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IoT-based Prototype for Fish Feeding and Water Monitoring System

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ABSTRACT
Keeping fish in an aquarium requires special attention. Aquarium owners often worry about feeding schedules and water conditions that must be monitored daily. To make this task easier, an IoT-based automatic fish-feeding and monitoring system has been developed. This tool allows for automatic feeding based on a predetermined schedule and monitors water conditions through an Android application. The system uses several components, including a NodeMCU ESP8266 microcontroller, an RTC timer, a temperature and pH sensor to monitor water conditions, an ultrasonic detector to show remaining fish food, and a servo motor to operate the fish feed valve. The objective of this research is to enable hobbyists to keep their pet fish without worrying about their well-being in case they are unable to attend to them regularly.

General Terms
Android, Firebase, Automation.

Keywords
Fish feed, NodeMCU, Internet of Things (IoT).

1. INTRODUCTION
Several important factors need to be considered when keeping fish, such as ensuring the time for feeding and maintaining good water conditions in the fish tank [1]. Feeding fish inefficiently can result in a buildup of excess feed which can harm the water quality of the fish tank and ultimately impact the health of the fish [1], [2]. Therefore, it is important to monitor and control feeding intensity and water quality. Feeding fish in an aquarium is typically done manually by sprinkling fish food into the pool, which is done every day. However, it can be challenging to feed the fish regularly, especially for busy individuals who leave the house for extended periods [3]. Fortunately, with advancements in technology, an automation system can be used to simplify the feeding process and monitor the water quality from a distance using an internet connection [4].

Access to the Internet provides many benefits, including the ability to use electronic equipment such as IoT-based feeders [4]. These feeders can be controlled and monitored through a website or application connected to a database [5]. This remote-control system makes it easier for users to manage IoT-based equipment that is located far away. The IoT concept aims to expand the benefits of continuously connected internet connectivity. Research has used servo motors in the fish food valve opening and closing system as the main component [6], [7], [8], [9], [10]. However, it's also important to consider monitoring the water quality of the aquarium, as it affects the health of the fish. By knowing the water quality, hobbyists can determine the right time to change the aquarium water. To solve these issues, it's necessary to have an automatic device that can check water quality parameters and feed the fish according to user preferences from anywhere using a smartphone. This research project aims to create a tool that fish hobbyists can use to ensure their fish are well-fed and healthy while they are away from home for an extended period using an IoT-based system and real-time database.

2. RESEARCH METHOD
In this research, the system development process utilized the waterfall method. This approach involves dividing the development process into several phases such as analysis, design, testing, implementation, and maintenance. The analysis stage aims to gather information about the software requirements for building the system. The design stage provides an overview of the system, including hardware and software design. In the testing stage, each module of the system is tested for functionality. Once a module is tested, the implementation stage is carried out to determine the overall system performance and identify any possible errors. During the maintenance stage, the system undergoes a review process where any errors missed in previous stages are identified and corrected.

This system is designed to automate the feeding process in aquaculture. The monitoring system continuously sends updates such as water temperature, pH levels, and remaining feed to a database, which can then be accessed by users via a mobile device connected to the internet. The components used in building the system are listed in Table 1, which includes an RTC module for time information, an SR04 ultrasonic sensor for detecting remaining feed, a DS18B20 temperature sensor for measuring water temperature, a pH sensor for measuring water pH levels, a servo motor SG90 for controlling the feeding process, and an Amica type NodeMCU used as a

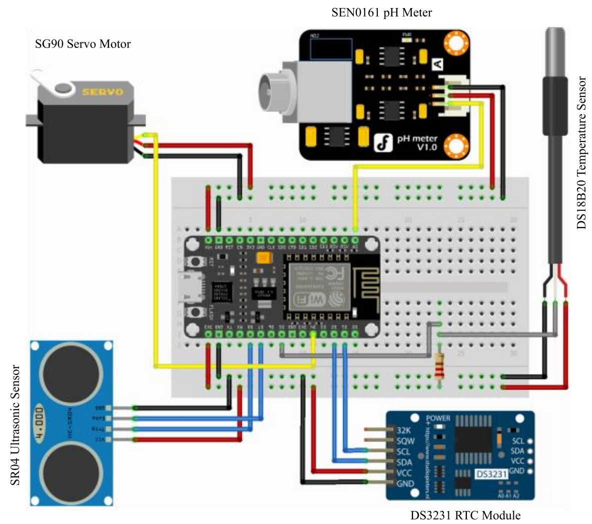

Figure 1 Wiring Diagram

microcontroller. Figure 1 illustrates the input and output components connected to the microcontroller, and Table 2 provides information on the pinout used by each module to connect to the microcontroller.

Table 1 List of materials

Materials	Units
NodeMCU (Amica)	1 Unit
RTC module (DS3231)	1 Unit
Ultrasonic sensor (HC-SR04)	1 Unit
Temperature sensor (DS18B20)	1 Unit
pH meter (SEN0161)	1 Unit
Servo motor (SG-90)	1 Unit
Breadboard (400 point)	1 Unit
Resistor (4.7K Ohm)	1 Unit
Servo mounting	1 Unit
Jumper cable	As needed

Table 2 Component Pinouts

Node MCU	RTC	Ultrasonic sensor	Temperature sensor	pH meter	Servo motor
3V3	VCC	VCC	VCC	-	-
Vin	-	-	-	VCC	VCC
GND	GND	GND	GND	GND	GND
A0	-	-	-	PO	-
D1	SCL	-	-	-	-
D2	SDA	-	-	-	-
D4	-	-	-	-	PWM

The complete functioning of the system is illustrated in Figure 2. The system collects data from each sensor. The collected data is then stored in the Firebase real-time database, which is a cloud-hosted database. This database is responsible for synchronizing data between devices and keeping data up-to-date. The stored data in the database is accessible to the user via the Android application. The application displays real-time data to users. Users can monitor the temperature and pH levels of the water, as well as the remaining amount of food in the container. The application offers two options: direct feeding, which dispenses food when the user initiates the command, and

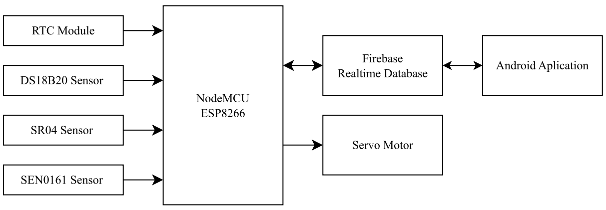

Figure 2 Block Diagram

scheduled feeding, which allows the user to set a specific time for the servo motor to activate and dispense food.

The flowchart system is divided into two parts. The first part shows the flowchart on the sensor module, while the second part shows the flowchart on the Android application. Figure 3 displays the flowchart for the sensor module. It begins with the NodeMCU reading data from each sensor. The NodeMCU then sends the acquired sensor data to the Firebase real-time database. Simultaneously, it retrieves feeding schedule data and "Status_Servo" as a function to activate the servo. The NodeMCU matches the time on the schedule with the time information from the RTC module. Additionally, the servo will automatically open when "Status_Servo" in the database is 1. This indicates a command to open the servo outside of the feeding schedule.

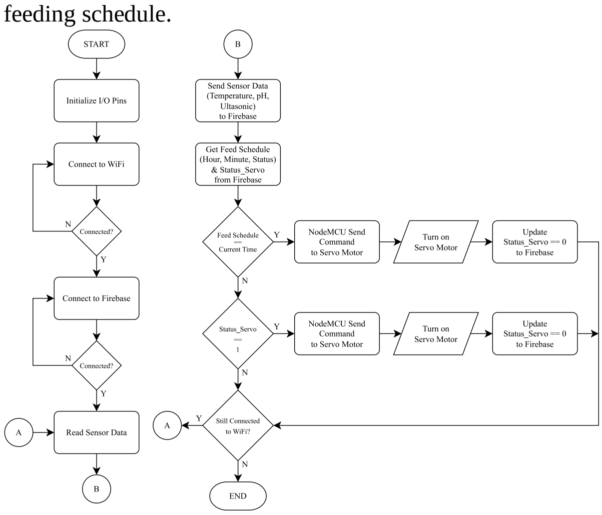

Figure 3 Sensor module flowchart

The flowchart displayed in Figure 4 represents the steps taken by the Android application upon being opened by the user. Firstly, the application connects to the Firebase Realtime Database using an internet connection. Once the connection with the database is established, the temperature, pH, and remaining feed data are retrieved and displayed on the application interface. This data synchronization process

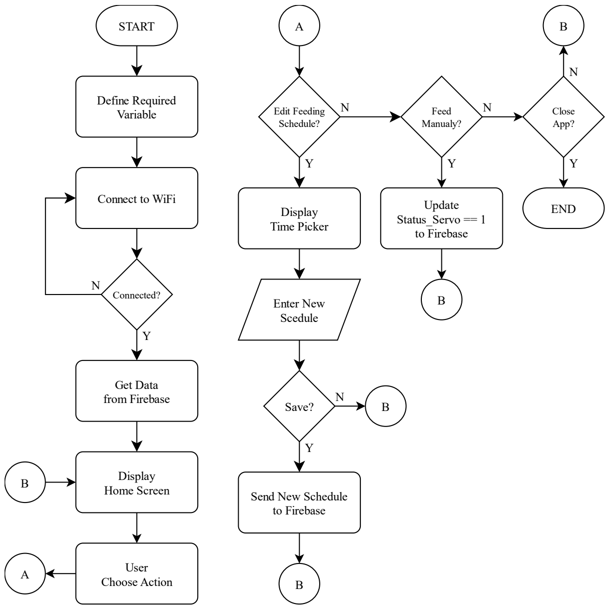

Figure 4 Android application flowchart

continues for as long as the application remains open, with the sensor module sending data to Firebase for updates.

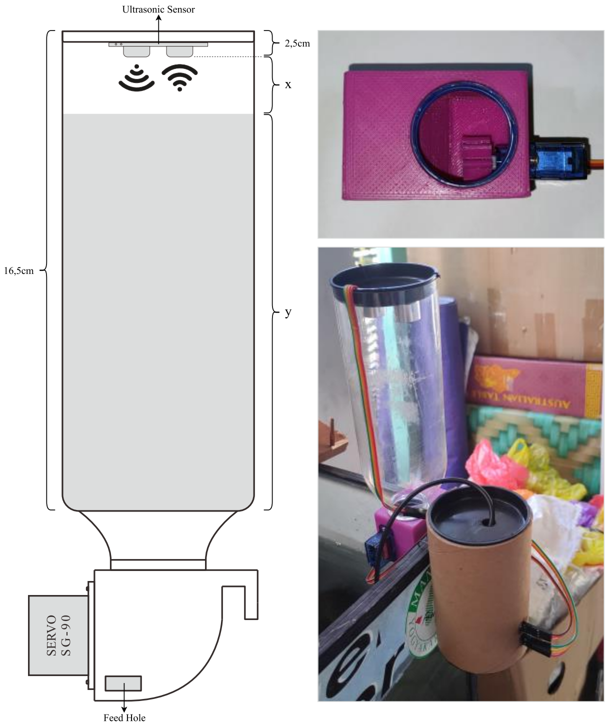

Figure 5 Prototype design

Figure 5 shows the prototype design, especially the feed container and servo installation. The container for feed has a height of 16.5cm and can hold a maximum of 14cm of feed due to the container lid design and ultrasonic sensor. The ultrasonic sensor continually sends out waves that reflect when they hit the surface of the feed. Based on the data of the ultrasonic wave reflection time, the sensor measures the distance from the feed surface to the sensor.

$$y = z - x \qquad (1)$$

$$\%\, remaining\ feed = \left(\frac{y}{z}\right) \times 100\% \qquad (2)$$

Equation (1) uses variables y, z, and x to represent the height of the remaining feed in the container, the height of the container, and the distance between the surface of the feed and the ultrasonic sensor, respectively. Equation (2) outlines the process to calculate the percentage of remaining feed in the container and sends the result directly to the database.

3. RESULT AND DISCUSSION

To ensure the proper functioning of each sensor, testing was conducted on every component, and compared the test results on the serial monitor in Arduino with the results of manual measurements. Tests on the DS18B20 temperature sensor were carried out 5 times and the results were compared with measurements using a thermometer to assess the accuracy of the sensor readings. The test results in Table 3 show that sensor reading results are quite accurate.

Table 3 Temperature sensor testing

Testing number	Sensor reading (°C)	Thermometer (°C)	Error (%)
1	26.8	26.4	1.4925
2	28.3	28.1	0.7117
3	27.3	27.1	0.738
4	28.6	28.3	1.0601
5	26.5	26.4	0.3788

Tests on the SEN0161 pH sensor were carried out 5 times and the results were compared with measurements using a thermometer to assess the accuracy of the sensor readings. The test results for the SEN0161 pH sensor in Table 4 show that the sensor reading results are quite accurate.

Table 4 pH sensor testing

Testing number	Sensor reading	pH meter	Error (%)
1	6	6.1	1.6393
2	7	7.3	4.1096
3	7	7.2	2.7778
4	6	6.5	7.6923
5	8	8.1	1.2346

Testing on the SR04 ultrasonic sensor was carried out 5 times. Tests are carried out to determine the remaining feed based on sensor reading values. The test results in Table 5 indicate that the remaining feed amount corresponds with the sensor readings.

Table 5 Ultrasonic sensor testing

Ultrasonic Sensor (cm)	Remaining Feed (cm)	Remaining Feed (%)
3.23	10.77	77
5.89	8.11	58
8.54	5.46	39
10.61	3.39	24
13.17	0.83	6

Testing on the SG90 servo was carried out 5 times. The SG90 servo test results in Table 6 show that the degree of servo rotation corresponds to the requested value.

Table 6 Servo motor testing

Testing number	Command angle (degree)	Moving angle (degree)	Error (%)
1	30	30	0.00
2	45	45	0.00
3	90	90	0.00
4	120	120	0.00
5	180	180	0.00

Table 7 below shows the results of testing the overall feeding and monitoring system, carried out in a 60x60x80cm aquarium with 2 catfish-type fish for 3 days. The testing aimed to verify if the system can carry out feeding according to the specified schedule and to ensure that the sensor data is successfully updated in the application.

Table 7 Overall system testing

Day	Time	Feeding process		Update monitoring parameters	Update remaining feed
		Conclusion	Delay (s)		
1	07.00	Succeed	1.2	Succeed	Succeed
	12.00	Succeed	1.8	Succeed	Succeed
	17.00	Succeed	1.4	Succeed	Succeed
2	07.00	Succeed	1.3	Succeed	Succeed
	12.00	Succeed	1.2	Succeed	Succeed
	17.00	Succeed	2.4	Succeed	Succeed
3	07.00	Succeed	1.1	Succeed	Succeed
	12.00	Succeed	1.3	Succeed	Succeed
	17.00	Succeed	1.8	Succeed	Succeed

Figure 6 shows an Android application that has been developed using Android Studio. The main page of the app displays the temperature and pH levels of the water in addition to the amount of feed remaining in the container. On this page, users can also view a list of automatic fish-feeding schedules that have been set up for each day. Users can easily modify the feeding schedule by selecting the "EDIT" button next to each schedule and setting the desired feeding time. The new schedule that has been created will be automatically saved to the database and updated on the application page.

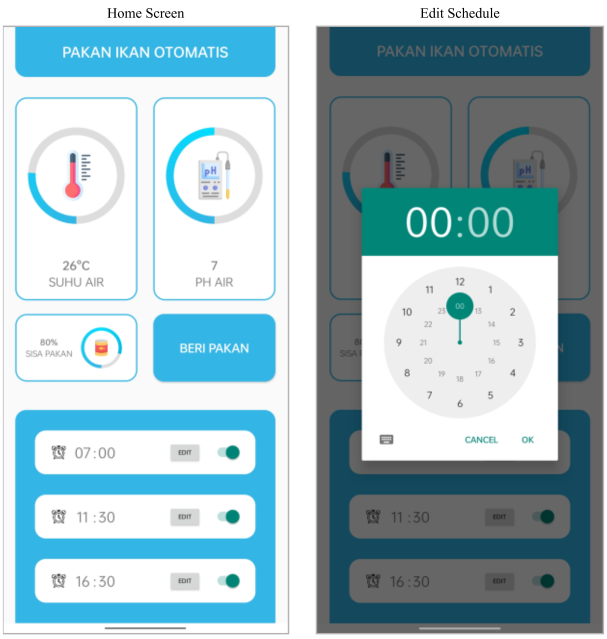

Figure 6 Android application display

Table 8 displays the test results for analyzing the application's features using Black box testing. Black box testing is a method of testing software without having detailed knowledge of the internal structure of the system or component being tested [11]. This method focuses on input/output testing or functional testing and checks for errors such as software interface errors, performance errors, data structure errors, and initialization or termination errors. The results of the black box testing indicate whether the application operates as expected without any issues.

Table 8 Black box testing

Testing Activities	Expected Outcome	Conclusion
Open the application	Load the main page	Succeed
Monitoring the temperature and pH of the water	Users can view the temperature and pH values of water in real-time	Succeed
Monitoring remaining feed	Users can see the remaining feed available	Succeed
Press the feed button	Activates the servo to feed and provides feedback if the feeding is successful	Succeed
Set a feeding schedule	Users can set feeding schedules	Succeed
Pressing (on/off) switch on the feeding schedule	Users can enable or disable feeding schedules	Succeed

4. CONCLUSION

From the results of testing the entire system in the aquarium, it can be concluded that the system can help fish owners provide consistent feed, the system is also successful in helping owners monitor the condition of their aquarium in real-time. The test results show that each component can perform its function well without experiencing significant problems, however, there is still a delay in sending data from NodeMCU to the Firebase real-time database which is caused by an unstable internet connection. For further development in the future, notification and feeding history features can be added to the system. as well as optimizing the motor system in the container so that it can provide feed on a larger scale and more accurately.

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