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SMART HUSBANDRY FEEDING SYSTEM USING IOT AND MOBILE APP'S TO DETERMINE THE MOST FEEDING ESTIMATION AND PROFIT MAXIMIZATION

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ABSTRACT

Chicken farms are typically situated far away from residential areas to prevent conflicts, pollution, and noise. However, this distance results in increased time and costs for managing remote coops. Effective control over chicken feeding is crucial for efficient farm management. An automated approach is necessary, as manual feeding is more wasteful, lacks regularity, and involves higher labor costs. This study proposes a smart feeding system that utilizes IoT and Mobile Apps. The key components of the device include Nodemcu, load cell sensor, DHT11 sensor, relay, RTC DS3231, servo motor, and I2C 16x2 LCD. Simultaneously, the mobile application manages various primary features, such as temperature, humidity, light settings, feed information, chicken quantity and age settings, and an auto/manual feed schedule. The system underwent a series of tests, and the assessment confirmed that the system can monitor data, manage feed, and regulate temperature of the coop using a lamp in real-time. Additionally, the mobile application allows users to access the feed history based on the feeding date. The remote-control system for feeding, temperature, and humidity offers reduced operational costs and helps maintain a safe distance between poultry and humans. The research results present significant implications as they streamline automated feeding processes for poultry farmers and introduce a precise algorithm for calculating feed requirements. The proposed tool and algorithmic system not only demonstrate cost-effectiveness but also showcase efficiency gains in terms of time and labor. This product is particularly well-suited for small and medium-sized enterprise (SME) chicken farmers, providing valuable contributions to the advancement of automated feeding systems within the poultry industry. It fosters enhanced management practices and economic optimization.

Keywords: *Smart Feeding System, IoT, Husbandry, Mobile App's, Profit Maximimization*

1. INTRODUCTION

Chicken is a highly favored food in Indonesia, and its industry has witnessed significant growth, as evidenced by the continuous rise in chicken production year after year. Over the past four years, there has been a steady increase in the average consumption of chicken. According to the 2022 report from the Central Statistics Agency of Indonesia, there has been a noteworthy 17.75% rise in average chicken consumption in Indonesia when compared to the consumption levels observed in 2018.

The maintenance of chicken farms is greatly influenced by feeding, which constitutes a significant portion of production costs [1]–[3].

Inadequate feeding practices can have a detrimental impact on poultry growth. The high production costs and physical strain associated with managing poultry farms often result in reduced profitability and low return on investment [4]. Expensive production costs and human fatigue in managing poultry farms lead to fewer profits and low return on investment. Therefore, it is crucial to implement an appropriate feeding method to minimize production costs in chicken rearing. The answer to this problem is to use the Internet of Things (IoT) in small-scale chicken farming business. The Internet of Things (IoT) enables numerous applications and sensors in everyday life to communicate with each other and share information [5][6]. The integration of this with specific autonomous capabilities will enhance the intelligence of the feeding system, thereby improving its quality.

Michie et al [7] stated that an optimized feeding strategy can reduce operational costs, minimize waste, and maximize profits. Several studies have explored the implementation of a smart feeding system utilizing Internet of Things (IoT) technology [1], [7]–[11]. Moreover, Paper [12] emphasized that IoT enables not only the monitoring of chicken stocks but also the creation of an optimal environment that ensures the well-being and breeding success of the animals. This combination of an optimized feeding setup and a comfortable growing environment is called Livestock IoT.

Maintaining the ideal temperature and humidity is crucial for the comfort of poultry. The recommended temperature inside the chicken coop is 32°C [13], which should be maintained consistently throughout the day, accompanied by a humidity level of 50-60%.

The traditional husbandry system relying on incandescent lamps is deemed ineffective due to its low efficiency and high-power consumption. Consequently, there is a need for a more efficient temperature and humidity control system. Another challenge small-scale husbandry operations face is their remote location, situated far from residential areas to mitigate conflicts, pollution, and noise.

Consequently, manual management of remote coops requires substantial time and expense. On the other hand, automated feeding is a more effective solution as it employs intelligent tools to feed chickens automatically at predetermined intervals and portions [14]. Automated systems offer superior efficiency, eliminate irregularities, and reduce labor costs compared to manual feeding.

This research aims to develop a supporting device capable of remotely feeding chickens (either manually or automatically) and controlling the lighting conditions. These activities were traditionally monitored remotely using mobile applications and IoT assistance. The developed system encompasses the following features:

- Facilitating remote feeding control for farmers with distant farms.
- Real-time monitoring of feed through the mobile application.
- Remote control of lighting conditions via the application when the temperature falls below 32°C.
- Manual feeding capability through the mobile application or automatic scheduled feeding on a daily basis, with the feeding time adjustable using the application.
- Budget control for feeding is based on the specific needs and age of the chickens.

This research yields noteworthy implications by streamlining automated feeding processes for poultry farmers and introducing an algorithm for precise feed requirement calculations. We offer enhanced planning capabilities and heightened production efficiency. Consequently, the management of chicken farms, particularly those operating at small-scale SMEs, stands to benefit, resulting in improved profitability. The proposed tool and algorithmic system for feed requirement calculations exhibit cost-effectiveness and demonstrate efficiency gains in terms of time and labor. Moreover, these innovations can mitigate interactions between livestock and handlers, thus reducing the likelihood of disease transmission within poultry populations. Our study contributes valuable insights to advancing automated feeding systems in the poultry industry, fostering improved management practices and economic optimization.

Based on problems related to limited feeding practices and expensive production costs, as well as limited human labor in managing farms, it is very important to implement the Internet of Things (IoT) in small-scale chicken farming businesses. So, the research question related to the criticism of the literature that has been presented is how to develop a support device capable of feeding chickens remotely and controlling lighting conditions?

2. RESEARCH METHODS

We implemented the research design illustrated in Figure 1 to conduct this study. The research diagram encompasses power supply components serving as the voltage source. Nodemcu functions as the central controller, responsible for coordinating all the components and executing the input program.

The HX711 module, in conjunction with the load cell sensor, serves as a weight gauge for measuring the amount of chicken feed. The DHT11 sensor is utilized to measure the temperature and humidity within the enclosure. Additionally, LCDs are employed to display the remaining feed data obtained from the load cell, temperature, and humidity sensors.

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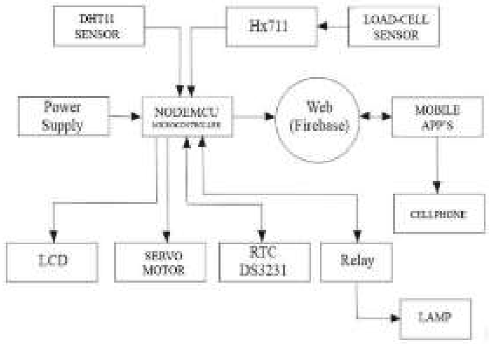


Figure 1. The Diagram of Research Design

The servo motor is responsible for operating the feed-gate puller, enabling the delivery of chicken feed. Additionally, the RTC (Real-Time Clock) is employed to set the chicken feed timer.

The relay is automatically configured to function as a circuit breaker and voltage connector for the lamp, based on the temperature data obtained from the DHT11 sensor. For data storage and control, Firebase is utilized, serving as a database that receives and processes data from the sensors and mobile applications. It also functions as a user interface for monitoring and controlling the devices. Firebase provides a NoSQL database that allows developers to store and synchronize data in real-time. It employs a JSON-based data model & supports auto data synchronization across various clients. The applications are accessed via smartphones.

The Rapid Application Development (RAD) model is employed in the development of mobile applications. Compared to traditional cycle methods, the RAD model is a life cycle approach aimed at enhancing product development. It focuses on shorter development cycles, iterative development, collaborative engagement between developers and stakeholders, rapid prototyping, and feedback loops. Studies conducted by [15] have demonstrated that RAD is a highly effective software development methodology, allowing for swift development and leveraging reusable code. RAD methodology is widely adopted by innovators for developing IoT and Mobile App projects, as reported by [16]–[19].

3. RESULTS AND DISCUSSIONS

The outcomes of this study are categorized into three distinct segments, encompassing hardware, electronic circuit, software, and testing aspects.

3.1. Hardware

The feeding system box structure incorporates wooden legs as barriers and employs thick plywood, measuring 2 cm in thickness, to create shelters for chicken feed. The dimensions of the structure are 1.2 m in height and 50 cm in width. The hardware design is illustrated in Figure 2, while the prototype is showcased in Figure 3.

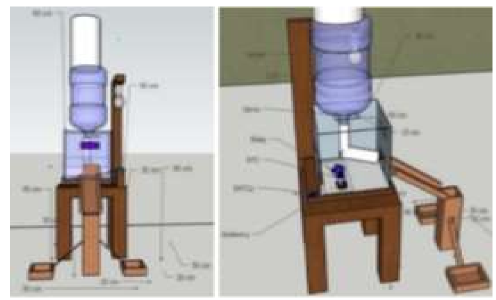
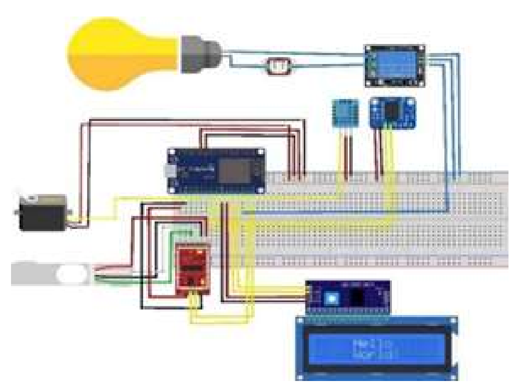


Figure 2. The Hardware Design

Figure 3. The Prototype of Feeding System Hardware

3.2. Electronic Circuit

The key components of this device include the Nodemcu (microcontroller), load cell sensor, DHT11 sensor, relay, RTC DS3231, servo motor, and I2C 16x2 LCD.



(a)

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(b)

Figure 4. (a) Design (b) Electronic Circuit

The electronic part of the poultry husbandry feeding system is depicted in Figure 4.

3.3. Software

The mobile application software was developed using an 'app-inventor' platform, which utilizes visual block programming. These blocks provide predefined events that are triggered when specific components are executed. Subsequently, the mobile application coding is implemented to enable the display and functionality of the following features:

- Login
- Sign Up
- Data Entry
- Main Menu
- Tool Selection
- Temperature, Humidity and Lights setting.
- Feed Information
- The Number and Age of Chickens
- Auto/Manual Feed Schedule and Tutorials

Examples of the mobile application menus can be observed in Figure 5.

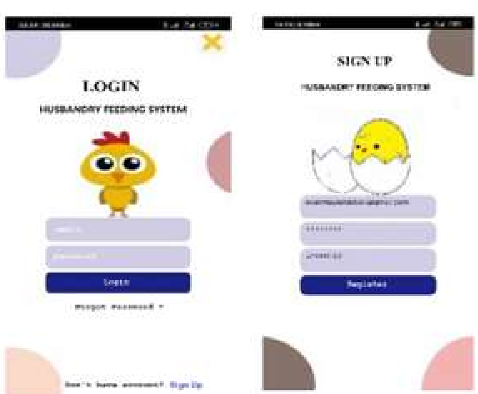

Figure 5. Login and Sign-Up Page

3.4. Testing

3.4.1 Sensor Testing

In order to ensure the functionality and accuracy of the sensors utilized in the automatic broiler feeding devices based on Nodemcu microcontrollers, a calibration and testing process was conducted. Table 2 provides a description of the testing procedure for the load cell sensors and hx711 modules. Various objects were employed to assess the precision and accuracy of this module. Additionally, precision tests were carried out for the DHT11 sensor, relay (used for the lamp), DS3231 RTC, and servo motor.

Table 2. HX711 Load Cell Test Data

Object Name	Weight of Objects Using Digital Scales	Weight of Objects Using Loadcells	Error %
Paint Cans	1145 Gram	1148 Gram	0,262 %
Liquid soap	792 Gram	795 Gram	0,379 %
Rice cup	597 Gram	599 Gram	0,335 %
Hammer	615 Gram	614 Gram	0,163 %
Chicken food	1348 Gram	1343 Gram	0,371 %

3.4.2. Data Retrieval Testing of Feed Quantity

The objective of this test is to assess the time required to adjust the feed-gate based on the age and number of chickens. A mg90s servo motor with a servo rotation degree set at 120° was employed. The data was collected based on three different criteria for the number of chickens, namely 100, 150, and 200 chickens, ranging from 1 week of age.

Table 3. Feed data (1-week chickens aged).

Data		Number of chickens		
		100	150	200
Data 1	Time (sec)	3,415	4,805	6,4
	Feed (gr)	264	400	547
Data 2	Time (sec)	3,42	4,81	6,405
	Feed (gr)	268	396	538
Data 3	Time (sec)	3,425	4,815	6,41
	Feed(gr)	271	393	532
Feed Average (gr)		267,7	396,3	537,7
Error (%)		2,96%	1,61%	3,40%

Table 3 displays the feeding duration required for different quantities of chickens aged 1 week. It is observed that there is a pressure difference between the initial and subsequent feed dispense, which necessitates an additional 0.005 seconds for each subsequent feed. Subsequently, similar experiments were conducted for chickens at different ages, including 2 weeks, 3 weeks, 4 weeks, and up to the slaughter age of 5 weeks.

These experiments resulted in error percentages of 0.5%, 1.27%, 0.76%, and 1.12%, respectively. The errors can be attributed to variations in the size of chicken feed. Some feed particles are large and dense, while others are small and fine, leading to variations in the dispensed amounts. Additionally, the pressure difference between subsequent feeds also contributes to the observed errors, as the pressure decreases towards the end of the feeding process.

3.4.3. Mobile Application Testing

The mobile application underwent testing using both white box and black box methods. In the white box testing, various modules within the application were examined by inputting data and verifying the correctness of the output (see [20]–[22].

Additionally, a user acceptance test was conducted with 117 participants who were given access to try the mobile application's monitoring and control functionalities. This allowed users to assess the real-time data monitoring capability, test the remote feeding functionality (both auto and manual modes), and explore all other features. The test yielded the following observations (Table 4):

Table 4. User Acceptance Test Results.

Menu	Information	Status	Notes
Login	Input email and registered password	Ok	appropriate
Register	User creates an account by registering email and password	Ok	After click register, user must jump directly to the login menu
Input Data	User enters username, phone-number, and device code	Ok	appropriate
Welcome Page	Display user-data on the welcome page	Ok	appropriate
Dashboard	1) Users monitor data on remaining feed, temperature (lamp state) number & age. 2) User can feed manually.	Ok	There is an exception error when the input is empty
Feed	Users can see feed data, the next feed time out, the history of all feed data.	Ok	History should emerge from recent data.
Temperature	Users can monitor temperature and humidity graph data in the cage.	Ok	Add the inscription °C
Lamp	Users can turn off and turn on the lights manually	Ok	appropriate
Timer	User can set timer time feed will come out	Ok	appropriate
Chicken number & age	Users can set the number and age of broiler chickens used.	Ok	appropriate
Tutorial	Users can see data on broiler chicken feed needs from 1 to 5 weeks of age.	Ok	appropriate

User feedback, as documented in Table 4, is meticulously reviewed, and promptly integrated into the application's ongoing development process.

3.4.4. Complete Testing

Finally, comprehensive testing (Figure 6) was conducted on the devices, applications, and databases. Each component underwent various tests, including manual/automatic feeding testing, manual lamp testing, and data monitoring testing for synchronization. These tests were carried out in the actual environment at the Cikande - Chicken Farm, Serang Regency, Banten. The farm consists of two-stage cages, with the first cage having a capacity of 1000 chickens and the second cage accommodating 4000 chickens.

Complete testing was conducted over a period of seven days, with a feeding frequency of five times per day. The total feed output was set at 600 grams daily, with each feeding frequency releasing 120 grams of feed.

Figure 6. Result of Complete Testing

The experiment results of the complete testing (Figure 6) revealed that the actual feed output did not precisely match the target of 600 grams. On the first day, the error percentage was below 0.2%. However, from Day 2 to Day 6, the feeding error increased due to diminishing pressure in the feed container. On Day 7, a small excess in feeding occurred due to the additional time allocated for opening the feed door to compensate for the pressure difference. Overall, the system functioned effectively with an error percentage below 1% (with a maximum error of only 0.67%). This IoT and Mobile Apps-based feeding system offers cost reduction benefits and is particularly suitable for small and medium-sized chicken farmers. The system's manufacturing costs (in US dollars) are outlined in Table 5.

Table 5. Components Cost

No	Components	Price	Quantity	Sub Total
1	NODEMCU LUA V3	2.65	1	2.65
2	Servo Motor SG90 9G	0.99	1	0.99
3	LCD 16x2	1.72	1	1.72
4	*Load cell* Sensor + HX7111	4.64	1	4.64
5	Jumper Cable	0.99	2	1.99
6	DHT11 Sensor	1.32	1	1.32
7	RTC DS3231	1.32	1	1.32
8	2 Channel Relay	0.99	1	0.99
9	Electronic Box	2.32	1	2.32
10	Feeding-System-Box	16.56	1	16.56
11	Lamp	1.99	1	1.99
Total				36.49

A feeding device, priced at US$36.49, has been developed to accommodate a maximum feed capacity of 18 kg for 200 chickens aged five weeks, with a daily feed requirement of 4.4 kg. Consequently, this device enables automatic feeding to be completed within four days. For a flock of 1000 chickens, only five machines were utilized, costing a total of 183 US$. According to references [8], [23]–[25] systems with similar functionalities are highly suitable for small and medium-sized enterprises (SMEs) due to their affordability. During the implementation tests conducted in a real-world setting, we observed that the product installation process is highly flexible. Additionally, the implementation test examined the average feed rate in grams per second.

Table 6. Feed Supply per Second.

Week (chicken number)	Feed Average (gram)	Feeding Time (second)	Feed per second (gram)
1 Week (100)	267.7	3.415	78.4
1 Week (150)	391	4.81	81.3
1 Week (200)	537.7	6.4	84
2 Week (100)	653	8.06	81
2 Week (150)	988.7	12.1	81.7
2 Week (200)	1315	16.3	80.67
3 Week (100)	1608.3	20	80.4
3 Week (150)	2443	29	84.24
3 Week (200)	3248	39	83.28
4 Week (100)	2179	26.7	81.6
4 Week (150)	3281	39.2	83.7
4 Week (200)	4294.7	53.8	79.8
5 Week (100)	2995.7	36.6	81.85
5 Week (150)	4473.7	54.4	82.24
5 Week (200)	5897.7	72.6	81.235
Total Average			**81.63**

Table 6 provides data on the average feed per second, which is recorded as 81.63 grams (± 82 grams). Additionally, an experiment was conducted to assess the growth of 40 chickens over a one-week period, where they were fed at a rate of 82 grams per second. The results showed that the average growth of these chickens was 197.75 grams per week. Assuming this growth rate remains consistent, the chickens would be ready for slaughter within the next five weeks. The proposed system also includes temperature control, with the ideal temperature set at 32°C. This temperature can be remotely managed, ensuring the comfort and high appetite of the chickens in the cage.

Furthermore, utilizing the data presented in Table 6, we have formulated an algorithm for calculating feed requirements as follows:

1. **Import the data from an external file(data_pakan)**
2. **Function calculate_feed_requirement (age_days, max_age_days, num_chickens, avg_feed_per_chicken):**
    a. **Calculate age_factor = age_days / max_age_days.**
    b. **Calculate feed_requirement = age_factor * avg_feed_per_chicken.**
    c. **Return feed_requirement.**
3. **Set max_age_days = 35 & age_multiplier = 7.**
4. **Print table header: "Age and Quantity", "Num Chickens", "Avg Feed (grams)", "Feed Requirement (grams)".**
5. **Print separator line: "=" repeated 90 times.**
6. **For each set of data in data_pakan:**
    a. **Get weeks, num_chickens, and avg_feed from the data.**
    b. **Calculate age_days = weeks * age_multiplier.**

c. **Call calculate_feed_requirement () with age_days, max_age_days, num_chickens, and avg_feed as arguments.**
d. **Print the calculated values in a formatted table row.**

Upon execution of the Python programming code employing the algorithm, the feed requirement per number of chickens aged 1 to 5 weeks is derived, as exemplified in Table 7:

Table 7. Feed Requirements

Age	Num Chickens	Feed Requirement (grams)
1 Weeks	100	53.54
1 Weeks	150	78.2
1 Weeks	200	107.54
2 Weeks	100	261.2
2 Weeks	150	395.48
2 Weeks	200	526.0
3 Weeks	100	964.98
3 Weeks	150	1465.8
3 Weeks	200	1948.8
4 Weeks	100	1743.2
4 Weeks	150	2624.8
4 Weeks	200	3435.76
5 Weeks	100	2995.7
5 Weeks	150	4473.7
5 Weeks	200	5897.7

The proposed algorithm can be converted into a more general mathematical formula:

1. **Age Factor** (*age_factor*)

$$age\_factor = \frac{age\_days_i}{\max\_age\_days}$$

2. **Feed Requirement** (feed_requirement):

feed_requirement =

$$\sum_{i=1}^{n}\left(\frac{age\_days_i}{\max\_age\_days}\right)\ avg\_feed\_per\_chicken_i$$

Here, n represents the number of datasets in the sub routine feed_data, and the summation iterates over each i-th dataset. The formula encompasses all the datasets within feed_data, where age_daysi and avg_feed_per_chicken denote the i -th dataset values.

Based on the results of research that have been described and passed several tests, the development of IoT-based feeding systems and Mobile Apps is able to feed chickens remotely (both manually and automatically). This system can control remote feeding for farmers, can monitor in real-time via a mobile application, and remote control of lighting conditions through the application when the temperature drops below 32° C has also been tested. The effect of this success is a reduced budget for feeding based on the specific needs and age of chickens.

Several studies have been found to have developed IoT-based feeding systems, However, many are found for Fish Feeding Systems, such as [26] by creating simulations IoT-based solar-powered automated fish feeding system using MATLAB Simulink software. [27] developed prototype of a dynamic fish feeder based on fish existence in the form of a NodeMCU microcontroller board ESP8266 programmed for the developed hardware. The controller controls the feeding and feedback mechanism based on the attached ultrasonic sensor. The use of IoT for chicken feeding systems has not been found much. The system for chicken farming is carried out by [28] but IoT-based systems developed for poultry monitoring in detecting chicken behaviour in poultry farms and providing valuable information to industry stakeholders for management decisions and health status of individual poultry. This research focuses on IoT-based feeding systems and mobile app's to determine the most feeding estimation and profit maximization. Developments made related to temperature, humidity, and time factors where this system has not been associated with health control of chicken behaviour are also interesting when integrated.

4. CONCLUSIONS

This study addresses the challenges faced by chicken farms located in remote areas, where distance increases operational costs and time for coop management. Recognizing the inefficiencies of manual feeding, we propose a smart feeding system integrating IoT and Mobile Apps. The system, comprising Nodemcu, load cell sensor, DHT11 sensor, relay, RTC DS3231, servo motor, and I2C 16x2 LCD, is controlled through a mobile application. Primary features include temperature, humidity, light settings, feed information, and auto/manual feed scheduling.

Extensive testing confirmed real-time monitoring and regulation of coop conditions. The mobile app provides historical feed data based on feeding dates. Experimentation with varying chicken ages and quantities estimated a feed consumption rate of 82 grams per second. Our study contributes valuable insights to the advancement of automated feeding systems in the poultry industry, fostering efficient farm management practices and economic optimization (profit maximization). In future

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developments, this feeding system could be integrated with solar panels and battery technology to enhance the sustainability of the chicken coop.

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