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Smart Egg Sorting Monitoring System Based on Internet of Things

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ABSTRACT

The poultry farming industry plays an important role in supplying affordable animal protein. However, egg sorting processes are still commonly performed manually, resulting in inefficiency and inconsistent classification. This research proposes an Internet of Things (IoT)-based egg sorting monitoring system utilizing an ESP32 microcontroller integrated with a load cell sensor for weight measurement and an LDR sensor for shell quality evaluation. The system automatically classifies eggs and transmits monitoring data in real time to the Thinger.io web platform. Experimental results demonstrate that the proposed system achieves high classification accuracy with minimal measurement error. The implementation of this system indicates that IoT technology can significantly enhance efficiency, accuracy, and digital data accessibility in poultry farming.

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1. INTRODUCTION

The rapid development of Internet of Things (IoT) technology has enabled the integration of sensing devices, embedded systems, and internet connectivity to support automation and real-time monitoring across various sectors, including agriculture and livestock farming [1]–[4]. IoT systems provide a foundation for data acquisition, communication, and intelligent decision-making, supported by advances in real-time data processing and machine learning techniques [5]. In addition, the application of IoT in agriculture has been widely recognized as a key driver in improving efficiency and productivity in smart farming systems [6]. The evolution of industrial technology toward Industry 4.0 has further accelerated the adoption of IoT-based solutions in various domains [7].

In the poultry industry, egg quality and weight classification are critical factors that influence market value and consumer acceptance [8]. However, conventional egg sorting methods still rely heavily on manual inspection and weighing, which are time-consuming, labor-intensive, and prone to inconsistencies due to human error and fatigue [9]. This issue is particularly evident in small and medium-scale poultry farms, where limited access to automation technologies leads to inconsistent product quality, higher risk of egg breakage, and reduced operational efficiency [10].

Several studies have explored automation and IoT-based solutions for egg sorting and monitoring. For example, microcontroller-based egg grading systems have been developed to classify eggs automatically based on weight, showing improvements in sorting speed and consistency [9]. In addition, IoT platforms such as Thinger.io enable real-time data transmission and monitoring, allowing users to remotely access system performance and production data [11]. Other research highlights the role of sensor data preprocessing and classification techniques in improving accuracy and reliability in IoT-based systems [12]. Furthermore, cloud-based IoT architectures support scalable data management, interoperability, and traceability in agricultural applications [13], [14]. General reviews on IoT also emphasize the importance of system integration and data connectivity in achieving efficient smart systems [15].

Recent studies have also highlighted the importance of intelligent data processing and sensor integration in enhancing IoT system performance. Sensor taxonomy and preprocessing techniques play a crucial role in improving the quality of data used in decision-making systems [16]. In addition, IoT architectures and communication protocols continue to evolve to support scalable and efficient system deployment [17]. Cloud-based IoT frameworks enable flexible and distributed data processing environments [18], while comprehensive reviews indicate that IoT systems are increasingly applied across multiple domains with growing complexity and capability [19]. Moreover, reference architectures provide structured approaches for designing interoperable and scalable IoT systems [20]. The integration of intelligent algorithms such as digital image processing and neural networks further enhances system capability in classification and pattern recognition tasks [21].

Despite these advancements, several limitations remain. First, most existing egg sorting systems focus primarily on single-parameter classification, particularly weight, without considering other important quality indicators such as shell condition [9]. Second, many IoT-based solutions emphasize monitoring capabilities but lack tight integration with automated sorting mechanisms, resulting in fragmented systems [11], [13]. Third, a significant portion of existing systems relies on relatively complex architectures or costly implementations, making them less accessible for small and medium-scale poultry farmers [10], [14]. These limitations indicate a clear gap in developing an integrated, low-cost, and multi-parameter egg sorting system with real-time monitoring capabilities.

Therefore, this research aims to develop an IoT-based egg sorting and monitoring system capable of automatically classifying eggs based on both weight and shell quality while providing real-time monitoring through a web-based platform. The proposed system offers a fully integrated pipeline combining sensing, classification, actuation, and IoT-based monitoring within a single architecture. In addition, this study emphasizes the use of low-cost and modular hardware design, making the system more accessible and scalable for small and medium-scale poultry farms. This combination of multi-parameter classification, system integration, and cost-efficient design constitutes the main novelty of this research.

2. METHOD

The proposed system consists of sensing, processing, communication, and monitoring components. An ESP32 microcontroller functions as the main controller. A load cell sensor is used to measure egg weight, while an LDR sensor evaluates shell transparency to determine egg quality. Sensor data are processed locally and transmitted via Wi-Fi to the Thinger.io platform for real-time visualization.

This system is designed to utilize an ESP32 as a microcontroller and data connection to the network. Furthermore, a proximity sensor detects the presence of eggs. A motor driver controls the motor's performance, which also drives the conveyor. An LDR sensor reads the egg density level to determine the condition or quality of the eggs. A load cell sensor measures the egg's weight. A servo motor pushes or sorts the eggs. The resulting classification process generates data that is then sent over the internet and can be viewed via an IoT web platform or an IoT application on a smartphone or laptop. The system block diagram is shown in Figure 1.

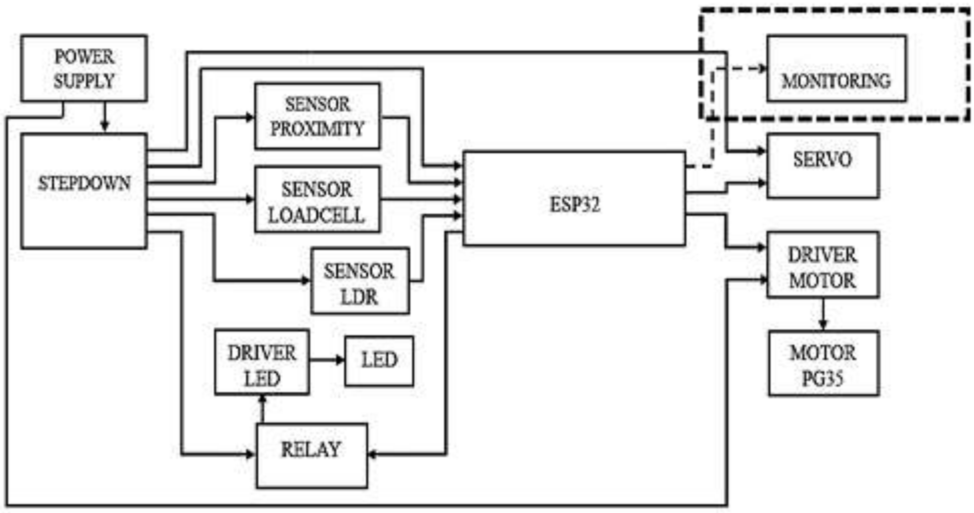

Figure 1. Block Diagram

Flowcharts are used to illustrate the concept and workflow of a system. The following is a complete flowchart of the automatic egg sorter, shown in Figure 2. The working principle of IoT-based chicken egg sorting monitoring can be described as follows:

1. System Initialization. The system prepares the hardware and software for operation.
2. Egg Data Acquisition. Egg data, such as the number and quality parameters of good or rotten eggs, and the size of large, medium, and small eggs, are obtained from sensor readings.
3. Data Processing and Sending to the IoT Platform. The data is processed by the ESP32 microcontroller and then sent to the IoT platform for monitoring.
4. Egg Data Display. The available data is displayed in an easy-to-understand format, such as a table or graph, for the user. This system is expected to operate automatically, and the egg sorting data can be displayed on the IoT platform for more efficient monitoring.

The wiring of the IoT-based chicken egg sorting system can be seen in Figure 3.

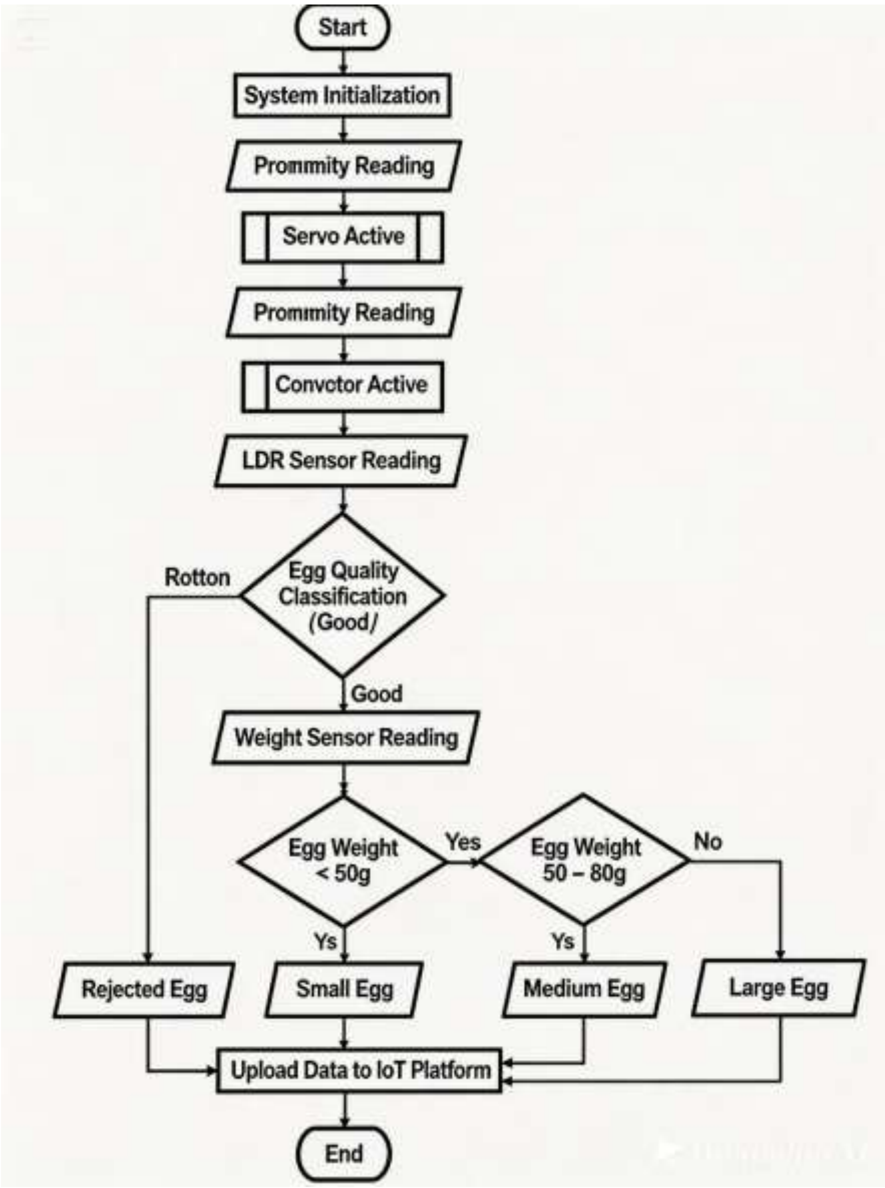

Figure 2. Flow Diagram

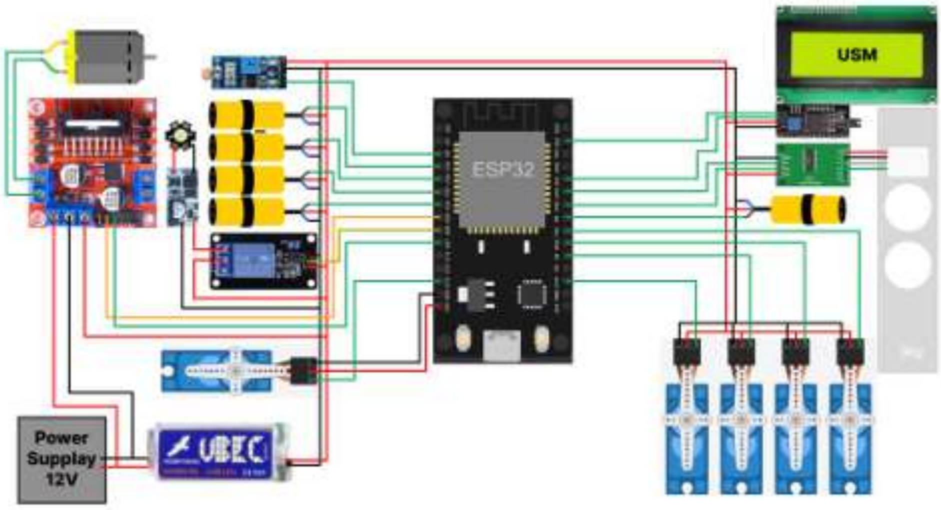

Figure 3. Wiring System

Table 1. The performance of ...

Table Head	TABLE I. TABLE COLUMN HEAD		
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3. RESULTS AND DISCUSSION

The program implementation of this research is explained by the Arduino IDE program code used on the ESP32 microcontroller. The ESP32 microcontroller processes the data from sensor readings and sends the data to the web or IoT platform, which will then display it as a monitoring display.

The data displayed on the Thinger.io website is real-time data uploaded by a microcontroller. The visual implementation of the web monitoring is designed to make it easy for users to understand and access the information presented. The data or information presented includes real-time egg weight, egg size classification, number of rotten eggs, number of small eggs, number of medium eggs, number of large eggs, total good eggs, and the total number of good eggs. A visual display of the dashboard settings on the Thinger.io website for visual monitoring results can be seen in Figure 4.

Figure 4. Dashboards Display on Web Monitoring

Furthermore, the visual implementation of the stored data is found in the data bucket section, which also displays data from sorting results during the sorting process and those that have occurred or are currently in progress.

Testing was conducted using four eggs to observe differences in the resulting results, especially on the web monitoring interface. The first test focused on LDR sensor readings to determine egg quality based on the level of shell transparency. If an egg appears too dark when exposed to light, it is considered poor quality or rotten. The following are examples of data collection, shown in Figures 5 and 6.

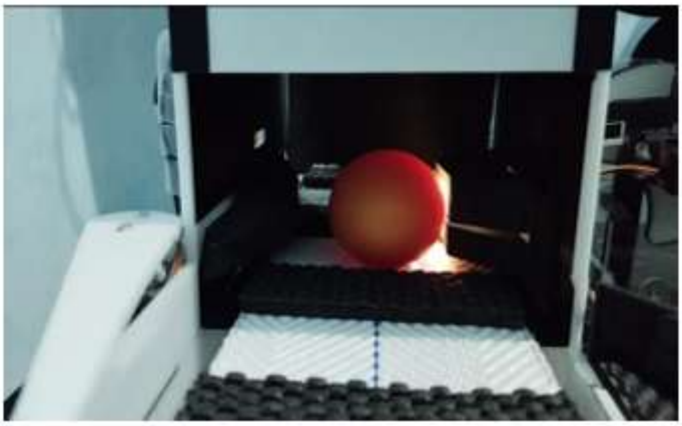

Figure 5. Testing the Quality of Eggs That Look Rotten

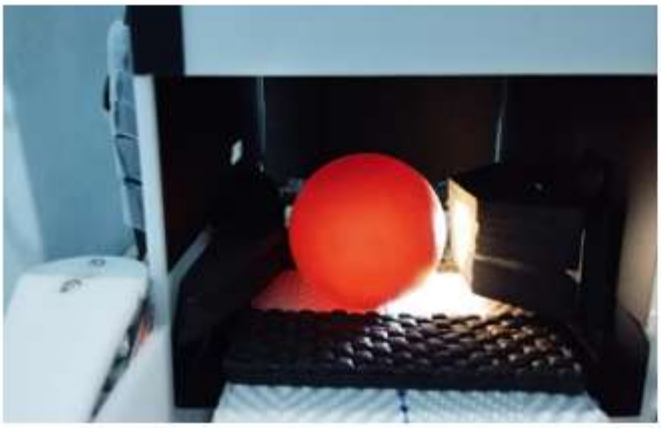

Figure 6. Egg Quality Testing That Reads Good

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The Figure 5 and 6 show an LDR sensor test to determine egg quality. If the light is too intense, the eggs are considered bad or rotten and will then be selected. If the transparency level is high, the eggs are considered good and will proceed to the next selection stage.

Table 1. Egg Testing

No	Test Object	Manual Egg Quality Assessment	Egg Quality Assessment Using LDR Sensor	Egg Quality Display on Web Monitoring	Error	Remarks
1	Egg 1	Good	Good	Good	0%	Match
2	Egg 2	Good	Good	Good	0%	Match
3	Egg 3	Good	Good	Good	0%	Match
4	Egg 4	Bad	Bad	Bad	0%	Match

Next, the egg weight was tested using three eggs. Measurements were taken using a load cell sensor and compared with a digital scale for comparison. The primary focus of this test was to determine the accuracy of the results displayed on the web monitoring platform, both in terms of weight and accuracy. The following are some sample images of data collection conducted to determine egg weight before proceeding to the next selection stage, as shown Table 2. Repeated testing was conducted to ensure the accuracy and consistency of sensor readings and the validity of the data displayed on the web monitoring. Although there were slight differences in weight values due to sensor tolerances, the results were within acceptable limits.

Table 2. Weight Testing

No	Test Object	Manual Egg Quality Assessment	Egg Quality Assessment Using Weight Sensor	Egg Quality Display on Web Monitoring	Error	Remarks
1	Egg 1	67	68	68	0.01%	Error
2	Egg 2	52	52	52	0%	Match
3	Egg 3	45	45	45	0%	Match

The final test is conducted to determine the egg weight classification results based on the following criteria: Weight <50 grams = Small (S), Weight 50-60 grams = Medium (M), Weight >60 grams = Large (L), This classification test is the next step in the egg weight measurement process.

In the classification process as shown Table 3, each egg weight reading is divided into three categories, and each egg with a different weight is selected into a designated container. The eggs are then pushed and directed by a servo motor into the designated container. The data from this selection process is then displayed on the web monitoring platform in the form of classification results. Thus, from the entire testing process that has been carried out, both in terms of quality, weight, and egg classification, the system has shown good performance and the results displayed on the web monitoring are in accordance with the sensor readings and comparison tools.

Table 3. Weight Testing

No	Test Object	Weight measurement results	Clasification	Egg Clasification Display on Web Monitoring	Error	Remarks
1	Egg 1	67	L	Large	0.01%	Match
2	Egg 2	52	M	Medium	0%	Match
3	Egg 3	45	S	Small	0%	Match

System testing was conducted using multiple egg samples with varying weights and shell conditions. The load cell sensor produced stable and accurate measurements, while the LDR sensor successfully distinguished egg quality categories. Monitoring data were displayed in real time on the Thinger.io dashboard. The results indicate that the system performs reliable classification and supports remote monitoring effectively.

4. CONCLUSION

Based on the results of the design, implementation, and testing, the developed IoT-based chicken egg sorting and monitoring system demonstrates strong performance, achieving a classification accuracy of 100 %, an average response time of 0.1 seconds, and a classification success rate of 99 %. These results indicate that the system is capable of performing real-time, accurate, and consistent egg sorting, making it suitable for practical application in small and medium-scale poultry farms. The integration between sensors, ESP32 microcontrollers, and the Thinger.io platform is able to support the monitoring process effectively. This system can present egg sorting data accurately and in real-time, both for egg quality using LDR sensors and weight measurements using load cells, and displays the results through cloud-based web monitoring. The IoT implementation has proven effective for remote monitoring, with easy and responsive data access. The test results show that the system achieves an accuracy of 100 %, with an average error value of 0.01%. These results indicate that the system is reliable and suitable for implementation in automatic egg sorting processes.

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