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IoT-based Automated Maintenance System for Fish Tank

Razin Zharif Zaharuddin[1], Herman Wahid[1*], Syahirul Nizzam Haron[1], Ruzairi Abdul Rahim[1,2]

[1] Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Malaysia.
[2] Vice Chancellor Office, Universiti Tun Hussein Onn Malaysia, Malaysia.

Corresponding author* email: herman@utm.my
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ABSTRACT

This work will develop a system that is able to monitor and control the water quality inside the fish tank using Internet of Thing (IoT). The developed automated fish tank system is flexible on its operation in which the fish can live in the best environment and condition. There are several factors to be considered in keeping the best environment for the aquatic lives to survive such as the water oxygen level, pH level, water temperature and water cleanliness. This project is aimed to assist fish keeper and aquarist in maintaining fish tank or aquarium which requires a lot of energy and time. It will introduce water monitoring system as well as self-feeding and water self-replacement mechanism. These mechanisms are important because fish owners normally find that maintaining the fish tank is a job which requires a lot of energy and time. Hence, this project is aimed to reduce the manual factor in maintaining the fish tank by also monitoring the important parameters which are crucial in their survivability of life. By including the sensors such as temperature sensor, turbidity sensor, level sensor and pH sensor, the water quality of the fish tank can be monitored so that the safe environment can be maintained continuously. The system will implement a self-refilling and self-feeding mechanism which the users can remotely control and monitor through their mobile devices using IoT technology.

Keywords: Water Quality; IoT System; Aquarium; Sensors; Auto Maintenance

1. Introduction

Fish keeping is one of the most popular trends or hobbies among people of all age groups. People love to store aquariums or fish tanks at their homes and offices for entertainment and decoration purposes. This hobby helps the owners to lower their anxiety and stress, as watching the fish tanks is similar to other types of relaxation therapy and meditation. However, many find that the effort to maintain the fish tank to be demanding and time-consuming, especially the first-time fish tank owners. If the fish tank is not maintained properly, the enjoyment will deteriorate when the fish keep dying for unknown reasons. There are several common problems in managing a fish tank such as dysfunctional water cycling system, overstocking of fish, and overfeeding. Consequently, the water will be cloudy and murky due to decompositions of uneaten food and waste materials. Plus, they tend to neglect and forget several important factors to keep the fish healthy such as water cleanliness, temperature and its pH value. Therefore, it is crucial and important to introduce a system which can monitor the important parameters as well as implement the maintenance mechanisms of the fish tank.

In general, the monitoring system measures several parameters of the water inside the fish tank such as water turbidity, temperature, level and pH value by using few sensors. Also, self-feeding and self-changing mechanisms are incorporated using servo motor and relay module to assist the owners in maintaining the fish tank. The relay will control the water inlet and outlet of the fish tank so that users can remotely change or displace the water inside the aquarium without using manual workforce. The data and readings taken by the components are transmitted to the users via Wi-Fi so that they can continuously monitor and maintain the fish tank through their mobile devices by using Blynk application.

2. Literature Review

There are several works which have been referred in carrying out this research relating to IoT automated fish tank. Firstly, the research done by Muzafar et al. [1] uses turbidity sensor to measure the water quality inside an aquarium. It uses relay for filtering system and Node MCU ESP8266 as the microcontroller. The results and output of this system are presented on a webpage and LCD display. Furthermore, Chen et al. [2] propose a system which uses temperature sensor, ultrasonic sensor and turbidity sensor to monitor the water quality. Then, it also includes relay for water displacing and servo motor for feeding mechanism. All the operations are controlled by the microcontroller, which is Arduino Mega and the Wi-Fi module, ESP8266. Then, the users are notified through IFTTT, a service platform which connects with many services such as Gmail, Twitter, Line and Facebook to grasp the situation of the fish tank and control the system using mobile application. In other literature written by Gundara and Risnandar [3], the sensors that are used for water monitoring system in a fish tank include temperature sensor and gas sensor to detect the ammonia level in water.

The feeding mechanism is controlled by servo motor to operate for three times a day through the RTC module. Arduino Uno R3 is used as the microcontroller to control all the components and the output is then illustrated on LCD display. Smart fish tank is a concept which has been introduced to equip the aquarium with multiple built-in features with the purpose of replacing the traditional fish tank. The paper, *Smart Fish Tank using IoT*, which is written by Patel et al. [4] proposes to maintain the fish tank by using pH sensor, ultrasonic sensor, relay and level sensor. The system is controlled through Arduino Uno as microcontroller and users will be notified via mobile application. Plus, they can also monitor the fish tank through a webpage which can send commands to the fish feeder and view the real-time status of the fish tank via a webcam. In another project done by Rewatkar et al. [5] uses four sensors to monitor the water parameters inside the aquarium which are turbidity sensor, IR sensor, temperature sensor and water level sensor. Oxygenator is also utilized to maintain the proper level of oxygen in the fish tank and camera is included to connect the owner to the real time status of the aquarium. Plus, food feeding and water displacing mechanisms are also included in this project. The microcontroller used is Arduino ATMega328 and the Node MCU ESP8266 is used as the Wi-Fi module.

Lastly, the *Aqua Eco: A Smart Aquarium*, a journal written by Richards et al. [6] focuses on monitoring water quality using three sensors which are turbidity sensor, temperature sensor and pH sensor. Servo motor is used for powering the fish feeder and LED lighting is also included to be placed inside the system as it provides many advantages to wide variety of fish and aquatic life like plants. ATMega328P is chosen as the microcontroller while the ESP8266 is used as Wi-Fi module for the system to connect with users via Android application. Since the Wi-Fi module is operated on 3.3V, voltage regulator is also needed to stabilize the voltage.

3. Methodology

Figure 1 illustrates the flowchart of this project. At the beginning of the project, the important factors and parameters to keep the best environment for the fish are studied. Next, research is carried out to determine the suitable and appropriate sensors, microcontroller and other components required for the system. After that, the schematic diagram can be designed and verified consequently the characteristics and datasheets of all the sensors need to be checked so that they comply with the system. New sensors will be needed if there is any false verification. Subsequently, the parts of the prototype as well as the programming sequence for the microcontroller can be assembled and developed. Finally, the hardware can be tested.

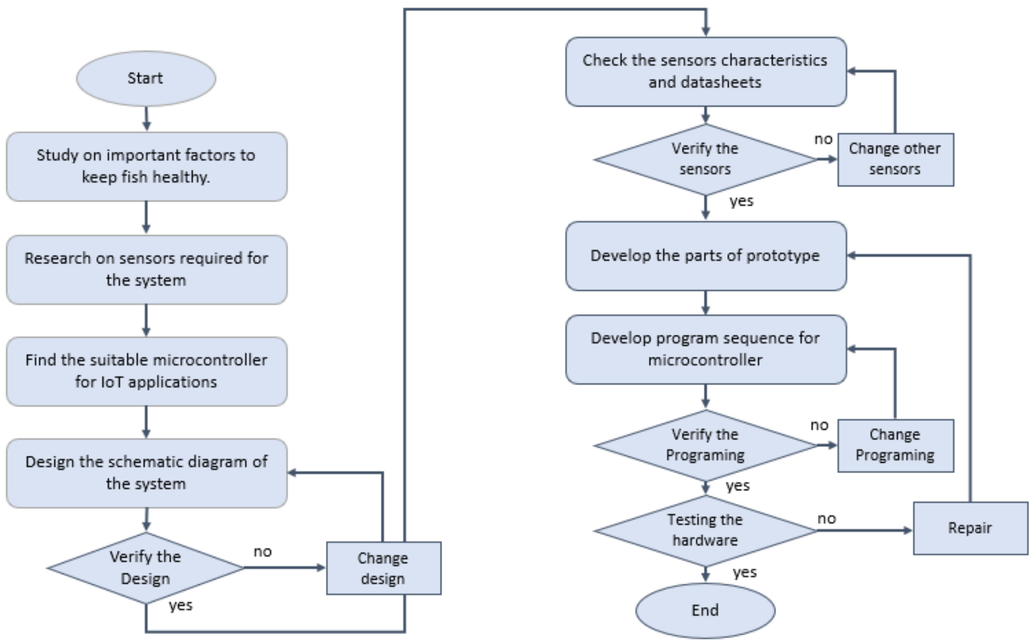

Figure 1. Flowchart of the project

In this project, there will be four sensors that are utilized in the electronic parts to measure different parameters of water in the fish tank. A turbidity sensor, a pH sensor, a temperature sensor and a level sensor were employed to perform these responsibilities. These sensors will collect data on a continual basis and send it to the Node MCU ESP32 microcontroller for processing. The readings from the sensors will then be converted to the appropriate unit in the Arduino IDE. Subsequently, the microcontroller will deliver the information and data to the users through Wi-Fi using the Blynk application when it has been processed. Plus, users can control the servo motor and the relay module to implement the fish feeding and water cycling mechanisms. As a result, users can continuously monitor the water quality as well as maintaining the fish tank at the same time through their mobile devices. Figure 2 illustrates the block diagram of the system.

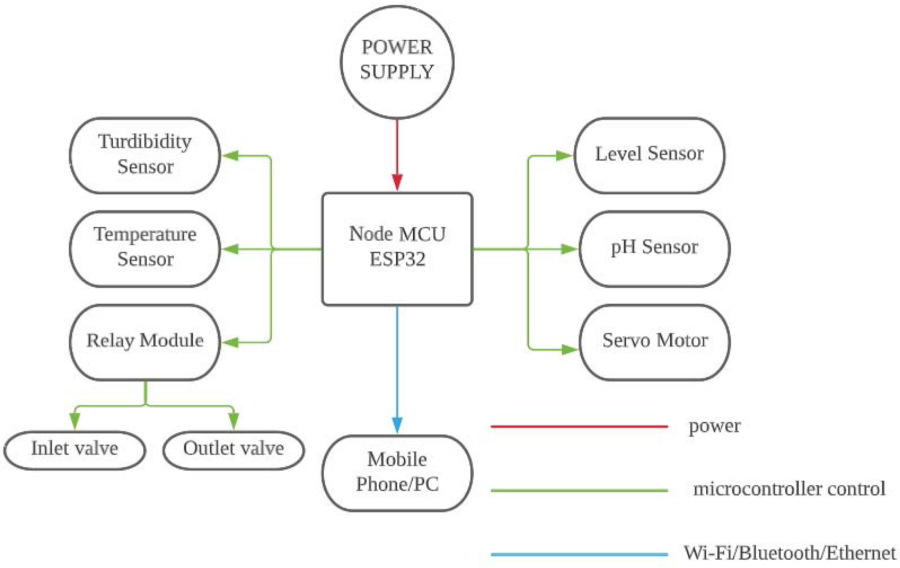

Figure 2. Block diagram of the system

In achieving and completing the project scopes, the mechanism aspect of this system plays an essential role for the implementation of the hardware. The system is carefully designed so that it can function properly and efficiently. The proposed design idea of the fish tank is as shown in Figure 3 and each component is labeled based on the table in the figure. Meanwhile, the circuit connection diagram of the components is as illustrated as in Figure 4.

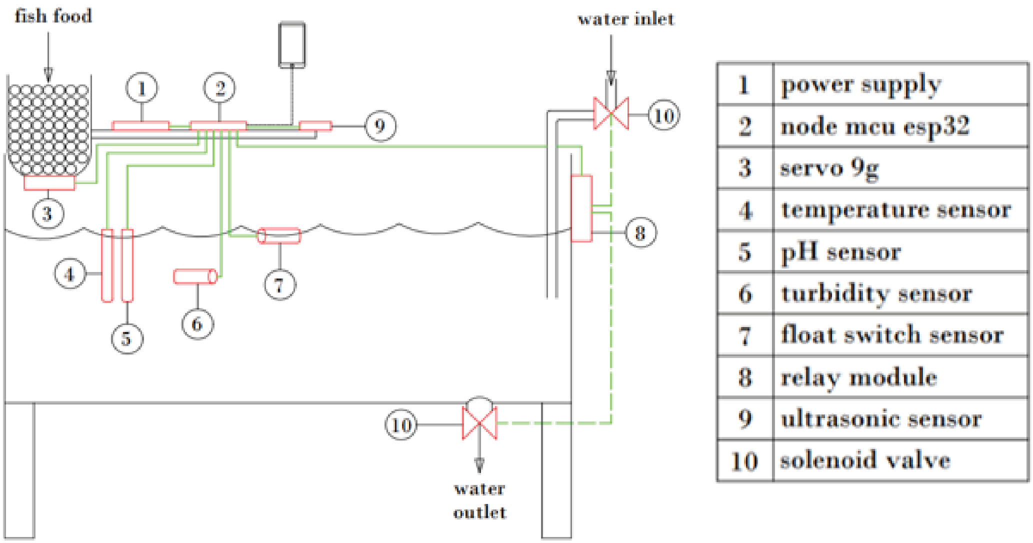

Figure 3. Overall system design

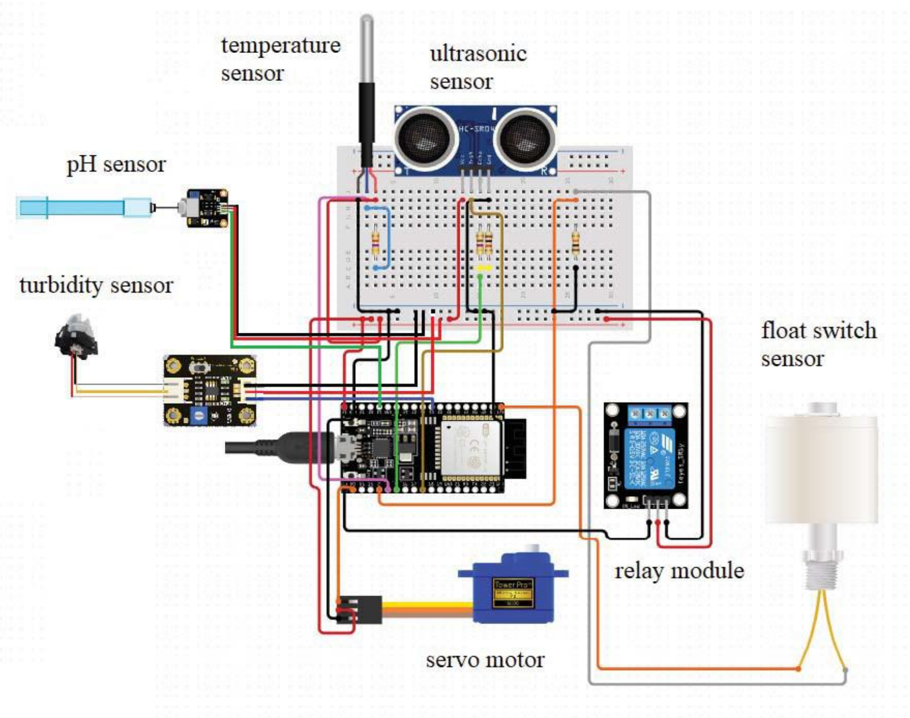

Figure 4. Circuit diagram of the system

3.1 NodeMCU ESP32

The proposed microcontroller which will be used in this project is Node MCU ESP32, which comes with a dual-core 32-bit processor, built-in 2.4 GHz Wi-Fi and Bluetooth, higher RAM, higher Flash memory and many other peripherals compared to other modules. It is responsible for controlling all the components through the programming in Arduino IDE. By using microcontroller ESP32, additional Wi-Fi module will not be required as it is able to serve the IoT applications support connection through Wi-Fi, Bluetooth and Ethernet. The microcontroller has 30 GPIO version and is based on the ESP- WROOM-32 module.

3.2 Temperature Sensor

DS18B20 Waterproof Temperature Sensor is used to measure the temperature inside the fish tank. It is a sealed digital temperature probe which enable the user to precisely measure temperatures inside the fish tank with a simple 1-Wire interface. Furthermore, the DS18B20 may draw power directly from the data line, removing the requirement for an additional power supply. Changes and variations in the ambient temperature will result to an analogue output voltage. Due to a physical and external change in heat, it will alter its electrical properties. Therefore, it can also be recognized as a transducer.

3.3 pH Sensor

The Gravity: Analog pH Sensor is the proposed sensor to be used in to measure the water pH value. Not only that it is compatible with the microcontroller such as Arduino UNO or Node MCU, but it can also determine the pH of the liquids accurately since it has an accuracy of 0.1 pH. The sensor can measure pH of water with temperature measuring from 0 ℃ to 60 ℃ and has a response time of less than 1 minute. Hence, the pH of water inside the fish tank can always be monitored by the users so that it remains at the optimum condition and environment.

3.4 Level Sensor

In this project, the proposed level sensor is Water Level Sensor Float Switch which can be connected to controller such as Arduino or Raspberry Pi to enable more possible application. Furthermore, this sensor is easy to use and acts as a mechanical switch or dry contact, extended out into 2 wires. The sensor is surrounded by a floatable cylindrical component. The switch is open when the cylinder and bottom are both open. When the water level rises, the cylinder is pushed upwards and the switch is closed.

In addition, HC-SR04 Ultrasonic Sensor is also incorporated to serve as water level detector in this system. This is to ensure that water level indicator can be observed in the Blynk application and the water displacing mechanism can be implemented efficiently.

3.5 Turbidity Sensor

The proposed turbidity sensor used in this project is the Analog Turbidity Sensor. The dispersion of light method is used to detect the turbidity in liquids. Turbidity is usually measured in NTU or JTU depending on the water quality measurement technique and these two units are usually equivalent. The turbidity measurement is usually measured in terms of NTU and the higher the NTU reading, the higher the number of suspended particles in the liquid. In other words, higher NTU will make water to look murkier and darker. These can be caused by either feces or algae and it will increase the stress levels of the fish. However, instead of NTU, the percentage of turbidity is applied in this project to provide a better understanding of turbidity and assess the murkiness of the liquid.

3.6 Servo Motor

The SG90 Servo Motor will be in charge of powering the automatic fish feeder. This small and compact motor will be used to feed the fish in the fish tank. If the user decides to create a larger fish feeder, it can be replaced with a larger servo or even a stepper motor because the servo meets our needs in the tiny area sector of the fish tank. To connect the motor, we used the Node MCU's powered digital inputs and a 5V power source. By referring to the Arduino library, the rotation angle of the servo motor can be controlled and it can be operated with a rotating motion that open and close the food dispenser. Hence, users can control the feeding mechanism using their mobile devices.

3.7 Relay Module

The relay module will act as a digital switch for the microcontroller to control the water pumping into the fish tank as well as water draining out of the fish tank. This module will play the role of automatic adjustment and safety protection of the system. It is essential for the automatic water replacement of the system so that the water can be changed when there is too much turbidity in the water or not appropriate pH values. In this project, the relay module that is proposed is the 2 Channel 5V Active Relay Module, with each channel to control the inlet and outlet of water in the fish tank.

4. Results and Analysis

4.1 Sensors Calibration

While most of the components that are used in this system can be programmed directly through coding or libraries in Arduino IDE, there are several sensors used specifically the analog sensors such as turbidity sensor and pH sensor which require some calibrations before providing the correct reading in Arduino serial monitor or Blynk application.

To calibrate the turbidity sensor, it is tested in two water samples with different turbidity which are clear water and soil water. The sensor gives a value of 1965 when it is submerged in clear water whereas it gives a value of 1650 in soil water. Both values are used in the coding to map the output to percentage values, by using the clear water sample as 0% turbidity and soil water sample as 100% turbidity.

On the other hand, the pH sensor is calibrated by testing the pH probe in pH buffer solutions. When the sensor is submerged in pH4.00 solution, the gives a reading of 387 and it gives a value of 2161 when submerged in pH7.00 solution. The values are included in the Arduino coding so that the correct pH values can be detected. The figures below show the reading in serial monitor after the calibration of pH sensor. To further validate the pH value, it has been tested by using a commercial instrument for measuring water quality which is Horiba U-52.

4.2 Prototype Testing

This system is developed and programmed by Arduino IDE and accompanied with Blynk to allow connection with mobile devices through Wi-Fi or Bluetooth. The finalized prototype is able to monitor the water quality parameters in the fish tank with the help of temperature sensor, turbidity sensor, pH sensor and level sensor. Besides, the system helps to feed the fish as well as change the water inside the fish tank through the utilization of the servo motor and the relay module.

The Blynk application serves as the communication link between the user and the components in the system. Its main goal is to analyze the best water condition and environment in which the fish can live healthily as well as perform automated operations such as feeding and changing the water. The figures below illustrate the Blynk mobile interface as well as the website interface of the system during testing. As can be seen from the figures, the water parameters can always be monitored and the automated operations can also be performed through the Blynk application.

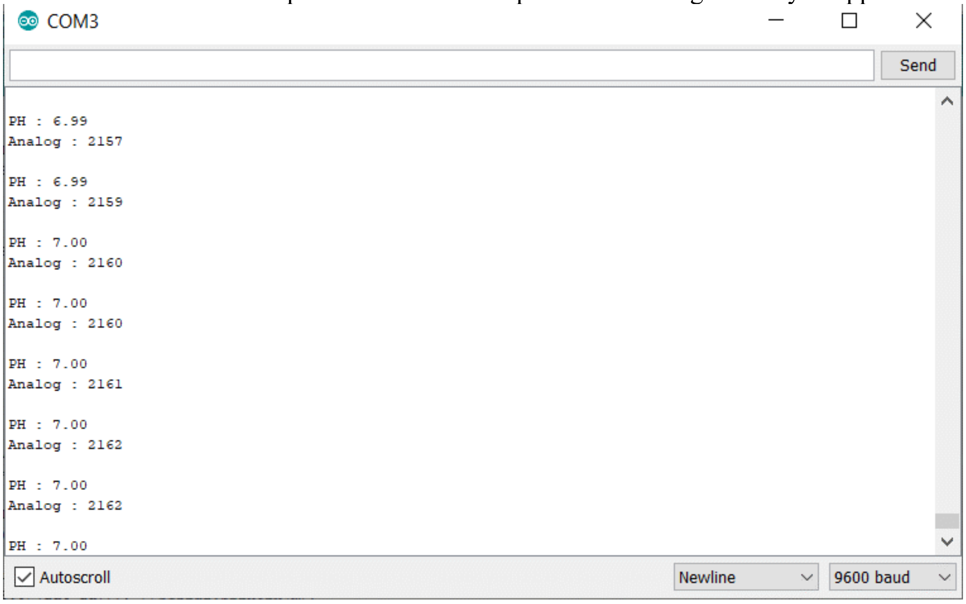

Figure 5. Examples of pH values in Arduino serial monitor

Figure 6. Blynk mobile application interface

Figure 7. Blynk console interface

The finalized design of the system is able to observe the water quality parameters in the fish tank with the help of temperature sensor, turbidity sensor, pH sensor float switch sensor and ultrasonic sensor. Furthermore, it will help fish keepers to create a balanced and healthy environment for fish to live as well as reduce the manual work of maintaining the fish tank. Moreover, this system implements an IoT based solution for user to always monitor the water quality inside the fish tank. Figure 8 and Figure 9 shows the setup of the components in this project. Besides, the system helps to feed the fish as well as change the water inside the fish tank through the utilization of the servo motor and the solenoid valves. Figure 10 illustrates the mechanisms that are included in the system.

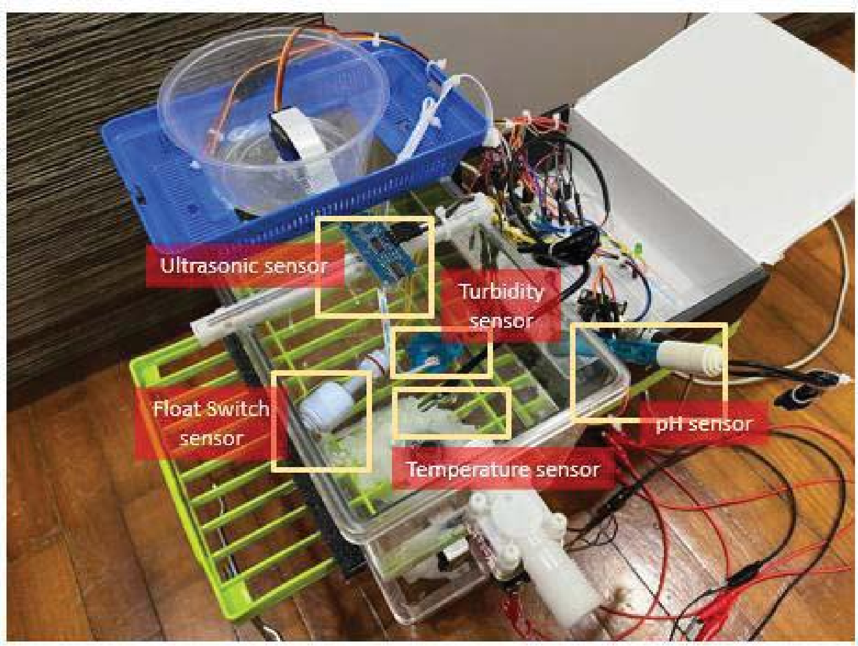

Figure 8. Front view of the project

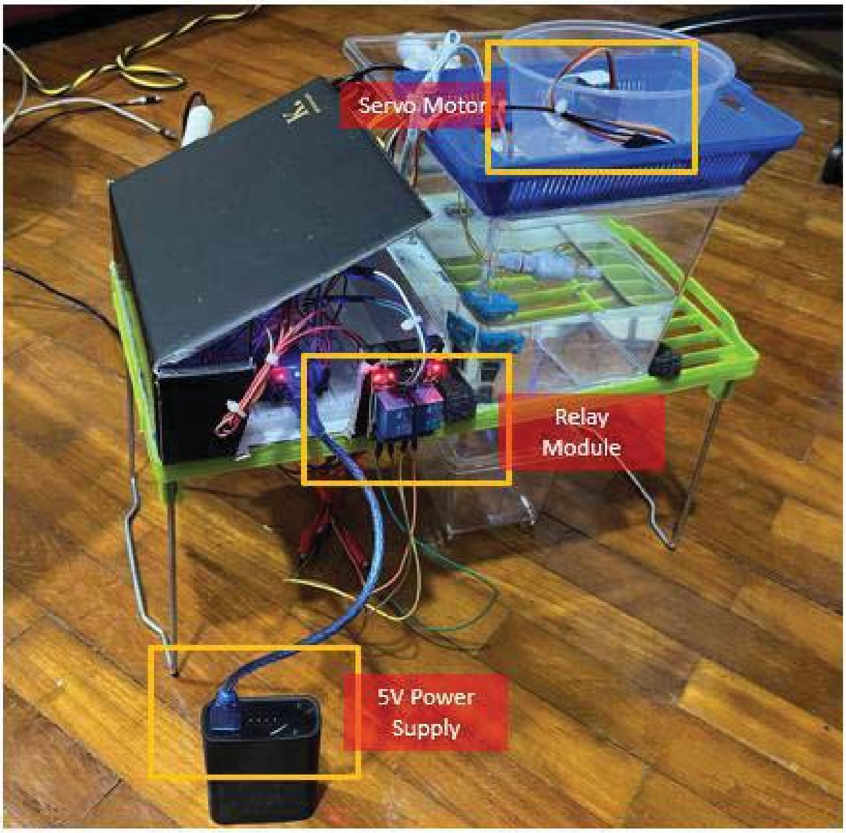

Figure 9. Back view of the project

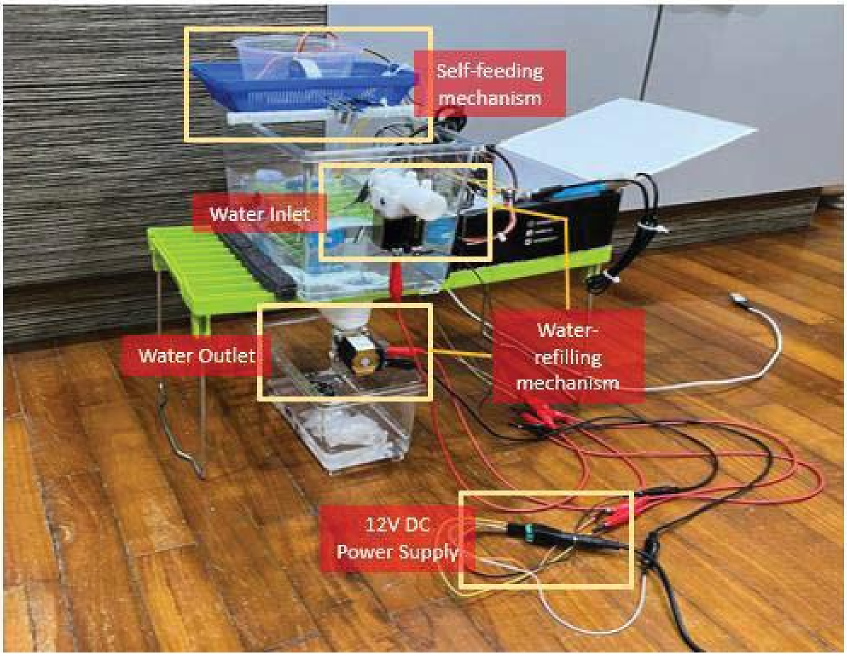

Figure 10. The mechanisms setup of the project

4.3 Advantages of the Proposed System

There are several advantages offer by the proposed system compared to existing devices as follows:

i. The system is employed to monitor the water quality and operate self-maintenance in fish tank.
ii. The system is portable and easy to setup.

iii. The feeding and water refilling mechanisms are controlled by servo motor and relay module.
iv. Blynk is used as an IoT platform for the system, which is user friendly and inexpensive service cost.

5. Conclusion

In conclusion, the challenges encountered by fish keepers in their everyday lives have been analyzed in this project and the IoT-based Automated Maintenance System for Fish Tank allows user to enjoy all of the benefits of owning an aquarium while eliminating any problem that might emerge by other alternatives that are available on the market. The fish tank prototype offers the user with the capability to identify any potentially dangerous environmental changes long before they become life threatening to the user's aquatic life by developing a wireless sensor network. With the help of Blynk application, users can monitor the water parameters inside fish tank as long as there is internet connection and the aquarium are supplied with the required power. The inclusion of self-feeding and self- changing of water mechanism will also assist the users in eliminating the manual workforce in maintaining an aquarium.

These sensors and mechanisms will help to create the greatest possible environment for aquatic life to live in the aquarium. With all of these features and capabilities, the IoT- based Automated Maintenance System for Fish Tank reignites the thrill of owning an aquatic pet and ushers the hobby into the twenty-first century.

Acknowledgment

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