acidity of water in ponds and streams
- Serious problems occur in lakes with a pH lower than 5or higher than 9.5.
- PH is measured on a scale of 0 to 14.
  1. Water above 7 is alkaline (or basic).
  2. Water below 7 is Acidic.

2.3.2 Turbidity sensor

- Refers to the clarity of water, the murkier the water, the greater the turbidity.
- Working:
- Water flows between the two projections of the transparent plastic can.
- These projections house the phototransistor and the photodiode respectively.
- The phototransistor emits light rays that are supposed to reach the photodiode.
- These light rays come across the water flow and lose their path when they meet any suspended particle in the water.
- As a result, the light received at the photodiode is less in amplitude when compared to that when it was emitted.
- This difference in amount of light sent and received is conveyed to the micro controller operating the sensor and decisions are taken in accordance to that.

2.3.3 Temperature sensor

- A temperature sensor is often a resistance temperature detector or thermocouple that measures temperature through an electrical signal.
- A change in temperature can change the physical, chemical, biological characteristics of water bodies.

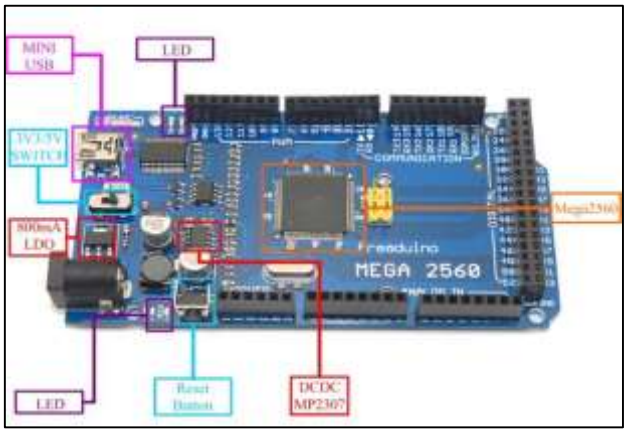
• A resistance temperature detector is a variable resistor that changes its electrical resistance in proportion to the changes in temperature in a repeatable, precise and nearly linear manner.

2.3.4 AC ADAPTER

An AC adapter is a type of external power supply, often enclosed in a case similar to an AC plug. Other common names include plug pack, plug-in adapter, adapter block, domestic mains adapter, line power adapter, wall wart, power brick, and power adapter.

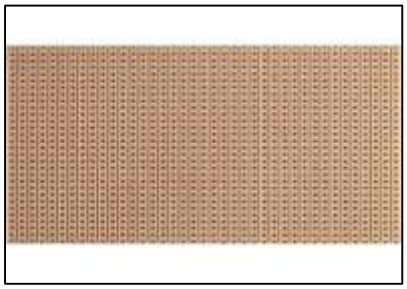
2.3.5 ARDUINO MEGA

The MEGA 2560 is used for more complex projects. It has 54 digital I/O pins and 16 analog inputs. It also has a larger space for sketch. it is the recommended for project including 3D printers and robotics projects. This gives for our projects plenty of room and opportunities. The Arduino Mega 2560 is a microcontroller that based on the ATmega2560 having 54 digital input/output pins (in which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It also contains each and everything that needed to support the microcontroller and simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.



2.3.6 STRIP-BOARD (DOTTED PCB)

Strip board is the generic name for a widely used type of electronics prototyping board characterized by a 0.1-inch (2.54 mm) regular (rectangular) grid of holes, with wide parallel strips of copper cladding running in one direction all the way across one side of the board.



2.3.7 ESP8266 (WIFI-MODULE)

The ESP8266 is a low-cost Wi-Fi chip with full TCP/IP stack and MCU (microcontroller unit) capability produced by Shanghai-based Chinese manufacturer, Express if Systems.

The chip first came to the attention of western makers in August 2014 with the ESP-01 module, made by a third-party manufacturer, AI-Thinker.

2.3.8 ANDROID STUDIO

Android Studio is the official integrated development environment (IDE) for Google's Android operating system built on JetBrains' IntelliJ IDEA software and designed specifically for Android development available for download on Windows, mac OS and Linux based operating systems. It is a replacement for the Eclipse Android Development Tools (ADT) as primary IDE for native Android application development.

2.3.9 BLUETOOTH MODULE

Bluetooth module is the one that is responsible for the wireless data transmission Android application gets the sensor value readings via Bluetooth over its range. It has range up to <100m which depends upon transmitter and receiver, atmosphere, geographic &

urban conditions. It is IEEE 802.15.1 standardized protocol, through which one can build wireless Personal Area Network (PAN). It uses frequency-hopping spread spectrum (FHSS) radio technology to send data over air.

3. Multi sensor network and real time water quality assessment using android app.

The system consists of a multi sensor wireless network which is capable of monitoring the system wirelessly. An Android application is developed which is used to show the sensor results. The application also has login and logout user option. The application includes provision of selecting a location of the system which user will set where the system is going to be installed. It includes the functionalities that raise an alarm in user's mobile when the predefined threshold value of sensor is exceeded. A prediction logic is also present that predicts the water quality using water quality index. This will help users understand the pattern of water quality degradation and will help deduce certain measures to tackle the situation more efficiently. When the algorithm predicts that the water quality is going to be degraded in few weeks a prompt can be send to user about this. Android application have a button called 'Show Result' which displays sensor results. Previous day's data of sensor can also be seen using the application just by putting the start date and end date. Data visualization of current and previous data is also possible. Sensor value data is visualized by using the graph and pie chart. The users may not able to recognize some hidden meaningful information but by using this visualization they are able to get the information using this feature. The data is stored in database and retrieved by the application for displaying and visualization. The website is used to display the visualization of the data. The application is continuously monitoring the results of sensors and giving the required predictions.

4. Water Quality Index:

Initially, WQI is selecting by 3 most commonly used water quality variables like pH value, turbidity value and temperature value. The assigned weight reflected significance of a parameter for a particular use and has considerable impact on the index. A general WQI approach is based on the most common factors, which are described in the following three steps:

1. The selection of the variables from the 3 classes namely pH value, Turbidity value and Temperature value, which have the considerable impact on water quality, are recommended.
2. Determination of Quality Function for Each Parameter Considered as the Sub-Index: Sub-indices transform to non-dimensional scale values from the variables of its different units (counts/volume etc.).
3. Sub-Indices Aggregation with Mathematical Expression: This is frequently utilized through arithmetic averages.

The WQI have been applied for evaluation of water quality in a particular area. Moreover, these indices are often based on the varying number and types of water quality parameters as compared with respective standards of a particular region. Water quality indices are accredited to demonstrate annual cycles, spatial and temporal variations in water quality and trends in water quality even at low concentrations in an efficient and timely manner. On the basis of reviewed literature survey, available indices have many variations and limitations based on number of water quality parameters (variables) used and not accepted worldwide. Hence, it needs worldwide acceptability with varying number of water quality variables. National Sanitation Foundation Water Quality Index WQI determination method have been described herein.

4.1 Computation of WQI:

The WQI is computed following the three steps.

First step – Assigning of weight (wi) to the selected water parameters (e.g., pH, TDS, TH, HCO3, Cl, SO4, NO3, Fe…) according to their relative importance in the overall quality of water for drinking purposes (weight may be from 1 to 5).

Second step – Computation of a relative weight (Wi) of the chemical parameter using the following equation:

$Wi = wi / \sum wi$ (i = 1 to n)

Where, Wi is the relative weight, wi is the weight of each parameter and 'n' is the number of parameters

Third step - Assigning of a quality rating scale (qi) for each parameter, as below:

$qi = (Ci / Si) \times 100$

where, qi is the quality rating, Ci is the concentration of each chemical parameter in each water sample in mg/l, and Si is the guide line value/desirable limit as given in Indian drinking water standard (BIS 2004).

For computation of WQI, the sub index (SI) is first determined for each chemical parameter, as given below:

SIi = Wi x qi

WQI = ∑ SIi - n

where, SIi is the sub index of ith parameter; Wi is relative weight of ith parameter; qi is the rating based on concentration of ith parameter and 'n' is the number of chemical parameters.

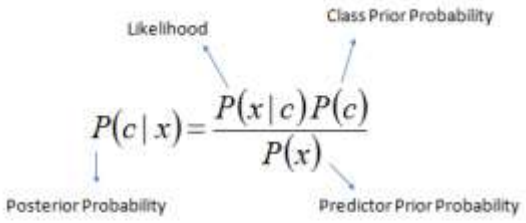
5. Prediction Logic: Naïve Bayes Algorithm

The main objective of this paper is the prediction of water quality using water quality index. Various water quality parameters: PH, turbidity and temperature are observed by multi sensor network which will generate a large amount of sensor values. This data can is used to predict the pattern of the water quality degradation. The classification of water based on whether it is safe for drinking or not can be done. The data generated by sensors can be used as training data and after deducing a modal from this data set a new sample and its quality can be assessed.

5.1 Naïve Bayes Algorithm

It is an algorithm which is based on Bayes algorithm with assumption that there is an independence among predictors. Thus is assumes that this classifier assumes the presence of a particular feature in a class is unrelated to presence of any other feature.

Bayes theorem provides a way of calculating posterior probability P(c|x) from P(c), P(x) and P(x|c). Look at the equation below:



$$P(c \mid X) = P(x_1 \mid c) \times P(x_2 \mid c) \times \cdots \times P(x_n \mid c) \times P(c)$$

Above,

- P(c|x) is the posterior probability of class(c, target) given predictor (x, attributes).
- P(c) is the prior probability of class.
- P(x|c) is the likelihood which is the probability of predictor given class.
- P(x) is the prior probability of predictor.

S.No	WQI	Status	Possible usages
1	0 – 25	Excellent	Drinking, Irrigation and Industrial
2	25 – 50	Good	Domestic, Irrigation and Industrial
3	51 -75	Fair	Irrigation and Industrial
4	76 – 100	Poor	Irrigation
5	101 -150	Very Poor	Restricted use for Irrigation
6	Above 150	Unfit for Drinking	Proper treatment required before use.

Table 1 WQI measures

III. CONCLUSION

WSN technology provides us approach to real time data acquisition, transmission and processing. Low power consumption, long battery life, No carbon emission, more flexible to deploy at remote site. It checks quality of water at the places where generally it is inconvenient to take frequent tests manually. It is the easy installation of the system where the base station can be placed at the local residence close to the target area and the monitoring task can be done by any person with minimal training. Based on a study of existing water quality monitoring system and scenario of water we can say that proposed system is more suitable to monitor water quality parameters in real time. The proposed system introduces wireless sensor networking using several sensors to measure water quality, microcontroller and IOT module which make sensor network simple, low cost and more efficiently. Furthermore, to monitor data from all over the word IOT environment is provided using Arduino for creating gateway and also, cloud computing technology is used to monitor data on the internet. Moreover, to make system user-friendly web browser application is there. WSN technology provides us approach to real time data acquisition, transmission and processing. Water quality prediction will help to give us more time to tackle with water quality monitoring issues

REFERENCES

[1] Zulhani Rasin and Mohd Abdullah International Journal Engineering & Technology,"Water Quality Monitoring System Using Zigbee Based Wireless Sensor Network", IJET Vol: 9 No: 10, http://www.ijens.org/91410-7575%20ijet-ijens.pdf

[2] Johan Lonn and Jonas Olsson, "Zigbee for Wireless Networking", March 15, 2005,

[3] J Goldman and D Estrin ,"Distributed Sensing System for Water Quality Assessment and Management", Feb 1, 2007,

[4] R R.Lakhe, "Wireless Network Using Zigbee" , International Journal of Engineering research and Applications (IJERA),http://www.ijera.com/special_issue/VNCET_Mar_2012/55.pdf.Zigbee,Wikipedia,http://en.wikipedia.org/wiki/ZigBee

[5] (2009) The Zigbee Alliance website [Online] http: //www.zigbee.org/

[6] China Unicom 100 Customers iPhone User Feedback Report, 2009.

[7] Estuary Ethier, Bedard, Jeannette " Development of a Real-Time Water Quality Buoy" for The Fraser River Estuary http://axystechnologies.com/wp-content/uploads/2013/11/Developmentof-a-real-time-water-quality-buoy-for-the-fraser-river-estuary.pdf