# TRIBHUVAN UNIVERSITY
## INSTITUTE OF ENGINEERING
## ADVANCED COLLEGE OF ENGINEERING AND MANAGEMENT
## DEPARTMENT OF ELECTRONICS AND COMPUTER ENGINEERING
## KALANKI, KATHMANDU


A Minor Project final Defense Report On

"AQUARIUM AUTOMATION"

**[EX654]**


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A Minor Project first report submitted to the department of Electronics and Computer Engineering in the partial fulfillment of the requirements for degree of Bachelor of Engineering in Computer Engineering

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# ADVANCED COLLEGE OF ENGINEERING AND MANAGEMENT
# DEPARTMENT OF COMPUTER AND ELECTRONICS ENGINEERING

## APPROVAL LETTER

The undersigned certify that they have read and recommended to the Institute of Engineering for acceptance, a project report entitled

”Aquarium Automation”

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In partial fulfillment for the degree of Bachelor in Computer Engineering.

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## ABSTRACT

Aquarium demands a constant attention of its wellbeing from the keeper. For a new Aquarium keeper, it is difficult task to start a viable aquarium and also a busy person does not have time to tend to all the aquarium needs. Hence, this project attempts to address this issue by creating Aquarium Automation (AA). Aquarium automation is a device for automation of the aquarium for the task such as monitoring aquarium health, feed introduction, aeration and controlling illuminance.

This system is designed to monitor the temperature which is the most critical environment factor for wellbeing of fish and maintain it a set range. It also automates the feeding and filter pump control. And monitors the basic parameters like pH and lightning.



**Keywords:** *aquarium***,** *automation, monitoring*

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# List of Abbreviations/Acronyms

| | |
|---|---|
| 3D | Three Dimension |
| AA | Aquarium Automation |
| ACEM | Advance College of Engineering and Management |
| DC | Direct Current |
| GPIO | General Purpose Input Output |
| IDE | Integrated Developing Environment |
| IoT | Internet of Things |
| LCD | Liquid Crystal Display |
| LDR. | Light Dependent Sensor |
| LED | Light Emitting Diode |
| pH | -log[$H^+$] Measure of the hydrogen ion concentration |
| PWM | Pulse Width Modulation |
| RTC | Real time clock |
| AI | Artificial Intelligence |

# CHAPTER 1

# INTRODUCTION

Aquarium is a popular hobby. This project attempt to deal with the challenges that one face for keeping the aquarium and its denizens healthy with suitable monitoring of environment parameters and providing automated and or remote control and giving early alarm to prevent a disaster.

## 1.1 Background

Aquarium (plural aquariums or aquaria) is a vivarium (containing live organism), usually contained in a clear-sided container of glass or high-strength plastic in which water-dwelling plants and animals (usually fish, and sometimes invertebrates, as well as amphibians, marine mammals, and reptiles) are kept in captivity, for personal hobby or for public display. Aquarium keeping is a popular hobby around the world, with growing enthusiasts worldwide. [1]

From the 1850s, when the predecessor of the modern aquarium was first developed as a novelty, the ranks of aquarist have swelled as more sophisticated systems including lighting and filtration systems were developed to keep aquarium fish healthy. Public aqua-ria reproduces the home aquarist hobby on a grand scale.

Wide range of aquarium setup is possible with the myriad of configuration possible even for the home aquarium. Many types' fish are kept in the aquarium. The cost of the fish range Rs. 100 a couple of fish to Rs. 10000 per fish.

Most fish kept in the aquarium are of tropical kind with very low tolerance to the fluctuation in the environment parameters mostly specific range of pH, temperature aeration and water flow. Fish are very sensitive to the ammonia and the nitrate content; its spike can kill all the fish in the aquarium resulting in the financial as well as emotional crisis.

Furthermore, the planted aquarium needs more stringent control of parameter to be successful. Precise control of temperature, illuminance, photo period, aeration as well as the carbon di oxide is must for the successful keeping of the planted aquarium.

## 1.2 Motivation

Having got the firsthand experience in the fish keeping and the problem we faced, we are motivated to automate the monitoring process so that we can be away from the home without needing to ask someone else to take care of the aquarium for the time being.

Furthermore, the early warning system and constant monitoring may enable us to detect a creeping crisis and enable us to avoid it.

## 1.3 Statement of the Problem

Aquarium automation is already implemented in the commercial scale in the public aquaria and in large exorbitant huge aquarium setup, but such system is wanting in case of Nepal and any monitoring of the aquarium require visual and manual inspection of various parameters.

Feeding system is available for to sustain the fish for few weeks but has its own side effects. Clockwork mechanism for feed introduction is also available but lacking feedback and certainty is always a game of chance We attempt to remove this game of chance and to bring relief to the aquarist that their beloved vivarium will stay a vivarium not some putrid calamity when they are back.

## 1.4 Project objective

To develop automation of aquarium.

### 1.5 Significance of the study

The most significant aspect of this study will be to enable an incipient aquarist to fulfill their dream of owning an aquarium and enable them to keep the fish and interact with it at their own convenience.

Also, it enables an enthusiastic aquarist to expand their reach in keeping the exotic and difficult to keep species and allow them also to be away from the aquarium and still provide means of the sustenance to the vivarium while away. That is, they no longer will be tied physically to the responsibility of keeping the denizens of aquaria alive.

# CHAPTER 2

# LITERATURE REVIEW

An aquarium (probably alteration of aquatic vivarium [1]; plural: aquariums or aquaria) is a vivarium of any size having at least one transparent side in which aquatic plants or animals are kept and displayed. Fish keepers use aquaria to keep fish, vertebrates, amphibians, aquatic reptiles, such as turtles, and aquatic plants. The term aquarium, coined by English naturalist Philip Henry Gosse, combines the Latin root aqua, meaning 'water', with the suffix -arium, meaning 'a place for relating to'. [2]

The typical hobbyist aquarium includes filtration system, artificial lighting system, air pump, and a heater on the aquarium's inhabitants. Many aquaria have cover or hood with lights to decrease evaporation and prevent fish from jumping out of aquarium. [2]

In antiquity glass aquariums commonly had slate or steel bottoms, which allowed them to be heated underneath by an open-flame heat source. These aquariums had the glass panels attached with metal frames and sealed with putty. Metal-framed aquariums were replaced by silicone-sealed one.  During 1970 Acrylic aquariums first became. Laminated glass is sometimes used for the added strength. [3] This shows that there has been continued effort to improve aquaria from antiquity.

In modern days, aquarium has become a common hobby rather than the people born with the silver spoon. Many people have fish as their pets at home. The fishes have been fed by the aquarist in the aquarium tanks which demands a proper setup for maintenance.

To be successful fine balance between various condition has to meet, which is more critical in small aquaria as huge Aquarium with Large volumes of water enable more stability in a tank by diluting effects from death or contamination etc. that push an aquarium away from equilibrium. [4] Hence smaller aquaria that are more common demand more attention from the keeper,

An aquarium must be maintained regularly to keep fish healthy. Daily maintenance consists of visual inspection for stress and disease of fish, quality of water ensuring it is not cloudy or foamy and the temperature of the water is appropriate for the particular species of fish are in the aquarium. Typically, weekly maintenance includes changing around 10–30% or more of the water while cleaning the gravel, or other substrate. [2] [4][5]

The problems faced are changes in water quality, feeding the fish, maintaining the temperature, controlling the lights, and difficulty checking the conditions of an aquarium manually. Therefore, it's necessary to monitor the physical parameters closely and enhance the water condition. So, this project proposes a system that is equipped with sensors to be operated in real-time. It performs temperature monitoring, water pH level detection, turbidity detection, and fish feeding. An IOT-based system is implemented to monitor and deliver the status of the aquarium to the user's web application. Thus, intelligent aquarium management has been implemented with a temperature sensor, pH sensor, and turbidity sensor so that the fish is neither over nor underfed and thereby reducing the manual effort required in the maintenance of the aquarium.

The most significant aspect of this study will be to enable an incipient aquarist to fulfill the dream of owning an aquarium and enable them to keep the fish and interact with it at their own convenience.

Also, it enables an enthusiastic aquarist to expand their reach in keeping the exotic and difficult to keep species and allow them also to be away from the aquarium and still provide means of the sustenance to the vivarium while away. That is, they no longer will be tied physically to the responsibility of keeping the denizens of aqua-ria alive.

**Automation in Aquaria**

Literature review and online research show myriad of automation solution that are help in maintain aquarium. Mostly targeted to the high-end system and are very expensive and are not easily obtainable in the Nepalese market. [6][7][8][9][10]

**Aquarium automation in literature**

The researchers Budi Prijo Sembodo et al. [11] have created a smart aquarium system that has an Arduino-based feeding system that controls the servo motor as an open and close system as the exit of fish feed into the aquarium. This system automatically delivers fish feed at preset time and auto switch light on off based on the light intensity and time of day, and had ability to automate drain and fill water.

Researcher's Daniel Patricko Hutabarat et al. [12] created a smart system based on an internet of things (IOT) application for a plant aquarium capable of maintains the environment's parameters such as light intensity and temperature. using ESP32 as the microcontroller, BH1750FVI as the light sensor, high power led(HPL) light-emitting diodes (LED) lamp as the light source, DS18B20 as temperature sensor, the heater, and the 220 VAC fan interfaced with smart phone.

Khairunisa et al. [13] designed a smart aquarium device in order to feed fishes automatically, namely using Android-Based Raspberry Pi over the internet network and management of the aquarium's ornamental lights.

Wen-Tsai Sung et al. [14] created a remote monitoring system using IOT technology for the aquarium environment. The main control development platform for this system was a MediaTek LinkIt 7697, and remote monitoring components include temperature, luminance, water level, and passive infrared sensor modules.

Chiu, M.C., 2010 [15] in the research titled “A Multi-Functional Aquarium Equipped with Automatic Thermal Control/Fodder-Feeding/water Treatment using a Network Remote Control System” used personal computer to control and manage all the sensors that were connected via different module. The module used were ADC, then, by using VB interfaces, the client PC can communicate with server-PC to monitor and control the aquarium based on the data from sensors.

M.Z. H. Noor, ET. al. [16] developed combined mechanical and electrical system in controlling fish feeding activity. This device, consists of pellet storage, former, stand, DC motor and microcontroller. Feeding was controlled by DC motor system based on timer and the user intervention. PWM was used to control the DC motor.

A.N.Prasad, et. al. [17] developed a system to collect water quality data using microcontroller board called Waspmote with external ADC connected to different sensors such as pH, water temperature, turbidity, conductivity sensors. The information was collected by the Waspmote microcontroller board and stored locally as well as in cloud using GSM module.

# CHAPTER 3

# REQUIREMENT ANALYSIS

Following hardware and software are required for this project:

**Hardware used:**

- Arduino
- Temperature sensor
- pH sensor
- Stepper motor and Driver.
- Aquarium Heater
- Filter Pump.
- Relays
- LCD Display
- Rotary encoder
- Push Buttons
- Buzzer
- LED
- RTC clock

**Software used:**

- Arduino IDE
  - The hardware and the technologies required for this project are readily available and for the part of the software development.

**Functional Requirements**

- The program should be able to automate the aquarium environment.
- The system should be able to monitor necessary parameters of the aquarium.
- Must be able to introduce the feed at the set time interval.
- Must be able to control all the parameters of the system.

## OPERATIONAL AND ECONOMIC FEASIBILITY

The operational and the economic feasibility is where to find the success of the project on the completion of the project at a minimal cost. The following point has been considered for the development of this project:

- The project has been developed using readily available hardware so the operational and economic cost is minimal.
- The end product will also be practically useful and easy to use making it proper commercial product as well with few iterations.

# CHAPTER 4

## SYSTEM DESIGN AND ARCHITECTURE

The block diagram of the Aquarium Automation is intended to be as follows

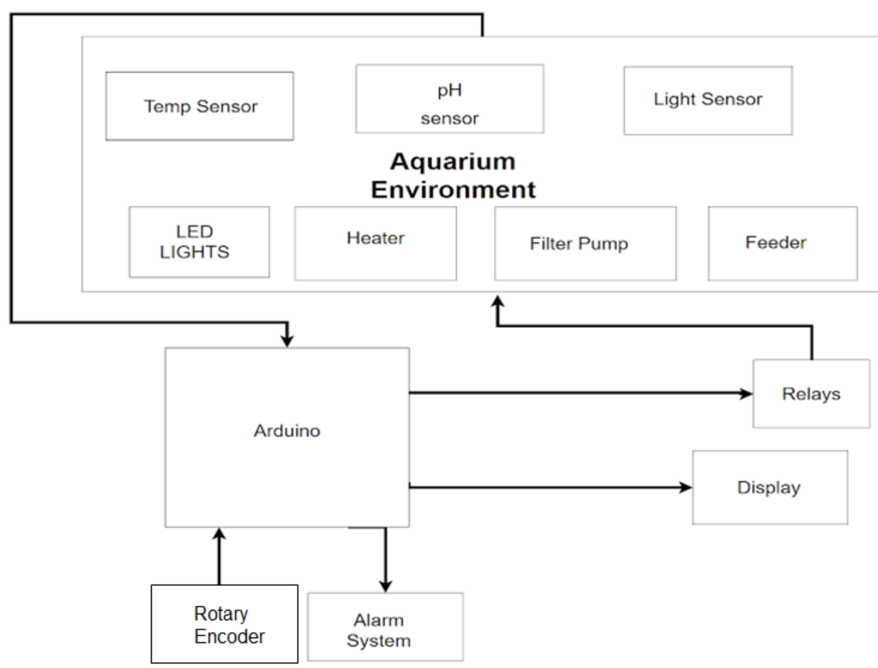



Figure 4.1: Block diagram of the Aquarium Automation

This project is centered in using the micro controller like Arduino. Its GPIO (analog and digital pins) is used to communicate with various sensor modules and control the various actuators as shown in figure above.

**The modules used in are**:

**Arduino Uno**: Arduino UNO is the basis for the project in order to achieve control and automation in many aspects of the project. UNO is the most used and documented board of the Arduino family making the operation relatively easier.

**Temperature sensor:** The temperature sensor in Arduino converts the surrounding temperature to voltage.

**pH sensor:** pH scale is used to measure the acidity and basicity of a water. it can have readings range from 1-14 where 1,7 and 14 shows most acidic, neutral and alkaline respectively. The module has an on-board voltage regulator chip which supports the wide voltage supply of 3.3-5.5V DC which is compatible to Arduino board.

**Photo-register:** is for detecting the light condition and to automatically turn on the LED when it is dark.

**Stepper motor:** A Stepper Motor or a step motor is a brushless, synchronous motor, which divides a full rotation into a number of steps. Unlike a brushless DC motor, which rotates continuously when a fixed DC voltage is applied to it, a step motor rotates in discrete step angles.

**LED strip:** for illumination of the aquarium.

**LCD display**: for displaying output

**HEX keypad**: for taking in input

**RTC clock**: for Keeping track of Time

**Buzzer:** for alarm

## 4.1 UML diagram

UML Diagrams: A UML diagram is a partial graphical representation (view) of a model of a system under design, implementation, or already in existence. UML diagram contains graphical elements (symbols) - UML nodes connected with edges (also known as paths or flows) - that represent elements in the UML model of the designed system. The UML model of the system might also contain other documentation such as use cases written as template texts. The kind of the diagram is defined by the primary graphical symbols shown on the diagram. For example, a diagram where the primary symbols in the contents area are classes is class diagram. A diagram which shows use cases and actors is use case diagram. A sequence diagram shows sequence of message exchanges between lifelines. UML specification does not preclude mixing of different kinds of diagrams, e.g. to combine structural and behavioral elements to show a state machine nested inside a use case. Consequently, the boundaries between the various kinds of diagrams are not strictly enforced. At the same time, some UML Tools do restrict set of available graphical elements which could be used when working on specific type of diagram. UML specification defines two major kinds of UML diagram: structure diagrams and behavior diagrams. Structure diagrams show the static structure of the system and its parts on different abstraction and implementation levels and how they are related to each other. The elements in a structure diagram represent the meaningful concepts of a system, and may include abstract, real world and implementation concepts. Behavior diagrams show the dynamic behavior of the objects in a system, which can be described as a series of changes to the system over time.

### 4.1.1 Dataflow Diagram

DFD is the abbreviation for Data Flow Diagram. The flow of data of a system or a process is represented by DFD. It also gives insight into the inputs and outputs of each entity and the process itself. DFD does not have control flow and no loops or decision rules are present. Specific operations depending on the type of data can be explained by a flowchart.

It is a graphical tool, useful for communicating with users, managers and other personnel. it is useful for analyzing existing as well as proposed system.

It provides an overview of:

- What data is system processes.
- What transformations are performed.
- What data are stored.
- What results are produced , etc.

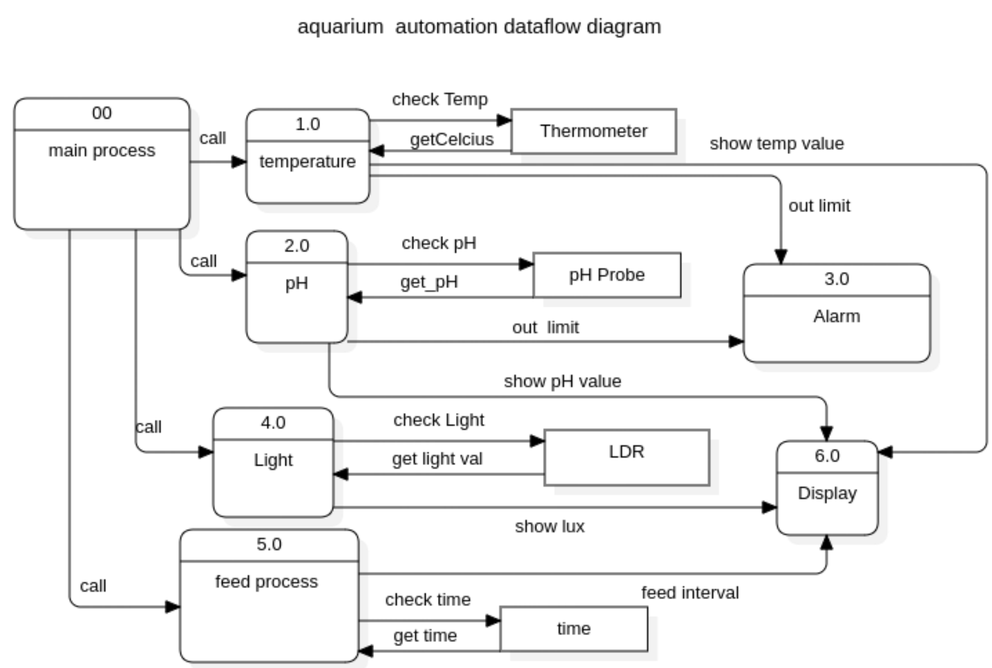



Figure 4.2: Dataflow Diagram

## 4.1.2 Class Diagram

is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among objects.

Purpose of class diagram

- Shows static structure of classifiers in a system
- Diagram provides a basic notation for other structure diagrams prescribed by UML
- Helpful for developers and other team members too
- Business Analysts can use class diagrams to model systems from a business perspective

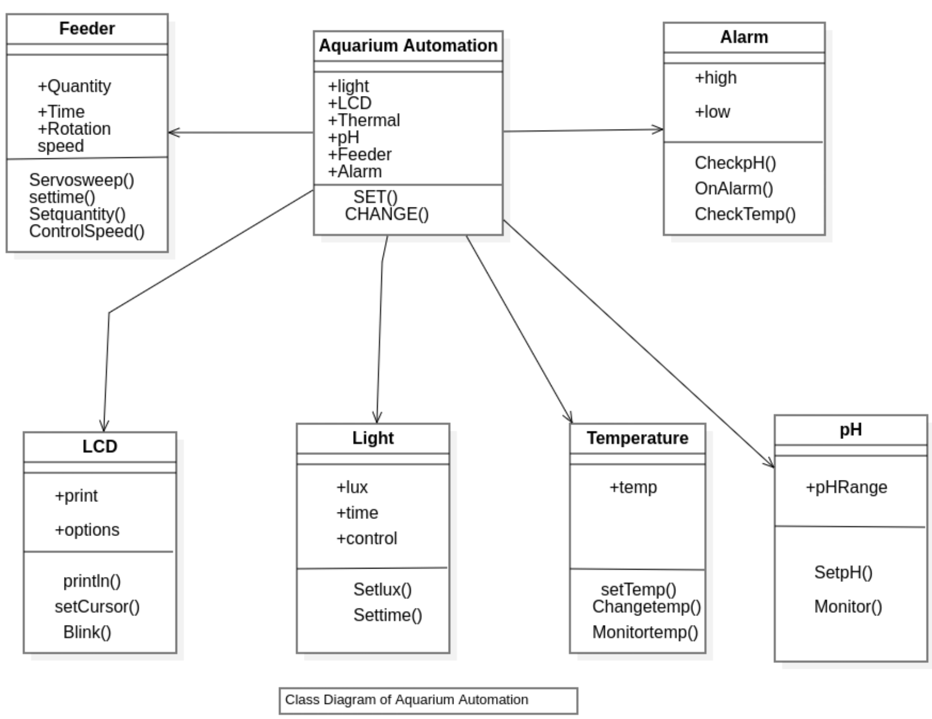



Figure 4.3: Class Diagram

## 4.1.3 Use case diagram

In the Unified Modeling Language (UML), a use case diagram can summarize the details of your system's users (also known as actors) and their interactions with the system. To build one, you'll use a set of specialized symbols and connectors. An effective use case diagram can help your team discuss and represent:

Scenarios in which your system or application interacts with people, organizations or external systems.

- Goals that your system or application helps those entities (known as actors) achieve.
- The scope of your system


Figure 4.4: Use case diagram

### 4.1.4 Sequence Diagram

A sequence diagram is a type of interaction diagram because it describes how and in what order a group of objects works together. These diagrams are used by software developers and business professionals to understand requirements for a new system or to document an existing process. Sequence diagrams are sometimes known as event diagrams or event scenarios. Sequence diagrams can be useful references for businesses and other organizations. Try drawing a sequence diagram to:

- Represent the details of a UML use case.
- Model the logic of a sophisticated procedure, function, or operation.
- See how objects and components interact with each other to complete a process
- Plan and understand the detailed functionality of an existing or future scenario.

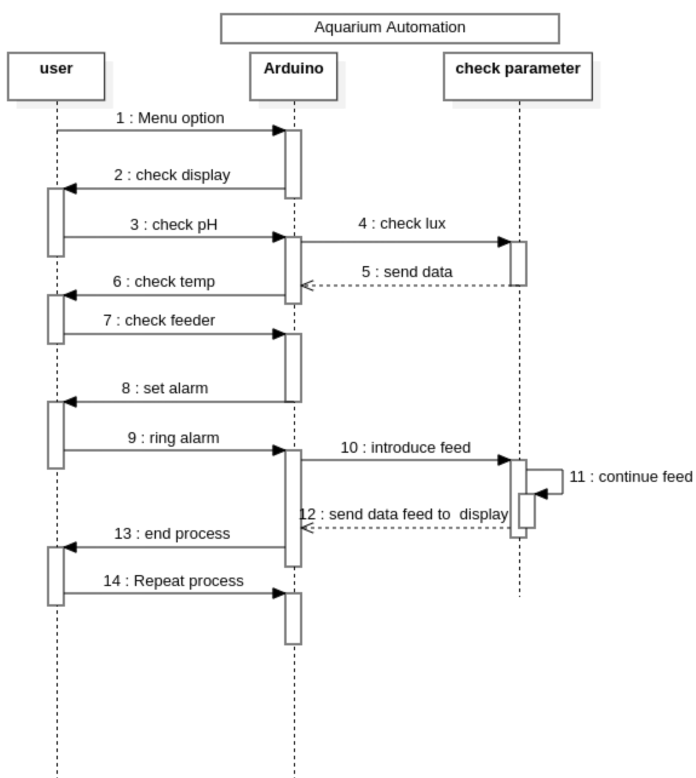



Figure 4.5: Sequence diagram

# CHAPTER 5

# METHODOLOGY

Arduino had 6 analog digital pins and 16 digital pins 2 of digital pin can function as serial port and 6 has PWM.

Following Table shows the use of pins by various hardware components,

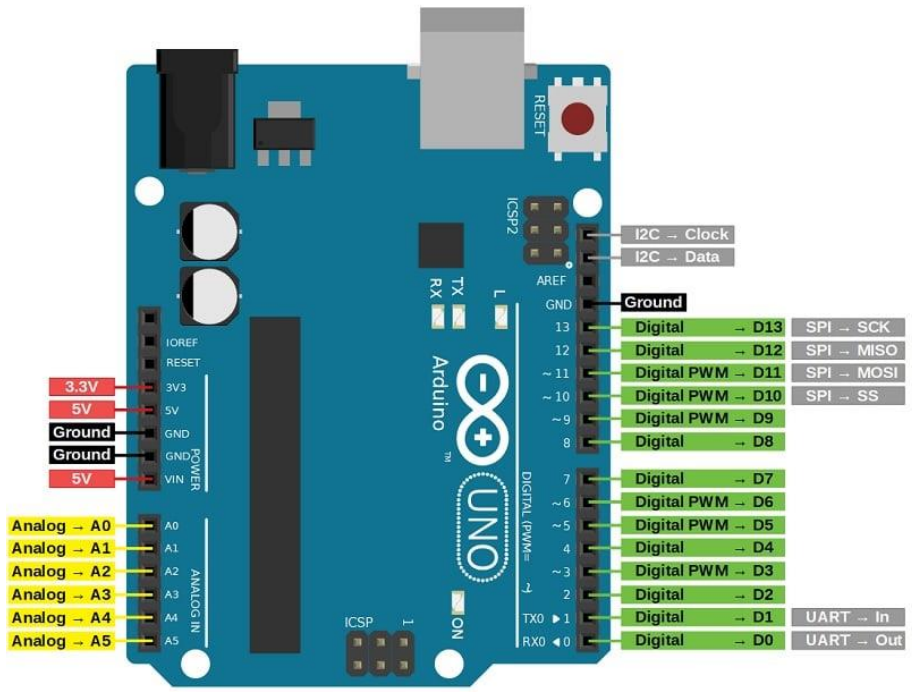



Fig 5.1 Arduino Board Pin layout

Table 5.1: Pin usage of Arduino

| pins | No of pins | Hardware Uses |
|---|---|---|
| Analog | 1 | LDR Sensor (light sensor) |
| Digital (serial) | 1 | Temperature (DS18B20) |
| Analog | 1 | pH |
| Digital | 8 | Hex Keypad |
| Digital | 6 | LCD |
| Digital | 1 | Motor control Relay |
| Analog | 2 | RT Clock (DS3231) |
| Total pin used<br>Analog 4 Digital 16 | | |

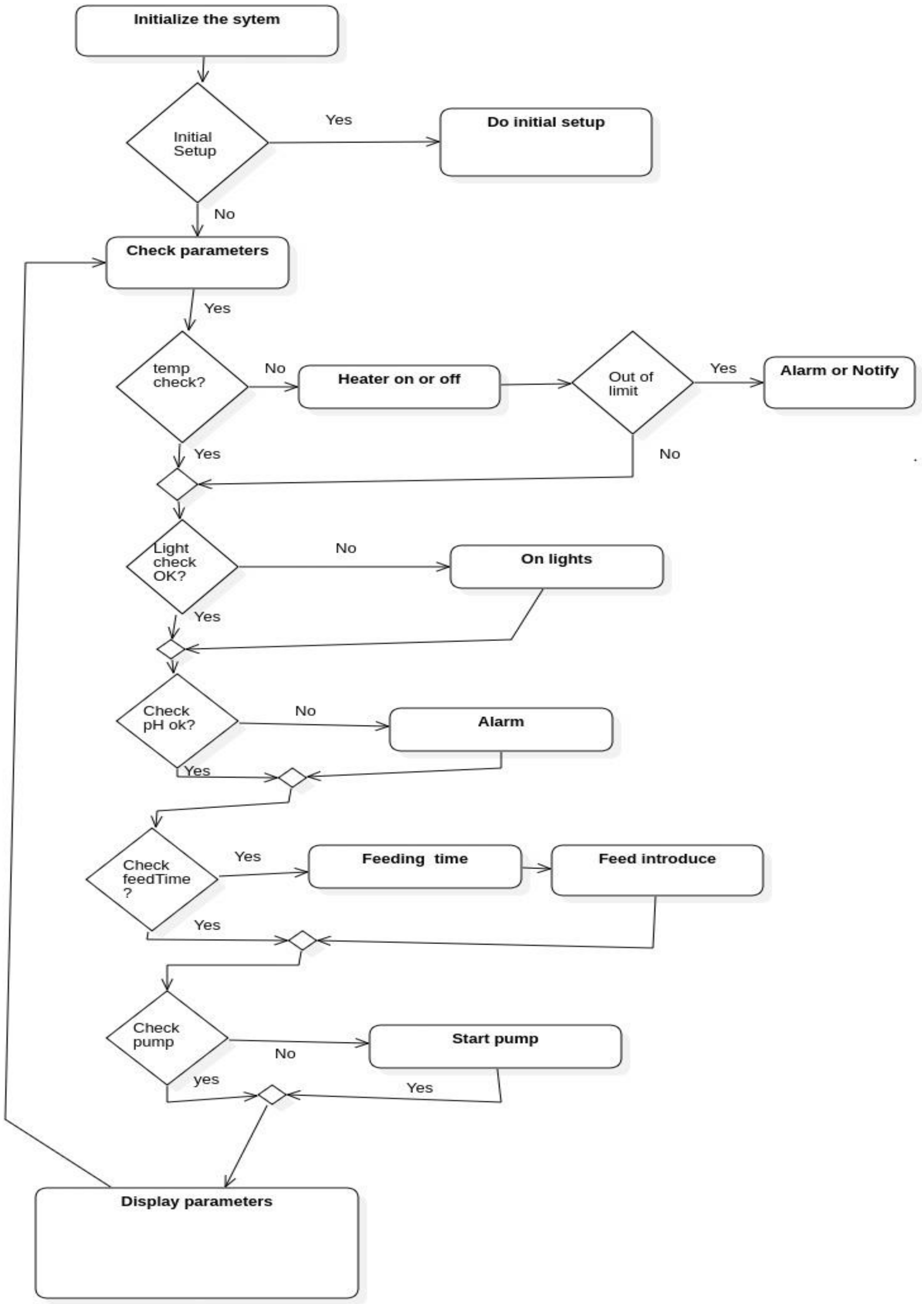



Figure 5.2 Operation mode of the System

The Aquarium automation checks the various state of sensor as per above loop and controls its actuators accordingly.

## **Hardware Required**:

5 V power source

Breadboard

Copper universal PCB

Rotary encoder

Jumper wires

LCD 16x4

LDR sensor.

LED aquarium light

Multimeter

pH sensor

Real time Clock (DS3231)

Relays for controlling the heater pump

Resistors etc.

Soldering kits

Stepper motor

Temperature sensor (DS18B20)

## **Software required**:

Arduino IDE

# CHAPTER 6

# RESULT AND ANALYSIS

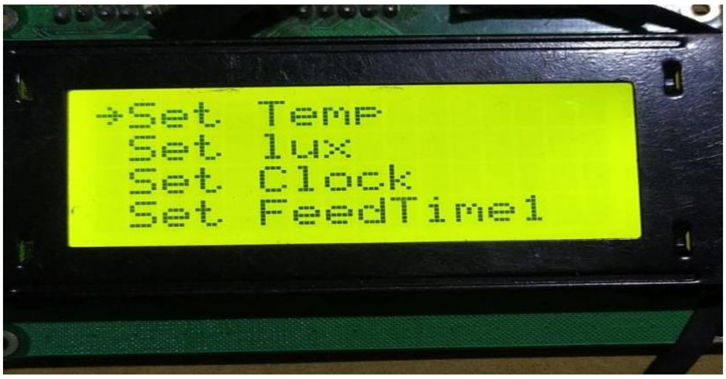
## Output

The experimental results section for this project details the results obtained after doing various observations and forming final outputs. The developed system has been able to automate the aquarium in multiple aspects including feed introduction, temperature control, pH control, light sensing to regulate temperature as well as control over the filter of the aquarium control system.


Figure 6.1: Output Screen

The figure of the output shows the different fields outputs carried out in the project where the temperature, the light intensity and the pH value has been shown along with the set options where the user can manually set the desired conditions for the running of the aquarium.


Set Clock
Set FeedTime1
Set FeedTime2
→Exit


→Set Temp
Set lux
Set Clock
Set FeedTime1


Temp Setting
23.5%


Clock
set HH (24)
19


Clock
set mm
57


FeedTime2
set HH (24)
00

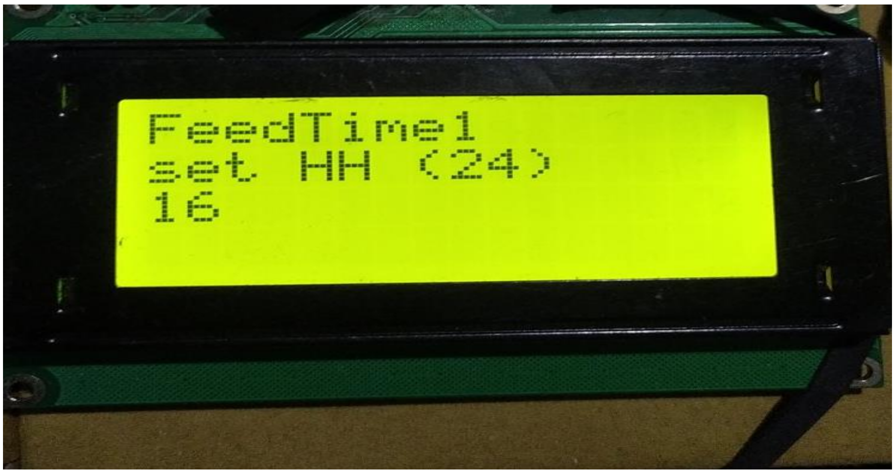

FeedTime1
set HH (24)
16


Figure 6.2: Menu option of system

The above figures are the menu options displayed in the display to implement the different functionalities of the system.

# CONCLUSION, LIMITATIONS AND FUTURE ENHANCEMENT

## CONCLUSION

In conclusion, an automated aquarium system can offer numerous benefits to aquarium hobbyists, including a more stable and consistent environment for the aquatic animals and plants, as well as reduced time and effort required for aquarium maintenance. By automating tasks such as temperature control, lighting, filtration, and feeding, the aquarium owner can ensure that the aquarium environment remains healthy and stable even when they are away from home or have limited time for aquarium maintenance. However, it is important to note that automated aquarium systems should not replace regular observation and care of the aquarium. The owner should still perform regular water changes, testing of water parameters, and monitoring the health and behavior of the fish and other inhabitants. Additionally, it is important to ensure that the automated system is set up and maintained properly to avoid any potential problems or malfunctions. Overall, an automated aquarium system can be a valuable tool for the aquarium hobbyist, but it should be used in conjunction with good aquarium maintenance practices and careful observation of the aquarium environment. With the right setup and maintenance, an automated aquarium system can help to create a beautiful, healthy, and thriving aquatic environment for both the aquarium owner and the inhabitants of the aquarium.

## LIMITATIONS

- Lack of good quality devices.
- pH meter is of laboratory type which need calibration for accurate each time.
- Lack of compactness because of jumper wires and connection made.
- Only small granular feed can be used.
- Due to lack of time adequate data collection is not available.
- Data logging has not been done in this project.

## FUTURE ENHANCEMENTS

- Machine learning and AI implementation to monitor the health of the fishes as well.
- App control with analog input in Arduino.
- Live feed using camera.
- Report generation of the health of aquarium and storage of the report in the database.
- Using PCB for downsizing of the project to make it concise.

# CHAPTER 7

## TIME SCHEDULE

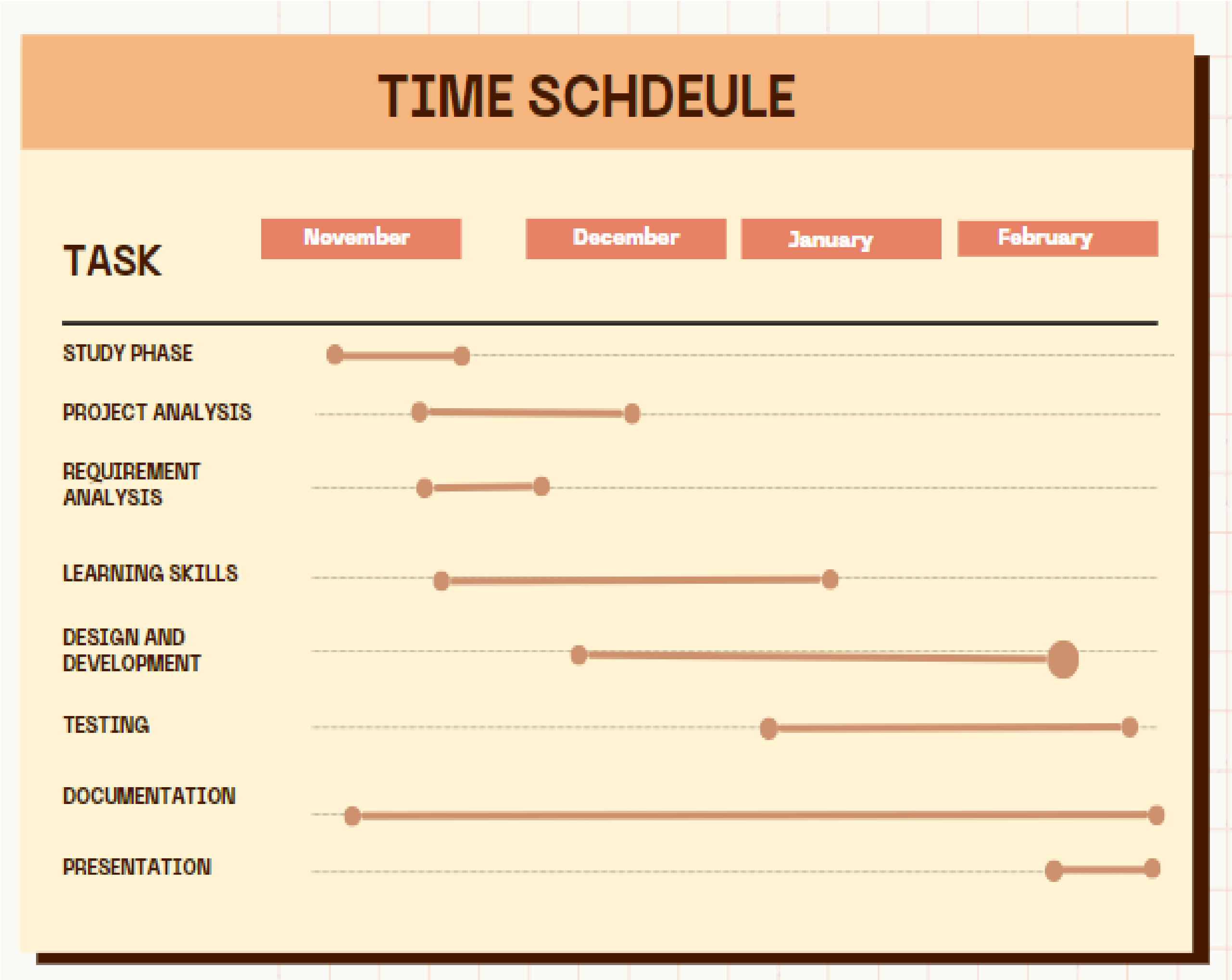



Fig 7.1 Gantt chart

# CHAPTER 8

# TOTAL COST

Table 8.1 Estimated Cost Based on Online market

| Components | Quantity | Price |
|---|---|---|
| 5V power supply | 1 | 500 |
| Arduino uno | 1 | 1700 |
| Breadboard | 2 | 300 |
| Buzzer | 1 | 90 |
| Copper universal board | 2 | 100 |
| Rotary Encoder | 1 | 400 |
| LCD display | 1 | 450 |
| LDR sensor. | 1 | 150 |
| pH sensor | 1 | 4000 |
| Relay | 4 channels | 600 |
| RTC | 1 | 500 |
| RTC clock (DS3231) | 1 | 500 |
| Stepper motor | 1 | 400 |
| Stepper motor driver | 1 | 200 |
| Temp sensor (DS18B20) | 1 | 250 |
| Miscellaneous | | 5000 |
| Total | | 15200 |

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# Appendix

```
uint16_t getLux(){  // returns Lux normal scale
  /***************** INFORMATION
      Typically
      RL=500/lux
      V0=5*(RL/(RL+R))
      V0=LDR_value*ADC_value
      lux=((2500/V0)-500)/R
      https://emant.com/316002
      https://www.allaboutcircuits.com/projects/design-a-luxmeter-using-a-light-dependent-resistor/

      //to prevent short circuit when LDR is highly illluminated
    [GND]--R[10k ohm resistor]--| -- [LDR] -- [5V]
                                |
                           [Analog Input A0]
  Different equation here but better is to calibrate (curve fixing by correlation) taking mobile sensor as reference

  Condition      Illumination(lux) analog reading of current LDR
  Sunlight         107527                    1022
  Full Daylight    10752                     1022
  Overcast Day     1075                      1022
  mobile flash light 25 cm away              690
  ----------> decision to turn light        ~600
  15 W LED bulb overhead in 10 foor room     425
  Very Dark Day    107
  Twilight         10.8                      <40
  Deep Twilight    1.08
  Full Moon        0.108
  Quarter Moon     0.0108
  Starlight        0.0011
  Overcast Night   0.0001
  */
```

Figure 9.1: getLux() function working and conditions

```
// for pH meter https://circuitdigest.com/microcontroller-projects/arduino-ph-meter
//  for(int i=2;i<6;i++)
//  avgval+=buffer_arr[i];
//  float volt=(float)avgval*5.0/1024/6;
//  float ph_act = -5.70 * volt + calibration_value;

uint8_t getPH() {  //returns in pH*10    //returns deci scale


#ifdef __DEBUG__PH_

  float tmp = 0, ana_pH;
  float cal_val = 7+1.8+.5;
  uint8_t n = 4;

  for (int i = 0; i < n; i++) {
    tmp += analogRead(currentPin_pH);
    delay(10);
  }

  float avgval = tmp / n;
  float volt = (float)avgval * 5.0 / 1024;
  ana_pH = -5.70 * volt + 21.34 + cal_val;


  Serial.print(F("volt:"));
  Serial.println(volt);
  Serial.print(F("after ana_pH:"));
  Serial.println(ana_pH);
  Serial.print(F("NOTE: IN THE ACTUAL FUNCTION  return analogRead(currentPin_pH)*bla bla  is used "));
  delay(2000);
  return (uint8_t) 10 * ana_pH;
#endif
```

Figure : getpH() function working and conditions.

```
uint16_t getCelsius(DeviceAddress deviceAddress) {

#ifdef __DEBUG__TEMP_
  Serial.println(F("Before blocking requestForConversion"));
  unsigned long start = millis();
#endif

  oneWireSensors.requestTemperatures();


#ifdef __DEBUG__TEMP_
  unsigned long stop = millis();
  Serial.println(F("After blocking requestForConversion"));
  Serial.print(F("Time used:"));
  Serial.println(stop - start);
#endif

  uint16_t tempC = 10 * oneWireSensors.getTempCByIndex(0);  //first tempSensor


#ifdef __DEBUG__TEMP_
   //Serial.println(' ');
  Serial.print(F("\nTemperature read from the thermometer"));
  Serial.println(tempC, 1);
#endif

  return tempC;
}
```

Figure : getCelsius() function working and conditions.