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IoT Based Smart Aquarium using NodeMCU

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Abstract

Important aspects of aquarium fish maintenance include the timing of fish nutrition, the availability of water, the temperature of the water, and the monitoring of the aquarium's condition. This study aims to develop an IoT-based aquarium, also known as an internet of things aquarium, that is capable of automatically sending images via telegraph, feeding fish, setting the time that the light turns on, detecting the temperature and level of the aquarium water, and setting the time that the light turns off. A Smart Aquarium consists of an Arduino IDE, an ESP8266 Microcontroller, an ESP32 Cam, a Water Level Sensor, a Buzzer, a PIR Sensor, an RTC DS3231 Module, CP1202 Modules USB to TTL, a 12 Volt DC Fan, a Relay, a Lamp, an Adapter, an LCD, and a Motor Servo. Based on functional and unit testing, the functionality of this tool is satisfactory.

Keywords: IoT, Smart Aquarium, NodeMCU.

1 Introduction

The advancement of science and technology has a significant direct and indirect effect on human routines [1], [2]. The Internet of Things (IoT) is an example of a technology that can be operated automatically or directly controlled by remotely connected devices [3]. IoT can be utilized in a variety of disciplines, such as by sellers or hobbyists of ornamental fish to remotely or automatically monitor the health of their fish [4]. This technology can also be useful for beginners or people who only want to keep ornamental fish, making it simple to monitor aquarium water quality or the fish feeding schedule, set the light turn time, detect the temperature and level of the aquarium water, and send images to a smartphone.

Goldfish is one of the fish presently being cultivated by fish breeders. One species of freshwater ornamental fish is the goldfish. To obtain high-quality ornamental fish, those who keep goldfish should be more attentive to their care. Goldfish are extremely sensitive to variations in oxygen levels, so it is necessary to maintain optimal water quality. For fish to live healthily and develop rapidly, they must be handled and cared for properly. excellent handling and care entails a number of essential factors, such as regular feeding and the right amount, excellent water conditions and regular water changes, as well as smooth circulation, aquarium cleanliness, etc. Important aspects of maintaining goldfish in an aquarium are the accuracy of feeding, lighting, water temperature, and monitoring the aquarium's condition. However, for maintainers who have many other outdoor responsibilities, these additional tasks could take days. This circumstance can cause the

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feeding process of fish, oxygen levels, and adequate light to be inconsistent with their schedules and portions.

The Internet of Things (IoT) will serve as the foundation for the development of solutions that will assist with the maintenance of ornamental fish [4], [5]. The name of this application is Smart Aquarium. This application will be able to take pictures, which will make it simpler for fish keepers to monitor the condition of the aquarium. It will also be able to monitor the water level, and if the water level drops by 10 percent, a buzzer will sound to alert the fish keeper that more water needs to be added to the aquarium by hand. Additionally, the application will be able to automatically feed goldfish according to a schedule that has been set using Android. The temperature in the aquarium is something that needs to be optimized It is advised that fluctuations in temperature changes do not exceed 27 degrees Celsius, particularly in the process of changing water or in activities involving transportation. Goldfish should not be exposed to temperature swings that are greater than 27 degrees Celsius. If the temperature is higher than 27 degrees Celsius, the fan will start running on its own, and the lights will be programmed to operate according to a schedule on Android, with a maximum usage time of 8 hours. This will ensure that the temperature in the aquarium is consistent. The purpose of this study is to develop an IoT-based aquarium, also known as an internet of things aquarium, that is capable of automatically sending images via telegraph, feeding fish, setting the time that the light comes on, detecting the temperature of the aquarium water, and the level of the aquarium water.

2 Materials

2.1 Arduino IDE

he Arduino IDE, which stands for "Integrated Development Environment," is a piece of software that may be utilized to write code for microcontrollers. consists of three different parts, the first of which is a program editor that may be used to write and edit processing language applications. The listing of programs on Arduino is referred to as a sketch. The second component is the compiler, which is a module with the purpose of converting processing language, also known as program code, into binary code. This is necessary because binary code is the only form of program language that can be understood by microcontrollers. the third component is known as the Uploader and it is a module that has the capability of uploading binary code into the memory of the microcontroller [6], [7].

2.2 ESP8266 Microcontroller

Figure 1: ESP8266

The ESP8266 microcontroller is a type of integrated circuit that combines the functions of a microcontroller and Wi-Fi, allowing it to connect to the internet. The ESP866 microcontroller can easily be integrated onto this tool using the Internet of Things conceptual framework [8].

2.3 ESP32 Cam

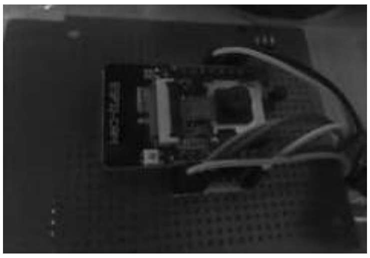

Figure 2: ESP32-CAM

ESP32-CAM is one of the microcontrollers with additional features, including Bluetooth, Wi-Fi, cameras, and even a microSD card port. ESP32-CAM is typically utilized for Internet of Things (IoT) applications requiring camera functionality [9].

2.4 Water Level Sensor

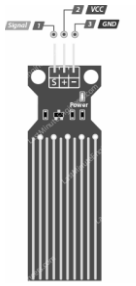

Figure 3: Water Level Sensor

Water Level Sensor is a piece of equipment that sends a signal to the control panel or alarm system to indicate that the water level has reached a predetermined level. The panel will receive a dry contact signal, also known as a NO/NC signal, from the sensor. This detector can be used to provide alarms as well as to move other automation devices [10].

2.5 DS18B20 Temperature Sensor

Figure 4: DS18B20 Temperature Sensor

The DS18B20 temperature sensor functions to convert the amount of heat captured into voltage [11].

2.6 Buzzer

Figure 5: Buzzer

A buzzer is an electronic component that can produce sound vibrations in the form of sound waves. Buzzers are more often used because of their minimal power usage size.

2.7 Passive Infra Red (PIR) Sensor

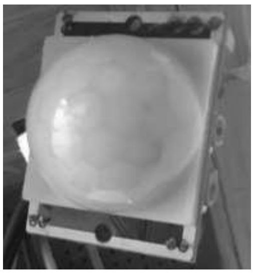

Figure 6: PIR Sensor

The PIR (Passive Infrared) sensor detects the presence of infrared light emission. PIR sensors are passive, indicating that they do not emit infrared light but instead receive it from the environment [12].

2.8 RTC DS3231 Module

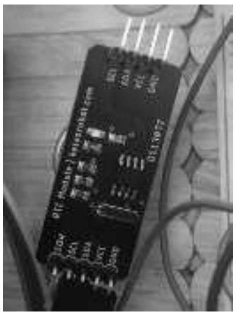

Figure 7: RTC DS3231 Module

The RTC DS3231 module is an embedded electronic system that functions to store time and date information with high precision or accuracy and is integrated with serial EEPROM AT24C32 for additional data storage functions [13].

2.9 CP1202 Modules USB to TTL

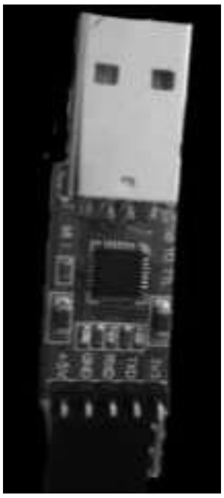

Figure 8: CP1202

CP2102 is a highly integrated USB-to-UART bridge controller that provides a simple solution to update RS-232 designs to USB using minimum PCB components and space. CP2102 includes a USB 2.0 full-speed function controller, USB transceiver, oscillator, EEPROM, and asynchronous serial data bus (UART) with full modem control signal in a compact 5 x 5 mm MLP-28 package.

2.10 Relay

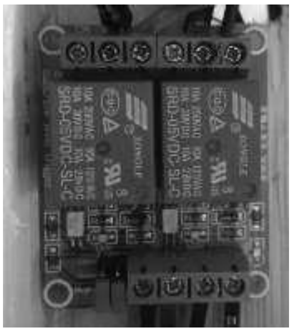

Figure 9: Relay

Relay is an electromechanical component consisting of two primary parts: electromagnet (coil) and mechanical (a set of switch contacts). Relay is an electrically operated switch [14].

2.11 12 Volt DC Fan

Figure 10: 12 Volt DC Fan

DC fans in aquariums function to reduce water temperature so that biota in the aquarium can grow properly.

2.12 Adapter

Adapter is an electronic device that is useful for being able to convert high AC current (alternating current) voltage into low DC (direct current) [15].

2.13 Liquid Crystal Display (LCD) 16x2 i2C

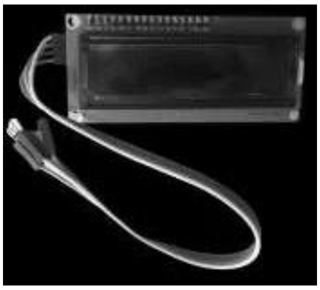

Figure 11: LCD

The LCD 16x2 display is one of the most common types of displays that is used as an interface between the user and the microcontroller. The 16x2 LCD display allows users to observe and monitor the current state of the sensor as well as the status of the program that is being performed.

2.14 Motor Servo

Figure 12: Motor Servo

A servo motor is a DC motor with a closed feedback system where the rotor position will be informed back to the control circuit in the servo motor which is designed with closed-loop feedback control (servo) so that it can be set-up or set to determine and ensure the angular position of the motor output shaft [16].

3 Methodology

3.1 Prototyping Method

This study employs prototyping techniques to create smart aquarium. Prototyping is defined as the process of creating a functional replica of an engineered product or system. It provides a miniature version of the final product and is used to collect consumer feedback [17].

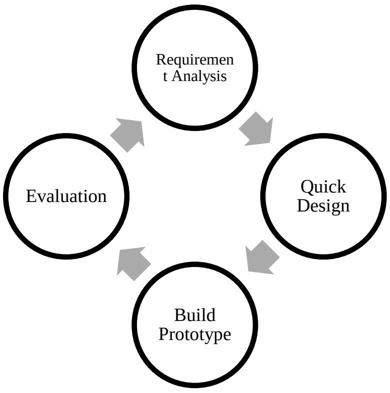

Figure 13: Prototyping Phase

Phase description:

- **Requirements analysis** is the first stage in designing a prototype model. In this phase, users are asked what they anticipate or desire from the system.
- **Quick Design**, this model addresses the fundamental design of the demand, making it possible to easily explain an overarching picture in a short amount of time.
- **Build Prototype,** this phase contributes to the construction of a physical prototype using the knowledge gained from prototype design.
- **Evaluation.** this step details the preliminary testing that takes place before the study of the performance model. The customer will provide feedback regarding the design's strengths and flaws at this point, and the feedback will be given to the developer.

3.2 System Design

Smart Aquarium system design shown in Figure 14.

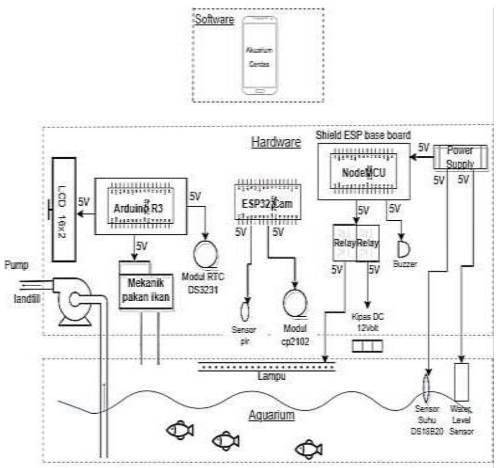

Figure 14: System Design

The main architecture of the system consists of a sensor for the water level, a sensor for the water level, a sensor for shooting using an ESP32 camera and a pear sensor, a sensor for the temperature using a DS18B20 sensor, a sensor for fish feed using a servo motor, a fan and lights connected to relay, and an Android device. In IoT-based smart aquariums, there are two steps that have to be completed before the fish can be fed, the water levels can be monitored, images can be taken, and the aquarium's temperature, fans, and lights can be adjusted. This element of the project is included in the first stage, which is titled "hardware planning," and it is made up of a NodeMCU ESP8266 that will be programmed with Arduino IDE software. NodeMCU spesifications show as Table 1.

Table 1: NodeMCU Spesifications

Specifications	NodeMCU
Microcontroller	ESP8266
Board size	57 mmx 30 mm
Input Voltage	3.3 – 5V
GPIO	13 PIN
PWM canal	10 canal
10 bit ADC Pin	1 Pin
Memory Flash	4 MB
Clock Speed	40/26/24 MHz
Wi-Fi	IEEE 802.11 b/g/n
Frequency	2.4 Ghz – 22.5 Ghz
USB Port	Micro USB
Card Reader	-
USB to Serial Converter	CH340G

Programming is done in order to enable the NodeMCU ESP8266 to establish connections with actuators and sensors, which serve respectively as input and output. Pear sensor, DS18B20 sensor, and water level sensor are the names of these three different types of sensors. The buzzers, relay modules, servo motors, DC fans, LEDs, and LCDs that show data on the device are all examples of actuators. While the second part of the process involves planning the Android application that will be used to show data.

4 Result and Implementation

4.1 Implementation

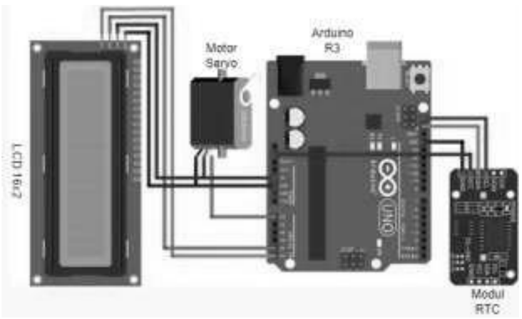

Figure 15: Fish Feed Circuit

Fish feed for Smart Aquarium circuit shows in Figure 15. The RTC module DS1307Z is used in the circuit that connects the ESP8266 to the servo motor. This module is displayed on the LCD. Users have complete control over the timing of fish feeding using the options that can be found on Android.

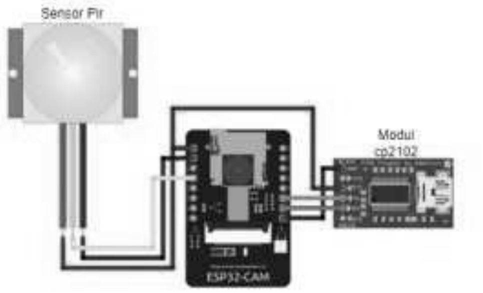

Figure 16: Camera Circuit

Camera circuit for Smart Aquarium shows in Figure 16. CP2102 modules are utilized in the ESP32-CAM circuit, which also contains the PIR sensor. When someone walks in front of this camera, it will start taking images on their own automatically. On this network, shooting commands are being communicated via the telegraph application. Users of Telegram will be provided with a number of commands, the most notable of which are flash and camera. A flash that activates the lights and camera in preparation for shooting. Immediately following the capture of the photograph, the image will be uploaded to the Telegram app.

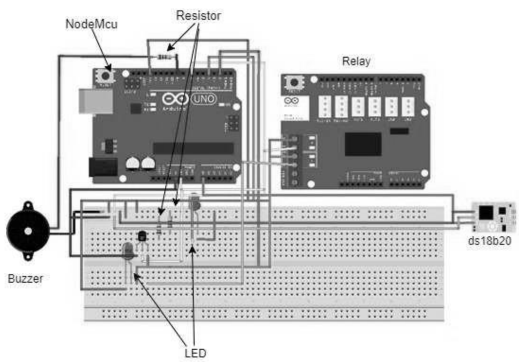

Figure 17: Temperature, Fan, Lamp and Water Level

Temperature, Fan, Lamp and Water Level circuit for Smart Aquarium shows in Figure 17. Arduino is used in the circuit that connects the DC fan, lamp, and water level sensor to the DS18B20. In this part of the series, the findings will be shown on the display of the Android. The aquarium is a clever creation as a whole as a consequence of its designer's efforts. In a smart aquarium using aquarium materials and on the tool there are several components such as NodeMCU ESP 8266, Shield ESP Base Board, ESP32 cam, Buzzer, relay, DS1820 Temperature Sensor, LCD 16x2 i2c, Water Level Sensor, RTC Module, Mini Submersible Water Pump, Servo Motor, DC Fan, Lights, Adapter, Pear Sensor, and jumper cables on this component also use mica material holders to place hardware components. Website with a focus on miniature design that sells fish food. It is vital to test this intelligent aquarium's hardware and software in order to determine whether or not it works for its intended function. The dimensions of the aquarium that was used are 32 centimeters high, 29 centimeters wide, and 41 centimeters long.

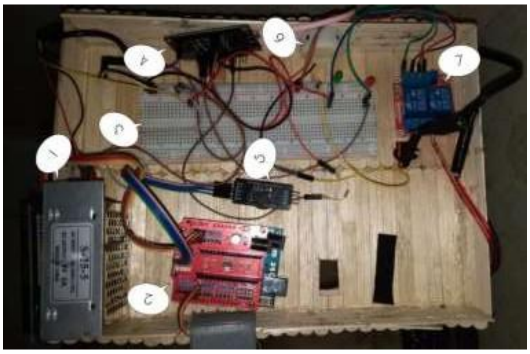

Figure 18: Implementation

Description:

1) Power Supply, the power supply here functions as a power booster because in the Lolin type Nodemcu there is only 3V vcc, so that the vcc becomes 5V, a power supply is used.
2) NodeMCU Uno R3 and Nano shield, serves to connect other devices.
3) Breadboard, a type of bread board that is usually used to make prototypes of electronic circuits.
4) NodeMCU type Lolin, microcontroller integrated with Wi-Fi for connectivity to the internet
5) RTC module, serves to store time and date data.
6) Buzzer, an electronic component that can produce sound vibrations in the form of sound waves
7) Chanel 2 Relay, electrically operated switch

4.2 Testing

The purpose of this test is to determine whether the implemented system conforms to the intended specifications and design. You select the test procedure based on the system's functionality and the parameters you wish to determine. The test method employs two types of methods: evaluating the functionality of each component and testing the entire system. Functionality testing is used to demonstrate that the implemented system meets the operational function requirements that were designed and planned in advance. While overall system testing seeks to obtain several parameters that demonstrate the system's capability and dependability in performing its operational functions. The testing of functionality is depicted in the Table II. DS18B20 testing aquarium water temperature with fan output and water level sensor testing aquarium water level with alarm output are among the components examined.

Table 2: Testing

Description	Output
Home page displays a temperature status of 26 degrees Celsius, which indicates that the temperature is normal.	Fan off

Description	Output
Main page displays a temperature status of 29 degrees Celsius, indicating that the temperature is too high for goldfish.	Fan on
Home displays a temperature status of 31 degrees Celsius, which is an aberrant temperature for goldfish.	Fan on
The water level is at 95.14 percent, indicating that there is still water in the aquarium.	Buzzer not alert
The water level is at 50.74 percent, indicating that there is still water in the aquarium.	Buzzer not alert
The water level is at 8.09 percent, indicating that the aquarium must be manually refilled, and the alarm will sound to alert the user.	Buzzer alert

In terms of functionality, smart aquariums have performed admirably and without error. In the fish feed component using Arduino UNO R3 with UNO Nano Shield using servo motor and RTC as real-time timing. The test results can be seen in Figure 19.

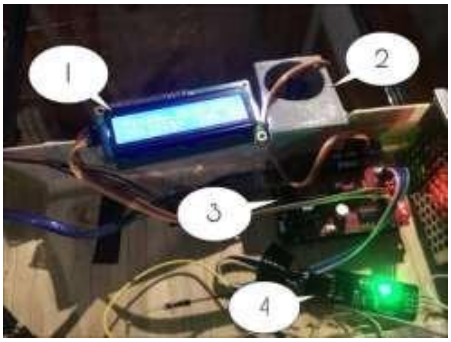

Figure 19: Fish Feed testing

Descriptions:

1) Lcd 16x2 i2C, lcd on fish feed testing is used to display day, date, month and time.
2) Servo motor, servo motor is used for fish feed open and close drive in real time.
3) NodeMCU Uno R3 and Nano shield, serves to connect other devices.
4) RTC module, serves to store time and date data with a high level of precision / accuracy and is integrated with EEPROM AT24C32 series for other data storage purposes.

In the aquarium shooting exercise, an ESP32 Cam equipped with a pear sensor and CP1202 USB TTL modules were used. This test's image capturing command employs a Telegram bot. The test outcomes are displayed in Figure 20.

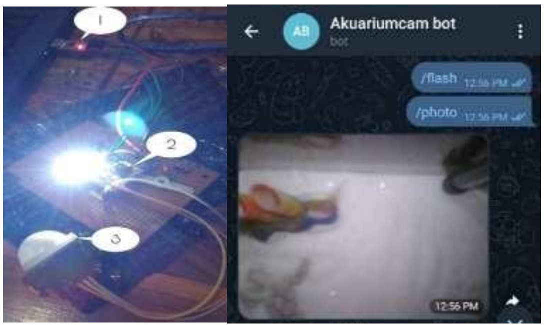

Figure 20: Take a picture testing

Descriptions:

1. CP2102, is a USB-to-UART bridge controller
2. ESP32 Cam, usually used for IoT (Internet of Things) projects that require camera features.
3. Pir sensor, a sensor used to detect infrared rays

In this water level test using a water level sensor with a siren, the buzzer will activate if the water level drops by 10%, indicating that the water must be manually refilled. When evaluating the aquarium's water temperature, if the temperature exceeds 27 degrees Celsius, the fan will automatically turn on; if the temperature falls below 27 degrees Celsius, the fan will turn off. The exam is displayed in Figure 21.

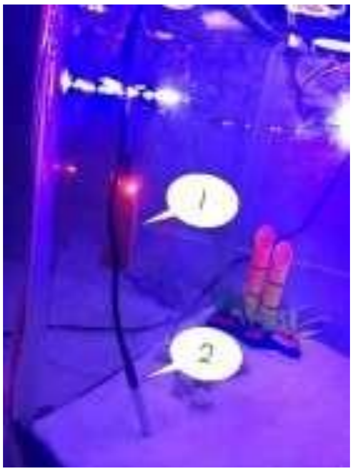

Figure 21: Water level testing

Description:

1. Water Level Sensor, to measure the water level in the aquarium.
2. DS18B20, detects water temperature in aquarium

Figure 22: Lamp Testing

During testing, the Android application's lights will be adjusted according to the user's preferences, but they can only be on for eight hours per day in order to keep fish alive in the aquarium. The test outcomes are depicted in Figure 22.

5 Conclusion

Based on the testing and analysis conducted by the development team for this final project, it can be concluded that the design and simulation of a functioning system for an IoT-based smart aquarium have been completed. The IoT-based Smart Aquarium can automatically provide food, turn on lights based on user preferences, accurately detect the aquarium's temperature and water level, and capture pictures using the Telegram application. Can receive sensor value data sent by hardware, send data to system hardware according to a schedule, and notify users. This tool is anticipated to make it simpler for fish farmers to monitor aquariums remotely.

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