Integration of Real-Time Scheduling and Feed-Level Monitoring in an Automatic Feeding System for Vannamei Shrimp Farming

Ronny Katuuk
Department of Computer Engineering
Manado State Polytechnic

Ali Ramschie
Department of Electrical Engineering
Manado State Polytechnic

Johan F. Makal
Department of Electrical Engineering
Manado State Polytechnic

Johan Pongoh
Department of Electrical Engineering
Manado State Polytechnic

ABSTRACT
Vannamei shrimp (*Litopenaeus vannamei*) aquaculture is one of the most economically valuable sectors in Indonesia's fisheries industry. However, manual feeding practices often lack consistency and accuracy, resulting in inefficient feed utilization and suboptimal shrimp growth. This study aims to design and evaluate a time-based automatic feeding system to improve feed management efficiency and reliability in vannamei shrimp farming.

The research employs a prototyping approach, consisting of literature review, hardware and software design, system model development, and functional testing. The system integrates a microcontroller as the control unit, a Real-Time Clock (RTC) module for precise feeding schedules, and motor actuators for automated feed distribution. Additionally, a feed-level detection sensor is incorporated to monitor feed availability in the silo and trigger an alarm when the feed is nearly depleted.

Experimental results demonstrate that the developed system is capable of executing feed distribution automatically based on predefined schedules while simultaneously detecting feed availability. The system's integrated mechanisms improve accuracy, reduce dependency on human labor, and provide timely alerts for feed replenishment.

Contribution this study lies in the integration of real-time scheduling with feed-level monitoring in a single autonomous system, which enhances precision, minimizes operational errors, and supports the implementation of smart aquaculture technology. This contributes to the advancement of sustainable vannamei shrimp farming practices, particularly in regions where feed management remains a critical challenge.

Keywords
Vannamei shrimp aquaculture, Automatic feeding system, Microcontroller, Real-Time Clock (RTC), Feed-level detection

1. INTRODUCTION
Pacific white shrimp (*Litopenaeus vannamei*) aquaculture has emerged as one of the most economically valuable sectors in global aquaculture, particularly in Indonesia, due to its high productivity and export potential. However, feed accounts for up to 60% of total production costs in intensive shrimp culture, making efficient feed management a key determinant of profitability and sustainability [1]. Manual feeding methods, which are still widely practiced, often lack precision in both timing and dosage. This inconsistency can result in feed waste, deterioration of water quality, and suboptimal shrimp growth performance [2], [3]. In contrast, automatic feeding systems allow for consistent and frequent feed distribution, improving growth rates, feed conversion ratios, and environmental conditions [4]. Recent technological advances have introduced smart aquaculture systems that integrate Internet of Things (IoT), sensors, and automation. Studies have shown that IoT-based automatic feeders combined with real-time monitoring of environmental parameters such as temperature, pH, and dissolved oxygen can significantly enhance aquaculture management [5], [6], [7]. Furthermore, Quality Function Deployment (QFD) and system prototyping approaches have been applied in aquaculture technology development to improve feeding strategies and ensure resource efficiency [8].

Sensor-based and feedback-controlled feeding systems have also been widely studied. Acoustic sensors that detect shrimp feeding activity can modulate feed release in real time, thus reducing waste and improving feed efficiency [9]. Meanwhile, fuzzy logic and artificial intelligence algorithms have been proposed to optimize feeding rates based on environmental variables, achieving feed savings of up to 35% without compromising growth [10], [11]. Computer vision methods have also been developed to detect uneaten feed and monitor shrimp behavior, enabling adaptive feeding control ([12], [13]. Despite these advancements, there is still a gap in the integration of time-based feeding schedules with feed-level monitoring within a single autonomous system specifically tailored for vannamei shrimp aquaculture. Therefore, this study proposes the development of a microcontroller-based automatic feeding system equipped with a Real-Time Clock (RTC) for scheduling, motor actuators for feed distribution, and feed-level sensors with alarm notifications. This integration is expected to improve precision, reduce labor dependency, and support sustainable shrimp aquaculture practices.

2. METHODOLOGI
Based on the prototyping method used in developing an automatic time-based fish feeding system model, the stages carried out include: literature review, data collection, system design consisting of hardware design (system block diagram) and software design (flowchart), system simulation using a simulation program (Wokwi) based on the system design (hardware and software), as well as performance testing of the system model in terms of automation of vannamei shrimp feeding, according to the predetermined schedule.

2.1 System Design
To develop a time-based automatic feeding system for

vannamei shrimp farming, the initial step is to present the system design in the form of a block diagram. The block diagram of the time-based automatic feeding system for vannamei shrimp farming is shown in Figure 1.

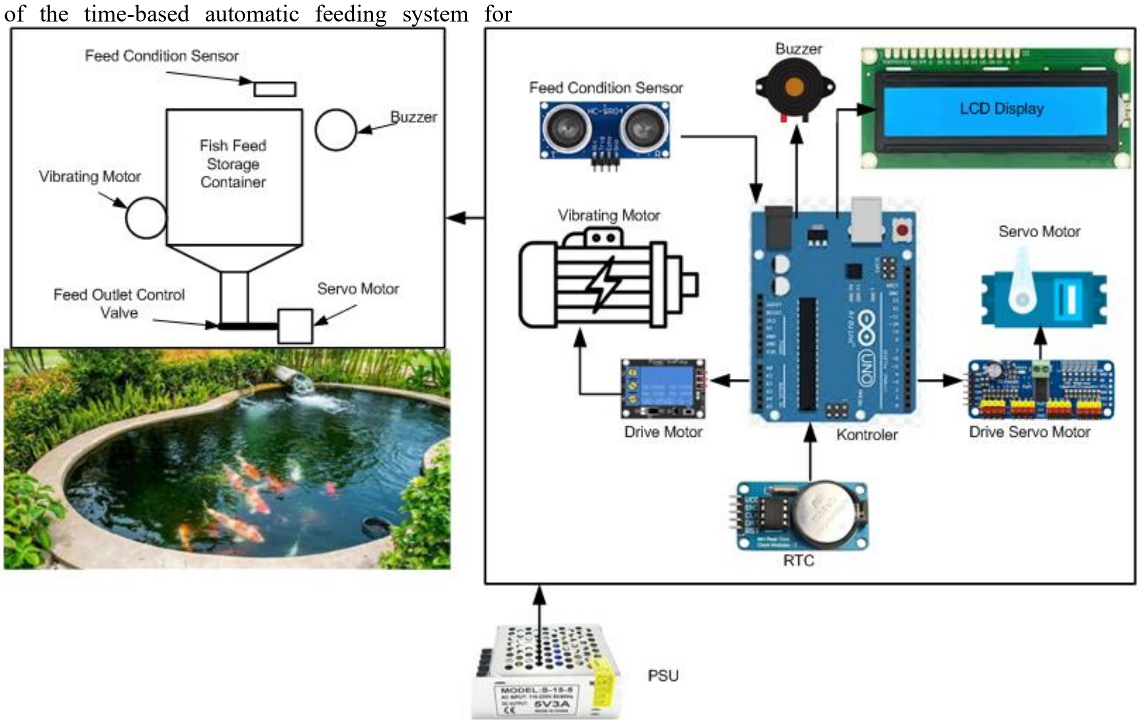

Fig 1: The block diagram of the time-based automatic feeding system for vannamei shrimp farmin

Referring to Figure 1, the functions of each system component can be described as follows:

Fish Feeding Section

1. **Fish feed storage silo** functions as a container for storing feed used in the vannamei shrimp feeding process.
2. **Feed condition sensor** is used to monitor the availability of feed in the storage container.
3. **Vibrating motor** serves to shake the storage silo so that the feed can flow smoothly during the feeding process.
4. **Feed control valve** functions to regulate the flow of feed released during the vannamei shrimp feeding process.
5. **Servo motor** is used to operate the open-close mechanism of the feed control valve.
6. **Buzzer** functions as a warning indicator when the feed in the storage container has run out.

Control System Section

1. **Controller** serves as the central unit for data processing and automatic control in the vannamei shrimp feeding system. The controller reads data from the RTC according to the predetermined feeding schedule. When the feeding time is reached, the controller automatically checks the feed condition in the storage container—whether it is still available, reduced, or completely depleted.
   - If the feed is still available, the controller activates the **servo motor** to a fully open position (90°) to open the feed control valve. Then, the **vibrating motor** is turned on to ensure smooth feed flow from the storage container.
   - If the feed level in the container decreases to a predetermined threshold, the **servo motor** is set to a half-open position (45°) to reduce the feed flow.
   - If the feed is completely depleted, the **servo motor** returns to its initial position (0°) to fully close the feed control valve, the vibrating motor is deactivated, and the **buzzer** is activated as an indicator that the feed in the container has run out.

Additionally, once the feeding duration ends, the controller closes the feed control valve by moving the servo motor back to the (0°) position and deactivates the vibrating motor.

2. **LCD Display** is used to show various information related to the operation of the vannamei shrimp feeding system.
3. **Feed condition sensor** functions to detect the state of the feed in the storage container and sends the data to the controller for processing.
4. **Motor driver** serves as the actuator to enable or disable the vibrating motor of the feed storage container.
5. **Servo motor driver** is used to control the movement of the servo motor in operating the open-close mechanism of the feed control valve.
6. **Switch** functions as a control button to set the operating status of the vannamei shrimp feeding system. When set to *set*, the system becomes active, and when set to *reset*, the system resets the feeding process when the feed in the storage container is detected as empty.
7. **RTC (Real-Time Clock)** functions as a timer in the feeding process, based on the predetermined schedule.
8. **PSU (Power Supply Unit)** acts as the power provider for the time-based automatic vannamei shrimp feeding system.

2.2 System Algorithm

The system algorithm is the initial stage in developing the software used to operate the time-based automatic vannamei shrimp feeding system. This algorithm is structured according to the procedural workflow of the system, which is illustrated in the form of a flowchart. The system workflow diagram is shown in Figure 2.

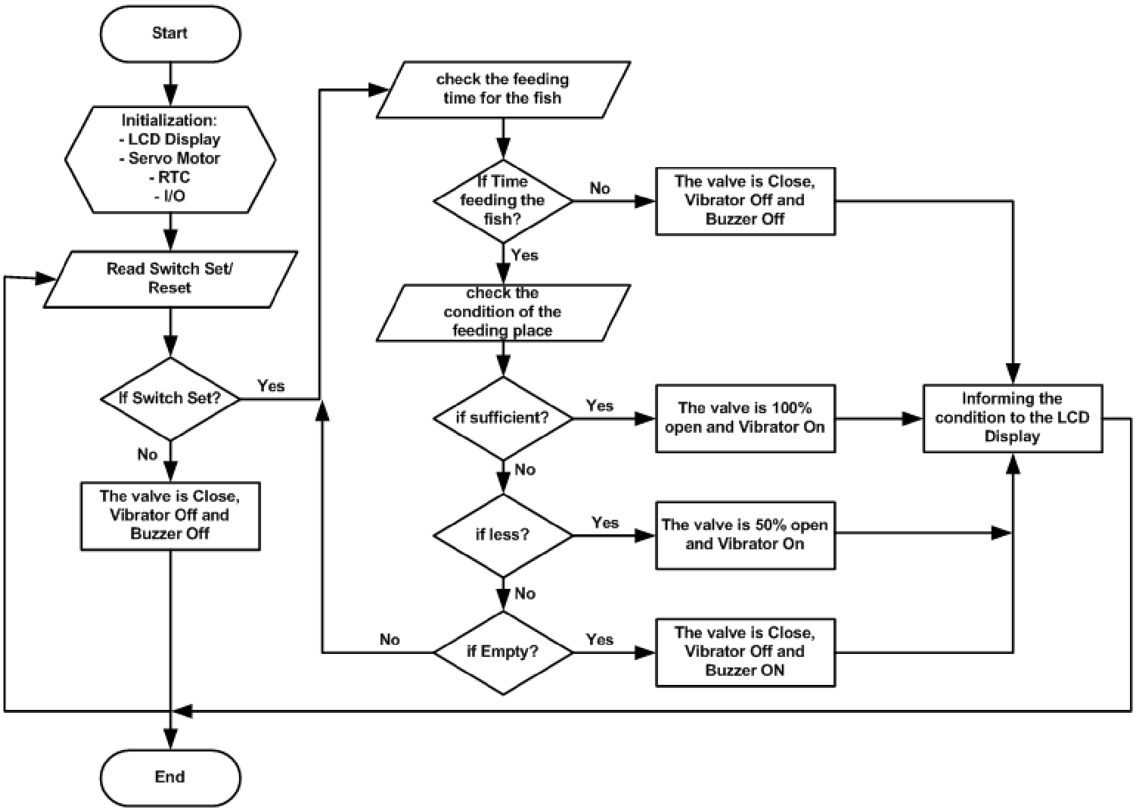

Fig 2:Flowchart system the time-based automatic vannamei shrimp feeding

System Flowchart Description in Figure 2:

When the system is activated, the procedures carried out are as follows:

1. The system first performs initialization and setup, which includes configuring the functions of the LCD display, servo motor, RTC, and the input-output settings to be used.
2. Next, the system reads the input condition from the switch, which has two states: *set* and *reset*.
3. If the switch is in the *reset* state, the system will execute instructions to deactivate the buzzer, close the feed control valve by setting the servo motor position to 0°, and turn off the vibrating motor. Afterward, the system will continuously monitor the switch condition.
4. If the switch is in the *set* position, the system will check the vannamei shrimp feeding schedule according to the time specified in the RTC.
   - If the scheduled feeding time has not yet been reached, the system will continue monitoring the feeding schedule.
   - If the feeding time matches the schedule, the system will automatically detect the feed condition in the storage container using the feed condition sensor.
   - If feed is still available (detected at a distance between 10 cm – 100 cm from the sensor), the servo motor will be set to 90° to fully open the feed control valve, and the vibrating motor will be activated.
   - If feed is detected at a distance between 100 cm – 130 cm, the system will adjust the servo motor to 45° so that the control valve is half-open, reducing the volume of feed dispensed.
   - If feed is detected at a distance greater than 130 cm (indicating the feed is depleted), the system will automatically close the valve completely by setting the servo motor back to 0°, and the alarm will be activated to indicate that the storage container is empty. In this case, the user can switch to the *reset* position. Once the switch is set to *reset*, the alarm will be deactivated, and the feeding system will stop functioning until the container is refilled with feed and the switch is set back to *set*.
   - If the feeding duration ends according to the RTC, the system will automatically deactivate the vibrating motor and close the feed control valve by moving the servo motor back to the 0° position.

2.3 System Manufacturing

The block diagram provides a conceptual framework that defines the interconnections among system components and outlines the overall operational workflow. Based on this design, the hardware architecture is constructed, followed by the development of the software that functions as the control unit. The software executes a predefined algorithm, which constitutes the core logic ensuring that the feeding process operates automatically according to the scheduled time.

In addition to hardware and software design, the development process includes a simulation stage conducted in the Wokwi environment. This simulation is essential for virtually testing the system's operation, validating the functionality of the implemented algorithm, and identifying potential errors prior to physical deployment. The use of Wokwi therefore not only expedites the validation phase but also improves the accuracy and reliability of the developed model. Figure 3 presents the system development process within the Wokwi simulation environment, serving as a practical platform for verifying the system workflow before real-world implementation.

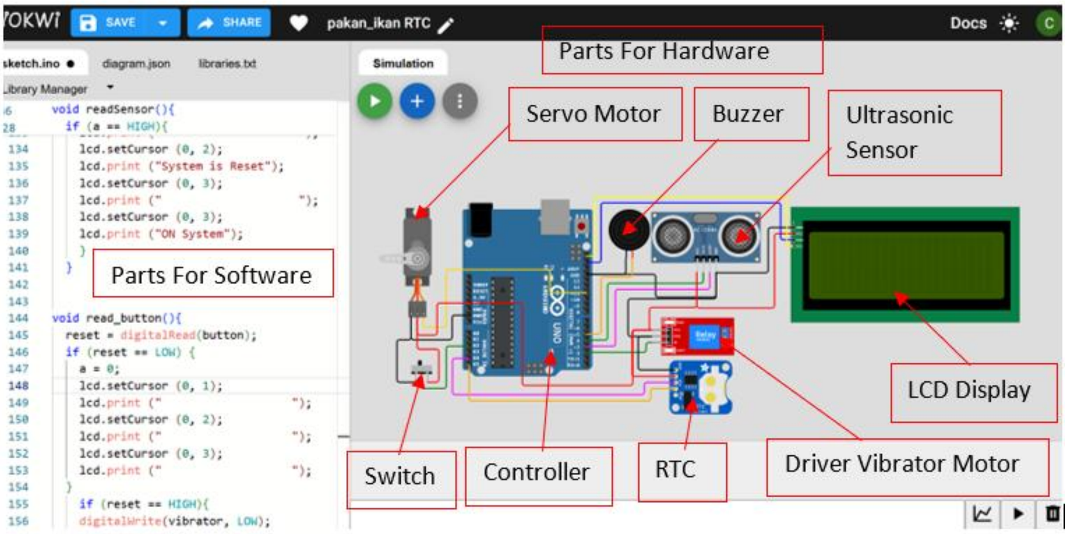

Fig 3: Development of a Time-Based Automatic Feeding System Model for Vannamei Shrimp

3. RESULT AND DISCUSSION

Based on the results of the research conducted, the stages carried out in developing a time-based automatic vannamei shrimp feeding system model can be described as follows:

3.1. Testing of the system model when first activated

When the time-based automatic vannamei shrimp feeding system model is first operated through the simulation program, the system initially checks the switch condition, whether it is in the *set* or *reset* position. If the switch is in the *set* position, the system proceeds to the feeding schedule detection procedure. If the feeding time has not yet been reached, this process will continuously run until the scheduled time is met. Once the feeding time is reached, the system activates the servo motor to move the valve to the 90° position, thereby opening the feed outlet. This process is illustrated in Figure 9.

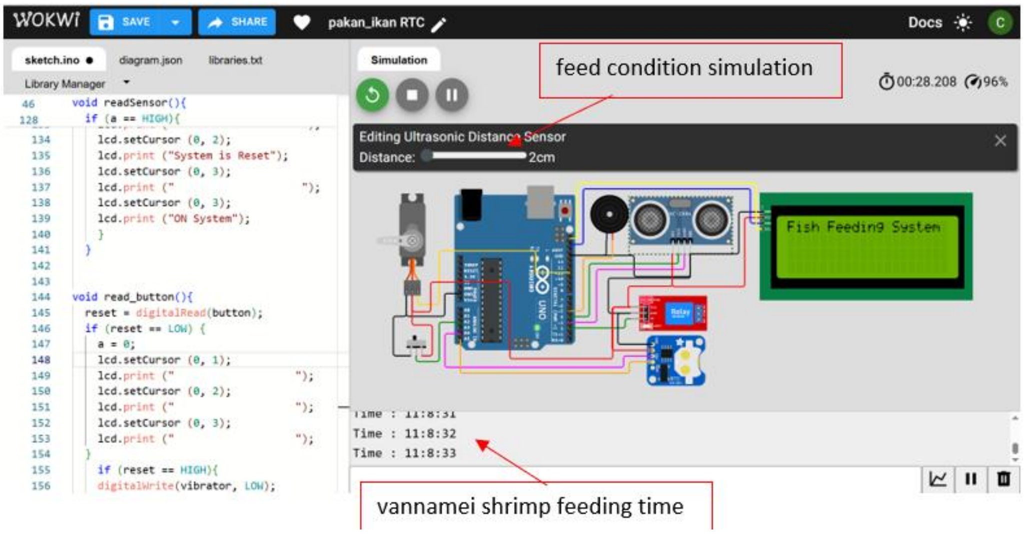

Fig 9: The process when the vannamei shrimp feeding system is activated.

3.2. Testing of the system model when the feeding time is reached

The system model testing was carried out when the vannamei shrimp feeding schedule was reached, specifically at 11:11 AM. Once the feeding time was met, the feed outlet valve automatically opened fully through the movement of the servo motor set at a 90° angle. Simultaneously, the vibrating motor was activated to shake the storage container, ensuring a smoother feed flow. In addition, the feed condition sensor functioned to monitor the availability of feed in the storage container. The process of testing the system model when the feeding time was reached is shown in Figure 10.

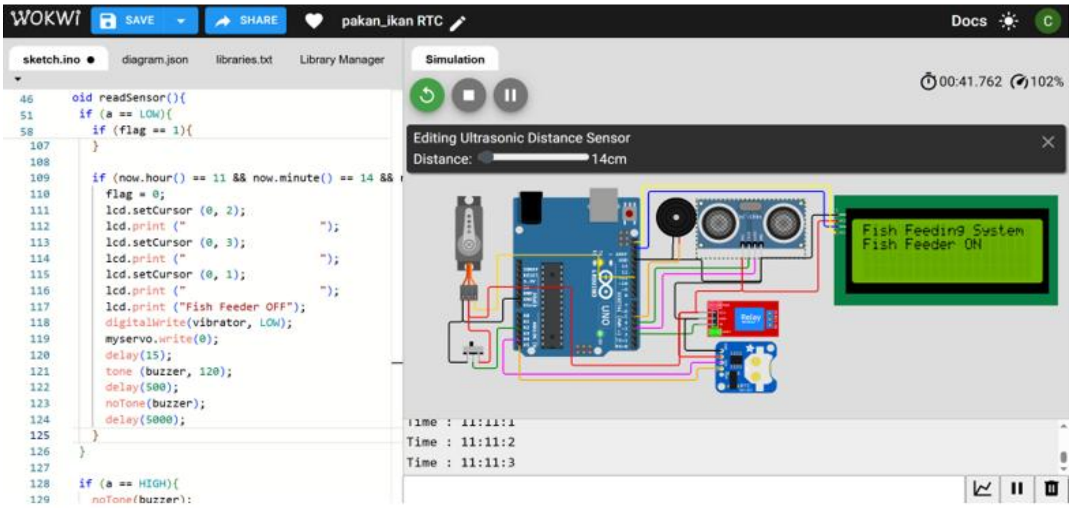

Fig 10: The process of testing the system model when the vannamei shrimp feeding time is reached.

ased on the test results shown in Figure 5, it can be observed that when the vannamei shrimp feeding schedule is reached, the system is automatically activated to carry out the feeding process. The procedure is as follows:

- When the feeding time is reached (11:11 AM), this condition is determined based on the time detection provided by the RTC component. The program section used to read the time from the RTC is as follows:

```
DateTime now = rtc.now();
  Serial.println ("Time : "+String (now.hour(),
DEC)+":"+String (now.minute(),DEC)+":"+String
(now.second(),DEC));

 // Feed Full
 if (a == LOW){
  // Check Time
  if (now.hour() == 11 && now.minute() == 11 &&
now.second() == 0){
  // Feeding Fish Active
  flag = 1;
  }
```

- When the feeding time is reached, the system will detect the feed condition in the storage container using the feed condition sensor, which in this case is an ultrasonic sensor. The program section executed to detect the feed condition is as follows:

```
if (flag == 1){
    digitalWrite(TRIG_PIN, LOW);
    delayMicroseconds(2);
    digitalWrite(TRIG_PIN, HIGH);
    delayMicroseconds(10);
    digitalWrite(TRIG_PIN, LOW);
    int duration = pulseIn(ECHO_PIN, HIGH);
    float distance = duration * 0.034 / 2;
```

The working principle of the ultrasonic sensor in detecting the feed condition in the container is based on measuring the distance between the feed surface and the sensor position.
The feed detection process in the storage container is divided into three conditions:

1. The first condition occurs when the feed in the container is categorized as still available, where the distance between the feed and the sensor is detected to be within the range of 10 cm – 100 cm. The section of the program executed by the system in this condition is as follows:

```
if (distance >= 0 && distance <= 100){
    myservo.write(90);
    delay(15);
    digitalWrite (vibrator, HIGH);
    lcd.setCursor (0, 2);
    lcd.print ("                ");
    lcd.setCursor (0, 2);
    lcd.print ("Feed Available");
}
```

When this part of the program is executed, the servo will automatically operate to open the valve and release the feed from the storage container, with the valve opening set to 90° (fully open). At the same time, the vibrating motor will be activated to facilitate the smooth flow of feed from the storage container.

2. The second condition is when the feed in the storage container is categorized as nearly empty, where the distance between the feed and the sensor is detected to be within the range of 100 cm – 130 cm. The section of the program executed for this condition is as follows:

```
if (distance > 100 && distance <= 130){
    myservo.write(30);
    delay(15);
    digitalWrite (vibrator, HIGH);
    lcd.setCursor (0, 2);
    lcd.print ("                ");
    lcd.setCursor (0, 2);
    lcd.print ("Feed is Running Low");
  }
```

When the ultrasonic sensor detects that the feed in the storage container is nearly depleted, with the distance between the feed and the sensor ranging from 100 cm to 130 cm, the system will automatically adjust the valve to a 30° angle to limit the feed release. Figure 11 illustrates the test results when the feed-to-sensor distance is detected within the range of 100 cm to 130 cm.

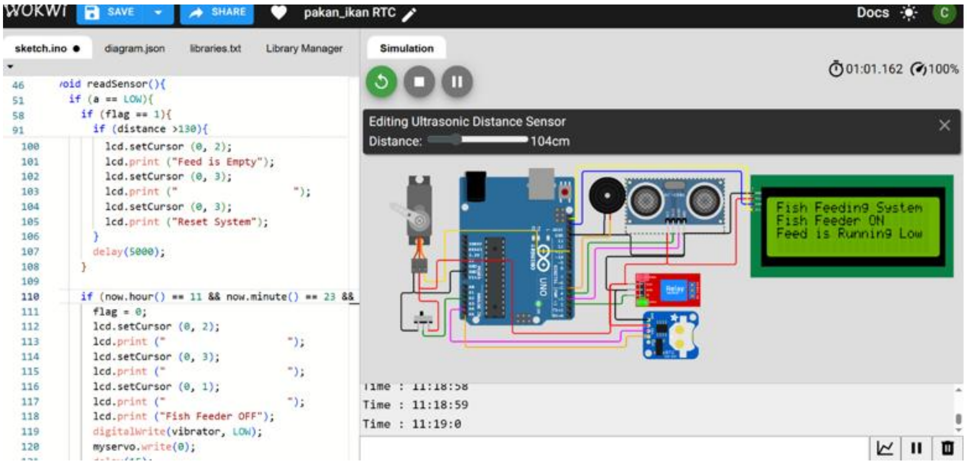

Fig 11: Test results when the distance between the feed and the sensor is detected to range from 100 cm to 130 cm.

3. The third condition corresponds to the category where the feed in the storage container is detected as depleted, indicated when the distance between the feed and the sensor is greater than 130 cm. The section of the program executed for this condition is as follows:

```
if (distance >130){
    digitalWrite(vibrator, LOW);
    myservo.write(0);
    delay(15);
    tone (buzzer, 120);
    delay(500);
    noTone(buzzer);
    lcd.setCursor (0, 2);
    lcd.print ("                ");
    lcd.setCursor (0, 2);
    lcd.print ("Feed is Empty");
    lcd.setCursor (0, 3);
    lcd.print ("                ");
    lcd.setCursor (0, 3);
    lcd.print ("Reset System");
}
```

When the ultrasonic sensor detects that the feed in the storage container is depleted, indicated by a distance greater than 130 cm between the feed and the sensor, the system will automatically set the valve to a 0° angle to close the feed outlet. At the same time, the vibrator motor will be deactivated, and the buzzer will be activated as an indication that the feed in the storage container has run out. Figure 12 shows the test results when the distance between the feed and the sensor is detected to be greater than 130 cm.

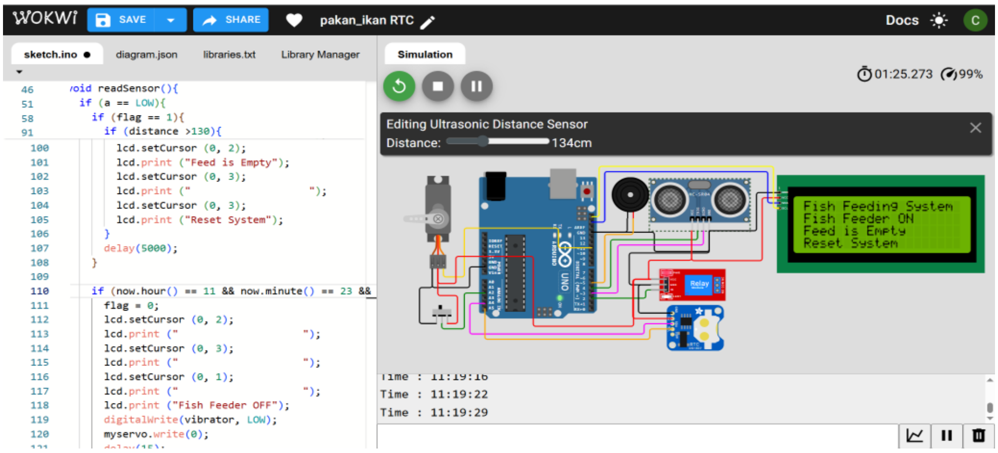

Fig 12: Test results when the feed distance detected by the sensor is greater than 130 cm.

If the feed in the storage container is detected as empty, the user can perform a system reset by setting the switch to the reset position, and then refill the storage container with new feed. The test results when the switch is set to the reset position are shown in Figure 13.

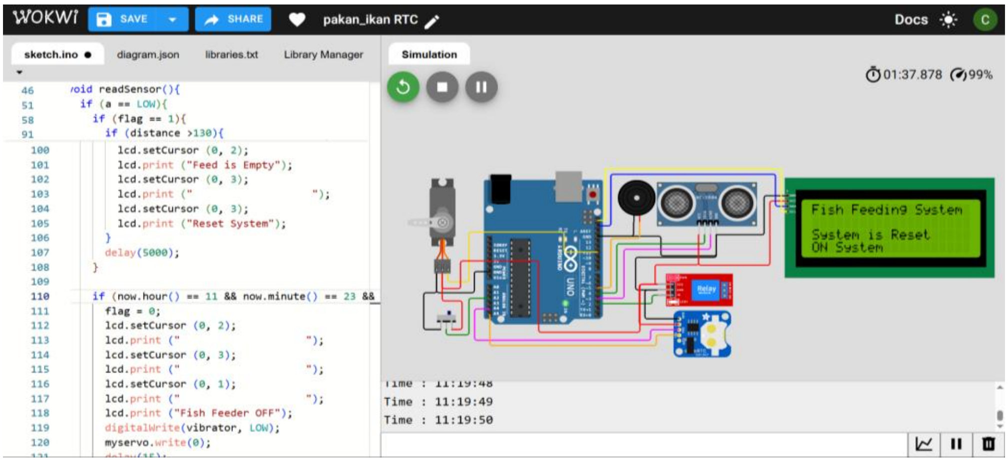

Fig 13: Test results when the switch is set to the reset position.

3.3. System model testing when the feeding time has ended

The system model testing was conducted when the feeding schedule for *vannamei* shrimp had ended, with the time set at 11:26 AM. At the completion of the feeding period, the feed release valve was automatically closed, and the vibrator motor was deactivated. The program segment executed for this condition is as follows:

```
if (now.hour() == 11 && now.minute() == 26 &&
now.second() == 0){
    flag = 0;
    lcd.setCursor (0, 2);
    lcd.print ("                ");
    lcd.setCursor (0, 3);
    lcd.print ("                ");
    lcd.setCursor (0, 1);
    lcd.print ("                ");
    lcd.print ("Fish Feeder OFF");
    digitalWrite(vibrator, LOW);
    myservo.write(0);
    delay(15);
    tone (buzzer, 120);
    delay(500);
    noTone(buzzer);
    delay(5000);
} }
```

When this part of the program is executed, the feed release valve is automatically closed by positioning the servo motor at an angle of 0°. Simultaneously, the vibrator motor is deactivated, preventing further vibration of the feed container. Figure 14 illustrates the system model testing process when the *vannamei* shrimp feeding period has ended.

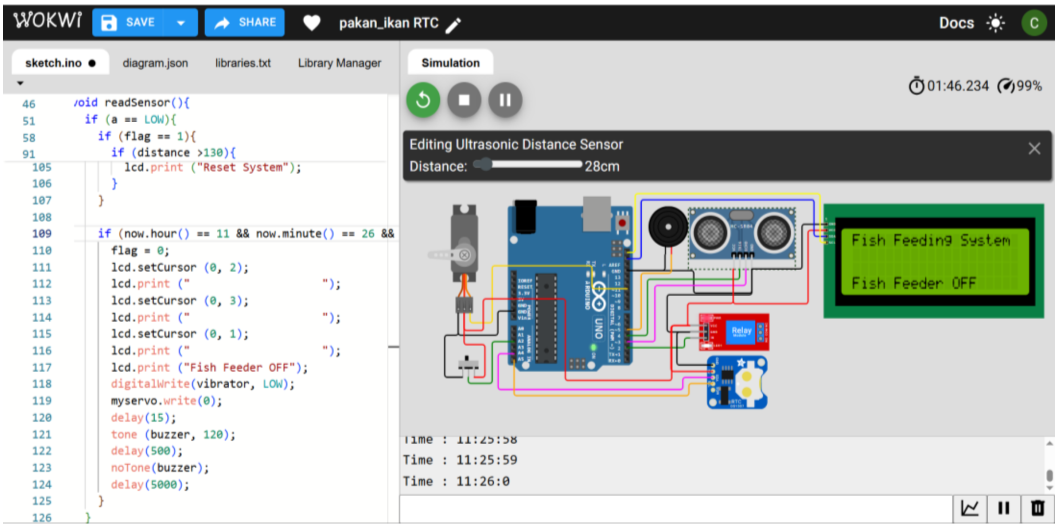

Fig 14: System model testing when the *vannamei* shrimp feeding period has ended.

4. CONCLUSIONS

Based on the testing results, the automatic *Litopenaeus vannamei* feeding system model, which operates on a time-based schedule, has been shown to function autonomously in delivering feed. When the feeding time is reached (set at 11:11 AM), the system automatically initiates the feeding procedure by first detecting the availability of feed in the storage container using an ultrasonic sensor. If the feed is detected within a range of 10–100 cm from the sensor, the valve fully opens through servo motor movement at a 90° angle, while the vibrator motor is activated to facilitate the release of feed. When the feed is detected within a distance of 100–130 cm, the valve opens at 30° to limit the amount of feed dispensed. Conversely, if the distance exceeds 130 cm, the valve automatically closes (servo motor at 0°), the vibrator motor is deactivated, and a buzzer is activated to indicate that the feed in the container has been depleted. In this condition, the user must reset the system and refill the storage container with new feed. Furthermore, when the feeding duration ends (set at 11:26 AM), the system automatically closes the valve and deactivates the vibrator motor, thereby stopping the feeding process. This feeding cycle will repeat automatically according to the predetermined schedule.

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6. REFERENCES

[1] Ajehani, A., Ahmadi, A., & Garcia, C. (2023). Control strategies and reinforcement learning approaches in aquaculture systems: A review. *Computers and Electronics in Agriculture, 205,* 107633. https://doi.org/10.1016/j.compag.2023.107633

[2] Arditya, R., Prabowo, H., & Nugroho, S. (2022). IoT-based automatic feeding system for aquaculture using NodeMCU and RTC. *Mechatronics and Artificial Intelligence Journal, 3*(2), 45–53.

[3] Chirdchoo, N., & Cheunta, S. (2020). Image processing techniques for detecting uneaten shrimp feed using HSV color space. *Journal of Telecommunication, Electronic and Computer Engineering, 12*(2), 37–42.

[4] Correia, E., da Costa, F., & Wasielesky, W. (2020). Automated feeding systems in pond production of Pacific white shrimp. *Aquaculture Research, 51*(12), 5145–5156. https://doi.org/10.1111/are.14853

[5] FAO. (2022). *The state of world fisheries and aquaculture 2022: Towards blue transformation*. Food and Agriculture Organization of the United Nations.

[6] Georgopoulou, D., Panagiotakis, C., & Maroulis, D. (2024). Vision-based monitoring systems for precision aquaculture: A deep learning approach. *Aquacultural Engineering, 104,* 102447. https://doi.org/10.1016/j.aquaeng.2024.102447

[7] Liang, X., Li, J., & Huang, G. (2025). Effects of automatic feeding frequency on growth and feed utilization of Pacific white shrimp (*Litopenaeus vannamei*). *Animals, 15*(2), 192. https://doi.org/10.3390/ani15020192

[8] Martínez-Córdova, L. R., Emerenciano, M., Miranda-Baeza, A., & Martínez-Porchas, M. (2017). Microbial-based systems for aquaculture of fish and shrimp: An updated review. *Reviews in Aquaculture, 9*(4), 345–370. https://doi.org/10.1111/raq.12158

[9] Setiawan, A., & Surantha, N. (2021). Smart aquaculture system design using Quality Function Deployment (QFD). *Journal of Information Systems, 17*(2), 103–116. https://doi.org/10.21512/commit.v17i2.9466

[10] Toruan, R., & Galina, H. (2023). IoT-based smart feeder for aquaculture with real-time monitoring of water quality. *ELTIKOM Journal, 7*(1), 88–96.

[11] Valle, B. C. S., Wasielesky, W., & Poersch, L. H. (2011). Comparison of feeding strategies in semi-intensive shrimp culture: Manual, timer, and acoustic-based automatic feeders. *Aquaculture, 321*(1–2), 130–135. https://doi.org/10.1016/j.aquaculture.2011.08.029

[12] Wang, C., Li, D., & Liu, Y. (2017). Fuzzy logic-based decision support for optimizing feed management in aquaculture. *Computers and Electronics in Agriculture, 135,* 150–160. https://doi.org/10.1016/j.compag.2017.01.001

[13] Xie, Y., Yu, L., & Wang, Q. (2021). Precision aquaculture: Real-time monitoring and intelligent management of aquaculture systems. *Aquacultural Engineering, 95,* 102188. https://doi.org/10.1016/j.aquaeng.2021.102188

[14] Dhinakaran, S., Kumar, A., & Gupta, R. (2023). IoT and machine learning approaches for aquaculture control and monitoring: A systematic review. *Journal of Aquaculture Research & Development, 14*(6), 1–15.

[15] Zhang, Y., Chen, X., & Wang, T. (2020). Intelligent aquaculture: Computer vision and behavioral analysis for feeding optimization. *Animals, 10*(9), 2709. https://doi.org/10.3390/ani10092709