Faculty of Engineering

HOME AQUARIUM CONTROLLER USING ARDUINO

Nurul Mirza Afiqah Binti Tajudin

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HOME AQUARIUM CONTROLLER USING ARDUINO

NURUL MIRZA AFIQAH BINTI TAJUDIN

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ABSTRACT

Studies have proven that people from this generation are becoming more dependent towards machine. Fish keeping are becoming a popular trend among people, thus, having an automatic system for the aquarium is a big help for them. The home aquarium controller is built to assist humans in maintaining their aquarium conditions. To approach this project, the aquarium controller will be using Arduino where the system built can monitor the temperature and control the lighting of the aquarium. A mobile application will also be developed to enhance the project in assisting human to monitor their aquarium condition even if they are outside of their house.

ABSTRAK

Kajian telah membuktikan bahawa masyarakat pada zaman ini semakin bergantung kepada mesin. Memelihara ikan telah menjadi trend yang popular dalam kalangan masyarakat, oleh itu, mempunyai sistem kawalan akuarium rumah adalah satu bantuan untuk mereka. Sistem kawalan akuarium rumah ini dibina untuk membantu manusia dalam menjaga keadaan akuarium mereka. Untuk memulakan projek ini, sistem kawalan akuarium akan menggunakan Arduino dimana sistem yang dibina dapat memantau suhu and mengawal pencahayaan akuarium. Aplikasi mudah alih turut dibina untuk memajukan projek ini dalam membantu manusia memantau keadaan akuarium rumah walaupun mereka berada di luar rumah.

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LIST OF ABBREVIATIONS

IDE	-	Integrated Development Environment
RAM	-	Random-access Memory
ROM	-	Read-only Memory
MIT	-	Massachusetts Institute of Technology
A/D	-	Analog to Digital
D/A	-	Digital to Analog
LED	-	Light Emitting Diode
USB	-	Universal Serial Bus
ICSP	-	In Circuit Serial Programming
I/O	-	Input/Output
SDK	-	Software Development Kit
VM	-	Virtual Machine
SMS	-	Short Message Service
API	-	Application Programming Interface
RTC	-	Real-time Clock
HID	-	High-intensity discharge
LCD	-	Liquid Crystal Display
IC	-	Integrated Circuit

CHAPTER 1

INTRODUCTION

1.1 Background

Pet ownerships have been increasing at a steady pace nowadays. After cats and dogs, fishes have become one of the popular choices for pet owners. Fish keeping is becoming a popular trend among people from all age groups. This trend is not limited to fish only, people also bring reefs, and aquatic plants into their aquarium as decorations. People see aquatic hobby as a stress reliever hobby where they could bring nature into their home instead of going to the ocean to see aquatic life.

The aquarium is an artificial pool for keeping life aquatic animals and plants for ornamental, research and breeding purposes [1]. There are 2 types of the aquarium which are public aquarium and home aquarium. A public aquarium is mostly for exhibitions and space is larger while home aquarium is smaller and the purpose of having them are for decorations and studies. Aquariums offer an amazing way to appreciate the beauty and diversity of aquatic life.

Aquatic lives in the aquarium are easily affected by the changes in the aquarium condition such as temperature, pH level, and the lighting. The fish success or failure of living in an aquarium depends on its surrounding in the aquarium which includes various parameters. The closer the surrounding to their nature, the longer their lifetime will be. When no swift action is taken for the aquarium, the risk of affecting the aquatic life in the aquarium increases which will eventually lead to the death of the aquatic life.

This project is focusing on the development of a home aquarium controller that could help the user monitor the temperature and control the lighting of the aquarium. The system is built using low-cost components. The usage of Arduino UNO will be maximized as much as possible. Home aquarium controller will be useful for fish keeping. A mobile application will be built along with the development of the hardware.

Adjustments can be made from time to time to achieve the goals of the project. Any recommendations and improvements for the projects can be made to produce the best system for a home aquarium controller.

1.2 Problem Statement

For aquarium caretakers, the most difficult task for them to do is to maintain the condition of the aquarium. For aquatic lives, there are the reef, fishes, aquatic plants and more, thus, their requirements for survival are different. Plants require sunlight for photosynthesis to stay alive. An ideal temperature for aquatic lives is necessary for their survival rates. Hence, this project will be focusing on these two parameters. The temperature sensor will measure the temperature of the water. The lighting used in this project will be functioning based on a real-time clock. The information will be sent to the Arduino board and signal will be analyzed before sending out the information to an app. The app that will be built is to display the data for temperature measurement as well as to control the desired lighting at any time. The project will be affected by the following factors:

i. The quality of the temperature sensor

   The temperature sensor should be able to function for a long period of time since it will immerse in the water all the time.

ii. The system programming

   The system has to be programmed correctly using Arduino IDE, thus, ability to analyze the coding is required.

iii. The connection between Arduino and Android

   The Arduino has to be connected to Android app for the purpose of data transmission, thus, the whole system will function as desired. However, knowledge is needed to develop the connection between Android and Arduino since the project will be utilizing Wi-Fi connection.

1.3 Project Objectives

The objectives of this project that have been discussed and identified are as follows:

i. To relate the concept of the temperature sensor in measuring temperature through an electrical signal with Arduino.

ii. To understand the how Arduino can monitor the temperature changes

iii. To implement high-level language by using Arduino IDE and Android Studio software in order to program the Arduino board and develop the app respectively.
iv. To understand the behavior of each component used for the device and carefully connects them together in order for the device to work properly.

1.4 Project Scopes

The software used to program Arduino boards is Arduino IDE. The language used to program Arduino in the software is C++ language which is considered as a high-level language. A good ability to program in C++ language and understand the language gives a huge advantage to avoid issues that will arise throughout the completion of the project. The usage of a temperature sensor in this project is to measure the water temperature and Arduino is used to analyze the data. The Arduino board is the microcontroller of the home aquarium controller.

The measurement of the temperature sensor and lighting will be displayed on an app. Android Studio will be used to build this app. A Wi-Fi module will be used on Arduino board to connect the app and Arduino.

1.5 Report Outline

This report is divided into five chapters. Each chapter is studied and explained carefully based on reading and understanding the case study.

Chapter 1 is the introduction part of the project where the background of the case study and the purpose of the project is explained thoroughly. The goals of the project are stated in this chapter. Problem statements, objectives of the project and the project scopes are included in this part.

Chapter 2 is the literature review of the project. It will include the studies of the usage of Arduino UNO, Arduino IDE and Android Studio in the project. Studies on sensors used will also be included in this part where its application in the project will be explained.

Chapter 3 is the methodology of the project. It will revolve around the methodology used to approach the project. Description and illustration of the system will be explained thoroughly in this part. The hardware components and techniques that will be used to operate the system is shown in this part.

Chapter 4 is the discussion of results of testing the system. Results shown are supported figures. The problems faced throughout the project period are discussed in this chapter too.

Lastly, a summary of the overall process and finding of the project is discussed in Chapter 5. The achievements of the project's objectives and suggestions for further improvement and future recommendation are included in this chapter too.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

In this chapter, it elaborates about Arduino UNO Rev-3, Arduino IDE, Android Studio and temperature sensor and real-time clock which are the crucial components that are used in this study. Arduino programming is required to produce a device that runs as desired. The design and architecture of Arduino are explained in this chapter too. The software used for Arduino programming which is Arduino IDE is also discussed in this chapter. The software used to build the mobile application is the Android Studio. The language used in programming the board and app are mentioned too.

2.2 Design Project

A hardware design project process steps are projected specification, design, simulation, prototyping, and production. Simulation accuracy of a large project is much slower. An efficient planning is needed to build a working prototype.

Software development has to be done effectively and as detailed as possible to produce the most efficient software products [1]. There are many steps, processes, and stages involved before the final product can be used. Software simulation is cheaper and very flexible.

When designing a hardware and software project, various factors have to be taken into account. The time taken to build the project plays an important role when it comes to the design project. For hardware production, costing has been very crucial since there would some stuff that have to be bought.

2.3 Microcontroller

The first microprocessor produced by Intel is 4004. By that time, there were demands for the microcontroller. Texas Instruments designed the contemporary TMS1802 especially for calculators before being used for other applications such as cash registers, watches and measuring instruments in 1971. In 1974, TMS 1000 was known as one of the first microcontrollers that have already been include with RAM, ROM and I/O on the chip.

The microcontroller is a compact integrates circuit that is built with peripherals, memory, and processor which can be used to conduct a specific operation in an embedded system. Generally, a microcontroller often includes a microprocessor, RAM, programmable ROM or flash memory, parallel or serial I/O. timers and signal generators, and Analog to Digital (A/D) or Digital to Analog (D/A) conversion. Microcontrollers are used in products and devices that are being controlled automatically, such as remote controls and automatic appliances [2]. The microcontroller can be programmed using assembly language or C language.

2.4 Arduino

There are many other microcontrollers and microcontroller platforms that are available for physical computing. Some examples that offer similar functionality are Parallax Basic Stamp, Netmedia's BX-24, Phidgets and MIT's Handyboard. These tools take the messy details of microcontroller programming and wrap it up in an easy-to-use package.

On the other hand, Arduino simplifies the process of working with microcontrollers. Ivrea Interaction Design Institute build Arduino as an easy tool for fast prototyping especially for students without electronic and programming backgrounds. Arduino is an open-source platform that can be used to construct and perform electronic programming [3]. The Arduino board consists of a microcontroller that can receive inputs from the sensors and can be used to drive motors, LEDs, sensors and other components. These components are physical computing and it is impossible to use other microcontrollers presents in the market. There are many examples of Arduino microcontrollers such as Arduino UNO, Arduino Mega, and Arduino Nano.

When compared to other boards, Arduino is inexpensive compared to other microcontroller platforms. The Arduino Software (IDE) can run on a various operating system such as Windows, Macintosh OSX, and Linux. Arduino Software (IDE) has a

simple and clear programming environment and is easy-to-use for beginners and flexible for advanced users. The Arduino software is published as an open source tooluser and a software that is available for extension. Arduino boards are also open source and can be extended.

2.5 Arduino UNO Rev-3

Arduino UNO is a type of Arduino board model. It is the most used model out of all Arduino family. The core of the Arduino UNO module is the ATMEGA328 microcontroller. It is a high-performance single chip microcomputer with a wide voltage, low power consumption and portable [4].

Arduino UNO is a microcontroller board that uses the ATmega328 as its base. It consists of 14 digital pins that can be used as input or output and 6 of them can be used pulse width modulation outputs [4]. There are also 6 analog input pins, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header and a reset button in the Arduino UNO.

The board uses 5V of voltage source to operate with a frequency of 16MHz. Since it uses low power consumption, less power is needed to operate a device that runs using Arduino UNO Rev-3. Arduino UNO Rev-3 can be connected to other devices or components to develop a new device.

2.6 Smartphone

The definition of mobile phones has changed with the evolution of smartphones. The usage of phones is no longer limited to the communication tool, the smartphone has become an essential device of people's daily life [5]. People are becoming too dependent on their smartphone as it is portable and have almost everything that human’s needs.

Based on a survey [6], informants state that they use smartphones for communication, entertainment, online social networking, information search and acquisition and facilitations. This proves that human uses smartphone in daily life that smartphone becomes a companion to them. Utilizing human's attachment to the smartphone, building an app that can notify the aquarists on their home aquarium will be a good addition.

2.7 Computer Language

Computer language can be referred to various kinds of languages as stated below;

i. Programming language
ii. Command language
iii. Machine and assembly language

Computer language can be categorized as low-level language and high-level language. To group the language depends on how close is the language to machine language.

2.7.1 Low-Level Language

The low-level language is machine codes where the instructions are in machine language in the form of binary digits, 0 and 1. This language is mainly used in a computer system to handle and operate its hardware and instructions set architecture. The main functions of the low-level languages are to operate, manage and manipulate all the hardware and software components of a computer. There are two types of low-level languages:

i. Machine language
ii. Assembly language

Machine language is a language that directly interpreted by the hardware. This language is the elementary level of a programming language where it can be understood directly by the computer. Assembly language is a human-readable form of machine language.

The low-level language is non-portable due to the limitation of language and machine language. However, this is the only language that computer understands. The speed of computer processing the data can be improved by making the language closer to 0s and 1s.

2.7.2 High-Level Language

The definition of high-level language is a programming language that is designed to simplify computer programming. The programming language is a set of rules that specify sequences of symbols which is a part of a program. It is also an artificial language that is designed to communicate with machine especially computer through instructions.

Using programming language, human can give instructions to the computer with commands that both computer and human can understand [7]. Different programming languages use different commands and different rules for entering those commands. Without knowing the internal structure of a computer, programming language helps

people in using the computer easily. Some examples of high-level language are C language, C++ languages, Java language and Pascal. High-level languages are closer to human language and further from machine language.

2.8 Arduino Integrated Development Environment

Arduino Integrated Development Environment known as Arduino IDE as shown in Figure 2.1 is the software used to program the Arduino board. The application uses C or C++ language as its processing programming language. It contains a text editor for writing code, a message area, a text console, a toolbar with buttons to for common functions and a series of menu.

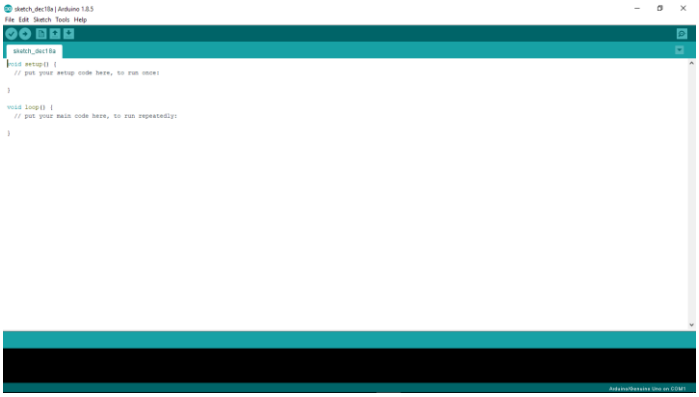

Figure 2.1: Arduino IDE Working Space

2.9 Android Studio

Android Studio is the IDE for Android announced by Google I/O Developer in May 2013 as an alternative for Android app development other than Eclipse [8]. Android Studio is an open-source software which is based on IntelliJ. Android Studio provides a unified environment where apps can be built for Android phones, tablets, Android Wear, Android TV and Android Auto.

The programming language used in Android Studio is Java. Android Studio is a workspace where files of the project can be written, edited and saved. Android Studio gives access to Android SDK or ‘Software Development Kit' where it is an extension to the Java code. This allows the Java code to run smoothly on Android devices. To run the code, there are two options to use either the emulator or through a piece of hardware connected to the computer. The feedback will explain crashes will be obtained as the program is debugging. Thus, the problem can be solved quickly. Figure 2.2 shows the workspace of Android Studio.

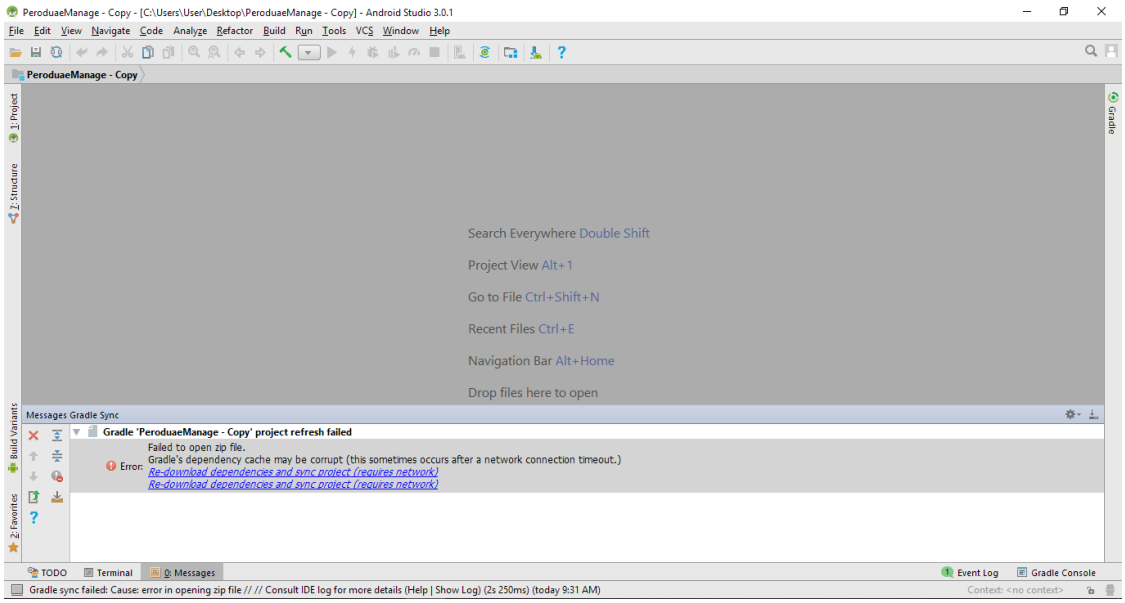

Figure 2.2: The Android Studio Workspace

2.10 MIT App Inventor 2

MIT App Inventor 2 is a blocks-based mobile application development tool. It lets the user build Android Apps quickly by using blocks-based programming. This online tool allows the user to freely explore the tools before starting a project. As it uses a blocks-based programming, it allows a beginner in android apps development to learn before proceeding to a higher level of programming.

2.11 Android Architecture

Android operates on a layered system. There are four layers of the Android operating system which is the Application layer, Application framework layer, Library layer, and Linux Kernel layer. Each layer is connected to one another.

2.11.1 Application Layer

The application layer is responsible for including an email client, SMS, program, maps, and others. Every single application is written using Java programming language.

2.11.2 Application Framework Layer

Since Android is an open development platform, developers have the ability to build innovative applications. Developers have full access to the same framework APIs used by the core application. All applications are a set of services and systems including

i. Rich and extensible set of Views that is mostly used to build an application such as text boxes, buttons, and embeddable web browser.

ii. Notification manager enables the application to display custom alerts in the status bar.

2.11.3 Library Layer and Android Runtime

There is a set of core libraries that provides most of the functionality available in the core libraries of Java programming language. Dalvik virtual machine, VM relies on Linux Kernel for functionality such as threading and low-level memory management. Dalvik has been written so that a device can run multiple VMs efficiently. The VM is register-based where it runs all classes compiled by Java language compiler which has been transformed into Dalvik Executable (.dex) format [5].

The Android library system is to reinforce the application framework. It is also the main connection that links application framework layer and Linux Kernel layer. The system will be registered in C or C++ language.

2.11.4 Linux Kernel Layer

The kernel takes care of all things that Linux is good at such as networking and a huge array of device drivers. This is to take the burden of interfacing to peripheral hardware. Kernel system provides operations like internal storage, process management and other core services which are based on Linux Kernel.

2.12 Aquatic Ecosystem

In Cambridge dictionary, aquatic means living in, growing in, happening in or connected to the water. In Oxford 10th Edition dictionary, ecology is a branch of biology concerned with the relations of organisms to one another to their physical surroundings. The ecosystem is a biological community of interacting organisms and their physical environment. The most important factors for aquatic organisms are temperature, dissolved oxygen, habitat structure, predation and plant nutrients [9].

When human is exposed to the natural environment, it will produce a calming effect, relaxing moment and reduce his or her stress level [10]. The natural environment always makes human feel at ease even just by looking by at a scenery picture.