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Real-Time Water Monitoring System for Fish Farmers Using Arduino

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ABSTRACT

In Malaysia, fish farmers mainly use the manual technique to monitor the quality of the water. Among the parameters monitored for determining the water quality is PH level, temperature and turbidity. These parameters are significant in making sure water is at the optimum level for fish farming. Using the manual technique is disadvantageous since it requires human intervention during the process of water sampling, testing and subsequently determining the water quality. The manual process may additionally affect the data integrity and lead to the possibility of inaccuracy in terms of the water analysis results. Besides that, it might be inefficient to manage all the water quality data by using the manual technique of water quality monitoring. Since the water being tested need to be taken to the lab for testing a delayed detection of contaminants. An even bigger impact of using the manual technique is the accumulation of operational costs dedicated to the water sampling and analysis process. Therefore, the Real-Time Water Monitoring System is proposed to alleviate these problems by utilizing the Internet of Things (IoT) technology to automate the water monitoring process. Digital sensors are used to measure the water PH level, temperature and also turbidity and these sensors are controlled using the Arduino board. The data collected from the sensors is wirelessly transmitted to a server and as such monitoring efficiency and data integrity is ensured. Fish farmers would be able to monitor the water quality in their fish farm ubiquitously via a mobile phone app. The system also recommends suitable measures to correct the water quality based on the current readings. It has been tested using functionality and data accuracy testing to ensure that the system operates accordingly.

Keywords:
Internet of Things, Water quality monitoring, fish farming

1. Introduction

This paper aims to investigate the potential of using the Internet of Things (IoT) technology in the field of agriculture, particularly fish farming. The sustainability of fish farms are affected by the complex physical and chemical factors as well as biological interactions that are directly dependent on the water quality. As such, an optimum level of quality for the water in fish farms is of utmost importance to be maintained.

Water sampling is the process of long-term monitoring of water quality by collecting a portion of water at the source and testing the sample for quality requirements. Water quality is of utmost importance in agriculture, and in particular fish farming. The water quality ensures fish health and performance of the fish being cultured. According to the fish species under culture, the water quality

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requirements will differ in terms of temperature, pH level, oxygen concentration, salinity, water turbidity, water hardness, etc [2].

The manual process of water sampling brings about many risks; leading to data loss during the process of capturing the sampling data. Additionally, human involvement in handling the data can occasionally affect the actual result of the water sampling. Firstly, manual water quality measurement involves storing the samples in a centralized location and subjecting the samples to laboratory analytical testing which would lead to delayed detection in contaminants, as highlighted by Thinagaran *et al*., [10], Vinod and Sushama [11]. Furthermore, important decisions which can be made when realtime water quality data is available. Secondly, Pappu *et al*., [6] emphasised on the water pollution monitoring technique which involves phases that are very expensive and time consuming. Finally, Pule, Yahya, and Chuma [8] discussed regarding one of the greatest challenges of water quality monitoring which is the necessity to gather a huge number of tests in order to guarantee exact and solid examination. This in effect poses a great complexity if using the manual way of sampling. Therefore, an automatic water sampling system is proposed to overcome the limitations of using the manual method.

The proposed automatic water sampling system uses the Internet of Things (IoT) technology involving the Arduino, which is a open source hardware and software platform and can integrate digital sensors for building intelligent objects that can be used to sense and control parameters for water sampling.

2. Literature Review

Aquaculture also known as aquafarming is the cultivation of fish or any other aquatic life where it involves raising fish commercially in tanks or enclosures. In order to achieve success in aquafarming, the fish farmers need maintain the quality of their product and also properly manage the water quality in the tanks or enclosures. The monitoring of several variables from physical and chemical such as oxygen, temperature and pH in water are essential to maintain adequate conditions and avoid unpleasant situations that may lead to the collapse of aquaculture systems. Also, continuous observation of the physical, chemical and biological parameters in tanks or enclosure could encourage prediction of negative condition and can be utilized to evade from the deterioration of the aquaculture environment [2].

2.1 Sensors

The sensors that are being used in this proposed system are used to collect data about the water temperature, pH level and turbidity level. Water temperature is a key water quality variable since it impacts all other water quality factors and aquatic creatures. The temperature of the water influences the behavior, growth, activity, feeding and reproduction of the fishes [1]. Each aquatic organism depends on particular temperature ranges for their health and many of this aquatic organisms utilize temperature as a flag about when to reproduce and when to migrate. If any abnormal temperature is detected inside the water, the balance of the aquatic ecosystem may be interrupted with disastrous impact. The water temperature sensor being used in this proposed system is the DS18B20. This is a pre-wired and waterproofed version and it is really suitable when the material being measured is in wet conditions. This sensor is good up to 125°C as the cable is jacketed with PVC and it is recommended to keep it under 100°C. This device could fit with any microcontroller by using a single digital pin and can even connect multiple ones with the same pin and can differentiate with each one has unique 64-bit ID that already burned in at the factory. Water temperature monitoring program is coded and implemented using Python than runs in Arduino as the core controller that is used to send real-time water temperature read from the sensors to the server. Temperature sensor is converted into amount of physical change in resistance that is accomplished through linear circuit and compensation circuit output voltage in order to eliminate common mode noise [12].

Water pH is a measure of level of acidity or alkaline of a solution. This procedure is considered an important parameter which is required to be constantly monitored and confirmed on the grounds that the water responses influences a large number of factors and furthermore the speed of many biological and chemical processes [3]. The pH scale is used to measure which ion among the two has greater concentration where pH of 7.0 means the concentrations of two ion groups are equal and it is considered as neutral while pH less than 7.0 means the concentration of hydrogen ions is more than of hydroxyl ions and it is considered as acidic. The sensor used to measure the pH level is SEN0169 that is specially designed for Arduino controllers. It uses an industry electrode and has built-in simple, convenient, practical connection and long life, also very suitable for online monitoring purpose. It also has an LED which act as Power Indicator, a BNC connector and PH2.0 sensor interface. This industry pH combination electrode is made of sensitive glass membrane with low impedance and it can be used with fast response and good thermal stability. This device is really suitable for long-term monitoring.

Water turbidity means the measure of the transparency of water. Reduced turbidity is related to the presence of suspended sediments. In aquaculture, the increment of turbidity in the water can cause problems in the fish and the impact of turbidity on fish is complex [7]. Turbidity is originated from living organisms such as algae and zooplankton that is known as bacteria and also from non-living things such as clay or mud. The lower the turbidity reading the cloudier the water. A certain amount of turbidity is considered as required in dams and ponds because in very clear water, some fish tend to hide in the daylight and without the certain amount of turbidity, it could increase the risk predation from birds. However, too high reading of turbidity can likewise cause problems. So it is indeed important to have a suitable amount of turbidity which are not too much and not too little. It is needed to continuously monitor the reading of water turbidity to prevent any problems to the fish farmer. In a study by Lambrou, Anastasiou, Panayiotou, Polycarpou [4], they have developed a low cost, easy to use and accurate turbidity sensor for continuous in-pipe turbidity monitoring. The type of sensor that has been used or implemented is SEN0189. This sensor is an electronic monitoring module that is specially invented to combine with microcontroller platforms such as Arduino and Raspberry Pi. The turbidity sensor uses light to identify suspended particles in the water by measuring light transmittance and scattering rate. From this measurement, it will change the amount of total suspended solids (TSS) in water. The relationship between TTS and turbidity level can be concluded as directly proportional where the increase in TTS will result in the increase of the liquid turbidity level.

Besides water temperature, pH level and turbidity some other parameters may be measured as discussed by a number of literature related in this field. Solpico *et al.*, [9] discusses the measuring of dissolved oxygen concentration in the water as a method for managing water quality in the Philippine lakes.

3. Research Methodology
3.1 System Design

The sensor data that needs to be captured in illustrated in the Entity Relationship Diagram (ERD) below. It relates the water temperature, pH level and turbidity to the cloud database using Thingspeak, an open-source API.

Fig. 1. Entity Relationship Diagram

The sensors will be connected via Arduino Uno it will send all of the collected data to Thingspeak as the cloud database. The system application will retrieve the data from Thingspeak and be displayed according to the function that will be provided through the application. Using a cloud database such as Thingspeak enables the system to promptly collect real time data from the sensors. The physical design of the Real Time Water Monitoring System is displayed in Fig. 2.

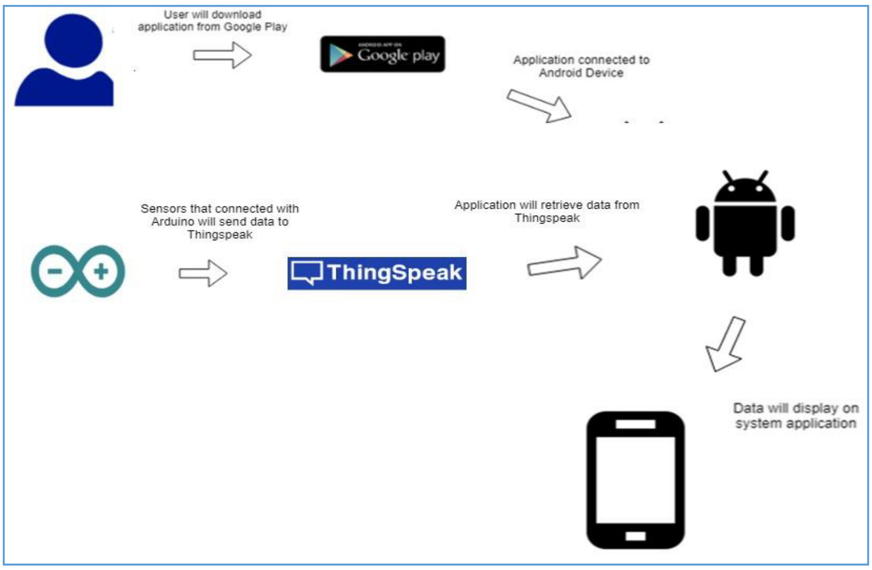

Fig. 2. Physical Design Diagram

4. Findings

The Real Time Water Monitoring system is using the Android platform. A user will be able to download the application and once successful installation is done, the user will be able to monitor real time readings of the sensor. Figure 3 displays the home interface of the application.

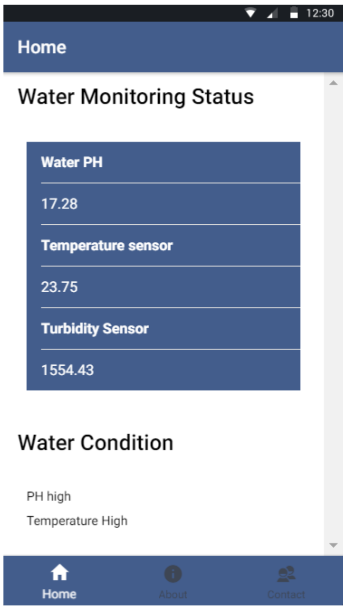

Fig. 3. Home Interface

Figure 3 shows the reading of the water temperature, pH level and turbidity taken on real time from the sensors. The application would be able to alert and categorize the water condition based on the specific requirements set by the user. Also, recommendation would be displayed based on the water quality. This conclusion on the condition of the water could help the user to maintain the quality of the water according to the specific requirements.

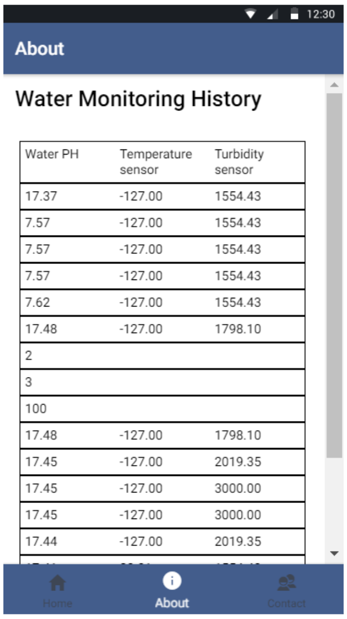

Fig. 4. Water Monitoring History

Fig 4 displays the water monitoring history where users will be able to view the records of water quality reading from the sensors. In this manner, the user would be able to make knowledgeable decisions based on the history of the water conditions. Any data being read from the sensors would be synchronized with the cloud database and will be immediately updated to the history.

By using the Thingspeak API, a more meaningful way of displaying the sensor data is also available for users. Thingspeak enables the sensor logging applications and a social network of things for status updates.

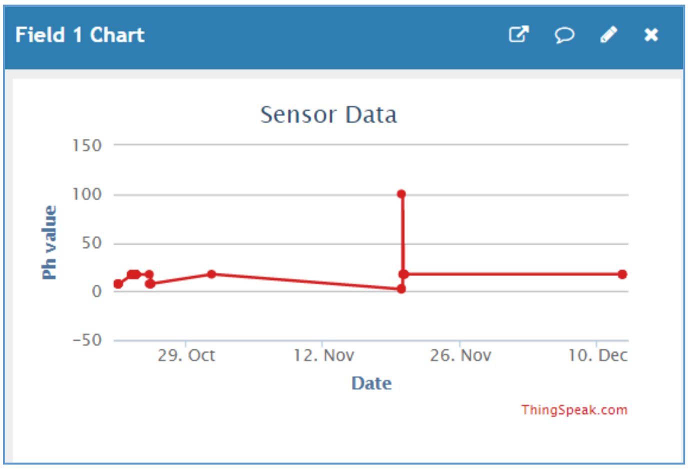

Fig. 5. Thingspeak Data View

Fig 5 displays the Thingspeak Data View for the pH level sensor in a graphical manner. It shows the exact date during the data upload process along with a timestamp and the value of the sensor readings.

4.1 Accuracy Testing

The sensors were tested to read a number of parameters to test their accuracy. Tables 1,2 and 3 displays the results for sensor testing to read all the available conditions of the water which are relevant to the application.

Table 1
pH Data Reading

pH	Success	Failure
Acidic	√	
Alkaline	√	
Neutral	√	

Table 2
Temperature Data Reading

Water Temperature	Success	Failure
Hot	√	
Cold	√	
Normal	√	

Table 3
Turbidity Data Reading

Water Turbidity	Success	Failure
Clear	√	
Muddy	√	

4.2 Real Time Sampling

In this testing, the sensors are tested to show the real time change in sensor readings when there is immediate change in the condition of the water. This testing was done with the use of acidic water and hot water where in the result the changes of the data in certain time is displayed. With this kind of testing, we can see the flow changes from data for example from high pH value will increase from low value to high value if add on with acidic thing on the water. It is same also for water temperature where it can see the changes of water temperature from hot to cold due to the proportional with time. The time that is used to execute in this testing is for 30 minutes. Fig 6 displays the change of data reading when the water condition is changed. In the figure, when an acidic agent is added to the water the sensor data changed from 7 to 4. It also occurred with the temperature value where it show the data value changes from 66 degree celcius drop to 28 degree celcius within 30 min.

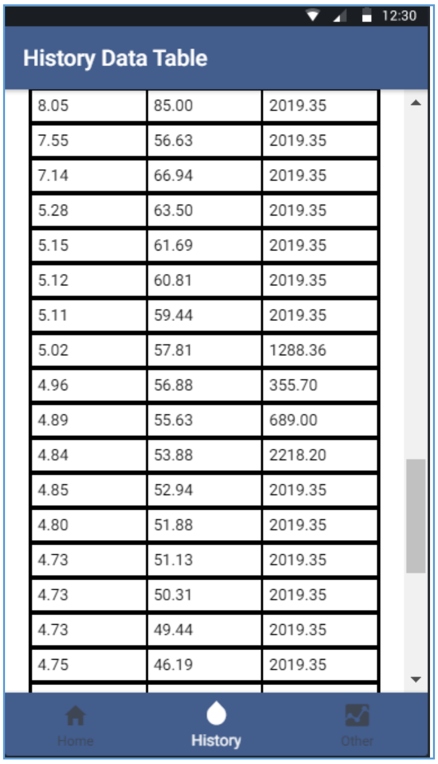

Fig. 6. Real Time Sensor Reading

5. Conclusion

This project is developed to propose a digital method of monitory the water quality in aquaculture environments instead of using the manual method which is costly, prone to errors as well as taking a longer time. Three digital sensors were used to illustrate the speed and accuracy at which the sensor data could be read. The sensors were integrated using the microcontroller Arduino Uno which is a simple and cheap device to integrate digital sensors and make the data immediately available to the users. By using the cloud database via Thingspeak API, the data being read from the sensors were digitally stored in real time, enabling the users to keep a record of the readings and by using the application that has been developed, the data was manipulated to be more user friendly and displayed in a graphical manner as well as in a historical view. In conclusion, the usage of the IoT technology to simplify and make more accurate the aquaculture industry is an attractive exploration to gather more accurate, real time data at a much cheaper cost.

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