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Development of IoT-based scheduled and efficient feeding system for broiler chicken

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ABSTRACT

The study adopts a prototype development method to create an efficient and scheduled feeding system for broiler chickens. The system includes automation devices capable of regulating chicken feed volumes and implementing regular schedules. Additionally, the system uses IoT technology, enabling remote control and real-time monitoring through an Android application. This system empowers farmers to efficiently monitor and manage chicken feeding without being physically present at the farm. Furthermore, scalability analysis to ensures even feed distribution, reducing waste, and maximizing feed utilization.

Based on cost efficiency tests for scalability of 5000 broiler chickens, it is concluded that the IoT-based Broiler Chicken Feeding System is 4.25 times more efficient than conventional systems.The development of this IoT-based feeding system for broiler chickens is expected to enhance efficiency and sustainability in poultry farming while positively contributing to meeting the future high demand for chicken meat.

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1. INTRODUCTION

Chicken farming businesses can make big profits. However, there is also a fairly high risk in the chicken farming business, which is proven by the number of chicken farming companies that have gon bankrupt due to various restrictions. Many factors can cause this phenomenon, such as financial problems, diseases, mistakes in breeding and others. Mistakes and carelessness in the care and handling of chickens are often a problematic factor in chicken farming [1].

About 75% of the production cost of a poultry farm is feed [2]. Also spacious, the use of human labor in almost all daily operations in the farm increases the cost of production. The it was found that the current deep waste system of poultry farming is characterized by inappropriate management nutrition, food waste, adverse weather conditions, manual stress, increased tendency onset of illness, fatigue and stress. With traditional manual feeding, farmers must dedicate significant time and effort to distribute feed to each chicken. However, with automatic systems, the entire feeding process is streamlined and can be scheduled to occur at regular intervals. This allows farmers to allocate their time other essential tasks, leading to increased productivity and efficiency [3] [4].

Automatic chicken feeding systems have revolutionized poultry farming by offering time labor savings, precise feed distribution, improved feed management, and the integration of advanced technologies. As the demand for efficient and sustainable farming practices continues to rise, automatic feeding systems prove to be an indispensable tool for modern poultry farmers.

2. THEORETICAL BASIS

IoT (Internet of Things) is a concept that refers to a network of physical objects that are connected and interact with each other through the internet. In the context of IoT, these physical objects can be electronic devices, sensors, vehicles, household appliances, or even animals or humans that have the ability to collect and exchange data [5]. the internet is experiencing rapid growth in terms of human engagement, leading to significant changes in the way people work. Thanks to the internet's assistance, various aspects of human workflow have become much more convenient. The emergence and advancement of the Internet of Things (IoT) have greatly contributed to enhancing everyday tasks and activities. With the integration of IoT into daily life, individuals now have the ability to effortlessly control and remotely access a wide range of devices and systems [6].

An example of IoT application is a scheduled and remotely controllable automated cleaning system for chicken coops[7]. Through internet-connected sensors and devices, the coop owner can monitor and control the cleaning process in real-time[8]. Notifications and alerts can also be received in case of any issues. This improves efficiency, maintains cleanliness in the coop, and prevents the spread of diseases among broiler chickens[9].

A microcontroller is a small-sized chip that serves as the main control unit in an electronic system. It consists of memory, communication pins, input and output pins, as well as analog-to-digital conversion systems[10]. Over time, microcontrollers have been developed alongside development boards, making it easier to program them. Arduino is a type of microcontroller that operates on a 10-bit memory capacity, equivalent to 1023[11]. Arduino Mega 2560 is one of the microcontroller models produced by the Arduino Company, which has a higher number of digital and analog pins compared to other Arduino models such as Arduino Micro, Nano, and Uno.

Firebase, a NoSQL-based service database offered by Google, provides developers with a convenient platform to build their applications. By utilizing Firebase, developers can reduce the amount of effort required to handle backend issues [12]. The specific Firebase service discussed in this paper is the Firebase Realtime Database. This database service is hosted in the cloud and allows data to be stored in JSON format. It enables real-time synchronization with users who are connected to mobile or web applications.

A motor used as DC servo motor usually has separate DC source in the winding and armature current or the ouput current. Field control has a number of advantages over anchor control. Similarly, anchor control has a number of advantages over field control. Based on the applications, the control should be applied to the DC servo motor. The DC servo motor provides a very precise and fast response to start stop command signals due to the low inductive reactance of the armature. DC servo motors are used in similar equipment and computer numerically controlled machines[13].

The ultrasonic sensor uses Sonar to determine the distance of an object such as bats. It provides excellent non-contact distance sensing with high accuracy and stable readings in an easy-to-use package from 2 to 400 cm or 1 to 13 feet. Sunlight or black material will not affect performance, although acoustically soft materials such as fabric may be difficult to detect. It comes complete with an ultrasonic transmitter and receiver module. An ultrasonic sensor uses the reflection of sound to obtain the time between the emitted wave and the received wave [14].

3. METHOD

The objective of the automatic feeding system for broiler chickens is to enhance the well-being of the livestock, improve efficiency in their care, and enhance the equality of the poultry products. The system is monitored automatically through a mobile application. The equipment is based on an Arduino Mega and consists of several components, including Arduino Mega, NodeMCU, LCD 16x2, SG90 Servo motor, and an Ultrasonic Sensor.

Input of this system is the Arduino Mega, which functions to control the main operating system for data processing, sensor sensing, and setting the timing of the application program. The Ultrasonic sensor is responsible for measuring the feed volume (in %). If the feed level is categorized as low, medium, or high, the data will be sent to the microcontroller to control the SG90 Servo Motor for open/close the feed pipe. The LED serves as a signal indicator to indicate wheter the feed has been dispensed or not. As for the output, LCD 16x2 displays processed data, and the NodeMCU connects the Arduino Mega to the intenet to send data information into the mobile application via Firebase.

Figure 1 shows an illustration of food storage. In this system, there is a servo and a food storage lis that are attached to each other. The servo rotates 90 degrees to open the feed capacity, which is adjusted according to the automatic scheduling system (set time by the system). If manual control is desired, it can be done by pressing the button located near the poultry cage or by activating the feed switch in the Android Application the check if the feeding schedule is being followed daily and to see the status of whether the feed has been dispensed or not. The feed capacity can be monitored through the Android application and the LCD screen. The condition of the capacity is categorized as follows: Low (<10%) – the system alrm will sound, Normal (>10% or <=75%), Good (>75% or <100%), and Full (100%). To determine the capacity condition, a ping or ultrasonic sensor is used to measure the distance from empty capacity. If the distance from the empty capacity is 7 cm, we can use a formula to determine the feed capacity condition. If the storage is filled to its maximum capacity (full), sensor ultrasonic to the feed will be 1 cm. The formula is ((7cm – 1cm) + 4) * 10 = 100%. Figure 2 shows an illustration of the system design starting from the power supply to data sent into database.

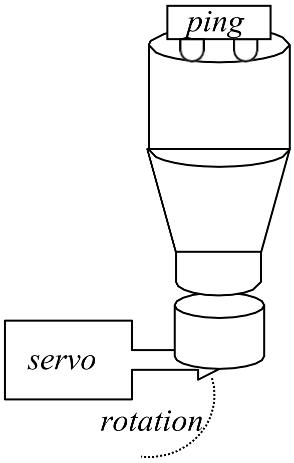

Figure 1. Food Storage System

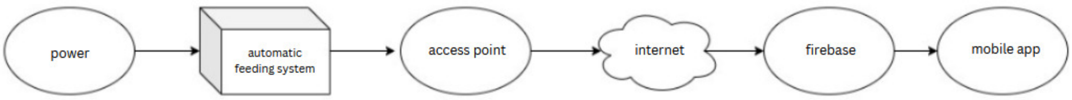

Figure 2. System Module

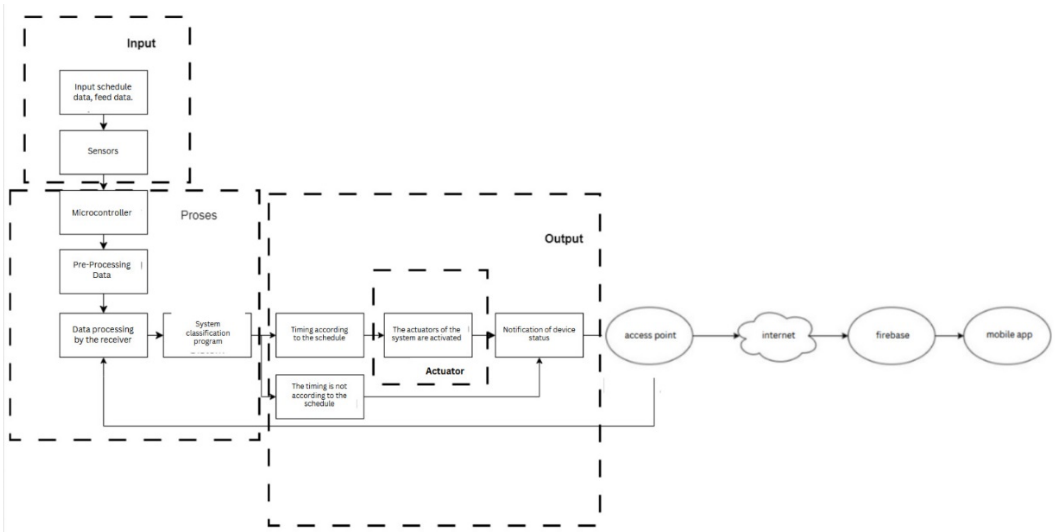

Figure 1. Block Diagram

Figure 3 shows the chicken feeding system, comprising interconnected components. The system is divided into three subsystems: input, processing, and output. The input subsystem is responsible for collecting data from sensors and setting program timing for further processing. The microcontroller then processes the data, including parameters such as chicken feed capacity, feeding schedule, and coop cleaning schedule. The output subsystem utilizes actuators to make decisions based on the processed data. The output is transmitted through data connectivity with the application interface. Actuators provide physical warnings through a buzzer sensor, while users receive notifications via the application interface. Users can adjust schedules and preferences through the application, which are then sent to the database, ensuring timely operation and scheduling of the chicken coop cleaning system.

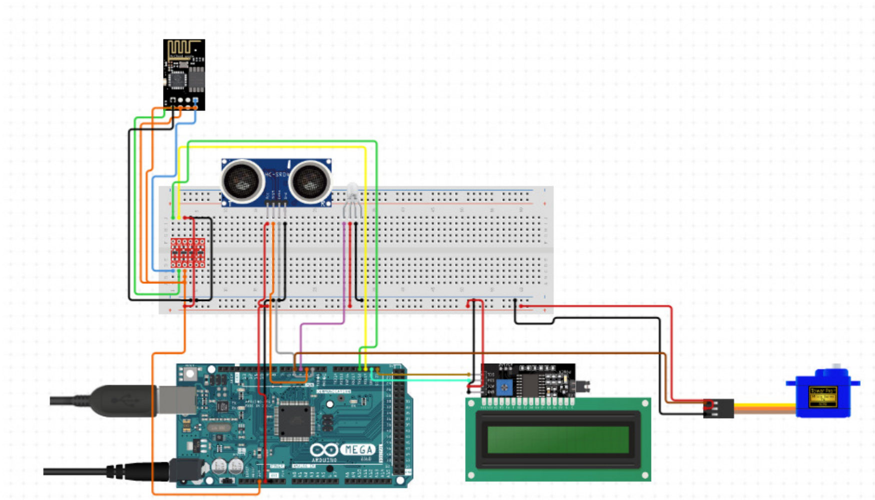

Figure 2. Hardware Design

Figure 4 shows an illustration hardware design. The microcontroller reads settings from database to ensure the system operates according to user-defined schedules and preferences. Data processing involves receiving data from the user and converting it into JSON format using the Firebase 8266 library. The converted data is then transmitted to the Firebase real-time database.

This system works according to the flowchart in Figure 5. When the microcontroller detects the sensor and the input schedule, the microcontroller will process the output of the sensor, which is the distance between the feed and the sensor, and the scheduled time. It will then produce the scheduled time or not. If the output is the scheduled time and the sensor input status is ≤ 10% of the total distance, the system actuator and the device status warning system will run or send notifications to the user onsite or through the application. If the output is not the scheduled time and the sensor input is ≥ 10% of the total distance, the system status warning is not required. Therefore, whether the time is according to the schedule or not, the output result will be sent to the microcontroller to be forwarded to the database and the Android application through connectivity.

4. RESULT AND DISCUSSION

4.1 Led Value Test

The functionality of the LED was tested by input while the chicken feeding process was running. The purpose of this testing is that the LED can produce the On and Off Signals. The results can be seen in Table 1. When button 1 is pressed or in the HIGH state, the servo with an initial position of 60 degrees will rotate towards 150 degrees and remain at the 150-degree position (open), while the green LED will light up if button 1 is pressed. Once button 1 is released, the position will return to 60 degrees, and the green LED will turn off.

Table 1. LED Test Result

Test case	Input	Result
Test 1	On	High
Test 2	Off	Low
Test 3	On	High
Test 4	Off	Low

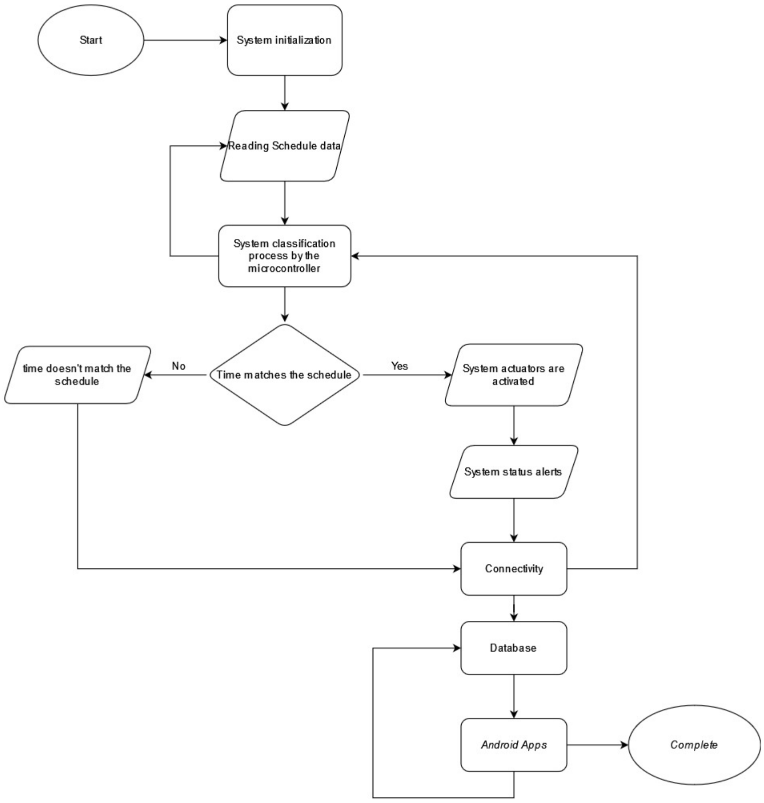

Figure 5. System Flowchart

For manual testing, hold button 2. If button 2 is still held, the system will open the chicken waste compartment by having a servo that is already wound with a string to unwind the roll when the system needs to open it. The same applies in reverse. Then, the water valve solenoid connected to a water source will flow water when button 2 is pressed. The pipe direction, which has been set inside the chicken coop, will irrigate the open chicken waste area for 5-10 minutes, after which the waste will naturally fall down. The system will also turn on a white LED during this process. When button 2 is released, the system will stop the irrigation, and the waste compartment will return to its initial position (servo at 0 degrees). The rolling position will take 10 times the amount of the initial condition, so if 1 rotation is equal to 360 degrees, the waste compartment system will use rotations up to 3600 degrees. Based on the results, it can be observed that the LED will high while the chicken feeding process was running, and led will off when feeding process was stop.

4.2 Feed Capacity Testing

The purpose of this test is to determine the chicken's capacity and feed requirements. The test is conducted using an Ultrasonic Sensor, the results are shown in Table 2.

Table 2. Feed Capacity Testing

Food Capacity	Low (<10%)	Normal (>10% or <= 75%)	Good (>75% or <100%)	Full (100%)
food in the storage 8%	low	-	-	-
food in the storage 9%	low	-	-	-
food in the storage 100%	-	-	-	full
food in the storage 56%	-	normal	-	-
food in the storage 78%	-	-	good	-
food in the storage 90%	-	-	good	-
food in the storage 36%	-	normal	-	-

The connected PING or Ultrasonic detects the distance and is adjusted accordingly. It is determined that the distance from the empty capacity is 7cm. When the storage is filled to its maximum capacity, the sensor distance to the feed is 1 cm. The formula for calculating the feed capacity is as follows: (((7 cm - 1 cm) / 10) + 0.4) * 100 = 100%.

When button 1 is pressed or in a HIGH state, the servo, initially positioned at 60 degrees, rotates towards 150 degrees, and remains at that position (open), while the green LED lights up if button 1 is pressed. Once button 1 is released, the position returns to 60 degrees, and the green LED turns off.

4.3 Control and Monitoring Testing

In this section, this is the result of monitoring trials on the application.

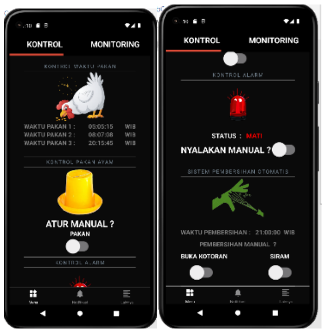

Figure 6. Menu Control

The Sub Menu Kontrol in the PaYot application allows users to have control over various aspects of the chicken feeding system. Users can manually control the feeding process, set alarms or notifications, and manage the cleaning system, including opening or closing the chicken waste compartments. Additionally, users can monitor the status of the system to ensure its proper functioning. The Sub Menu Kontrol provides a convenient interface for users to manage and monitor the feeding system efficiently. The flow UI Application in Figure 7.

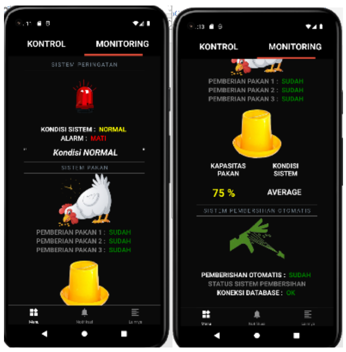

Figure 7. Monitoring Menu

The Monitoring submenu in the PaYot application provides real-time monitoring of various system parameters related to the broiler chicken feeding process. Users can view and track important information such as feed capacity, system status, and any potential issues or alerts. This submenu enables users to have a comprehensive overview of the system's performance and make informed decisions based on the data presented. In the monitoring menu, users can only view the status of the system's condition as it operates. For example, in Figure 10, if the feeding time 1 has passed the current time, the status will change to "SUDAH" (already) and the text will be displayed in gray color. The flow UI Application in Figure 7.

4.4 Analysis Results

The results of testing the power consumption of the entire system are as follows in the table 3.

Table 3. System Power Consumption Test Results

Tool's Name	Amount	Voltase (V)	Ampere (A)	Watt
Arduino Mega 2560 WiFi	1	5 V	0.1 A	0.5 watt
Power Supply AC to DC	1	12 V	3 A	48 watt
Servo MG995	1	5 V	1.5 A	7.5 watt
Servo SG90-9G DC	1	5 V	0.6 A	3 watt
Water Valve Selenoid NC	1	12 V	1 A	12 watt
Relay 4-Channel	1	5 V	1 A	5 watt
Buzzer	1	5 V	0.03 A	0.15 watt

LED	1	4.4 V	0.02 A	0.176 watt
Ultrasonic Sensor	1	5 V	0.02 A	0.1 watt
Button Switch	1	5 V	0.1 A	1.5 watt
		Overal total power		78,426 watt

This analysis provides an overview of the amount of power required by each component in the system and provide important information in power planning and selection of appropriate resources for the system.

Table 4. Projection of the Cost of Electricity Needs for the Entire System

Tool's Name	Watt	Daily Use (O'Clock)	Total Consumption	Rate Electricity	Cost Per Day
Arduino Mega 2560 WiFi	0.5 watt	24	0.012 kWh	1,444	17.328
Power Supply AC to DC	48 watt	24	1.152 kWh	1,444	1660.288
Servo MG995	7.5 watt	24	0.180 kWh	1,444	259.92
Servo SG90-9G DC	3 watt	24	0.072 kWh	1,444	103.968
Water Valve Selenoid NC	12 watt	24	0.288 kWh	1,444	415.392
Relay 4-Channel	5 watt	24	0.120 kWh	1,444	173.28
Buzzer	0.15 watt	24	0.0036 kWh	1,444	5.1984
LED	0.176 watt	24	0.004224 kWh	1,444	6.09
Ultrasonic Sensor	0.1 watt	24	0.0024 kWh	1,444	3.4656
Button Switch	1.5 watt	24	0.036 kWh	1,444	51.984
		Overal total power			2697.33

In table 4 Projection of the Cost of Electricity Needs for the Entire System contains detailed electricity cost estimates for each component in the system during a certain period. The following is the result of the total cost of electricity in 31 days, based on data electricity tariff: Electricity Rates in 1 month = Electricity Rates per day x 31 Total electricity tariff in 1 month = Rp. 2697.33 x 31 = Rp. 83617 So, the total cost of electricity in 31 days is based on the projection in Table 5.4 with a tariff of 1444 Rp/kWh is around Rp. 83617 Rupiah.

Table 5. Prototype System Cost

Tool's Name	Amount	Cost (Rp)	Total Cost (Rp)
Arduino Mega 2560 WiFi	1	200.000,00	200.000,00
Power Supply AC to DC	1	50.000,00	50.000,00
Servo MG995	1	30.000,00	30.000,00
Servo SG90-9G DC	1	20.000,00	20.000,00
Water Valve Selenoid NC	1	30.000,00	30.000,00
Relay 4-Channel	1	5.500,00	5.500,00
Buzzer	1	500,00	500,00
LED	2	50,00	100,00
Ultrasonic Sensor	1	9.000,00	9.000,00
Button Switch	3	300,00	900,00
PCB Button and Alert	1	10.000,00	10.000,00
Cage Cost	1	200.000,00	200.000,00
Application Cost	1	600.000,00	60.000,00
	Overal total cost		1.156.000,00

The price of the prototype system offered is one million one hundred fifty six thousand rupiah. In addition, the price of the PaYot System (Pakan Chicken IoT) without the price of cage infrastructure is 956

thousand Rupiah.With this affordable price, breeders can have a prototype systemquality that has been designed to meet the needs of livestock advanced.

Table 6. Estimated Cost of The PaYot System for 5000 Broilers

System's Name	Cost (Rp)
PaYot System	965.000,00
Overall Power System	83.617,00
Feed Storage 1000 L	985.000,00
Additional Feed Valve Servo	20.000,00
Power Cost 1 Additional Feed Valve Servo	3.223,00
Cost of 1 Technician/Operator	2.000.000,00
Internet Cost	100.000,00
Other Additions	400.000,00
Total Cost	4.520.840,00

In Table 6 is the estimated cost of the PaYot System for 5000 broiler chickens on a farm. It can be assumed that the above prices are outside costs for cage construction costs, water demand power costs, and costs accommodation, the cost of feed requirements, and other costs are not taken into account. For the first month, you only need an investment of Rp. 4,520,840. After that, for the next month, breeders only need to think about power costs, costs technicians, and internet costs.

Table 7. Conventional Cost Estimates for 5000 Broilers

System's Name	QTY	Working Hours Per Day	Cost (O'Clock)	Total Wage Per Day
Feeding Operator	1	8	12.000,00	96.000,00
Drinking Officer	1	6	10.000,00	60.000,00
Cleaning Officer	1	4	12.000,00	144.000,00
Total Cost Of Workers' Wages Per Day (Rp)				300.000,00
Total Cost Of Workers' Wages Per Month (Rp)				9.300.000,00

In Table 7 is an estimated cost incurred on the system conventional, which involves more workers than 101 modern system. This fee is a daily and monthly fee issued by the breeder.

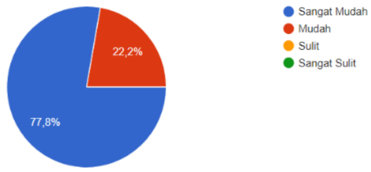

Figure 8. The Graph Represents the Results of the Application Survey

For the analysis and to assess the convenience for farmers in using the application, a survey method was employed with 18 respondents. One of the questions posed was, "Is the appearance or user interface of the PaYot application easy to understand?" The results indicated that 22.2% of the respondents rated it as easy, while 77.8% rated it as very easy.

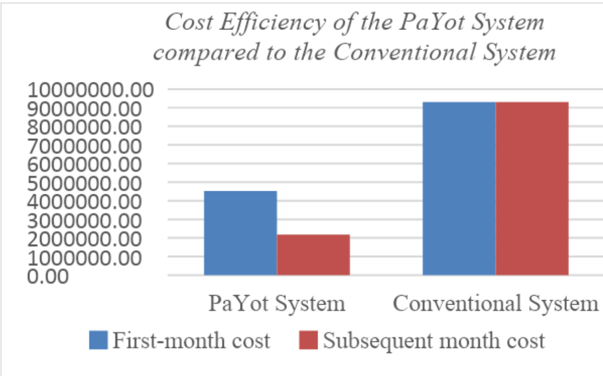

Figure 9. Cost Efficiency Graph of PaYot System compared to Conventional System

Based on Figure 9, the PaYot system shows better cost efficiency, with initial costs less than half of the conventional system. Despite the PaYot system's fixed cost in the following months, it remains more economical than the conventional system due to its lower usage cost in the long term.

5. CONCLUSION

Based on the testing results of the implementation of the IoT-based automatic feeding system for broiler chickens, the following conclusions can be drawn: The system functions according to user needs, allowing the device to operate effectively. Furthermore, testing on each system and component yielded data with minimal errors, reducing the frequency of maintenance requirements. Therefore, the implementation of this system has successfully achieved its initial goals, which are to improve productivity efficiency, enhance the well-being of livestock chickens, and enable real-time monitoring of livestock feed requirements.

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