Automatic Feeding System in Pond Fish Farming Based on the Internet of Things

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ARTICLE INFORMATION

Article History:

Submitted 22 February 2022
Revised 25 March 2022
Accepted 22 May 2023

Keywords:

Internet of Things (IoT);
NodeMCU;
WiFi;
Real Time Clock (RTC);
Ultrasonic;
Motor Servo

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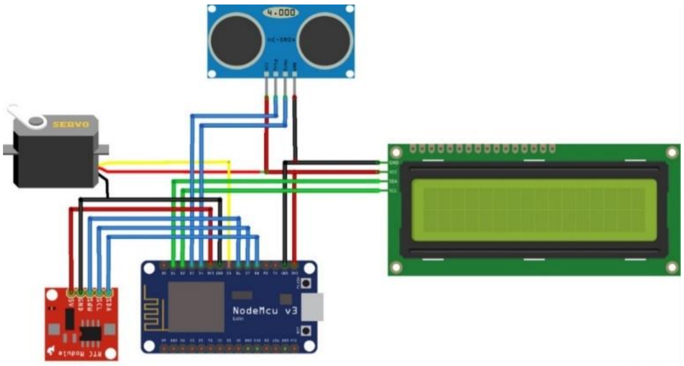
ABSTRACT



One of the fish commodities consumed by the Indonesian people is catfish because it tastes good. Cultivation of catfish requires special attention regarding feeding because if it is not enough it can cause the fish to become cannibals, whereas if too much feed can cause disease. Therefore, it is necessary to monitor and control the provision of fish feed on a scheduled basis. This study aims to facilitate catfish farming in automatically scheduled fish feeding by utilizing the Internet of Things (IoT). This system is built using a NodeMCU micro controller which is connected to a Real Time Clock (RTC) sensor to adjust the feeding schedule. In addition, ultrasonic sensors are used to monitor feed conditions and servo motors to open and close the fish feed storage valve. This study succeeded in providing catfish feed automatically and on time according to a predetermined schedule, namely at 06.00 am, 12.00 noon, and 18.00 pm. Timing is based on the active hours of catfish. The system has also been successfully monitored and controlled remotely via the internet using the Blynk application. In addition, the system has also been able to identify the remaining feed reserves remaining in the storage container. This automatic feeding system has been operating in accordance with the purpose of the system, which is to provide fish feed according to the feeding hours of catfish so that cannibals or fish that are sick with ammonia are not found from leftover feed that is not eaten by catfish.

Document Citation:

T. C. Mahendra and S. Sunardi, “Automatic Feeding System in Pond Fish Farming Based on the Internet of Things” *Buletin Ilmiah Sarjana Teknik Elektro*, vol. 5, no. 2, pp. 190-200, 2023, DOI: 10.12928/biste.v5i2.5784.

1. INTRODUCTION

Indonesia is a country that is very rich in natural products. Indonesia's wealth is very diverse, one of which is the wealth of fishery resources [1]. As a maritime and archipelagic country, Indonesia has diverse ecosystems such as coasts, oceans, rivers and lakes. This diversity has an influence on the many types of fish that can live. In Indonesia there are recorded 2000 species of freshwater fish, sea or brackish. Most freshwater fish can be consumed by the public [2][3][4].

Fish farming in Indonesia has promising opportunities. This is due to the high demand for the fisheries sector as food for the Indonesian people [5]. The Central Statistics Agency noted that in 2020 there were 271,066,400 people in Indonesia who needed animal protein. This need will continue to increase along with the increasing number of Indonesian people who use fish as a source of animal protein and vitamins [6]. The high public demand for fresh water fish must be balanced with the many results of the fisheries sector. Fisheries cannot solely rely on the natural capture fisheries sector because it will reduce fishery resources in nature and if done continuously can run out [7][8].

One of the efforts to increase yields from the agricultural sector is cultivating fish. Fish farming has great opportunities if developed seriously. In addition, by cultivating it can minimize fish extinction from nature [9][10]. Fresh fish farming can adapt semi-intensive fish farming by making fish ponds in the form of tarpaulin or concrete ponds as a medium for starting a fish farming business [11][12].

Some things that need to be considered in cultivating freshwater fish include water quality, water pH, water temperature, and fish feed [13][14]. Feed is one of the most important things in cultivating. Quality feed allows fish to live healthy and large. In addition to the quality of the feed, the time of feeding is also important. If you feed too often, it can make the fish grow faster, but the remaining feed can contaminate pond water quality. Too much pressure on large fish is not the best option, on the other hand giving too little feed will result in slow fish growth, such as catfish can become cannibals and eat each other [15][16]. In general, feeding is done manually by sprinkling it into the pond area so that it is distributed evenly and trying to get all the fish to get food [17].

Based on this background related to feeding, this research utilizes the Internet of Things (IoT) to create a system that can provide and monitor fish feed automatically [18][19][20]. In previous research on feeding fish with IOT, it was stated that smart feeding makes it possible to remotely control feeding and monitor pond conditions so that fish growth can be maximized [21]. NodeMCU is one of the controllers that carries the internet of Things, NodeMCU can stand alone without having to add additional WiFi (Wireless Fidelity) modules [22]. The use of a time sensor or commonly known as RTC (Real Time Clock) helps the system know and determine the right time for feeding fish. Blynk is used for users to monitor the results of feeding and also monitor the contents of fish feed in containers, on blynk users can also regulate the feeding time of catfish [23].

The system is expected to provide feed automatically remotely via the internet. The system can also monitor the time and condition of feeding. This system is expected to help fish cultivation run optimally, especially in overcoming the lack of regular fish feeding.

2. METHOD

The system design is carried out in two stages, namely hardware design and software design. Hardware design requires block diagrams, circuit diagrams, and tool designs. The design of the software contains flowcharts of the methods used.

2.1. Hardware Design

The hardware design of this automatic fish feeding system relies on the NodeMCU controller which controls all sensors and actuators. The hardware design block diagram can be seen in Figure 1.

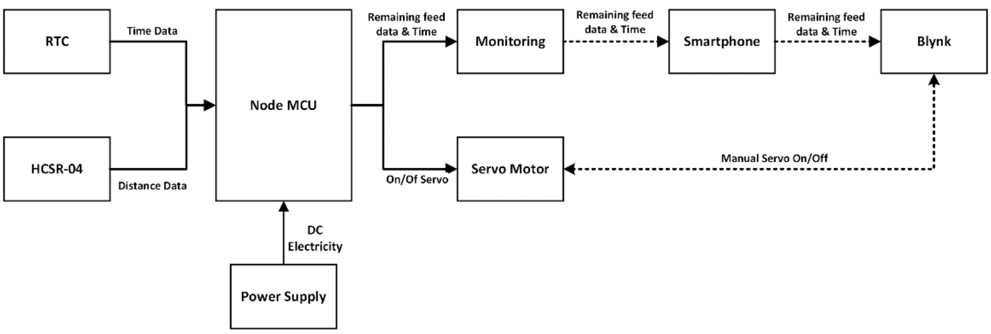


Figure 1. System design block diagram

The design of this automatic feeding system uses the NodeMCU microcontroller which regulates control of the RTC component as a timer for fish feeding. NodeMCU also controls HC-SR04 to obtain information regarding food reserves in feed storage containers. Apart from that, NodeMCU also controls the movement of the servo motor in opening/closing the valve to distribute the fish feed. One of the reasons for choosing NodeMCU as a controller is because this system can connect to the internet. NodeMCU is a controller that can control sensors and can be connected to the internet so that it can be monitored remotely when using it. The condition of the information received by the sensor can be sent to the internet via the Blynk application.
Hardware design begins with making a wiring diagram of all the components used and continues with hardware assembly. Assembly is the process of connecting the cables of all devices until a value reading is obtained from the sensor and runs it. The whole system wiring diagram can be seen in Figure 2.

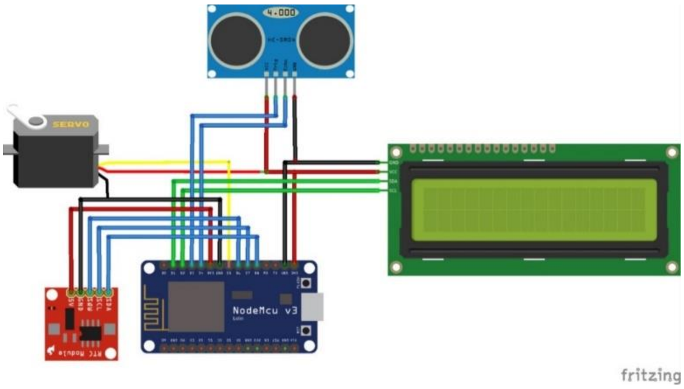


Figure 2. System design wiring diagram

Figure 2 is a series of systems and all of them are powered by NodeMCU from the power cable. The entire system is connected to each other with the NodeMCU control center. The MCU node is given a stepdown so that the ultrasonic sensor can operate at a voltage of 3.3 Volts, while the RTC and servo are connected to the NodeMCU's 5 Volt power. The pins used on nodeMCU can be seen in Table 1.

Table 1. Input/output

Pin NodeMCU	Specification
D1, D2, Gnd, VCC	12C LCD
D5, Gnd, VCC	Servo
D6, D7, D8, Gnd, VCC	RTC
D3, D4, Gnd, VCC	HCSR

2.2. 3D Design

The mechanical manufacture of this system begins with 3D manufacture to obtain an estimate of the hardware size. The design includes the entire system which is divided into two important parts, namely the system control box and the fish feed storage box. At the bottom of the storage container there is a servo which functions to open the lid of the storage valve. The 3D design of the overall system can be seen in Figure 3.

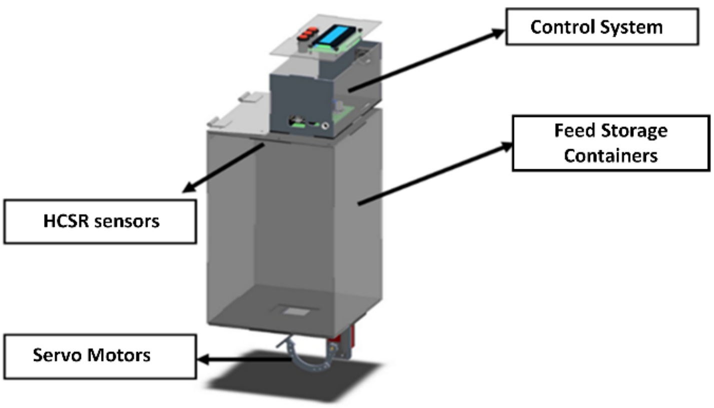


Figure 3. System 3D design

The control system section contains a controller in the form of a NodeMCU connected to sensors and actuators. The control system is at the top of the storage case. At the top there is an LCD and push buttons for system indicators. At the bottom of the control system is placed an ultrasonic sensor that leads into the storage container. The 3D design of the control system can be seen in Figure 4 with information shown in Table 2.

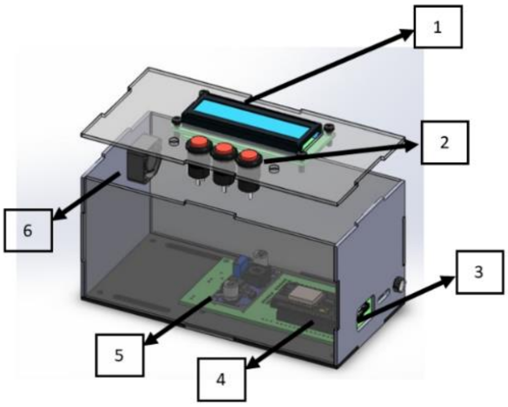


Figure 4. System control box design

Table 2. System control box description

No	Component	Information
1	LCD 16x2	As an interface to the user that contains system data
2	Push button	There are 3 push buttons, each of which functions for power, reset, and test
3	Jack adaptor	Functioning as the system's power supply, the system will power on when connected through this jack
4	Node MCU	The controller that will control the whole system
5	Stepdown	Step down for HCSR
6	RTC	Real time clock sensor to determine real feeding time

2.3. Software Design

The software design, namely the program for the NodeMCU controller, is made through the Arduino IDE application and downloaded via a USB cable to the node board. Figure 5 is an explanation of the system flow chart.

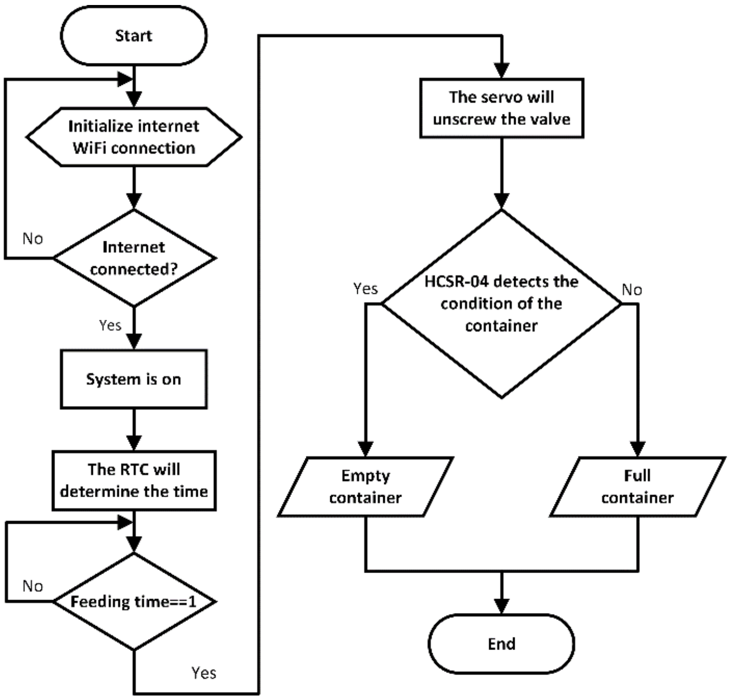


Figure 5. System flow chart

This system is IoT which is connected to wifi first. Wifi that has an internet connection connects this system with Blynk as a monitoring application. NodeMCU controls sensors and actuators. The RTC determines the real time of the current conditions so that the appropriate time for feeding is obtained. Feeding time can be set in the program.

As explained in Figure 5, the system will open the lid of the feed storage container if the RTC has detected the right time to feed the fish. The servo motor will move to open the storage container and spread the catfish feed. After the servo motor stops moving, the ultrasonic sensor detects the conditions in the holding container. Furthermore, the results of the conditions in the container are displayed on the LCD or Blynk via the internet. This system can also work manually, if the user wants to provide catfish feed outside the programmed schedule, the user can do this in the Blynk application by changing the automatic mode to manual mode. The servo valve can be controlled manually, when it is finished the user can change the mode back to automatic.

2.4. Research Flow Design

In this study, the process of identifying problems in automatic feeding of catfish farming in ponds was carried out automatically. The factors that were considered in this study were the timing of automatic feeding in the system and feeding from the storage container. To get optimal results, a study is carried out and then the appropriate hardware and software are made to operate the system from sensors and actuators. After that, tool testing is carried out to obtain data that will be processed and compared with previous studies. The flowchart of research on automatic feeding systems can be seen in Figure 6.

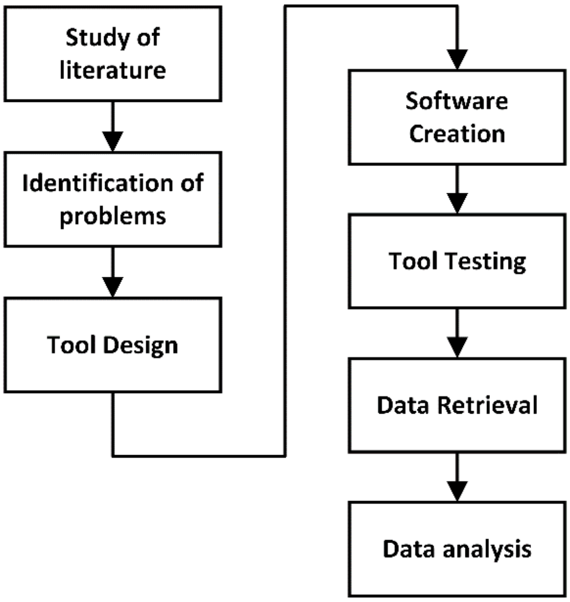


Figure 6. Research flowchart

3. RESULTS AND DISCUSSION

3.1. Real Time Clock (RTC) Testing

Testing is carried out by activating the RTC sensor and setting the time and date on the sensor, after which the RTC sensor is tested by comparing the time set on the sensor with the actual time. Pan is taken by comparing the time shown on the Blynk application with the clock on the cellphone. The results of testing the sensor time with actual time can be seen in Table 3.

Table 3. RTC Testing

No	Time on RTC	Time on Mobile	Information
1	08.15	08.15	Suitable
2	10.15	10.15	Suitable
3	12.00	12.00	Suitable
4	16.00	16.00	Suitable
5	18.00	18.00	Suitable

In Table 3, 5 trials are shown to compare the time obtained by the RTC sensor with the actual time obtained via a mobile phone. In the five experiments, it was found that the RTC sensor displayed the time according to the time on the cellphone so that it can be ensured that the RTC can run as desired and then the fish feeding process can run according to the time specified in the system program.

3.2. Ultrasonic Sensors

Tests on the HCSR04 ultrasonic sensor were carried out to determine the success of the sensor in identifying feed in storage containers. Ultrasonic sensors are used to determine the remaining feed in the storage container by utilizing the ultrasonic signal reflected by the sensor so that it can determine the contents of the feed container. Ultrasonic sensors get results in the form of distances in cm units. The distance between the sensor and the feed will be converted into a volume of space to get the amount of feed in the catfish feed storage container with the Equation (1).

$$Volume = length \times width \times change\ in\ height \tag{1}$$

From the space volume equation, the results are obtained from the contents of the catfish feed container. Change in food volume based on height, with L x W x H = 15 x 15 x 24 = 5,400 cm3. This equation can be done using the map function on Arduino Uno, namely **VolContainer = map(distance,0,28,5400,0/0);**

$$VolFood = map(distance, 0, 28, 100, 0);\ //\ create\ a\ range\ of\ 0 - 100\%$$

Systems can be created to remap numbers from one range to another. That is, values from low will be mapped to low, values from high will be mapped to high, etc.

From the space volume equation, the results are obtained from the contents of the catfish feed container. When the system opens the valve, the ultrasonic sensor will identify the condition of the storage container. The sensor will automatically display the contents of the storage container into Blynk. The results of this experiment can be seen in Table 4.

Table 4. Ultrasonic experiment

No	Feed (cm^3)	Feed (%)
1	226	5
2	451	9
3	676	13
4	1126	22
5	2026	38
6	3601	68

The experiments in Table 4 were carried out sequentially from the lowest feed content to the almost full feed content. In the six experiments, the ultrasonic sensor can convert sensor data results into data in the form of volume so that the volume value of the storage container is obtained. In addition, the system is able to convert volume data into data in the form of % so that users can find out the contents of the container in the form of % in the Blynk application.

3.3. Servo Motor Actuator Testing

Servo testing was carried out using the system's automatic mode and manual mode via Blynk. The servo will open the valve cover for 2 seconds, after which the servo will close the storage valve again. Automatic mode will open the servo according to the time, namely at 06.00, 12.00 and 16.00. In manual mode, the servo can open according to user instructions through the Blynk application. Servo testing can be seen in Table 5.

Table 5. Servo experiment

No	Mode	Servo State		Duration	Information
1	Automatic	06:15:56 06:15:58	Closed Open	2 second	Managed to open and remove fish feed
2	Automatic	11:22:23 11:22:25	Closed Open	2 second	Managed to open and remove fish feed
3	Automatic	16:10:13 16:10:15	Closed Open	2 second	Managed to open and remove fish feed
4	Manuals	13:05:10	Closed	2 second	Managed to open and remove fish feed

3.4. System Testing

Testing on the Blynk application is carried out by testing the tools on Blynk to the system directly. Blynk for this prototype automatic feeder has a display similar to Figure 7 with the respective functions and descriptions described in Table 6.

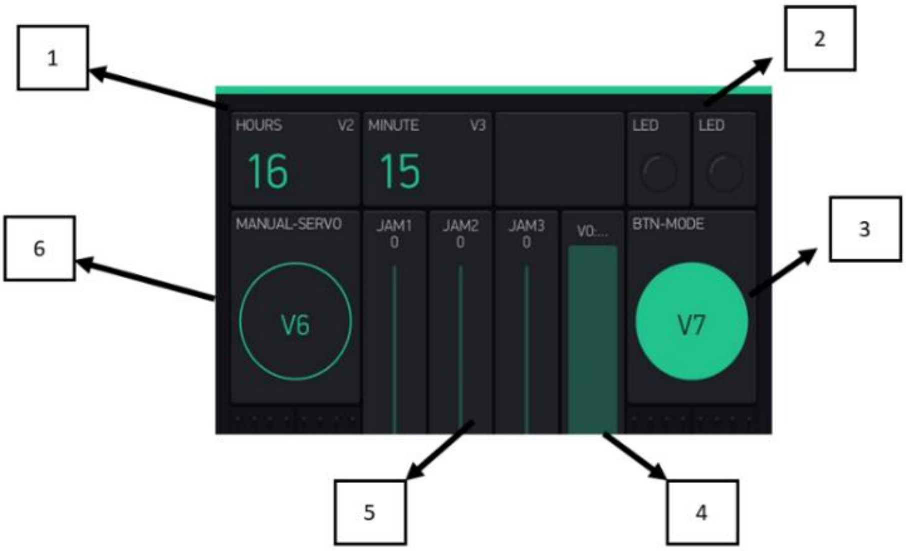


Figure 7. Blynk view

Table 6. Description of Blynk

No	Information	Function
1	Time	Shows hour and minute time
2	LEDs	Shows identification of open and close servo valves
3	Button V7	To open and close the valve manually
4	VD	For a description bar the contents of the feed in the container
5	Hour1, Hour2, Hour3	To identify the condition of the servo
6	V6	Selection of Auto Mode or Manual Mode

The results of testing the entire system are carried out in real time using pellets carried out in fish ponds. Pellets are put into the fish feed storage container. The experiment was carried out based on predetermined times, namely at 06.00, 10.30 and 23.00 as usual catfish were fed 3 times a day.

After testing the RTC and servo which are able to open and close the valve and have obtained data on fish feeding, then tests are carried out on the entire system in automatic or manual feeding. The first experiment was carried out with automatic feeding mode at 06.00, 10.30 and 23.00. The experimental results of the entire system automatically can be seen in Table 7 and displayed in graphical form as can be seen in Figure 8 and Figure 9.

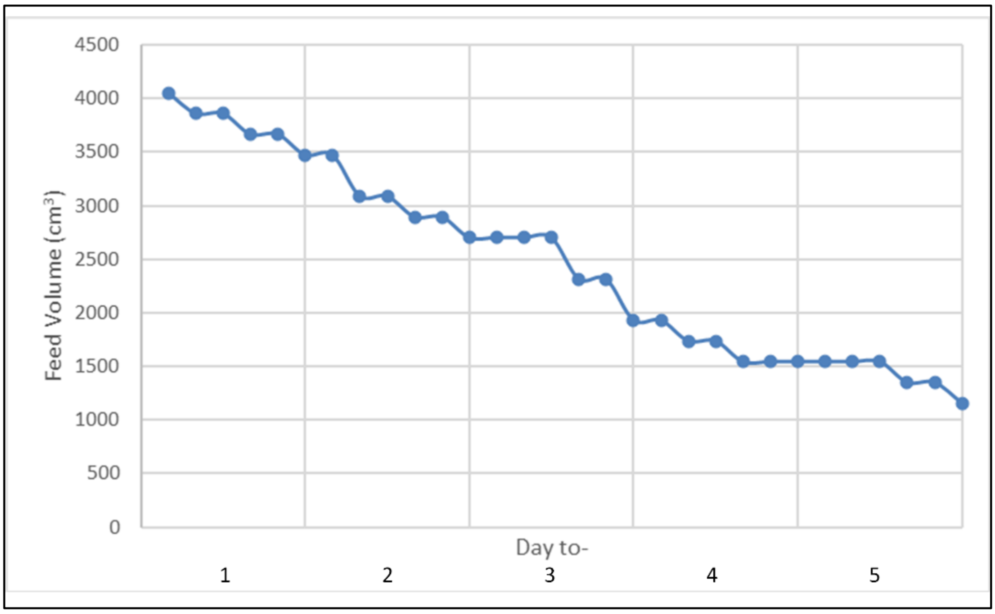


Figure 8. Change in feed volume (cm^3)

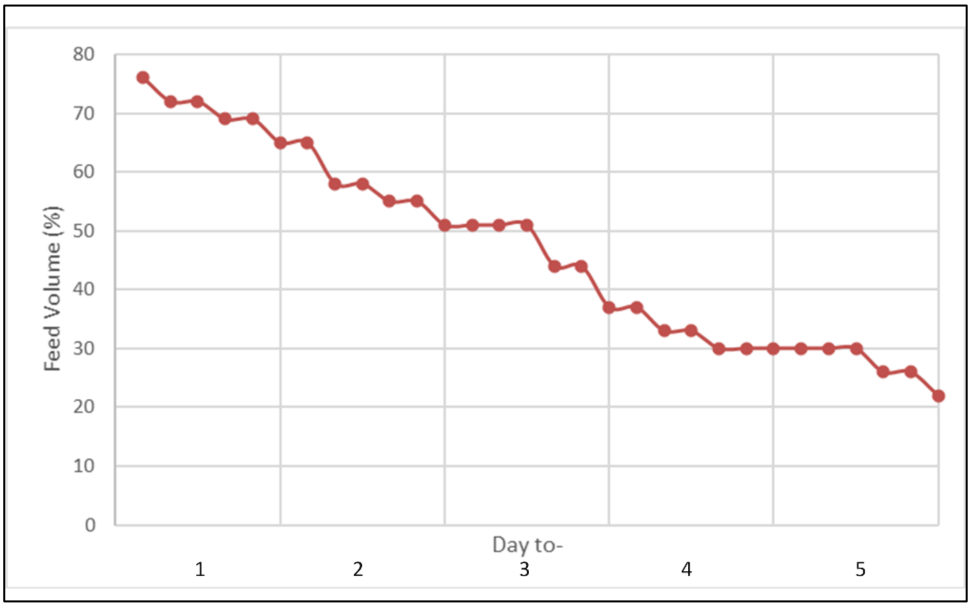


Figure 9. Change in feed volume (%)

Table 7. Test results for the entire automated system

No	Time			Servo Condition	Feed Container Information	
	Hour	Minute	Second		Volume (cm^3)	Percent (%)
1	06	00	20	Closed Condition	4051	76
	06	00	22	Open Condition	3858	72
	10	30	20	Closed Condition	3858	72
	10	30	22	Open Condition	3665	69
	23	00	20	Closed Condition	3665	69
	23	00	20	Open Condition	3472	65
2	06	00	20	Closed Condition	3472	65
	06	00	22	Open Condition	3087	58
	10	30	20	Closed Condition	3087	58
	10	30	22	Open Condition	2894	55
	23	00	20	Closed Condition	2894	55
	23	00	20	Open Condition	2701	51
3	06	00	20	Closed Condition	2701	51
	06	00	22	Open Condition	2701	51
	10	30	20	Closed Condition	2701	51
	10	30	22	Open Condition	2315	44
	23	00	20	Closed Condition	2315	44
	23	00	20	Open Condition	1930	37
4	06	00	20	Closed Condition	1930	37
	06	00	22	Open Condition	1737	33
	10	30	20	Closed Condition	1737	33
	10	30	22	Open Condition	1544	30
	23	00	20	Closed Condition	1544	30
	23	00	20	Open Condition	1544	30
5	06	00	20	Closed Condition	1544	30
	06	00	22	Open Condition	1544	30
	10	30	20	Closed Condition	1544	30
	10	30	22	Open Condition	1351	26
	23	00	20	Closed Condition	1351	26
	23	00	20	Open Condition	1158	22

In Table 8 it is found that the system has been running according to the predetermined time and works at the 20th second every time. The servo opens the valve for 2 seconds and approximately 100-200 grams of fish feed will come out. This is known from the remaining feed after automatic administration. In terms of percentage, there is also a decrease of 4-7% in each automatic grant. This feeding system experiment can also be done manually. This system has two modes that can be set via the Blynk application by changing the mode. Users can control this system manually by touching Blynk then the valve will open.

Table 8. Test results for the entire manual system

No	Time			Servo Condition	Feed Container Information	
	Hour	Minute	Second		Volume (cm^3)	Percent (%)
1	10	16	10	auto open	676	13
	10	16	12	auto close	676	13
2	10	23	10	auto open	676	13
	10	23	12	auto close	676	13
3	11	8	10	auto open	451	9
	11	8	12	auto close	451	9
4	11	16	10	auto open	226	5
	11	16	12	auto close	226	5
5	11	23	10	auto open	226	5
	11	23	12	auto close	226	5

From Table 8, the results of manual feeding experiments are obtained which are regulated by the user through the Blynk application. In manual mode, the user can provide feed at any time as long as feed supplies are still available in the container. In Table 8, a feeding experiment was carried out at adjacent times. Figure 10 and Figure 11 are an automatic fish feeding system and also an experiment to open and close the feeding servo.

Figure 10. Display of the automatic fish feeder

Figure 11. Servo open/close experiment

3.5. Toolkit

The entire series of tools that have been tested and put together can be seen in Figure 12. The results of the 3D designs and prototypes that have been tested have almost similar results. At the top there is a control system box in which there is a system control center connected to sensors and actuators. In the middle there is a fish feed storage container equipped with an ultrasonic sensor inside. At the very bottom there is an actuator in the form of a servo motor to open and close the catfish feed storage valve. The results of this system will provide catfish feed from the container and display the remaining feed on the Blynk and LCD applications.

Figure 12. Prototype of automatic fish feeder

4. CONCLUSION

From the results of the tests that have been carried out, it was found that the prototype catfish feeding system can automatically run according to the research objectives, namely a system that can control automatic/scheduled or manual feeding. The system can monitor the condition of the catfish feed storage container making it easier for users to monitor which can be done remotely via the internet with the help of the Blynk application. Feeding was carried out 3 times a day with an interval of 6 hours with 109 grams per catfish feed. The system can provide information regarding the remaining feed in the container by displaying data in the form of feed content from the total volume of the container in cm3 units and in percentage form to make it easier for the user to find out the contents of the feed container.

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