Design and Development of A Semi-Automatic Catfish Feeder Device Based on Arduino

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ABSTRACT: *Fish feed is one of the most important factors in fish farming and plays a crucial role in determining the success of the cultivation. One of the most commonly farmed fish species in the community is catfish. The feeding of catfish must be carefully managed to optimize their growth by providing feed accurately and regularly so that they can be harvested with maximum results. In this thesis research, a semi-automatic catfish feeder was designed to optimize the feeding process. The device is designed with a semi-automatic system so that when monitoring the catfish pond, farmers can simultaneously feed the fish. This device also uses a solar panel as an energy source to make it more efficient, especially in areas far from electrical sources. The feeder operates using Bluetooth transmission and can be controlled via a smartphone. It includes a feed dispensing system and a feed weight monitoring system, which displays the feed weight in grams on an LCD screen. On the smartphone, a parameter called "Feed Capacity" is displayed to indicate the amount of feed based on its height inside the feed container. This device has a load cell sensor with an average error of 0.5% and a servo motor with an average error of 0.6%.*

KEYWORDS: *Bluetooth, Solar Panel, Catfish Feed, Semi-Automatic, Smartphone.*

I. INTRODUCTION

In the field of fisheries, feed constitutes the most critical factor influencing the success of aquaculture, as high-quality feed promotes the production of healthy and superior fish [1]. An automated feeding device is therefore essential to dispense feed accurately according to the appropriate timing and dosage. The use of automatic feeders can significantly enhance the efficiency of fish farmers by optimizing both time and energy expenditure. Among the various species cultivated in Indonesia, catfish is the most commonly farmed. Feeding catfish typically occurs at specific intervals, with deliberate fasting periods usually implemented prior to harvest [2].

According to interviews with catfish farmers, automatic feeders for catfish are already available in the market. However, these devices are often unsuitable because the feed distribution range is excessively wide, resulting in significant feed wastage and inefficiency for farmers managing relatively small ponds. Furthermore, most catfish farms are located in rural areas where access to PLN electricity is limited or unavailable [3].

Based on these problems, a tool is made that is needed for catfish farmers, namely a semi-automatic feed spreader that is not too far away, the tool utilizes solar energy and the tool can be controlled via *smartphone*. Moreover, this device is designed to serve two ponds simultaneously, featuring two feed dispensers positioned at the front and rear. The design of this automatic feeder aims to assist catfish farmers in administering feed accurately according to prescribed doses and feeding schedules, thereby enhancing catfish production while maintaining high quality [4].

II. OVERVIEW

A. SOLAR PANEL

Solar panels are devices designed to convert solar energy into electrical energy through the use of photovoltaic cells. These cells are typically composed of semiconductor materials, with silicon being the most commonly used due to its natural abundance. Photovoltaic technology directly transforms solar radiation into electric current, and these cells are assembled into modules connected in series or parallel configurations [5]. In practical applications, solar panels are integrated with inverters, charge controllers, batteries, and additional supporting components such as meters and trackers to form a complete system [6].

The main components supporting solar panels include:

1) Batteries, which store excess energy generated during the day and used at night or when solar intensity is low [7].

2) Charge Controller, plays a role in regulating the process of charging and discharging energy from and to the battery, while preventing overcharge [8].

In addition, planning a solar panel system requires calculating the daily energy capacity, the number of modules required, and the specifications and number of batteries according to the user's energy needs.

B. CATFISH

Catfish (Clarias sp.) is a popular freshwater commodity due to its fast growth and ease of cultivation. The species commonly cultivated in Indonesia is *Clarias gariepinus* (sangkuriang catfish).

The success of catfish cultivation is strongly influenced by feed quality and water conditions [9].

1) *Catfish Feed*

Feed is a key factor in catfish growth. These fish are carnivorous and require feed with high animal protein content. Currently, artificial feed in the form of pellets is widely used because its nutritional content has been adjusted to the growth needs of catfish. The amount of feed is adjusted based on the body weight and age of the fish, and is divided based on the stages of maintenance, namely hatchery and enlargement [10].

2) *Water Quality*

In catfish (*Clarias gariepinus*) farming, water quality is a crucial factor that affects fish growth and survival. The three main parameters that need to be considered are temperature, pH, and dissolved oxygen (DO). The optimum water temperature ranges from 25°C to 30°C, as temperatures that are too low can slow down fish metabolism, while temperatures that are too high can reduce dissolved oxygen levels, cause stress, and increase the risk of mortality. The ideal acidity (pH) is within the range of 6.5 to 8.5; extremes in pH can disrupt the physiological balance of fish, lower their immune system, and cause death. Dissolved oxygen levels required by catfish range from 3.5 to 6 mg/L to support their biological activities. Lack of oxygen can lead to decreased appetite, slow growth, and even death. Therefore, regular monitoring and management of these three parameters is essential to ensure an optimal culture environment for catfish [11]

One study that supports the importance of these water quality parameters was conducted by Ramadhani et al. (2023), which showed that temperatures ranging from 25.1°C to 31.7°C, pH between 7.51 to 9.15, and DO between 3.7 to 5.9 mg/L are suitable conditions for sangkuriang catfish enlargement. This study confirms that good water quality management greatly affects the growth and survival of catfish.

C. *Sensor*

Sensors are electronic devices that function to detect changes in the environment and convert them into electrical signals [12]. Sensors are divided into:

- Active Sensors: require an external energy source to work (e.g. photodiode, piezoelectric).
- Passive Sensors: do not require external energy, work based on natural responses to physical changes (example: microphone).

Sensors are widely used in various fields, such as industrial automation systems, medical equipment, and robotics.

D. *Microcontroller*

A microcontroller is a mini computer chip that has a CPU, memory, input/output ports, and other supporting devices such as ADC (Analog to Digital Converter), DAC (Digital to Analog Converter), and timers. Microcontrollers are capable of managing input processes, processing them according to program instructions, and producing outputs. In automation projects, microcontrollers such as Arduino are widely used because of their ease of programming through the Arduino IDE which is based on the C/C++ language [13].

E. *Semi-Automatic System*

Semi-automated systems combine machine automation functions with manual intervention by humans. These systems are designed to improve the efficiency and accuracy of human work in operational processes, especially in the industrial and agricultural sectors. In the context of this research, a semi-automated system is applied in the design of a fish feeder that is controlled using a Bluetooth-based smart device (smartphone) with a power source from solar panels [14].

III. METHOD

Research on arduino-based semi-automatic catfish feeders using arduino Mega follows several systematic and structured research methods. The methods used are literature study, collection of tools and materials, system design, tool testing, and evaluation.

A. Tools

This research uses a computer/laptop as a tool to program the components used.

B. Material

Tbl. Materials Used

No.	Hardware & Software	Description
1.	DC motor	DC motors are motors that convert electrical energy into mechanical energy. DC motors are often used to automate the movement of a component.
2.	Solar Panel	Solar panels are an arrangement of several modules that can convert solar energy into electrical energy.
3.	Solar Charge Controller PWM	*Solar Charger Controller* functions as a regulator of the incoming energy from the *solar panel* to the battery.
4.	Battery	The battery functions as a store of electrical energy generated by the *solar panel* while absorbing sunlight.

5.	Arduino Mega	Arduino UNO is a microcontroller based on ATmega2560. Arduino Mega has 54 digital input/output pins
6.	HC-SR04 ultrasonic sensor	Ultrasonic sensors can convert sound into electricity or vice versa
7.	Servo	Servo motors are devices with a feedback control system (*close loop control*)
8.	HC-05 Bluetooth Module	The *Bluetooth* HC-05 module is a wireless communication module with a working frequency of 2.4 GHz.
9.	L298N H-Bridge Motor Driver	The L298N H-Bridge motor driver is a DC motor driver module that functions as a speed controller and direction of rotation of the DC motor.
10.	LCD (Liquid Crystal Display) 16x2	LCD (*Liquid Crystal Display*) is a small screen, which is commonly used by microcontrollers.
11.	I2C module	*Intergrated Circuit* or commonly called I2C is a two-way serial communication standard that has two money channels specifically made to send or receive data.
12.	Load Cell Sensor	Load Cell is a weight sensor used in digital scales
13.	HX711 Module	The HX711 module is a component designed for *loadcell* sensors (weighing sensors).
14.	Arduino IDE	Arduino IDE (*Integrated Development Environment*) is *software* used to do programming and assign it to Arduino *hardware*.

C. Procedure

The following presents a block diagram and flowchart that describes the overall working system of a semi-automatic catfish feeder designed using an Arduino microcontroller as its main control unit. These diagrams and process flows aim to provide a clearer understanding of the operational stages of the system, starting from sensor input, data processing by Arduino, to the execution process in the form of semi-automatic controlled feeding:

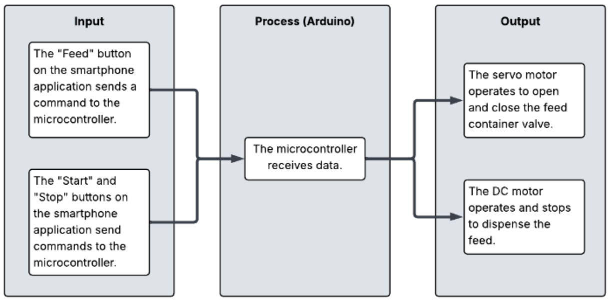

Figure 1. Block diagram of feed stocking process

The block diagram in Figure 1 is a block diagram of the feed spreading process where the input is in the form of the "Give Feed", "Start", and "Stop" *buttons* from the application on the *smartphone.* The input will be processed by a microcontroller in the form of an Arduino Mega which will then produce an output in the form of a servo will work to open and close the feed valve, and the DC motor will rotate and stop to spread the feed.

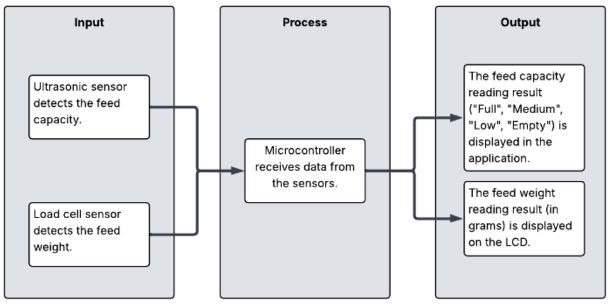

Figure 2. Block Diagram of Feed Weight Monitoring

The block diagram in Figure 2 is a feed *monitoring* block diagram where the input is an ultrasonic sensor detecting feed capacity and a load cell sensor detecting feed weight. The input will be processed by a microcontroller in the form of Arduino Mega which will then produce output in the form of feed capacity readings on the application on a *smartphone* and the results of feed weight readings displayed on the LCD.

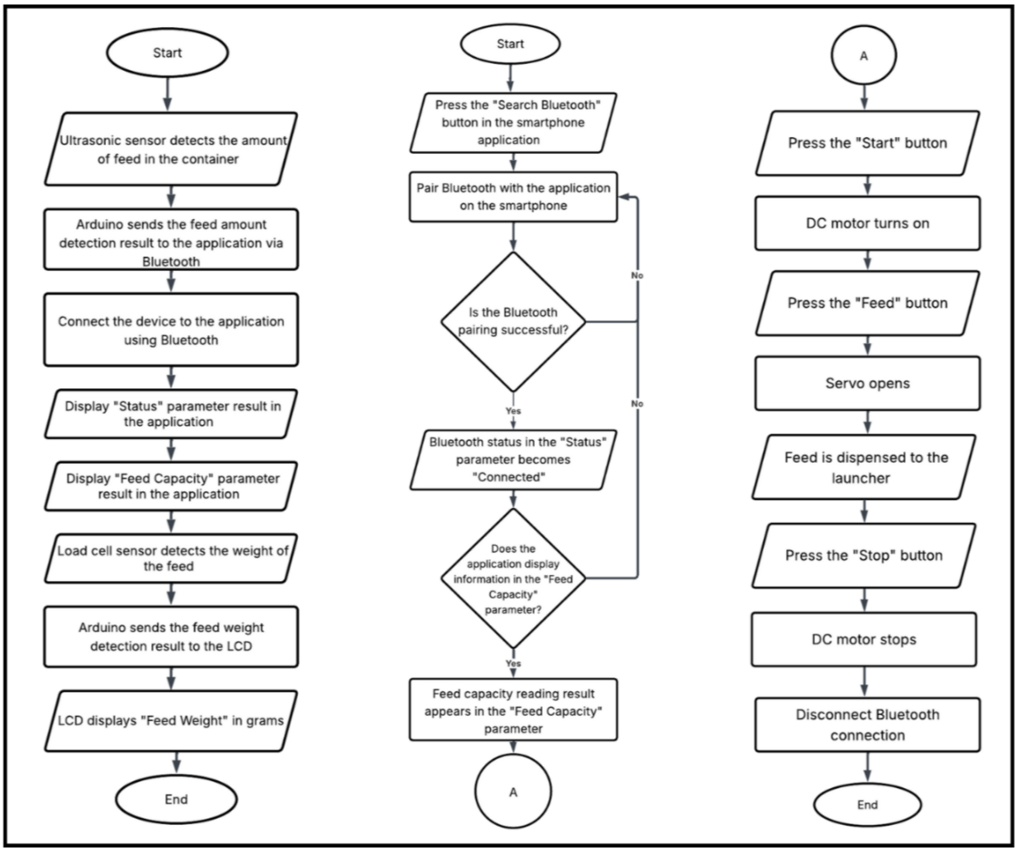

Figure 3 . Flowchart

The flowchart shown in Figure 3 illustrates the overall process flow of the feed weight monitoring system as well as the mechanism for automatic feed stocking. The work process of this system begins with the initial stage of detecting the feed capacity and the weight of the feed available in the feed container. The results of this detection will then be displayed in real-time on two media, namely the application installed on the user's smartphone device and on the LCD screen installed on the device.

The device is designed to connect with an application on a smartphone via a Bluetooth connection. To initiate the connection, the user simply presses the "Search Bluetooth" button located on the application interface. After a successful pairing process between the device and the smartphone, the application will automatically display information about feed capacity in a special parameter that has been provided to show the data.

Once the device and app are connected, the user can operate the system through several buttons available on the smartphone app. These buttons allow the user to execute the tool's functions as needed, such as starting the feed stocking process automatically.

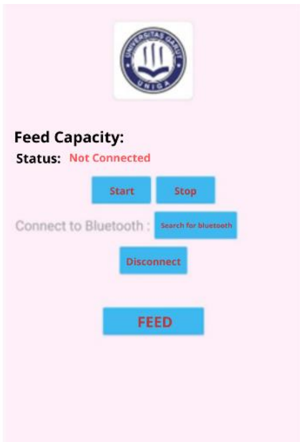

Figure 4. Application User Interface

Figure 4 presents the user interface of the application on a smartphone. It shows how information about feed capacity is presented as well as the position of the control buttons that make it easier for users to operate the device remotely via their mobile devices.

IV. RESULTS AND DISCUSSION

A. *LOAD CELL SENSOR TESTING RESULTS*

The following is the data from testing the load cell sensor as a measure of the weight of the feed in the container. The reading results of the load cell sensor are compared with the reading results by digital scales. When comparing the reading results by the load cell sensor and digital scales, the reading results will have a difference that makes the difference an *error*. The *error* can be calculated using the equation below [15].

$$\% \; error = \frac{|x_{experimental} - x_{actual}|}{x_{actual}} \times 100$$

$$\%error = \frac{error \; absolut}{x_{actual}} \times 100 \qquad (1)$$

Description:
= Percentage *error*
$x_{experimental}$ = Average value of sensor measurement
x_{actual} = Actual average value
Absolute *Error* = Difference between the measured value and the true value.

Tbl 2. Load Cell Sensor Testing Results

No.	Digital scale result (gram)	LCD Display (grams)	Error (%)
1.	518	518	0
2.	328	328	0
3.	234	234	0
4.	163	164	0,6
5.	23	23	0
6.	45	45	0
7.	415	415	0
8.	254	254	0
9.	642	643	0,15
10.	1365	1376	0,8
Average error			0,52

B. ULTRASONIC SENSOR TESTING RESULTS

The following in Tbl 3 is the test result data of the ultrasonic sensor as a feed capacity meter based on the height of the feed in the container.

Tbl 3. Ultrasonic Sensor Testing Results

No.	Capacity reading results by ultrasonic sensor	Capacity reading result by ruler (cm)	Criteria Validation
1.	Many	1	As per
2.	Many	1,5	As per
3.	Many	3	As per
4.	Medium	6	As per
5.	Medium	8,5	As per
6.	Medium	10	As per
7.	A little	13	As per
8.	A little	11	As per
9.	Blank	16	As per
10.	Blank	19	As per

C. SERVO TESTING RESULTS

Servo testing is done so that the servo can function properly as a feed container valve. The following are the results of servo testing:

Tbl 4. Servo Testing Results

No.	Servo Testing Results using Program	Servo Testing Results using Arc	*Error* (%)
1	80˚	80 ˚	0
2	90 ˚	90˚	0
3	60˚	60,5˚	0,83
4	45˚	45˚	0
5	20˚	20,1˚	0,5
Average error			0,67

D. DC MOTOR TEST RESULTS

DC motor testing is done to find out how much speed is right to catapult the feed as far as needed. To adjust the speed of the DC motor can be through the large PWM value, in this test DC motor testing was carried out with a PWM value which can be seen in Tbl 5.

Tbl 5. DC Motor Testing Results

No.	PWM Value	Feed Throw Distance (m)
1	255	3,91
2	125	3,05
3	55	1,6

E. RESULTS OF FEED DEPLOYMENT EFFICIENCY MEASUREMENT

The feed stocking efficiency measurement is conducted to determine at what distance more feed is released. This efficiency measurement is done through calculations with the following formula [16]:

$$\text{Efisiensi}(\%) = \frac{\text{output actual}}{\text{output maximal}} \times 100 \qquad (2)$$

Tbl 6. Results of Feed Deployment Efficiency Measurement

No.	**Distance (m)**	**Weight (gram)**	**Efficiency (%)**
1	1	27	13,5
2	2	48	24
3	3	125	62,5

V. CONCLUSION

The design of this semi-automatic catfish feeder uses Arduino Mega 2560 16U2 as its microcontroller. The data read by each sensor will be sent to the Arduino to be processed until the output will appear on the LCD and in the application. In addition, the servo and DC motor are also connected to the application via *bluetooth* where the process of sending commands through Arduino.

This semi-automatic catfish feeder is controlled using an application on a *smartphone*. This tool can be controlled using a smartphone via *bluetooth* transmission. The parameters displayed in the application are "Feed Capacity" which is integrated with the ultrasonic sensor, and the "Status" parameter which is integrated with *bluetooth*. The servo and DC motor are also controlled through the application using *bluetooth* transmission where both components can be controlled when pressing the "Feed" button to run the servo, pressing the "Start" button to run the DC motor, and pressing the "Stop" button to stop the DC motor.

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