Faculty of Electronics and Computer Technology and Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Development of IoT based SMART AQUARIUM CONTROLLER

KIROSHA A/P MACHAP

Bachelor of Computer Engineering Technology (Computer Systems) with Honours

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Development of IoT based SMART AQUARIUM CONTROLLER

KIROSHA A/P MACHAP

A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Computer Engineering Technology (Computer Systems) with Honours

Faculty of Electronics and Computer Technology and Engineering

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FAKULTI TEKNOLOGI DAN KEJUTERAAN ELEKTRONIK DAN KOMPUTER

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PROJEK SARJANA MUDA II

Tajuk Projek : Development of IoT based SMART AQUARIUM CONTROLLER

Sesi Pengajian : 2023/2024

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I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Computer Engineering Technology (Computer Systems) with Honours.

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DEDICATION

To my beloved mother, Vijayaletchumy, and father, Machap,

and

To my loving family

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ABSTRACT

The main goal of this project is to create an aquarium monitoring system utilising the ESP32 single chip computer. This project's major goal is to assist people who are having trouble keeping up with their indoor aquariums, particularly those who frequently travel and can't continuously check on their tanks. With the help of this system, consumers can routinely check on and maintain their fish aquariums using the internet and gadgets like smartphones and the Blynk app. The programme includes a few capabilities, including a water pH sensor, fish feed, and temperature detection via notifications from the aquarium. This system's primary function is to give users access to a server with data that they can use to monitor and maintain their fish aquarium. This includes doing chores like timely fish feeding, monitoring the water temperature, and checking the liquid level.After logging in, the user can access the application to see how their aquarium is doing. In addition, sensors including water level sensors and water temperature sensors are needed to ensure that the system runs smoothly. In addition, a water pump, water filter, and motors for fish feeding are needed. The prototype model choosed as the modelling approach for this project because of its flexibility, which includes the capability to go back to a prior phase if a system issue or error needs to be fixed.

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ABSTRAK

Tujuan projek ini adalah membina Sistem Pemantauan Akuarium menggunakan komputer cip tunggal yang disebut ESP32. Tujuan utama projek ini adalah untuk membantu mereka yang menghadapi kesukaran untuk menjaga akuarium dalaman mereka, terutama mereka yang sering keluar, sehingga tidak dapat memantau akuarium mereka secara berterusan. Melalui penggunaan sistem ini, pengguna dapat memantau dan memelihara akuarium ikan mereka secara berkala melalui internet, menggunakan perangkat seperti telefon pintar melalui aplikasi yang disebut aplikasi Blynk. Aplikasi ini terdiri daripada beberapa ciri seperti makanan untuk ikan, pengesan suhu dengan mendapatkan pemberitahuan dalam aplikasi dari akuarium dan sensor pH air. Peranan utama sistem ini adalah untuk membolehkan pengguna memantau dan memelihara akuarium ikan mereka melalui pelayan data, yang merangkumi tugas-tugas seperti memberi makan ikan tepat pada waktunya, memeriksa suhu air dan memeriksa tahap cecair air. Pengguna kemudian akan log masuk ke aplikasi untuk memeriksa status akuarium mereka. Selain itu, sensor seperti sensor suhu air, sensor kekeruhan dan sensor paras air juga diperlukan untuk memastikan sistem berfungsi dengan optimum. Selain itu, pam air, penapis air dan motor untuk memberi makan ikan, juga diperlukan. Saya memilih model Prototaip sebagai kaedah pemodelan dalam projek ini kerana fleksibiliti model ini, yang merupakan kemampuan untuk kembali ke fasa sebelumnya jika terdapat bug atau kesalahan dalam sistem yang perlu diselesaikan.

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LIST OF ABBREVIATIONS

V - Voltage

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CHAPTER 1

INTRODUCTION

1.1 Background

The concept of the "Internet of Things (IoT)" has gained recognition in recent years, referring to the integration of the physical world with the virtual world of the Internet. It involves a network of physical objects embedded with technology to communicate and interact with their environment. Various products, including smartphones, smart watches, and household electronic devices, have been built based on this concept. One notable application is the aquarium monitoring system, which is currently attracting attention. An aquarium is a container or pond used for keeping aquatic animals or plants, and it holds cultural significance in different traditions such as Vaastu and Feng Shui. Smart aquarium projects have been reviewed for reference, involving features like feeding mechanisms, temperature monitoring, and water level checks. However, there are gaps in these projects, and the proposed project aims to address them by introducing a monitoring application that helps users maintain their aquariums. The application includes features like fish feeding, pH sensing, and temperature monitoring, providing real-time notifications and allowing users to manage their aquariums remotely using IoT devices.

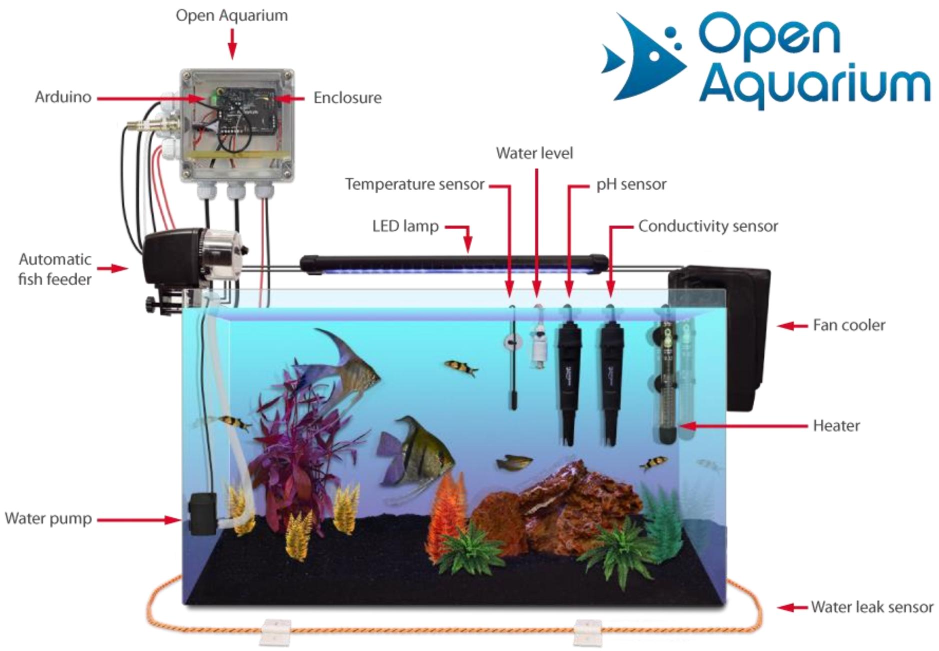

Figure 1-1 Smart aquarium System [1]

1.2 Global Issues

The management of aquariums presents a complex task intertwined with several pressing global issues that demand immediate attention. Chief among these concerns is the sustainability of the aquarium industry, as the demand for exotic and rare species often results in unsustainable fishing practices and the depletion of natural habitats. It is imperative to promote responsible sourcing practices and encourage the breeding and propagation of captive-bred species as viable alternatives, thus minimizing the impact on wild populations.

Another significant global issue revolves around the conservation of coral reefs and marine ecosystems. While live corals are highly sought-after by aquarium hobbyists for their contribution to the health and biodiversity of coral reefs, their collection and trade can detrimentally affect these delicate ecosystems. To counter this, it is crucial to support sustainable alternatives such as aquacultured corals and raise awareness about the importance of preserving natural coral reefs.

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Water pollution constitutes a pressing global issue that affects both freshwater and marine aquariums. Incorrect handling of chemicals, overfeeding, and insufficient filtration systems can lead to harmful water conditions, thereby jeopardizing the well-being of aquatic organisms. It is essential to implement effective filtration systems, promote responsible chemical usage, and educate aquarium owners regarding proper maintenance practices to mitigate water pollution.

The introduction of invasive species poses a significant threat to global aquatic ecosystems. When non-native species are released or escape from aquariums, they can disrupt local ecosystems, outcompeting native species and causing ecological imbalances. Stringent regulations and meticulous quarantine procedures are necessary to prevent the unintentional introduction of invasive species into natural environments.

Education and awareness play pivotal roles in addressing global issues concerning aquarium management. Promoting responsible aquarium ownership, educating hobbyists about sustainable practices, and fostering awareness regarding the importance of conservation are key aspects of cultivating an environmentally conscious aquarium community.

Addressing these global issues necessitates collaborative efforts among aquarium enthusiasts, industry stakeholders, conservation organizations, and regulatory bodies. By implementing sustainable practices, supporting captive breeding programs, preserving natural habitats, and encouraging responsible ownership, we can collectively work towards a more sustainable and environmentally friendly approach to aquarium management.

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1.3 Problem Statement

The current state of aquarium maintenance lacks an efficient and comprehensive solution for monitoring and controlling the aquarium environment. Existing smart aquarium controllers have limitations and do not provide a holistic approach to managing the aquarium's conditions. There is a need for a smart aquarium controller that offers advanced features, ease of use, and seamless integration with IoT technology to ensure the well-being of aquatic life and enhance the user's aquarium experience.

The main challenges that need to be addressed include:

1. Inadequate Monitoring Capabilities: Existing solutions lack a comprehensive range of sensors to monitor essential parameters such as water temperature, pH levels, oxygen levels, and lighting conditions. This hinders the user's ability to maintain optimal environmental conditions for the aquarium.[2][3]

2. Limited Control and Automation: Current smart aquarium controllers have limited control options, often focusing solely on basic functions like feeding and lighting. There is a need for an intelligent system that can automate various aspects of aquarium management, including controlling pumps, filters, heaters, and lighting systems based on real-time data.[6]

3. Lack of User-Friendly Interface: Many existing aquarium controllers have complex interfaces and require technical expertise to operate effectively. It is crucial to develop a user-friendly interface that simplifies the setup process, provides intuitive controls, and offers real-time monitoring and control through a smartphone or web application.[3]

4. Insufficient Connectivity and Integration: The ability to remotely monitor and control the aquarium is essential for users who are away from home or have multiple

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aquariums. Existing solutions often lack robust connectivity options and fail to integrate seamlessly with other smart home devices or IoT platforms.[6]

5. Poor Notification and Alert System: Timely alerts and notifications are crucial for addressing emergencies and maintaining optimal aquarium conditions. Existing solutions often lack customizable alert systems that can notify users about critical events such as water leaks, abnormal temperature fluctuations, or equipment failures.[8]

To address these challenges, a smart aquarium controller system needs to be developed that incorporates advanced monitoring sensors, offers comprehensive control and automation features, provides a user-friendly interface, enables seamless integration with IoT devices, and includes a robust notification system for timely alerts. This will revolutionize the way aquariums are managed, ensuring the health and well-being of aquatic life while providing an enhanced user experience for aquarium enthusiasts.

1.4 Project Objective

i. To study about monitor pH level, control lighting and fish feeding system.
ii. To design an aquarium controller with an automated fish feed system.
iii. To Validate the performance of the smart aquarium controller system.

1.5 Scope of Project

The scope of the project entails designing and developing a unique and innovative smart aquarium controller system that incorporates advanced features and functionality. The aim is to create a comprehensive solution that addresses the limitations of existing smart aquarium controllers and provides aquarium enthusiasts with an exceptional user experience. The project will encompass the following key aspects:

1. Hardware Development:

- Design and prototype a compact and efficient hardware system for the smart aquarium controller.
- Integrate a range of sensors for monitoring crucial parameters such as water temperature, pH levels, lighting conditions, and potentially other relevant factors.
- Implement control mechanisms to automate various aspects of aquarium management, including feeding systems, lighting control, water circulation, and equipment operation.
- Ensure the hardware is compatible with IoT technology and supports seamless connectivity and integration with other smart home devices and platforms.

2. Software Development:

- Develop a user-friendly and intuitive software interface for the smart aquarium controller.
- Implement real-time data visualization and historical data tracking to provide users with insights into the aquarium's conditions and trends.
- Develop algorithms for intelligent control and automation, allowing users to set custom schedules and rules for optimal aquarium management.
- Incorporate a notification and alert system to promptly notify users of critical events such as abnormal parameter fluctuations, equipment failures, or maintenance requirements.

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3. Testing and Validation:

- Conduct thorough testing of the hardware components and software functionalities to ensure accurate monitoring and reliable control of the aquarium's environment.
- Validate the performance and effectiveness of the smart aquarium controller system through extensive real-world testing in different aquarium setups and conditions.
- Gather user feedback and iterate on the design and functionality based on the testing results and user requirements.

The project scope aims to create a fully functional and unique smart aquarium controller system that revolutionizes the way aquariums are managed. By incorporating advanced hardware, intelligent software, and seamless integration with IoT technology, the smart aquarium controller will provide users with enhanced monitoring capabilities, automation features, and a user-friendly interface for optimal aquarium maintenance and an exceptional user experience.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The literature review conducted for this project focused on exploring existing research, studies, and surveys related to internet of things (IoT) applications in aquarium systems. A thorough literature review is essential as it contributes to the development of a strong theoretical framework and provides valuable insights for the present study. Previous research in this field has demonstrated the increasing trend of pet ownership and the importance of providing proper care for animals, including fishes. Fishes require specific environmental conditions such as temperature range, pH levels, and suitable oxygen and CO2 levels, which are different from land animals. While traditional aquarium equipment like oxygen pumps, heaters, and filters are commonly used, they are not sufficient to replicate the natural habitat accurately. Numerous scientists have studied the impact of meteorological and hydrological factors on aquatic environments across different scales. Manual maintenance of these conditions is challenging, and automating the process can significantly reduce fish mortality rates and offer convenience to aquarium owners. The primary cause of fish death in aquariums and fish farms is often attributed to the inability to provide adequate care. Automation, including the use of IoT technology, is considered a highly productive approach to simplify tasks and enhance overall efficiency.

The literature review examined five previous projects related to aquarium systems. These projects include an Arduino-based monitoring system, a smart aquarium system with remote monitoring and control capabilities, an IoT-based mini aquarium system with voice control, a smart water quality monitoring system using Waspmote microcontroller, and an Arduino-based fish monitoring system. However, a notable gap identified among these projects is the absence of a comprehensive monitoring application dedicated to managing the entire smart aquarium system. The proposed project aims to bridge this gap by developing an application that enables users to remotely monitor and control their aquarium, receive notifications, and manage crucial parameters such as pH levels and temperature. By integrating water temperature and pH sensors into the system, users can eliminate concerns about water current, and the low power requirements of Arduino make it suitable for such applications. The development of an application specifically tailored for the care of the entire aquarium will provide owners with convenience and peace of mind, allowing them to manage their aquarium from anywhere and at any time.

The literature review serves multiple purposes for the project. Firstly, it allows the researcher to identify better solutions and approaches by analyzing past projects. It also helps in understanding the challenges and finding appropriate solutions in a systematic manner. Additionally, conducting a literature review ensures that the project follows a well-structured approach, leading to a high-quality output. Comparisons with previous projects in terms of relevance, procedures, outputs, techniques, methods, advantages, and disadvantages enable a comprehensive evaluation of the proposed project. Overall, the literature review serves as a valuable source of ideas, evaluation, and guidance for the project.

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The main objective of this project is to reduce labor time and provide remote control capabilities through a smartphone application, utilizing the Blynk app. IoT technology plays a crucial role in achieving this objective by facilitating communication between devices and minimizing human intervention. By automating routine tasks and enabling machine-to-machine communication, IoT-based systems enhance efficiency and allow for continuous monitoring through sensors. This level of monitoring helps identify breakdowns or errors before they occur, enabling manufacturers to take proactive measures such as shutting down the machine or replacing faulty parts. Ultimately, IoT technology enhances user convenience by ensuring timely delivery of necessary items and eliminating unnecessary worries. The amalgamation of various concepts in IoT creates an autonomous and user-friendly product that performs tasks effectively, while also simplifying diagnostics and problem-solving processes for manufacturers.

2.2 Review of Project

Ten related projects that use various irrigation system approaches will be explored in this section in order to perform better improvements and comprehend the fundamental idea of how an irrigation system should operate.

2.2.1 PREVIOUS RELATED PROJECT 1

Arduino Based Aquarium Monotoring

The primary objective of this project is to create a smart aquarium that can be monitored and controlled through switches, remotes, and internet connectivity. The system includes a servo motor for feeding the fish, which can be monitored remotely. To ensure optimal conditions for the fish, a temperature sensor is utilized to track the water temperature. The LCD display shows both the internal and external water temperatures, and users can also access this information through a web interface over the internet. The project offers three different methods to operate the lighting system, allowing users to conveniently control it through switches, remotes, or internet connectivity. Moreover, the system emphasizes energy efficiency by turning on the lights only when necessary. Overall, this project aims

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to enhance aquarium management by providing remote monitoring and control capabilities, along with features such as automated feeding, temperature tracking, and flexible lighting control.[2]

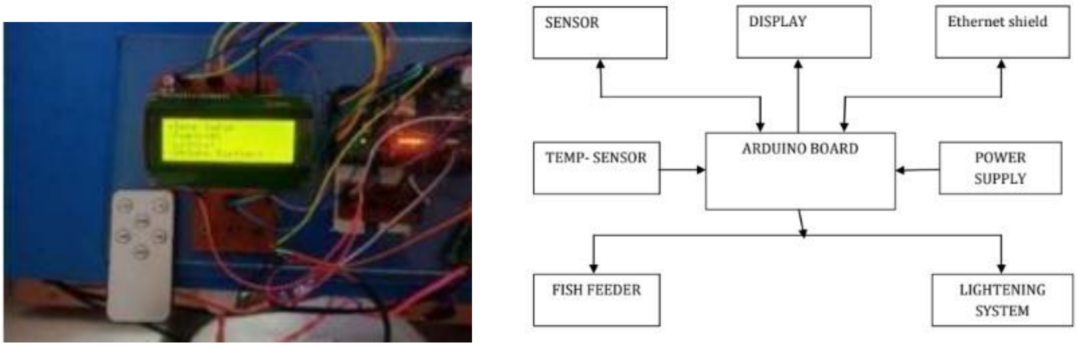

Figure 2-1 The output of temperature and items of project [2]

2.2.2 PREVIOUS RELATED PROJECT 2

Implementation of Smart Aquarium System Supporting Remote Monitoring and Controlling of Functions using Internet of Things

The project was conceived with the idea of developing an automated system for fish care that can be controlled remotely via the cloud. The primary goal was to create a solution that would effectively manage essential tasks such as maintaining pH levels, water level, and temperature in the aquarium. Leveraging IoT technology, the system can monitor these variables, provide data visualization, and even allow manual control of specific features through internet connectivity. This successful implementation highlights the project's capability to streamline operations and ensure a stable aquatic environment. An additional notable aspect of the project is the original design and implementation of the fish feeding system. While numerous complex designs exist, this project emphasizes simplicity without compromising efficiency. The straightforward yet effective design accomplishes its purpose. This approach offers advantages such as increased efficiency, time savings, and

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cost-effectiveness compared to overly complicated alternatives. By practically, this project not only addresses a crucial management-related issue but also contributes to creating an ideal environment for aquarium fish. The automation of tasks and the ability to control the system remotely offer convenience and ensure optimal care for the aquatic inhabitants. Overall, this project serves as a practical demonstration of our abilities while providing a solution to an important challenge in aquarium management.[3]

Figure 2-2 The output of feeding level, water temperature level and water level [3]

2.2.3 PREVIOUS RELATED PROJECT 3

An IoT-Based Mini Aquarium System

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This project has developed an IoT solution called IoT Talk, which is applied to various smart campus applications such as smart dorms and smart gardens. Specifically, for aquariums, the project utilizes the Fish Talk system, enabling real-time interaction between the aquarium sensors and actuators. Unlike simple "threshold control," Fish Talk offers intelligent features that allow more precise and effective management of the water environment. Through the time series charts displayed in Fish Talk, fish owners can easily understand the interplay of various water factors. This goes beyond providing raw data, as the sensors provide valuable insights into the aquarium environment. The Fish Talk application was developed for the National Taiwan Science Education Centre to educate junior high school students on aquarium science experiments. One common mistake made by fish owners is overfeeding, which leads to water pollution due to uneaten food. Previous solutions lack a fish feeding mechanism, except for those relying on mechanical timers, which can be unreliable and potentially harmful if excessive food is dispensed, endangering the fish. With Fish Talk, smart feeding can be easily implemented, allowing fish owners to remotely control the feeding process and ensure that the fish are neither underfed nor overfed. This aspect will be described in detail in Section V of the project. Overall, Fish Talk offers an innovative solution that not only provides efficient monitoring and control of aquarium environments but also addresses the crucial issue of fish feeding, enhancing the well-being of the fish and improving the overall aquarium experience.[4]

Figure 2-3 Monitoring the aquarium by application [4]

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2.2.4 PREVIOUS RELATED PROJECT 4

Smart Water Quality Monitoring System

In a research study titled "Smart Water Quality Monitoring System" conducted by A.N. Prasad, K.A. Mamun, F.R. Islam, and H. Haqva in 2019, a microcontroller board called Waspmote was utilized alongside external ADC and various sensors including pH, water temperature, turbidity, and conductivity sensors. These components were sourced from Libelium World, a reputable European company. The system collected water information using the Waspmote microcontroller, which could then be either sent to the cloud via GSM or stored in an SD card. This project boasted user-friendly features, allowing easy access to water quality information for applications like aquariums, lakes, or ponds, utilizing personal devices. The portability of the system was highlighted, as the compact size of the Waspmote microcontroller made it easily transportable.

However, despite the system's usability, the cost of the product was deemed excessively high for many potential users. The price breakdown, obtained from the official website of Libelium World, revealed that the temperature, pH, turbidity, and conductivity sensors alone cost approximately €3375, excluding the calibration kit. Furthermore, when including the Waspmote microcontroller board, specifically the Plug & Sense! SEPRO LoRa - 868 model priced at €415, the total cost of the entire system amounted to approximately €3790 or RM17234 in Malaysian currency. While European users might consider this cost reasonable, it proves prohibitive for Asian users, making it unlikely for them to invest such a substantial amount solely for monitoring an aquarium. In contrast, the projected cost of my project amounts to approximately €158.90 or around RM700. This makes it significantly more affordable compared to Libelium World's Smart Water Monitoring System. Although we employ less expensive products in our project, such as Raspberry Pi, their performance and durability are comparable to commercial alternatives.[5]

Figure 2-4 Deployment Setup with the sensors and Waspmote microcontroller board [5]

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2.2.5 PREVIOUS RELATED PROJECT 5

Arduino based Fish Monitoring System

The progress in monitoring, automation technology, and aquaculture research has led to advancements in production techniques, enhancing the quality of fish ponds and fish production. Water quality plays a crucial role in the growth of aquacultural organisms, ultimately impacting fish production. Fish act as vital agents in the restoration of water bodies, as they integrate various ecological processes and are sensitive to environmental attributes, such as hydrologic connectivity. The aquatic environment holds ecological and cultural significance, serving as a foundation for ecological restoration and preserving cultural heritage.

Fish survival primarily relies on the conditions of their habitat. Imbalances in the water environment can lead to fish mortality, resulting from factors like natural predation, aging, injuries, starvation, suffocation, pollution, diseases, or parasites. Continuous real-time monitoring of water parameters not only facilitates effective aquaculture management but also generates accurate data for optimizing farming processes, reducing costs, and enhancing efficiency. Monitoring water quality on a daily basis in pond aquaculture research has proven beneficial in addressing various pond-related issues. It acts as a remedy for many problems associated with fish susceptibility to diseases and other complications caused by poor water quality.

To ensure proper water monitoring, it is essential to have appropriate equipment, skilled labor, and extensive experience in accurately gathering and interpreting data. This article aims to design and implement an affordable system for monitoring fish supply processes and water quality in aquaculture tanks. The system comprises sensors that measure diverse water quality parameters (such as temperature, pH, water level, turbidity, conductivity, etc.), monitor tank conditions (including illumination and water level), and observe fish feeding behavior. By implementing this low-cost monitoring system, aquaculturists can gain valuable insights into their operations, leading to improved fish farming practices and overall efficiency. [6]

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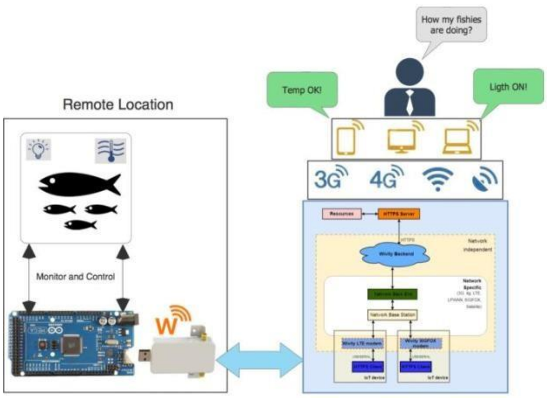

Figure 2-5 Based monitoring system [6]

2.2.6 PREVIOUS RELATED PROJECT 6

A Smart Fish Feeding System for Internet of Things based Aquariums

Fishkeeping is a popular hobby worldwide, known for its calming effects and potential benefits for Alzheimer's patients. However, maintaining proper fish feeding schedules can be challenging for aquarium owners due to busy lifestyles. Underfeeding can lead to starvation and death, while overfeeding can harm fish health and water quality. Although smart aquarium solutions exist, they primarily focus on monitoring environmental parameters rather than automating fish feeding. This paper aims to address this gap by proposing an algorithm and system for automated fish feeding in IoT-based aquariums. The paper reviews related works, explores the parameters influencing fish feeding, presents an innovative feeding algorithm, describes the system implementation, and evaluates its performance. The limitations are discussed, and recommendations are provided to enhance the proposed algorithm. Overall, this paper contributes to the literature on automated fish feeding in smart aquariums.[7] Fish feeding algorithm and a corresponding smart fish-feeding system called AutoAquatech. The algorithm considers various factors such as aquarium environmental parameters, fish species, and density to determine feeding time and the number of pellets required. The AutoAquatech system consists of an Arduino component with a fish feeder and sensors for environmental data collection, along with a mobile application for user interaction. The algorithm and system were evaluated with five participants owning distinct aquariums, and feedback on accuracy and effectiveness was gathered. The results demonstrated high precision and recall in aquariums with a low number of fish species, but a decrease in precision and recall was observed as the number of fish species increased. The paper suggests recommendations for improving the algorithm's accuracy and effectiveness. As future work, the algorithm could be enhanced further,

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considering the limitations discussed in the paper.[7] Additionally, incorporating Artificial Intelligence (AI) techniques like machine learning and reinforcement learning could be explored to gather fish details and intelligently compute the number of pellets.

Figure 2-6 Deployment Setup with the sensors and Waspmote microcontroller board [7]

2.2.7 PREVIOUS RELATED PROJECT 7

Smart Aquarium Management System

In recent times, there has been a noticeable rise in the number of fish enthusiasts, resulting in increased challenges for aquarium owners in maintaining their aquatic environments. Proper maintenance is crucial to ensure the well-being of the fish. However, the conventional approach requires aquarists to manually monitor and regulate various parameters such as fish feeding, lighting, heating, and oxygenation. This poses difficulties, especially when the aquarist is absent, as there is no mechanism to feed the fish in their absence.To address these issues, we have developed a cost-effective solution called the Smart Aquarium Management System. This innovative system offers improved efficiency by automating the maintenance processes and can be easily installed in any aquarium. By replacing the traditional manual procedures, it simplifies the overall management and ensures the optimal care of the fish.[8] The Smart Aquarium Management System has been introduced as an effective solution,

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aiming to enhance the convenience of aquarists. This user-friendly system offers easy implementation, providing a comfortable experience for aquarium owners. With the capability to be accessed remotely via mobile phones, it enables users to control various aquarium parameters such as water temperature, fish feeding, lighting, and oxygen flow through an internet connection. This innovative system functions seamlessly and can be successfully implemented on any type of aquarium, effectively addressing the limitations of the conventional approach.[8]

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Figure 2-7 Aquarium Setup [8]

2.2.8 PREVIOUS RELATED PROJECT 8

Aqua Fishing Monitoring System Using IoT Devices

The Internet of Things (IoT) has experienced significant growth, extending beyond high-end devices to encompass everyday objects like televisions and thermostats. It connects various entities, including humans, animals, and machines, allowing them to exchange data without direct human interaction. The convergence of wireless technologies, MEMS, microservices, and the internet has fueled the evolution of IoT, breaking down barriers between operational and information technology. This convergence enables the analysis of machine-generated data for valuable insights and improvements.[9]Leveraging IoT, modern technologies can assist fish farmers in overcoming challenges. IoT facilitates monitoring of water conditions and ensures an optimal environment for fish. Dedicated platforms provide fish-related information based on ongoing aquaculture research, leading to increased and stable production. Remote monitoring of fish farming systems using sensors, such as pH, temperature, and water level, mitigates risks. Real-time data from these sensors is collected and transmitted to an IoT platform via the internet. To assess the water's suitability for fish farming, a comprehensive web framework is proposed for effective data collection and analysis.Overall, IoT empowers fish farmers with automated monitoring and precise data acquisition, fostering better fish farming practices and optimizing productivity.[9]

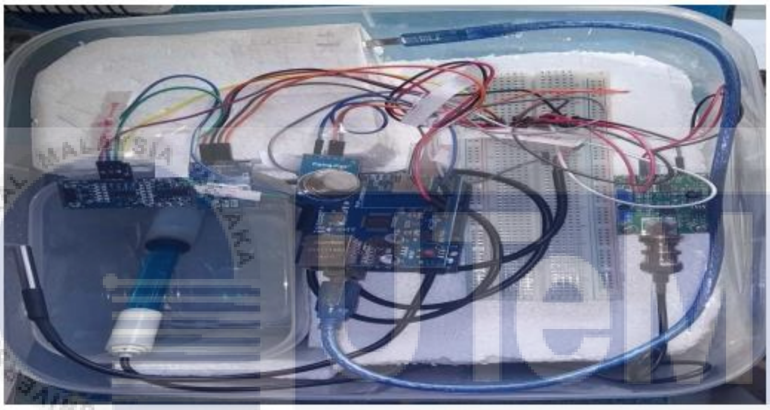

Figure 2-8 Aquarium Setup [9]

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2.2.9 PREVIOUS RELATED PROJECT 9

IOT Based Smart Aquarium

Aquariums are popular containers made of glass or acrylic used to house aquatic and amphibious creatures, adding beauty and aesthetic appeal to homes and workspaces. With the increasing popularity of fish keeping, the global aquarium market is thriving, leading to the demand for innovative ideas to simplify the process.Maintaining an aquarium can be challenging, especially for individuals with busy schedules. [10]Controlling various components like filters, heaters, and air pumps manually can be tricky and time-consuming. In the case of planted aquariums, precise control of lighting duration is necessary to prevent unwanted algae growth and maintain water transparency.The manual tasks involved in aquarium maintenance, such as water changes, feeding, and monitoring temperature and turbidity levels, can be burdensome and overwhelming, especially for beginners. Automation in the control mechanism of aquarium equipment can address these challenges effectively.[10]The SMART aquarium project has been designed to cater to the needs of those who cannot devote daily attention to their aquariums. The system allows remote feeding of fish through an Android application, as well as remote control of aquarium lighting. Temperature sensing and reporting to the user, as well as automatic maintenance of water levels using water level sensors, are also integrated into the system.By incorporating automation, the SMART aquarium provides a convenient solution for aquarium maintenance, alleviating the challenges faced by busy individuals. This unique approach simplifies the tasks associated with fish keeping and enhances the overall experience of aquarium owners.[10]

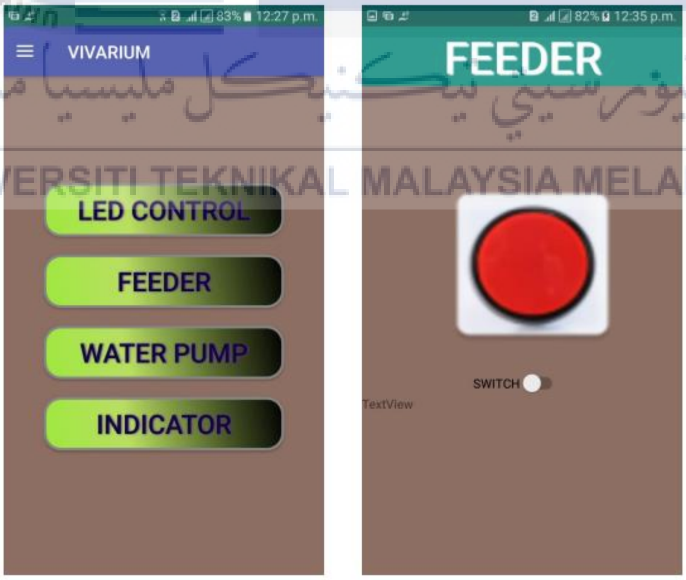

Figure 2-9 Android Application Layout [10]

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2.2.10 PREVIOUS RELATED PROJECT 10

The popularity of owning pets, particularly freshwater fish, has been on the rise. However, maintaining a fish aquarium can be a challenging task. The current manual system requires individuals to perform various tasks, such as turning off the powerhead or air pump, manually feeding the fish, and controlling equipment like lights, heaters, and filters using electrical switches.This manual approach makes aquarium maintenance more difficult and time-consuming. [11]Feeding the fish twice a day necessitates the owner physically going to the tank to feed them and then turning the equipment back on. Additionally, when owners go on vacation, they have no control over the aquarium and cannot feed the fish.To address these challenges, the project proposes the development of a Smart Aquarium that surpasses existing systems in terms of efficiency and cost-effectiveness. The target audience for this project includes individuals interested in keeping fish at home or in offices but lack the time or worry about entrusting the care of their fish to neighbors.The Smart Aquarium system offers automation to replace manual maintenance. It allows users to monitor water conditions such as temperature, pH value, and turbidity. Furthermore, it enables actions like fish feeding and control of temperature using a fan and bulb.By implementing this automated system, fish owners will be able to monitor and maintain their aquariums more effectively, even when they are away. The Smart Aquarium aims to simplify the task of fish keeping and provide a convenient solution for those who are unable to dedicate significant time to their aquariums.[11] The project was born out of the idea to create an automated system that could take care of fish and allow remote control of devices through cloud connectivity. It successfully achieves tasks such as maintaining steady pH levels, water level, and temperature, thanks to the utilization of an IoT platform. This platform enables monitoring, data visualization, and even manual control of certain features over the internet.One notable aspect of the project is the mechanical design and implementation of the fish feeding system,

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which is an original and efficient design. Unlike other complex designs, this project focuses on simplicity, efficiency, time-saving, and cost-saving.Overall, this project showcases the practical implementation of skills to solve an important management problem, ensuring an ideal environment for fish in an aquarium.[11]

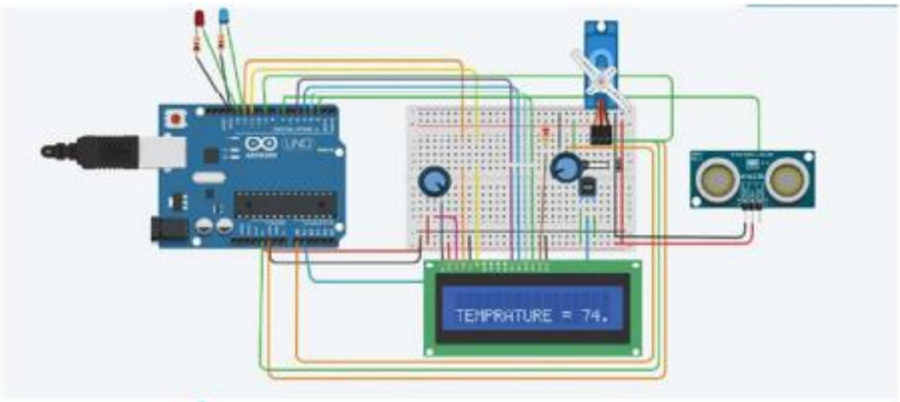

Figure 2-10 Working of Temperature Sensor [11]

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2.3 Analysis between the previous and proposed project

Project Title	**Arduino Based Aquarium Monotorin G System** [2]	**Implementation of Smart Aquarium System Supporting Remote Monitoring and Controlling of Functions using Internet of Things** [3]	**An Iotbased Mini Quarium System**[4]	**Smart Water Quality Monitoring System**[5]	**Arduino based Fish Monitoring System**[6]	**Development of IoT based SMART AQUARIUM CONTROLLER**
Database	Web Base	Web Base	Mobile Application	NA	Mobile Application	Mobile Application

Functionality	Feeding fish and measuring water temperature.	Feeding fish and measuring water temperature.	Feeding fish and measuring water temperature	Water quality evaluation	Fish feeder, water sensor	Feeding fish and measuring water temperature ,control fan and light
Technology Used	Sensor, LCD, Servo, Temperature Sensor, Arduino, and Ethernet Shield	Ultrasonic sensor, ESP8266, LCD 20x4, temperature sensor, servo motor, four channel relay module, water heater, and fan are all components of the Arduino Mega 2560.	pH Sensor, Temperature Sensor, EC Sensor, Fan, RO Filter, Servo, Arduino One, and ROHM Iot KitAr	pH, water temperature, conductivity sensors, turbidity, gsm, and Ardiuno	Arduino UNO, sensors, servo.	ESP32, LCD, temperature sensor, servo motor, two channel relay module, ph sensor,light and fan
Platform	Ardiuno uno	Ardiuno Mega	Ardiuno uno	Ardiuno uno	Ardiuno uno	ESP32

Table 2-1 Systematic Review Table

Feature	Smart Aquarium Controller System	Arduino Based Monitoring	IoT-based Mini Aquarium	Smart Water Quality System	Arduino-Based Fish Monitoring
Monitoring Capabilities	Advanced sensors for pH, temperature, O2 levels	Temperature sensor	Voice-controlled sensors	Multiple quality sensors	Basic sensors
Control & Automation	Comprehensive automation of feeding, lighting, etc.	Basic switches control	Basic voice control	Automated quality control	Basic feeding system
User Interface	Intuitive smartphone/web application	LCD display	Smartphone control	Dashboard interface	Simple display interface
Connectivity	IoT integration, multi-platform	Internet connectivity	IoT enabled	IoT with data transmission	Limited connectivity
Alert System	Customizable, real-time alerts	Basic alerts	Real-time notifications	Alerts based on thresholds	Basic alerts
Remote Accessibility	Full remote monitoring and control	Limited remote monitoring	Full remote control	Remote data access	No remote feature mentioned
Energy Efficiency & Cost	Low power consumption, cost-effective	Moderate power use	Moderate power use	Variable power use	Low power consumption, cost-effective

Table 2-2 Validate the performance of the smart aquarium controller system.

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2.4 Summary

These previous projects focused on developing smart aquarium systems with remote monitoring and control capabilities. Project 1 aimed to create a smart aquarium that could be controlled through switches, remotes, and internet connectivity, featuring automated fish feeding, temperature tracking, and energy-efficient lighting control. Project 2 emphasized the management of essential tasks like pH levels, water level, and temperature, highlighting the simplicity and efficiency of their design. Project 3 introduced an IoT solution called Fish Talk, offering real-time interaction between aquarium sensors and actuators, along with intelligent features for precise water environment management. It also addressed the crucial issue of fish feeding. Project 4 involved a smart water quality monitoring system that utilized a microcontroller board and various sensors, but the high cost of components limited its accessibility. Finally, Project 5 discussed the importance of continuous real-time monitoring of water parameters in aquaculture, emphasizing the need for affordable systems to improve fish farming practices.

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CHAPTER 3

METHODOLOGY

3.1 Introduction

The rules on how to collect the necessary data and the strategy that produces the outlines to make the procedure well-done are known as the methodology. Included in this are the theoretical considerations and hypotheses that guide the application of various methodologies. methods or techniques that are specific to finding, choosing, processing, and analysing information about a subject. The methodology part of a research report gives the reader the chance to examine a study's overall validity and dependability. Several relevant and applicable notions exist in methodology. This comprises the project's Gantt chart, workflow, list of used materials, and budget. As a result, the author's future projects will be more well-informed and exact.

The first step is to purchase the hardware a temperature sensor, a cooling fan, and a pH sensor that will be utilised in this project. The next step is to purchase the Servo motor, 4 Channel Relay, NodeMCU ESP 32, and Breadboard, which are components linked to the circuits used in this project. The third stage involves adding a button widget to the Blynk application so that it may be configured to direct hardware devices like fish feeds, cooling fans, and lights to open or shut. The Arduino IDE software is used to create the programme code in the fourth stage. The Arduino IDE software is used to combine the Blynk application and programme code in the fifth phase.

The next stage is to upload the programme code to the Node MCU ESP32 components using a jumper wire in accordance with the existing pins on those components after producing the programme code and integrating it into the application. The relay board will then be turned on. The next step is to connect the 2 pin connector to the AC power socket and the live wire found in the cooling fan and lamp wire connections to the relay board output. Then, using a jumper wire in accordance with the component's existing pins, connect the servo motor to the MCU Node. The Node MCU, Blynk app, and electrical apparatus will then be linked and operational. Next, a button widget that has been added to the Blynk app via an internet connection is used to turn electrical appliances on or off straight from the phone.

In summary, NodeMCU must be used to control electrical equipment through the internet, and a relay board must be used to connect NodeMCU to electrical equipment. A smartphone must be used in order to activate the button widget in the Blynk app to turn on or off NodeMcu.

3.2 Selecting and Evaluating Tools for a Sustainable Development

Sustainable development approach in designing a smart aquarium controller, several factors come into play. Firstly, it is crucial to prioritize energy-efficient components and technologies. Opt for low-power sensors, LED lighting, and efficient circuitry to minimize energy consumption and reduce the environmental impact. Additionally, consider the lifecycle of the materials used in the tools. Choose environmentally friendly and recyclable materials while avoiding hazardous substances. Conduct thorough research on suppliers to ensure their commitment to sustainable practices.

Water conservation should be a key consideration when selecting tools. Look for tools that enable efficient water usage. Evaluate the durability and reliability of the tools to minimize the need for replacements and reduce electronic waste. Another important aspect is the compatibility and integration capabilities of the tools with IoT technology. Ensure that the tools can seamlessly connect to the smart aquarium controller and enable remote monitoring and control. This allows users to manage their aquariums efficiently from anywhere, reducing the need for physical presence and minimizing carbon emissions.

Consider tools that provide data-driven insights and analytics. Tools with advanced monitoring capabilities and data collection features can provide valuable information about temperature fluctuations, and energy usage. This data can guide decision-making and optimization of resource utilization for a more sustainable approach.

Lastly, evaluate the tools based on their user-friendliness and accessibility. Tools that are easy to install, operate, and maintain will contribute to the long-term sustainability of the smart aquarium controller. Additionally, prioritize tools from manufacturers that offer support and educational resources to promote responsible aquarium practices and sustainable development. By carefully selecting and evaluating tools based on energy efficiency, materials, water conservation, IoT compatibility, data-driven insights, and user-friendliness, a smart aquarium controller can be designed with a strong foundation for sustainable development. These considerations contribute to minimizing environmental impact, conserving resources, and promoting responsible aquarium management practices.

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3.3 Methodology

Methodology is the module or procedures use to produce and briefing about the project in details. These measures are taken because it is very important to ensure the project is completed with successfully in a predetermined time. In addition, there are ways to test the durability of materials, installation of components and project specifications. The method further facilitate work processes and ensure the project functioning successfully. The methodology also includes a number of methods, Block diagram of project flow chart process including the design of systematic work, make a sketch of the project and project design. These measures should be carried out with be outmost precision in order to produce a project quantity and quality.

3.3.1 Project Planning

Project planning is known as project management to plan and report the progress within the project environment. Figure 3.1 shows the estimation general process flow.

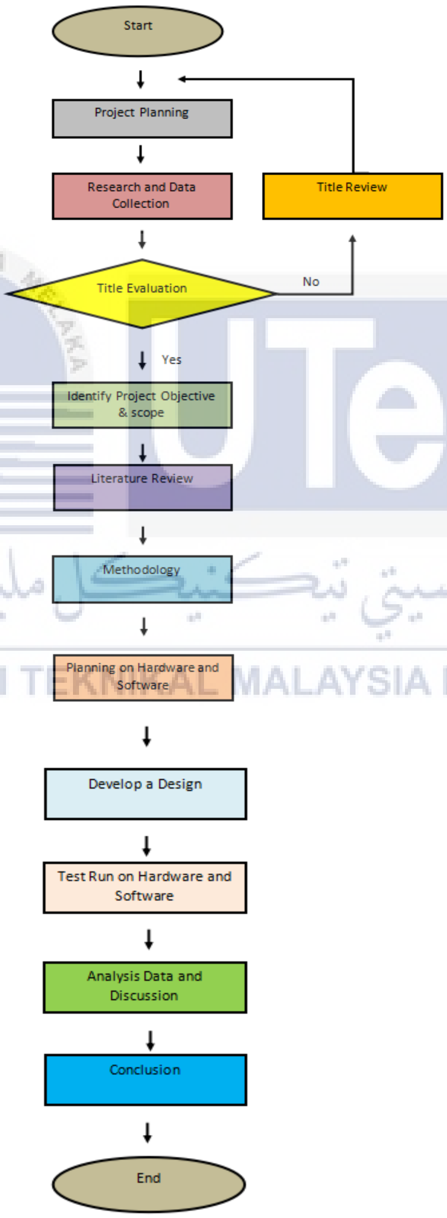

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Figure 3-1 Project Planning

3.3.2 Block Diagram

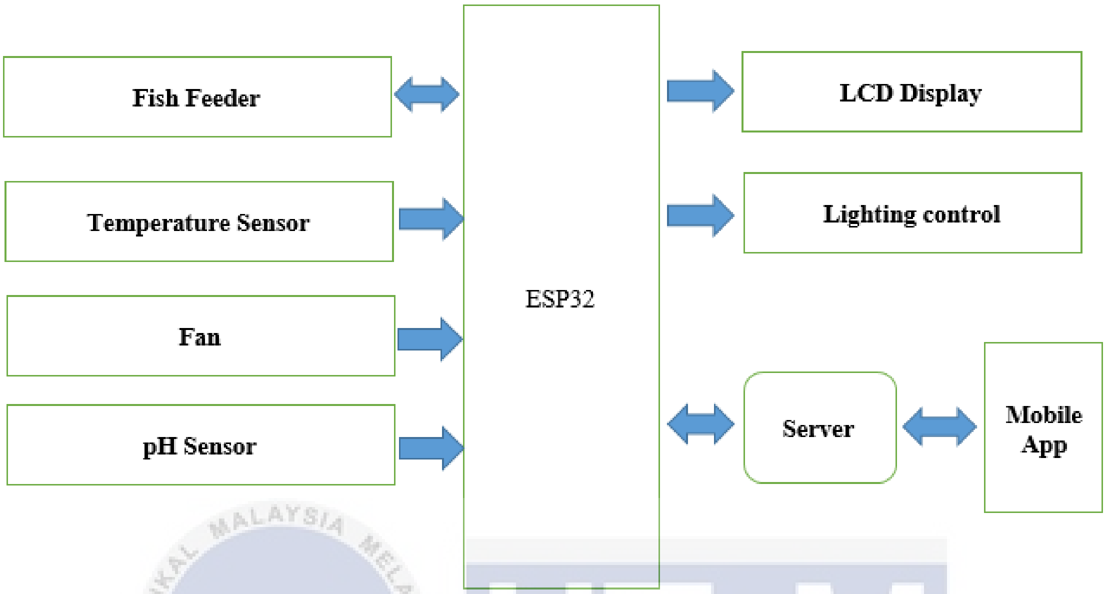

Figure 3-2 Block diagram of Smart Aquarium Controller

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3.3.3 Flow Chart

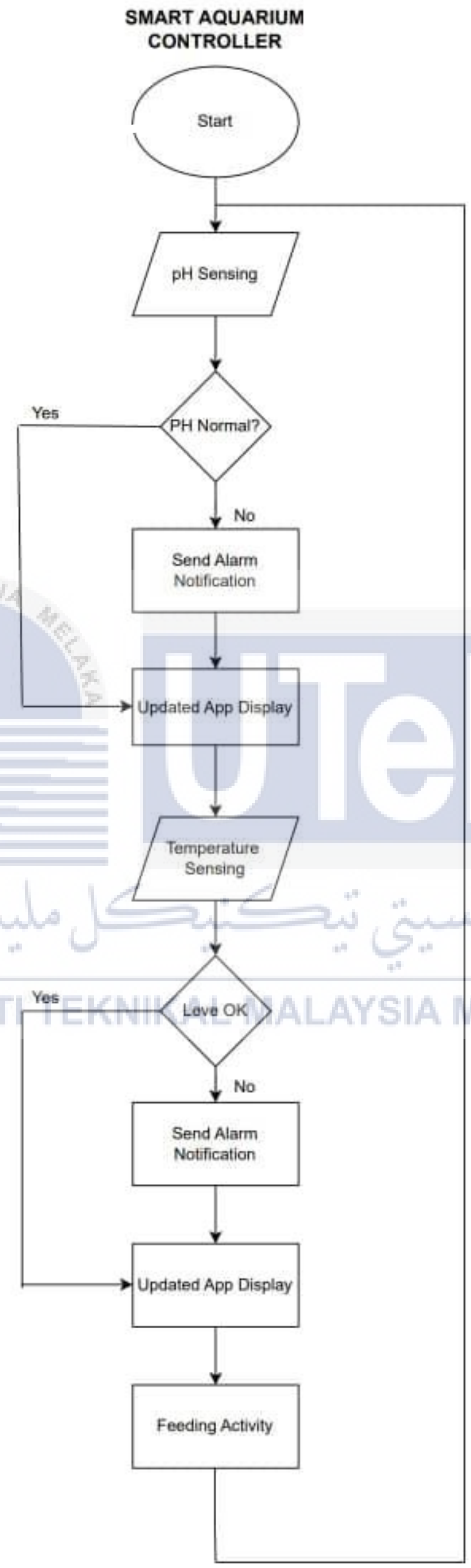

Figure 3-3 Flow Chart

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3.3.4 Schedule

Gantt chart is used to schedule a appropriate time frame for all of the project workflow tasks. Figure 3.4 indicate the Gantt chart of the project, respectively. The scheduling of activities is important to avoid undesirable delays and ensure the project is completion on time. Nevertheless, planning and scheduling of activities can increase productivity.

Task	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
Planning and Research	X	X												
Define Requirements and Features	X													
Research Components	X	X												
Create Schematics		X						M						
Material Acquisition		X						I						
Circuit Assembly			X					D						
Wiring and Connections			X					T						
Verify Circuits			X					E						
Install Development Environment				X				R						
Develop Sensor Readings				X				M						
Control Mechanisms				X	X									
Blynk App Integration					X			B						
Test Communication					X			R						
Integration of Hardware and Software						X		E						
Functional Testing							X	A						
Calibration								K	X					
Performance Testing									X					
Documentation									X	X	X			
Presentation and Finalization												X	X	X

Figure 3-4 Gantt chart of the project

3.4 POTENTIAL SOLUTION INSTRUMENT REVIEW

3.4.1 SOFTWARE

3.4.1.1 Arduino IDE

Figure 3-5 The Arduino IDE Logo [12]

The Arduino Software (IDE), also known as the Arduino Integrated Development Environment, provides various components for programming and communication. These

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include a text editor for writing code, a message area for displaying information, a text console, a toolbar with common function buttons, and a set of menus. The IDE establishes a connection with Arduino and Genuino hardware, allowing users to upload programs and communicate with the devices.

3.4.1.2 Blynk Application

Figure 3-6 Blynk App Logo [13]

Blynk is a company specializing in the Internet of Things (IoT) that provides a platform for creating mobile applications (compatible with iOS and Android) to connect electronic devices to the internet. These applications enable users to remotely monitor and control their connected equipment. Pavel Bayborodin, an expert in mobile and automotive user experience (UX), founded Blynk. The IoT platform was introduced in 2014.

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3.5 USING IoT (Internet of Things)

The network of physical items is referred to as the Internet of Things, or IoT. These devices can share data without the need of a human. There are several categories of IoT devices besides computers and equipment. An IoT object is anything that has a sensor and a unique identifier (UID). The primary goal of the Internet of Things is the development of self-reporting devices that can communicate with users and each other in real time..[14]

Table 3-1 Using IoT

KEY ASPECTS	DESCRIPTION

Remote Monitoring	IoT-enabled aquarium controllers allow you to monitor the vital parameters of your aquarium, such as temperature, pH level, water quality, and lighting conditions, from anywhere using a mobile app or a web-based interface. This enables you to keep an eye on your aquarium's health even when you are away.
Automated Control	IoT aquarium controllers can automate various tasks, such as controlling lights, heaters, pumps, and filters based on pre-defined schedules or specific conditions. For example, you can program the controller to simulate natural lighting patterns or adjust the temperature based on time of day or specific temperature thresholds.
Alerts and Notifications	IoT aquarium controllers can send you real-time alerts and notifications if any parameter goes beyond the desired range or if there's a system failure. This enables you to take immediate action and prevent any potential issues that could harm your aquarium inhabitants.

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Data Logging and Analysis	IoT controllers can log and store data from various sensors over time, allowing you to analyze historical trends and make informed decisions about your aquarium's conditions. This data can be valuable for identifying patterns, detecting issues, and optimizing the overall environment for your aquatic life.
Integration with Other Devices	IoT controllers can integrate with other smart devices, such as smart lighting systems, voice assistants (e.g., Amazon Alexa, Google Assistant), or home automation platforms.
Feeding Automation	Some IoT-enabled aquarium controllers come with the ability to automate fish feeding. You can set up feeding schedules or trigger feeding remotely through the controller. This feature ensures that your aquatic pets are fed even when you're not physically present.
Cloud Connectivity	IoT controllers can leverage cloud connectivity to provide additional benefits. For instance, you can store your aquarium data securely in the cloud, access it from

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	multiple devices, and even share it with fellow aquarium enthusiasts or experts for advice and troubleshooting.

When incorporating IoT into your aquarium controller, it's essential to ensure proper security measures are in place, such as strong passwords, encryption, and regular firmware updates, to protect your system from potential vulnerabilities. Overall, using IoT in an aquarium controller brings convenience, remote monitoring, automation, and advanced control capabilities, enabling you to create and maintain a healthy and thriving aquatic environment.

3.6 HARDWARE

3.6.1 Arduino Mega

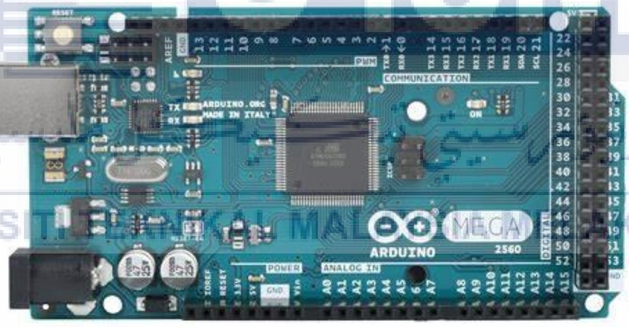

Figure 3-7 Arduino Mega [15]

The Arduino™ Mega 2560 is a powerful microcontroller board that utilizes the ATmega2560 chip. Equipped with 54 digital I/O pins, including 14 that can function as PWM outputs, as well as 16 analog inputs, this board provides extensive connectivity options. Additionally, it features 4 UARTs for serial communication, a 16-MHz crystal oscillator for accurate timing, a USB interface for easy connection to a computer, a power connector, an ICSP header for programming, and a reset button. With its comprehensive set of components, the Arduino™ Mega 2560 is a versatile platform that can be powered by a

USB connection, an AC/DC adapter, or even a battery. It is compatible with a wide range of shields designed for Arduino™ Due, Duemilanove, or Diecimila, expanding its capabilities and making it suitable for various projects.

The ESP32 and Arduino Uno are different hardware platforms used for microcontroller-based projects. Here are the key differences between the two:

Table 3-2 Comparison Table Between Arduino and ESP32

Key Distinctions	ARDUINO UNO	ESP32
Microcontroller	The Arduino Uno is based on the Atmega328P microcontrolle	The ESP32 integrates a more powerful dual-core processor with additional features like Wi-Fi and Bluetooth.
Processing Power	The Arduino Uno has a single-core processor running at 16 MHz.	The ESP32 offers significantly more processing power compared to the Arduino Uno. The ESP32 has a dual-core processor running at up to 240 MHz
Memory	The Arduino Uno has 2 KB of SRAM and 32 KB of flash memory.	The ESP32 provides more memory compared to the Arduino Uno.

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		The ESP32 supports both 2.4 GHz and 5 GHz Wi-Fi bands. The ESP32 has a dual-core processor running at up to 240 MHz
Connectivity	The Arduino Uno does not have these features by default, but they can be added using external modules or shields.	The ESP32 includes built-in Wi-Fi and Bluetooth capabilities, allowing for wireless communication.
Peripherals	he Arduino Uno offers a range of digital and analog input/output pins for connecting sensors, actuators, and other devices.	The ESP32 provides similar GPIO (General Purpose Input/Output) pins but also offers additional interfaces such as UART, SPI, I2C, I2S, and SDIO, providing more options for connecting to various peripherals.
Libraries and Ecosystem	The Arduino Uno has a large and well-established ecosystem with a vast collection of libraries, examples, and community support	The ESP32, while also having a growing ecosystem, may have fewer resources available in comparison.
Power Consumption	The Arduino Uno generally has lower power consumption	The ESP32 has Higher power consumption

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	compared to the ESP32, which can make it suitable for battery-powered or low-power applications	

It's important to note that while the Arduino Uno is a simpler and more beginner-friendly platform, the ESP32 offers more advanced capabilities, especially in terms of wireless connectivity and processing power. The choice between the two depends on the specific requirements of your project, such as processing needs, memory requirements, connectivity requirements, available libraries, and budget considerations.

3.6.2 ESP32

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Figure 3-8 ESP32 [16]

The ESP32 is a highly versatile and powerful microcontroller board that has gained significant popularity in the realm of embedded systems and IoT applications. It features a dual-core processor, making it capable of handling complex tasks with ease. The ESP32 incorporates built-in Wi-Fi and Bluetooth connectivity, enabling seamless communication and integration with other devices and networks. With its ample memory and storage capacity, it provides ample room for data processing and storage. The ESP32 also offers a wide range of I/O pins, including digital and analog interfaces, making it suitable for connecting various sensors, actuators, and peripheral devices. Furthermore, it supports multiple protocols and interfaces, such as SPI, I2C, and UART, enhancing its compatibility and expandability. The ESP32 can be programmed using the Arduino IDE or other development frameworks, allowing for easy development and deployment of applications. Overall, the ESP32 empowers developers and enthusiasts to create innovative projects and solutions by combining its computational power, wireless connectivity, and extensive I/O capabilities.

ESP (NODE)

Table 3-3 Comparison Table Between ESP8266 and ESP32

Key Distinctions	ESP8266	ESP32
Processing Power	The ESP8266 has a single-core processor running at up to 80 MHz.	The ESP32 is more powerful than the ESP8266 in terms of processing capabilities. The ESP32 features a dual-core processor running at up to 240 MHz, while the ESP8266 has a single-core processor running at up to 80 MHz. This higher processing power of the ESP32 allows for more complex applications and multitasking capabilities.

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		This higher processing power of the ESP32 allows for more complex applications and multitasking capabilities
Memory	The ESP8266 usually has 80 KB of RAM and 4 MB of flash memory.	The ESP32 has more memory compared to the ESP8266. It typically offers up to 520 KB of SRAM and 4 MB of flash memory. The additional memory in the ESP32 is beneficial for running more extensive programs and storing larger amounts of data.
Wi-Fi Performance	Have built-in Wi-Fi capabilities, The ESP8266 only supports 2.4 GHz.	Both microcontrollers have built-in Wi-Fi capabilities, but the ESP32 provides enhanced Wi-Fi performance compared to the ESP8266. The ESP32 supports both 2.4 GHz and 5 GHz Wi-Fi bands. The ESP32 offers better Wi-Fi range, higher throughput, and improved security features.

Bluetooth Support	The ESP8266 is its integrated Bluetooth support.	One significant advantage of the ESP32 over the ESP8266 is its integrated Bluetooth support. The ESP32 includes both Bluetooth Classic (BR/EDR) and Bluetooth Low Energy (BLE) capabilities, making it suitable for a wide range of IoT applications that require wireless communication
Peripheral Interfaces	The ESP8266 offers a limited range of peripheral interfaces	The ESP32 offers a wider range of peripheral interfaces compared to the ESP8266. It includes additional UART, SPI, I2C, I2S, and SDIO interfaces, allowing for more versatile connectivity options and easier integration with various sensors, displays, and other devices.
Power Consumption	The ESP8266 generally has lower power consumption	The ESP32, making it suitable for battery-powered or low-power applications. However, it's worth noting that power

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		consumption can vary depending on the specific use case, firmware optimizations, and the configuration of the microcontroller.

Overall, the ESP32 is a more advanced and capable microcontroller compared to the ESP8266. It offers higher processing power, more memory, better Wi-Fi and Bluetooth support, and a broader range of peripheral interfaces. However, the choice between the two depends on the specific requirements of the project, including processing power needs, memory requirements, connectivity options, and budget constraints.

3.6.3 Jumper Wires

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Figure 3-9 Jumper [17]

A jump wire, commonly referred to as a jumper, jumper wire, or DuPont wire, is an electrical wire or a cable consisting of multiple wires. It is designed with connectors or pins at each end, although some may be left without connectors and simply "tinned" for easy use. The primary purpose of a jump wire is to establish connections between various components in a breadboard, prototype circuit, or testing setup. It enables interconnection either internally within the circuit or with external equipment or components. Jump wires provide a convenient means of connecting elements without the need for soldering, offering flexibility and versatility in electronic projects and experimentation.

3.6.4 pH Sensor

Figure 3-10 pH Sensor [18]

A pH sensor is utilized to gauge the concentration of hydrogen ions in a solution, providing an indication of its acidity or alkalinity. The core component of a pH sensor is the glass pH electrode, which is widely employed for this purpose. The electrode operates based on the principles of a voltmeter, utilizing potential differences to measure and compare voltage levels in the solution. An optimal pH value for a solution is considered to be pH 7, indicating neutrality. Solutions with pH values higher than 7 are classified as basic or alkaline, while those with pH values lower than 7 are deemed acidic. By measuring and analyzing the potential difference, a pH sensor enables the determination of the pH level, thus providing valuable insights into the acidity or alkalinity of a solution.

Table 3-4 Characteristic Table

BNC Electrode Probe Connector Hydroponic	CHARACTERISTIC	Tongda Laboratory Electro Probe BNC Controller
Plastic	Material	ABS
BNC	Terminal	BNC
0 – 14	PH Range (pH)	0 - 14
<=85	Relative Humidity (%)	<=55
5 – 40	Temperature Range (oC)	0 - 50
75	Cable Length (cm)	110

3.6.5 Temperature Sensor

Figure 3-11 Temperature Sensor [19]

Temperature sensors are crucial components in various applications, including the monitoring of temperature in fish aquariums. Typically, temperature sensors can be thermocouples or RTDs (Resistance Temperature Detectors). In the case of fish aquariums, we have employed a thermistor-based temperature sensor that is specifically designed to measure water temperature. This type of sensor operates based on the principle of inverse time characteristics. As the temperature rises, the resistance of the thermistor decreases, providing a signal indicating the increase in temperature. By monitoring the resistance of the thermistor, the temperature sensor effectively detects and relays information about the water temperature in the aquarium.

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3.6.6 DC Water Pump Motor

Figure 3-12 DC Water Pump Motor [20]

The DC water pump motor is an essential component with both an inlet and an outlet, commonly employed for water extraction or refilling purposes in tanks or aquariums. This motor operates within a voltage range of 6V to 12V DC. It has a maximum rated current of 1.2A and a maximum rated power of 16.8W. With a flow rate of 10 litres per minute, it efficiently moves water through the system.

3.6.7 Servo Motor

Figure 3-13 DC Servo Motor [21]

The servo motor operates by responding to the control signal applied to its control pin. It functions on the principle of Pulse Width Modulation (PWM). The servo motor's structure includes a DC motor, variable resistors, and a gear mechanism. Depending on the configuration, it can provide movement in a range of 180 degrees or a full 360 degrees, which can be adjusted as needed. The motor's response and motion are influenced by the pulse received. When a high pulse is applied, the servo motor exhibits a correspondingly high response and moves back and forth. The servo motor's design allows for precise control and positioning in various applications.

3.6.8 Two Channel Relay Module

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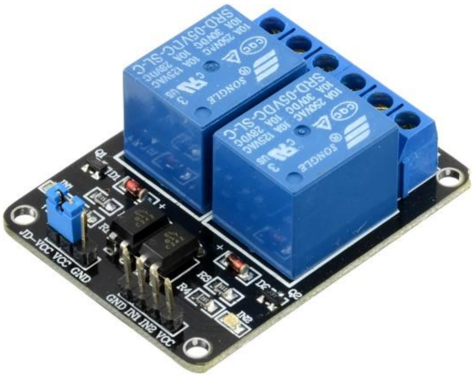

Figure 3-14 Two Channel Relay Module [22]

With a single module, two distinct circuits can be controlled by a 5-volt, 2-channel relay module. Each channel has output pins for connecting external devices and signal input pins for turning on the relay. In automation, robotics, or home electronics, it functions as a switch by utilising a low-voltage signal to manage higher-voltage circuits. Common uses include safely turning on and off lights, motors, and other appliances. To guarantee that the relay operates properly and doesn't harm the components it controls, it's imperative to understand the right connections and voltage needs.

3.6.9 Fan

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Figure 3-15 Fan [23]

A fan is a device that utilizes rotating blades to regulate and control the movement of air by compressing it. Its primary function is to circulate air and provide cooling effects. By drawing in cool air from the surroundings, the fan creates a flow that is directed into a designated area. Its purpose is to reduce the temperature of the environment or object it is directed towards. In the context of a tank or aquarium, a fan has been strategically installed to maintain optimal temperature conditions. When the water temperature exceeds a predetermined threshold, the fan automatically activates, aiming to restore and balance the temperature inside the tank. This ensures that the aquatic environment remains within a suitable range for the well-being of its inhabitants.

3.6.10 Ultraviolet Light

Figure 3-16 Ultraviolet Light [24]

UV light, also known as ultraviolet light, serves as a substitute for sunlight in certain applications. It refers to electromagnetic radiation with wavelengths shorter than visible light. In the context of aquariums, UV light finds application in various ways. One notable application involves the control of heterotrophic bacteria population. Organic matter produced by fish and other sources can lead to an increase in heterotrophic bacteria, resulting in reduced water clarity. UV sterilizer light effectively eliminates these bacteria, helping to restore water clarity and cleanliness. UV light serves as a natural method for dechlorinating fish water. Chlorine and chloramine are common additives in tap water, and their presence can be harmful to fish. UV sterilizers prove highly effective in removing chlorine and chloramine, ensuring a safer environment for aquatic life. It is worth noting that UV sterilization plays a vital role in the process of dechlorinating fish water.

3.6.11 Fish Feeder

Figure 3-17 Fish Feeder [25]

The feeding mechanism consists of individual compartments filled with food, providing a diverse selection. A clock-driven mechanism facilitates the rotation of these compartments, ensuring that the food is released into the aquarium at specific predetermined intervals. This automated feeding system allows for regular feeding of the fish without the risk of overfeeding. By providing a controlled and scheduled release of food, it promotes a healthy feeding routine, maintaining the well-being of the fish while preventing excessive consumption.

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3.6.12 Type of Aquarium

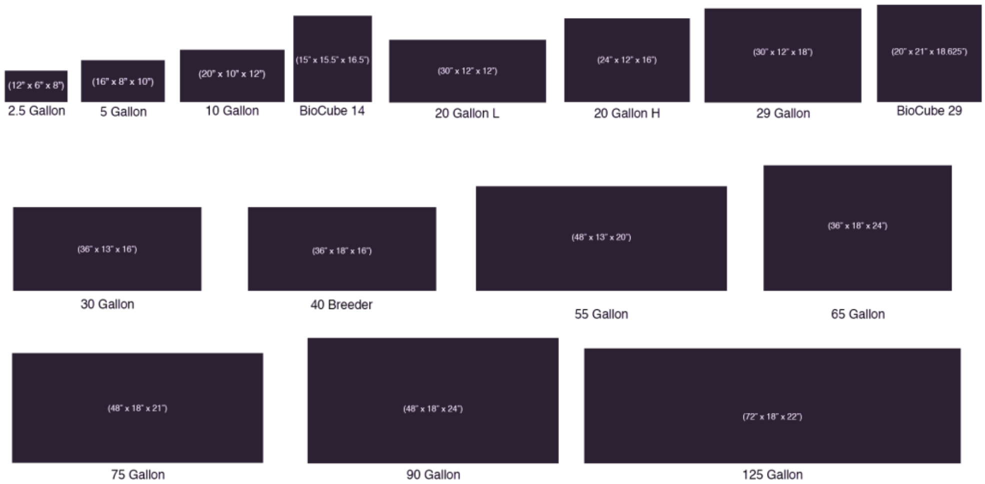

Figure 3-18 Aquarium Types [26]

A diverse range of aquarium types and sizes cater to various preferences and environments. Among the commonly recognized types are the Freshwater Tropical Aquarium, Coldwater Aquarium, Marine Aquarium, and Brackish Aquarium. The Freshwater Tropical Aquarium is widely known and favored by many due to its ease of maintenance, affordability, and the availability of a wide variety of freshwater fish species. Coldwater fish, on the other hand, thrive in room temperature conditions and often include popular species like Koi and Goldfish. While Coldwater setups can be relatively more expensive, they offer their own unique appeal. Marine aquariums require saltwater to support the fish and other marine life within them. Specialized salt mixes are added to the water to create the necessary salinity before introducing fish and coral. The marine environment boasts exceptionally beautiful fish species, but it demands higher costs for both acquiring the fish and maintaining the aquarium's delicate balance.The Brackish Aquarium presents an intriguing blend of freshwater and saltwater. It serves as a habitat for brackish fish such as catfish, pufferfish, gobies, and more. This type of aquarium offers a distinctive experience by combining elements of both freshwater and marine setups.

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3.7 Connections

	Relays Pin	Connected with	Reason
Input Pins	IN1	D13 of ESP32	To send a signal from ESP32 to Relay 1.
	IN2	D14 of ESP32	To send a signal from ESP32 to Relay 2.
Output pins	Relay1 (NO)	Coling Fan	To Turn ON/OFF Cooling Fan.
	Relay2(NO)	Light	To Turn ON/OFF Light.
Power Pins	Vcc	Vcc	To Enable Relay Module.
	Ground	Ground	To Complete the circuit.

Table 3-5 Explanation of 2-relay module connections

Esp32 Module		
ESP pins	**Connected To**	**Reason**
D4	Temperature Sensor	For transmitting Temperature sensor's processed data to internet through ESP32.
D2	pH Sensor	For transmitting pH sensor's processed data to internet through ESP32.
D5	Servo Motor	To Activate the DC Servo Motor.
D5	Cooling Fan	To Activate the DC Cooling Fan.
D6	Light	To Activate the DC Light.
D18 D19	LCD SDA Pin LCD SCL Pin	To Display the Readings.
Vcc	Vcc of all Components	To Turn on ESP32.
Ground	Ground of all Components	To complete the circuit.

Table 3-6 Explanation of ESP module connection with Components

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3.8 Cost Estimation

Table 3-7 Cost Estimation

Components	Price
ESP32	RM 35.00
Jumper cable (male-male)	RM0.80
Jumper cable(male-female)	RM 4.00
Jumper cable(female-male)	RM 4.00
DS18B20	RM 11.00
Servo Motor	RM20.00
DC Colling Fan	RM15.00
2 Channel Relay 5V	RM9.00
DC Light	RM20.00
Fish Feeder	RM15.00
1 Resistor	RM1.00
DC Water Pump	RM25.00
LCD Display	RM25.00
pH sensor	RM140.00
Total	**RM 324.80**

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3.9 Equipment

The proposed system's hardware should be utilized or incorporated based on the specified minimum requirements outlined in Table 3.2. This table provides a comprehensive breakdown of the system's hardware needs, including the functionality associated with each individual component. Additionally, Table 3.3 outlines the system's software requirements and corresponding functionality in detail.

Table 3-8 Hardware details

No	Hardware	Functionality
1.	ESP32	The microcontroller for this project is an ESP32.
2.	Servo Motor	To open a little door and fill a fish feeder with food.

3.	DS18B20 Temperature Sensor	Ds18B20 water temperature sensor uses an application to notify users and monitor the water's current temperature in aquariums..
4.	pH Sensor	The pH sensor E201-BNC is used to measure how acidic aquarium water is.
5.	DC Light	Aquarium lighting is used to improve nighttime viewing.
6.	DC Water Pump Motor	Pumps, including power heads, have two main purposes: aerating and generating currents, and transporting water through a variety of ancillary devices such sumps, filters, and skimmers.
7.	Two Channel Relay Module	The water pump, which requires a lot of current and voltage, will be controlled by a relay.
8.	Cooling fan	A cooling fan with powerful ventilation capabilities to lessen heat transfer from the aquarium.
9.	ESP32 Expansion Board	ESP32 expansion board extends the capabilities of the ESP32 microcontroller, providing extra features like more pins, connectivity, sensors, and displays for diverse project development.
10.	Fish feeder	Providing fish food at the time
11.	Resistor 4.7K	To connect with DS18B20 Temperature Sensor

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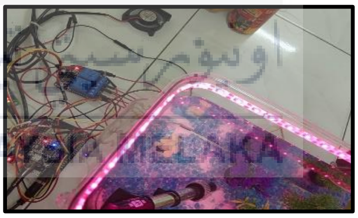
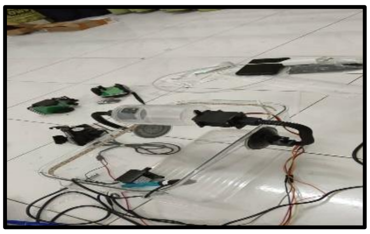
Table 3-9 Software details

No	Software	Functionality
1.	Arduino IDE	Used to create and upload irrigation system programming.
2.	Blynk App	Used to design applications that allow for remote control of aquarium systems.

3.10 Circuit Operation

The project's goal is to gather background information on feeding fish food faster. We also learn how to construct circuits, how to utilise ESP32, and what the greatest distance is at which a gadget can operate properly. Apart from the low expenses, it is crucial to identify the most appropriate and effective technique to use in this project. Prior to implementing the hardware, the circuit design needs to be ready. The primary assignment is to do background research on the circuit design, hardware construction, testing, and performance analysis of the device.

No	Details	Picture
1.	Use a small drill to make holes in flexible PVC for installing the ESP32 and Relay.	 Figure 3-19 flexible PVC
2.	Connect the Light with Relay to connect with ESP32	 Figure 3-20 Realy with light
3.	Install food containers onto the aquarium lid by adhering them with a hot glue gun. Attach the servo motor inside one of the containers to automate fish feeding.	 Figure 3-21 Servo Motor

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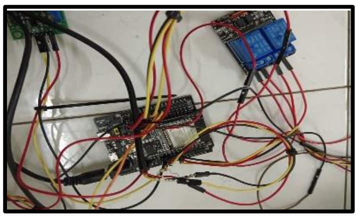
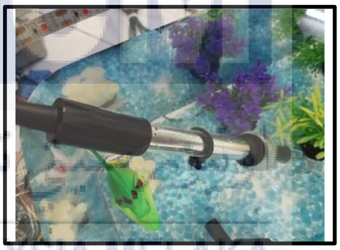
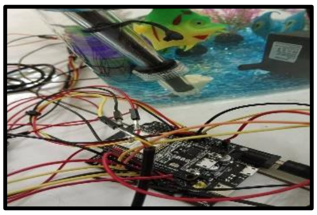
4.	Connect the temperature sensors within the aquarium.	 **Figure 3-22 Temperature Sensors**
5.	Connect jumper wire with cable connector to ESP32.	 **Figure 3-23 Connect Jumper Wire**
6.	Install the pH sensor within the aquarium.	 **Figure 3-24 pH Sensor**
7.	pH sensor is connected with ESP32.	 **Figure 3-25 pH Sensor with ESP32**

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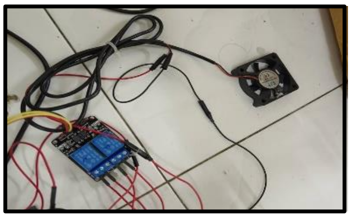
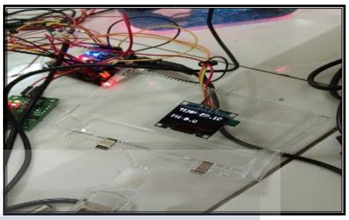
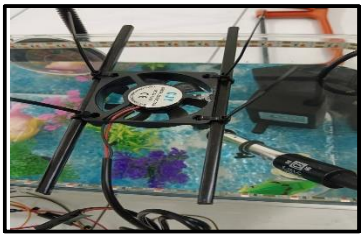
8.	Connect the Cooling Fan with Relay to connect with ESP32	 **Figure 3-26 Relay with Cooling fan**
9.	Connect the LCD Oled to ESP32	 **Figure 3-27 LCD Dispplay**
10	Placed the DC water pump into the Aquarium.	 **Figure 3-28 DC Water Pump**
11	Process the fixed the cooling fan on top of the aquarium.	 **Figure 3-29 Fixed Cooling Fan**

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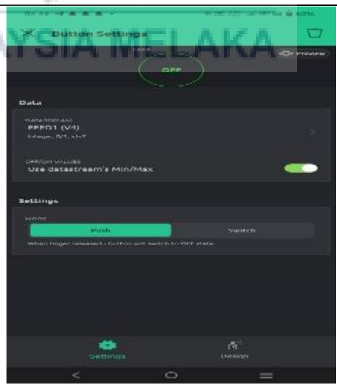
3.11 Blynk Setup

No	Details	Picture
1.	Place the gauge and button widget to monitor temperature vaslue and pH value and to control the lamp, cooling fan, fish feeder	 Figure 3-30 Blynk widget
2.	Next, select the V4 vitrual pin for the Feeder.	 Figure 3-31 Feeder Button

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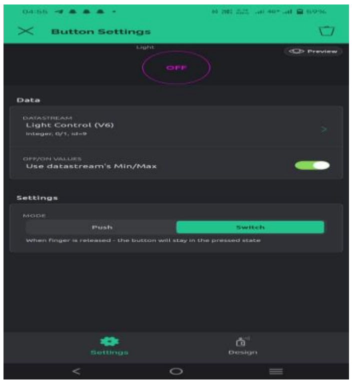
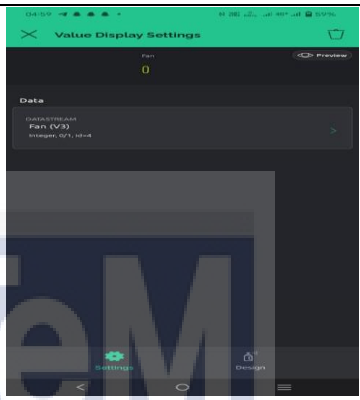
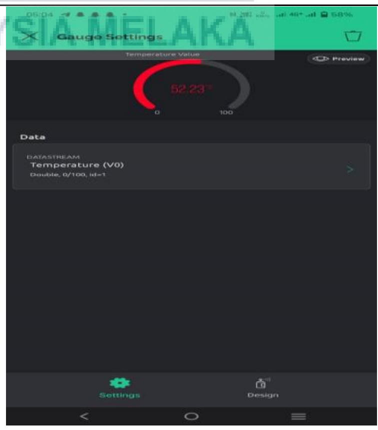
3.	Select the V6 virtual pin for Light Control.	 **Figure 3-32 for Light Control Button**
4.	Then, choose the V3 pin to show the fan status	 **Figure 3-33 Cooling Fan status**
5.	Select the V2 virtual pin to show the value of the temperature in the gauge widget.	 **Figure 3-34 Temeprature Gauge**

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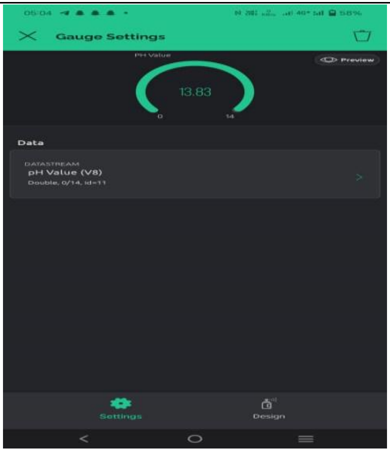
6.	Next, choose the V8 virtual pin to show the value of the pH in the gauge widget.	 **Figure 3-35 pH Gauge**

3.12 Summary

From this chapter 3, can conclude that the hardware and software included. Hardware picture has inserted along and the software is the coding provided at previous page. Furthermore, the functions of each major components have explained according to this project. Moreover, the choices of design and the approval for the main design also shown above. In addition, the inputs and outputs are clearly identified to make sure this project work successfully without any obstacles. The flowchart of this project designed to be the almost procedures to be followed by all students and lecturers. Last but not least, the circuit operation is the most efficient to be discussed that its component also plays the major role in this Smart Aquarium Controller.

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CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

A prototype is a pre-production sample, model, or version of a product that is created to validate a concept or method. It is commonly used in various fields such as semantics, design, electronics, and software development. The purpose of a prototype is to assess and refine a new design, allowing system analysts and users to provide feedback and improve its accuracy.

In electronics, prototyping involves constructing a physical circuit based on a theoretical design to test its functionality and provide a platform for troubleshooting. Techniques like wire wrapping or breadboarding are used to create prototypes, resulting in circuits that are electrically equivalent to the design but not necessarily physically identical to the final product.

To document electronic prototypes, especially those created using breadboards, open-source technologies like Wowki can be utilized. These tools help in documenting the prototype and moving towards physical production. Prototyping platforms like Arduino also simplify programming and communication with microcontrollers, enabling developers to easily launch their ideas using the platform or replace it with only the microcontroller chip and related circuitry.

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4.2 Results

Figure 4.1 indicates the display of "TEMP" and "PH" on the LCD.

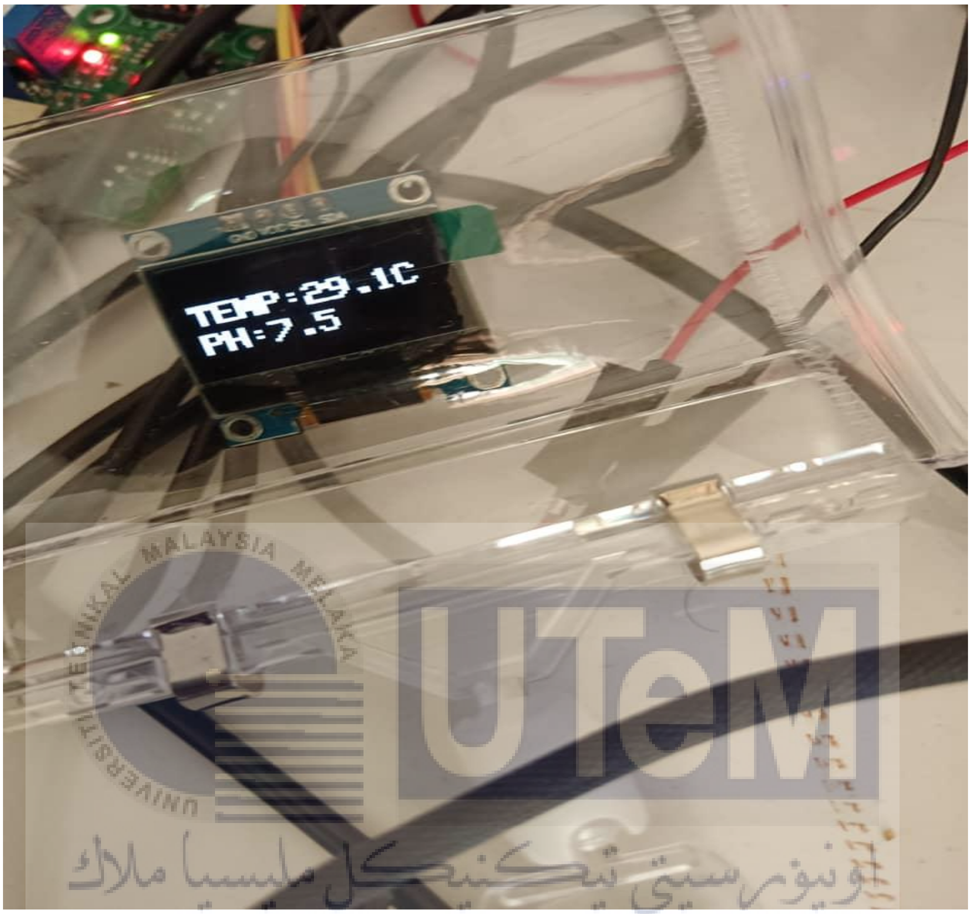

Figure 4-1 Temperature and pH Reading in LCD Display

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Figure 4.2 indicates the "BLYNK" platform setup in a device

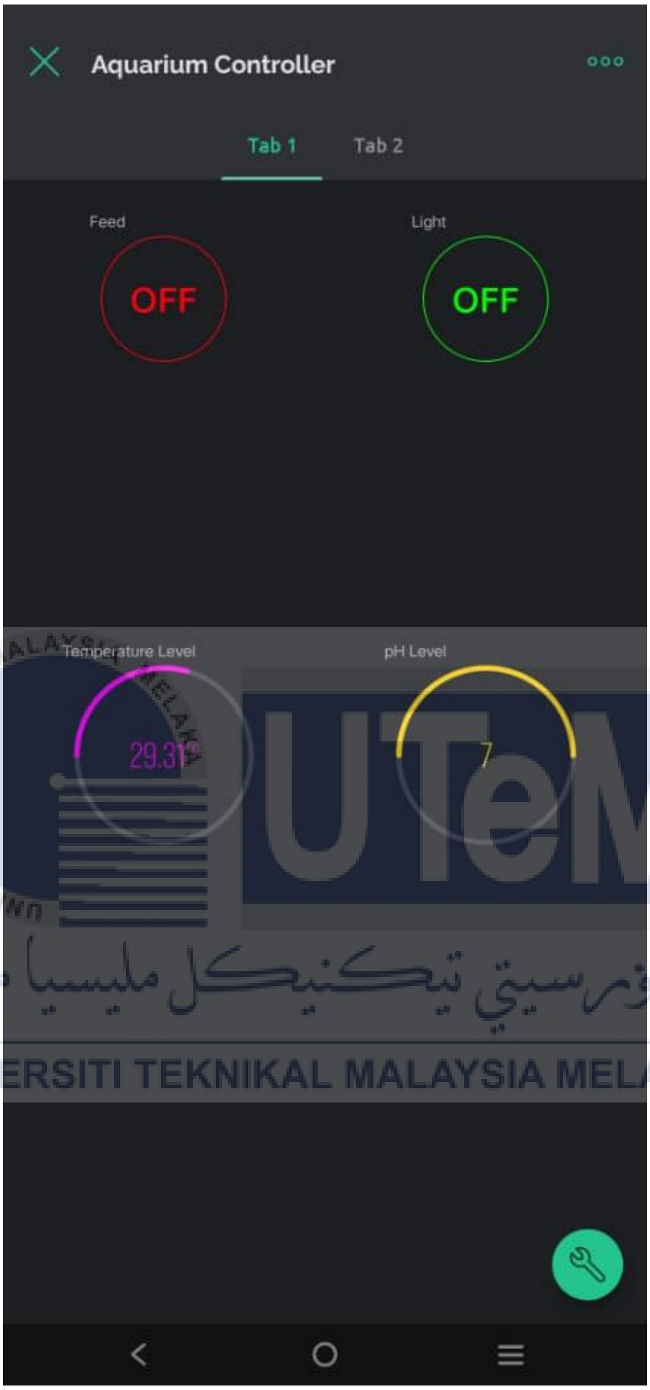

Figure 4-2 : "BLYNK" platform setup in a device

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Figure 4.3 indicates the prototype is measuring their temperature and the cooilng fan will be automatically ON when the Temperature is Above 28 Celcius.

Figure 4-3 Measuring the temperature

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Figure 4.4 indicates the LCD Display “Feeding” when the feeder move to 180 degrees

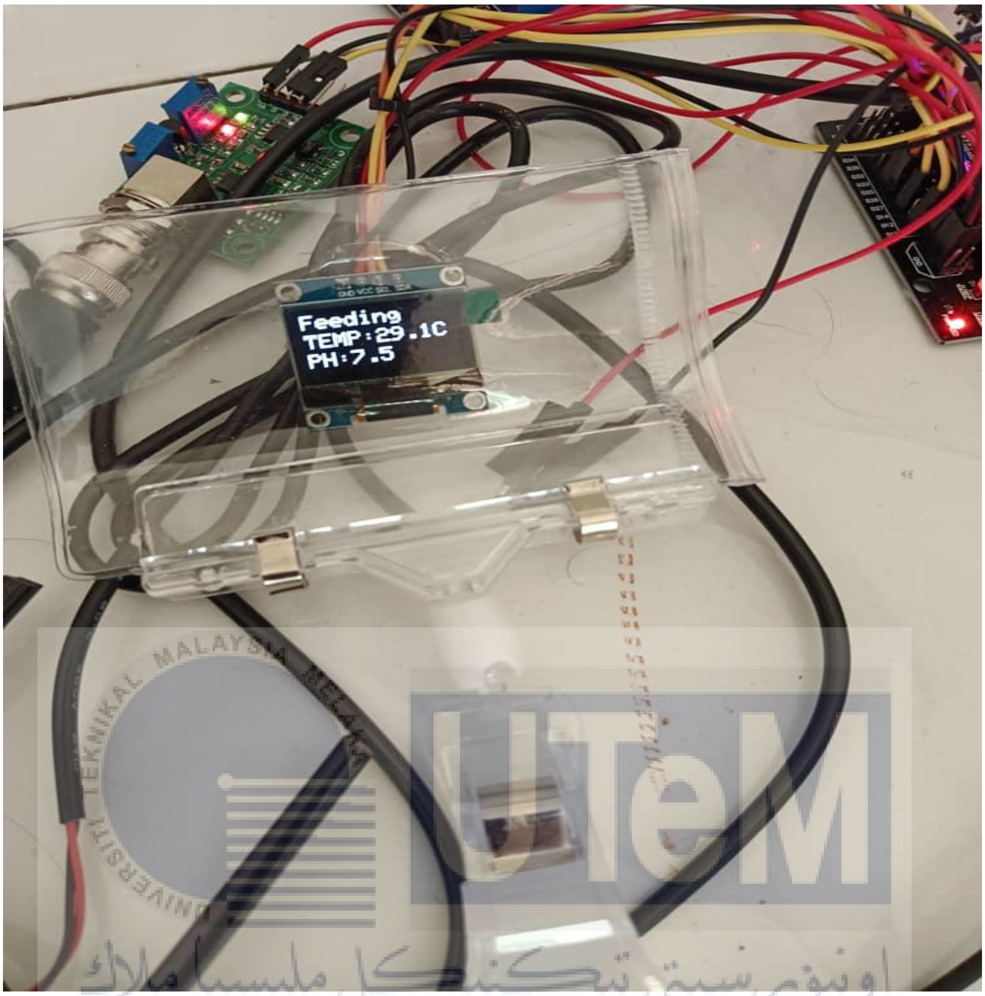

Figure 4-4 LCD Display “Feeding

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Figure 4.5 indicates the light turn On when control with with Blynk.

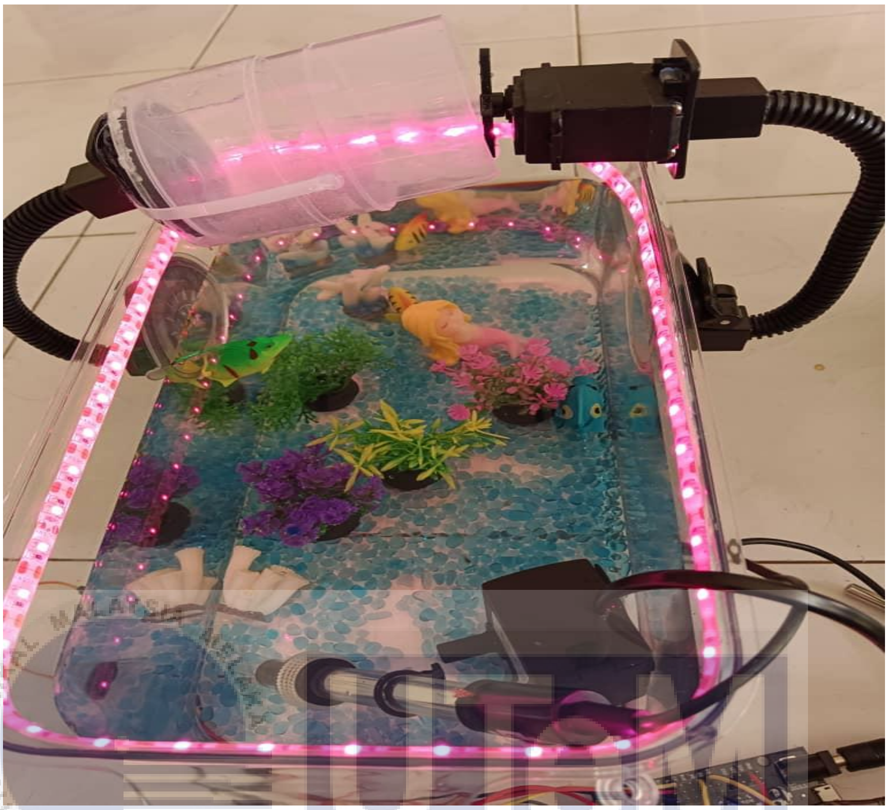

Figure 4-5 Control Light with blynk

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Figure 4.6 indicates the notification setup in Blnk of room and object temperature reading to the user when it is normal.

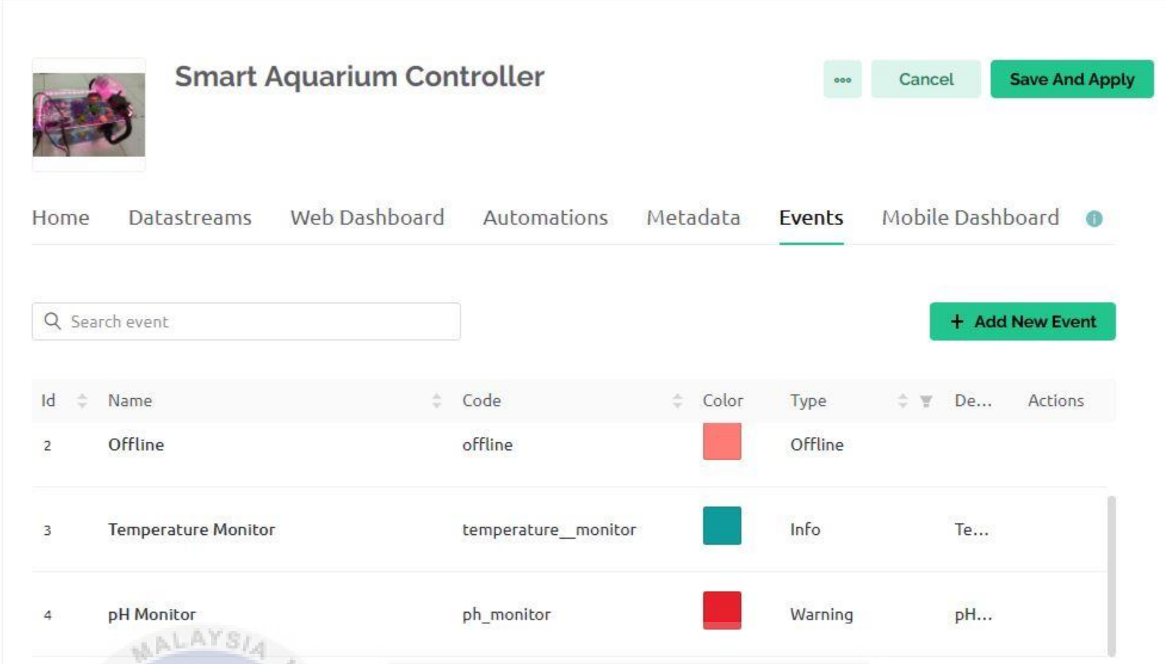

Figure 4-6 Setup Notications in Blynk

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Figure 4.7 indicates the Blynk Automation Dashboard

Figure 4-7 Blynk Automation Dashboard

Figure 4.8 indicates the Blynk Automation for Temperature.

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Figure 4-8 Blynk Automation for Temperature

Figure 4.9 indicates the Blynk Automation for pH Level.

Figure 4-9 Blynk Automation for pH Level

Figure 4.10 indicates the alert notification of temperature reading of the aquariumwhen it is abnormal.

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Figure 4-10 Alert Notification of temperature

Figure 4.11 indicates the alert notification of pH reading of the aquariumwhen it is abnormal.

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Figure 4-11 Alert Notification of pH Level

Figure 4.12 indicates the automation for feeder.

Figure 4-12 Automation for feeder

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Figure 4.13 shows the Blynk mobile

Figure 4-13 Blynk Mobile Dashboard

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4.2.1 PH Formula

The analog pH value (analog pH reading) from a pH sensor can be obtained using the following formula:

$$\text{Analog pH Value} = \frac{\text{map} \times (\text{Raw Analog Reading} - \text{Analog Min})}{\text{Analog Max} - \text{Analog Min}} \times \left(\frac{\text{pH Max} - \text{pH Min}}{10}\right) + \text{pH Min}$$

Figure 4-14 pH Formula

Where:

- {Raw Analog Reading}\) is the raw reading obtained from the analog pin of the pH sensor.

- {Analog Min}\) is the minimum analog value (usually 0).

- {Analog Max}\) is the maximum analog value (usually 4095 for a 12-bit ADC).

- {pH Min}\) is the minimum pH value.

- {pH Max}\) is the maximum pH value.

This formula maps the raw analog reading to the specified pH range, considering the characteristics of the analog sensor and the pH scale. The division by 10.0 ensures that the result is a floating-point value with one decimal place.

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Result was shown in the table below by hours and pH water level.

The pH water level increases when the hours increases.

Hour	**pH Level**
1	5.9
2	6.1
3	6.37
4	6.5
5	6.9
6	7
7	7.21
8	7.47
9	8.0
10	8.6

Figure 4-15 Testing Checklist for pH Level Reading

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4.2.2 Temperature Range for Fish

An ideal temperature range falls between 76°F to 80°F (25°C to 27°C) for most species. Some varieties may thrive in slightly higher temperatures, while others may prefer a few degrees cooler conditions.

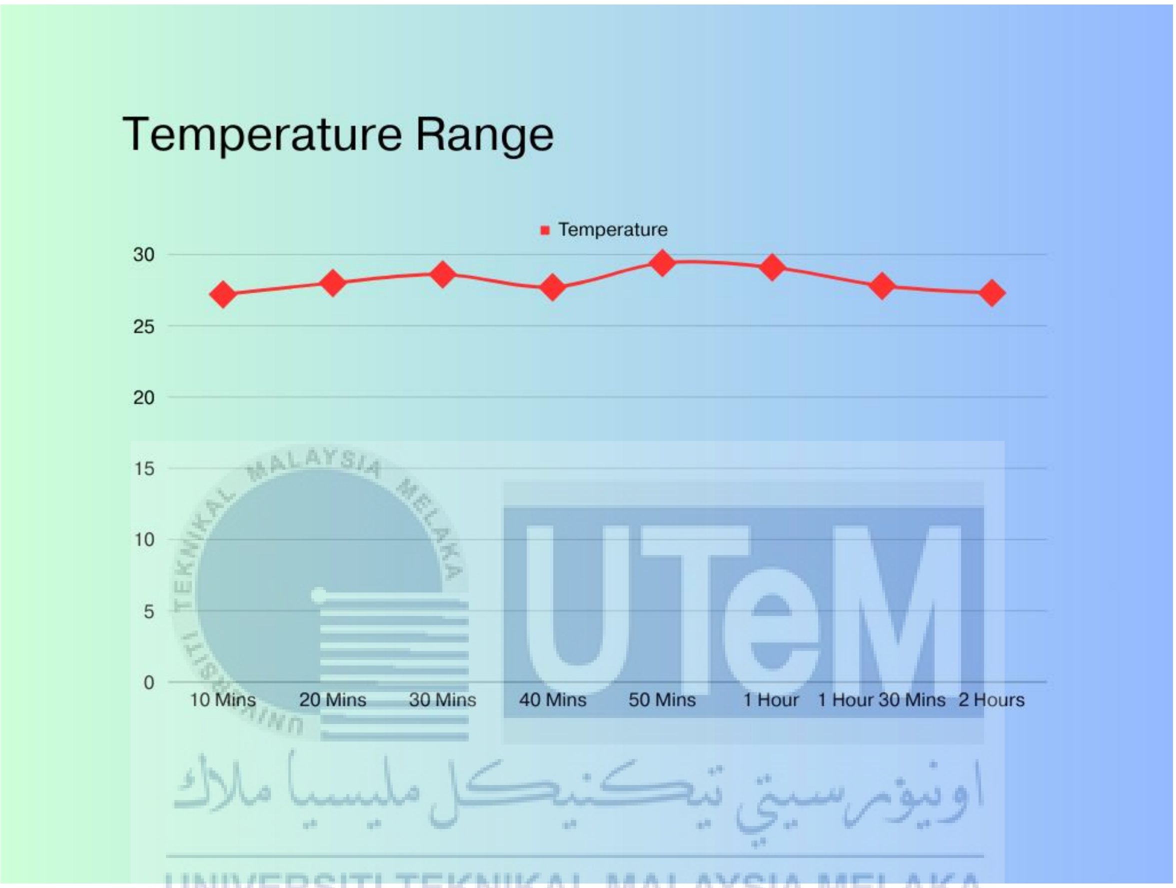

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Figure 4-16 Temperture Range

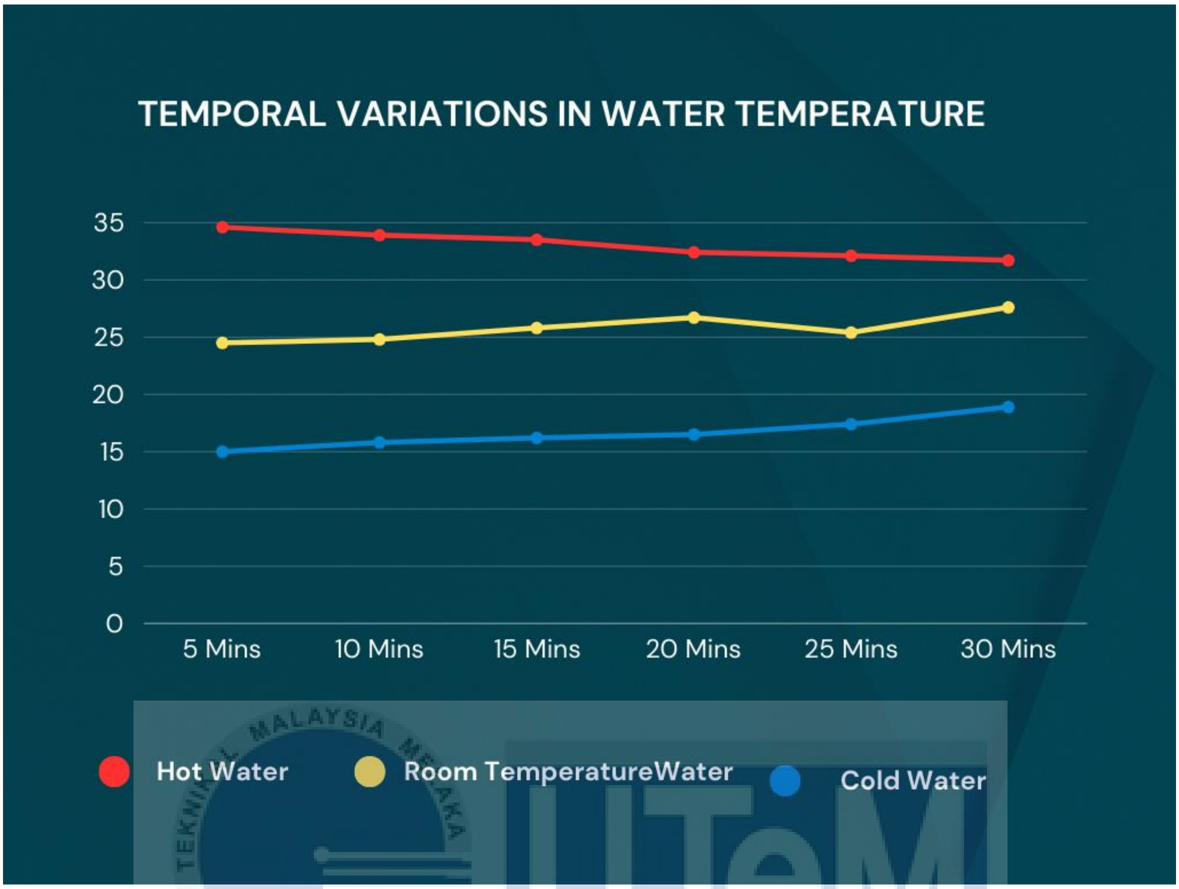

Figure 4-17 Temporal Variations in Water Temperature

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4.3 Final Prototype

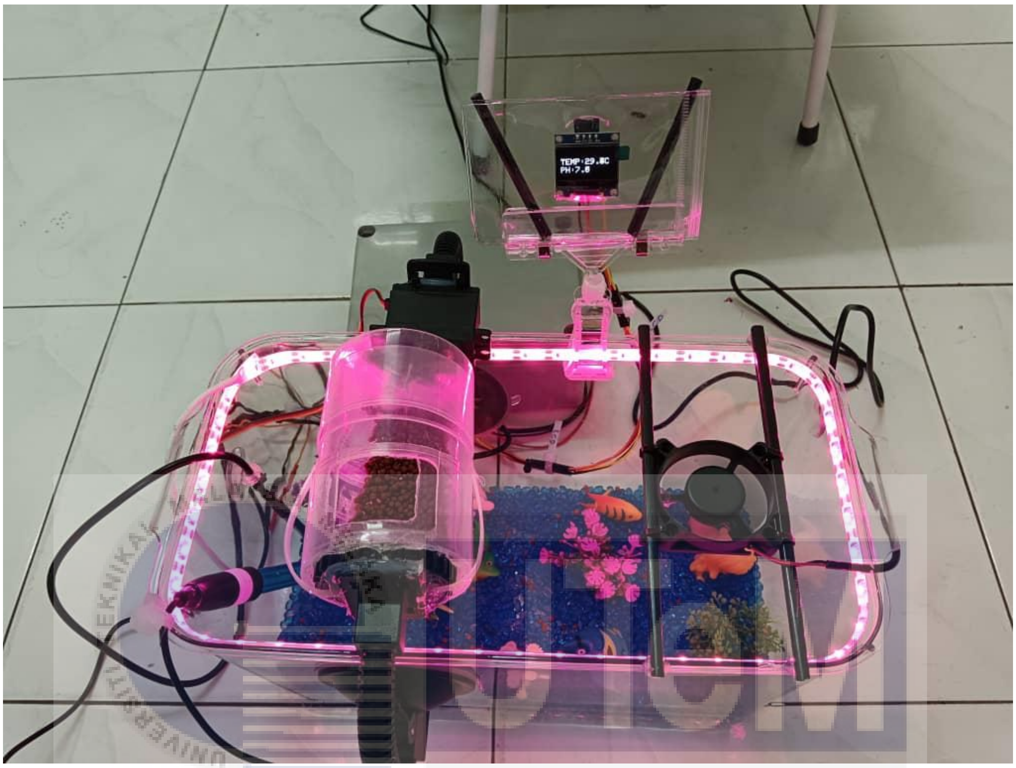

Figure 4-18 Final Prototype

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4.4 Project Testing

Following are all the testing checklist :

Table 4-1 Testing Display

No	Condition	Expected Result	Outcome
1.	Temperature sensor data is sent from NodeMCU ESP32 to Blynk, which displays it.	The information is shown and updated immediately..	PASS
2.	NodeMCU ESP32 sends the Ph sensor data to Blynk for display.	The information is shown and updated immediately.	PASS
3.	The NodeMCU ESP32 fish feeder data is transferred to the Blynk for display.	The information is shown and updated immediately.	PASS
4.	The temperature sensor is placed near hot and cold water.	The temperature data that will display the 2 different C.	PASS

Table 4-2 Testing Checklist of the Hardware and Software

No	Condition	Expected Result	Outcome
1.	The NodeMCU ESP32 will connect to the internet after being powered by a power supply.	Connecting to WiFi automatically and running mobile apps	PASS
2.	The mobile applications will show the system is offline if no Internet connection is found..	The system is in offline mode, according to the mobile application.	PASS
3.	Blynk receives temperature sensor data from NodeMCU ESP32 and displays it.	The data is directly updated and shown.	PASS
4.	NodeMCU ESP32 sends the Blynk data from the pH sensor for display.	The information is directly updated and displayed.	PASS
5.	The NodeMCU ESP32 fish feeder data is transferred to the Blynk for display.	The information is directly updated and displayed.	PASS

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4.5 Project Coding

4.5.1 PH Sensor

```
// Ph Voltage Calibration

int pH_Value;
float Voltage;

void setup()
{
  Serial.begin(9600);
  pinMode(pH_Value, INPUT);
}

void loop()
{
  pH_Value = analogRead(32);
  Voltage = pH_Value * (3.3 / 4096.0);
  Serial.println(Voltage);
  delay(500);
}
```

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The provided Arduino code is intended for calibrating the voltage output of a pH sensor. The code operates by reading an analog signal from the pH sensor, which is connected to pin 32 of the microcontroller. The analogRead function retrieves a raw value representing the voltage generated by the pH sensor. The obtained raw value is then converted to an actual voltage using the formula Voltage = pH_Value * (3.3 / 4096.0). This formula scales the raw analog value to a voltage within the 0 to 3.3 volts range, reflecting the analog-to-digital conversion capabilities of the microcontroller (4096 is the maximum value of a 12-bit ADC).

The calculated voltage is subsequently printed to the serial monitor for observation and analysis. The delay(500) function introduces a 500-millisecond pause between readings, regulating the speed of data output.

This code facilitates the calibration of a pH sensor by providing real-time voltage readings through the serial monitor. The user can use these readings to adjust and fine-tune the pH sensor's output, ensuring accurate and reliable pH measurements in practical applications.

```
// Ph Sensor Coding

int rawPhValue = analogRead(PH_SENSOR_PIN);
Serial.print("Raw pH Value: ");
Serial.println(rawPhValue);

// Assuming pH sensor range is 0-3.3V
float pH_value = map(rawPhValue, analogMin, analogMax, pHMin * 10, pHMax *
10) / 10.0;
```

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The provided Arduino code serves the purpose of pH measurement using a pH sensor while implementing a calibration mechanism. The code operates by reading the analog signal output from the pH sensor, which is connected to pin 32 on the microcontroller. The analogRead function captures the raw analog value, and this value is subsequently converted to a voltage using the formula TeganganPh = 3.3 / 4095 * nilai_analog_PH. The result represents the voltage generated by the pH sensor.

The calibration process involves adjusting the measured voltage to correspond to pH values. In this context, the variables PH4 and PH7 are utilized for calibration purposes. PH4 and PH7 represent the expected voltages generated by the pH sensor at pH values of 4 and 7, respectively. The PH_step variable is calculated as the difference between PH4 and PH7 divided by 3, reflecting the pH step size.

The pH value (Po) is then calculated using the formula Po = 7.00 + ((PH7 - TeganganPh) / PH_step). This equation maps the measured voltage to a pH value, taking into account the calibration values. The results are printed to the serial monitor, providing real-time feedback on the pH measurement.

The delay(1000) function introduces a one-second delay between consecutive pH readings, regulating the frequency of data output. Overall, this code facilitates pH measurement and calibration, offering a foundation for accurate and reliable pH sensing in various applications.

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4.5.2 Temperature sensor

```
//Temperature Sensor Coding

sensors.requestTemperatures();
temperature = sensors.getTempCByIndex(0);

  if (temperature < 28) {
    digitalWrite(FAN_RELAY_PIN, HIGH);
    fanStatus = true;
  } else {
    digitalWrite(FAN_RELAY_PIN, LOW);
    fanStatus = false;
  }
```

This code snippet is part of a smart aquarium controller program. It reads the temperature from a sensor and checks if it is below 28 degrees Celsius. If the temperature is below this threshold, it activates a fan relay by setting the corresponding pin to HIGH, indicating the need for cooling. Conversely, if the temperature is equal to or above 28 degrees Celsius, it turns off the fan relay by setting the pin to LOW. This temperature-based control ensures that the fan operates when necessary, helping maintain a stable and desired temperature within the aquarium.

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4.5.3 Servo Motor (Feeder)

```
//Servo Motor Control Coding

BLYNK_WRITE(SERVO_CONTROL_PIN) {
  int servoControl = param.asInt();
  if (servoControl) {
    servo.write(180);
    display.setTextSize(2);
    display.setTextColor(SSD1306_WHITE);
    display.setCursor(0, 0);
    display.println("Feeding");
    display.display();
    delay(3000);
    servo.write(0);
    display.clearDisplay();
    display.display();
  }
}
```

This bit of code manages the control of a servo motor and is a component of an Internet of Things (IoT) project built with Blynk. The code is activated when a virtual pin ({SERVO_CONTROL_PIN}) in the Blynk mobile application changes in value. Activating the associated control triggers the `BLYNK_WRITE` callback function on the Blynk app user's end. The value that was received from the app and saved in the variable `servoControl` is checked by the code inside this method. In the event that {servoControl} is not zero, signifying the user's desire to engage the servo, the code directs the servo motor to spin in the direction of 180 degrees. It simultaneously updates an OLED display with the message "Feeding," alerting the user to the fact that a feeding activity is underway.

Three seconds of delay are added to mimic the length of the feeding operation. Following the wait, the OLED display is cleared and the servo motor returns to the 0-degree position. This code section essentially shows an example of IoT-based servo motor control with a

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user interface by allowing users to connect with the Blynk app and remotely start a feeding action for a smart system.

4.5.4 Cooling Fan Control

```
//Cooling Fan Control Coding


BLYNK_WRITE(FAN_CONTROL_PIN) {
  int fanControl = param.asInt();
  digitalWrite(FAN_RELAY_PIN, !fanControl);
}
```

The given code segment is a portion of a larger programme that seems to be controlling a fan's operation by using sensor temperature readings. This particular code's goal is to regulate the condition of a relay that's attached to a fan. This is the reasoning behind it:

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A smart aquarium system's ambient temperature is assumed to be less than 28 degrees Celsius. In this case, the code sets the FAN_RELAY_PIN to HIGH, activating the relay and signalling that the fan should be turned on. It also sets the current fan status to true by setting the `fanStatus` variable to true.

On the other hand, the code changes the FAN_RELAY_PIN to LOW, turning off the relay and signalling that the fan should be turned off, if the temperature reaches 28 degrees Celsius or above. Additionally, it changes the fanStatus variable to false, indicating that the fan is not operating at this time.

This section of code builds a simple temperature-based fan control system. When the temperature drops below a predetermined point—in this case, 28 degrees Celsius—the fan is turned on; otherwise, it is turned off. This type of control is frequently utilised in systems such as smart aquariums to maintain the right temperature and provide the best possible environment for the aquarium's occupants.

4.5.5 Light Control

```
//Light Control Coding


BLYNK_WRITE(LIGHT_CONTROL_PIN) {
  int lightControl = param.asInt();
  digitalWrite(LIGHT_RELAY_PIN, !lightControl);
}
```

This code snippet is part of an Arduino program designed for a smart aquarium controller, specifically focusing on the control of aquarium lighting. It utilizes the Blynk IoT platform, and the function `BLYNK_WRITE(LIGHT_CONTROL_PIN)` is a callback function triggered whenever there is a change in the virtual pin associated with light control in the Blynk app. The function receives the updated value of the virtual pin as an integer parameter (`lightControl`). The subsequent line of code, `digitalWrite(LIGHT_RELAY_PIN, !lightControl)`, inversely sets the state of the relay pin connected to the aquarium lights based on the received value. If the value is 1 (indicating the user's desire to turn on the lights), the relay pin is set to LOW, activating the lights. Conversely, if the value is 0 (indicating a request to turn off the lights), the relay pin is set to HIGH, deactivating the lights. This code facilitates remote control of aquarium lighting through the Blynk app, providing a user-friendly interface for managing the aquarium's lighting conditions.

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4.5.6 LCD Display

```
//OLED Display (Displaying Temperature and pH)


// Display the text without blinking
display.setTextSize(2);
display.setTextColor(SSD1306_WHITE);
display.setCursor(0, 20);
display.print("TEMP:");
display.print(temperature, 1);  // Display temperature with 1 decimal place
display.print("C");
display.setCursor(0, 40);
display.print("PH:");
display.print(pH_value, 1);  // Display pH value with 1 decimal place
display.display();
```

This code is responsible for updating an OLED display with real-time information about the temperature and pH values in a smart aquarium system. The code utilizes the Adafruit SSD1306 library to control the OLED display. It sets the text size, color, and cursor positions on the display to format the information properly. The temperature, obtained from a sensor and stored in the variable `temperature`, is displayed with one decimal place precision, labeled as "TEMP:" and followed by the unit "C" for Celsius. Similarly, the pH value, stored in the variable `pH_value`, is displayed with one decimal place precision, labeled as "PH:". The entire information is then updated and presented on the OLED display. This code enhances the user interface of the smart aquarium controller, providing a clear and concise display of key parameters for monitoring the aquarium environment in real time.

4.6 Summary

This chapter aims to create a highly efficient and automated aquarium system by harnessing the power of the ESP32 microcontroller and integrating it with Internet of Things (IoT) technologies. By utilizing the ESP32's built-in Wi-Fi or Bluetooth capabilities, users will have the ability to remotely monitor their aquarium through a dedicated mobile or web application. This will provide them with real-time access to crucial information such as temperature and pH levels. Additionally, the ESP32's capabilities will enable automated control of the aquarium, allowing users to set predefined thresholds for parameters like temperature and have the system adjust accordingly using sensors and actuators. Furthermore, the smart aquarium system will be equipped to send notifications and alerts to the user's mobile device in the event of critical changes or emergencies, such as abnormal temperature fluctuations or power outages. Lastly, the ESP32's data logging feature will enable the collection and analysis of historical data, empowering users to gain insights into long-term trends and make informed decisions about their aquarium's management. Overall, the integration of the ESP32 with IoT technologies promises to enhance the functionality and convenience of aquarium management, providing users with a comprehensive and intelligent solution.

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, the first objective of this study which was to study about monitor pH level, control lighting and fish feeding system was successfully accomplished in Chapter 2 (Literature review) and Chapter 4 (Results) .We have execute it by using analog ph sensor, DC light which controlled the ON and OFF by connect with Relay. We have learned a lot about the creation of an IoT-based smart aquarium Controller by looking at the technology elemetnts and design issues, as well as by analysing relevant research and advances. In the process of completing the project to design an aquarium controller with an automated fish feed system which is second objective has reaches a fully accomplishment in Chapter 3 (Methodology) and also in Chapter 4 (Results) implement using servo motor as fish feeder. The methodology highlighted the importance of careful implementation and adherence to established protocols during each phase of the project to ensure efficient and reliable operation. The block diagram illustrated the flow of information from the sensors to the ESP32, relay module, and LCD, while the flowchart depicted the process of monitoring temperature and pH levels and controlling the water pump accordingly. Last Objective, which to validate the performance and effectiveness of the smart aquarium controller system is also fully fulfilled through monitoring the temperature level via blynk app in Chapter 4 (Results and Discussion). Implementing features like automatic feeding mechanisms or light control based on a timer or light intensity can enhance the convenience and overall health of the aquarium inhabitants. Integration with existing aquarium equipment like protein skimmers, filters should be explored to create a more integrated and efficient system.

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5.2 Potential for Commercialization

The smart aquarium controller project, incorporating an ESP32 microcontroller, temperature sensor, pH sensor, servo motor, light, and cooling fan, holds significant potential for commercialization in the burgeoning field of smart home automation and pet care. By leveraging the capabilities of the ESP32 and integrating sensors for real-time monitoring of temperature and pH levels, the system provides an intelligent and automated solution for aquarium enthusiasts. The inclusion of a servo motor enables the automated feeding of fish, enhancing the overall care process. The Blynk platform facilitates remote monitoring and control, allowing users to manage the aquarium environment through a user-friendly mobile application. The project's ability to maintain optimal conditions for aquatic life, coupled with the convenience of remote control, positions it as an attractive proposition for aquarium hobbyists. With the rising interest in smart home technologies and the growing popularity of aquariums as a recreational pursuit, the smart aquarium controller holds promising commercial potential, addressing the needs of pet owners seeking innovative and efficient solutions for aquatic life management.

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5.3 Future Works

In the future, the current system can be enhanced by incorporating more advanced sensors and actuators to elevate its monitoring capabilities. Additional sensors such as water level, salinity, and oxygen level sensors can be integrated to provide a more comprehensive view of the aquarium environment. To further advance the system, the inclusion of artificial intelligence features becomes crucial. This may involve implementing algorithms to detect unusual patterns in sensor data over specific time intervals. Moreover, exploring computer vision technology can enable the system to recognize and understand the behavior of specific fish species within the aquarium. The evolution of this aquarium monitoring system should also include the development of a dedicated mobile application, empowering users with convenient control and management capabilities.

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APPENDICES

```
#define BLYNK_TEMPLATE_ID "TMPL6UbIWaLUj"
#define BLYNK_TEMPLATE_NAME "Smart Aquarium Controller"

#include <Wire.h>
#include <OneWire.h>
#include <DallasTemperature.h>
#include <ESP32_Servo.h>
#include <BlynkSimpleEsp32.h>
#include <WiFi.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>

#define SCREEN_WIDTH 128
#define SCREEN_HEIGHT 64
#define SDA_PIN 25
#define SCL_PIN 26

#define OLED_RESET -1

Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire,
OLED_RESET);

char auth[] = "xmdSeilyApHCXPUcWCJnHAAnEwJlmKzn";
char ssid[] = "Rosha";
char pass[] = "11223344";

#define PH_SENSOR_PIN 2
#define DS18B20_PIN 4
#define SERVO_PIN 5
#define FAN_RELAY_PIN 13
#define LIGHT_RELAY_PIN 14

#define LIGHT_CONTROL_PIN V6
#define FAN_CONTROL_PIN V3
#define SERVO_CONTROL_PIN V4
#define PH_DISPLAY_PIN V8
#define TEMP_DISPLAY_PIN V0

OneWire oneWire(DS18B20_PIN);
DallasTemperature sensors(&oneWire);
Servo servo;

bool fanStatus = false;
float phValue = 0.0;
float temperature = 0.0;
```

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```
BlynkTimer timer;

BLYNK_WRITE(LIGHT_CONTROL_PIN) {
  int lightControl = param.asInt();
  digitalWrite(LIGHT_RELAY_PIN, !lightControl);
}

BLYNK_WRITE(FAN_CONTROL_PIN) {
  int fanControl = param.asInt();
  digitalWrite(FAN_RELAY_PIN, !fanControl);
}

BLYNK_WRITE(SERVO_CONTROL_PIN) {
  int servoControl = param.asInt();
  if (servoControl) {
    servo.write(180);
    display.setTextSize(2);
    display.setTextColor(SSD1306_WHITE);
    display.setCursor(0, 0);
    display.println("Feeding");
    display.display();
    delay(3000);
    servo.write(0);
    display.clearDisplay();
    display.display();
  }
}

void updateBlynkValues() {
  Blynk.virtualWrite(PH_DISPLAY_PIN, phValue);
  Blynk.virtualWrite(TEMP_DISPLAY_PIN, temperature);
  Blynk.virtualWrite(FAN_CONTROL_PIN, fanStatus);
}

void setup() {
  Serial.begin(9600);

  Wire.begin(SDA_PIN, SCL_PIN);

  if (!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) {
    Serial.println(F("SSD1306 allocation failed"));
    for (;;)
      ;
  }

  WiFi.begin(ssid, pass);
  while (WiFi.status() != WL_CONNECTED) {
    delay(1000);
    Serial.println("Connecting to WiFi...");
```

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```
  }
  Serial.println("Connected to WiFi!");

  Blynk.begin(auth, ssid, pass);

  servo.attach(SERVO_PIN);

  pinMode(FAN_RELAY_PIN, OUTPUT);
  pinMode(LIGHT_RELAY_PIN, OUTPUT);

  sensors.begin();

  timer.setInterval(1000L, updateBlynkValues);
}

void loop() {
  Blynk.run();
  timer.run();

  sensors.requestTemperatures();
  temperature = sensors.getTempCByIndex(0);

  int rawPhValue = analogRead(PH_SENSOR_PIN);
  Serial.print("Raw pH Value: ");
  Serial.println(rawPhValue);

  // Map the raw pH value to the 0-14 pH scale
  phValue = map(rawPhValue, 0, 4095, 0, 140) / 10.0;

  if (temperature < 28) {
    digitalWrite(FAN_RELAY_PIN, HIGH);
    fanStatus = true;
  } else {
    digitalWrite(FAN_RELAY_PIN, LOW);
    fanStatus = false;
  }

  // Display the text without blinking
  display.setTextSize(2);
  display.setTextColor(SSD1306_WHITE);
  display.setCursor(0, 10);
  display.print("TEMP:");
  display.print(temperature, 1);  // Display temperature with 1 decimal place
  display.print("C");
  display.setCursor(0, 40);
  display.print("PH:");
  display.print(phValue, 1);  // Display pH value with 1 decimal place
  display.display();

  // You may add a delay if necessary
```

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```
  // delay(500);
}
```

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