

Internet of Things-Based Automatic Fish Feeding System Using ESP32 with Real-Time Monitoring

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ARTICLE INFORMATION		ABSTRACT
Received	: 25 – 07 – 2026	Uncontrolled feeding can reduce the efficiency of fish farming. This study develops an Internet of Things-based automatic fish feeding system using ESP32, integrated with a load cell sensor, an ultrasonic sensor, and an RTC module for scheduled feed dispensing and real-time monitoring through the Blynk application. The test results showed that the ultrasonic sensor had an error of 0%, while the load cell had an average error of 5.61%. Operational testing over 14 days resulted in feed dispensing ranging from 206 to 219 g per session. Compared with the manual method, which had an average error of 48.9%, the automatic system provided more consistent and measurable feed portions. These results indicate that an IoT-based system can improve precision in feed management for fish farming.
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I. Introduction

Feeding management is an important factor in fish farming because it affects growth and production efficiency [1]. In conventional practice, feeding is still performed manually based on estimates, making it difficult to ensure consistent feed quantities and feeding times [2]. Such inaccuracies can result in feed wastage and reduce the effectiveness of fish farming.

The development of the Internet of Things (IoT) enables the integration of sensors, actuators, and network connectivity to build automated systems that can be monitored in real time [3]. Various studies have developed microcontroller- and IoT-based automatic feeding systems [4], [5], including the integration of environmental parameter monitoring, such as temperature and water quality [6]. Arduino- and RTC-based systems have also been used to automate feeding schedules [7], but have not emphasized direct feed weight measurement as the primary control parameter [8].

Recent studies have also reported the use of ESP32 with Telegram-based notifications [9], [10], as well as fuzzy logic approaches to determine feed quantities based on water conditions [11]. Other systems use ultrasonic sensors and mobile applications such as Blynk for remote monitoring [12]. Nevertheless, the integration of load cells as the primary means of directly controlling feed quantities has not yet been widely optimized.

Accordingly, this study develops an IoT-based automatic fish feeding system using ESP32, integrated with a load cell sensor for measuring actual weight and an ultrasonic sensor for detecting feed availability. The system provides real-time monitoring and notifications through the Blynk application, along with a dispensing lockout mechanism when feed stock falls below a threshold. Evaluation is based on sensor accuracy and the consistency of dispensed feed compared with the manual method.

II. Methods

This study implements an Internet of Things (IoT)-based automatic fish feeding system using ESP32 as the main controller. The method includes system architecture design, sensor and actuator integration, and performance testing based on the accuracy and consistency of dispensed feed.

A. System Architecture

The automatic fish feeding system is developed based on the Internet of Things (IoT) and consists of three main layers: the perception layer, network layer, and application layer.

In the perception layer, an HC-SR04 ultrasonic sensor is used to detect the feed level in the hopper, a load cell sensor with an HX711 module measures feed weight, and a DS3231 RTC module controls the feeding schedule.

In the network layer, NodeMCU ESP32 serves as the main controller, processing sensor data and controlling servo motor actuators. ESP32 connects to a WiFi network to transmit and receive data in real time.

In the application layer, the Blynk application provides an interface for monitoring and controlling the system through a smartphone.

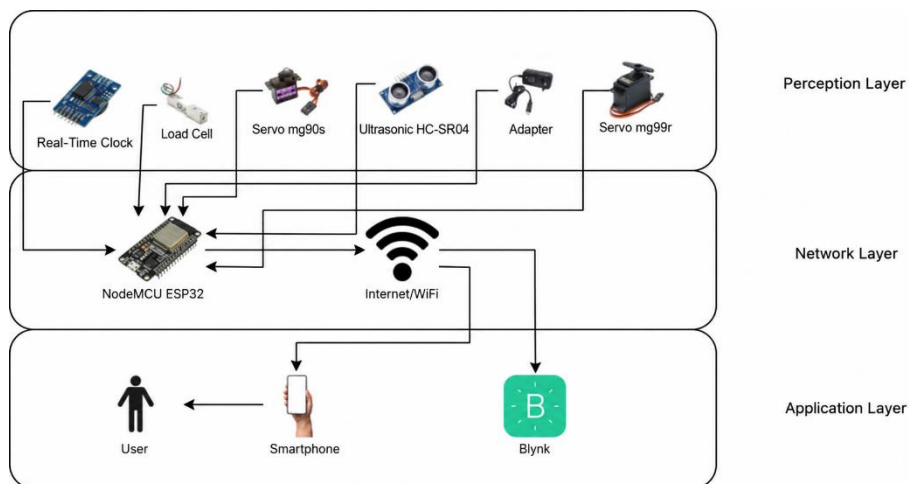


Figure 1. System Architecture

B. System Flowchart

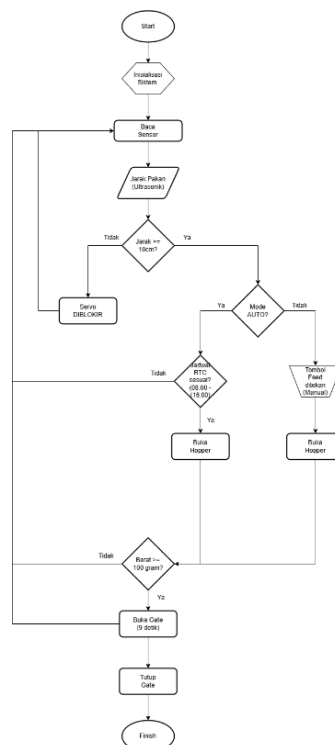


Figure 2. System Flowchart

The system operates in two modes: automatic and manual. In automatic mode, feeding is performed twice daily at 08:00 and 16:00 based on the time provided by the RTC.

The process begins by reading the feed level using the ultrasonic sensor. If the detected distance is ≥ 17 cm, the system identifies a nearly depleted feed condition and blocks dispensing. If feed is available, the hopper servo opens the outlet to the weighing container. The load cell sensor measures feed weight in real time. A value of ≥ 100 g is set as the trigger weight. Once the weight approaches the target of ± 200 g, the gate servo opens to dispense the feed into the pond.

The overall system workflow is shown in Figure 3.

C. Testing Parameters and Scenarios

Testing was conducted in a pond containing 137 tilapia. Biomass was estimated using a sampling method by weighing a sample of 10 fish with a total weight of 806 g, yielding an average weight of 80.6 g per fish. Based on this average, the total fish biomass was estimated at approximately 11.04 kg. With a daily feed requirement of approximately 3% of biomass, the daily feed requirement was approximately 331 g. Because feeding was performed twice daily, in the morning and afternoon, the system was set to dispense ± 200 g per session, equivalent to approximately 3.6% of biomass per day, which remains within the feed requirement range for medium-sized fish.

For the manual method, the percentage error was calculated by comparing the actual weight of hand-measured portions with the target of 200 g per session. The calculation was performed using the following equation:

$$\text{Error \%} = \frac{200 - \text{Actual Weight}}{200} \times 100\% \quad (1)$$

This calculation was used to evaluate the deviation of the manual method from the predetermined dispensing target.

III. Results and Discussion

A. Results

1) Hardware Implementation

After the design and assembly processes were completed, the automatic fish feeding system was deployed directly at a fish farming pond to test its performance under real-world conditions. Figure 3 shows the system hardware implementation, consisting of a hopper for feed storage, a load cell-based weighing container, and a supporting frame as the main structure of the device. The hopper was designed to allow feed pellets to flow by gravity toward the dispensing outlet without clogging.



Figure 3. Hardware implementation of the automatic fish feeding system and feed storage hopper

The load cell-based weighing container is used to measure feed weight before the feed is dispensed into the pond. The container is mounted directly above the sensor so that all incoming feed can be weighed accurately. Once the feed reaches the predetermined weight, the gate servo opens and the feed flows into the pond through the dispensing outlet. The feed weighing and dispensing process is shown in Figure 5.



Figure 4. Load cell-based weighing container and feed dispensing mechanism into the pond

2) Automatic Feeding System Testing

The system was tested for 14 days, with feeding performed twice daily. The test results showed that the dispensed feed weight was relatively consistent and close to the target of ± 200 g per session. This indicates that the system can operate stably under repeated use.

Table 1. Week I Testing

Day	Feeding Time	Feed Level (cm)	Feed Weight (g)	Hopper Servo Status	Remarks
Monday	08:00	9 cm	206 g	Open	Normal
	16:00	12 cm	209 g	Open	Normal
Tuesday	08:00	12 cm	210 g	Open	Normal
	16:00	13 cm	207 g	Open	Normal
Wednesday	08:00	14 cm	211 g	Open	Normal
	16:00	15 cm	210 g	Open	Normal
Thursday	08:00	15 cm	211 g	Open	Normal
	16:00	16 cm	210 g	Open	Normal
Friday	08:00	19 cm	0 g	Closed	Feed nearly depleted
	08:10	10 cm	215 g	Open	Normal
	16:00	10 cm	215 g	Open	Normal
Saturday	08:00	11 cm	214 g	Open	Normal
	16:00	13 cm	214 g	Open	Normal
Sunday	08:00	13 cm	212 g	Open	Normal
	16:00	15 cm	213 g	Open	Normal

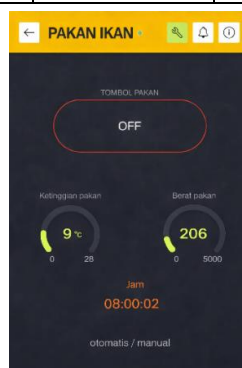


Figure 5. Application Testing in Week I

Figure 8 shows the Blynk application display at 08:00:02, in accordance with the automatic feeding schedule. The feed weight reading was 206 g, and the feed level was 9 cm. These values are consistent with the data in Table 3 (Week I, Monday at 08:00). This agreement indicates that the IoT system can transmit sensor readings in real time according to the time specified by the RTC module.

Table 2. Week II Testing

Day	Feeding Time	Feed Level (cm)	Feed Weight (g)	Hopper Servo Status	Remarks
Monday	08:00	15 cm	207 g	Open	Normal
	16:00	16 cm	211 g	Open	Normal
Tuesday	08:00	17 cm	214 g	Open	Normal
	16:00	20 cm	0 g	Closed	Feed nearly depleted
	16:20	10 cm	208 g	Open	Normal
Wednesday	08:00	10 cm	214 g	Open	Normal
	16:00	11 cm	212 g	Open	Normal
Thursday	08:00	13 cm	219 g	Open	Normal
	16:00	13 cm	216 g	Open	Normal
Friday	08:00	15 cm	216 g	Open	Normal
	16:00	17 cm	212 g	Open	Normal
Saturday	08:00	19 cm	0 g	Closed	Feed nearly depleted
	08:18	10 cm	211 g	Open	Normal
	16:00	10 cm	216 g	Open	Normal
Sunday	08:00	13 cm	217 g	Open	Normal
	16:00	14 cm	219 g	Open	Normal

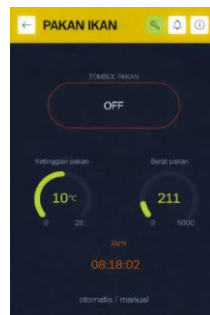


Figure 6. Application Testing in Week II

Figure 9 shows the Blynk application display on Saturday at 08:18:02. The feed weight reading was 211 g, and the feed level was 10 cm. These data correspond to the records in the testing table for Saturday at the same time. This agreement indicates that the IoT system can transmit sensor readings in real time according to the operational timing controlled by the RTC module.

3) Manual Feeding Testing

For comparison, manual feeding was tested using hand-measured portions without prior weighing. The actual weight was then measured using a digital scale.

Table 3. Manual Feeding Testing

Day	Time	Actual Weight (g)	Difference (g)	Error (%)
Monday	11:00	100 g	100 g	50 %
	13:00	106 g	94 g	47 %
Tuesday	11:00	106 g	94 g	47 %
	13:00	107 g	93 g	46.5 %
Wednesday	11:00	106 g	94 g	47 %
	13:00	100 g	100 g	50 %
Thursday	11:00	99 g	101 g	50.5 %
	13:00	92 g	108 g	54 %
Average				48.9 %

4) Blynk Application Notification Testing

Notification testing was performed to ensure that the system could issue an alert when the feed supply approached the predetermined minimum level. When the ultrasonic sensor detected a feed level exceeding the programmed parameter, the system automatically sent a notification to the Blynk application and stopped feed dispensing.



Figure 7. Blynk Notification Testing

The notifications received by users indicate that the system successfully integrated sensor readings with an IoT-based alert mechanism. This shows that the system not only performs automatic dispensing but also provides users with real-time information on feed stock conditions.

B. Discussion

The test results showed that the automatic feeding system operated according to the specified parameters. The ultrasonic sensor had an error of 0%, allowing the feed level readings to serve as a stable reference for system control. The load cell sensor showed an average error of 5.61%, with the largest deviations occurring at low weights, but remained sufficiently accurate within the dispensing range of approximately 200 g.

Operational testing over 14 days showed that the feed weight ranged from 206 to 219 g per session and that feeding followed the schedule. The mechanism for stopping dispensing when the feed supply was nearly depleted also functioned properly, and the data were successfully displayed in real time through the Blynk application.

For comparison, the manual method produced an average error of 48.9% relative to the 200 g target. This difference indicates that the sensor-based automatic system provides more consistent and measurable feed dispensing than the conventional method.

IV. Conclusion

The IoT-based automatic fish feeding system using ESP32 successfully operated according to the specified parameters. Testing showed that the ultrasonic sensor had an error of 0% and the load cell an error of 5.61%, with feed dispensing ranging from 206 to 219 g per session over the 14-day testing period.

Compared with the manual method, which had an average error of 48.9%, the automatic system provided more consistent and measurable results. Integration with the Blynk application also enabled real-time monitoring of feed conditions.

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