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Water Quality Monitoring System for Fisheries using Internet of Things (IoT)

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Abstract. Fish production has significant impacts on the investment and operating costs of the modernization of fish ponds. Water quality monitoring system may help to overcome all the problems by using the implementation of the internet of things (IoT) technology. The project aims in detecting the presence of fishes using an ultrasonic sensor and investigating the parameters of pH and temperature sensors. The system is used pH and temperature sensor as the factors affecting the quality of water and fish growth, the ultrasonic sensor for detecting the presence of fishes, Blynk application through a smartphone for notifications, NodeMCU ESP8266 as its central controller and wireless fidelity (Wi-Fi) as the communication technology. A sample of three different measurement times in the early morning, midday, and evening based on temperature, pH levels and the fish distance show that this farm has high-quality water. From the measurement at the field test, temperature value increase in the midday, pH level remains constant in the three different times and the fish distance underwater always changes as a fish needs to find oxygen and a portion of food. As a result, a farmer need not hire workers at their site, consequently, drive down operating costs and improve efficiency.

1. Introduction

Fisheries aquaculture remains an important source of food, nutrition, income and livelihoods for hundreds of millions of people around the world. According to The State of World Fisheries and Aquaculture 2018 [1], the world fish supply in 2016 reached 171million tons, of which 88 percent was utilized for direct human consumption, thanks to relatively stable capture fisheries production, reduced wastage and continued aquaculture growth. Fisheries are one of the key Sustainable Development Goal SDG 14 which is to conserve oceans, seas and marine resources while supporting those ecosystem services that are of crucial importance for humans. More sustainable use of resources, changes in production patterns and improved management of human activities will help to reduce negative impacts on the environment and allow the benefit of aquatic ecosystems for present and future generations. However, efforts need to be made to ensure that as the population in the country grows and demand for food and employment likewise grows, the benefits that fishery resources provide are protected through sustainable management and value addition. All fish depends entirely on the water to live, eat, grow and perform other body functions, regardless of the type of water available or the species were chosen. Therefore, it is no surprise that a fish farming establishment's success is largely due to the quality of its water. Temperature and pH are some of the most important parameters in aquaculture [2]. The fisheries management relies totally on water quality monitoring.

Water is a special kind of environmental resource which is a fundamental basis to sustain the ecosystem on earth. Water as an ecosystem not only supports human life and behaviors but also helps preserve the ecological structure, ecological processes and regional environment [3]. Water is not a



renewable source, but it needs to be reused. With the rapid development of the economy, more and more serious problems of the environment arise, water pollution is one of these problems. Recently, an illegal tyre recycling factory had allegedly dumped chemical waste in Sungai Kim Kim in Pasir Gudang Johor on the 6th March 2019 due to this effect many lives get into danger [4]. It contaminates the whole water in the lake. So, it affects thousands of fishes. Routinely monitored parameters of water quality are temperature, pH, and turbidity. It is important to collect this water quality measurement because these factors might affect water quality including pollution, wind, weather and rain runoff may affect fish health [5]. Because of continuous monitoring, the parameters help to reduce the problems arrived in the future. In order to improve the lifestyle which makes it easy and effortless, they need to implement this modern technology which is the Internet of Things (IoT) in every field.

The internet of Things (IoT) is a revolutionary new concept that has the potential to turn virtually anything "smart". IoT is a network of physical objects. The goal of the IoT is to enable things to be connected anytime, anyplace, with anything and anyone ideally using any path or network and any services [6]. IoT is much more than machine-to-machine communication, wireless sensor networks, WI-FI, GPS, microcontroller and microprocessor. IoT is not a single technology, but it is a mixture of different hardware and software technology used to store, retrieve, and process data and communications technology which includes electronic systems. It allows controlling or monitoring any objects remotely, from any part of the world through the existing network. However, the fact remains that there are many challenges and issues related to the use of IoT, this brings advantages and disadvantages to the internet of things (IoT).

In this advanced technology, some projects of remote monitoring and sensing system to improve the quality of water and increase fish farm production. One of the projects that use to detect fishes and the presence of an object underwater by using a waterproof ultrasonic sensor JSN-SR04T. This project uses Arduino as the central performance control system by an additional HC-05 Bluetooth Shield that enables Arduino to communicate with Android smartphones [7, 8]. To monitor water characteristics that influence fish production by using remote monitoring via wireless communication technologies like cellular, LoRaWAN, Wi-Fi or Satellite communication. One of the projects is an automated IoT system for automated fish farming where they monitor the water temperature, pH and water level, using Wi-Fi remote connection [9]. The project developed real-time fish pond monitoring and automation where they measure the water, temperature, pH and DO levels integrated with aerating and water supply pumps using Arduino [10]. Another project developed a control and monitoring system where they monitor the pH, Dissolved Oxygen, Temperature and Salinity parameters using PiLeven microcontroller to communicate with sensors and utilize Raspberry Pi microprocessor as a computer interface [11].

There is also a project designed ZigBee-based Wireless Sensor Network system and the Internet of Thing (IoT) [12] - [15]. Sensing data is transmitted through the ZigBee network, stored in a cloud-based database and the LabVIEW is used for the graphical user interface. This system is a low cost, low power consumption, scalable, versatile, distributed, mobile and accurate. Then, another project proposed a smart water quality monitoring system using a GSM network to transfer sensing data to a cloud server by sending SMS messages to the end-user as a notification [16] – [18]. The disadvantage of this proposed GSM system is the process of notification to the end-user after specific time intervals or after a certain parameter value is reached, and not in real-time.

To overcome this in one sense of real-time monitoring, the project in [19] proposed a system with moving cameras, which constantly monitors the fish farming pond based on Deformable Multiple Kernels. Another project is the proposed technology LoRa-based wireless sensor network and a lightweight Message Queuing Telemetry Transport (MQTT) protocol for exchanging messages between small, embedded devices, mobile devices, and sensors [20]. LoRaWAN can be used to cover large areas, and especially satellite communication where can reach areas that are typically not covered by mobile-cellular networks.

The objectives of this project are to monitor and detect the presence of fishes using an ultrasonic sensor and NodeMCU ESP8266 microcontroller. This system is to automate the monitoring and maintenance of a fish farming pond in remote locations by using remote monitoring via wireless

communication technologies. This project also highlights investigating the parameters of pH and water temperature value towards water quality systems. This smart system aims to the reduction of the environmental stress that affects the fish population in the fish farming pond. From this project, the user got notification from the user email when the sensor was inserted into the water and at the same time turn on the Wi-Fi connection.

2. Methodology

2.1. Study Area

Freshwater fish pond in Malaysia has the largest total numbers of anglers and it has been in the angling industry for years. Fish pond in Section 24 Shah Alam is one of the best places to fishing. The field test was conducted in fish pond Section 24 Shah Alam, Selangor which is located on the west coast of Peninsular Malaysia with the latitude at 3°2'10.5864"N and longitude at 101°31'17.04"E. The field test was performed for this project in an outdoor fish pond which is a real-world environment to validate the usability of the platform when given commands via a smartphone application.

The fish pond shown in figure 1 has an area of 6070.3 m² and a depth of 4.0 m (typical water level). The pond produces Mekong, Amazon Catfish, Tiger Catfish, Red Tails Catfish, Pacu, Toman, Patin Albino, Patin Choaphraya, Tongsan, Big Head Carp and Rohu. The fish pond also using a pump to continuously give oxygen to the fishes.



Figure 1. Field Test at Fish Pond Section 24 Shah Alam

2.2. Framework

Figure 2 shows the framework of the system. The framework is divided into two major parts includes the software and hardware design. The software has two developments for the program the progress networking which is database and IoT. Database from Blynk application was used for monitoring fisheries and water quality system and get the notification from user email. Arduino IDE was used for IoT coding to interact with Wi-Fi connection and the mobile application. The hardware used is the microcontroller NodeMCU ESP8266, sensors of temperature, pH and ultrasonic as an input, and actuators of LEDs, LCD, and buzzer as an output of the program.

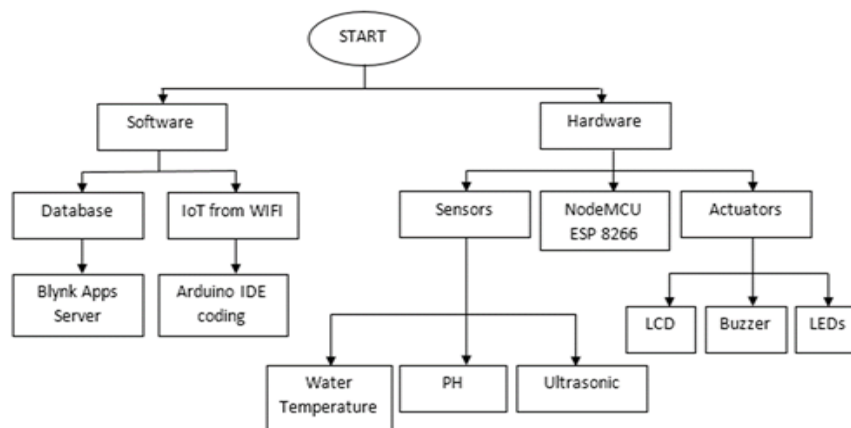


Figure 2. Frameworks of The System

2.3. Project Overview Concept

Figure 3 shows the project overview of the system. The sensors will interface with the microcontroller NodeMCU ESP8266 that acts as an open-source IoT platform, it will send the data to the cloud storage which is the Blynk server that has been developed to store the data information. Arduino IDE is a programming language that supports a library for Blynk that can connect any hardware over Wi-Fi. Blynk application is a platform with IOS and Android apps to control NodeMCU ESP8266 through its inbuilt Wi-Fi shield. It can display the digitalized information data from the sensor and convert the data from CSV files to Excel format and store it in a database.

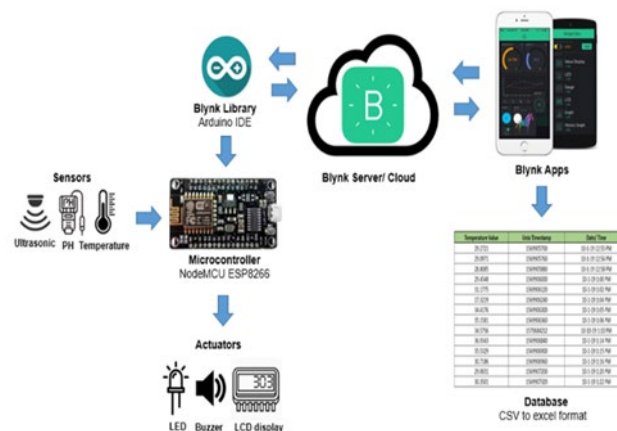


Figure 3. Project Overview of The System

2.4. Flowchart of Overall System

Figure 4 shows the flowchart of the system. The flowchart starts by having three sensors (ultrasonic, pH and temperature) detecting the presence of fishes, measuring the hydrogen ion concentration of water and detecting the current temperature of water respectively. The ultrasonic sensor will detect the presence of fishes that move underwater. The range for detecting the fishes is between 0 to 400 cm based on the depth of the fish pond at Section 24, Shah Alam which is 4.0 m. The distance will be display on the LCD. If the distance is out of the range the buzzer will turn on and display "Out of range!" on the LCD. The pH sensor measures the acidity or alkalinity of water. The optimal pH range for fishes is 6.5 to 8.5. The temperature sensor measures the temperature of the water and indicates each stage of temperature level by different colors of LEDs. If the water temperature is below 29 °C, the yellow LED will light up. If the water temperature is between 29 °C to 35 °C, the green LED will light up. This value shows that the normal temperature for fishes to grow. If the water temperature is above 35 °C, the red

LED will light up. Then, all the sensors will be sent and display the data on the Blynk application through a smartphone by using a Wi-Fi connection.

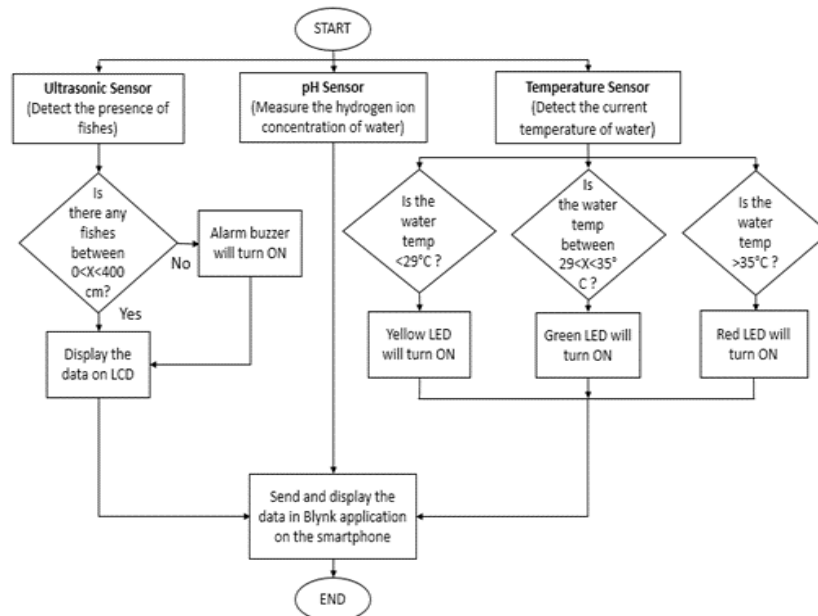


Figure 4. Flowchart of Overall System

2.5. Circuit Design of the System

Figure 5 shows the circuit diagram of the system. The components such as the temperature sensor, ultrasonic sensor, pH sensor, buzzer, 3 different light-emitting diodes (LED), a resistor of 100 ohms and the liquid crystal display (LCD) are connected to the different pins on the NodeMCU board.

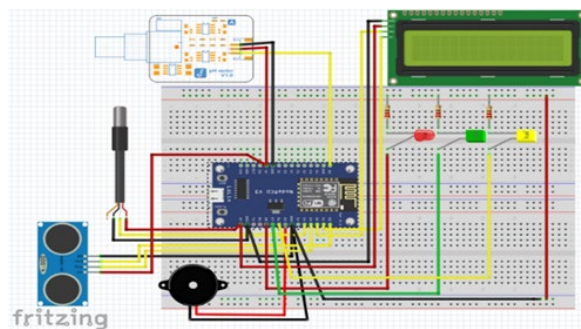


Figure 5. Circuit Design of The System

2.6. Hardware Development

2.6.1. NodeMCU ESP8266. Figure 6 shows the NodeMCU which is a development board featuring the popular ESP8266 Wi-Fi chip. As it turns out, it can program the ESP8266 just like any other microcontroller. Its obvious advantage over the Arduino or PIC is that it can readily connect to the Internet via Wi-Fi. The NodeMCU solves this problem by featuring 10 GPIO pins each capable of using PWM, I2C and 1-wire interface [21].

2.6.2. Ultrasonic sensor (JSN SR04T). Figure 7 shows JSN-SR04T ultrasonic sensor distance measurement module that can provide a 20 cm to 600 cm non-contact distance sensing function and

ranging accuracy up to 2 mm. This waterproof ultrasonic sensor for locating fishes. The distance range for detecting underwater fish was set from 0 cm to 400 cm based on the depth of the fish pond.

2.6.3. Analog pH sensor (SKU: SEN0161). Figure 8 shows the pH sensor that is to measure water whether is acidic or alkalinity. The pH scale is a logarithmic scale whose range is from 0 – 14 with a neutral point being 7. The value above 7 indicates an alkaline solution and values below 7 would indicate an acidic solution. It operates on a 5V power supply and it is easy to interface with NodeMCU. The optimal pH range for fishes is 6.5 to 8.5. Low and high pH level harms fish especially the young fish in immature stages because they are extremely sensitive to pH levels. The young fish may die when the pH level is below 4 and above 9.

2.6.4. Temperature sensor (DS18B20). Figure 9 shows the temperature sensor, DS18B20. It is a waterproof sensor which detects the temperature of its surrounding. Most of the functions in this development are sensing variables in water, thus the DS18B20 being waterproof helps in detecting the temperature of water without being damaged. It can measure extreme temperature from -55 °C to 125 °C with very good accuracy. The normal range temperature for fishes is 29 °C to 35 °C.



Figure 6. NodeMCU microcontroller **Figure 7.** Ultrasonic sensor



Figure 8. pH sensor

Figure 9. Temperature sensor

2.7. Software Implementation

2.7.1. Arduino IDE. Figure 10 is an Arduino IDE software which is an open-source software used to implement hardware and software. It is used to write and upload programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards. This software allows interference between nodeMCU and the sensors. The language used for this software is C++. The codes were programmed by using Arduino software.

2.7.2. Blynk application. Figure 11 shows the Blynk application. Blynk application is used to connect data in the microcontroller to the smartphone. For this project, the Blynk application connected with nodeMCU to the cloud using a Wi-Fi connection. It displays the data and the graph on the smartphone.

2.7.3. Fritzing. Figure 12 is Fritzing software. Fritzing is used to design the circuit beforehand and is used for simulation before transferring it onto hardware.

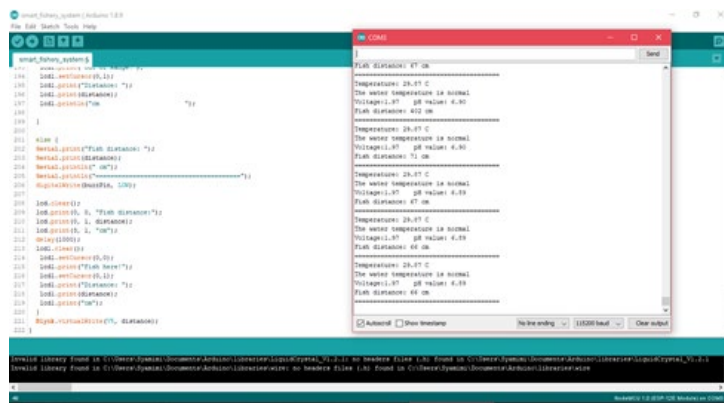


Figure 10. Arduino IDE software



Figure 11. Blynk application

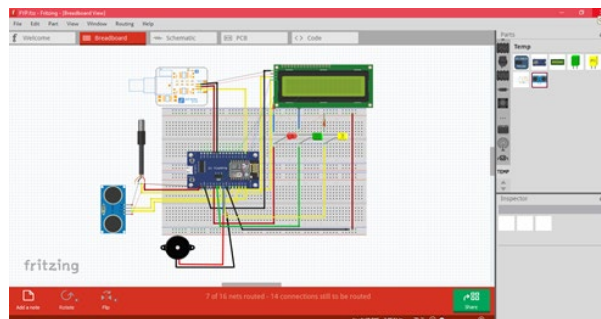


Figure 12. Fritzing software

3. Result and Discussion

The smart fishery and water quality monitoring system using Blynk application to be monitored and linked to one another via Wi-Fi using NodeMCU ESP8266 microcontroller. The measured data were displays through the Blynk application and the result is recorded in the database through a CSV file. The implementation of the project and the prototype are discussed below.

3.1. Hardware Implementation

Figure 13 shows the implementation of the project prototype after testing and troubleshooting. It is equipped with an ultrasonic sensor, temperature sensor and pH sensor as the input. The ultrasonic sensors detect the fishes underwater and at the same time, the temperature and pH sensor measure the water quality that will affect the growth of fishes. The data from monitoring will be sent to user email through a smartphone. The cost is low to build this prototype and easy to bring anywhere.

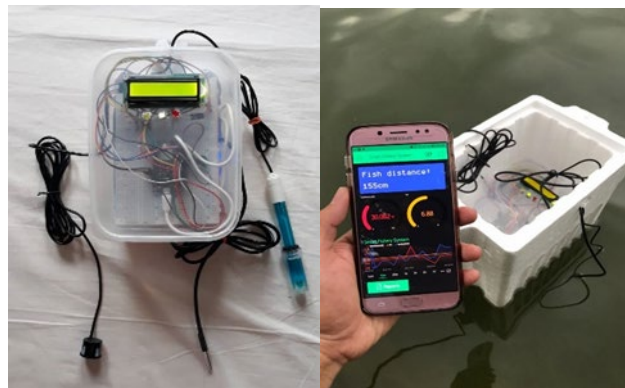


Figure 13. Setting up the hardware and the prototype in the field test at fish pond Section 24, Shah Alam

3.2. Software Implementation

In the software implementation, the data monitoring will be display in two sections which are in the serial monitor on the computer and the Blynk application on the smartphone. Figure 14 shows the data that will display in the serial monitor is the distance of fish, the temperature value and the pH value. If the water temperature is between 29 °C to 35 °C, "The water temperature is normal" will be displayed. If the water temperature is below 29 °C, the serial monitor will notify the user "Warning! The temperature is below 29". If the water temperature is above 35 °C, the serial monitor will notify the user "Warning! The temperature is above 35".

Figure 15 shows the design interfaces for the project using the widgets provided. The widget that is used is LCD that displays the distance of fish, two gauges that display temperature and pH value and a super chart that displays the graph of temperature, pH and ultrasonic. After getting the connection to the cloud using Wi-Fi, the LCD on the Blynk apps will display "Fishery and Water Quality System" in 5 seconds then the display the data monitoring from each sensor. The LCD will display "Out of Range" if the distance is above 400 cm based on the depth of the fish pond.

```

COM3
Fish distance: 195 cm
-----
Temperature: 29.87 C
The water temperature is normal
Voltage:1.97    pH value: 6.89
Fish distance: 71 cm
-----
Temperature: 29.87 C
The water temperature is normal
Voltage:1.97    pH value: 6.89
Fish distance: 30 cm
-----
Temperature: 29.87 C
The water temperature is normal
Voltage:1.97    pH value: 6.89
Fish distance: 68 cm

```

Figure 14. The data monitoring will be display in the serial monitor in the computer

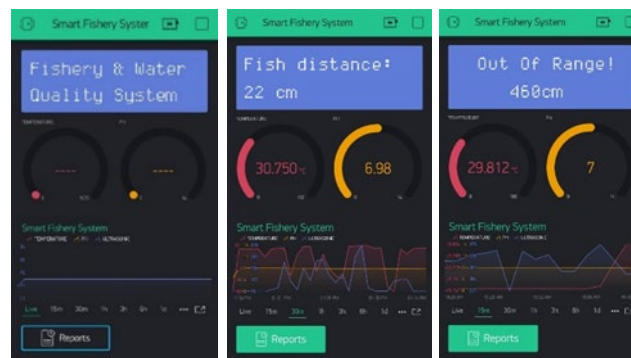


Figure 15. Data monitoring will be display on the smartphone.

3.3. Database

Sample measurements are collected throughout the day at three different times in the morning, noon, and evening for water temperature, pH levels and the fish distance show that this fish pond has high-quality water. From the measurement at the field, temperature value increase in the noon as the sun hits directly to penetrate the water's surface. PH level may rise from a morning value of 6.5 to an afternoon peak of 7 due to photosynthesis which removes carbon dioxide from the water and in the evening, respiration releases carbon dioxide and pH falls continually until daybreak. This condition is normal for the growth and health of fishes. The fish distance underwater always changes as a fish needs to find oxygen and food. As a result, a farmer need not hire a worker at their site, consequently, drive down operating costs and improve efficiency. The database is used to store the data tracked by the history graph. The data which is in a form of a CSV file will be converted into Excel format. All the information is needed to monitor for future improvement of the system.

3.3.1. Early Morning Measurement. Figure 16 shows data and the graph of three sensors in the Blynk application. From this graph, the value of temperature is constant at 29 °C at 10:30 am, the pH value remains constant with 6.9 and the highest distance of fish from prototype implementation and the depth of the fish pond is 370 cm and the lowest distance of fish is 80 cm.

Table 1 shows the list of the data value from the history graph in Blynk application for temperature, pH and fish distance value on 21/11/2019. In the early morning, the measurement value of temperature water is 29°C. The water in the early morning is cold and does not heat up because the sun is low and does not hit the water surface. The pH value remains constant from 6.5 to 6.9. During the day, underwater photosynthesis usually exceeds respiration, so pH rises as carbon dioxide is extracted from the water. The fish become lethargic and tend to be inactive in cold water so that fish swim more in shallow water for meals.

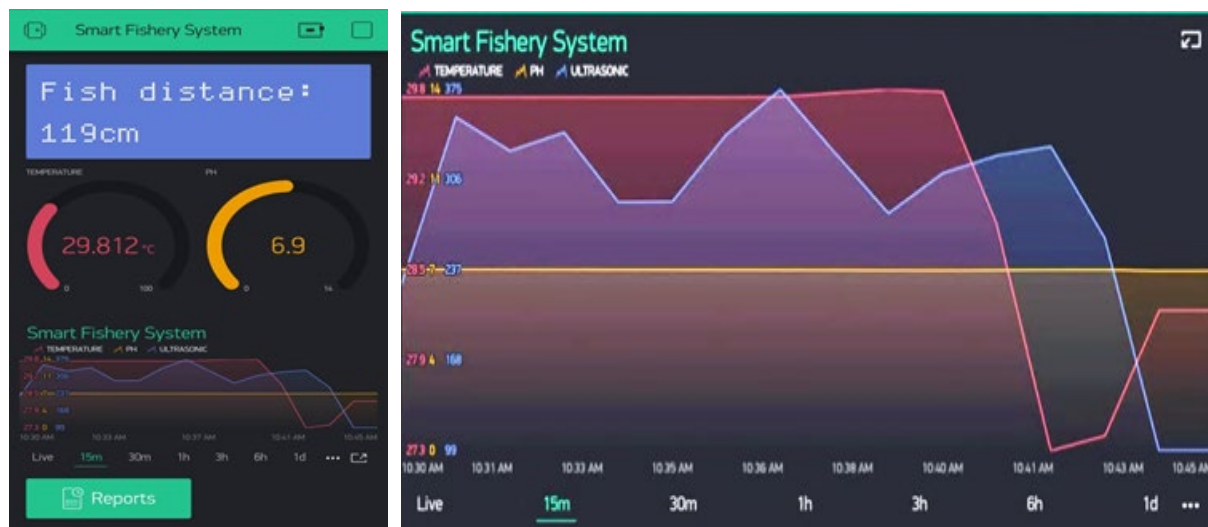


Figure 16. Data displayed and graph of temperature, pH and ultrasonic sensor in Blynk application in early morning

Table 1: The graph in Blynk application for temperature, pH and fish distance value in the early morning on 21/11/2019.

Time	Temp Value (°C)	pH Value	Distance Value (cm)
10:00 AM	29	6.5426	27.0869
10:05 AM	29.1713	6.8037	33.3478
10:10 AM	29.6825	6.8422	29.7826
10:15 AM	29.812	6.9	119.3441
10:20 AM	29.7113	6.8301	234.7826
10:25 AM	29.7284	6.8312	168.2608
10:30 AM	29	6.8677	369.6521
10:35 AM	29.75	6.8392	283.4782
10:40 AM	29.75	6.8337	304.6086
10:45 AM	29.75	6.8332	80.9545

3.3.2. Mid-day measurement. Figure 17 shows the graph of three sensors in the Blynk application. From this graph, the highest value of temperature is 35 °C and the lowest value of temperature is 29 °C the pH value remains constant with 7 and the highest distance of fish from prototype implementation and the depth of the fish pond is 390 cm and the lowest distance of fish is 22 cm.

Table 2 shows the list of the data value from the history graph in Blynk application for temperature, pH and fish distance value on 1/10/2019. During mid-day, the measurement value of temperature water has increased from 29 °C to 35.5 °C. The water at noon is hot than in the early morning because the sun hits directly the surface of the water. When the sun in the peak hour, plants resume photosynthesis and remove carbon dioxide from water, causing pH to rise again. The pH value has increased to 7. The movement of fish increases as the metabolism of fish accelerates, feeding and respiration increases in warm water so that fish swim more on the surface of the water.

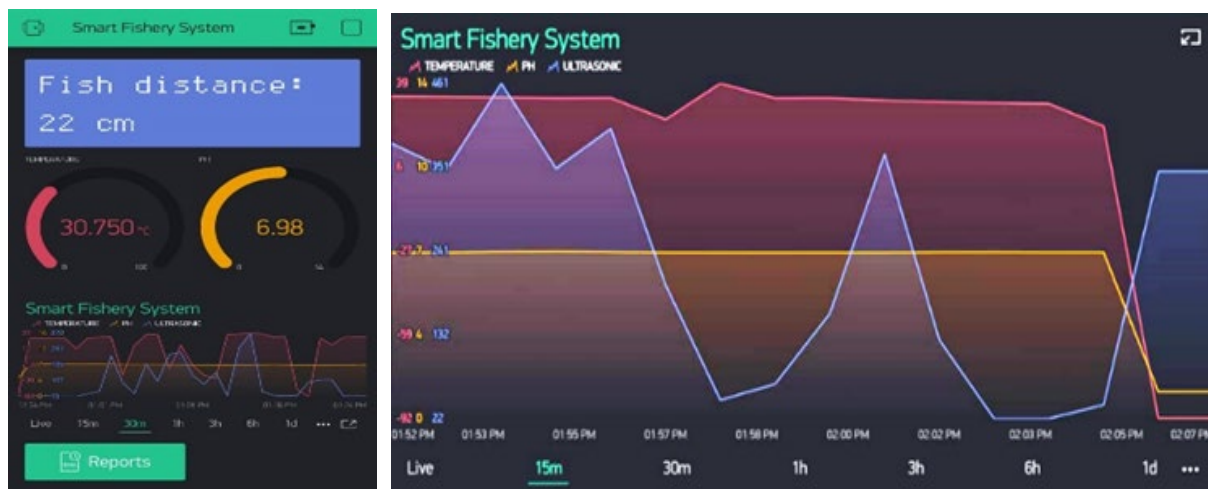


Figure 17. Data displayed and graph of temperature, pH and ultrasonic sensor in Blynk application during mid-day

Table 2: The graph in Blynk application for temperature, pH and fish distance value during mid-day on 1/10/2019.

Time	Temp Value (°C)	pH Value	Distance Value (cm)
12:55 PM	29.2721	6.9717	22.1053
1:00 PM	29.4548	7.1173	34.4444
1:05 PM	34.4176	7.0660	201.2105
1:10 PM	34.5756	6.9725	86.7500
1:15 PM	35.5329	7.0107	47.1579
1:20 PM	29.0031	6.9625	110.1579
1:25 PM	30.6880	7.0235	116.2778
1:30 PM	30.750	6.98	22
1:35 PM	29.4341	6.9568	147.1053
1:40 PM	32.6809	6.9536	45.5714
1:45 PM	34.8882	6.9768	90.2105
1:50 PM	34.2795	6.9340	333.4737
1:55 PM	33.0936	6.9907	390.5263
2:00 PM	33.1560	6.9332	110.3684
2:05 PM	30.1095	6.9470	39.7692

3.3.3. Evening measurement. Figure 18 shows the graph of three sensors in the Blynk application. From this graph, the value of temperature is constant at 30 °C, the pH value remains constant with 6.9 and the highest distance of fish from prototype implementation and the depth of the fish pond is 375 cm and the lowest distance of fish is 126 cm.

Table 3 shows the list of the data value from the history graph in Blynk application for temperature, pH and fish distance value on 20/11/2019. In the evening, the measurement value of temperature water is between 27 °C to 30 °C. The fish pond in the evening during rainy days makes the water became cold. The pH value remains constant from 6.9 to 7. As the sun begins to set in the late evening, photosynthesis decreases and eventually stops, so pH falls throughout the night as respiring organisms add carbon dioxide to the water. The distance of fish always changes as a fish needs to find oxygen and food underwater.



Figure 18. Data displayed and graph of temperature, pH and ultrasonic sensor in Blynk application at noon.

Table 3: The graph in Blynk application for temperature, pH and fish distance value in the evening on 20/11/2019.

Time	Temp Value (°C)	pH Value	Distance Value (cm)
5:25 PM	27.1795	6.9388	268
5:30 PM	30.188	7.0571	290.5909
5:35 PM	30.0626	6.9321	126.3913
5:40 PM	30.1414	6.9161	275.5652
5:45 PM	27.5463	6.9263	259.7391
5:50 PM	30.0849	6.8841	323
5:55 PM	30.062	6.9	248
6:00 PM	30	6.8953	375

4. Conclusion

In this project smart fisheries and water quality monitoring system using IoT in the pond, the objective will focus on the criteria of quality of water and detect the presence of fish was achieved. In this system, it will conclude that earlier prevention of water pollution can help to reduce the amount of fish dead. Monitoring systems using IoT will enable the detection of the quality of water and presence of fish earlier by sending the notification towards the fishermen or community. With technological growth, it will make it easier for fishermen to operate, such as discovering fish as their knowledge of which area that most fish landing based on water conditions. The fishermen can monitor the pond condition using a smartphone and this can help to warn them about pollution of water and at the same can detect the area of fish landing. The water pollution by the human can be prevented earlier thus, reduce the amount of fish dead.

For future works, it can be upgraded from ultrasonic sensors to the sonar with moving cameras based on deformable multiple kernels for more accuracy to detect and track the fishes underwater. Further on, the module for web interface should be developed for easier user interaction. In the future to expand the IoT water monitoring system by adding more parameters for the most secure purpose. The use of the LoRaWAN system as its low-powered sensors and wide coverage area measured in kilometers for future recommendation.

5. Acknowledgment

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