Design and Implement a Smart Conveyor System for Sorting Eggs Based On Quality and Weight

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Abstract. Eggs are a common and accessible culinary item. Eggs are a vital source of nutrients for the human body and have a high nutritional value. Selecting high-quality eggs is essential since low-quality eggs can have a negative impact on health. Due to the human eye's limited capacity to accurately sort vast amounts of eggs, farmers typically experience problems with errors in egg quality selection. This final project intends to develop an Internet of Things-based conveyor system for size and quality sorting of eggs. A smartphone running Android can be used to sort eggs by quality and keep track of their quantity on the conveyor belt. According to the findings of the tests, the accuracy for identifying egg quality is 92%. 4.6% is the load cell sensor's standard error, which is considered to be minimal. The throughput calculation was 4.002 Mbps, and the delay calculation findings were 900 ms when assessing the relative Quality of Service. (*Abstract*)

Keywords: Egg Quality, Conveyor, Internet of Things, Quality of Service.

1 Introduction

Eggs are a food ingredient that is very often and easily found among the public. Eggs themselves have pretty good nutritional content and are an essential source of nutrition for the human body. However, if one requires information regarding the viability of eggs in terms of their quality, distinguishing between those that are still suitable for consumption and those that are not, it will inevitably impact the nutritional composition of the eggs. The quality of eggs impacts the humans who consume these eggs.

In this modern era, the livestock industry has experienced significant progress in efforts to increase efficiency and productivity. One thing that continues to be a challenge is sorting good-quality eggs[1]. Eggs are an essential commodity in the livestock industry, and egg quality greatly influences sales value and customer satisfaction.

However, farmers often need help manually sorting tens or even hundreds of eggs. The limited ability of the human eye to sort egg quality with high and consistent

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accuracy is a significant obstacle. The human eye is susceptible to visual fatigue and human error, especially if the sorting task must be repeated over a long period[2].

Sorting eggs manually also requires a significant investment of time. This process takes significant time, which can ultimately hurt livestock productivity. Meanwhile, farmers must focus on various aspects of livestock management, such as animal care, feed management, and environmental management, so the time spent manually sorting eggs becomes increasingly limited.

On laying hen farms, the egg sorting system is the process of sorting eggs to determine the quality of the eggs before they are distributed to traders or consumed by consumers. Some manual techniques that can be done are, for example, placing the egg in water, shining a flashlight on the egg in a dark place, and then looking at its contents. In research [3] using an LDR sensor to determine the quality of eggs, good or bad, then using an Arduino Nano ATMega328 microcontroller and LCD as a display of the status of the eggs being tested and a servo motor as the driver of the egg sorter to separate good eggs from rotten eggs automatically.

Based on the problem description above, to complement the shortcomings of previous research, an idea was created to build a conveyor for sorting. The conveyor will be more efficient, effective, and selective in selecting good-quality eggs because, in the prototype, there is a sensor that can determine whether eggs are good or bad. The weight of eggs ranges from small to medium-large. The notification system is in the form of an LCD, which will display egg information, and there is also an application that can be used for monitoring.

2 Literature Review

There are several studies regarding egg quality sorting. In research conducted [4], egg quality sorting was carried out using an LDR sensor. The eggs are illuminated using a lamp, then the brightness level is measured. Data from LDR sensor measurements is sent to a Google Sheet and then displayed on Android. There is also research on detecting egg conditions and sorting egg sizes using Arduino Uno [5]. In this research, an LDR sensor was used to determine egg quality, and an ultrasonic sensor to detect egg size. The weakness of this research is that there needs to be IoT technology for monitoring.

Research using IoT technology used to count the number of eggs automatically has been carried out. One of them is making Egg-o-Matic, which can automatically count eggs using an infrared sensor and NodeMCU8266 [6]. Egg count data is stored in Firebase and displayed on the website. Apart from Egg-o-Matic, there is also research using IoT to monitor the number of eggs. Research conducted in [7] can detect egg quality with 95% accuracy using an LDR sensor. A website for monitoring egg quality and quantity uses a MySQL database.

The majority of egg-quality sorting is done using an LDR sensor. There is a method for sorting egg quality using fuzzy logic based on the results of LDR sensor readings. The accuracy of egg sorting using fuzzy logic has an accuracy of 95% [8]. Apart from detecting egg quality, there is research to detect egg size based on weight. Egg weight detection using a load cell sensor [9]. Selection of egg size based on weight using a servo motor. Egg weight selection can be done with a video sensor and measurement cell [10]. The accuracy rate for measuring egg weight is 94-98%.

3. Research Methods

The Prototyping Method is a system development procedure that uses an approach to build a program effectively so that users can evaluate it. Model prototyping is the development of a system method in which the results of the analysis of parts of the system are directly applied to a model without waiting for the entire system to be completed so that later, it can be directly evaluated by system users and the evaluation results are used as a reference in creating the system [5]. The steps are as in Figure 2.1.

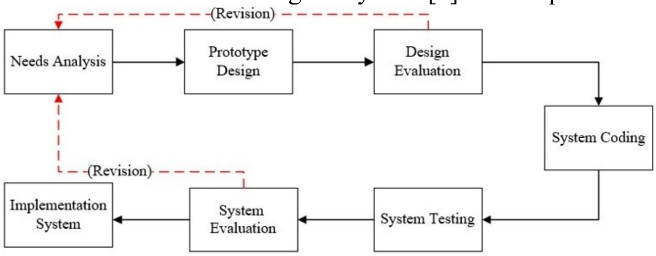

Fig. 1. Prototyping Method

An IOT-Based Egg Quality and Egg weight sorting conveyor is made with the help of requirements analysis, which examines the hardware and software requirements. The necessary hardware specifications include: ESP32, Load Cell Sensor, LDR Sensor, Infrared Sensor, LED, Servo Motor, DC Motor, Power Supply, Conveyor, and LCD. Some of the software utilized is Arduino IDE, Android Studio, Firebase.

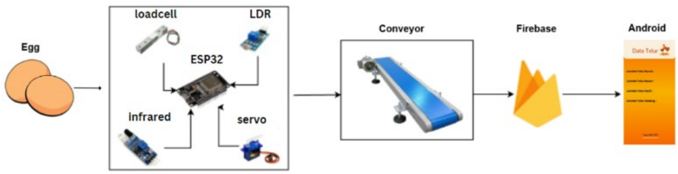

Fig. 2. Block Diagram of The System

Implementing a conveyor system enables egg farmers to enhance their efficiency in sorting eggs by quality and weight. Before assessing egg quality, the egg's weight is measured via a load cell. Once the measurement of the egg's weight has been successfully determined, the egg will subsequently proceed along the conveyor. The identification of egg quality entails the utilization of an LDR sensor in conjunction with LED light to provide illumination to the eggshell.

If the quality of the eggs is poor, the eggs will travel to the end of the conveyor. However, if the quality of the eggs is good, the eggs will be sorted by weight. The egg-weight sorting process uses a sorter connected to a servo motor. Eggs will be grouped based on size. They were determining egg size based on egg weight. The food is categorized as significant if the weight is more than 60 grams. The food is categorized as medium if the weight is greater than 50 grams and less than 60 grams. Then, if the egg weighs less than 50 grams, it is categorized as minor. More details about how the conveyor system works are shown in Figure 3.

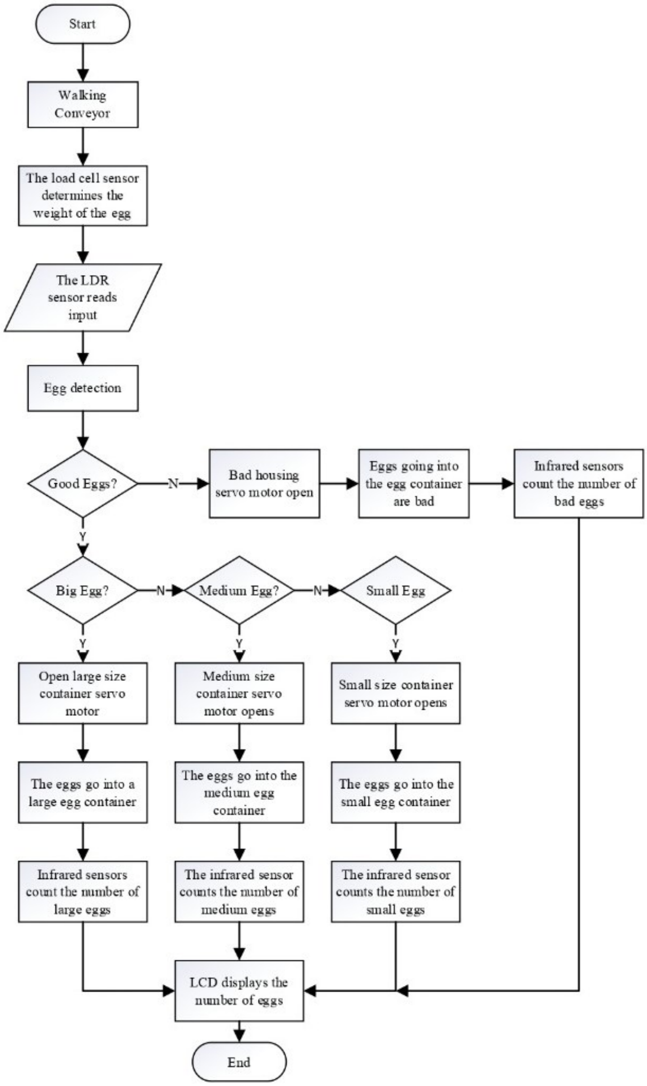

Fig. 3. Flowchart for a Conveyor System

According to Figure 3, the system will weigh the eggs using a load cell and then utilize LDR to sort their quality from good to bad before placing them in the designated container. The broad description of the system design that is being produced will be explained by the block diagram.

4. Findings and Discussion

4.1 Functional Analysis of System

The ESP32 microcontroller is the central component within this system, functioning as a control system for a diverse range of sensors. The egg quality sorting conveyor system is equipped with various sensors. These sensors include a DC motor responsible for the movement of the conveyor. Additionally, a load cell sensor is utilized to detect the weight of the eggs. An LDR sensor is employed to assess the quality of the eggs, distinguishing between good and bad ones. Furthermore, an infrared sensor is utilized to count the number of eggs. Lastly, a servo motor is employed to direct the eggs into the appropriate container based on their predetermined weight. The conveyor view that has been assembled is depicted in Figure 4 and Figure 5.

Fig. 4. The side view of a conveyor system

Fig. 5. Top View Conveyor System

The prototype model depicted in Figure 4 and Figure 5 is constructed using wood and acrylic materials. The load cell sensor is positioned within the arrangement of the acrylic containers, while the LDR sensor is situated on the acrylic ceiling. Additionally, each container is equipped with an infrared sensor, and a servo motor is employed to control the orientation of each container.

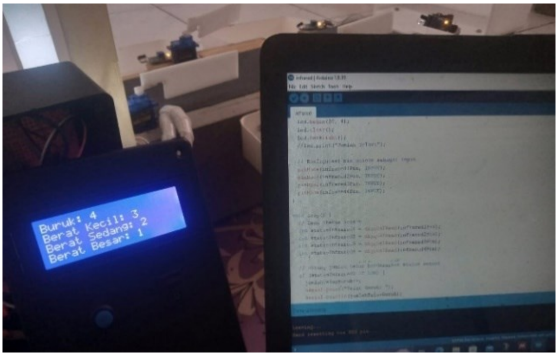

Fig. 6. Infrared Sensor Testing

Figure 6 illustrates the experimental evaluation of the infrared sensor, wherein it is evident that the implemented algorithm effectively displays the corresponding egg weight measurements.

4.2 Android Functional Analysis

The purpose of developing an Android application is to provide users with the ability to view the quantity of eggs in each respective category. The Android application's main page presents data retrieved from Firebase. The Android application is utilized for real-time monitoring of the quantity of eggs in each category. During the testing phase, the data presented on the screen will dynamically alter in response to the readings obtained from the sensor. The subsequent findings pertain to the evaluation of the primary menu page depicted in Figure 7.

Fig. 7. The Application Interface for Monitoring Egg Numbers

4.3 The Assesment of Egg Quality

An LDR sensor is utilized in testing to assess the degree of egg quality. If the egg's analog-to-digital converter (ADC) value is less than 1200, it is classified as good. Conversely, if the ADC value of the egg exceeds 1200, it is classified as rotting. The detection process is further facilitated by utilizing a white LED light, which emits illumination upon the LDR sensor's detection of the egg. Additionally, manual observation is conducted by directing light onto the eggshell. If the light emitted by the lamp can permeate the eggshell, the egg is deemed satisfactory.

Conversely, if the light emitted by the lamp fails to penetrate the eggshell, the egg is considered spoiled. In order to conduct this examination, a total of five tests were performed, with a sample size of ten eggs. During five experimental trials, an error occurred in the Light Dependent Resistor (LDR) sensor's ability to capture the Analog-to-Digital Converter (ADC) data. This error was attributed to the erroneous positioning of the egg while it was placed beneath the LDR sensor. The percentage error calculation is shown in Equation 1. Meanwhile, the average error calculation is shown in Equation 2.

$$Error\ (\%) = \frac{Manual\ Value - Prototype\ \ Value}{Manual\ Value}\ x\ 100\% \qquad (1)$$

$$Average = \frac{Total\ Value}{Amount\ of\ Data}\ x\ 100\% \qquad (2)$$

Table 1 displays the outcomes of recapitulation calculations conducted for the purpose of assessing egg quality.

Tabel 1. Recapitulation of Egg Quality Testing

Egg Data	Reading Egg Values with LDR Sensor					Acc
	Test 1	Test 2	Test 3	Test 4	Test 5	
Rotten Eggs	√	√	√	√	X	80%
Rotten Eggs	√	√	√	√	√	100%
Rotten Eggs	√	X	√	√	√	80%
Rotten Eggs	√	√	√	√	√	100%
High-quality Eggs	√	√	√	√	√	100%
High-quality Eggs	√	√	√	√	√	100%
High-quality Eggs	√	√	√	√	√	100%
High-quality Eggs	√	√	√	√	√	100%
High-quality Eggs	√	X	√	√	√	80%

High-quality Eggs	√	√	√	√	X	80%
Average						92%

Table I reveals that the accuracy value for egg quality detection is 92%. It can be concluded that the system can identify mole quality accurately. The LDR sensor must be calibrated often to achieve accurate data readings.

4.4 Experimental Evaluation of Loadcell Sensor Readings

The purpose of this experiment is to assess the weight of eggs by employing a load cell sensor. The eggs are categorized into three sizes: small (weight less than or equal to 50 grams), medium (weight greater than 50 grams and less than or equal to 60 grams), and large (weight greater than 60 grams). The measurement is conducted using a manual scale. During the totalload cell sensor measuring experiment, a value of '0' was observed, indicating the absence of any measurable quantity.

The examination is conducted by the comparison of weight measurement data obtained from the load cell sensor with that obtained from conventional scales. To determine the error, one can calculate the average error using equation (1), and also compute the average of all values using formula (2) provided.
Table II presents the outcomes of weight measurements obtained through the utilization of the load cell sensor for the purpose of determining egg weight.

Tabel 2. Summary of Egg Weight Monitoring Experiments

Data	Egg Weight (gram)			
	Manual Measurement	Loadcell Measurement	Measurement Difference	Error (%)
1.	56	54	2	3,57
2.	55	53	2	3,63
3.	54	52	2	3,70
4.	57	54	3	5,26
5.	56	53	3	5,35
6.	57	54	3	5,26
7.	57	54	3	5,26
8.	53	51	2	3,77
9.	55	53	2	3,36
10.	57	54	3	5,26
11.	57	53	4	7,01
12.	58	55	3	5,17
13.	59	56	3	5,08
14.	55	52	3	5,45
15.	54	52	2	3,70
16.	53	51	2	3,77
17.	56	53	3	5,35
18.	57	54	3	5,26
19.	53	51	2	3,77
20.	55	53	2	3,63
21.	58	55	3	5,17
22.	54	52	2	3,70
23.	59	57	2	3,38
24.	56	53	3	5,35

25.	55	52	3	5,45
26.	53	50	3	5,66
27.	52	50	2	3,84
28.	56	54	2	3,57
29.	55	53	2	3,63
30.	53	50	3	5,66
Average			2,5 Gram	4,60%

The average difference in egg weight is 2.5 grams, and the percentage error in egg weight is 4.6%. Graph Figure 8 shows the comparison of egg weight differences more clearly.

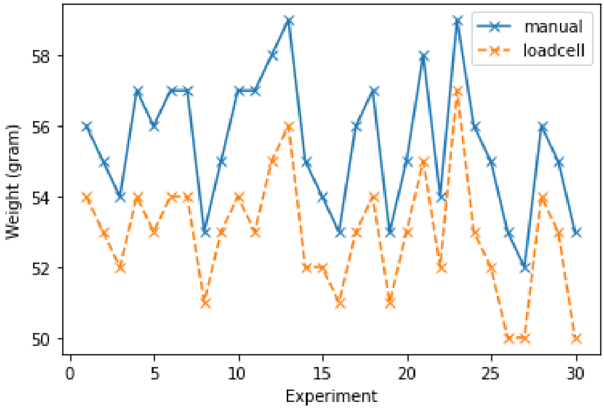

Fig. 8. A Comparative Analysis of Egg Weights

The test findings indicate that the loadcell sensor exhibits a commendable ability to accurately detect the weight of eggs, with a comparatively minimal margin of error. While hand measurements may exhibit variations, these discrepancies are acceptable in several situations. The findings of this study demonstrate the precision of the load cell sensor in quantifying the weight of eggs, particularly in the case of medium and small-sized eggs. While there exists a minor distinction, the mistake is mainly tolerable. Hence, load cell sensors exhibit a high degree of reliability and effectiveness in accurately detecting the weight of eggs.

4.5 Quality Of Service (QoS) Parameter Testing

Quality of Service (QoS) testing is conducted in order to assess the caliber of network and system services. The quality of service (QoS) criteria that were assessed in this study were delay and throughput. The experiment involved conducting delay and throughput tests on five separate occasions. The test results are presented in Table III.

Tabel 3. QoS Testing

Data	QoS Parameter	
	Delay (ms)	*Throughput* (Mbps)
Test 1	505	1,46
Test 2	552	7,60

Test 3	1.129	3,71
Test 4	1.143	3,67
Test 5	1.173	3,57
Average	900	4,002

Based on Table III's QoS parameter testing results, a visualization of the delay test results is obtained in the Figure 9 graph and the throughput test results in Figure 10.

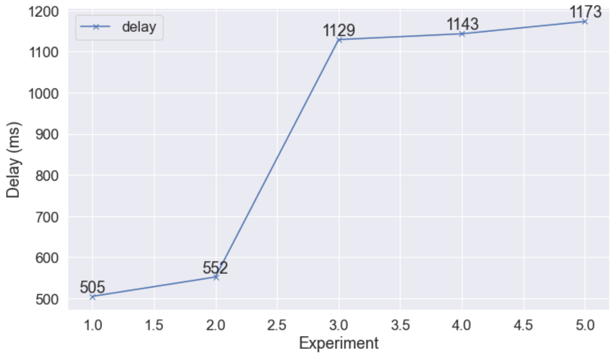

Fig. 9. Delay Testing

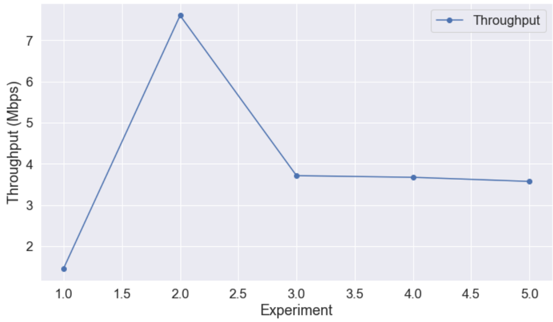

Fig. 10. Throughput Testing

Based on the QoS test results, it is known that the average value of the throughput test is around 4.002 Mbps, and the average value of the Delay test is around 900 ms. According to the Tiphon standard, this value is included in the Excellent category.

5 Conclusion

According to the test results, the constructed conveyor system demonstrates a 92% accuracy rate in detecting egg quality. The weight of eggs can be determined using a load cell sensor installed on the conveyor system. The percentage inaccuracy in egg weight is relatively insignificant, specifically about 4.6%. The distribution of eggs into categories of large, medium, and small is determined based on their respective weights. The detection of egg quantities can be achieved by using an Android smartphone. The constructed conveyor system demonstrates a high Quality of Service (QoS) excellence by the Tiphon standart [11]. This is supported by the empirical data, which indicates an average throughput value of 4.002 Mbps and an average latency value of 900 ms.

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