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Research paper



Real-Time Water Quality Monitoring with Multi-Sensors

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Abstract

Water quality monitoring plays an important role in human well-being, environmental preservation and sustainability. This paper presents the study that has been carried out on the development of water quality monitoring with the tenacity of alerting the user with real-time and online water quality information based on important parameters through a web-based dashboard. The sensors are able to measure the parameters of water quality, such as turbidity, pH, temperature, and the level of the water. Audio and coloured lightings alert are triggered when any water quality parameter reaches unsafe levels. A Wi-Fi transmitter module sends the data to the receiving node over long distance range and display the output in real-time. The result demonstrates that a real-time with multi-parameter remote monitoring of water quality data can be precisely attained and displayed in real-time by using the proposed monitoring system.

Keywords: *Intelligent Systems; Mobile Communications; Multi-Sensors; Real-Time Monitoring; Water Quality Monitoring*

1. Introduction

Maintaining a good water quality is an important task for a healthy life and for environmental sustainability. Clean and unpolluted water is an important resource for human well-beings [1]. Drinking the water from the home pipeline is not necessarily safe for consumption [2], [3]. The aging and poorly maintained infrastructure contributed to the problem as well [4], [5].

Thus, observing the water condition and quality is necessary for ingesting. Taking water samples followed by testing it in the laboratory is the conventional approaches in observing water quality [6], [7]. These approaches are conversely expensive and delaying the response detection. Thus, it is essential to emerge with a more effective monitoring approaches.

Many researchers have studied the consequences of pollutants, water cleansing methods, and systemized water quality monitoring. The United States Environmental Protection Agency (USEPA) [8] found that water parameters are affected by contaminants in explicit ways and can be sensed and observed using suitable water quality sensors. The available products in the market which are able to monitor such factors are generally large and relatively costly [9].

In this paper, the development of a multi-sensor and wireless approach for evaluating the water quality factors that empowering instantaneous checking through a web-based system is presented. The water quality parameters under study are turbidity, pH, temperature, and level of water. All records from the sensors are processed, analysed, and communicated in wireless mode to a server. We developed algorithms to detect possible impurities. A web-based system can be used by the users to monitor the real-time values of water parameters and at the same time the system notifies the user either the water is safe or unsafe.

The remaining of this article is ordered as follows: In Section 2, we review existing work in water quality monitoring. We continue by enlightening our design and development with experimental study in Section 3. Consequently, the results and discussion are presented in Section 4. Finally, Section 5 concludes the paper with pointers to future works.

2. Related Work

The conventional method of determining water quality is using offline method where water samples are collected and brought to the laboratory for testing. However, in recent years, the use of sensors allowing the possibility for real-time checking of water quality.

The water monitoring system implemented by [9] measures water quality parameters to detect water contaminants in real-time. They are using ZigBee receiver and transmitter module for communication between the measuring and notification nodes. A similar work by [10] measures the parameters with of-the-shelf measuring device and data is transmitted to a receiving node through GPRS.

A distributed system for measuring water quality with turbidity, pH, conductivity, and temperature sensors are executed in [11].

All the above-mentioned past related research in water quality monitoring are not providing a web-based dashboard for contented monitoring of the water quality parameters. Also, only GPRS, GSM, and ZigBee have been tested as the wireless communication. On the other hand, in this paper, we are utilizing Wi-Fi signals as the wireless communication medium [12] and a web-based system is developed to monitor the water quality parameters.

3. Real-Time Water Quality Monitoring with Multi-Sensors

To design and develop the proposed real-time water quality monitoring system, a number of important water quality parameters were selected based on [1], [7], and [9], as well as the most suitable wireless communication systems.

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3.1. Water Quality Parameters

The water quality parameters which are the focus of this study are turbidity, pH, temperature, and level. These parameters can be used to detect certain water contaminations.
The detailed series of each parameter are specified in Table 1.

Table 1: Water Quality Parameters Used in Monitoring Activity

Parameter	Unit	Safe Quality Range
Turbidity	NTU	0 to 5
pH	pH	6.5 to 8.5
Temperature	°C	(variable)
Level	cm *or* m	(variable)

3.2. Design and Development

3.2.1. Hardware Design

The hardware that have been used in the development of the system are a turbidity sensor, a pH sensor, a 2-in-1 temperature sensor (can detect water and surrounding temperature), ultrasonic sensor (to detect level of water), Arduino mega board, a 16x2 LCD display, four RGB LED, a buzzer, and a wireless communication transmitter. Figure 1 illustrates the graphical view of the circuit diagram.
Data from the sensors is transmitted in wireless mode to any receiving device. In this study, a Wi-Fi transmitter is used to transmit the sensors information. The reason for choosing Wi-Fi instead of other wireless communication protocols is because it has a high data rate with long range capabilities. This is in comparison to Bluetooth and ultra wideband (UWB) that can only capable of very short-range communication and ZigBee which provide a lower data rate.

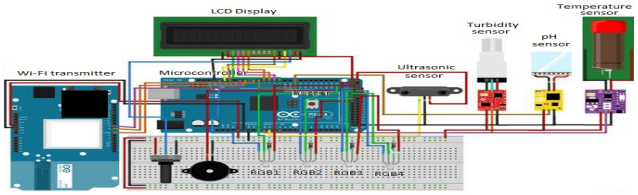


Fig. 1: The graphical view of the hardware setup.

3.2.2. Prototype Development

The user interface at the sensing and measurement node provides audible as well as visual component. The audio component is for cautions and the visual component is to convey the actual readings of each water parameter. The output is showed in LCD with measured values and appropriate message.

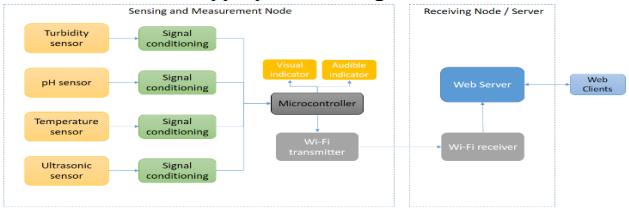


Fig. 2: The proposed water quality monitoring overall block diagram.

In addition, a web-based system is developed in order for the users to monitor the real-time information of each water parameter as well as the overall system. Figure 2 depicts the overall block diagram of the proposed water quality monitoring system.

3.3. Experimental Study

3.3.1. Experimental Setup

As being described in the design subsection as depicted in Figure 1, the setup of the sensing and measurement is as being illustrated in Figure 3.

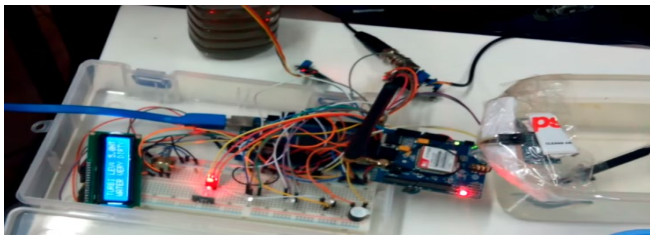


Fig. 3: The sensing and measurement setup

The experiment was conducted in a building where the sensing and measurement node is placed further apart from the receiving node, where the receiving node consists of a machine with Wi-Fi receiver and web server. The distance is to allow wireless communication to be tested using Wi-Fi. A short and long distance between the transmitter and receiver, interchangeably, have been tested.

3.3.2. Experimentation

During the experimentation, the water quality is tested based on four different parameters, which is turbidity, pH, temperature, and level of the water. If all parameters are within the safe quality range, the water quality is considered good and green light will light up for each parameter indicator.
Otherwise, if any one of the four parameters fall outside the safety quality range, the water quality is considered unsafe and red light will light up for the particular parameter indicator together with buzz sound from the buzzer. The examples of the testing output are shown in Figure 4.
We also tested the individual parameter by only activating the parameter being tested for validation and verification.

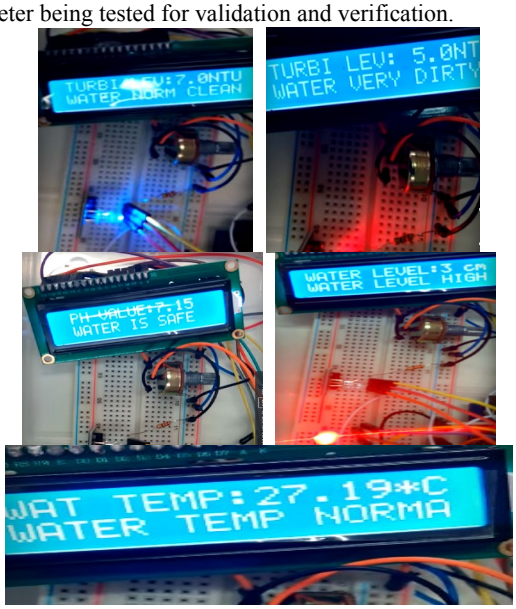


Fig. 4: Examples of output display from the LCD for each parameter, together with green lighting (indicating safe water quality) or red lighting and audible sound from a buzzer (indicating unsafe water quality).

For a remote monitoring by the user, the output is also available in a web-based system that displays the information of the water quality parameters in real-time. The example of it is shown in Figure 5.

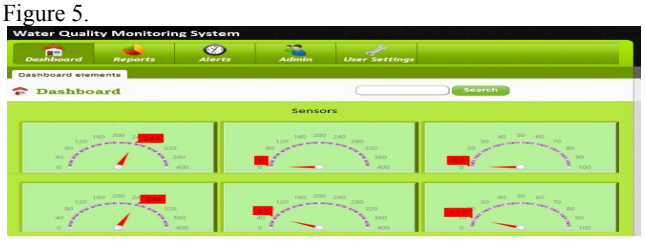


Fig. 5: Examples of the GUI of the online real-time water quality monitoring system.

4. Results and Discussion

This section elaborates the results from our experimental study which includes the water quality detection performance based on each water parameter and the performance of the wireless communication between the sensing and measurement node and the receiving node.

4.1. Performance by Parameters

The water quality is considered unsafe when any one of the parameters falls outside the safe range (as specified in Table 1). A total of 404 testing of different quality of the water for many combinations of each parameter with known true values have been used in the testing.

Figure 6 shows the Receiver Operating Characteristics (ROC) curves which representing the overall results on the performance of the system by parameters. As indicated in the figure, an average of 97% is achieved for all parameters.

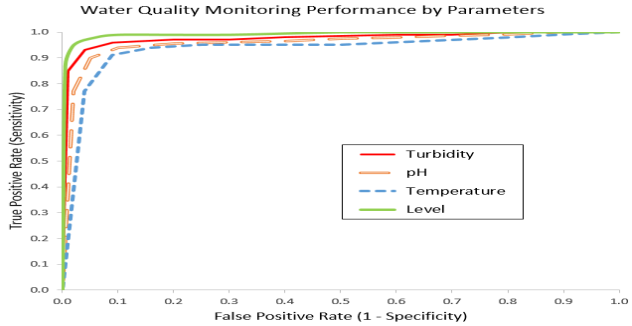


Fig. 6: The ROC curves representing the performance of the proposed water quality monitoring by parameters. the parameters are turbidity, pH, temperature, and level.

The level and turbidity detection shows very good performance with above 97% and the pH and temperature also perform well with at least 95%. The detection results correspond to the actual water quality which were premeasured.

4.2. Wireless Communication

The wireless communication between the sensors measurement node and the receiving node using Wi-Fi transmitter and receiver have been tested. The distance of the wireless communication varies from as short as 5 meters to as far as 100 meters.

As illustrated in Figure 7, the results obtained were 99.3% of success rate from 404 tests. This high percentage performance shows that Wi-Fi is a suitable medium to be used as the wireless communication to transmit data that has been collected by the sensors to the server.



Fig. 7: The result of the wireless communication testing shows that a very good percentage of 99.3% is achieved through Wi-Fi medium.

5. Conclusion

Turbidity, pH level, temperature and level of water are the important parameters in determining the quality of water. In this study, each of the parameter values has been measured by respective sensors and being processed. Wireless communication between the sensors and the receiving nodes with a long distance range was achieved. The water parameter values and corresponding message are demonstrated visibly on the liquid crystal display with caution sound is activated from the beeper when parameter is at a precarious state. The system is able to display the parameters in real-time from online web-based system.

This is a work in progress, where in later stages of the study, the system is planned to be implemented to detect and predict the water quality in remote rivers near the timber logging area.

Future work could include the design and implementation of a conductivity sensor and minerals sensor, as this is also an important quality monitoring parameter.

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