Using IoT LoRa to monitor the condition of fish farms

By

Kuek Yee Ben

17003487

Dissertation submitted in partial fulfillment of

the requirements for the

Bachelor of Information Technology

(IT)

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Universiti Teknologi PETRONAS

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CERTIFICATION OF APPROVAL

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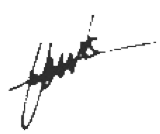

Dr Yew Kwang Hooi

UNIVERSITI TEKNOLOGI PETRONAS

BANDAR SERI ISKANDAR, PERAK

SEPTEMBER 2021

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons

Kuek Yee Ben

Abstract

The issue that is being faced by the fisherman is that they are unable to permanently monitor the condition of the water in the fish farms due to issues such as distance and much more. This research aims to create devices that are able to fulfill the purpose of monitoring the pH values and the water temperature of the fish tanks.

The methodology that is used in this paper is the waterfall methodology, in which there are various planning and preparations in this the development of the project. The part which makes this paper unique is that the data that is being monitored is being directly saved and can be analyzed immediately to improve the situation. By the end of this research paper, what I hope to improve is that the paper is able to act as a guidance for further projects. In terms of practical improvement, it should be able to monitor and send data accurately to the user.

The project will be limited to 24 weeks (168 days), which includes the total duration of FYP 1 and FYP 2. This project will aim to help the fishermen that are opting for Aquaculture using numerous new technologies, such as using IoT and the Arduino programming language to program the IoT devices.

Acknowledgement

To begin with, I would like to express my deepest and most sincere gratitude to Universiti Teknologi PETRONAS (UTP) for allowing me to do my Final Year Project in the university.

I would like to express my deepest thanks to my supervisor, Dr Yew Kwang Hooi, for giving me a chance and allowing me to be under his supervision. I am grateful that he provided me with timely updates and guidance to me so that I am able to work splendidly that will help in the research paper itself. He also helped guide me when I was clueless regarding the topic that he had recommended me to do research upon and patiently helped me in the progress meeting by answering all questions patiently and explaining it in a way that I could understand. The amount of trust he had in me, his support and teaching has helped me to become a better person, in extremely huge and is much appreciated.

Next, I would like to thank my family for giving me moral support and constantly asking about my wellbeing despite me not being to contact them frequently due to the packed schedule that UTP has. Lastly, I would like to thank my friends for also giving me mental support when I was feeling down despite them also being in a packed schedule and trying to complete their assignments and dissertation on time.

With the writing of this report, it signifies the end of my studies in UTP.

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Chapter 1: Introduction

Background

According to the annual report of the Food and Agriculture Organization of the United Nations (FAO) – Malaysia Fisheries Division in 2019, it is reported that in the year of 2017, the total fishery production of Malaysia is amounted to 1.7 million tonnes. By further breaking it down, 1.5 million tonnes are from capturing it in the wild, while 0.2 million of it are from aquaculture productions. In terms of non-living fish, Malaysia produced 0.2 million tonnes of farmed seaweeds through Aquaculture as the world seventh largest producers, as well as ranked at third for tropical carrageenan seaweeds farming.

In terms of quantity, Malaysia is a net importer of fishery product and is a country that offers high prices for the fishery products, far exceeding their neighboring countries but lower than countries such as Norway (mainly salmon). In terms of profit, Malaysia exported high value fishery products such as shrimps and sashimi tuna, with the total export earning amounting to USD 714.1 million in 2017.

Why is Aquaculture on the rise?

According to the statistic provided by the FAO, it is stated that there has been a rise in total food fish consumption from 1990 to 2018, with an increase on 122%. This shows that there is an upward trend in the consumption of fishes, in which there is a total rise of 527% in aquaculture production from 1990 to 2018. Figure 1 below shows the increase of Aquaculture

AQUACULTURE						
	1995	2000	2005	2010	2015	2018
Africa	69	100	189	255	355	386
Americas	279	257	241	336	377	388
Asia	7426	12355	14826	17910	19533	19617
Europe	98	104	100	118	115	129
Oceania	6	8	8	6	10	12
Total	7878	12825	15364	18625	20390	20533

Figure 1 The rise of aquaculture in countries

However, despite a huge number of increases of percentage, the success achieved in some countries and regions have not been sufficient to reverse the global trend of overfished stocks (FAO,2018). Statistics show that there has been a decrease of 25.2% from 90% to 65.8% of fish stocks that live within biologically sustainable levels. Figure 2 shows the statistic of overfishing

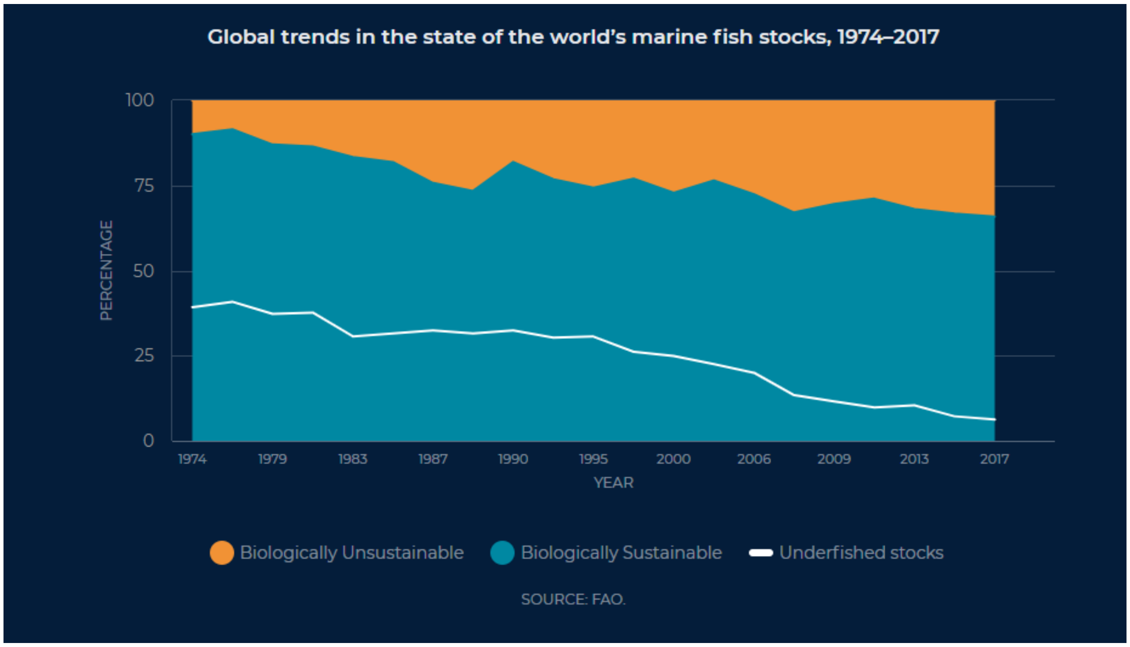

Figure 2 Global Trends in the state of the world's marine fish stocks

From the figure, it shows that the statistic of overfishing is increasing over the years, with underfishing decreasing over the years. Hence, to combat these issues, there are countries that are opting into aquaculture. Aquaculture has expanded fish availability to regions and countries with otherwise limited or no access to the cultured species, often at cheaper prices, leading to improved nutrition and food security. At the global level, since 2016, aquaculture has been the main source of fish available for human consumption. In 2018, this share was 52 percent, a figure that can be expected to continue to increase in the long term (FAO,2018).

Besides trying to combat the obvious trend of depleting fishes, aquaculture is also increasing due to the following reasons:

- Increase in production of fishes in Aquaculture
- Technological developments
- Rising incomes worldwide
- Reductions in loss and waste
- Increased awareness of the health benefits of fish

In Malaysia, according to the Laporan Tahunan 2018 LKIM (Lembaga Kemajuan Ikan Malaysia), Malaysia is also supportive of fisherman that are adopting the aquaculture methods to raise fishes.

Tahun	Peruntukan (RM)	Perbelanjaan (RM)	Peratus Perbelanjaan (%)
2018	69,145,975	66,530,593	96%
2017	47,695,762	39,491,845	83%
2016	35,600,000	33,990,781	95%
2015	20,150,000	14,288,985	71%
2014	26,966,463	14,757,160	-

Figure 3 The amount of money spent by the government to support aquaculture

This shows that, there has been quite an amount of money being invested into the fishery section.

How water conditions are monitored

Currently, in most aquaculture industries in Malaysia, the monitoring process of the water quality is carried out manually using a portable sensor (Sridharan, 2014). Previously, monitoring activity needed to be done manually at the site and record it in a logbook and can only be done by trained and qualified personnel. (Myint, Gopal, Aung, 2017). This process often takes a long time (could take up to half a day to gain the measurements). With the portable sensor, it brings forth the issue of distance. This means that, when the distance of the sensor is far away, data will be unable to send accurately.

Problem statement

i. The current existing models are unable to alert the users if the pH values drops below a certain level

ii. Data obtained can only be sent to the user if the user is close to the model and not far away

Objectives

i. To identify if the data obtained can be accurately sent to the user

ii. To be able to test in a testing environment without any fault

iii. To analyze the data collected for further improvement

Scope of study

Focus – To ease and try to solve the issue of connection range

Users – The users will be the fishermen that are doing Aquaculture

Time Limitation – 24 weeks (168 days throughout the duration of FYP 1 and FYP 2)

Technologies used – IoT related technologies, such as IoT Transmitter, IoT Receiver and Arduino programming to program the IoT technology

Chapter 2: Literature review and/or theory

To further find the required information to continue with this research paper, multiple sources were found out and looked into in order to find essential information that is essential for this research. Firstly, we will analyze into LoRa and what techniques has been used and found.

<u>LoRa</u>

For small waters, the Zigbee protocol can meet the application requirements due to the distance between the data collection points. However, for larger river and lakes where aquaculture operations are located, the distance between monitoring points does not need to be close. Hence, this increase the deployment cost and reduce the reliability of water quality monitoring (Mao et al, 2019). This is because, short range multi-hop technologies will require more nodes to fully cover the distance of the whole lake. In order to solve this issue, satellite remote sensing technology is used to detect water quality through spectral analysis and image processing but does not provide comprehensive and detailed water quality data (Mao et al, 2019).

Hence, in order to solve the issue of distance, a simple network protocol that utilizes low power consumption, LoRa technology is sufficiently representative, and its application field is expanding and can meet the requirement of monitoring water condition from a big range (Mat et al., 2019).

LoRa (Long Range) is developed by Cycleo and was released in 2012 as a non-licensed technology. It has a range of 11km and a transmission speed of around 10kbps and their network has been implemented in 34 countries with an investment value of $241 billion. (Roberto & Sang, 2019). A table has been made below to explain IoT LoRa in comparison with 4G LTE.

Technology	IoT LoRa	LTE
Modulation Technique	Chirp Spread Spectrum (CSS)	Frequency Division Multiple Access (FDMA)
Data Rate	50 kbps	10M Mbps
Link Budget	154 dBM	130 dBM
Power Consumption	Low	High

Firstly, let us talk about the modulation technique. Modulation is the process of converting data into electrical signals that is optimized for transmission. The figure below shows the modulation technique for both IoT LoRa and LTE. As you can see, CSS has more signals per period and FDMA only has 1 signal per period. What this will mean is, lower power is needed as compared with FDMA and the amount of data that can be sent is limited. As low power consumption is needed, the battery of the IoT LoRa technology can last up to 10 years. Data rate refers to the amount of information that can be sent at a time. As per the table, IoT LoRa can only send data up to 50kbps while LTE can send data up to 10Mbps. This means that, the data that can be sent through LoRa is only bits of information and cannot be long sentences. For example, if both LoRa and LTE are required to send information, the data send by LoRa could be, Water Temp: 30, Turbidity:100 while LTE could be, the water temperature is currently at 30 degrees Celsius and the water turbidity is at 100%. The last part is the link budget. It is essentially how far the information can be sent that will also consider the obstacles between the receiver and transmitter. The link budget of LoRa in 154 dBM while LTE is 130 dBM. This means that, LoRa is able to transmit data to further places as compared to LTE.

How LoRa works in a water monitoring system is as follow. The system is divided into 3 modules, namely the Sensor terminal network module, Data transmission module and Network data service module (Mao et al., 2019). The function of the sensor network module is for data acquisition and sending and receiving of sensor terminals. Data transmission module is responsible for LoRa network and GPRS network data transformation and data transmission to the other 2 modules (Lauridsen et al., 2017), including the gateway leading role in realizing LoRa protocol. The data service module mainly realizes the collection, analysis, processing, and preservation of the collected information. (Al-Turjman F et al., 2016).

This is useful for this project as if I am able to replicate and use LoRa for my project, it will be able to solve the distance issue that is currently an issue. As I am also doing the data transmission for the data that I have collected, I will also be attempting to replicate the 3 modules that has been stated.

To get the standard range of water quality parameter, I have obtained it from the Fisheries Research Institute (FRI) Malaysia. However, I will only be using the temperature and pH parameter and not water flow. This is because, according to research done by De Belen and his team, it shows that “pH is inversely proportional to temperature, but flow rate has no effect on pH and temperature”. Hence, I will only be focusing on those 2 requirements.

Parameter	Standard Ranges	Unit
Temperature	28 – 32	°C
DO	> 4	ppm
pH	6.5 – 8.5	
Salinity	24 - 32	ppt
Ammonia (NH3-N)	0.1 – 0.5	ppm
Nitrate (NO3)	0 – 10	ppm
Nitrite (NO2)	< 0.3	ppm

Figure 4 The parameter set by the Fisheries Research Institute

Chapter 3 Methodology

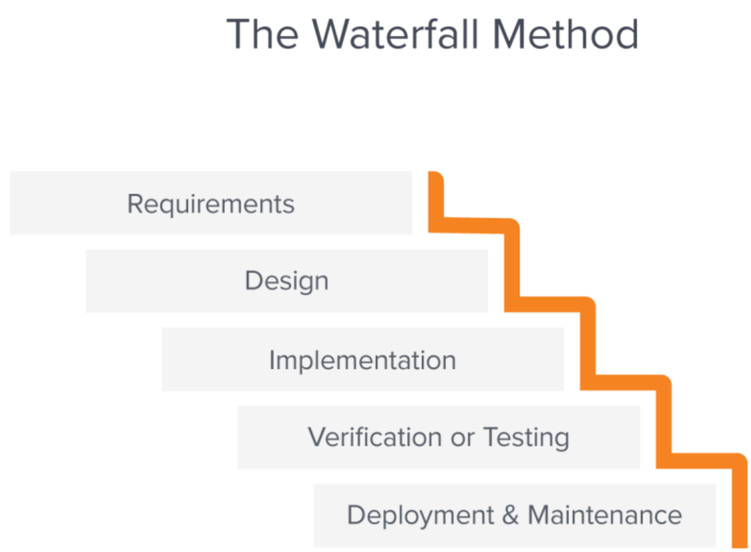

Figure 5 The waterfall methodology

The methodology that I have chosen is the waterfall methodology. It is chosen as my methodology as it can allow me to properly plan each phase and it aids me in the documentation as documentation is done after each step to ensure that nothing is amiss. Furthermore, this approach is very structured, and it is easier to set milestones and do reference according to the milestones. Lastly, I used this methodology as I can have more time to do the development and testing stages.

Requirement

During the requirement analysis phase, I analyzed the concept of IoT LoRa to see if it is applicable in my project using the SMART objectives. The SMART objectives is to see if the concept is specific, measurable, achievable, realistic and time bound. After reading a lot of research papers, I have come up with the idea to implement the concept of IoT LoRa to monitor the condition of fish farms. Besides that, I have also come up with a list of materials to buy in order for me to do the project, which was a pH sensor, water temperature sensor, water tank and an IoT transmitter.

Design

In the design phase, when the items that I bought had arrive, I set it up to how to the experiment is shown as below.

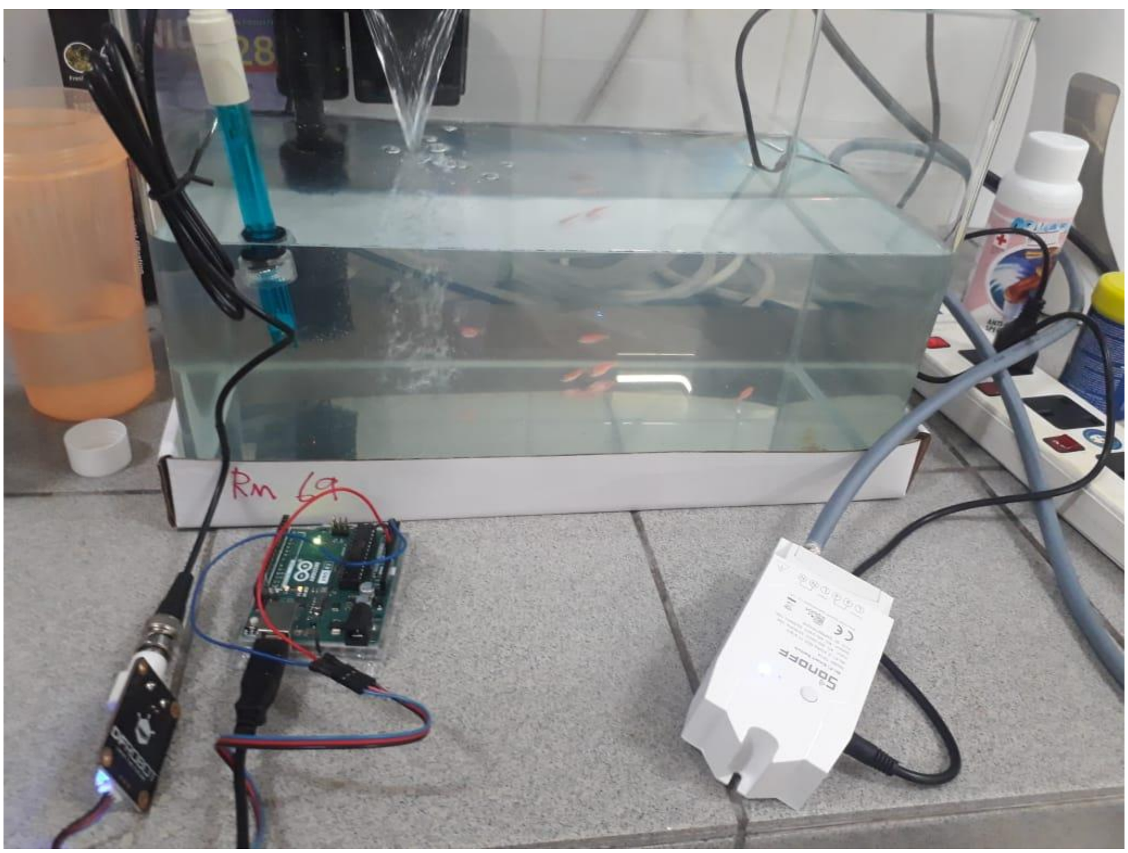

Figure 6 The experiment set up

Implementation phase

In this stage, I have done some technical things. This includes the setting up of the Arduino pH sensor which uses C programming language to do.

```
 * date  2018-04
 */

#include "DFRobot_PH.h"
#include <EEPROM.h>

#define PH_PIN A1
float voltage,phValue,temperature = 25;
DFRobot_PH ph;

void setup()
{
    Serial.begin(115200);
    ph.begin();
}

void loop()
{
    static unsigned long timepoint = millis();
    if(millis()-timepoint>1000U){                  //time interval: 1s
        timepoint = millis();
        //temperature = readTemperature();         // read your temperature sensor to execute temperature compensation
        voltage = analogRead(PH_PIN)/1024.0*5000;  // read the voltage
        phValue = ph.readPH(voltage,temperature);  // convert voltage to pH with temperature compensation
        Serial.print("temperature:");
        Serial.print(temperature,1);
        Serial.print("^C  pH:");
        Serial.println(phValue,2);


     if (phValue<6) {
       Serial.print("ph abnormal, current ph is: ");
       Serial.print(phValue);}

     if (phValue>8) {
       Serial.print("ph abnormal, current ph is: ");
       Serial.print(phValue);}


     else
     Serial.print("Normal ph, current ph is :");
     Serial.print(phValue);
     }
```

Figure 7 The code for pH sensor

Firstly, we need to include the library of the pH sensor, which was the "DFRobot_PH.h". After uploading the library, we can start with the coding. In the setup phase, we first have to set the baud rate. The baud rate is the rate at which information is transferred in a communication channel. After setting the bud rate to 115200, we go to the coding part. The code will print the pH value of what the sensor is doing every 1 second. Lastly, if the pH value is below 6 or above 8, it will print the message "pH abnormal, current ph is: " along with the phValue. If it is normal, then it will print the message stating that is it the normal pH. Then, I tested to see if the code would work in a pH 5 solution. As you can see, it prints the message that I have coded.

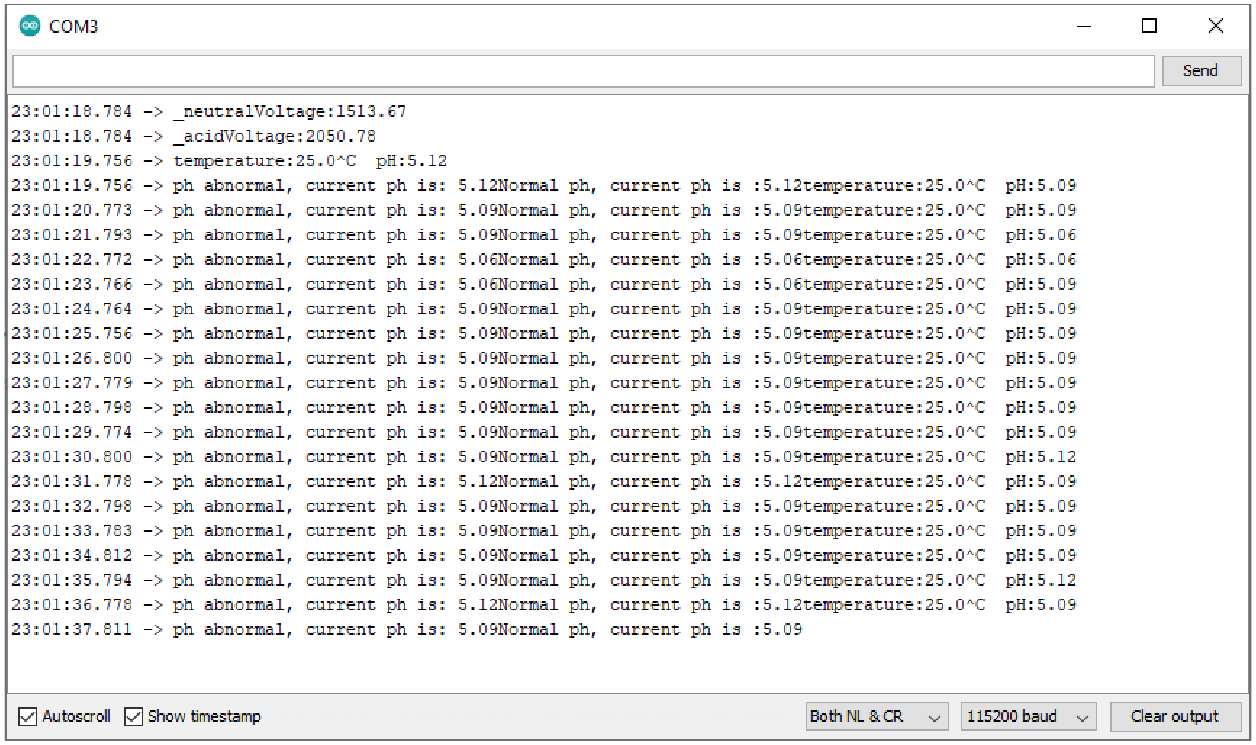

Figure 8 The serial monitor that shows pH value

The pH sensor was configured with jumper wires and my Arduino Uno R3 board as follow.

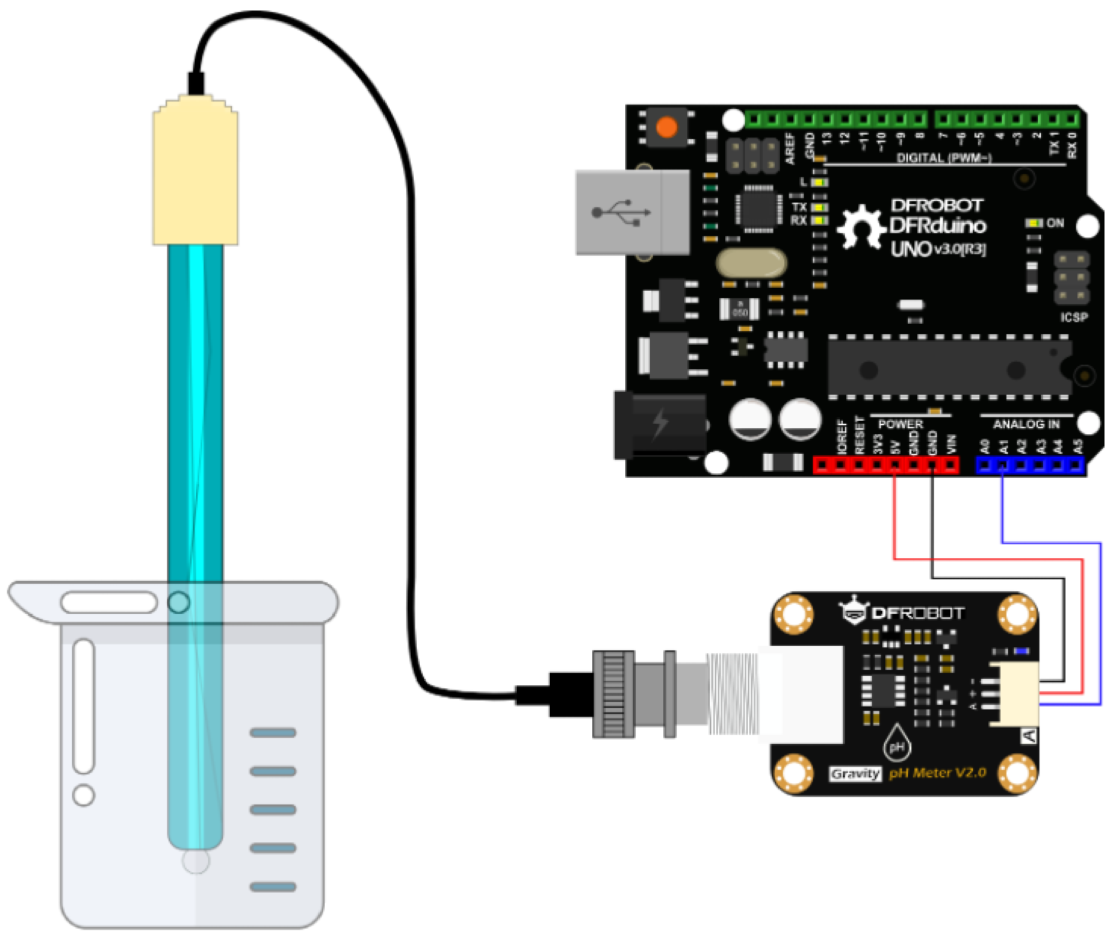

Figure 9 The configuration of the jumper wires to arduino board

Verification and testing

After done with the testing phase, now we move on to the testing phase. Here I have tested the pH sensor first. How I did this experiment is that I first put the pH sensor in the fish tank, after 10 seconds I put pH4 acid into the fish tank. Any changes was monitored into the excel sheet.

21:12:59.86	lormal ph	[pH:6.43	
21:13:00.86	lormal ph	[pH:6.40	
21:13:01.86	lormal ph	[pH:6.43	
21:13:02.87	lormal ph	[pH:6.40	
21:13:03.87	lormal ph	[pH:6.43	
21:13:04.87	lormal ph	[pH:6.43	
21:13:05.87	lormal ph	[pH:6.40	
21:13:06.87	lormal ph	[pH:6.40	
21:13:07.87	lormal ph	[pH:6.43	
21:13:08.88	lormal ph	[pH:6.43	
21:13:09.88	lormal ph	[pH:6.43	
21:13:10.88	lormal ph	[pH:6.45	
21:13:11.88	lormal ph	[pH:6.43	
21:13:12.88	lormal ph	[pH:6.43	
21:13:13.89	lormal ph	[pH:6.43	
21:13:14.88	lormal ph	[pH:6.45	
21:13:15.89	lormal ph	[pH:6.37	
21:13:16.89	lormal ph	[pH:6.40	
21:13:17.89	lormal ph	[pH:5.55	
21:13:18.89	abnormal	lormal ph	[pH:5.20
21:13:19.89	abnormal	lormal ph	[pH:5.04
21:13:20.90	abnormal	lormal ph	[pH:4.95
21:13:21.90	abnormal	lormal ph	[pH:4.87
21:13:22.90	abnormal	lormal ph	[pH:4.87
21:13:23.90	abnormal	lormal ph	[pH:4.85
21:13:24.90	abnormal	lormal ph	[pH:4.85
21:13:25.90	abnormal	lormal ph	[pH:4.85
21:13:26.91	abnormal	lormal ph	[pH:4.85
21:13:27.90	abnormal	lormal ph	[pH:4.85
21:13:28.91	abnormal	lormal ph	[pH:4.82
21:13:29.91	abnormal	lormal ph	[pH:4.82

Figure 10 The data collected in the Excel sheet

This was the result of the experiment. At 9:13:16, the pH of the water tank was still normal, with the reading displaying normal pH values. After I poured the pH4 acid into the water tank, you can see the sudden decrease of the pH level, with it showing that the overall pH value of the water tank decreasing to an abnormal level.

Next, to test out the temperature sensor, I used a temperature sensor. As the temperature sensor came with a built-in application for me to use it to monitor water temperature, I decided to just use it instead of building my own.

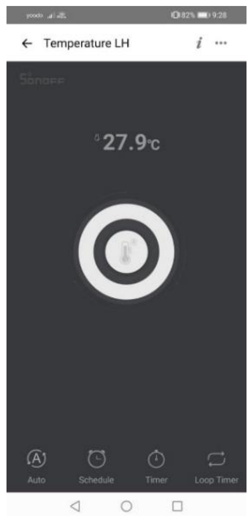

Figure 11 Before the water temperature above 30

Initially, before the fish tank was added with warm water, the temperature was 27.9 degree Celsius. After warm water was added, the water temperature raised.

Figure 12 The application turns on after temperature more than 30

The original design for the temperature sensor was, once the temperature rises above 30 degrees Celsius, the water pump will automatically kick in and release cooler water into the water tank. However, due to some error from my part that will be explained later in the discussion, it did not work.

Lastly, after obtaining the pH data that was sent over to Excel, I then used Power BI to further visualize the data obtained. This was done to predict future pH spikes. This means that, the user will be able to predict the next time there is a spike in the pH values and act upon it immediately.

Maintenance phase

After doing the testing phase, I went back to refine the code further to add more of the error checking mechanism and added it.

Tools used

1. Analog pH Sensor/Meter Kit V2

Figure 13 Analog pH sensor/meter kit v2

This is used to measure the pH of the fish tank. The blue rod is dipped into the fish tank and the reading will be sent to the computer.

2. Sonoff TH16 – 15A WiFi RF Smart Switch

Figure 14 Sonoff TH16 - 15A WiFi RF Smart Switch

This is used to help measure the temperature. The water temperature apparatus is connected physically to this. Afterwards, the data will be sent to the phone via WiFi.

3. Sonoff DS18B20 – Waterproof Temperature Sensor Module

Figure 15 Waterproof Temperature Sensor Module

The part is dipped into the water. The metal rod will detect the temperature of the water and send it to the TH16.

4. Arduino Uno Rev-3 Main Board

Figure 16 Arduino Uno Rev-3 Main Board

This board is used to connect the pH sensor to the computer. This enables the data to be sent directly to the computer. The board also allows me to access the DFR board that is built in the pH sensor, enabling me to use the built in functions and do the coding on the board.

5. USB B Type Cable

Figure 17 USB B Type Cable

This is used to connect the PC to the Arduino board and supply the power to the board.

6. Male to Male jumper

Figure 18 Male to male jumper

This is to connect the pH sensor board to the Arduino board. The pH sensor board cannot connect to the PC itself, hence this connects it to the Arduino board that connects to the PC.

7. Microsoft Excel

Figure 19 Microsoft Excel

Excel is used to directly obtain the data from the pH sensor and stream it into excel table format.

8. PowerBI Desktop

Figure 20 PowerBI Desktop

PowerBi is used to visualize the data that is obtained from the excel sheet. After saving and editing the data that is obtained from Excel, the data is sent over here for visualization.

Chapter 4: Results and Discussion

After using the data that we have obtained, I used PowerBI to display and visualize the data. The data is shown as below.

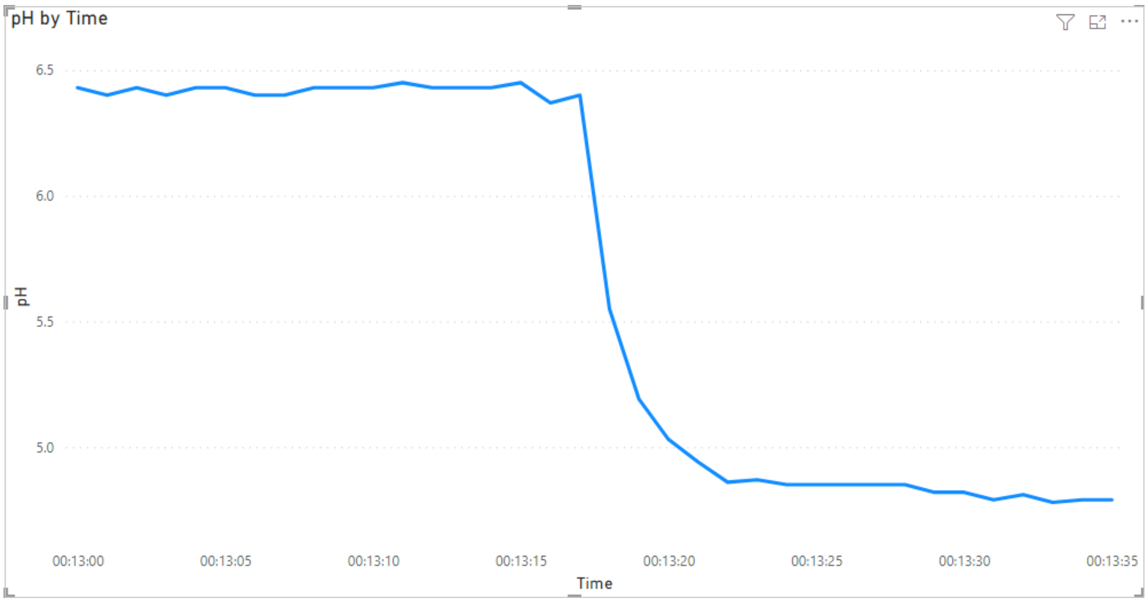

Figure 21 pH by time

As shown here, the pH sensor is working fine as it is able to detect the sudden change when I poured acid into the fish tank. This data could be used further to analyze when and what time there could be a potential spike or drop in the pH value by doing predictions based on this.

Figure 22 Water temperature changes

In terms of the water temperature sensor, it is working fine as it is able to detect the increase in temperature. Lastly, despite me using a smaller fish tank as compared to the larger scale fish tank, I would want to prove the concept that I am able to send the data to the user, in which the larger scaled fish tank would still be able to prove the same concept that I would want to conclude, just maybe taking a bit longer to change the pH value as the fish farms tanks are bigger in size.

Let me explain regarding the error that I wanted to talk about in the methodology above. Initially, my project was to monitor and regulate the water temperature, in which if the water temperate is above 30, the Sonoff TH16 would automatically open the water pump, and the water pump would be able to pump water from another source to cool the high temperature water. When I plug it in to use, it tripped the circuit breaker, causing a blackout until I opened back the power source.

After consulting with my friend that takes Electrical Engineering, it is found that the problem that I had was the water pump that I have bought is using Direct Current (DC) instead of Alternating Current (AC). Hence, the way to solve it is to buy a transformer to lower the voltage entering the water pump or a rectifier to change the current from AC to DC or to buy a separate battery that is powerful enough to power up the water pump. However, the transformer and rectifier are in a niche market, hence, it is limited in stock, and it was expensive, with the price being more than 200 ringgit, which is way overbudget as compared to what I have as I am just a student as the total cost of the project is around 600 ringgit already.

The next issue I have is that the alert function is just a simple if else statement. This is because, initially I wanted it to send an email or a pop out notification to the user's phone using either Blynk or pushsafer. However, it would require me to purchase the internet smolder board which is pricy. Even if that is available, it would require me to solder the board which I do not have access to as the EE labs in UTP is not available. The other option was to buy an Arduino board with built in WiFi. However, the product is not compatible with my components, and it is always out of stock in all websites.

Lastly, I had to change my project to using IoT instead of using IoT LoRa. This is because of 2 reasons. Firstly, the concept of IoT LoRa, despite it coming out in 2012, does not have a lot of documentation that I can follow. The next issue is that IoT LoRa is not publicly available in Malaysia. There is a company in Klang area that attempted to use IoT LoRa to do their project, however the cost that they used to build a framework is very high. So even if I was to connect to the IoT LoRa gateway, I would have to be at Klang. Lastly, there are several LoRa compatible Arduino boards. However, they are really old and is not compatible with a lot of devices, which could be costly if I do not buy the correct tools. There are a few that are still compatible with my components but is discontinued.

Chapter 5: Conclusion and Recommendation

In terms of results and objective, I can say that I have managed to achieve my objectives that has been set. The pH sensor can accurately send data to the user and the user can monitor the water temperature through the usage of the app, in which the device is connected to the internet through IoT. My project can be used and continued by other students, in which they can explore better alternatives instead of using IoT which I am using right now.

My recommendation is as that, firstly I would say that my model is not perfect now. Hence, they can make better changes, such as connecting the pH sensors through the internet so that it is able to send a pop-up notification to the user's device if anything is wrong. Next, they can add in the water pump to regulate the water automatically by just buying the correct current or by buying a transformer or rectifier. Lastly, they can add a water turbidity sensor so further measure the amount of oxygen is in each water particle.

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