Analysis of the Efficiency of a Microcontroller-Based Automatic Feeder Prototype in Aquaculture

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Abstract

This research aims to analyze the efficiency of a microcontroller-based automatic fish feeder prototype to support the optimization of aquaculture. The device utilizes an Arduino microcontroller, an LCD for the interface, and a mechanical motor for automatic feed dispensation twice daily, with volumes adjusted according to the fish's age. The experimental method was conducted in a fish farming pond, comparing automatic and manual feeding over 90 days for 100 fish. Results showed that the automatic system reduced average daily feed usage from 200 grams (manual) to 180 grams, and feed efficiency increased from 75% (manual) to 85% (automatic). Average fish weight gain with the automatic system reached 85 grams, 15 grams higher than the manual method (70 grams). The Feed Conversion Ratio (FCR) for the automatic system was 1.91, which is better than the manual FCR of 2.57. Ultimately, the automatic feeding system proved to be more efficient in feed usage and supported better fish growth. Keywords: Automatic Feeder, Efficiency, Aquaculture.

Keywords: *Automatic Feeder, Aquaculture; Efficiency*

1. Introduction

Fisheries play a strategic role in supporting national food security. In Indonesia, fisheries production has reached 10.86 million tons with an average growth rate of approximately 10% per year [1]. As the global population increases, the demand for fishery products also continues to rise, making this sector increasingly crucial. To address these challenges, the optimization and enhancement of added value from fishery products can be achieved through various innovations, such as the development of cultivation technology [2], financial management [3], and the utilization of digital marketing [4].

However, operational efficiency remains a major constraint, especially in the aspect of feeding. Uncontrolled feeding often leads to waste, increased production costs, and a decline in the quality of aquatic environments due to the accumulation of leftover feed, which can inhibit fish growth. Therefore, an efficient and controlled feeding system has become one of the main focuses in modern aquaculture research.

Along with technological advancements, various automation approaches have been implemented in fish farming, including microcontroller-based systems like Arduino [5], [6], to IoT platforms that integrate sensors and actuators with cloud-based data processing [7]. Previous studies have explored automated feeding systems based on time [8], feed weight [9], and even artificial intelligence algorithms that consider fish eating behavior [10]. Some systems have also adopted camera-based technology and machine learning to identify fish feeding needs in real-time [11].

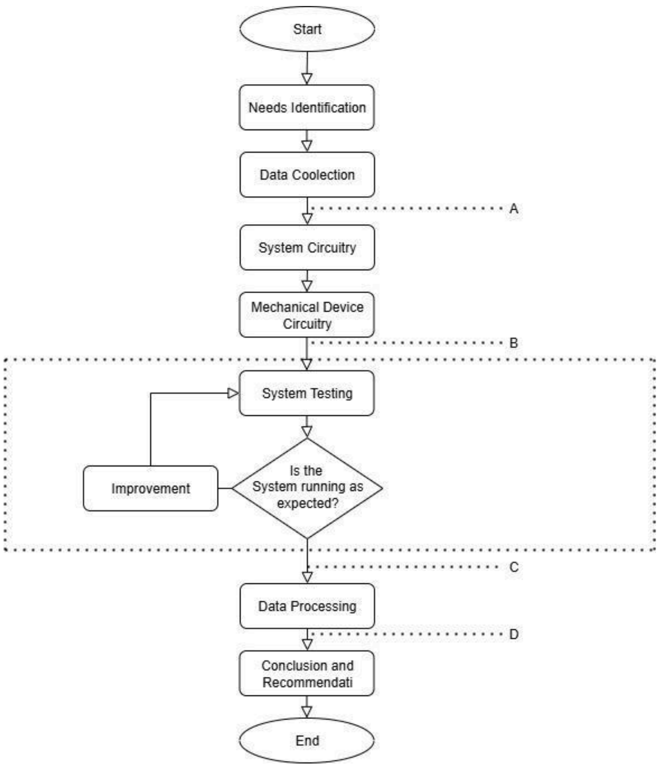
Nevertheless, many of these systems still face challenges such as installation complexity, high development costs, limited scalability, or minimal field adaptation by small and medium-scale cultivators. Therefore, this research presents a prototype of an automatic microcontroller-based feeding system designed with the principles of simplicity, low cost, and direct implementability in small to medium-scale cultivation environments.

The novelty of this system lies in the integrative approach between the Real-Time Clock (RTC) module for time precision, a servo actuator as an efficient feed dispenser, and an LCD display for informative yet cost-effective user interaction. Additionally, this system is designed without reliance on internet connectivity, making it suitable for implementation in areas not yet covered by digital communication networks. Furthermore, the prototype was directly tested in a real cultivation environment with measurable parameters, such as feed consumption and fish growth, to evaluate its impact on efficiency and production sustainability.

This research aims to analyze the effectiveness of the prototype in reducing feed waste and supporting optimal fish growth, while also contributing to the development of applicable and sustainable automation technology in the aquaculture sector.

2. Metode

This study utilizes an experimental method to test and analyze the efficiency of the automatic feeding device compared to the manual method in a fish farming environment. The research steps conducted in this study follow the flowchart below :



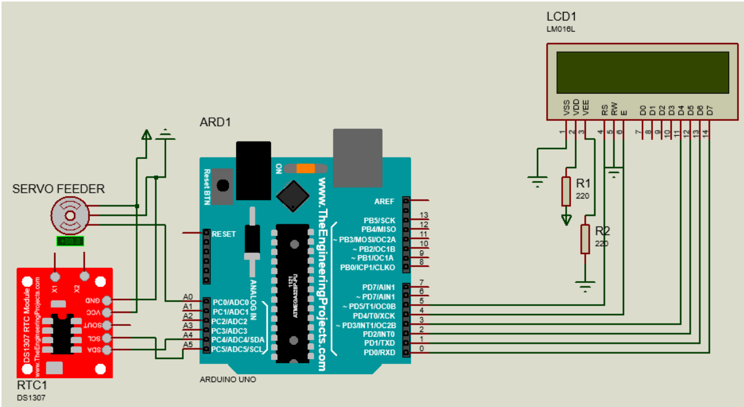
Picture 1. Research Flowchart

Using an experimental method, the automatic fish feeder was tested directly in an aquaculture environment. The research was conducted by analyzing the efficiency of automatic feeding compared to the manual method, as well as measuring fish growth over a specific period..

a. Needs Identification

This stage involved identifying the feeding requirements of the fish. Parameters such as feed amount, feeding frequency, and fish response were determined.

b. System design
This consisted of creating a system flowchart, designing the electronic circuit for the automatic device, designing the feed release mechanism using a servo/DC motor, and establishing the feeding schedule.



Picture 2. Schematic Microcontroller-Based Automatic Feeder

In this system, the electronic circuit design focuses on automating the feeding process using an Arduino microcontroller as the main control unit. The Arduino receives time information from a Real-Time Clock (RTC) module connected via I2C communication. The RTC module functions to store and provide accurate time data, enabling scheduled feeding based on predetermined times. A servo motor is used to execute the feeding mechanism. This servo moves to open or close the feed container according to signals from the Arduino. Additionally, the system is equipped with a 16x2 LCD as a user interface display that shows the current time, feeding status, and other system messages. All components are powered with a 5V supply from the Arduino. With this design, the automatic feeder system is capable of operating independently and in real-time to support efficiency in the feeding process.

c. System Testing
Testing the tool in real conditions (fish ponds) then comparing automatic and manual feeding. The next stage involves measuring fish growth using the daily growth ratio (SGR) and Feed Conversion Ratio (FCR). FCR is utilized to measure feeding efficiency [12], [13], [14]. The smaller the FCR value, the better the conversion of feed into fish growth.

$$FCR = \frac{Amound\ of\ Feed\ Given\ (Grams)}{Total\ Fish\ Weight\ Gain\ (Grams)} \quad (1)$$

d. Data Analysis
Analyze data in the form of feed efficiency, measuring fish growth from fish weight data..

3. Results and Discussion

Smart Feeder system testing was conducted for 90 days to assess the effectiveness of the automation system on the growth of 100 fish, with feeding 3 times a day compared to the manual method.

Feeding Data

The amount of feed is adjusted according to the fish's age and average weight each month. Feed settings are presented in Table 1.

Table 1. Feeding Data

Fish Age (Days)	Fish Weight (gram/Fish)	Total Fish Weigh (grams)	Feed (%) of Fish Weight	Feed/Day (grams)
0-30	10-25	1000-2500	5%	50-125
31-60	25-50	2500-5000	4%	100-200
61-90	50-100	5000-10000	3%	150-300

Feed Formula :

$$FCR = \frac{Amound\ of\ Feed\ Given\ (Grams)}{Total\ Fish\ Weight\ Gain\ (Grams)} \times Total\ Fish\ Weight \tag{2}$$

Feeding is adjusted to the fish's age and body weight for optimal growth and to avoid waste. At 0-30 days of age (weight 10-25 g/fish), feed is given at 5% of the total fish weight. As they grow to 31-60 days of age (weight 25-50 g/fish), the feed percentage becomes 4%. At 61-90 days of age (weight 50-100 g/fish), the feed percentage decreases to 3%. This change in percentage adjusts to the fish's changing metabolic needs as they grow. The daily feed amount ranges from 50-125 grams (0-30 days), increasing to 100-200 grams (31-60 days), and 150-300 grams (61-90 days).

Fish Growth Data

After 90 days, fish growth was measured based on average weight, as shown in Table 2.

Table 2. Fish Growth Data

Fish Age (Days)	Average Initial Weight (grams)	Average Final Weight (grams)	Weight Gain (grams)
0-30	10	25	15
31-60	25	50	25
61-90	50	100	50

Fish experienced significant growth over 90 days. The weight gain in the 0-30 day period was 15 grams (from 10 g to 25 g). In the 31-60 day period, the weight gain was 25 grams (from 25 g to 50 g). In the 61-90 day period, the weight gain was 50 grams (from 50 g to 100 g). The highest growth occurred in the 61-90 day period, indicating a good response to the feeding pattern. The fish growth rate (G) is calculated using formula [15]

Weight Growth Formula:

$$G = \frac{Wt - Wo}{t} \tag{3}$$

Where:
G = fish growth rate (grams/day)
W_t = final fish weight (grams)
W_0 = initial fish weight (grams)
t = Time (Days)

Comparison of Automatic and Manual Feeding Effectiveness

Tabel 3. Data perbandingan

method	Average (grams) Feed/Day	Feed Efficiency	Weight Gain (grams)
Manual	200	75%	70
otomatis	180	85%	85

From the results above, the automation system was able to increase feed efficiency by 10% and increase fish growth by 15 grams more compared to the manual method..

Feed Efficiency Analysis

Feed efficiency was measured using FCR (Equation 1). The results of the FCR calculation are as follows::

$$FCR = \frac{Amount\ of\ Feed\ (Grams)}{Fish\ Weight\ Gain\ (Grams)} \tag{4}$$

Manual:

$$FCR = \frac{18000}{7000} = 2.57$$

Automatic:

$$FCR = \frac{16200}{8500} = 1.91$$

The lower FCR value for the automatic method (1.91) compared to manual (2.57) indicates that the automation system is more efficient in converting feed into fish growth. The smaller the FCR value, the better the feed efficiency. The automation system successfully reduced the FCR value by 0.66, demonstrating more optimal feed usage and better fish growth.

4. Conclusion

Based on the research results, the microcontroller-based automatic feeding system shows significant advantages compared to the manual method in terms of feed usage efficiency and fish growth. The use of the automatic system was able to reduce the average daily feed amount from 200 grams (manual) to 180 grams (automatic). Feed efficiency increased by 10%, from 75% for the manual method to 85% for the automatic method. Fish weight gain with the automatic system was higher (85 grams) compared to manual (70 grams) over 90 days, indicating more optimal growth. The FCR value of the automatic system (1.91) was much better than the manual system (2.57), indicating more efficient conversion of feed into fish biomass. Overall, the automated feeding system is superior in supporting efficient and productive fish farming.

This research contributes to the development of simple and cost-effective automation solutions for aquaculture, significantly enhancing feeding efficiency and supporting sustainable aquaculture practices. Future work could include integrating Internet of Things (IoT) capabilities for remote monitoring and control, developing an automatic weight sensor for more precise feed dispensing, and exploring the implementation of this system on an industrial scale to further optimize large-scale fish farming operations.

Reference

[1] N. Fuada, S. Muljati, & A. Triwinarto, "Sumbangan ikan laut terhadap kecukupan konsumsi protein penduduk indonesia", Penelitian Gizi Dan Makanan (The Journal of Nutrition and Food Research), vol. 41, no. 2, p. 77-88, 2019. https://doi.org/10.22435/pgm.v41i2.1889

[2] R. Riyantini, P. Muljono, I. Diatin, & D. Gandasari, "Jaringan komunikasi inovasi pembudidaya pembesaran ikan konsumsi skala kecil kabupaten bogor", Ekspresi Dan Persepsi : Jurnal Ilmu Komunikasi, vol. 6, no. 3, p. 396-408, 2023. https://doi.org/10.33822/jep.v6i3.6462

[3] H. Budiantoro, P. Santosa, Y. Paramitra, A. Palloge, & N. Zahra, "Pelatihanmanajemen keuangan, solusi daya saing dan omzet pokdakan naminasang farm & co", Jurnal Inovasi Penelitian Dan Pengabdian Masyarakat, vol. 4, no. 2, p. 264-272, 2024. https://doi.org/10.53621/jippmas.v4i2.387.

[4] A. Lindya, S. Espeperansa, F. Lestari, N. Pattiasina, N. Caniago, M. Ghifariet al., "Pelatihan implementasi pemasaran digital produk pertanian kwt riski dinari dusun pakis kulon", Jurnal Abdi Insani, vol. 11, no. 2, p. 1398-1409, 2024. https://doi.org/10.29303/abdiinsani.v11i2.1533.

[5] S. Mustafa, S. Shaleh, R. Shapawi, A. Estim, F. Ching, A. Ibrahimet al., "Application of fourth industrial revolution technologies to marine aquaculture for future food: imperatives, challenges and prospects", Sustainable Marine Structures, vol. 3, no. 1, p. 22-31, 2021. https://doi.org/10.36956/sms.v3i1.378.

[6] R. Saputra, R. Ardiansyah, M. Mirdanies, A. Santoso, A. Nugraha, A. Muqorobinet al., "Dc brushless motor control design and preliminary testing for independent 4-wheel drive rev-11 robotic platform", Journal of Mechatronics, Electrical Power, and Vehicular Technology, vol. 2, no. 2, p. 85-94, 2012. https://doi.org/10.14203/j.mev.2011.v2.85-94.

[7] I. Ficili, M. Giacobbe, G. Tricomi, and A. Puliafito, "From Sensors to Data Intelligence: Leveraging IoT, Cloud, and Edge Computing with AI," *Sensors*, vol. 25, no. 6, p. 1763, Mar. 2025. [Online]. Available: https://doi.org/10.3390/s25061763

[8] B. D. C. Ximenes, S. Alfarisi, and W. S. Budi, "Automatic fish feeding system based on RTC and Arduino Uno for aquarium application," *JREEC (Journal Renewable Energy, Electronics and Control)*, vol. 1, no. 1, pp. 1–9, May 2021. [Online]. Available: https://ejurnal.itats.ac.id/jreec/article/view/1593

[9] Y. Peng, Z. Zeng, E. Lv, X. He, B. Zeng, F. Wu, J. Guo, and Z. Li, "A real-time automated system for monitoring individual feed intake and body weight of group-housed young chickens," *Applied Sciences*, vol. 12, no. 23, p. 12339, Dec. 2022. [Online]. Available: https://doi.org/10.3390/app122312339

[10] Y.-P. Huang and S. P. Khabusi, "Artificial Intelligence of Things (AIoT) Advances in Aquaculture: A Review," *Processes*, vol. 13, no. 1, p. 73, Jan. 2025, doi: 10.3390/pr13010073.

[11] S. Son and Y. Jeong, "An Automated Fish-Feeding System Based on CNN and GRU Neural Networks," *Sustainability*, vol. 16, no. 9, p. 3675, May 2024, doi: 10.3390/su16093675.

[12] J. Pérez-Fuentes, C. Pérez‐Rostro, M. Hernández‐Vergara, & M. Monroy‐Dosta, "Variation of the bacterial composition of biofloc and the intestine of nile tilapia oreochromis niloticus , cultivated using biofloc technology, supplied different feed rations", Aquaculture Research, vol. 49, no. 11, p. 3658-3668, 2018. https://doi.org/10.1111/are.13834.

[13] H. Hadijah, L. Loar, M. Mardiana, W. Kantun, & Z. Zainuddin, "Dietary probiotics and its effect on growth rate, survival rate, and feed conversion ratio of clarias gariepinus", Jurnal Riset Akuakultur, vol. 18, no. 4, p. 227, 2024. https://doi.org/10.15578/jra.18.4.2023.227-238.

[14] M. Muhammad, A. Alimuddin, M. Zairin, & O. Carman, "Respons pertumbuhan dan efisiensi pakan pada ikan nila ukuran berbeda yang diberi pakan mengandung hormon pertumbuhan rekombinan", Jurnal Riset Akuakultur, vol. 9, no. 3, p. 407, 2014. https://doi.org/10.15578/jra.9.3.2014.407-415.

[15] Z. Muchlisin, F. Afrido, T. Murda, N. Fadli, A. Muhammadar, Z. Jalilet al., "The effectiveness of experimental diet with varying levels of papain on the growth performance, survival rate and feed utilization of keureling fish (tor tambra)", Biosaintifika: Journal of Biology &Amp; Biology Education, vol. 8, no. 2, p. 172, 2016. https://doi.org/10.15294/biosaintifika.v8i2.5777.

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