

MILKFISH CULTIVATION SUPPORTS AUTOMATION OF FISH FEEDING IN THE PEN CULTURE SYSTEM

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Abstract

This study presents the design and implementation of an Internet of Things (IoT)-based automated fish feeding system for milkfish cultivation using the pen culture method. The research employed a prototype methodology, integrating microcontroller-based hardware with sensors, servo motors, and RTC modules to enable precise, scheduled, and remotely monitored feeding. Initial stages included problem identification, literature review, and system requirement analysis, followed by system design connecting multiple microcontroller devices for automatic data processing and feed distribution. The developed prototype was tested both indoors and outdoors, with monitoring via laptops and mobile devices through the Blynk application. Results demonstrate that the system efficiently automates feed distribution, reduces feed waste, minimizes manual labor, and facilitates real-time monitoring, thus enhancing operational efficiency and productivity in milkfish farming. The implementation of this IoT-based solution offers a cost-effective, sustainable, and practical approach to optimize aquaculture management, improve fish growth, and support data-driven decision-making for farmers. This study contributes to advancing smart aquaculture technologies in Indonesia.

Keywords: *IoT, automated fish feeding, milkfish, pen culture, aquaculture*

INTRODUCTION

The cultivation of milkfish (*Chanos chanos*) is one of the important fisheries sectors that makes a significant contribution to meeting the protein needs of the community, especially in Southeast Asian countries including Indonesia (Ilvi & Masruchin, 2022). The milkfish has the characteristic of being easily cultivated in various aquatic environments (Firmansyah, 2021), both in brackish waters and ponds (Darmansah et al., 2017; Johan et al., 2009). Another advantage of milkfish farming is its resilience to environmental changes that often occur in coastal ecosystems, such as fluctuations in salinity and water quality (Firmansyah, 2021). Milkfish has high nutritional value, especially in terms of protein, omega-3 fatty acids, and other important vitamins and minerals, making it one of the most favored fish for consumption by the public (Rahma et al., 2024). Fish farming in pen culture is a method of fish maintenance conducted in open waters using pen structures, which usually consist of nets or fences installed within the water (Bidayani et al., 2022; Setiyowati & Sulistyowati, 2018). One of the advantages of the pen culture method is its ability to support various fish species. For example, tilapia and milkfish can be cultivated in a pen culture system with varying densities, allowing for adjustments to environmental conditions and market demand (Sapkota et al., 2022).

Pen culture or fixed net cages allow fish to obtain natural food from the aquatic ecosystem, but additional feed is still necessary to ensure optimal growth (Rupawan et al., 2017)(Jasmadi, 2018). As the demand for fishery products increases, the efficiency of fish farming management becomes a top priority to achieve optimal and sustainable production. One of the core aspects that greatly influences the success of fish farming is feed management (Fernanda & Wellem, 2022; Skad & Nandika, 2020). The concept of smart fish farming is the automatic management of fish feed based on a predetermined schedule. Feeding fish is an important factor in their development. The weight and frequency of regular feeding affect fish growth (Anindita et al., 2022). The concept of feeding using IoT helps fish farmers monitor feed supplies automatically. The concept of IoT-based fish feeders consists of several interconnected devices to form an automated system. The use of Internet of Things (IoT)-based automation technology in fish farming in pen culture areas offers innovative solutions that enhance production efficiency and sustainability. The NodeMCU ESP8266 microcontroller can be controlled remotely via Wi-Fi connectivity. Sensors

such as ultrasonic and infrared sensors can monitor feed availability and ensure even and scheduled distribution. Additionally, the DS1307 RTC module is used to set the feeding time accurately, making the feeding process more scheduled and consistent without relying on human labor. The problem that arises is how to ensure that feeding is done on schedule, considering that feed is the largest cost component in fish farming. Inefficiency in feed distribution often leads to waste and environmental pollution. The operation of this system begins with the collection of data from sensors that monitor the amount of feed in the dispenser and the environmental conditions around the pond. This data is then processed by the microcontroller to activate the servo motor, which opens the feed valve as needed. Timely and controlled feed distribution helps improve the conversion of feed into fish growth. The main advantage of this system compared to manual methods lies in the savings of time and operational costs. This technology reduces the need for manual labor in feeding, while also increasing productivity through consistent and scheduled feeding. More optimal fish growth not only accelerates harvest time but also increases farmers' income. Additionally, the ability to monitor in real-time facilitates data-driven decision-making for production optimization and risk management. The formulation of the problem in this research is how to design an efficient fish feeding automation system in milkfish farming using the pen culture method and what factors influence the success of fish feeding automation in the pen culture system in milkfish farming. The objective of this research is to propose a prototype to develop and analyze the fish feeding automation system in milkfish farming by utilizing pen culture technology or floating net cages.

LITERATURE REVIEW

Cultivating milkfish using the pen culture system faces various challenges in the efficient and sustainable management of feed. This system uses pen culture nets placed in open waters, where fish obtain natural food from the aquatic ecosystem but still require additional feed for optimal growth. Automation of feeding based on the Internet of Things (IoT) becomes an innovative solution to address this issue. This technology enables scheduled and controlled feed distribution through an integrated system of sensors and microcontrollers. According to Marhawati and Ma'Ruf, milkfish is not only consumed domestically but also exported, making it a very important commodity in Indonesia's fisheries sector (Marhawati & Ma'ruf, 2018). In addition, Basthomi noted that the production of milkfish in ponds reached more than 10,000 tons, demonstrating the significant contribution of this fish to aquaculture yields (Yazid Al-Basthomi, 2023). In aquaculture practice, the factors affecting the production of milkfish are very diverse. Kurniati et al. emphasize the importance of good management to achieve production efficiency, where farmers must pay attention to the use of production factors such as feed, seeds, and pond management. (Kurniati et al., 2019).

Muhammad Hibrian Wiwi and colleagues focused their research on designing fish feed independently using an Arduino Uno-based microcontroller. This is essential for developing automation technology in fish feeding using a simple microcontroller-based system (Wiwi & Ode, 2023). Pratisca and Sarji wrote about fish feeding being closely related to the growth and development rate of fish. The problems faced by farmers are the sometimes high production costs of fish feed and the ineffective and inefficient feeding strategies (Pratisca & Sardi, 2020). Edi Nurhadi and colleagues conducted research on fish feeding using Telegram to control large amounts of fish feed (Nurhadi et al., 2023). M. Safii and Syadam also conducted research on an automatic counter tool for ornamental fish that can be relied upon for feeding. When fish farming does not have time to feed. The system consists of four main parts: power, an efficient framework, mechanical connections, and a logical program (Safii & Syaddam, 2021). Then Fonna and others researched the feeding of ornamental fish using Internet of Things technology with Raspberry Pi (Fonna et al., 2020). In previous research, it was explained about automatic fish feeding, where some use the internet and some do not, some only control it through Telegram, and then there are those that use Internet of Things technology, but the cost of the control device is still relatively expensive. So, what we want to investigate in this study is the implementation of inexpensive Internet of Things technology using the internet to optimize the feed for milkfish in pen culture or floating net cages, which can be controlled and monitored for their feed materials.

METHOD

The method applied in this study is the use of prototypes. The prototype method is a system development approach that utilizes prototypes to depict the system based on a functional model. Prototypes are used to reduce the risk of something being analyzed or further developed (Iot et al., 2023). The researcher prepares the tools and components needed for the system design and development. The software used is Arduino IDE, and the hardware includes decorative lights, servos, relays, LCD, I2C module, jumper adapter, NodeMCU ESP8266 microcontroller, fish feeder tube, ultrasonic sensor, infrared module, and RTC DS1307.

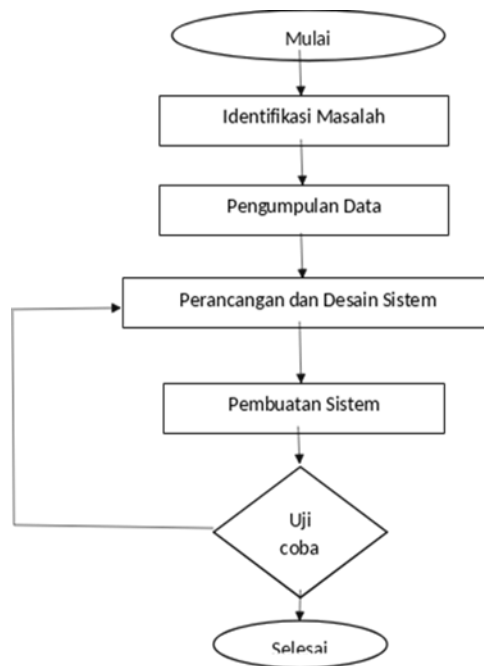


Figure 1. Research Flowchart

The stages of the research conducted are as follows: identification of the problem and observation of the research location. To formulate a program or tool as a prototype. The Literature Review or library study that is relevant and supports theories related and consistent with the research problem being conducted. Before designing and planning the system, a needs analysis is conducted with the aim of creating a system that is required. For example, external system requirement analysis and internal system requirement analysis. The next stage involves analyzing the existing needs and designing or planning the system, such as how to connect various microcontroller devices as controllers. The process of searching, processing, and automatically and continuously transmitting information can run smoothly, with the data coming from the field so that it can be read by users. The process of system and program development, the system being built is a system on hardware and software. The hardware system as shown in Figure 2. The prototype that is made will be tested indoors and outdoors. Monitoring will be conducted using a laptop or mobile phone. The final stage is to evaluate the system.

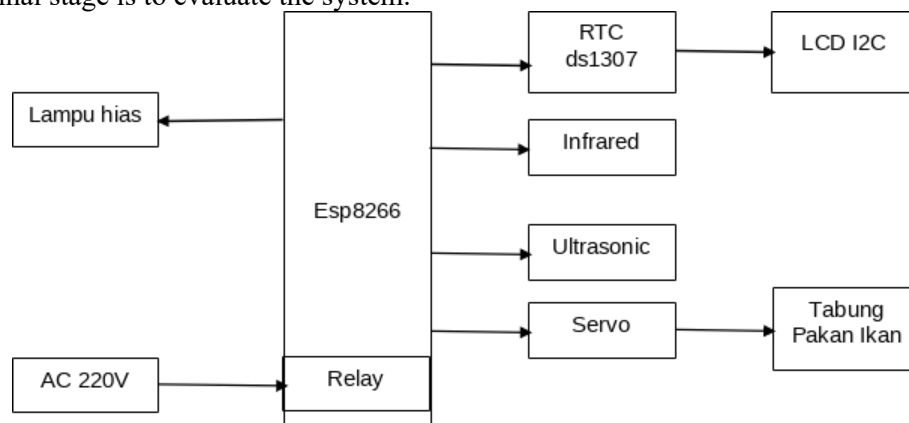


Figure 2. Block Diagram of Automatic Fish Feed

Figure 2 explains the process of making automatic fish feed controlled by the NodeMCU Esp8266 microcontroller, which includes a neon lamp or light source to illuminate the floating cage. The power supply is 220V, entering thru an adapter that has been set to 12V and 2A. It is then controlled by the NodeMCU Esp8266 as the CPU and system memory, and connected to a relay integrated into a single NodeMCU Esp8266 shield. The RTC module functions as an electronic clock in the form of a chip that can accurately count time (from seconds to years) and maintain/store that time data in real-time. The infrared sensor works to detect obstacles in front of the sensor module, in this case, detecting feed particles inside the tube. Similarly, the ultrasonic sensor detects objects in front of it, and the servo acts as an electrical device that functions to push or rotate objects. Then the I2C LCD Module is

used to display characters, numbers, letters, and even graphics as information that has been installed in the system. Next, the prototype components are connected to the internet, allowing them to be monitored and controlled remotely to feed the fish in the aquarium.

RESULTS AND DISCUSSION

The fish feeding automation and monitoring prototype is a system that uses technology to simplify the automatic feeding process while monitoring availability. This system utilizes the NodeMCU microcontroller connected to several sensors.

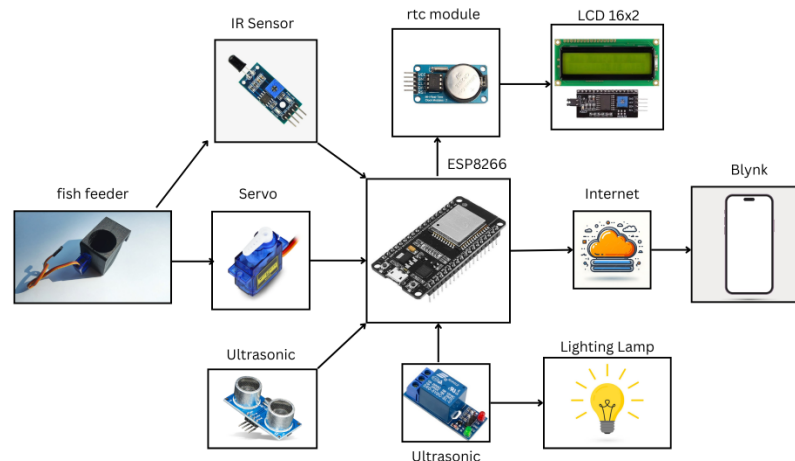


Figure 3. Fish Feed Monitoring Architecture

Figure 3 shows an automation system for fish feeding based on the Internet of Things (IoT) and operated by the ESP8266 microcontroller. This system consists of several main components, such as an IR sensor, ultrasonic sensor, RTC (Real-Time Clock) module, 16x2 LCD, servo motor, fish feeding tube, relay, lighting, and a connection to the Blynk application via the internet. The ESP8266 functions as the main controller that receives information from various sensors and modules, then processes and sends instructions to actuators such as servos to operate the fish feeder, and relays to turn on the lights when needed. The servo motor is directly connected to the fish feeder to regulate the distribution of food according to instructions from the ESP8266. IR sensors are used to detect the presence of fish food, while ultrasonic sensors function to measure water height or detect objects in the aquarium. The RTC module ensures that the system can automatically dispense feed at the predetermined time. Information from the RTC and sensors is processed by the ESP8266, and the output can be displayed on a 16x2 LCD so that users can see the system status directly. In addition, the system is also connected to the internet so that users can monitor and control the device through the Blynk application on their smartphones, offering convenience in remote supervision.



Figure 4. Hardware Testing Process

Components such as the ESP8266, ultrasonic sensor, IR sensor, servo motor, relay, RTC module, and 16x2 LCD are arranged on a circuit board or breadboard. Each cable is connected meticulously to avoid any connection errors, and the entire circuit is stored in a safe container to facilitate testing and maintain the neatness of the equipment. Testing the function of each component individually. The ultrasonic sensor is tested to ensure it can detect the height or remaining feed in the container, while the IR sensor is tested to determine whether the fish feed is empty or still present. The servo motor is tested to ensure its ability to open and close the feed container according to instructions from the ESP8266, either automatically based on time from the RTC module or manually through the Blynk

application connected to the internet. Then the relay was tested to control the lighting, and the sensor readings and device status were displayed on a 16x2 LCD. The final stage of testing is the integration of the entire system, where all components are operated simultaneously. Information from the sensors is sent to the ESP8266, processed, then the results are displayed on the LCD and sent to the Blynk application for remote monitoring.

```
File Edit Sketch Tools Help
papan_blynk
#define BLYNK_TEMPLATE_ID "TMPL6rkHqnsGX"
#define BLYNK_TEMPLATE_NAME "monitor pakan"
#define BLYNK_AUTH_TOKEN "jh55HW5IbiX0Fa7jXCvmdsf9pcc2XQc7"
#define BLYNK_PRINT Serial

#define BLYNK_PRINT Serial
#include <SPI.h>
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

#include <Wire.h>
#include <Servo.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27, 16, 2);

Servo myservo;
BlynkTimer timer;

char ssid[] = "Tess";
char pass[] = "azmar123";
```

Figure 5. Listing Program Sistem

The testing of the software program list was conducted after all the hardware such as the ESP8266, ultrasonic sensor, IR sensor, servo, relay, RTC module, and 16x2 LCD were assembled and connected properly. This test aims to ensure that every line of code in the program can manage and read data from the hardware according to its purpose. During the testing process, each software function such as sensor reading, servo control, scheduling via RTC, and data transmission to the Blynk application is tested both individually and simultaneously. If there are issues such as slow response, missing data, or devices not responding to commands, then a re-examination of both the code and hardware connections is necessary. Thus, the software program list testing ensures that the entire IoT-based automatic fish feeding system can operate stably, responsively, and meet the needs of remote monitoring and control.

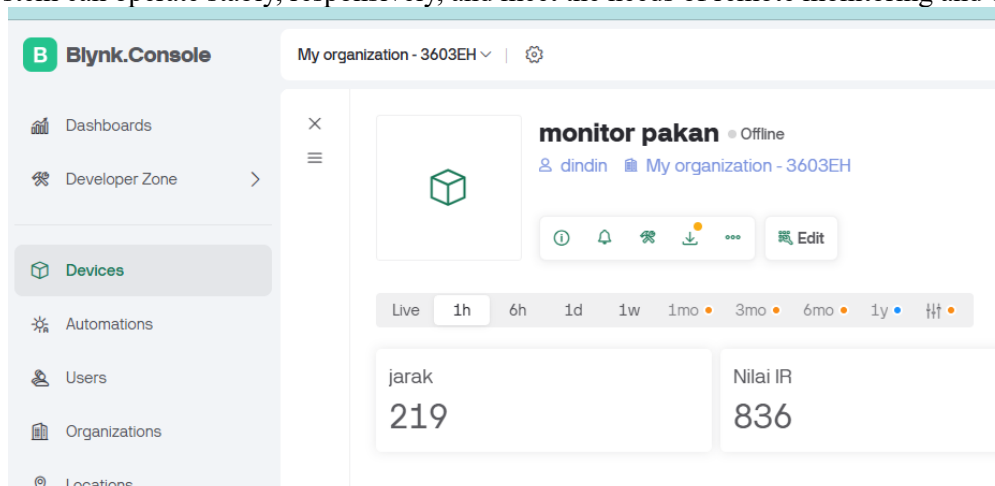


Figure 6. Blynk Application Display on Laptop

The fish feed monitoring display in this system utilizes the Blynk Console platform, which can be accessed via laptop or mobile phone. In Figure 6, the monitoring dashboard is visible, displaying data in real-time, such as distance (measured by the ultrasonic sensor) and IR value (measured by the infrared sensor). This dashboard presents information in the form of clear numbers and offers the option to view data in real-time or over a specific period. With the laptop display, users can access a dashboard with a wider screen, making it easier to monitor multiple parameters simultaneously and make more detailed system adjustments. All navigation menus such as Devices, Automation, Users, and others can also be easily accessed on the left side of the screen. Additionally, this interface also allows for historical monitoring, enabling users to analyze feed performance data over a specific period. This monitoring system can also be accessed thru the Blynk app on a mobile phone. Therefore, users can continuously check the condition of the fish feed anytime and anywhere, without having to sit in front of a laptop. The information

displayed on the phone remains synchronized with the data on the laptop because both are connected via the internet and Blynk cloud. This provides a high level of flexibility for users to monitor and control remotely, making the system more practical and responsive to fish maintenance needs.

CONCLUSION

This research successfully designed and implemented a prototype of an Internet of Things (IoT)-based automated fish feeding system for milkfish cultivation in a pen culture or floating net cage system. The test results show that the system is capable of distributing feed automatically, on schedule, and in a measured manner, thereby increasing feed usage efficiency, reducing waste, and lowering operational costs and the need for manual labor. Additionally, IoT-based monitoring makes it easier for farmers to oversee feed availability and feeding conditions anytime and anywhere. The implementation of this system can increase productivity and farmers' income. Research on IoT-based fish feeding automation in pen culture systems is an innovative, effective, and efficient solution in supporting sustainability and improving the yield of milkfish farming in Indonesia.

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