2018 IEEE Conference on Systems, Process and Control (ICSPC 2018), 14–15 December 2018, Melaka, Malaysia

Aquaculture Monitoring System using Arduino Mega for Automated Fish Pond System Application

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***Abstract*— Fish farming industry has become one of the sources of income to people who are involved in business. An entrepreneur in this industry can make more money when the fish pond is equipped with the suitable device. With the existence of such device which capable in controlling the water level, monitor the temperature and so forth; then the entrepreneur has nothing to worry since everything is automated and can be monitored closely by just using a smartphone with Blynk application. This system is designed to control the water level, monitor the water temperature, automatic feeding and automatic water replacement of an aquaculture environment. The user gets to view the live measurement of the water temperature and water level. This study is limited to only a small aquarium where the maximum height is 15cm since it is only a prototype. The Arduino Mega 2560 is used as the microcontroller in this study since its program is easy to change and the language of this microcontroller is more familiar rather than other microcontrollers. This study results in a reliable water level controller which works continuously to regulate the water level to the desired water level. Besides that, this system also capable to feed the fishes automatically every 90 minutes and change the water in the aquarium for every two days. The graph of water level and the water temperature is updated from time to time and the data can be downloaded if the user intended to do so.**

Keywords*— *Aquaculture; Fish Pond; Water Level Monitoring; Monitoring System.

I. Introduction

The fish farming entrepreneurial field is becoming more popular these days as the supply of fish is on demand from time to time. For instance, a man from Nigeria named Abiodun Eniola [1] has earned extra income and able to set his own record in fisheries (catfish) business. He started the business with N200,000 and up to this day, he already owns 15 ponds. However, entrepreneurs in this field should be exposed with the importance in monitoring the fish farming environment [2] so that the business can be sustained. This is because fish farming itself produces chemicals that are dissolved in the water and affect the water quality [3] which eventually makes the ecosystem unbalanced. The chemical such as ammonia is excreted by fishes through fish gills as a by-product due to the protein metabolism [4]. In Vietnam, the fish farm is monitored closely by controlling the water quality in ponds and tanks [5] since they are one of the main worldwide fish suppliers This proves that the water quality brings a big impact on the aquaculture environment. The bad quality of water leads to decrement in rate of production or life span of fishes [6]. Nevertheless, the impurities in the water are such a concern when it causes chemicals to diffuse into the water and this matter has become into consideration to propose this system to provide a self-regulating system in controlling the water quality.

Other than that, people who have fishes as their pets are likely to abandon the aquarium due to tight schedule of their daily routine [7]. Career men are the target market who will eventually make use of this proposed system. This system is called "Fish Pond Monitoring System" where it is an automated system for fish pond environment monitoring. Some significant parameters are being measured and controlled to ensure an optimum environment for fish pond so that it can sustain and be profitable to those entrepreneurs. This system is suitable for everyone including children who are interested to keep the fishes as pets for hobby. They may not pay too much attention to their pets at times, but the fishes are still taken care by the system since it is automated.

This system is implementing the technology of embedded system which allows electronics and software programming within a product. The input and output interfaces can be easily installed and can be used by everyone since it is very handy and user friendly. Furthermore, the user can analyse the data of the aquaculture environment and any changes on the system can be easily done. This system also allows users to monitor the fish pond environment continuously using any device with Internet connection by downloading the Blynk application which is available in Google Play Store and App Store; then log in into the application with the registered Blynk account.

The Blynk application is provided with a list of widgets that can be selected to be included in the project. However, this project only uses two of the widgets which are the "SuperChart" and the LCD display. The SuperChart can plotted more than one parameter in one graph provided the application is linked through software implementation with the system. These widgets have to interact with the system and hence a particular coding is added to the system in order to enable these functions. The setup of virtual pins is needed so that the application can understand the inputs received from the system and interpret the data into the language used in the application. These data are then plotted in the graph for further use.

II. Literature Review

A. Solar-powered Fish Pond Management System for Fish Farming Conservation

Fish farming has been a way of fish conservation and systems are required to monitor ecosystem [10]. The purpose of this Solar-powered Fish Pond Management System is to develop a solar powered autonomous fish pond management system that is designated for fish conservation. The system is made up of a floating node and sensors which can regulate the pH level of the water and equipped with food feeder to dispense food into the water when needed. The main objectives of this project are to control the pond's temperature and dissolved oxygen.

The system consists of three subsystems known as measuring node, base node, and server that are connected to each other using two different wireless methods. The node in measuring node is connected to the base Station through a Zigbee networking protocol for peer-to-peer networking or point-to-multipoint. The wireless technology required between base node and server was connected through WiFi. Wireless connection between the node and control unit is via ZigBee meanwhile a WiFi connection is applied between the mobile client and control unit. The control unit must be able to accurately adjust the temperature of the environment by taking into consideration different data from the sensors from the wireless sensor node.

The sensors that are identified in this project are dissolved oxygen sensor, pH sensor and temperature sensor. On the other hand, the actuator involved are fish feeder and chemical dispenser which controls the pH of the water. The pH should be kept at a consistent level of pH7. In an environment that only contain an element which is water, the pH would be consistent at a value of 7 but practically the real-time situation involves other elements too such as chemical solutions [11].

For user interface, the project involves mobile application. It is compatible with Android model only. This allows the user to start or stop the management system as well as to schedule the feeding times and set the amount of dissolved oxygen threshold. This user interface also enables the capability of viewing the sensor in real time. For the solar charging function, power harnessing controller is used to charge the battery during the daytime. As a result, this system has succeeded in improving the life of fish in a pond environment by development of a self-sustaining floating node which takes sensory data readings and sends them to a user interface wirelessly. However, users with iOS devices will not be able to use the mobile application.

B. An Efficient Routing Protocol for RGB Sensor-based Fish Pond Monitoring System

This system uses the technology of RGB sensor where R stands for red, G stands for green and B stands for blue. Basically this system monitors water level and water quality of a fish pond [12]. It implies Wireless Sensor Network (WSN) technology [13] to control those two parameters; water level and water quality. The system is designed to fulfil criteria where it is a low-cost, energy efficient and sustainable fish pond monitoring system invention.

A rectangular fixed pillar that contains the colour mark (RGB) regions is equipped in the pond to monitor the water level. A waterproof transparent floater contains a RGB sensor is assembled to detect the colour marks of the pillar. For normal condition, the RGB sensors will be at green colour zone. On the other hand, when the water level is low, the RGB sensor indicates blue colour meanwhile for high water level, the RGB sensor will indicate red colour.

III. Methodology

A. Block Diagram

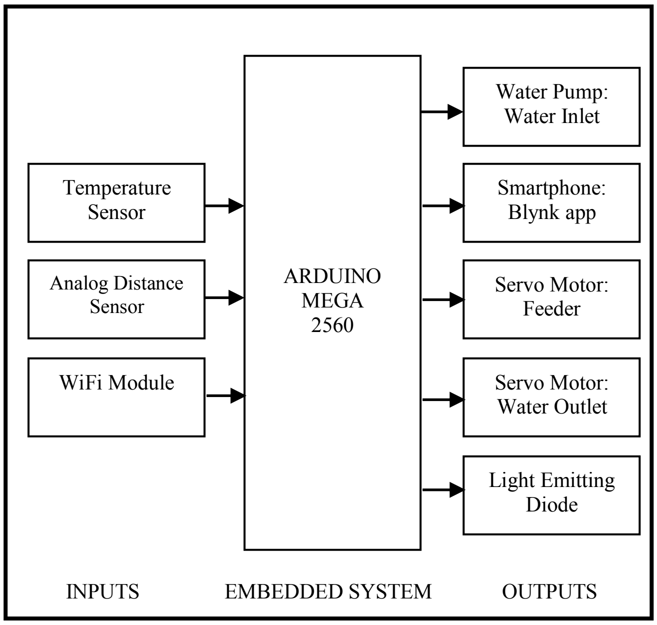

Figure 1: The block diagram of the Fish Pond Monitoring System

Figure 1 shows the block diagram of the fish pond monitoring system which uses the Arduino Mega as its embedded system. On the left side of the block diagram indicates the inputs of this system which are the water temperature sensor, analog distance sensor and the WiFi module. On the right side of the block diagram shows the outputs; Blynk application, two units of servo motors, a water pump and LEDs. The servo motors are used for the automatic feeder and as the valve opening for the water outlet.

The inputs and outputs are connected to the Arduino Mega's ports and the operation is programmed in Arduino software. The water temperature and water level sensors are sensing changes in the environment continuously and the WiFi module is connected to the port too since Arduino Uno does not have built-in wifi. The WiFi module is used to make an internet connection between the system and the external environment. The data collected through the process are sent to Blynk via the Internet connection provided by the WiFi module. The Arduino Mega can only be connected to the IP address of fixed internet connection that has been setup in the coding in Arduino software.

Water pump is used at the water inlet in order to cater pressure from the external water supply and makes the system capable in letting the water to flow into the aquarium. On the other hand, a simple concept is used at the water outlet where only servo motor is applied to open and close the water outlet by moving its shaft position. The position of the shaft can be varied between 0^{o} to 180^{o}.

B. Project Flowchart

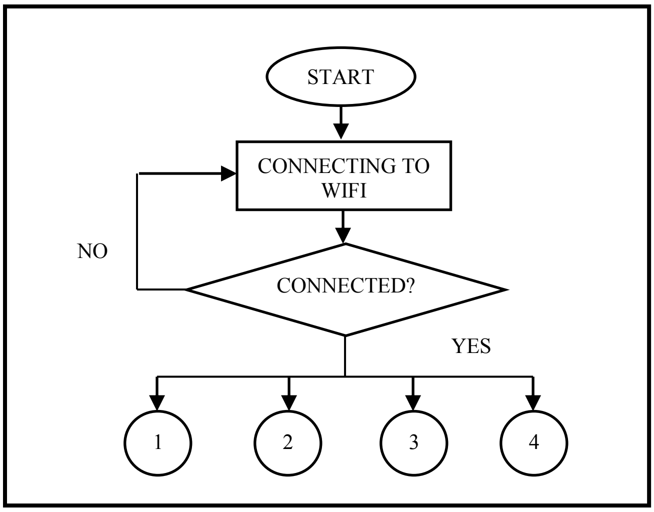

Figure 2: Flowchart of Fish Pond Monitoring System

Figure 2 shows the main flowchart of this system. When the system is activated, it will make a connection to the WiFi that has been setup in the Arduino. The system will analyze the available networks at the nearby areas and find the matching SSID (network's name) and password of the default network. When the system has connected to a WiFi connection, it enables the system to upload the data collected to the Blynk apps and all four subsystems are operating simultaneously. This system can be divided to four subsystems as illustrated by 1, 2, 3 and 4 in the figure above. Subsystem 1 is water temperature control system meanwhile subsystem 2 is water level control system. Subsystem 3 is the automatic feeder and lastly the subsystem 4 is the water changing system. Subsystem 2 and subsystem 4 are interdependent because the water replacement must be monitored by the water level system so that the water level is not going to drop below than 7cm throughout the process of water changing.

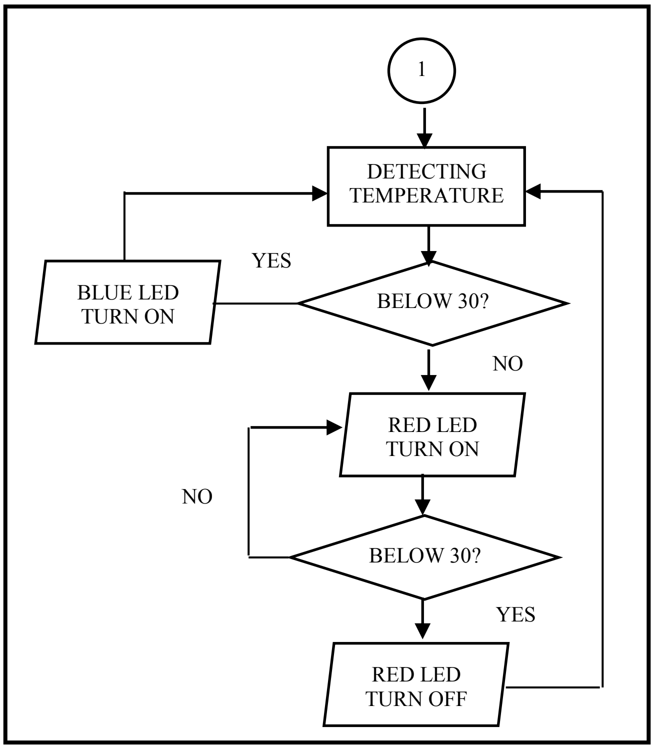

Figure 3: Flowchart of subsystem 1 of Fish Pond Monitoring System

Figure 3 shows the first subsystem which controls the water temperature by measuring using waterproof temperature sensor continuously. When the water temperature is higher than 30°C, the red LED will turn on. The red led turn on until the temperature drops to the optimum level at 27°C and blue LED will turn on to indicate optimum temperature.

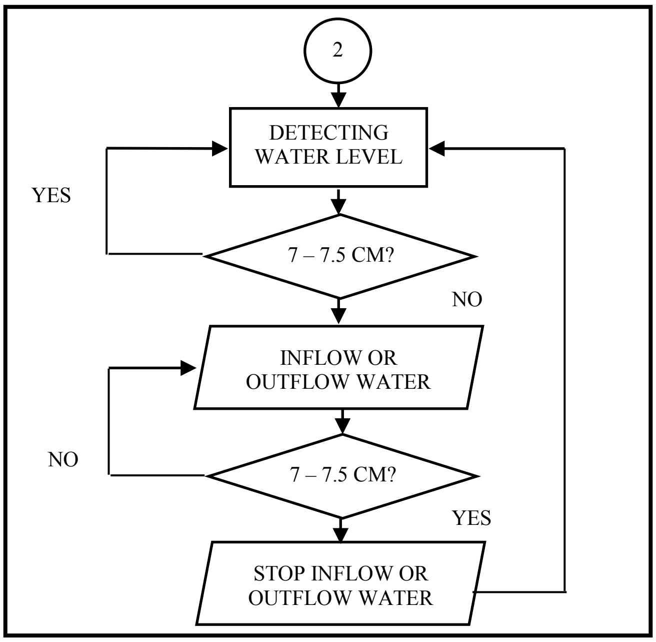

Figure 4: Flowchart of subsystem 2 of Fish Pond Monitoring System

Figure 4 shows subsystem 2 which is for water level where the system will sense the water level at all times. This is because the action taken as the water is being changed after some intervals. This may cause the water to overflow from the designated area. Hence, when the water level is low or high, the system will add water or spill water regarding to the situation. When the system detected a reading of water level being below than 7cm, the system will automatically supply water through the water inlet and will stop the process when it reaches a reading of water level between 7cm to 7.5cm. The water pump is implemented at the water inlet to ensure that the pressure is sufficient for the water supply to flow into the aquarium. On the other hand, when the analog distance sensor detects that the water level exceeded 7.5cm, the system will interpret the situation as high level of water inside the aquarium and eventually allow the servo motor at the water outlet valve to move its shaft so that the valve is opened. The water will continuously be flowing out until the desired water level of 7cm to 7.5cm is achieved.

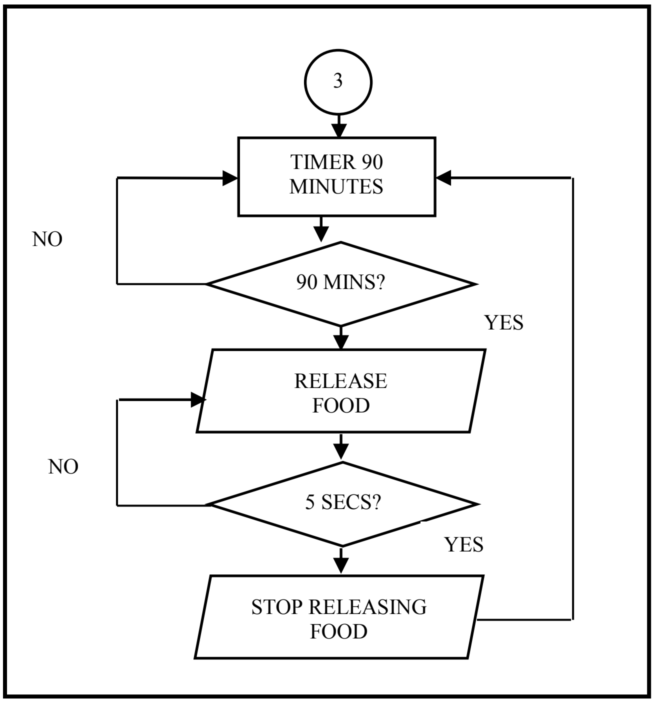

Figure 5: Flowchart of subsystem 3 of Fish Pond Monitoring System

Figure 5 shows the automatic feeder. The timer is set to 90 minutes and when it is up, the food will be released by moving the servo motor to open the food tube for 5 seconds. The process will be repeated for every 90 minutes. The amount of the food being released by the system is not measured by its weight, but it is released according to the time given since some trials and errors have been made in finding the suitable time interval with a reasonable amount of food released in that interval for that fish pond prototype (aquarium).

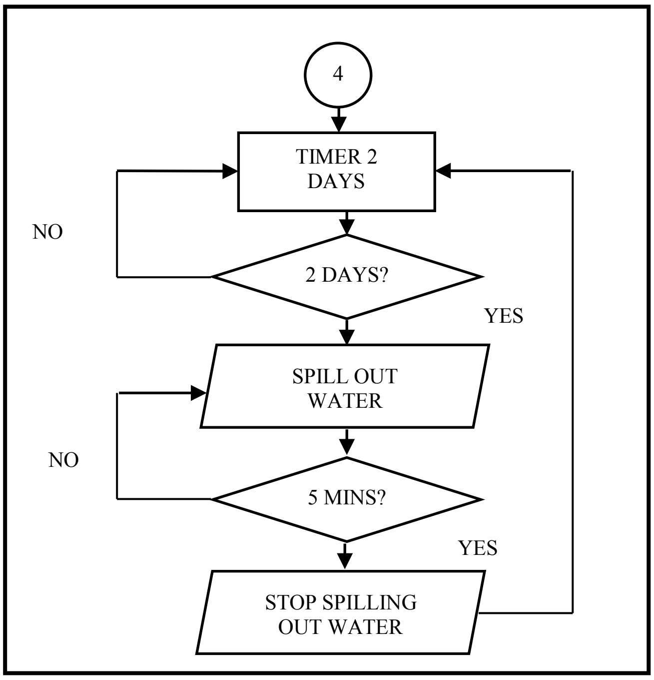

Figure 6: Flowchart of subsystem 4 of Fish Pond Monitoring System

Figure 6 shows the subsystem 4 which is the water changing system. For every 2 days, the system will open the water outlet valve for 5 minutes to spills out the old water. At the same time, the subsystem 2 will also take action to match the desired water level.

C. *Hardware Implementation*

The temperature sensor that is used is the waterproof model of DS18B20 which is compatible with the Arduino. Waterproof model is chosen due to the sensor needs to be immersed into the water solution to detect its temperature. This sensor can measure temperature within -55℃ to +125℃. It is accurate up to ±0.5℃ with range from -10℃ to +85℃.

This analog distance sensor allow user to ensure that the water level is corresponding to the number of fishes in the pond or aquarium. By maintaining the right water level, the fishes are able to sustain and maintain the balance ecosystem for aquaculture.

The Arduino module allows input and output mechanisms to interact with the system and external environment. There are two types of Arduino board, known as Arduino Uno and Arduino Mega. For this proposed project, Arduino Mega is selected as it is more convenient to use compared to Arduino Uno.

WiFi module is used for data extraction and to publish the data. Once the data is collected from the system, it will be available online. The model of WiFi module to be used is ESP8266. The servo motor is used to activate the water outlet. Besides that, it is also applied to allow the food release.

D. *Software Implementation*

Arduino software is used to integrate or program the system into the Arduino Mega board. It has its own library for input and output interfacing. The program created in the software can be accessed easily and changes can be done at user's preferences. The Arduino IDE software need to be updated from time to time to ensure that the libraries are up-to-date to prevent any error while running the program. Some libraries are not provided in the Arduino software and hence the programmer has to take the initiative to add on the libraries needed according to the necessity of the study.

Blynk application is used to browse the information on the parameters measured by this system. the interfaces of the widget in this Blynk application can be chosen according to the necessity of the project. It has its own library which make it easier to design a system with this Blynk application. This application is user-friendly as it can be used on both Android and iOS devices unlike any other smartphone application which only available on Google Play Store (for Android).

IV. Results and Discussions

Once the system is activated, it will make an attempt to connect to the default internet connection. After it gets connected to the network, the user will be able to view the data which have been pushed to the cloud of the Blynk.

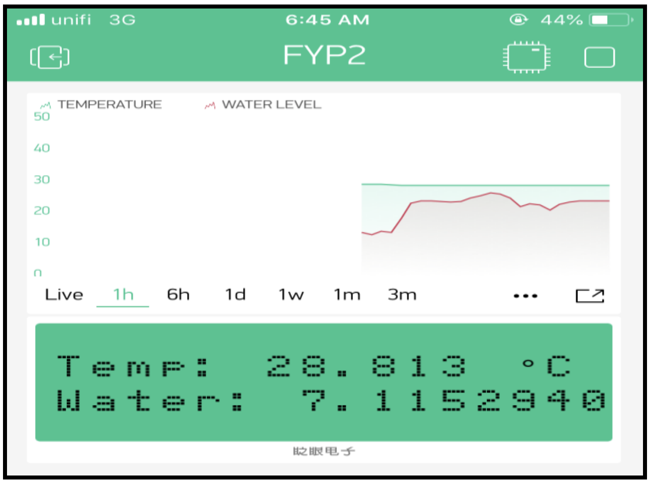

Figure 7: Blynk application viewed from the smartphone

Figure 7 shows the Blynk application that has been installed on a smartphone. The widget used is the smart chart, which allows users to view all the graphs of the measured parameter. In this study, the graphs plotted on the smart chart are for water temperature and water level. The same parameters are shown on the other widget too, which is the LCD display which display the current reading of those parameters.

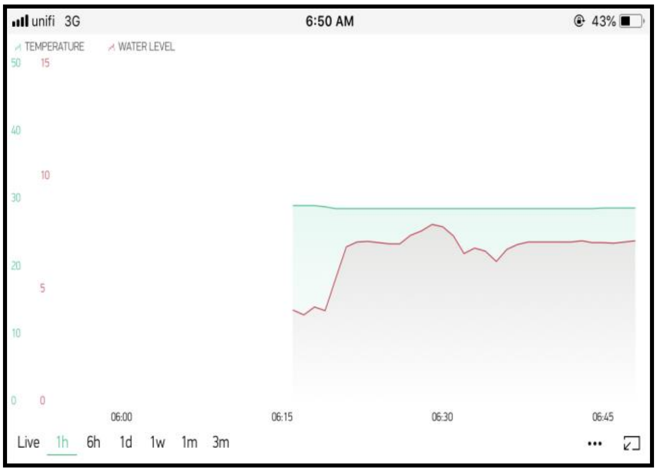

Figure 8: Water temperature and water level graphs

Figure 8 shows the graphs plotted in the Blynk application. The data collected by using the function of push data is gathered and updated into the graph.

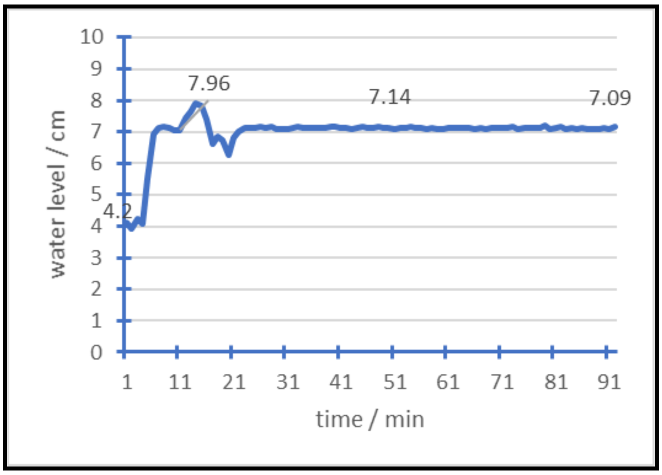

Figure 9: The water level graph

Figure 9 shows the water level measured after the system is indicated. As shown in the Figure 4.3, the water is at low level initially and it started to increase. This is because the system has detected that the water level is lower than the desired water level which is between 7cm to 7.5cm, hence the water pump starts to fill in some water in the aquarium to match the desired measurement. From the Figure 4.3 above, the water level is decreased after some time. This occurs due to the water is being changed. The water outlet is opened for 5 minutes to spill out the old water and at the same time, the water pump is catching up by filling in the water so that the desired water level is achieved.

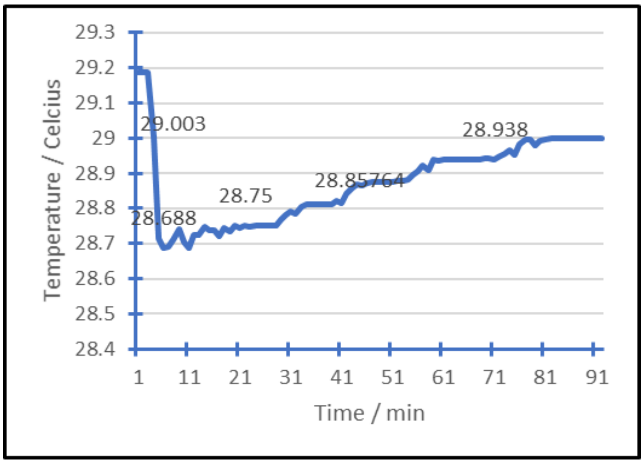

Figure 10: The water temperature graph

Figure 10 above shows the graph plotted for data collected from the water temperature sensor. It can be observed that the water temperature does not change drastically from time to time as compared to the environment temperature. However, the water temperature is affected by the environment temperature.

While completing this study, some problems had occurred. The problems may come from the software or the hardware and the combination of both. For example, the temperature sensor cannot detect a logical value of temperature which is -127°C after being connected directly to the Arduino board. The solution to this problem is by adding a 4.7kΩ resistor between the signal pin and the power supply pin. Other than that, the angle of shaft position for the servo motor must be made sure to react accordingly to the hardware.

Moreover, the analog distance sensor can hardly detect the distance on clear surface such as the water surface. Sometimes the sensor is detecting the right distance which is the water surface and get the value of water level and sometimes it detects the distance from the sensor to the bottom of the aquarium. This is because the analog distance sensor works by using reflection on the surface of the object which is also being affected by the light. Therefore, to overcome this problem, a floater is placed on the surface of the water and must be facing the analog distance sensor. With the presence of this floater, a solid object is detected easily and a reliable measurement of water level is obtained.

V. CONCLUSION

In conclusion, this study has enable student to figure out on how to make a connection between software and hardware input/output interfaces. The hardware part has been successfully reacted to the condition that has been set which is determined by the reading from the sensors. The connection to the Arduino correctly manage to get the precise readings from the sensors. This study has shown that the Blynk application is more user friendly compared to Thingspeak website in monitoring the system. The water level subsystem managed to keep the water level at desired level which is between 7cm to 7.5cm. However, the water inlet which its valve is supposed to be controlled using servo motor has been replaced with water pump to cater the pressure so that the water can flow from the water supply region into the aquarium.

AKNOWLEDGEMENT

The author would like to acknowledge and thank the Faculty of Electrical Engineering, Universiti Teknologi MARA, Shah Alam for their logistic and opportunity given to the students to improve their thinking skills and knowledge.

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