University of Regina

Faculty of Graduate Studies, Computer Science Department

Final Project Report

Title

IoT Based Fish Farm Monitoring

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Abstract

Over time, fish productions have grown exponentially with the increase in demand for fish and its products. The growth opportunity of this area of agriculture has not been utilized fully due to the lack of complete automation. In fish farming, the success and yield of your farm are highly dependent on the quality of water in the pond. Poor water quality impacts negatively on fish production, which in turn affects yield and returns. Improper care of the fish farm water quality is widespread amongst various fish ponds, which results in uncontrollable death of the fish and loss of money to the owner of the pond. Water quality depends on the proportion of some parameters present in the water at a particular time. These parameters are required in the right percentage to keep the fish alive and healthy. Of all the water parameters, pH level, dissolved oxygen, and temperature play the most crucial role in determining the quality of water. In this project, I developed an IoT system that captures, stores, analyzes, and report pH level, dissolved oxygen, and temperature in graphical form on an IoT cloud platform. This system notifies the pond owner of any condition of the farm that would affect it negatively with an email alert. Also, it provides the pond owner with a forecast of the expected weather condition of the farm environment 24hours ahead. The fish farm monitoring system was implemented using the Arduino microcontroller, sensors, and actuators.

Keywords

Internet of things, IoT, Fish farm, Sensors, Arduino, pH level, Dissolved oxygen, Aquaculture, pond

1.0 Introduction

The term internet of things is the interconnection of a physical device, objects, and the internet for communication and exchange of information. IoT involves our everyday objects connecting and exchanging data within the immediate environment and externally through the internet. Examples of things are our everyday objects like phones, smart TV, sensors, actuator, etc. Linking of things and the internet enables communication between things and things and also things and people [2]. IoT makes it possible for computational devices such as sensors and actuators to build integration and communication with each other's and working as a single system [5]. In recent year, IoT has gained a lot of attention and is one of the useful areas of research which has a lot of application in our everyday society. IoT has made a significant impact in the community today due to its widespread use in various domains ranging from the hospital, homes, cities, agriculture, etc. The IoT architecture comprises of three major parts, the sensor, communication, and application layer. The sensor consists of various devices that are used to collect data from the environment. The network layer uses the wireless or wired network such as the internet and mobile Internet infrastructure to upload data. The application layer uses some services to analyze data for controlling IoT devices [3].

IoT in agriculture is the application of internet of thing in agriculture. IoT in agriculture involves making various aspects of agriculture smart to keep track of multiple changes and improve yield and productivity and as well, minimizes physical presence and labor cost. IoT based fish farm monitoring is one of the numerous aspects of IoT in agriculture, which is the main focus on the project.

Fish farming, also known as pisciculture is the artificial breeding/cultivation of fish in an enclosure with a favorable condition for fish, for various purposes, mainly for consumptions as food, lake restocking, and pets. A lot of research has been conducted in this area of agriculture due to its importance in society. Currently, fish farming is a source of revenue for small scale owners (entrepreneurs), government agencies, etc. This is due to the growing demand for fish (protein source) and its products. This practice also serves a hubby to some individuals that breed some domestic fish as a pet. Fisheries and aquaculture bolster the earnings and occupations of 660-820 million individuals, around 10-12 percent of the total populace [4]. IoT in fish farming is the application of the Internet of things technology in fish farming. For IoT to work effectively in the area of fish farming, specific parameters need to be taken into consideration. Those parameters revolve around the water quality (PH level, dissolved oxygen, salinity) and environmental condition (temperature and Humidity) of the pond. On the most basic level, we can differentiate two types of ponds, ponds that breed tropical fish that are used as pets commonly known as aquariums, and ponds that breed fish for food [4]. This project is not specific to any of the mentioned kind of pond as the study related to the water quality and the surrounding environment of the fish pond in general. Manual investigation of the environmental activities is a tedious task and time consuming, and this made it necessary for automation in this area.

This project monitors and updates the quality of water in the pond by dictating the PH level for the water, the presence of the dissolved oxygen, water level, Humidity, and the water temperature with sensors. These parameters are going to be monitored remotely, and the data transferred to the cloud for visualization and storage. This project would also include a forecast of the atmospheric condition for the next day. The forecast will keep the pond owner informed on the expected changes that are likely to occur in the environment.

2.0 Related Works

YuHwan Kim1 et al. proposed the concept of thermal energy management of hot water in the area of fish farming through the internet of things. Wastewater energy, according to the work is resultant hot water from the cold water used for cooling the turbines. They stated the need for

reusing hot waste water channeled to the sea by most power companies. Microcontrollers were used for water looping and management and also a various sensor for water quality monitoring [7]. Massage Queue Telemetry Transport (MQTT) communication protocol was used in the project to achieve communication with the user devices for monitoring. A system was developed to autonomously control water in the fish farm using centrifugal pumps and electric valve controlled over the internet.

Asma Fatani et al. proposed the concept of an automated pH level sensor using the internet of things [2]. This project focused on the real-time monitoring of the pH level in a solution. Arduino microcontroller and sensors were used in this project for the monitoring of environmental parameters. A system was developed to maintain the pH level (The amount of acid and alkaline contained in a solution). This project was achieved by periodically toping of an acid/alkaline in a solution using an automated process. The system determines the amount of acid or alkaline to be added based on the specified level entered by the user [2]. A statistical tool was used in the project for viewing the changes in pH level in a solution.

Flordeliza L et al. worked on the automation of an Aquaponics system. They defined this system as a system that is made up of a combination of Aquaculture and Hydroponics (Growing plants with water minerals, without soil). This system is a symbiotic ecosystem of the fish and the plant where the fish waste (ammonia) serves as the food (nitrates) for the plant, and in turn, the plant absorbs the fish waste to keep the water clean for the fish. This system encourages recirculation and reuse of resources. Their study focused on developing an aquaponics with fish and vegetable farming. They argued that with the increase in the population of the world, there would be a time when there won't be enough agricultural space/farmland to produce enough food for the populace. The objective is to compare the growth rate of the fish and vegetable in monitored aquaponics system with that of the unmonitored traditional fish and vegetable farm. The research was conducted with a Tilapia and Romaine Lettuce aquaponics system through the internet of things with the use of Intel Edison. The proposed system would automatically monitor the aquaponics pH level of water, the water temperature as well as that of the plant, refilling of the water, etc. with the use of internet of things and mobile or web interface. They were able to experiment with a Romaine Lettuce Seedling with an initial height of 4 to 5cm and Nile Tilapia Fingerlings with initial length 5.5 to 5.7cm over four weeks, and they were able to monitor the pH and temperature parameter of the water [5] and also got a positive with regards to the health and growth of the Romaine Lettuce Seedling and Tilapia.

Francis E. Idachaba et al. studied the management of catfish farming in Nigeria. The system called the pond management system according to this group monitors ponds using the CCTV camera to capture the activities around the pond and transfers information to the cloud. It also feeds the fish and changes the pond water. A mobile application was created to returns information about the pond on request with the help of the cloud storage and the GSM module. The pond management system developed in the project comprises of five parts, which includes the water management system, water changing system, feeding system, pond controller, and pond management application [6]. The water monitoring system monitors the quality of the water in the pond, and this was made possible by transferring the light pulse from the transmitter to the receiver. When the dissolved food in water reaches a particular threshold where the light pause is delayed or cannot get to the receiver, this is seen by the sensor as weak water states that needs immediate change or action. The water changing system monitors when water needs to be discharged from the pond. This system could be as a result of poor water state or presence of low pH level, dissolved oxygen in the water or high temperature. They noted that feeding is very crucial to the growth of the fish, and the feeding system monitors the nutrition and makes sure the fish are fed promptly and in the right proportion. They used the timing technique to determine when the fish needs to be fed. The feeding cycles is 24hours with 6hours interval (4 times) daily. The pond manager is the application level of the fish management system that contains the software needed for management of the pond. For sufficient and efficient energy management, they proposed the solar energy for managing and powering the pond controller.

Charlotte DUPONT et al. researched and implement a low-cost fish farm monitoring system in Africa. They studied the numerous challenges of minimizing the cost of owning a fish farm in Ghana by setting up a system that monitored the water qualified for several months. The project was performed under WAZIUP which is an EU H2020 programme within the specific topic of cooperation between EU and sub-Saharan countries [10]. In January 2017, about 8 ponds was deployed with two species of fishes (Catfish and Tilapia fish) with the lifecycle of 6-8 months. By the end of the project lifecycle, they were able to gather information about the water quality from the ponds. Certain variation in the water parameters was identified by this group during the time of this study. They claimed the PH level falls at night and reaches its minimum in the morning. Various water parameters were plotted on a graph which shows the trends on each of the parameter during the day.

3.0 Problem Statement

Fish farming is a very time-consuming business. The pond owner needs to be available at all time to keep track of the situation of the farm. Proper management of a fish farm involves keeping favorable living conditions for the fish by making sure that various water and environmental parameters are within the required rating. The pH, temperature, dissolved oxygen, and water level of the fish pond should be within the specified range at all time. Manually doing this is very time consuming, and human oversight often leads to a significant loss depending on the extent of the negligence. The burden of always having to be physically present to monitor various situations could be managed efficiently with the use of the Internet of things. This work is proposing the full delegation of the water parameter and environmental management within the pond to an internet of things device. From the literature review above, a lot of impressive work has been initiated and completed in this regard.

Systems have been developed to make use of various sensors and microcontrollers to monitor the pond. Some of the existing systems get multiple water parameters, upload the data to the cloud, and alert the pond owner when his or her attention is needed. They also made use of actuators to perform some actions (feed the fish, change the water, increase and decrease the temperature, etc.) on the absence of the pond owner. However, none of the existing systems has been able to forecast the expected weather condition of the farm environment 24hours ahead, so that the pond owner could prepare ahead of time. Avoiding some hazardous situations on the farm is possible with prior information about them. A forecast of the temperature, rain, wind speed, etc. could help the farm owner take a particular action like covering/opening the pond as the case may be.

I intend to create a system that monitors the temperature, humidity, and pH level of the pond. This system will provide a real-time graphical representation of all the parameters, forecast the expected weather condition of the environment, and also email the owner. The project focuses on monitoring the water quality of the pond by;

- Determining the level of available pH
- Monitoring of the temperature
- Provide next day weather forecast
- Transferring the information to the cloud and
- Provide a visualization of the data using a third-party IoT cloud platform.
- Email notification of the farm owner when a particular threshold is reached

4.0 Methodology

This project was implemented using some components, which includes Arduino microcontroller, Sensors, Wi-Fi communication protocol, and thingspeak IoT cloud platforms. These components work together to detect and control the dissolved gases and other environmental factors. To better understand each part and their use, I will go into details in the following sections.

4.1 Arduino Board

Arduino is an open-source platform that provides a strong base for hardware and software [9]. This is a microcontroller board that helps to program and coordinate sensors and actuator. There are several models of the board. I used the Arduino Uno board in this project.

Fig 1: Arduino UNO Board

Arduino Uno is a Microcontroller board with several digital input and output pins, analog input pins, power source, etc. Arduino has an integrated IDE used for programming the board for effective management of the sensors connected to it. Data collected from the sensors are processed slightly at this level before transfer for further processing and storage.

4.2 PH Sensor

To monitor the PH level of the water, I used a PH sensor from DFrobots. PH sensors are calibrated according to the PH standard of 0 to 14 scale. PH is the degree of acidity and alkalinity of a solution. A PH of 7 is considered to be neutral, and that is the standard PH level of clean water. For fish to thrive, the PH value of the pond water must be maintained between 6PH and 8.5PH. A PH value below 6(acidic) or above 8.5 (alkaline) are considered not favorable for most fish species as this might lead to a stunted growth for the fish, the low yield for the farm or even death of the fish.

Fig 2: PH Sensor

Fig 2 above is an analog PH sensor from DFrobots. This sensor interfaces with the Arduino board and transfers analog PH signals from the solution to the board.

4.3 Temperature Sensor

Fig 3: DHT11 Temperature Sensor

DHT11 temperature and humidity sensor are used to sense the temperature of the environment and also the relative humidity of the atmosphere. The usefulness of the sensor is to maintain the temperature and humidity of the environment within a specific range. The optimal/average temperature of most species of fish is between 25*C to 30*C. Temperature above or below this causes harm to the fish in the pond. Firstly, they stop feeding at a certain temperature, and this results in a stunted growth on the fish and consequently Leads to death.

4.4 Wi-Fi Module

I used nodeMCU Wi-Fi module in this project for establishing a connection to the internet/cloud. This module runs on the ESP8266 Systems. The transfer of data between the Arduino microcontroller and the module involves a serial connection between each other. The module consists of a list of input ports for reading data directly from the sensor devices just like an Arduino microcontroller board, and also some output ports.

Fig 4: NodeMCU Wi-Fi Module

4.5 Cloud Service

Cloud storage is essential in every internet of things project. This is to enable the storage of data for future use and processing. In this project, I used an IoT cloud platform known as Thingspeak. The platform provides an API key through which the Wi-Fi module connects to it and transfer data for storage. This platform has a lot of features for visualizing, storage, and further transmission of data through emailing and some other means.

4.6 Forecast

OpenWeatherMap provides an API for the weather forecast of various countries and cities in the world. This API and a private key provided by OpenWeatherMap was utilized in this project to capture forecast data in JSON format. The captured JSON data was filtered based on the requirements of this project.

4.7 Email Server

When a certain threshold is passed, it is important to notify the pond owner of the happenings on the farm to avoid damages. Using the thingspeak cloud services and IFTTT webhooks provider

[8], I created an applet that monitors data received by the cloud platform to see if there is any need to notify the farm owner. IFTTT is a web service that allows users to create an applet which is triggered immediately certain conditions are met. This service refreshes every 5 seconds to see if there is a need to send an email or stay mute.

Below is the system design on how the various components discussed above are interconnected and how they interact with each other.

5.0 Proposed system design

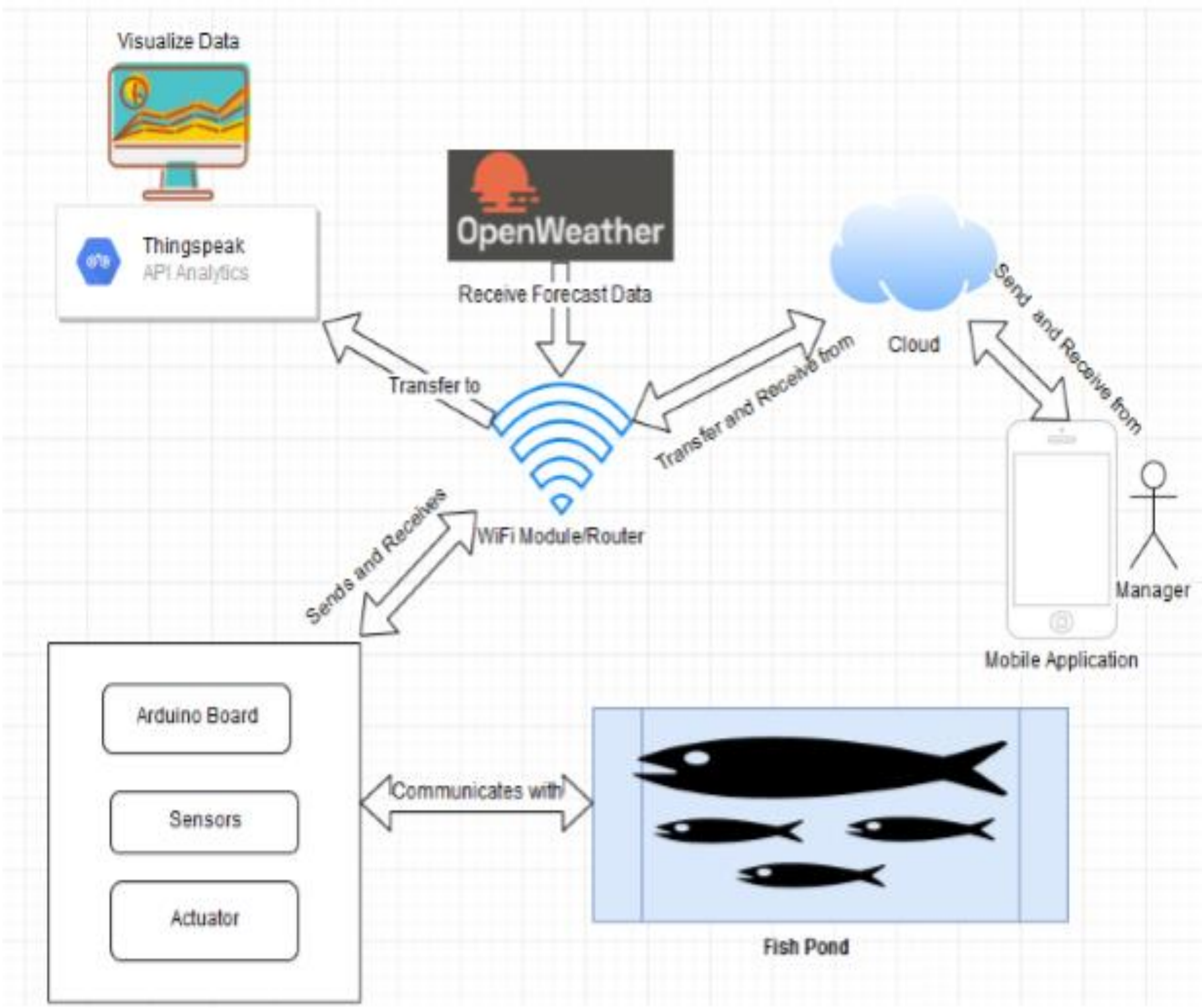

Fig 5: System Design

6.0 Implementation and Results

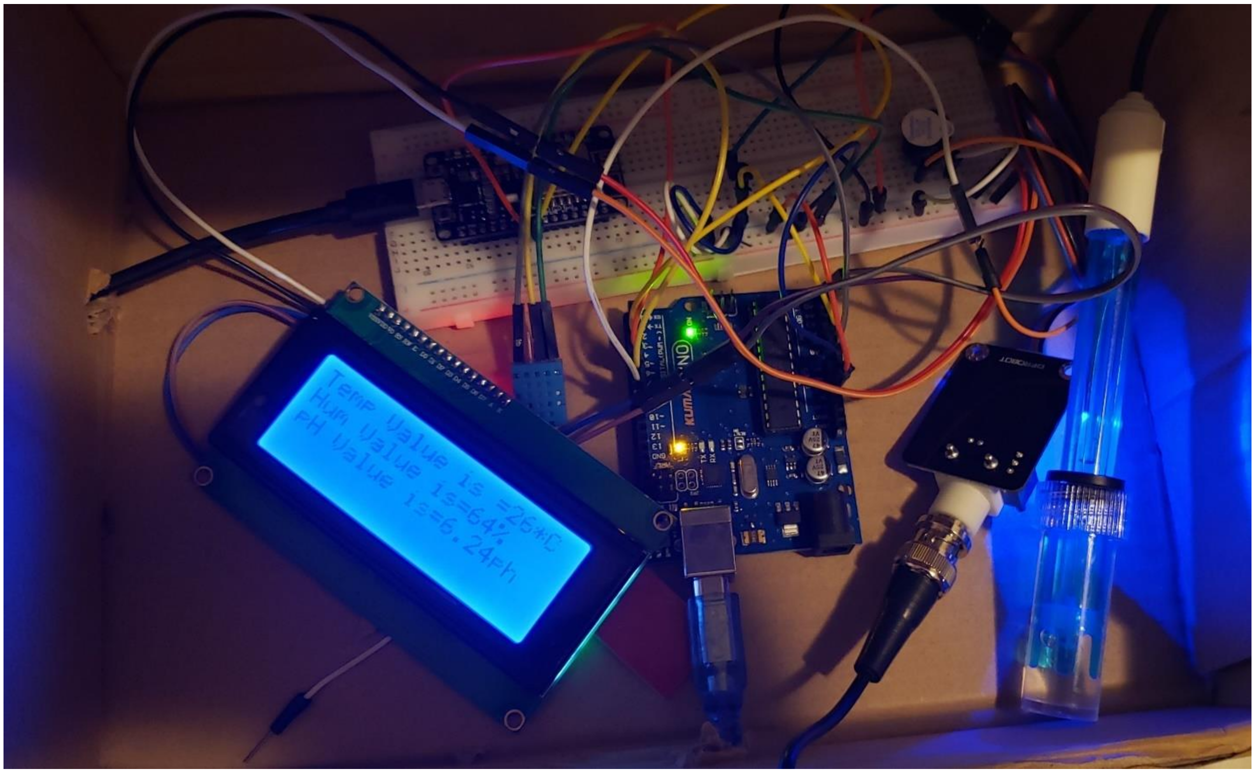

Fig 7: Project Screenshot

Fig 7 Above is the screenshot of a final working implementation of the project as at the time this report was documented. At this stage, I was able to bring together every component discussed above and implement the proposed system as described in fig 5.

Arduino IDE was used for the project coding and programming of the devices. Two boards were connected to the Arduino IDE. For each board to communicate with the IDE through my computer, separate com ports were assigned to each. The two boards used in this project include the Arduino board (Using com5) and the nodeMCU board (Using com3). For the Arduino board and the nodeMCU board to communicate with the sensor devices used in the project, some special libraries and drivers need to be installed from the Arduino IDE library collections. Libraries are installed on Arduino IDE through the Manage Library option of the dashboard which offers a large community of open-source library options from different vendors.

7.0 List of Libraries used

8.1 DHT Library

DHT Library is installed for the Arduino board to recognize and read data from the dht11 temperature and humidity sensor. DHT11 library from Ardafruit was used in this project.

8.2 SoftwareSerial

Arduino hardware has some built-in support for serial communication on pin1 and pin2. The SoftwareSerial library was developed to allow communication on other digital pins of the Arduino board, replicating the functionality using the software [10].

8.3 ArduinoJson

Arduino library enables the exchange of data with the board connected to the Arduino in JSON format. This was used for the exchange of data received and processed by the Arduino board with the nodeMCU board for transfer to the cloud.

8.4 LiquidCrystal_I2C

This library enables communication and printing of information on the liquid crystal screen.

8.5 ESP8266WiFi

This is a special library for the nodeMCU Wi-Fi module. This enables a Wi-Fi connection and communication to occur in the Arduino project

8.0 Sensor Data on Serial Monitors

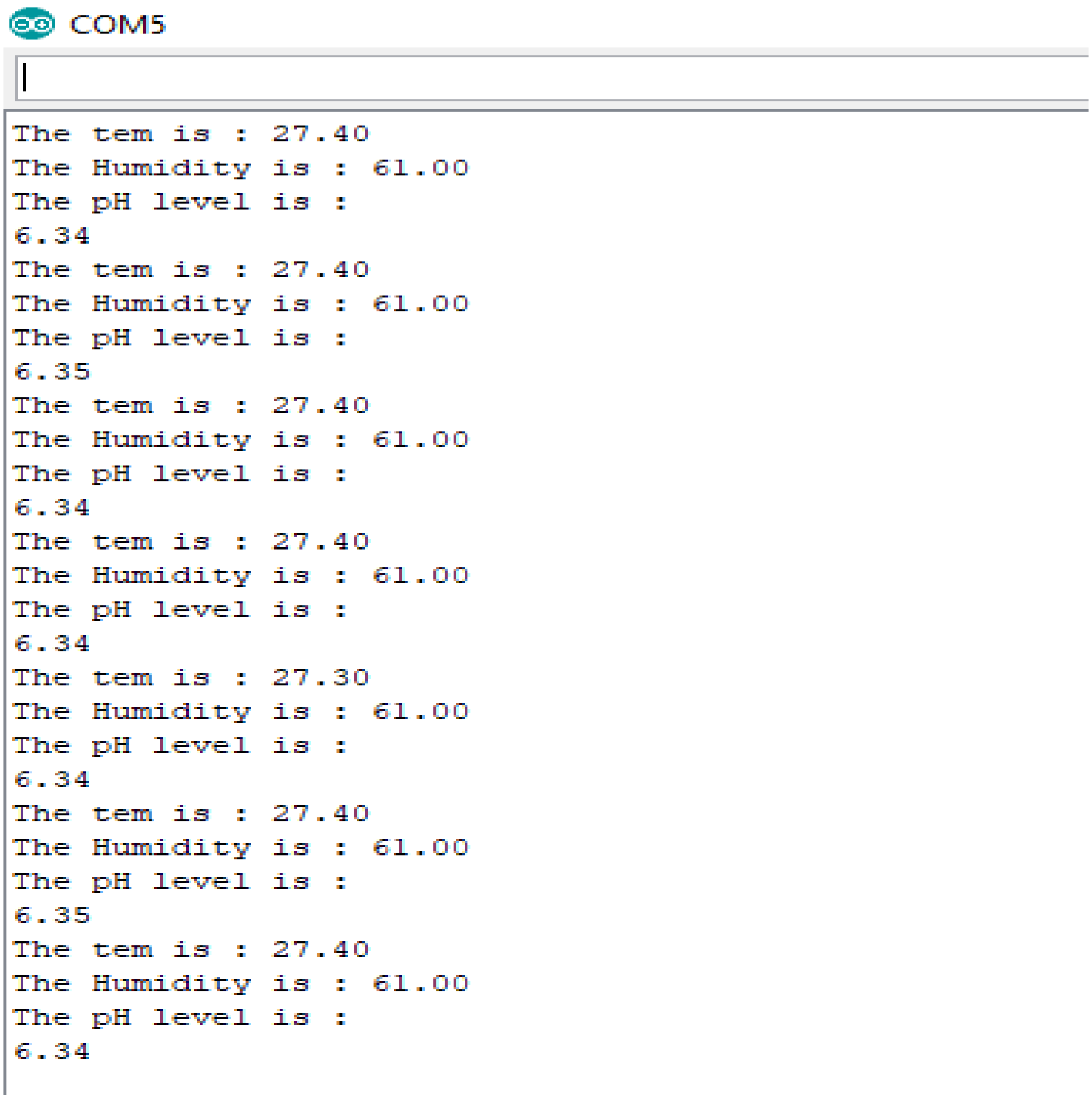

Fig 8: Serial output from the Arduino Board

Arduino board is connected to the computer through the com 5 port, and information gotten from the sensors are printed to the serial monitor using the Serial.print() keyword. Fig 8 shows the data gotten directly from the sensors before any form of modification/processing are performed in the data.

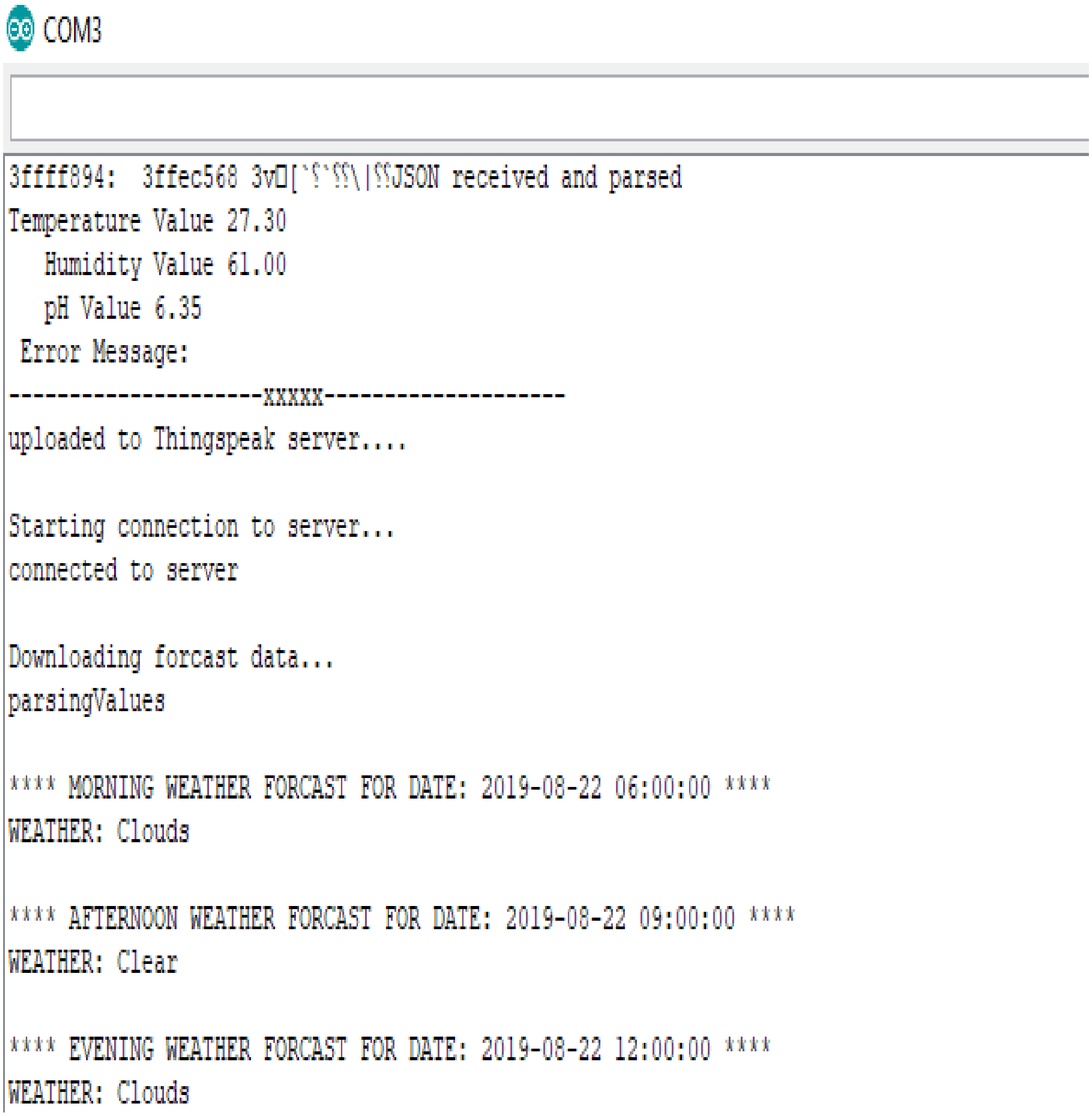

Fig 9: Serial output from the NodeMCU Board

Information gotten from the sensors through Arduino board are transferred in JSON format to the nodeMCU board through serial communication between both boards. Fig 9 above, shows the sensors data as well as weather data gotten from the 'openweathermap' API. The sensor and weather information are printed to the serial monitor using the Serial.print() keyword.

9.0Thingspeaks Cloud (Visualization and Data Store)

Thingspeaks is an IoT cloud platform for the transfer, storage, and processing of IoT sensor data transmitted to it. For data to be transmitted to this platform, a channel needs to be created. The channel gives a unique API needed to read from and write to it. My thingspeaks channel gets the temperature, humidity, and PH data from through the API, stores, and provides a visual representation for the data. Below are the screenshots are taken from my channel for visualization of the sensor data.

9.1Temperature data

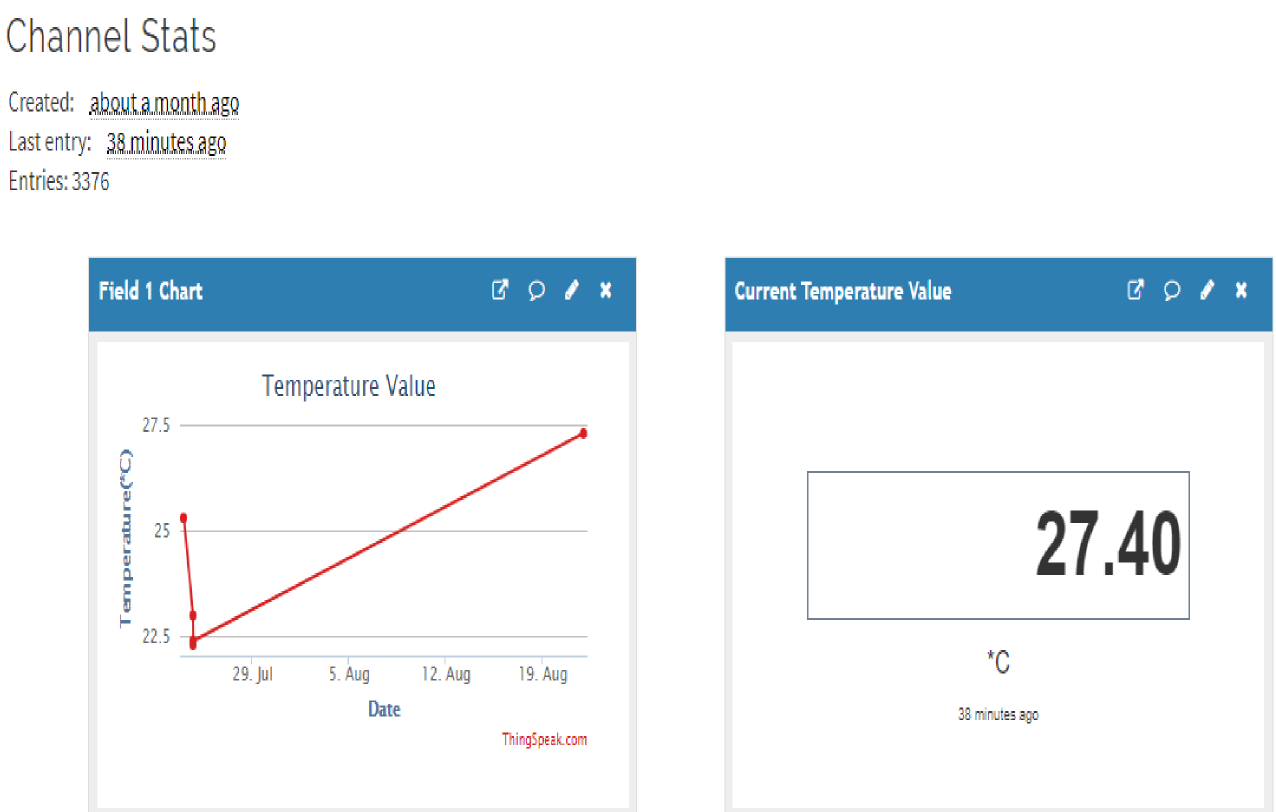

Fig 10: Temperature dashboards

Fig 10 provides a graph of temperature against data and time. The view on the right side represents the last value transmitted to the channel at every given time. The channel receives data every second.

9.2Humidity data Visualization

This provides the visual representation for the humidity data received from the temperature sensor. The red side of the dashboard is the none acceptable range while the green side is acceptable.

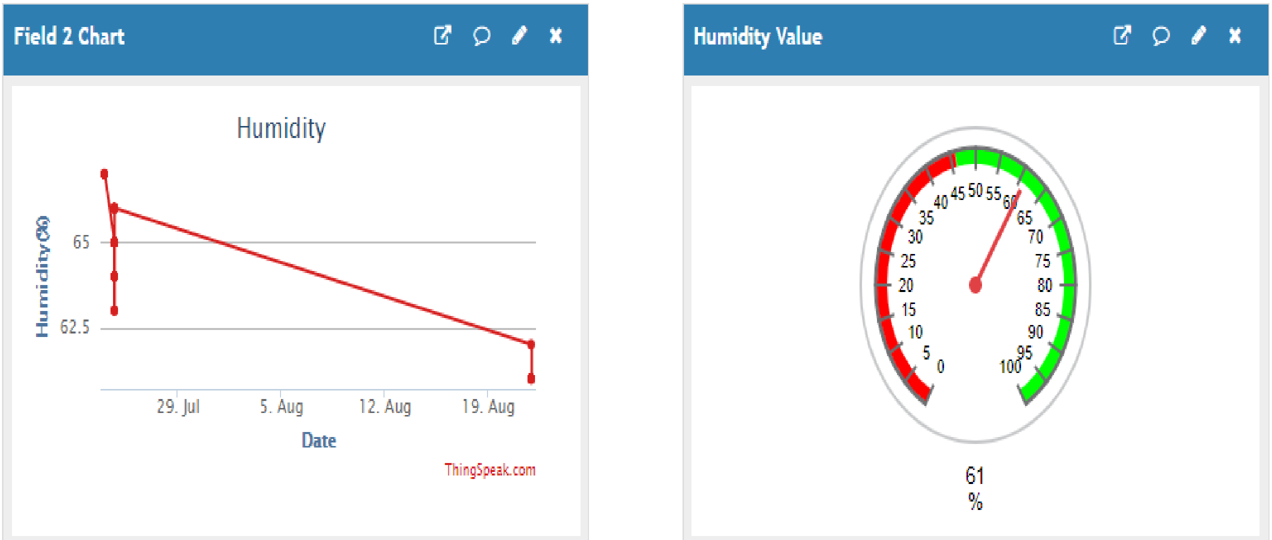

Fig 11: Humidity dashboard

9.3Ph Value data

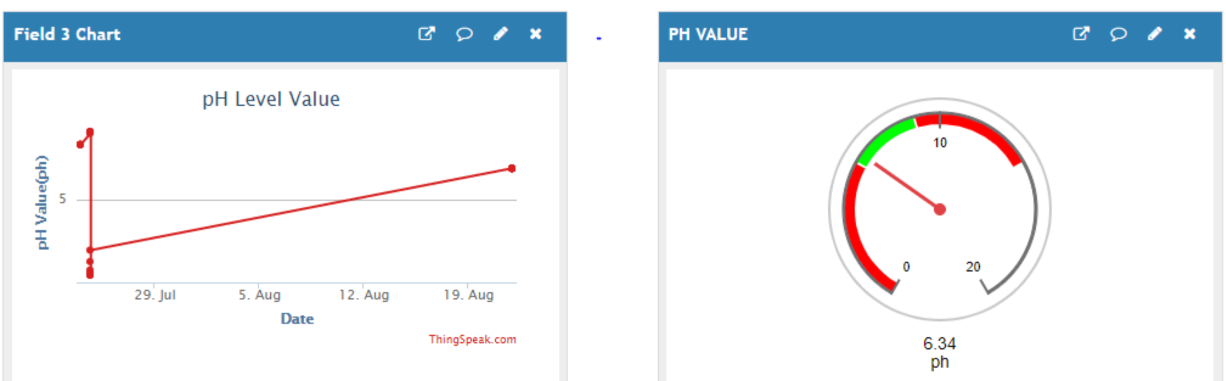

Fig 12: PH dashboard

Fig 12 graph displays the PH value obtained from the PH sensor. The display by the right shows the current range of the PH value from the last transmitted data. The green region falls within the adequate amount of PH required for the fish to survive. The red region is either highly acidic and alkaline region.

10.0 Event Manager

Thingspeaks server provides the MatLab analysis component that monitors the data received from the sensor after every interval specified on the configuration of each parameter.

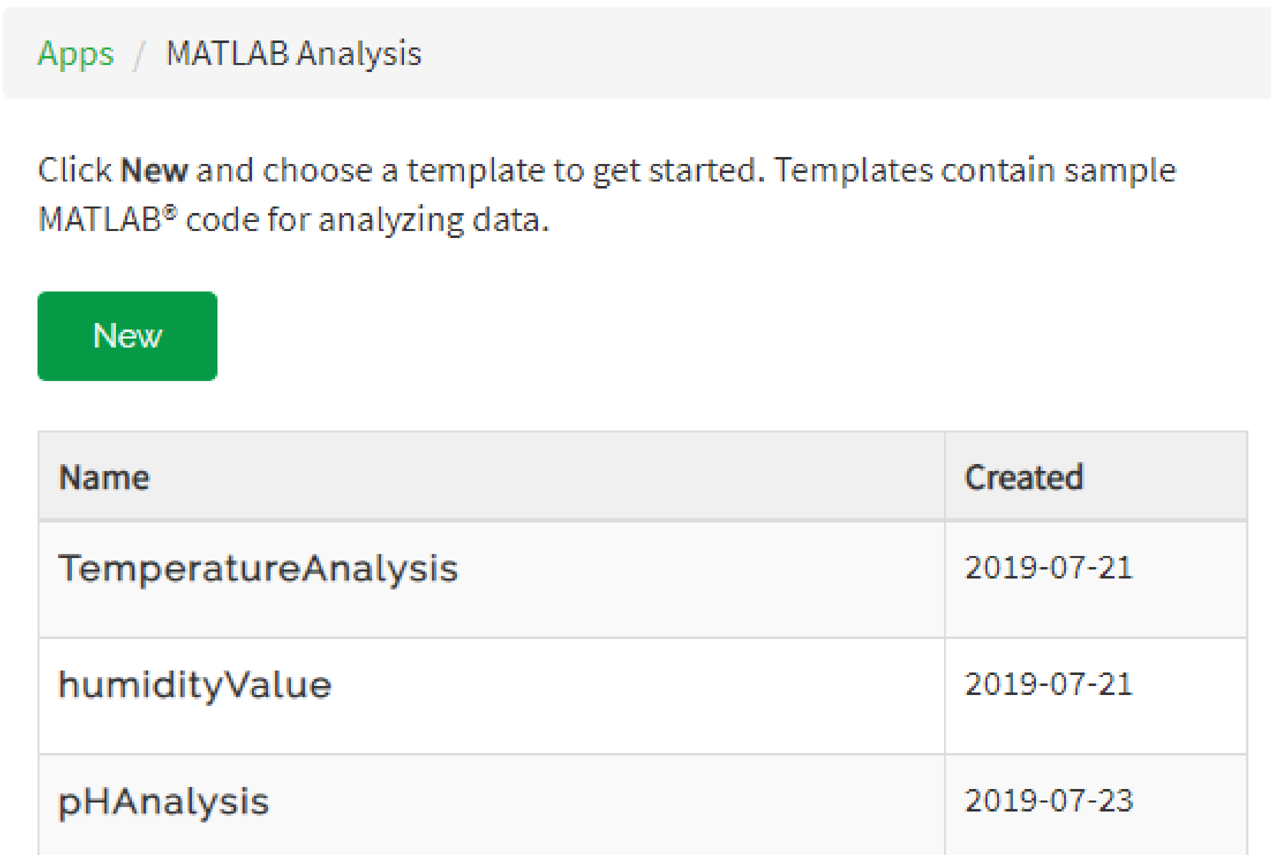

Fig 13: List of Events

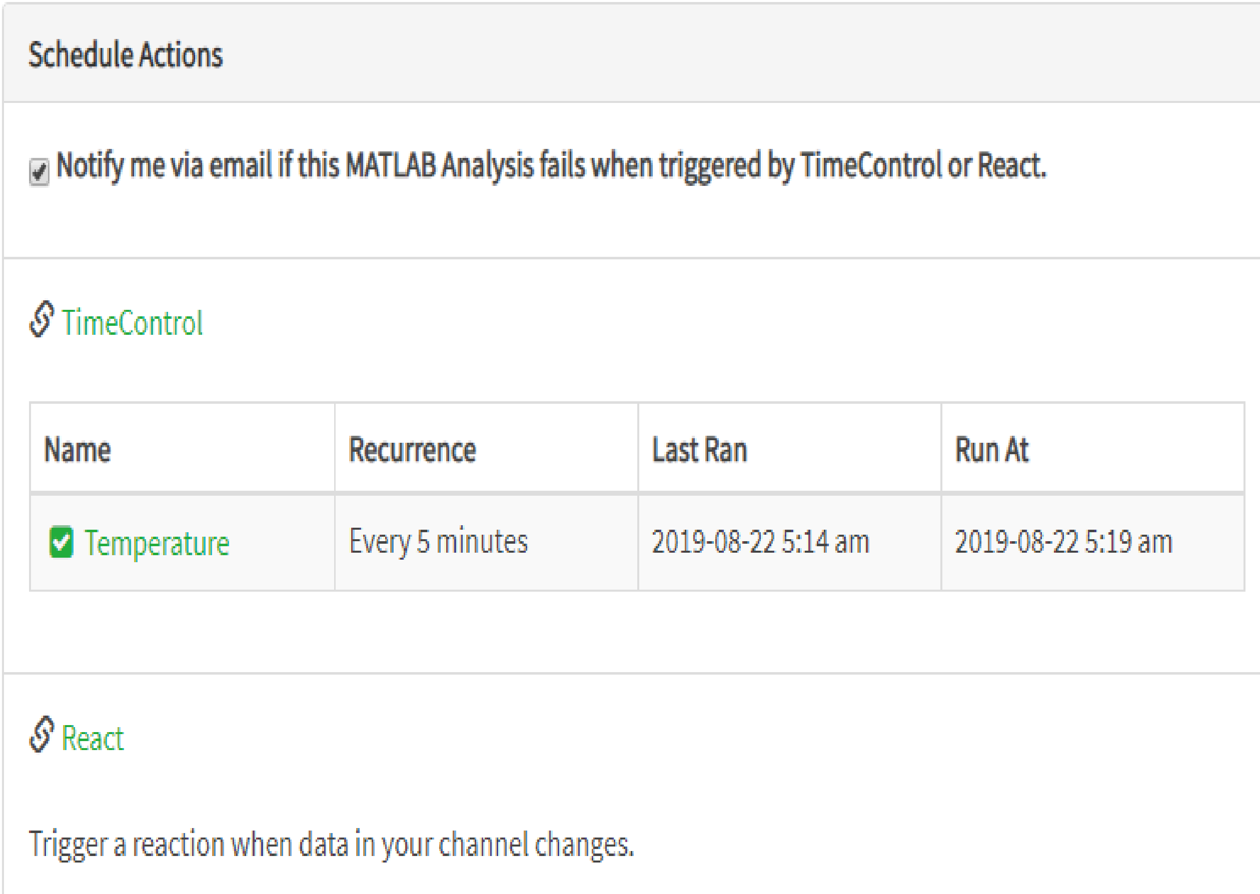

Fig 14: Sample Event

Each of the events executed every 5 minutes. Fig 14 shows the temperature event monitor that executed every 5mins.

10.1 IFTTT (Email Applets)

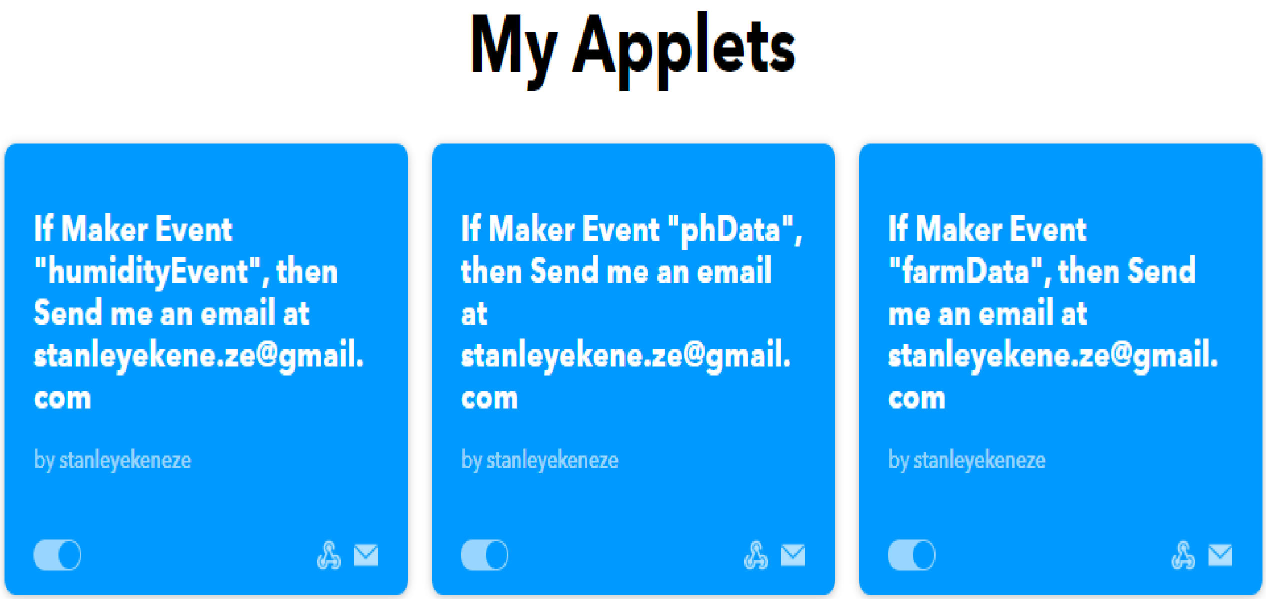

Fig 15: IFTTT Applets

It is important that the pond owner is notified of every activity of the farm, most especially when the activity would affect the farm negatively. This is why emailing component of this project is very important. When an event is executed in the thingspeaks MatLab analysis dashboard, there should be a way of analyzing such event to see if notification needs to be sent. IFTTT provides a service that enabled me to create an applet that monitors thingspeaks and perform a certain action (sends an email) if there is a need for that. This applet monitors the temperature, humidity, and PH value to see if they are above or below the required range. In the event of a parameter exceeding the required range, the applet sends an email notification to the pond owner.

10.2 Sample Email Notifications from IFTTT applets

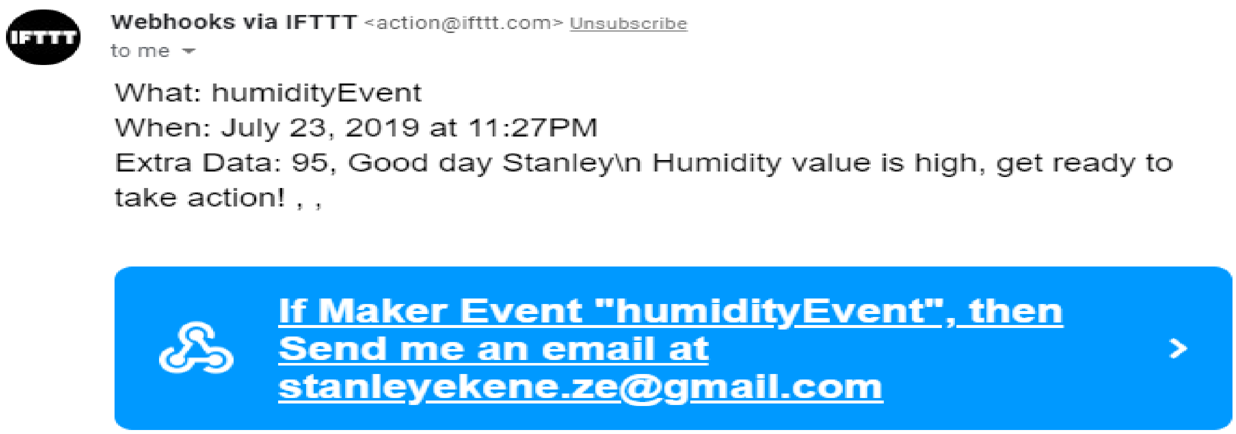

Fig 17: Sample Humidity Email Notification

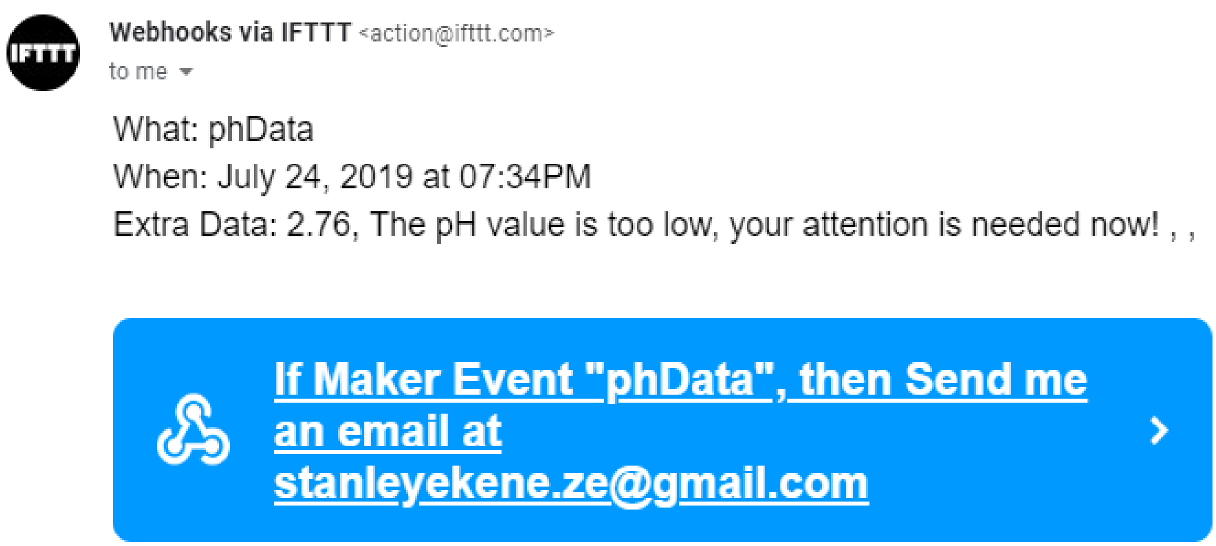

Fig 18: Sample PH Email Notification

11.0 Conclusion

It is obvious that IoT technology is becoming necessary in every aspect of life. It is one of the fastest-growing areas of agriculture in terms of automation. This IoT project only focused on capturing data and transmitting to the cloud and also notifying the farm owner of a certain situation if necessary. As the world is moving towards data utilization and artificial intelligence, incorporating AI into the IoT in fish farming management would be a good idea. This involves using some supervised and unsupervised machine learning algorithm to dictate and predict the well been of the fish. I hope to work on this in the future, and also perform actions with the use of some actuators.

12.0 References

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Appendix A

I uploaded the implementation codes(Arduino and nodeMCU code) on below GitHub link.

https://github.com/kenstufsz/Fish-Farm-Monitoring/tree/master/ArduinoCodes-IoT