

# Application of IoT Technology for Automatic Provisioning Systems in Freshwater Fish Farming at STMIK Kaputama

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## Abstract

The development of secure vault systems is essential in addressing limitations found in traditional security mechanisms, such as physical keys and numerical combinations. This study presents the design and implementation of an Internet of Things (IoT)-based vault security system that integrates dual biometric authentication, facial recognition using ESP32-CAM, and fingerprint verification using the AS608 sensor. The system enforces a sequential authentication process, ensuring the facial scan is verified before activating the fingerprint module. Successful dual authentication triggers a solenoid lock to grant access, enhances security, and prevents unauthorized entry. The system communicates with Firebase for real-time status updates and access logs, which can be monitored through an Android application. Hardware and software testing confirmed the effectiveness of component integration, biometric reliability, and real-time connectivity. The device also operates effectively on battery power, increasing portability. The results demonstrate that dual biometric verification significantly increases vault security while providing a practical and efficient user experience.

**Keywords:** *Internet of Things, Automatic Provisioning, ESP32, Firebase*

## 1. Introduction

Modern technology has advanced quickly, and it now has many features that help simplify daily work. In the face of joblessness, freshwater fish farming is currently one approach to strengthen the local economy. Electronic technology can be used to produce sophisticated, automated, and extremely accurate tools. Indicates that, as part of an integrated system, all real-world items can talk with one another by using the Internet as a connector [3]. Freshwater fish are fish that spend part or all of their lives in freshwater, such as rivers and lakes, with a salinity of less than 0.05%. Many factors distinguish freshwater environments from marine environments, but salinity levels are the most distinguishing feature. To survive in freshwater, fish need to undergo physiological adaptations to maintain the ion balance in their bodies [5].

The problem that often occurs nowadays is that the daily feed requirement for fish must be met, for example, by feeding the fish three times a day. This can become an obstacle for the activities of fish farmers, potentially leading to ineffective and inefficient feeding times. This fish farming venture can be said to be very promising in terms of results, but besides that, there is still a lot of work to be done in this fish farming activity. One of the important aspects in fish farming is feeding. However, the current fish feeding system still relies on human resources for manual feeding [7]. One technology used for feeding is an automatic fish feeder device, which functions by automatically dispensing feed and can be adjusted for feeding frequency. In addition to the efficiency in feeding, this device also helps reduce the labor and time required by fish farmers [9].

## 2. Theoretical Framework

This research is supported by several theories closely related to Internet of Things (IoT) technology, automatic feeding systems, and the concept of freshwater fish farming. The Internet of Things (IoT) is a concept that enables physical devices such as sensors, actuators, and microcontrollers to connect through the internet to exchange data in real-time. In the context of this research, IoT technology is applied to control and monitor the automatic fish feeding system, both in terms of timing and the amount of feed dispensed [14]. One of the main components in this system is the ESP8266 microcontroller, which serves as the central controller for the entire automation process. This microcontroller is capable of connecting to the internet and executing commands based on a predetermined schedule. To schedule feeding, an RTC (Real Time Clock) module is used, which provides accurate and continuous time information, even in a power outage. The information from the RTC will serve as a trigger for the microcontroller to activate a servo motor, which opens the feed container valve [17].

Additionally, this system is supported by an ultrasonic sensor that detects the availability of feed in the storage container. This sensor will measure the height of the feed and provide information if the container is nearly empty, allowing the user to refill it immediately. All data and system status are sent to an Internet of Things (IoT) platform such as Thingsboard, which provides a remote monitoring interface through smartphones or computers [8]. The application of this technology aims to improve the quality and continuity of fish feeding, especially in freshwater fish farming. With the integrated automation system through IoT, it is hoped that fish farmers will no longer need to conduct manual supervision, allowing time and effort to be allocated to other more productive activities.

### 3. Methods

The author used the Research and Development technique in this study. It is anticipated that this approach will result in new goods or solutions that can improve efficacy or quality in a particular industry. To create innovations or new components pertaining to the study's goals, the research and development approach will be applied. A cloud-based system for remote monitoring and centralized data administration, as well as the application of artificial intelligence for adaptive decision-making based on fish eating patterns, are the developments made in this study. These advancements allow the system to facilitate aquaculture that is more accurate, sustainable, and data-driven.

#### 3.1 System Requirements Analysis

In this research, data collection was conducted through a literature review relevant to the topic, specifically related to the application of Internet of Things technology in automatic fish feeding systems in freshwater fish farming. Internet of Things technology enables the feeding process to be carried out automatically and efficiently based on environmental time parameters, and it can be monitored in real-time through digital devices.

The analysis of the system requirements needed in the development of this system includes two main aspects, namely hardware and software.

1. The hardware used in this research is as follows:

- a. NodeMCU ESP32
- b. Ultrasonic Sensor
- c. Servo Motor
- d. Connecting Cables
- e. LCD 16x2 1602 Plus I2C
- f. Adapter
- g. Smartphone

2. The software used in this research is as follows:

- a. Arduino IDE
- b. Android Studio
- c. Fritzing
- d. Draw.io

#### 3.2 System Block Diagram

Hardware design is the process of designing electronic components so that they have the desired function. In general, the stages of planning the design of the tool are shown in Figure III.1 below:

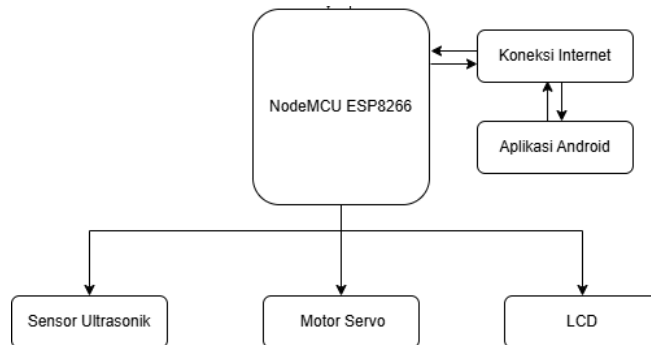
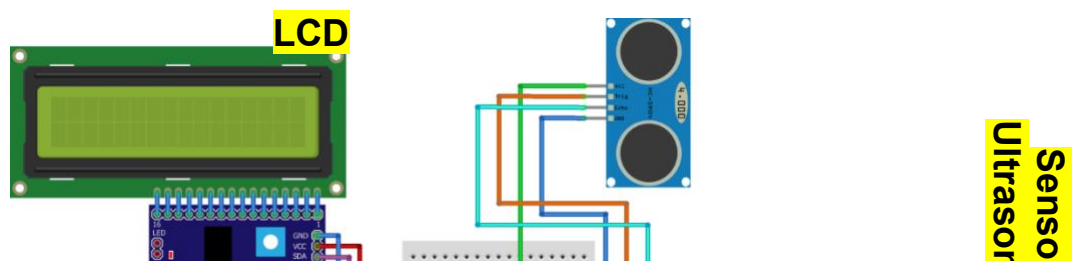


Fig. 1: System Block Diagram

The block diagram shows how the ESP32-based automatic fish feeding system works, integrated with various sensors and supporting modules. NTP (Network Time Protocol) provides accurate time information to the ESP32 as the control center. Based on the specified schedule, the ESP32 activates the servo motor to automatically open the feed container. The ultrasonic sensor monitors the height of the feed in the container and helps determine the feeding time. Time information, feeding status, and system conditions are displayed through a 16x2 LCD with an I2C module for pin efficiency. Additionally, the ESP32 sends feeding activity data via an IoT connection to the application, enabling real-time remote monitoring and control, making the feeding process scheduled, efficient, and easy to supervise.

#### 3.3 Overall Equipment Arrangement

The overall circuit of the device is designed to ensure its function aligns with the expected purpose. The arrangement and operation of each component in interacting to achieve optimal performance can be seen in Figure III.2.





**Fig. 2:** Overall Circuit of the Device

**Description:**

- NodeMCU ESP32 functions as the main processing and control center in the electronic system. This device is responsible for receiving input, processing data, and controlling various other components in the system, thereby ensuring that the entire system operates according to the desired function.
- This ultrasonic sensor functions to detect the height of the feed in the container.
- The Servo Motor functions to open or move the feed container valve so that the feed can fall into the fish pond.
- This LCD is used to display important information such as the current time, feeding status, or internet connection. The use of the I2C module allows for the saving of pin count on the microcontroller.
- Smartphone Application The ESP32 microcontroller is configured to connect with Firebase, which serves as the medium for sending notifications to the user's application on the smartphone. With this system, users can monitor the device remotely via an internet connection.

### 3.4 Interface

The interface of the automatic fish feeding application is designed to be simple and user-friendly to facilitate users in monitoring and controlling fish feeding both manually and automatically through Android devices, as shown in Figure III.3.



**Fig. 3:** Interface of the Automatic Fish Feed Application

On the application interface titled "Automatic Fish Feed". Below it, the system displays the status in real-time. The main feature, "Set Feed Schedule," functions to set the feed schedule directly and send it to the ESP32-based IoT device. At the bottom, there is the "Active Feed Schedule" feature that shows the active feed schedule that has been set in the feed schedule settings. The display for Set Feed Schedule can be seen in Figure III.4.

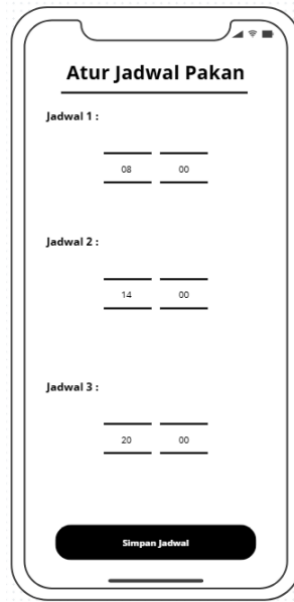


Fig. 4: Feed Schedule Adjustment

The automatic feeding time setting page, which has three sessions (Schedule 1, Schedule 2, and Schedule 3), is displayed to users upon pressing the "Set Schedule" button. All things considered, this interface makes it simpler for users to control the feeding schedule and guarantees that the system will function automatically by their requirements.

### 3.5 Flowchart Network

The design of the device begins with a flowchart to facilitate the planning and creation of the program on the microcontroller. The creation of the flowchart aims to make it easier to understand the working process of the tool, which can be seen in Figure III.5.

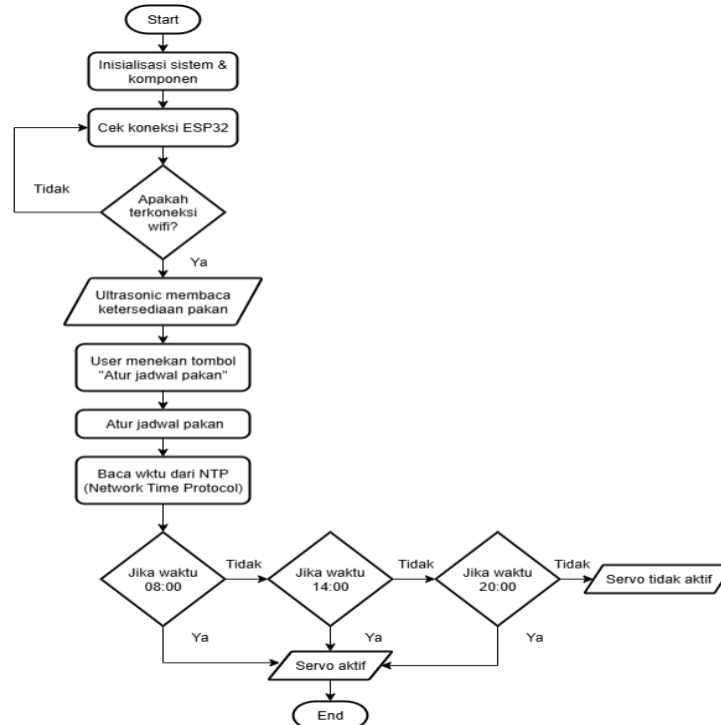


Fig. 5: System Flowchart

Description:

- a. Start The process begins when the system is activated, and all components, such as the microcontroller, sensors, and actuators, receive power.
- b. System & Component Initialization The system initializes all the components used, including the ultrasonic sensor, servo motor, and LCD. Pins and variables are also declared at this stage to ensure all devices are ready for use.
- c. Check the Wi-Fi network Connection on the ESP32 to see if it is connected or not.

- d. Ultrasonic Reading of Feed Availability The ultrasonic sensor reads the distance between the feed surface and the sensor position. This data is used to determine the remaining volume of feed in the tube.
- e. Read Time from NTP The system reads the current time from the NTP (Network Time Protocol) module to determine if it is currently the scheduled feeding time.
- f. Check if the time is 08:00 / 14:00 / 20:00? The system checks whether the current time matches one of the three feeding schedules.
  - 1) If the time matches, the system will activate the servo.
  - 2) If it does not match, the servo will remain inactive.
- g. Active Servo If the time matches the schedule, the servo will activate and open the feed valve so that the feed can flow into the fish pond.
- h. Inactive Servo If the time has not yet reached one of the specified schedules, the servo motor will not be activated, and the system will wait for the next cycle.
- i. Finished The feeding process for that time is complete. The system will return to the initial process and wait for the next cycle based on the RTC time and the status of the feed tube.

### 3.6 Supply Place Design

The ultrasonic sensor is placed at the top of the feed tube cover, specifically at a height of 17 cm. This position has a 2 cm difference from the maximum filling height of the tube. This sensor has a reading accuracy level of 3 mm with an effective detection range from 2 cm (indicating the tube is full) to 17 cm, which shows that the tube is empty and needs to be refilled immediately. The illustration of the storage tank size can be seen in Figure III.6.

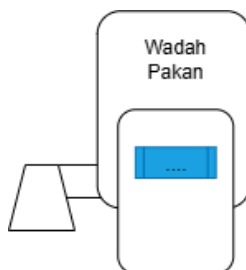


Fig. 6: Feed Place Design

Description:

- a. Total height of the tube: 17 cm
- b. Diameter of the tube: 12 cm
- c. Maximum capacity: 1.9 liters
- d. Sensor position: At the top of the tube (height 17 cm)
- e. Principle of Ultrasonic Sensor Operation

The ultrasonic sensor is placed at the top of the feed tube cover at a height of 17 cm, 2 cm below the maximum surface level of the feed when full. Based on the principle of measuring the distance from the sensor to the feed surface, a reading of 2 cm indicates that the feed is full, as the feed surface is very close to the sensor. Conversely, a reading of 17 cm indicates that the tube is empty, as the feed surface has moved away from the sensor.

## 4. Discussion Results

The outcomes of the deployment of the previously designed Internet of Things (IoT)-based automatic fish feeding system will be covered in this chapter. Hardware and software are the two primary parts of this system, which, combined, offer an automated way to feed freshwater fish at STMIK Kaputama.

The implementation of the system begins with the assembly of electronic components according to the designed circuit diagram. NodeMCU ESP32, as the main microcontroller, is connected to various sensors and actuators, including the HC-SR04 ultrasonic sensor, servo motor, 16x2 I2C LCD, buzzer, and relay. Each component is configured with the appropriate pins and programmed using the Arduino IDE to perform specific functions within the system. The Android application software is developed using Android Studio with Firebase as a real-time database for communication between hardware and the mobile application. This application allows users to monitor system status and schedule feeding times.

### 4.1 Software Evaluation

#### 4.1.1 Testing with Arduino IDE

Software testing on the ESP32 microcontroller is conducted using the Arduino IDE to ensure all functions work properly. Testing is conducted in stages for each component and system. In the software testing process, several important stages must be carried out, including the following:

- a. The initial stage begins with opening the Arduino IDE application, which will then display the main interface as shown in Figure IV.1 below.



Fig. 9: Program Display

#### 4.1.2 Testing with Android Studio

The Android application is developed and tested using Android Studio and its integration with Firebase for real-time data management. In the implementation of testing on Android Studio, several stages need to be considered, including:

- The initial step that needs to be taken is to open the Android Studio application, then create a new project. After that, the initial application development interface will be displayed, as shown in Figure IV.5 below.

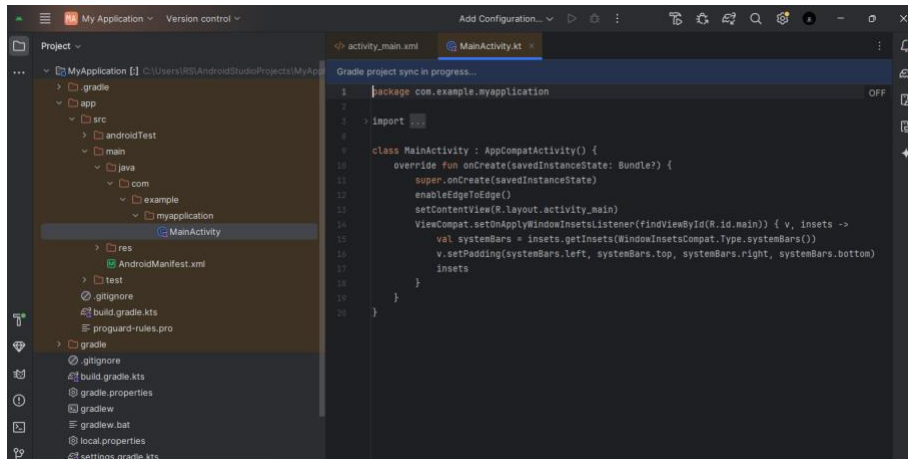


Fig. 10: Android Studio Software

- To integrate Android Studio with Firebase, the next step is to open the "Tools" menu, then select the "Firebase" option and proceed with "Get started with Realtime Database". After that, click "Connect to Firebase" to start the connection process. The illustration of this process is shown in Figure IV.6 below.

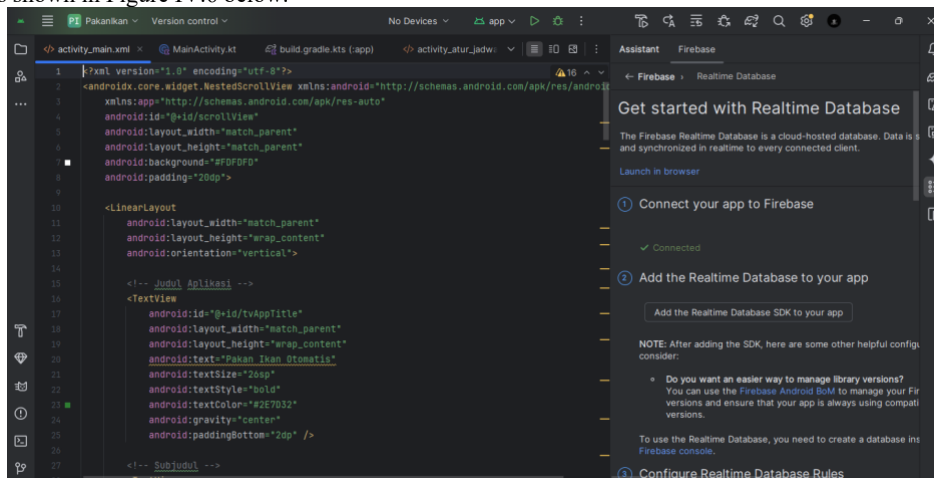


Fig. 11: Firebase Tools Menu

- The next step in the application development process is to write the program code according to the needs and functions that have been designed. An example of the program code writing can be seen in Figure IV.7 below.

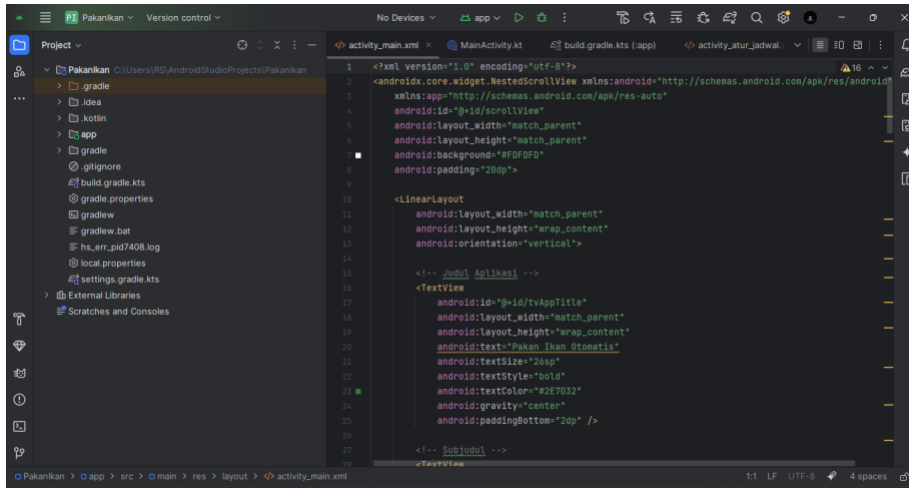


Fig. 12: Program Display

4.1.3 Result of the Home Interface Display

Users can easily monitor and arrange feeding times thanks to the Automatic Fish Feed application's straightforward and educational main interface. The program title appears at the top, followed by an information box that shows the device status, the latest feeding time, and the amount of feed left. Then, to control the automatic feeding schedule, press the green "Set Feeding Schedule" button. A list of active feeding schedules is displayed to users at the bottom, organized into three time slots: Schedule 1, Schedule 2, and Schedule 3. This is seen in the following image IV.8.



Fig. 13: Home Interface Display

4.1.4 Results of the Schedule Management Interface Display

Users can schedule automated feeding times three times a day using the application's Feed Schedule Settings page, which has an easy-to-use UI. Schedules 1, 2, and 3 all have a time picker component that allows users to choose their hours and minutes. Because of the basic design of this interface, users can easily change the time to suit their needs. Once all of the times have been set, the user can save the configured settings by clicking the green "Save Schedule" button at the bottom. seen in the following figure IV.9.

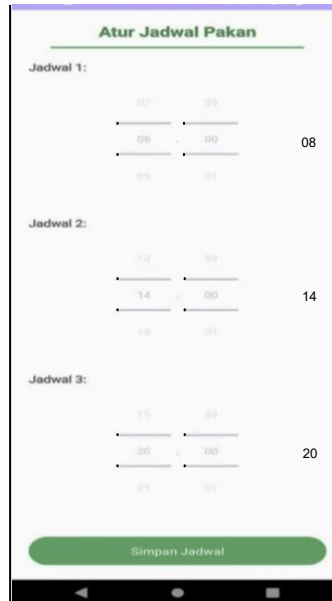


Fig. 14: Schedule Settings Interface Display

#### 4.1.5 Data Results in Firebase Realtime Database

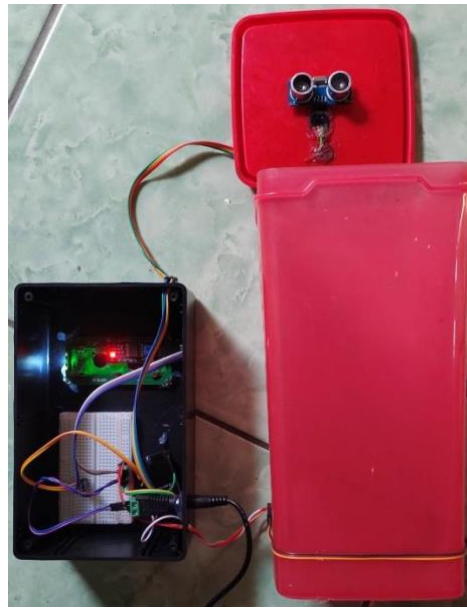
Time activity data is automatically saved in the Firebase Realtime Database following system execution and a successful connection. The status of each schedule, feed level, device status, and last feed are among the details that Firebase stores in a JSON tree structure format. Figure IV.10 below provides an illustration of the data storage system.



Fig. 15: Data Results on Firebase Realtime Database

#### 4.2 Hardware Assessment

The next stage is to integrate all of the device's circuits and components when all of the designed circuits have been finished. The ESP32, LCD, servo motor, ultrasonic sensor, and other parts that have been modified to fit the system architecture are all part of this integration. The tool design circuit's output is displayed in Figure IV.11 below, which also displays the arrangement and connections of each component.



**Fig. 16:** Overall Equipment Circuit

### 4.3 Overall Device Assessment Results

After the hardware is put together and the microcontroller is loaded with the relevant software, the automatic fish feeding system is prepared to be employed to ascertain the anticipated outcomes of this study. Figure IV.12 below shows the outcomes of the device testing as a whole.



**Fig .17:** Overall Device Testing Results

## 5. Conclusions

Based on the research results and the implementation of the IoT-based automatic fish feeding system at STMIK Kaputama, it can be concluded that:

- The NodeMCU ESP32, ultrasonic sensors, servo motors, I2C LCD, and Firebase Realtime Database were used to successfully develop and construct the system, allowing for automatic feeding by the predetermined timetable.
- The Firebase-integrated Android app offers customers scheduling ease by displaying feed availability, feeding schedules, and device status data in real-time.
- The system's ability to decrease reliance on hand feeding and increase time and labor efficiency in freshwater fish farming is demonstrated by testing.
- This system's use of IoT technology demonstrates how combining hardware and software can result in creative solutions for more accurate and planned fish feed management.

## 6. Suggestions

For further development of this dual biometric authentication safe security system, it is recommended:

- a. Subsequent development could include adding water quality sensors such as pH, temperature, and dissolved oxygen levels to provide more comprehensive environmental data.
- b. The addition of an automatic notification feature in the application is necessary if the feed stock is running low or if there is a system malfunction.
- c. The system can be developed to support multi-tank control with a single application to enhance large-scale operational efficiency.
- d. The design of the feed container and mechanical components can be modified to be more resistant to outdoor environments and extreme weather, allowing the system to be used in outdoor fish farming.

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