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Development of Geo-IoT Platform for Water Quality Monitoring

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1．Introduction

Water Quality Monitoring (WQM) is identified as a major discipline in the field of environmental monitoring. Numerous challenges in WQM have identified in recent scientific literature (Kamaruidzaman *et al.*, 2019). Conventional methods for WQM are time consuming and expensive task (Chen *et al.*, 2020). Proliferation of mobile phones and development of the Internet of Things (IoT) have increased ubiquity of data collection by integrating sensors and smartphones. Major development from this study is to develop a platform by integrating mobile phones and sensors which can measure the chemical parameters of water. The quality of water bodies such as rivers, ponds, and lakes can be evaluated by monitoring parameters such as pH, temperature, and Electrical Conductivity (EC), which are the most commonly used indicators to monitor water quality. These parameters are recoded along with the location information. The system consists of spatial data acquisition, analysis and sharing and by following OGC standards which enables spatial data proliferation.

2．Method and System Components

Open Data Kit (ODK, https://opendatakit.org/) that provides tools to facilitate collection and transmission of georeferenced data to a centralized server is used for data collection and aggregation. ODK consists of three modules; namely ODK Build, ODK Collect and ODK Aggregate. ODK collect is capable of recording GPS location, text, multi-media content such as image, video, audio and barcodes. External sensor recordings are inserted to ODK Collect using Sensor app (https://github.com/niroshansb/sensors_app) which is an Android mobile application developed by this study.

The system consists with sensor device which includes microcontroller, sensor signal converter modules and Bluetooth module. Components and the connectivity of devices are illustrated in Figure 1. Conventional glass electrode sensor has been used to measure pH (Stock Keeping Unit (SKU): SEN0161 from dfrobot.com). The pH sensor is capable of measuring values from 0 to 14 with ±0.1 (25 ℃) accuracy. The DS18B20 temperature sensor (SKU:DFR0198 from dfrobot.com) which provides 9 to 12-bit temperature readings with ±0.5℃ accuracy for −55 ~ 125℃ ranges over a 1-Wire communication bus is selected to measure the temperature. EC is measured using analog electrical conductivity meter (SKU:DFR0300 from dfrobot.com). EC k=1 sensor is selected due to its suitability in water culture, aquaculture for inland water bodies with the detection range of 0 to 2,000mS/m along with ±5% accuracy (DFRobot EC Sensor wiki, 2020). Recommended detection range for EC sensor is 100~1500 mS/m.

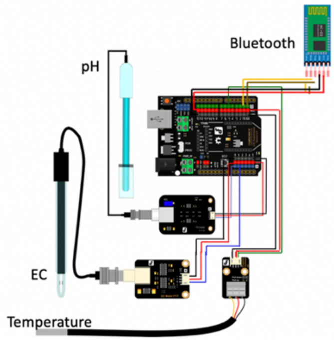

Figure 1: Schematic diagram of system components

Obtained sensor measurement values of physiochemical parameters of water and were first transferred via Bluetooth from sensor device to the mobile phone. Transferred data were inserted into the fields in ODK Collect form. The data is achieved in ODK Aggregate using the PostgreSQL database backend. A Web-GIS client was implemented for visualization of field data with the integration of GeoServer and OpenLayers JavaScript library. Furthermore, the collected data is published using OGC WFS standard. The workflow of the developed system is elaborated in Figure 2.

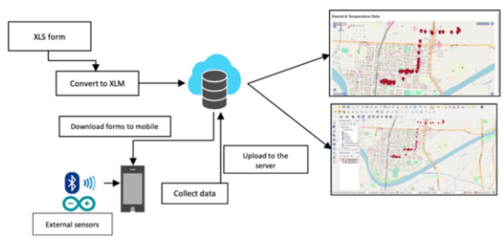

Figure 2: Data flow of developed system

3. Performance and Accuracy Assessment

Laboratory experiment was carried out to evaluate system performance and accuracy as shown in Figure 3. Ten water samples were collected randomly from ponds and Yamato river near Osaka City University. The sensors are calibrated as per the instructions given by the manufacturer. Values were recorded using ODK Collect app. Completed ODK Collect forms were uploaded to the server. Furthermore, same samples were measured using Horiba-D-74 water quality instrument. The measurements show high coefficient of determination (R^2) for both pH (0.99) and EC (0.89). The experiment reveals the suitability of the system for field data collection.

Figure 3: Experiment setups in the laboratory

4. Data Collection and Results

The system is deployed to measure physiochemical parameters of water in different locations along the Yamato river, as a field experiment. Total 20 samples were measured on the site from both the developed system and Horiba-D-74.

Locations and data collection method is shown in Figure 4. Samples were collected in a standard method for water sample collection. The correlation between pH, EC and temperature values obtained from Horiba-D-74 and developed system is illustrated in Figure 5. pH values are varying from 7 to 9 while EC has a significant variation. The temperature show consistent values for all 20 samples. Considerable changes and low R^2 (0.55) is noticed while measuring the EC with DFRobot sensor due to degradation of probe. Therefore, the EC sensor was replaced with Atlas Scientific EC probe (ENV-40-EC-K1.0 from atlas-scientific.com) which has ±2% accuracy for 0.5 to 20,000 mS/m measuring range and data were collected again from the same experiment sites. Data from Atlas EC probe consistent measurement and high R^2 (0.92) compared to Horiba-D-74.

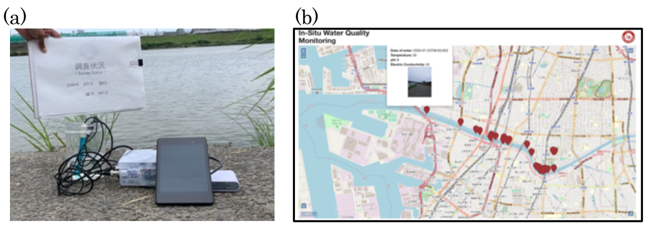

Figure 4: (a) Sample collections and measuring method
(b) Data collection points displayed on Web interface-GIS Client

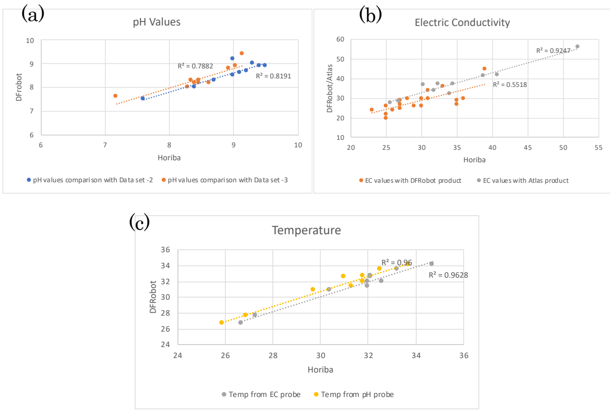

Figure 5: (a) pH values,
(b) Electric conductivity in mS/m, (c) Temperature in Celsius

5. Conclusion

This study was conducted to identify the user experience and limitations of the developed system when using for field data collection. Developed system has several advantages such as capability of visualizing readings on the interactive web interface based on different locations near real-time. It enables monitor and identify the changes from remote locations to the field. Moreover, sensors can be replaced or added easily to the system. Additionally, data can be recorded and sent on site. Similarly, data can be recorded offline as well. In such situation, data can be transmitted when the internet is available. More importantly, this system has the capability of changing and adding parameters in data collection from both human observation and external sensor input data simultaneously.

6. Future Development

This system allows the fast and automated data aggregation, sharing and visualization. Study identified that in-situ water quality monitoring is not adequate to investigate water quality changes. Therefore, the capability of the system will be extended by adding continuous water quality measuring devices. The data will be recorded in the same system from both in-situ and continuous monitoring.

Reference

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