Real-Time River Water Quality Monitoring and Control System

ABSTRACT

Current water quality monitoring system is a manual system with a monotonous process and is very time-consuming. This paper proposes a sensor-based water quality monitoring system. The system consists of several sensors which is used to measure physical and chemical parameters of the water. The main components of Wireless Sensor Network (WSN) include a microcontroller for processing the system, communication system for inter and intra node communication and several sensors. Real-time data access can be done by using remote monitoring and Internet of Things (IoT) technology. Data collected at the apart site can be displayed in a visual format on a server PC with the help of Spark streaming analysis through Spark MLlib, Deep learning neural network models, Belief Rule Based (BRB) system and is also compared with standard values. If the acquired value is above the threshold value automated warning SMS alert will be sent to the agent. The uniqueness of our proposed paper is to obtain the water monitoring system with high frequency, high mobility, and low powered. Therefore, our proposed system will immensely help Bangladeshi populations to become conscious against contaminated water as well as to stop polluting the water.

Introduction

The environment around consists of five key elements e.g., soil, water, climate, natural vegetation, and landforms. Among these water is the utmost crucial element for human life. It is also vital for the persistence of other living habitats. Whether it is used for drinking, domestic use, and food production or recreational purposes, safe and readily available water is the need for public health. So it is highly imperative for us to maintain water quality balance. Otherwise, it would severely damage the health of the humans and at the same time affect the ecological balance among other species. Water pollution is a foremost global problem which needs ongoing evaluation and adaptation of water resource directorial principle at the levels of international down to individual wells. It has been studied that water pollution is the leading cause of mortalities and diseases worldwide.

The records show that more than 14,000 people die daily worldwide due to water pollution. In many developing countries, dirty or contaminated water is being used for drinking without any proper prior treatment. One of the reasons for this happening is the ignorance of public and administration and the lack of water quality monitoring system which makes serious health issues. In this paper, we depict the design of Wireless Sensor Network (WSN) that assists to monitor the quality of water with the support of information sensed by the sensors dipped in water. Using different sensors, this system can collect various parameters from water, such as pH, dissolved oxygen, turbidity, conductivity, temperature, and so on. The rapid development of WSN technology provides a novel approach to real-time data acquisition, transmission, and processing. The clients can get ongoing water quality information from far away. Now a day's

Internet of things (IoT) is an innovative technological phenomenon. It is shaping today's world and is used in different fields for collecting, monitoring and analysis of data from remote locations.

IoT integrated network if everywhere starting from smart cities, smart power grids, and smart supply chain to smart wearable. Though IoT is still under applied in the field of environment it has huge potential. It can be applied to detect forest fire and early earthquake, reduce air population, monitor snow level, prevent landslide, and avalanche etc. Moreover, it can be implemented in the field of water quality monitoring and controlling system. Water quality monitoring has gained more interest among researchers in this twenty-first century. Numerous works are either done or ongoing in this topic focusing on various aspects of it. The key theme of all the projects was to develop an efficient, cost-effective, real-time water quality monitoring system which will integrate wireless sensor network and internet of things. In this research, we monitor the physical and chemical parameters of water bodies inside Chittagong city by using an IoT based sensor network.

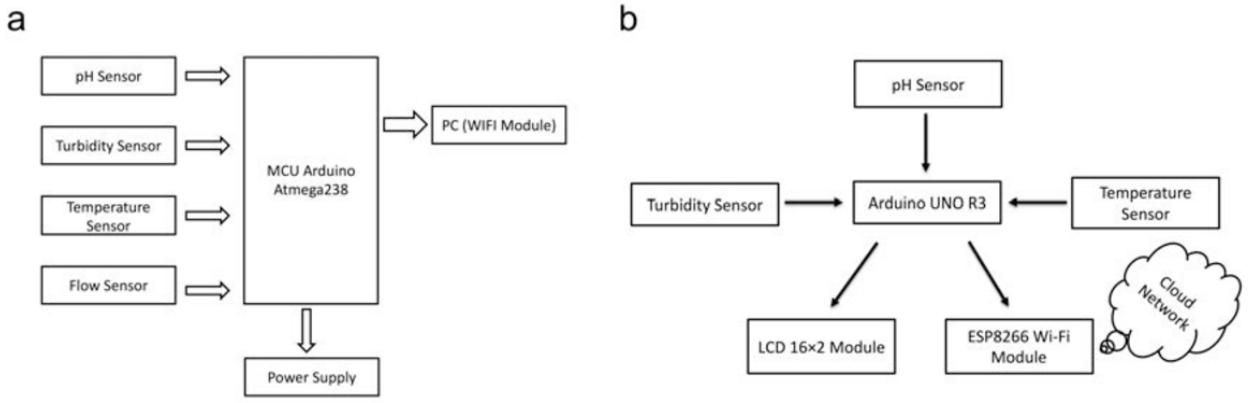
Software design

The proposed water quality monitoring system based on WSN can be divided into three parts:

- **IoT platform**
- **Neural network models in Big Data Analytics and water quality management.**
- **Real-time monitoring of water quality by using IoT integrated Big Data Analytics.**

IoT Platform

The quality parameters are labeled datasets including desired outputs of specific combination of inputs. The neural network will produce output to classify water quality as dangerous, be careful, and good. The classification layer will run on top of Hadoop cluster. The advantages of using neural network based analytics are like Artificial Neural Networks (ANNs) are good in learning and modeling non-linear relationships, and high volatile data. Though neural networks are prone to over fitting, the neural network model used in water quality monitoring system is not complex enough to cause over fitting problem. Also, there are many countermeasures to avoid over fitting. Also, computation overload is not going to delay the response of system as there are only a few water quality parameters. The detailed scheme of IoT platform is shown in Figure 2 (a and b).



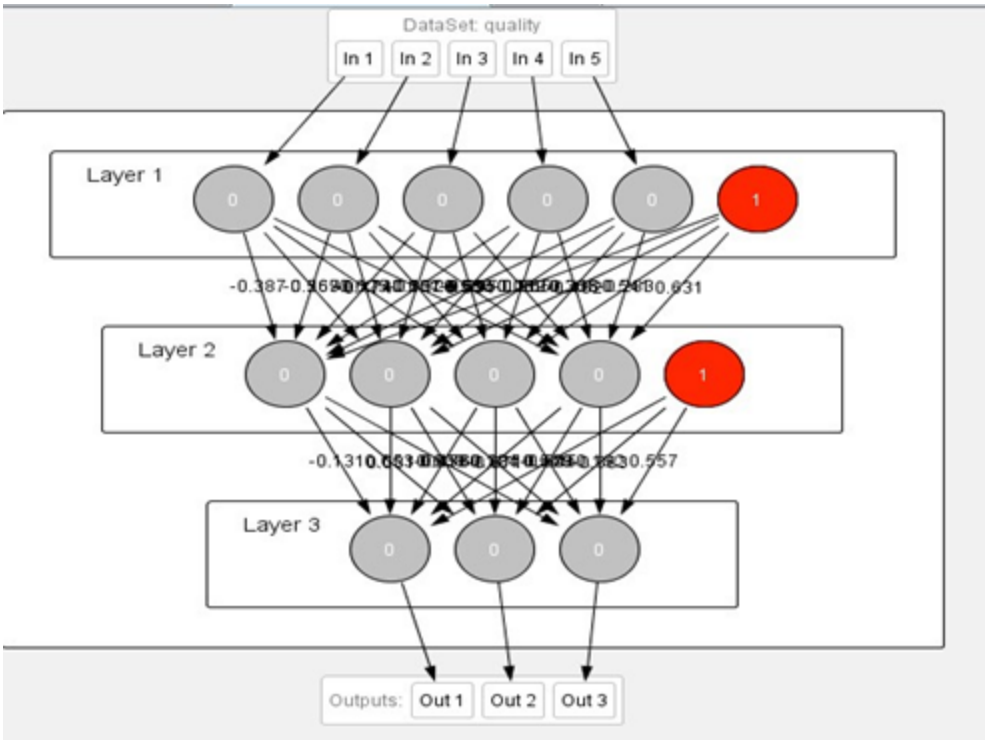
Block diagram and IoT Platform of the proposed system. (a) Turbidity sensors, the pH sensor, the temperature sensor directly connected to the microcontroller are used for turbulence measurement of water,

pH measurement of water, checking the temperature of water accordingly. The microcontroller collects the data and processes it with Wi-Fi module. The Wi-Fi module (ESP8266) transfers data to the PC where the data analysis is done. LCD display has also displayed the output correspondingly. (b) The classification of the IoT platform layer will run on top of Hadoop cluster.

Neural network models in Big Data Analytics and water quality management

The use of artificial neural networks for the prediction of water quality parameters has already been investigated long before. Multi-layer neural network model is depicted below having five inputs In 1, In 2, In 3, In 4, In 5 in input layer, a hidden layer with four neurons and three neurons in output layer. There are two bias input neuron connected to hidden layer neurons and output layer neurons. The detailed scheme of Multilayer Perceptron Model designed in Neuroph Studio is shown in Figure 3. In the neural network model 5 inputs can be pH value, temperature, turbidity, ORP, and conductivity and 3 outputs will be dangerous, be careful, and good. Before training the neural network model few other parameters need to be set; as for example: Learning rate = 0.01, Learning algorithm = Back Propagation, Bias input = 1, Connection weights = randomly assigned, Activation function = sigmoid function. The output of sigmoid function neuron with inputs: Xj, weights: Wj and bias b is

$$F(X) = 1 / (1 + \exp(-\sum j\, wjxj - b))$$



Multilayer Perceptron Model designed in Neuroph Studio. Multi-layer neural network model is depicted above having five inputs In 1, In 2, In 3, In 4, In 5 in input layer, a hidden layer with four neurons and three neurons in output layer. There are two bias input neuron connected to hidden layer neurons and output layer neurons. The quality parameters are labelled datasets including desired outputs of specific combination of inputs. The neural network will produce output to classify water quality as either good or bad.

Real-time monitoring of water quality by using IoT integrated Big Data Analytics

IoT devices use various types of sensors to collect data about turbidity, ORP, temperature, pH, conductivity, etc. of river water continuously. Also, IoT devices have capability to stream the array of collected data wirelessly to the remote Data Aggregator

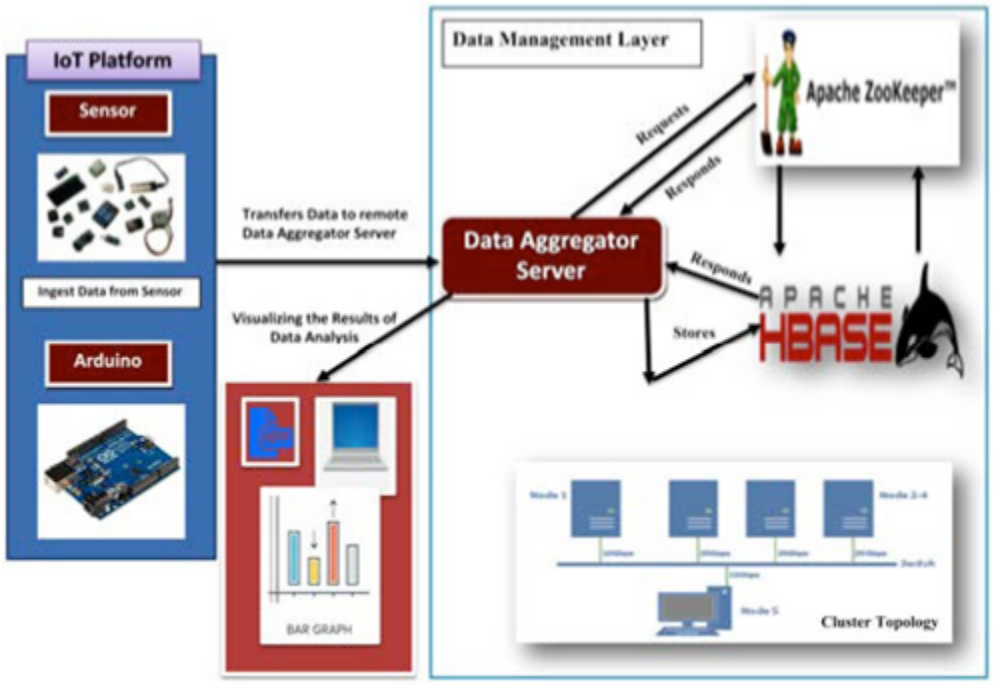
Server in the cloud. Moreover, the volume of semi structured data increases with time in such a velocity that only the Big Data Analytics applications can efficiently store and analyze the data constantly.

The system should be reliable and scalable. So, data management layer will be deployed and operational on the Apache Hadoop cluster. Hadoop helps distributed storing and processing of big data across cluster of computers. Also, such operational environment is horizontally scalable i.e. nodes or computers can be added to a cluster later while volume and velocity of data streaming will be increasing. Hadoop cluster is fault tolerant as jobs are redirected automatically to the running nodes when nodes are failed. The data in Hadoop is highly available as multiple copies of data are stored in data nodes managed by name node, standby name node, journal nodes and failover controller.

IoT applications need high speed of read/write of data and highly available data in the database. So, the system will use Apache HBase NoSQL database to store big data as HBase runs on top of Hadoop. Hence, the data is distributed across Hadoop distributed file system (HDFS). Besides, HBase is capable of executing real-time queries as well as batch processing. High-availability of data is provided by the HBase as it is stored in HDFS.

Hadoop clusters are spanning over many servers which are managed by Apache ZooKeeper. Such centralized management of the cluster is required to provide cross-node synchronization services and configuration management. Applications can create znode (a file which persists the state of the cluster in the memory) in zookeeper. Nodes will register to znode to

synchronize task executions across the cluster by sharing and updating status changes in nodes through the use of zookeeper znode. Apache HBase is managed by Apache ZooKeeper. The IoT application will help the users to visualize the water quality analysis results produced by the data management layer over different time series continuously. The data visualization application runs on client devices such as Smart phones, laptops and desktops. The root users will be able to generate daily/monthly/yearly water quality report from data management layer and visualize in the client devices. The detailed outline of IoT Water Quality Monitor Station and Data Management Layer Architecture Integration.



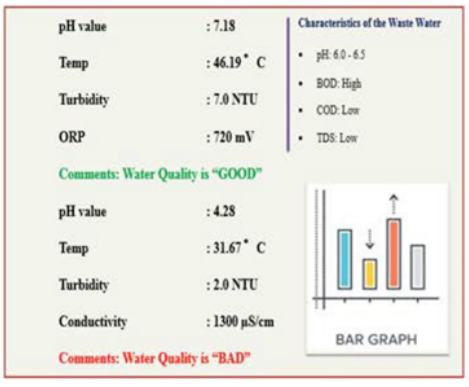
IoT Water Quality Monitor Station and Data Management Layer Architecture Integration. Turbidity, oxidation reduction potential (ORP), temperature, pH, conductivity, etc. of river water are gathered continuously through IoT devices. IoT devices have capability to stream the array of collected data wirelessly to the

remote Data Aggregator Server in the cloud which are efficiently stored and analyzed through the Big Data Analytics applications. Thus, the Data Aggregator Server can retrieve the analysis result and transfer the result to the applications running on smart phones, tablets, laptops, and desktops in the cloud.

Results

we are displaying the resulting sensed pH, temp, turbidity, and ORP values. It continuously senses the values of pH, temp, turbidity, and ORP and the resulting values are displayed to the LCD, PC or mobile in real-time. If the acquired value is above the threshold value comments will be displayed as 'BAD'. If the acquired value is lower than the threshold value comments will be displayed as 'GOOD'. A bar/line graph will also be shown for perfect understanding. The time series representation of sensor data with decision.

a



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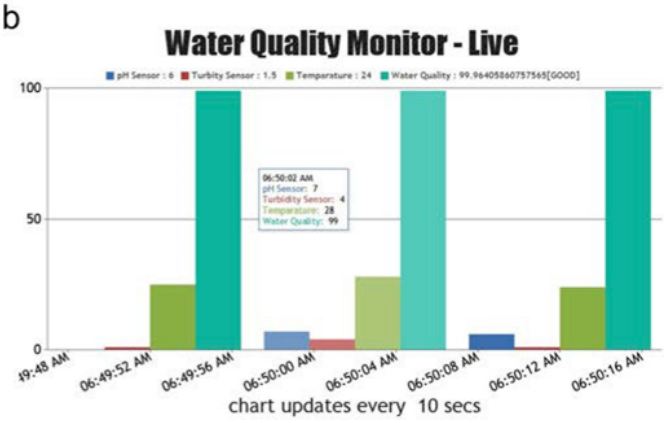

(a) The figure displays the resulting sensed pH, temp, turbidity, and ORP values. It continuously senses the values of pH, temp, turbidity, and ORP and the resulting values are displayed to the LCD, PC or

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Conclusions and future works

Real-time monitoring of water quality by using IoT integrated Big Data Analytics will immensely help people to become conscious against using contaminated water as well as to stop polluting the water. The research is conducted focusing on monitoring river water quality in real-time. Therefore, IoT integrated big data analytics is appeared to be a better solution as reliability, scalability, speed, and persistence can be provided. During the project development phase an intense comparative analysis of real-time analytics technologies such as Spark streaming analysis through Spark MLlib, Deep learning neural network models, and Belief Rule Based (BRB) system will be conducted. This research would recommend conducting systematic experimentation of the proposed technologies in diverse qualities of river water in Bangladesh.

Due to the limitation of the budget, we only focus on measuring the quality of river water parameters. This project can be extended into an efficient water management system of a local area. Moreover, other parameters which wasn't the scope of this project such as total dissolved solid, chemical oxygen demand and dissolved oxygen can also be quantified. So the additional budget is required for further improvement of the overall system.