Autonomous Aquatic Rover for Water Quality Testing and Helping in Fish Farming

BRAC UNIVERSITY

Inspiring Excellence

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DECLARATION

Thesis Submission to the Department of Computer Science and Engineering, BRAC University, Dhaka, submitted by the authors for the purpose of obtaining the degree of Bachelor of Science in Computer Science, and the degree of Bachelor of Engineering in Computer Science and Engineering. We hereby announce that the results of this thesis are entirely based on our research. Resources taken from any research conducted by other researchers are mentioned through reference. This thesis either in whole or in part, has not been previously submitted for any degree anywhere.

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ABSTRACT

Nowadays we know that water pollution is very much common in Bangladesh. Waste from industries and rubbish dumping are two of the major sources. This causes much harm to farmers in their marine agriculture since it very largely hampers the quality of water and affects fishes. This is a very serious issue and need to be solved.

Our focus is on rural areas. We chose this because fish farming is mainly popular in villages. Our team aims to solve these problems by building a rover which will help test the quality of water and detect water pollution. We will do so my measuring the pH level and the Temperature. This will determine the acidity or alkalinity of the water, and the availability of salts underwater. By sensing this we will get different readings of pollution in different areas. Thus we will know which areas are good for what type of marine farming. By this we can make awareness of the problem which will help reduce pollution in the future.

The task that we endeavor to accomplish is not an easy one. The robot must be capable of covering long distances withstand water currents and other underwater barriers like drifting objects and marine life interactions. Maintaining a steady connection with the satellite and synchronizing with the host server is also challenging.

Our mission will have a significant impact on the fishing industry. Farmers will know where to fish, and what type of fishes they should agriculture and in what areas. Fishes will be chemical free and hence the people consuming it will also be not affected.

ACKNOWLEDGEMENT

The idea of this thesis project came to our team mate Rahatul Amin Ananto. We thought about it and discussed it with our supervisor Dr. Amitabha Chakrabarty, Assistant Professor of the School of Computer Science and Engineering of BRAC University. He thought we were worthy of this project and encouraged us to go along with it. All of us – Anas Shahab, Md Jahan Ali Shohan and Rahatul Amin Ananto have contributed our level best for this thesis with unmeasured perseverance and extreme tolerance.

We would like to heartily thank our supervisor Dr. Amitabha Chakrabarty, Assistant Professor of the School of Computer Science and Engineering of BRAC University, immensely for his continued support. Without his guidance this thesis project would not have been possible. We are honored that he allowed us to work under his supervision.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Water is an essential part of our lives. It is needed for us and all the other living organisms for sustaining their lives. More than 70% of Earth is covered by water. Water and water bodies, like ponds, lakes, rivers, oceans and seas have been playing its part since the beginning of life and has also been a key part of a civilization. Water bodies are houses to many aquatic animals, mainly fish. Fish farming has been around since the beginning and has become a very crucial part of an economy.

Bangladesh is a land of rivers. The fish farming sector of Bangladesh is huge and plays a big role in export businesses. It helps improves the economy of Bangladesh. Autonomous Aquatic Rover for Water Quality Testing and Helping in Fish farming is our thesis project where we have built a rover that determines the quality of a water body. With the sensors connected, it checks the parameters required for fish farming and gives us a tabular and graphical view of whether a water body is suitable for fish farming or not.

Water pollution has been a big problem for the society as well. It promotes sickness and death. Pond water and lake water is being used by the rural people for their everyday use. Using our rover, and the data we have collected, we can determine if the water that they are using is safe.

1.2 Motivation

We wanted to contribute to the society using the knowledge we have achieved from our university. We wanted to do something for the people who are being affected by illness due to the water bodies being polluted. At the same time, we wanted to help the economy of our country grow by increasing fish farming by identifying the water body that can favor the process.

Project based thesis is very exciting. Since we have done our works in robotics sector before, we wanted to take it a step further. We wanted to meet the challenges and problem that water can impose on us and face it head on.

1.3 Thesis contribution

This thesis can contribute in the fields of fish farming. We can send our rover to water bodies that are not reachable by humans and we can also send it under water. We have done all of these at a much lower expenses. The sensors that we have connected are dedicated in measuring most of the parameters that are required to ensure that the water condition is safe for farming fish. With the camera attached to it, we can see the clarity of the water as well.

We are measuring the pH, temperature and conductivity of the water. These can be used to determine if water is polluted or is it safe for use.

1.4 Problem statement

Making a rover is not easy. We have faced a lot of problems while making it. One of our biggest challenges was waterproofing it. In fact, this was the most dangerous challenge of all since leakage of water can easily damage all of our equipment. The next challenge was to balance it. We needed to keep equal balances on both sides and at the same time we had to balance it in such a way that with the slightest of force, it can sink and get up as well.

Communications under water is difficult. Wi-Fi gets disconnected when our rover submerges under water. Of course there were problems managing the sensors. We couldn't regulate the current properly and thus we burned our micro-controllers and one motor shield.

1.5 Solutions

We first used silicon to seal our rover but it proved to be ineffective. We then moved on to metal epoxy and it was suitable to our needs. We changed our entire previous model and made it more aerodynamic shaped. In order to balance it, we took the center of gravity of our frame and placed the big motor with the fan in it. We also put equal masses on all the sides to make it perfectly balanced. The details of the architecture will be described later on.

In order to ensure communication, we have used long cables and at the end of it, we have used an extended Wi-Fi dongle. If the built in Wi-Fi in our processor board fails, we can use the secondary which will be above the water. For the sensors, we have calibrated it properly, so that any error in reading can be checked by educated estimation. Previously, we have been supplying unregulated current, which was burning our micro-controllers and motor shield. We then ensured that the current was regulated well.

1.6 Methodology

In the literature review, we will see that rovers such as ours have been designed previously. We are using the similar principles but we are narrowing it down, making it smaller and with less expense. Our rover can submerge up to 10 feet under water and can take the readings of the water conditions. It can also record with our 4K Handy Cam, clear image of the clarity of the water. Since this is a prototype, we focused less on the autonomous part and focused on data gathering and sending it to our database along with the location. The readings can be viewed from the ground station on the shore and also in an app of the registered moderator. The pH sensor can measure the pH of the water. If the water is too acidic, or too basic, it is harmful. It is both polluted and not possible for any fish to survive. We are also taking the conductivity reading and also the temperature of the water. The readings are then sent to the database, with the current location of our rover and create a graph for easier visualization. It can also show how the readings are changing overtime until a constant reading is taken.

Since this is a prototype and we have been successful in running it effectively, we are also putting forward hypothesis. Our rover can be used for 3-D mapping the entire under water using LIDAR. Moreover, it can be made autonomous as well.

1.7 Summary of contributions

The work presented in this thesis contributes to improving the quality of fish farming in our country. The details of our rover are already present later in the paper. This is the future of initiation of fish farming of the country and is affordable at a much cheaper price. We have built the properly working prototype and have opened a vast field of work for the future. Drones and rovers are now the most used research and making subjects. Our initiation can lead to further improvement of our rover and the efficiency can be improved by a greater amount.

Moreover, further accurate and efficient reading can be taken from our rover by using more sensors in the future works and thus, more contribution to water pollution reduction and fish farming can be made.

1.8 Goals

The main objective of our thesis project is to aid in fish farming and reduce pollution at a much cheaper price. The readings that can be taken using our rover can be processed and predicted future pollution probability. We are opening a field in machine learning as well. We can use more sensors, like the DO sensor and Ammonia sensor to see the levels of dissolved oxygen and ammonia in water that is important in fish farming. We can map the entire underwater surface and this can open another field in image processing as well. All these can be done in a very cheap price because at the end of the day, our goal is to improve efficiency at a lower price.

1.9 Thesis outline

Chapter 1 gives a brief overview of what we are doing, what we plan to do and what are our problems and achievements.

Chapter 2 is the research analysis and discusses about the previous work that has been done in this field. It analyzes the data and readings we have achieved from our rover and discusses about the research that we have done for properly executing our goals and plans.

Chapter 3 describes the algorithm and system architecture. It gives a detailed description of how we have established the communication with our database and shows our system in terms of hardware and software.

Chapter 4 is the research analysis. It analyzes the data and readings we have achieved from our rover.

Chapter 5 is the conclusion of our thesis and the future work.

CHAPTER 2

RESEARCH AND LITERATURE REVIEW

2.1. Literature Review

Many have built underwater robots before us. We got our first inspiration from an oceanographer, David Lang. He built a small prototype to help underwater explorations. As we began our research we came to know a robot known as Autonomous Underwater Vehicle (AUV) was made at the Applied Physics Laboratory at the University of Washington. This was used to study diffusion, acoustic transmission, and submarine wakes. Furthermore a unique robot known as Global Explorer ROV was made by Chris Nicholson of Deep Sea Systems International, Inc. of Falmouth, MA. This is being used to collect live specimens as well as photographs and video of unusual and unfamiliar specimens. Furthermore we found that Scorpio is a brand of underwater submersible Remotely Operated Vehicle (ROV). Originally developed by AMETEK Straza of El Cajon, United States, it was subsequently developed by Perry Tritech. It was used by sub-sea industries such as the oil industry for general operations, and by the Royal Navy and the United States Navy for submarine rescue services. All these opened our minds to new possibilities. We thought why not make an underwater robot for some other purposes which will benefit the society as a whole. Thus we had the idea of Autonomous Aquatic Rover for Water Quality Testing and Helping in Fish Farming.

2.2. Proposed Working Principle

The Autonomous Rover will work more like a companion rather than an intelligent machine. We will measure all the required measurements manually beforehand. We need to go to a desired position of the water body, collect samples of water and then bring it over to test it by pouring chemicals and by other methods. But this rover will be able to intelligently move around the water body taking readings from all over the place and updating its database all on the go.

The Rover will comprise of 3 sensors namely a pH Sensor, a Temperature Sensor and a Dissolved Oxygen Sensor. It can also be equipped with an Ammonia Sensor, a Conductivity Sensor and many other sensors to read different information about the water. The Rover will be able to measure all these using the sensors which are connected to an Arduino Mega. The Arduino will be connected to a Raspberry Pi which has an external memory of 16GB. All the readings will be measured and then the Arduino will send data to the Raspberry Pi and the Raspberry Pi will store every data according to its time of reading. This will help to sort out the data easily when it is needed.

One of the features of our application is it will be able to show the data in a 3D graphical view according to the size of the water body. As the position of the rover underwater is not possible to measure perfectly we will come up with an algorithm which will be able to visualize the data as we want. The algorithm will consist of 2 variables. They are Left and Right. Whenever the rover detects something blocking its way it will turn left or right according to its system. It can detect these with micro switches attached to its body. If there is something blocking the right path it will turn itself towards the left and increment the Left variable. If it turns right it will increment the Right variable. So when we put the data on a graph we can visualize the data by determining the X-Axis and the Y-Axis.

The Rover will collect data for a certain amount of time and then it will resurface and establish a connection with the server with its GSM module or Wi-Fi. After making a connection it will upload its data to the online database and these data can be processed to show visually on a personal computer or a mobile application.

The Rover will be a bit larger than we want it to be because it will be a prototype for now. But when we will make the Rover for commercial purposes we have a plan to make it a pocket sized rover. This will enable it to just be tossed to the water body whenever we want and it will not consume much power to operate. There will be charging stations floating on the water consisting of Batteries and solar panels. The batteries will be charged with solar panels and whenever the Rover needs to be charged it will come towards the charging station and connect itself on a magnetic port. So there is no hassle in charging the Rover whatsoever.

Another plan is to make plenty of rovers work alongside as swarm robots so that the measurements can be taken more quickly and the data can also be processed quicker than before. These rovers will be able to communicate among themselves and work along side by side on different depths of the water body collecting different information simultaneously. It will basically be a smart monitoring system for smart fish farms.

Our first approach would be introducing these on commercial purposes to the NGO's of our country who will have the rovers in the first place. They will introduce these by using it on other fish farms. By this the fish farmers will be able to know the importance of the device. After the successful launch in the national market we will start our journey for the international market. The main goal is to make a product which is sustainable in harsh conditions and weathers. It needs to be user friendly and also eco-friendly at the same time. The Rover will be made from recycled plastics. 3D printed models will be used in producing the Rovers.

2.3. Present working principle

The rover, at present, in not autonomous. It is because it is the first prototype of our thesis. We wanted to keep the rover in control manually so that we can be able to move the rover intentionally to where we want the rover to be via a handmade analog button controller which is attached to the Arduino mega with an Analog pin of the Arduino. The analog button module is helping the rover to be controlled from the surface.

The rover can get GPS co-ordinates via A Geo 6m-0-001 GPS module. The GPS module looks for any geostationary satellite above it. If it finds any satellite it connects with it and gives many types of values, such as Latitude, longitude, Altitude, and many more. When the rover is taken out for testing, it can detect a nearby satellite and save its position of each second and store it in the raspberry pi as a text file which will eventually be uploaded to the database once the data has been finished taking.

Fig 1. GPS Module

Fig 2. Temperature Sensor

We used a pH Sensor Kit –E-201 for measuring the pH value of the water at different depths. The pH sensor is basically made of a glass membrane. Silver AgCl wire and reference electrolyte is inside the glass probe. Every solution got Hydrogen ions. Acidic solutions have more rather than any alkaline solution. The pH probe can measure the voltage difference or the potential difference of the solution and measure what the pH value of the solution is by that information.

Another sensor that we used is a waterproof temperature sensor. A temperature sensor may be a device, typically, a thermocouple or RTD, which gives for temperature estimation through an electrical sign. A thermocouple (T/C) will be aggravated from two different metals that produce electrical voltage clinched alongside immediate extent to progressions to temperature. When the voltage increases, at that point those temperature ascents and there is a voltage drop between the transistor terminals about base & emitter, they would be recorded eventually by the temperature sensors. Whether those Contrast clinched alongside voltage is amplified, the simple indicator may be created toward those gadget and it may be specifically proportional of the temperature.

At the moment we only used these because of our short budget but we can eventually use many more sensors and gadgets alongside our previously used ones. All the data from these sensors are taken with an Arduino Uno which is connected to a Raspberry Pi 3. Here the Arduino Uno is working as a slave and the Raspberry Pi 3 is the master who is controlling the Arduino. The data is transferred from the Arduino to the Raspberry Pi through serial connection. These data are then printed on the serial monitor of the Raspberry Pi’s interface and saved in a .txt file. The Raspberry Pi is programmed with an APK of ThinkSpeak. ThinkSpeak is an online IoT database. In this database it is very easy to upload all the data taken from the sensors of our Rover and visualize them properly as we want them to be shown to the users. By doing this we can view the data from our smartphone also. So it is very convenient to use an online database like this for this type of IoT based projects.

All the data then gets analyzed on the website and the results are then shown in charts, tables, 3D models and many more. By doing this we are able to know the water quality of the selected water source and we can be able to conclude if the water is suitable for any fish to live, what type of fishes can live there and how can we be able to improve the water quality more. If the pH level is more then we have to add some Sodium bisulfate (also called dry acid) and muriatic acid. If the pH needs to be increased then we can use baking soda or many other chemicals that are not harmful for fishes to live in.

Fig 3. pH Sensor

Fig 4. Thingspeak Website

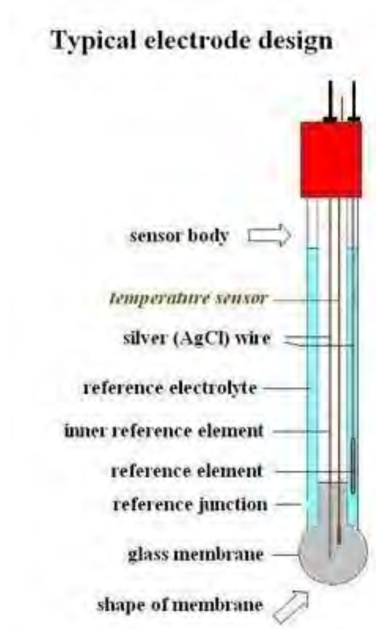

Fig 5. pH Design

2.4. Circuts

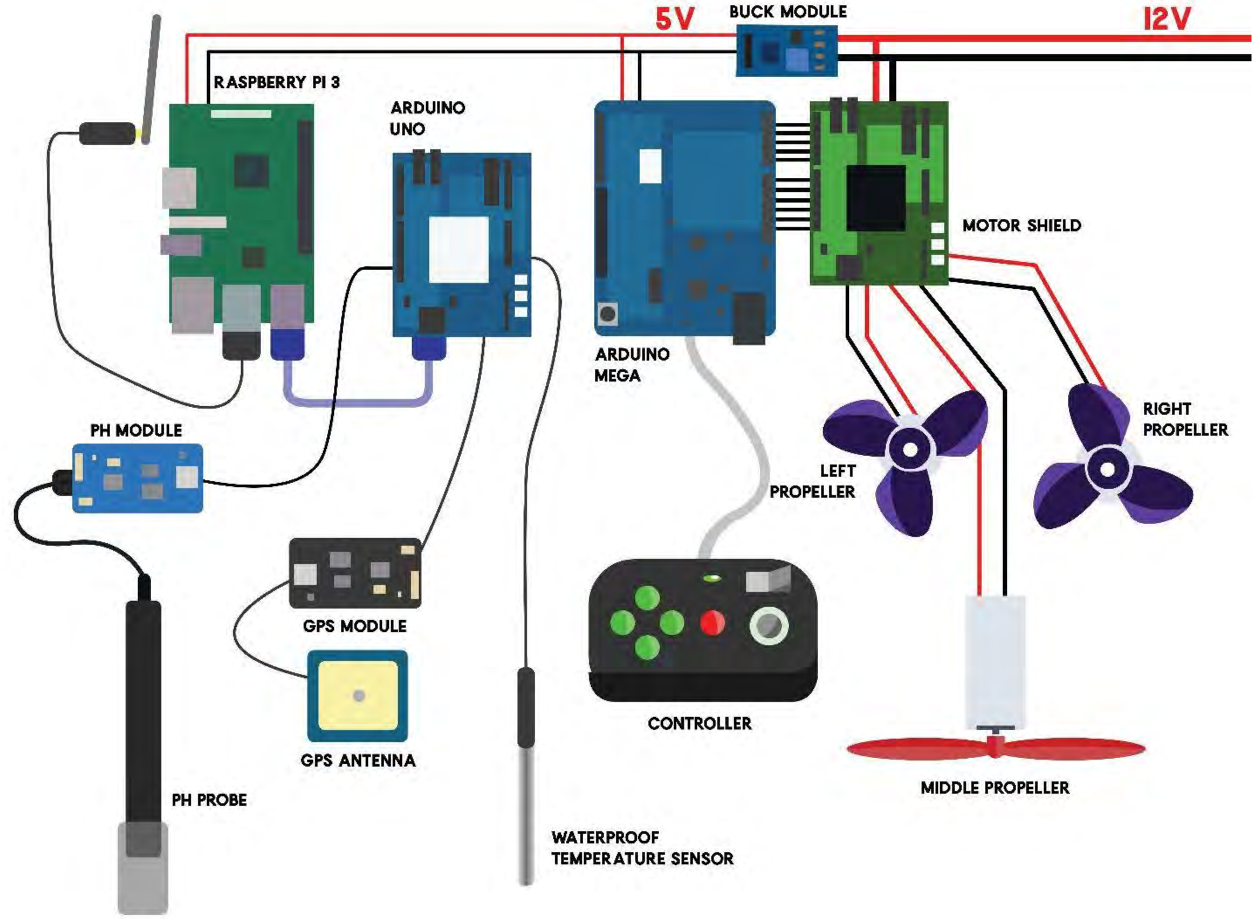

Fig 6.The block diagram of the circuit of the rover is given

2.5. Circuitry Explanation

2.5.1. Motor Control Unit:

We used an Arduino mega and an Adafruit motor shield for controlling the motors. The purpose of using the Adafruit motor shield is that, there are libraries for this particular motor shield which can be easily imported and the codes become less stressful and fast. The motor shield is powered up by an external 12V power supply since the motors that we used are of 12V. This 12V power supply turns the motor shield on and the motors get the desired power from the shield. But to power up the Arduino Mega we have to use a buck converter to convert the 12V power supply to 5V, since Arduino can't handle 12V power supply and it may burn down if provided. The motor shield can be attached directly to the Arduino Mega from the top. The 5V power supply turns the Arduino Mega On and the motor shield now can get information of how to spin the motors from the Arduino. An analog button controller is connected to the Arduino Mega. This particular button controller got 3 pins. One is VCC, another one is Ground and the last one is ADC. This pin is an analog pin and needs to be connected to the Arduino to send commands.

A potentiometer is also attached in the controller to increase and decrease the speed of the middle propeller to make the rover go upwards or downwards underwater. This also sends an analog signal to the Arduino.

Fig 7. Potentiometer

Fig 8. Analogue Button

Fig 9. Motor Shield placed on Arduino MEGA

2.5.2. Sensor Unit:

The Raspberry Pi 3 is powered up with the 5V input coming from the buck converter. Since Raspberry Pi 3 needs 5V and minimum of 2mA of power to boot, the buck converter comes in handy. The buck converter can give a constant output of 5V and 2mA. Even if there is a spike in the voltage, the buck converter takes the whole load of that spike and saves anything that is attached to it. So by using this we are actually having 2 benefits. The Raspberry is getting the exact amount of power which it needs to operate and safety from voltage spikes.

The Raspberry Pi is then connected to an Arduino UNO which is powered up by the Raspberry Pi's serial communication port. The Arduino UNO can also be given an external power source if necessary when more sensors would be attached to it. The pH Probe, GPS module & the temperature sensor is connected to the Arduino Uno. The Arduino is coded perfectly to get all the information from the sensors.

The pH sensor probe gets attached to a pH module. This module got 3 output pins. VCC, Ground and Data. VCC and Ground is provided from the Arduino Uno. The data pin gets connected to a digital pin of the Arduino since the pH sensor is a digital sensor and it sends out digital data.

The GPS module got 4 pins. VCC, Ground, TX & RX. The VCC and Ground is provided from the Arduino like before. But the TX from the GPS module is connected to the RX of the Arduino Uno. The RX from the GPS module is connected to the TX of the Arduino Uno. TX refers to Transfer and RX refers to Receive. So the connection is like this because, the data which are transferred from the GPS module needs to be received by the Arduino. The data which are transferred from the Arduino needs to be received by the GPS module.

The Waterproof temperature sensor got 3 pins. VCC, Ground and Data. VCC and Ground is provided by the Arduino as usual and the data pin gets connected to a digital pin of the Arduino since the Temperature sensor gives out digital data signals. This data is then printed on the serial monitor.

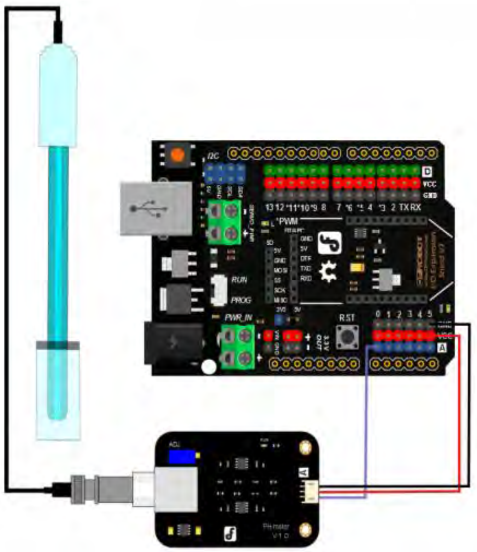

Fig 10. pH Sensor Connection

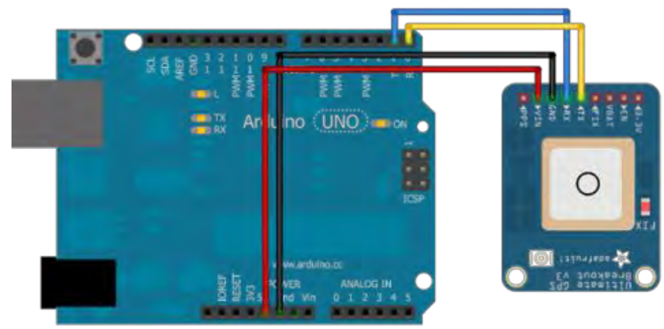

Fig 11. GPS module Connection

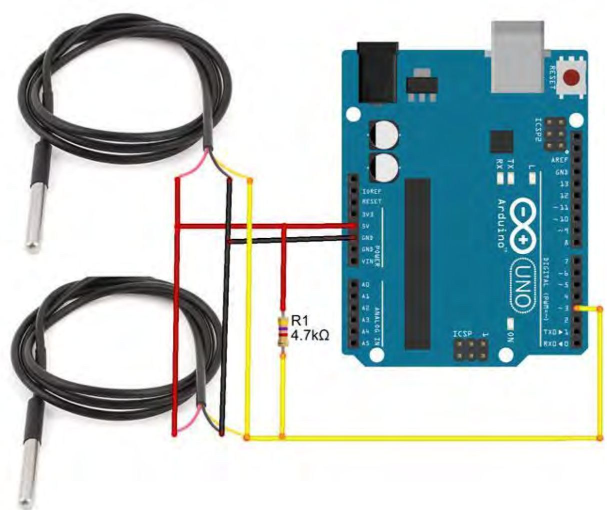

Fig 12. Temperature sensor connection

2.5.3. Serial Communication:

Previously we got to know that the Arduino is connected to the Raspberry Pi through the USB. The data which are read by the sensors are now being displayed on the serial monitor of the Arduino. These data are transferred to the Raspberry pi via a simple command and then these are printed on the script. These data are then transferred to the database which will be covered.

2.6. Things to keep in mind

These are some of the things that need to be kept on mind.

1. Arduino has to be powered up by 5V-8V maximum. Too much voltage will destroy the Arduino.
2. The Motor shield that gets attached to the top of the Arduino mega has a 9V pin which gets directly connected to the Arduino Mega’s Vin, which supplies the Arduino Mega with a voltage of 9V. This might be hazardous for the Arduino. Arduino will heat up and even catch fire. To solve this problem we need to cut the 9V pin of the motor shield and power the Arduino with an external 5V power supply.

Using Buck converter can be a very useful method to save your Raspberry Pi, Arduino and all the other components from burn

CHAPTER 3

ALGORITHM AND SYSTEM ARCHITECTURE

3.1 Intro to Architecture

The whole body of the rover has been built with materials which can be found easily anywhere near us. For the frame and body we used PVC pipes. The PVC pipes are connected with PVC connectors. The frame is designed in a way in which it can be able to take a lot of load as well as surf underwater very smoothly. The design can be improved more precisely for future applications if necessary.

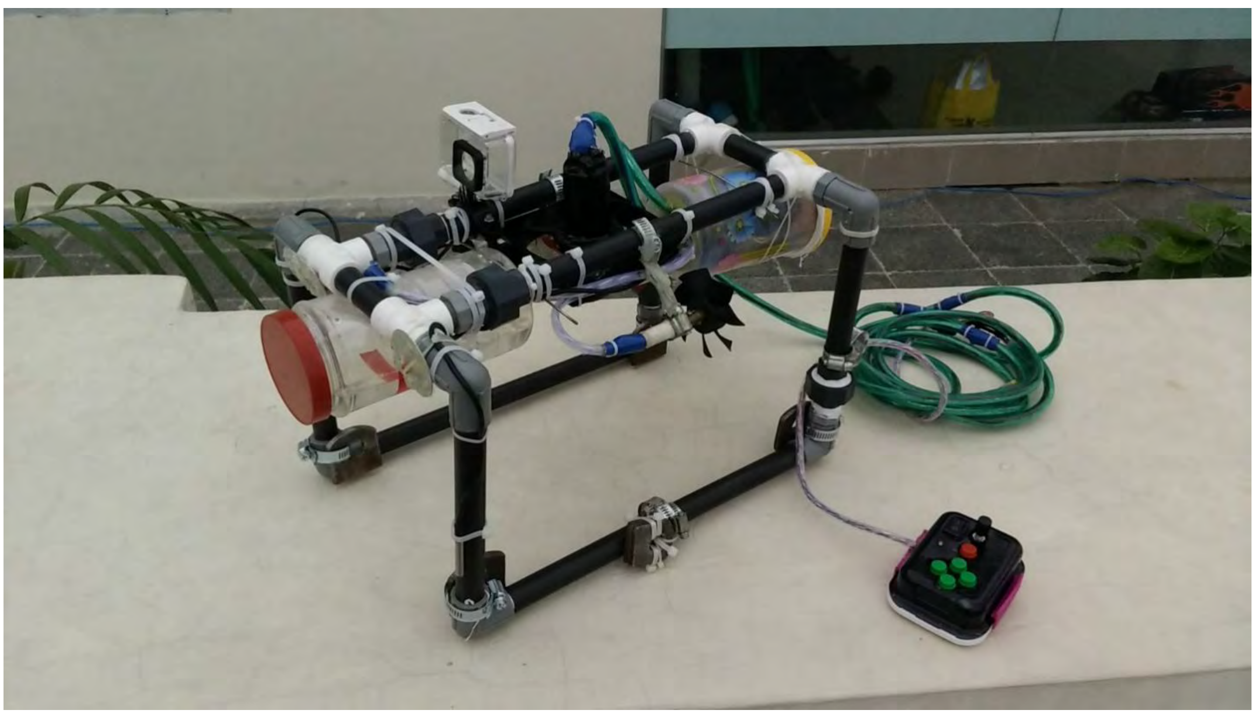

Fig 13. The body of the Rover

3.2. Materials Used

The reason we use PVC pipes is because these pipes are light weight and hollow inside. The hollow part contains air and the light weighted materials weight is almost cancelled out by the air inside. This helps the rover to float around easily.

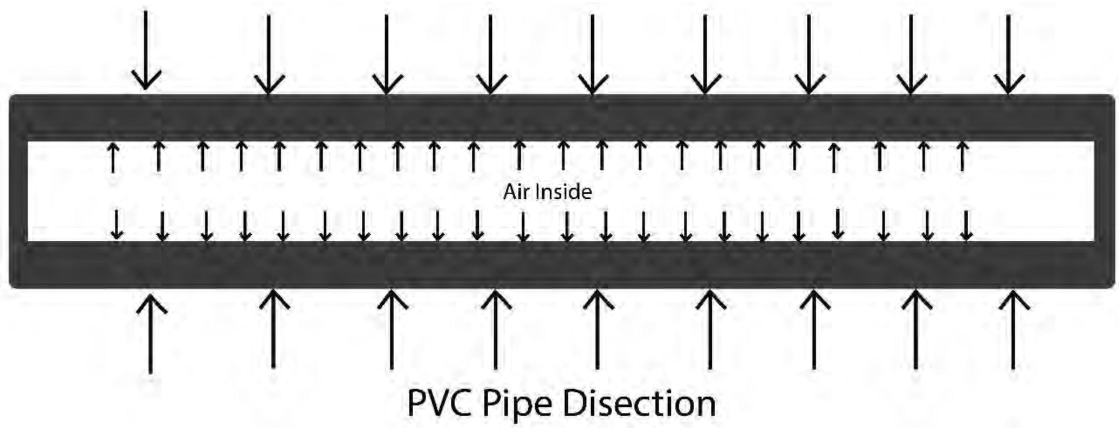

Fig 14. PVC Pipe Disection

3.3. Motor Functions

The motors are connected at the center of the Rovers body. We attached the motors at the center part because that is where the gravitational point is situated. By putting the middle motor at the very middle of the body we are actually making the Middle Motor capable of taking the whole load of the body precisely. By this way the rover won't tilt when the middle motor is being used to drag the rover downwards underwater, or else the rover might flip. The left motor and the right motor are also kept just beside the middle motor. By doing this we are actually making the rover more feasible in making sharp turns. Although underwater sharp turns are very difficult to make and for that we would require 2 more motors which should be connected to the body slightly turned towards the left and towards the right respectively for sharp turns. This can be added to the next version of the rover very easily. The right and left motors are doing 4 jobs. They are making the rover go straight by spinning clockwise. The rover will go right when the left motor spins clockwise and the right motor turns anti-clockwise. The rover will go left when the left motor spins anti-clockwise and the right motor turns clockwise. The rover will also go backwards if both of the motors are spinning anti-clockwise.

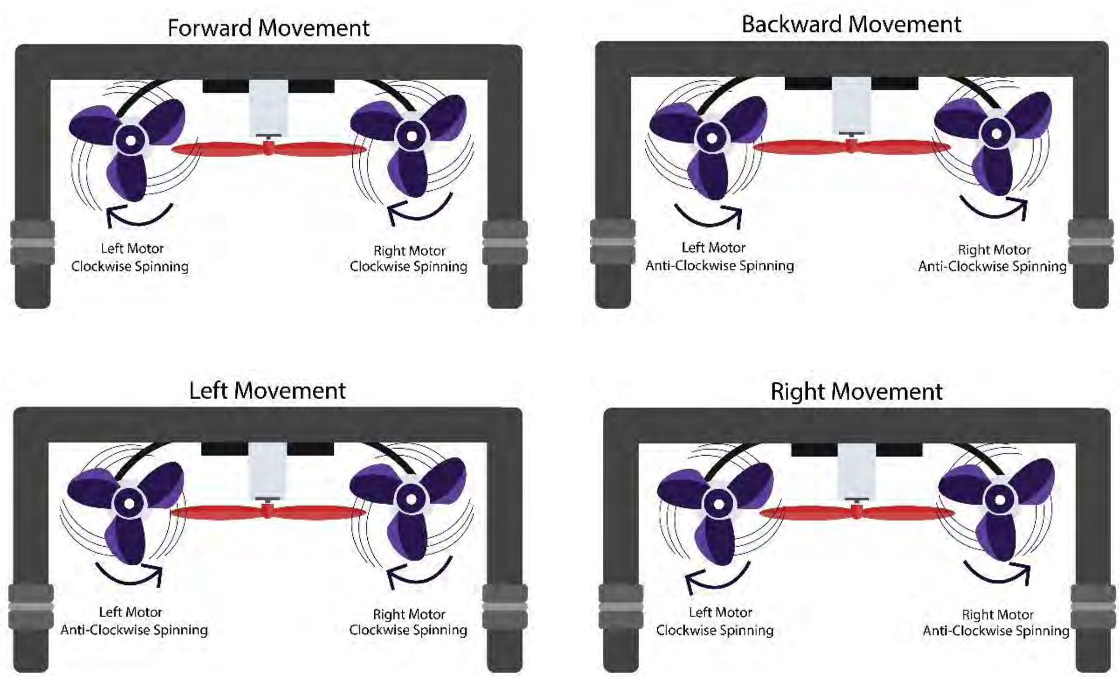

Fig 15. Motor Movements Explained

3.4. Components

All the components of the rover are kept in a plastic container right behind the middle motor. The container contains these components:

1. Arduino Mega
2. Motor Shield
3. Arduino Uno
4. Raspberry Pi
5. pH sensor Module
6. GPS sensor & antenna

These components are kept very tightly in the rear compartment and all the wirings are driven out through small holes at the back of the plastic container. The wires are taken out of the container through rubber pipes for easier insulation and water tightening the compartment. The holes are cut by measuring the thickness of the rubber pipes precisely so no additional tiny holes are helping the water to get into the compartment. We used Plus-Minus Epoxy glue to seal off the holes made for the wires. The glues are firstly mixed together and are made to react with each other which eventually hardens them in only 12 hours. So we applied the glue on the opening of the holes and set it to dry for 12 hours. Then after 12 hours we applied a second layer of the glue to make it more secure.

3.5. Buoyancy

There is another plastic container attached to the body. It is located at the front of the body. This container is there for buoyancy (the ability or tendency to float in water or air or some other fluid). Since we can open and close the container very easily we can also put in some water if we want to precisely do the weight management of the rover.

Fig 16. Attached container for Buoyancy management.

3.6. Weight Management

The first time when we got the rover underwater we saw that the rover keeps on tilting to the left. So we attached some extra weights to the right to cancel out the weight of the left. Eventually we had to attach some more weights to make the rover cancel out the upwards force of the water for the buoyancy of the whole body and also the downwards force for the gravitational pull. By doing this the rover seems like a feather on the water which can be easily moved underwater by simply giving it some small pressure by turning on the middle motor. The rover can be kept in a frozen position underwater by managing the speed of the middle motor properly.

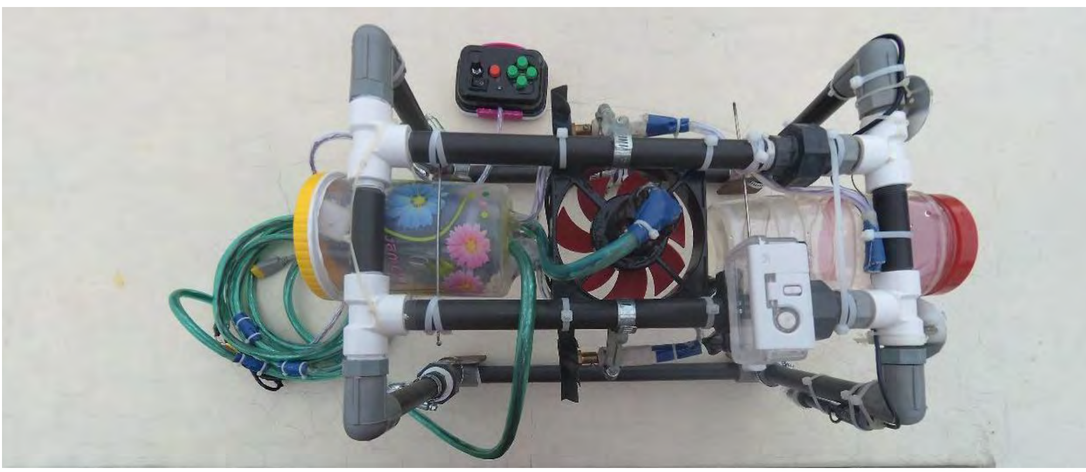

Fig 17. Top view of the Rover Body.

3.7. Outside Components

Only a long rubber pipe comes out of the rover to the surface. At the ending of the pipe there is the controller of the rover which is also handmade by cheap materials found around us. The control box got 5 buttons, 1 switch, 1 LED & a potentiometer. The black switch on the top right is used for turning on the whole rover which is indicated by the greed LED. The 4 green buttons on the left are used to steer the rover by controlling the left and right motors. The red button is used to turn on and off the LEDs on the rover body. The potentiometer plays a vital role in the whole project. It controls the speed of the middle motor of the rover. By controlling the speed we are getting the access to get the rover underwater and also to make the rover kept on a frozen position if we want. The rover is powered by 12V DC supply which can be supplied through a jack on the controller. A very convenient and safe way to power the rover and also making the rover light-weight because there is no onboard battery. If we had placed an onboard battery on the rover, then it might have exceeded the weight management criteria. But in the future version we are planning to set up onboard power supply to make the rover wireless and also autonomous.

Fig 18. The long pipe with the wires inside.

Fig 19. The Analog Button Controller.

3.8. Sensors

The pH sensor probe is attached on the front right leg of the rover which tie wraps so it can be removed if we want to upgrade or change the probe or if we want to calibrate the sensor more. The temperature sensor is attached to the front left leg of the rover, which is also connected with tie wraps and can be easily removed if we want. We have enough space on the bottom of the rover if we want to attach more sensors like the Dissolved Oxygen probe, Conductivity

probe, Ammonia detection probe and many more. The underwater camera is attached at the top of the rover. The camera is Wi-Fi enabled and can transmit footage wirelessly.

Fig 20. The rover body from the Front.

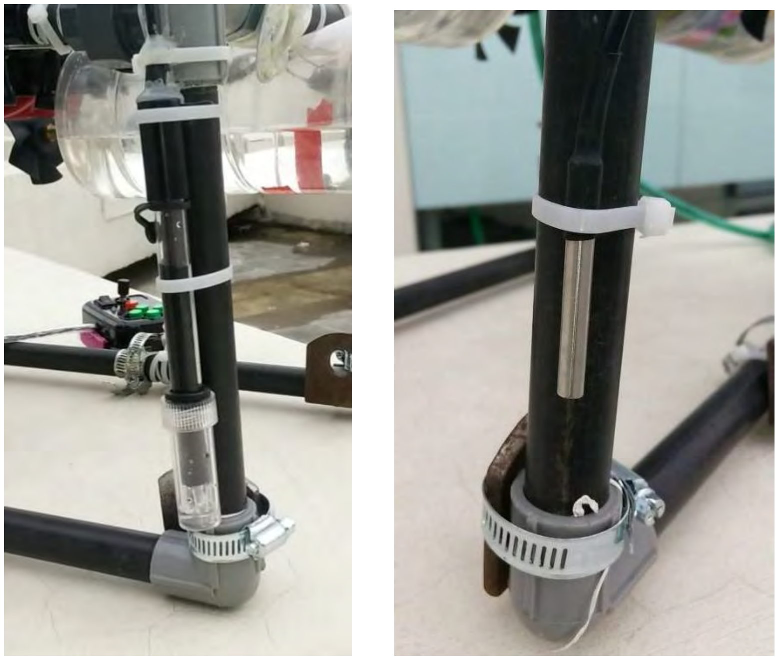

Fig 21. pH Sensor and The Temperature Sensor.

3.9 Proposed Algorithm:

Begin loop:

First ← 1

Middle ← 2

Last ← 3

READ-COORDINATES();

SAVE-INITIAL(latitude, longitude);

Begin while for five minutes:

START-SENSORS();

Latitude ← GPS.readLat();

Longitude ← GPS.readLong();

Print sensor-data;

```
            Print Latitude;

            Print Longitude;

            TAKE-SONAR-READINGS();

            Move ← 2;

            if(TAKE-SONAR-READINGS() == ∞)

                Go-FORWARD(Move);

            else

                if(TAKE-SONAR-RIGHT() == ∞)

                    Go-RIGHT(Move);

                else if(TAKE-SONAR-LEFT() == ∞)

                    Go-LEFT(Move);

                else

                    Go-BACK(Move);

                repeat START-SENSORS();

            END while;

        Motor-OFF(Middle);

        Send-DATABASE(depth);

        Go-To(Primary-Location);

        Motor-ON(Middle);

        Motor.Speed(High);

End Loop

repeat;
```

CHAPTER 4

SIMULATION RESULTS AND DATA ANALYSIS

4.1 Tabular Details of Readings

4.1.1 Clean Water Readings

Temperature	Voltage	pH	Latitude	Longitude
24.7	0	0	23.706	90.426
24.7	0	0	23.706	90.426
25	1.2	2.1	23.706	90.426
25.4	1.5	2.4	23.706	90.426
25.4	2	3.7	23.706	90.426
25.4	2	5.6	23.706	90.426
25.4	2.4	7.2	23.706	90.426
25.4	2.4	7	23.706	90.426
25.4	2.4	7.7	23.706	90.426
25.4	2.4	7.7	23.706	90.426

Fig 4.1a: Table of Data

Readings obtained from clean water are shown above in a tabular format. Initially the readings fluctuated as it took time for the sensors to adjust. Then they gave a steady data.

4.1.2 Pond water Readings

Temperature	Voltage	pH	Latitude	Longitude
25.4	0	0	23.706	90.426
25	0	0	23.706	90.426
24.7	0	0	23.706	90.426
24	1.3	1.8	23.706	90.426
23.6	2.3	2.2	23.706	90.426
23.6	2.3	4.9	23.706	90.426
23.6	2.3	6.8	23.706	90.426
23.6	2.3	6.4	23.706	90.426
23.6	2.3	6.4	23.706	90.426
23.6	2.3	6.4	23.706	90.426

Fig 4.1b: Table of Data

Readings obtained from pond water are shown above in a tabular format. Initially the readings fluctuated as it took time for the sensors to adjust. Then they gave a steady data.

4.2 Simulation of Results from Readings

4.2.1 Clean water Graphs

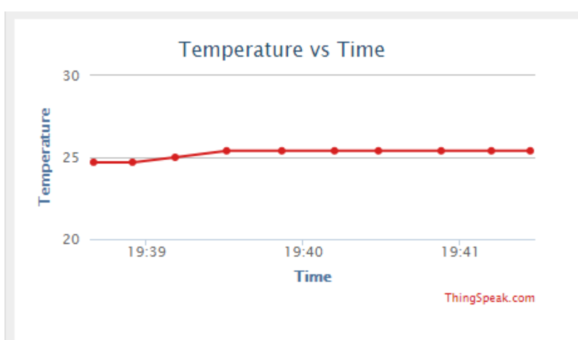

Fig 4.2a: Temperature vs. Time

Readings of temperature and time obtained from clean water are shown above in a graph.

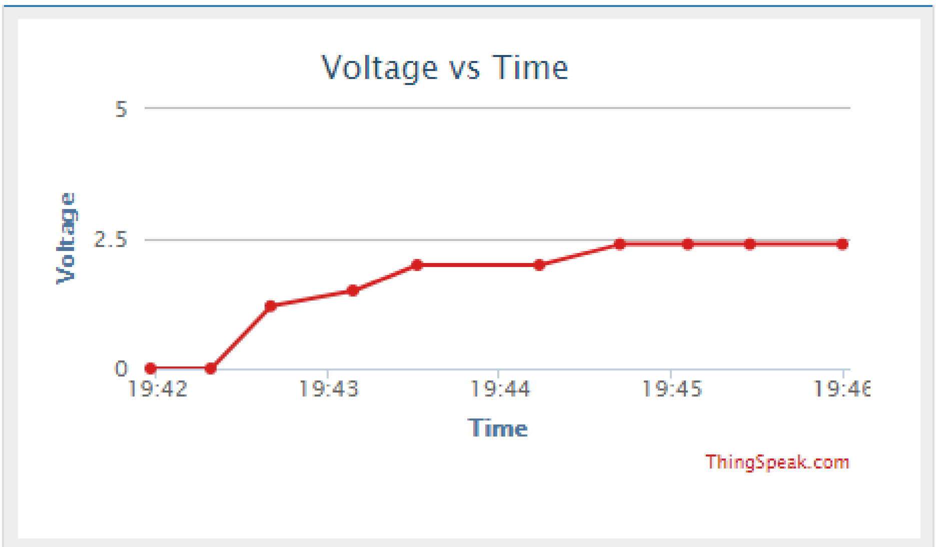

Fig 4.2b: Voltage vs. Time

Readings of voltage and time obtained from clean water are shown above in a graph.

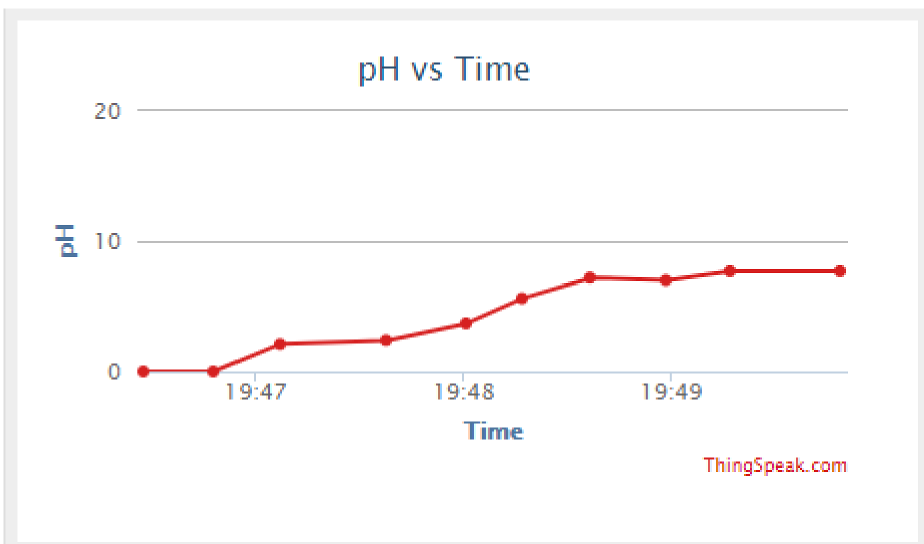

Fig 4.2c: pH vs. Time

Readings of pH and time obtained from clean water are shown above in a graph.

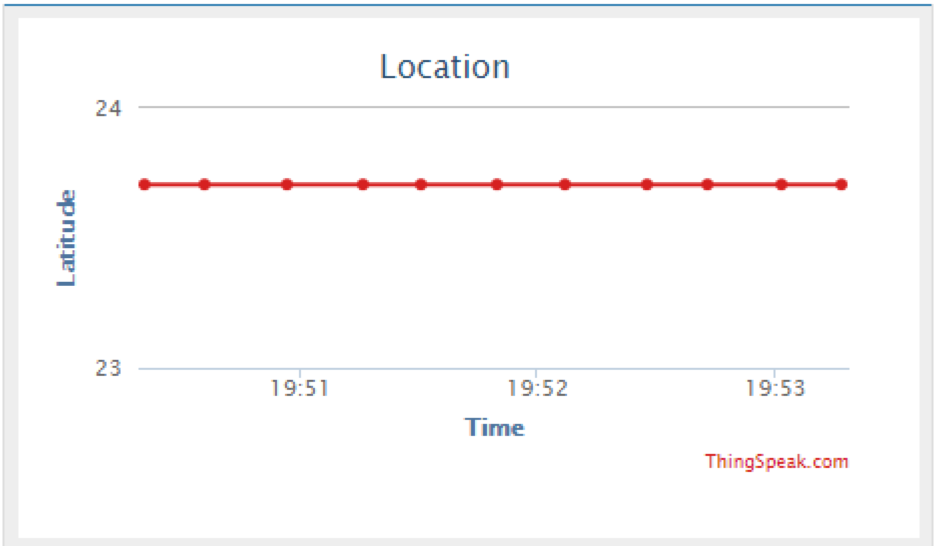

Fig 4.2d: Latitude vs. Time

Readings of Latitude and time obtained from clean water are shown above in a graph.

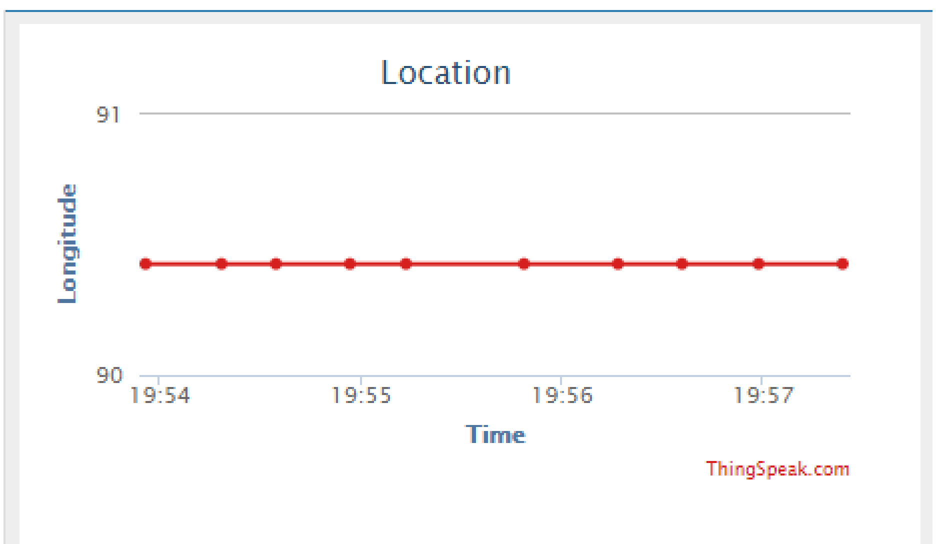

Fig 4.2e: Longitude vs. Time

Readings of Longitude and time obtained from clean water are shown above in a graph.

4.2.2 Pond water Graphs

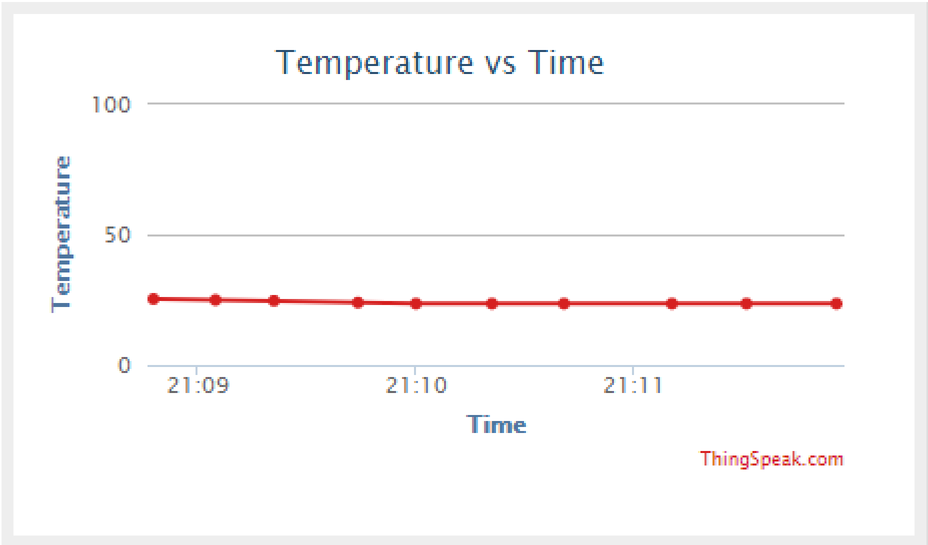

Fig 4.2f: Temperature vs. Time

Readings of temperature and time obtained from pond water are shown above in a graph.

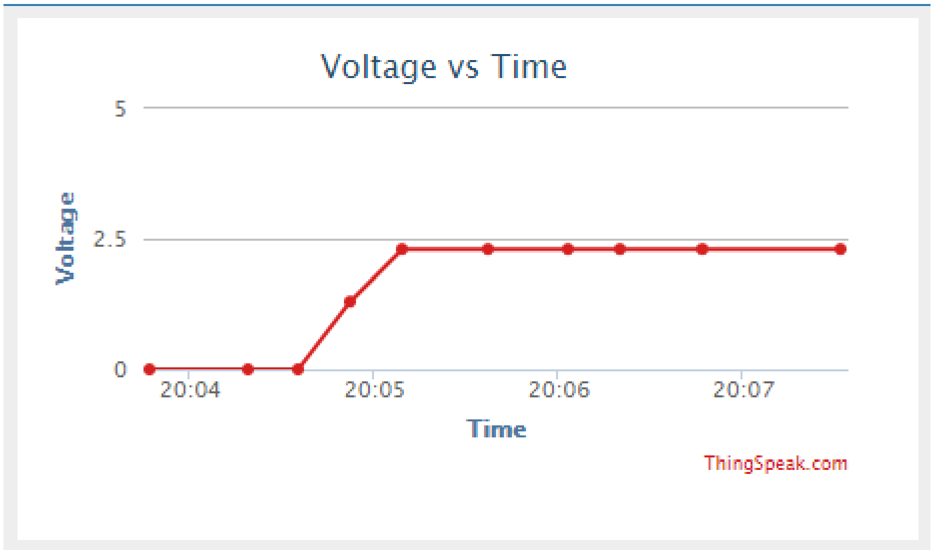

Fig 4.2g: Voltage vs. Time

Readings of Voltage and time obtained from pond water are shown above in a graph.

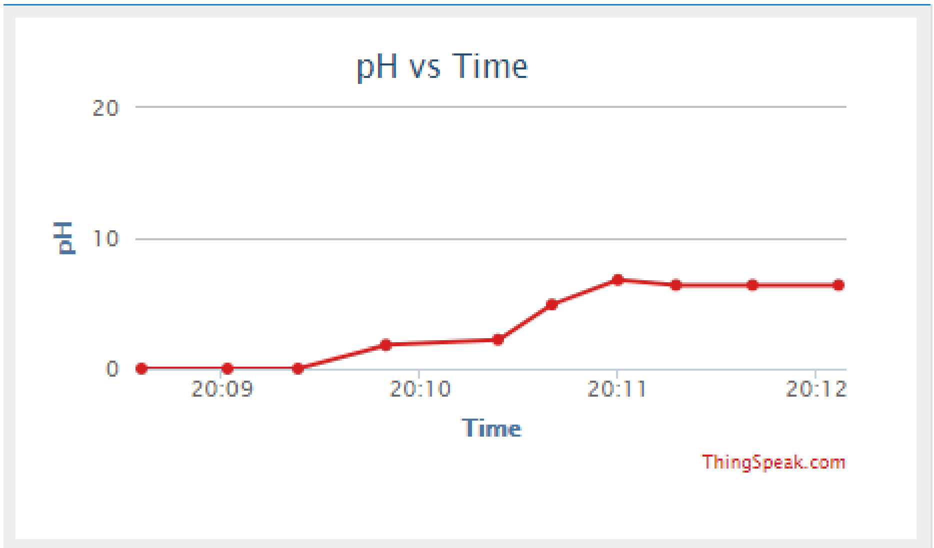

Fig 4.2h: pH vs. Time

Readings of pH and time obtained from pond water are shown above in a graph.

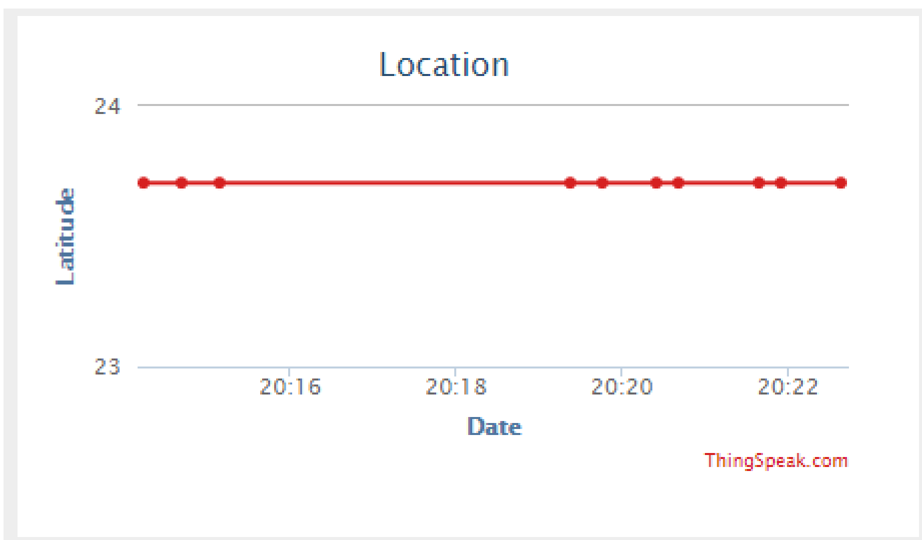

Fig 4.2i: Latitude vs. Time

Readings of Latitude and time obtained from pond water are shown above in a graph.

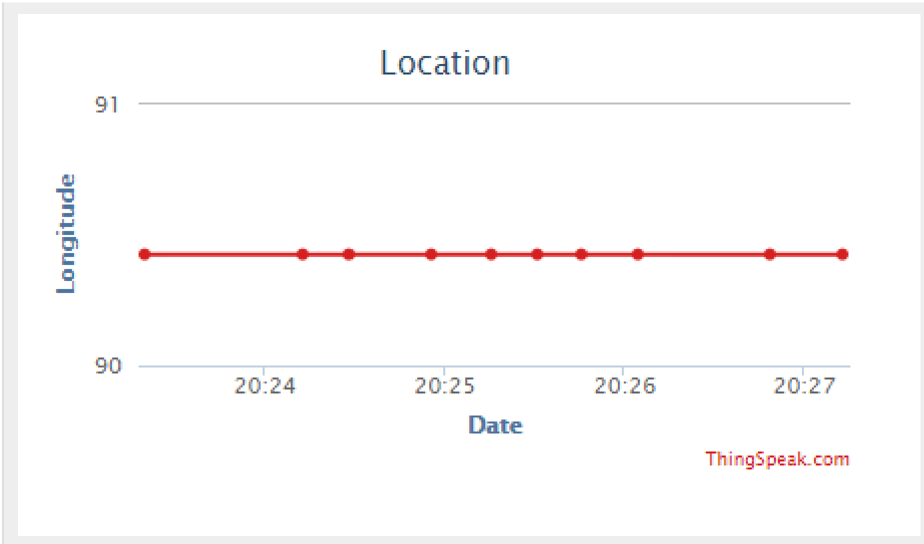

Fig 4.2j: Longitude vs. Time

Readings of Longitude and time obtained from pond water are shown above in a graph.

4.3 Analysis of Results

Temperature in clean water started from 24.7 degree Celsius and gave a constant reading of 25.4 degree Celsius. In pond water it was seen that at the surface it was 25.4 degree Celsius and as the rover went underwater it gave a final of 23.6 degree Celsius.

Voltage and pH readings in clean water were 2.4V and 7.7 respectively.

Voltage and pH readings in pond water were 2.3V and 6.4 respectively.

CHAPTER 5

CONCLUSION

5.1 Conclusion

We believe our work can help the fish farmers significantly. An important sector like fish farming deserves all the help it needs. Through our help they can solve the existing problems and boost up this sector. At the end of the day it’s us consumers who are having the fishes. So indirectly the benefit also reaches us. Our rover is simple and portable. This will cause ease for the farmers in using and carrying.

5.2 Future Work

In the future we wish to carry this project further. This is not the end. We will overcome the lacking we faced this time, one of the major being time shortage. Currently we have just provided two sensors, Temperature sensor and pH sensor namely. In the future we plan to include more sensors to more accurately measure the parameters necessary for the survival of healthy fishes. Moreover further developments in the body of the rover shall also be made to make it stronger and more stable. Motivation is what is necessary and our team has all the motivation it needs.

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