Automated Egg Incubator with Camera-Assisted Candling

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ABSTRACT
Hatching abandoned chicken eggs is crucial for embryo survival and chick development, requiring optimal temperature and humidity levels. Fluctuations can lead to developmental issues or low hatch rates. There are existing solutions, such as placing the abandoned egg under another brooding hen. However, since not all eggs can be covered by another brooding hen, the option of a do-it-yourself incubator arises, allowing for the incubation of multiple eggs until more convenient technologies emerge, leading to the invention of more advanced incubators. The proponents proposed enhancing such incubators with a camera-assisted candling device and automated features. These enhancements were inspired by existing solutions discovered during online research, this system efficiently selects fertile eggs and ensures precise conditions. Its mobile application allows remote monitoring, as long as they have internet connectivity. The proponents are motivated by a strong desire to improve egg hatching by developing an automatic incubator. The system aims for precise conditions and automated detection, optimizing efficiency and success rates. This innovation not only improves hatching success rates but also contributes to the welfare of the chicks.

Keywords
Automated Egg Detection, Automated Incubator, Automated Separation, Candling, Embryo Development, Hatchability

1. INTRODUCTION
Poultry egg incubation is a meticulous process requiring precise care and monitoring to ensure successful hatchability. It is important to maintain specific temperature and humidity levels throughout the incubation and hatching phases. However, distinguishing between fertile and rotten eggs poses a significant challenge, particularly for large- scale poultry farms where manual inspection is impractical. To address these challenges, innovative solutions have emerged, building upon existing technology like the

"Automated Egg Incubator with Raspberry Pi-Based Camera Assisted Candling and R-CNN-based Maturity" by LK Tolentino [1]. This system integrates sensors, cameras, and image processing to automate egg separation and monitor embryo development. By distinguishing between fertile and rotten eggs, it streamlines the incubation process, enhancing efficiency and reducing waste. Moreover, advancements such as the inclusion of a conveyor belt and IR sensor in the "Automated Egg Incubator with Camera-Assisted Candling" further improve functionality. This system employs technology like the ESP32 and DHT22 sensors to regulate internal temperature and humidity, while a mobile application enables remote monitoring and control.

By leveraging these innovations, poultry enterprises can optimize hatchery operations, saving time and resources while improving hatch rates. Ultimately, these advancements aim to foster the growth of poultry farming and enhance sustainability within the industry.

2. RELATED LITERATURE
Researches related to this study were gathered data and served as the basis for the study. [2] One of these is the comprehensive exploration of egg incubation systems and their crucial components, including temperature control, humidity regulation, ventilation, and egg flipping mechanisms El-Ashram, M.M. This research delved into the optimization of incubation conditions to ensure optimal juvenile quality and volume. [3] Additionally, it introduced the concept of integrating IoT technology with smartphone applications for enhanced monitoring and operation of smart incubation systems Niranjan, L., et al.

This emphasized the importance of monitoring temperature and humidity levels during egg incubation to ensure successful hatching which plays a crucial role in embryo development and hatchability rates. Furthermore, the significance of egg flipping during the incubation process to prevent embryo attachment and ensure optimal hatchability. This underscores the importance of proper management practices in egg incubation.

$$\text{Percentage} = \frac{\text{Total no of "yes" got in survey}}{\text{Total no. of question } \times \text{No. of Respondents}} \times 100 \quad (1)$$

$$\text{Percentage} = \frac{\text{Owner+Assistant}}{2} \quad (2)$$

Moreover, the development of LED-based candling systems, as discussed by Pan, C., et al., provided innovative methods for automatically detecting egg fertility, which is essential for increasing hatchery efficiency and reducing costs [4]. Innovative approaches such as image processing techniques for egg candling, as described by Sebastian, V. C. R., et al., provided efficient and non-destructive methods for assessing egg fertility and detecting abnormalities [5]. These advancements contribute to improving hatchery operations and ensuring the quality of hatched chicks. Additionally, the study of Zhu Z., et al. introduced machine learning models for the accurate detection of infertile and dead-embryo eggs, offering fast and reliable methods for activity detection in hatcheries [6]. Such technological advancements are crucial for optimizing hatchery efficiency and reducing resource wastage.

Overall, these studies provide valuable insights into the complex process of egg incubation and chick production, offering innovative solutions and best practices for optimizing hatchery operations and improving poultry production efficiency.

3. METHODOLOGY

The proponents conducted an interview and observation for the proposed project, entitled Automated Egg Incubator with Camera-Assisted Candling for the abandoned chicken egg. The proponents built an Automated Egg Incubator with Camera-Assisted Candling for abandoned chicken eggs, giving them a chance to hatch and live. The incubator acts as a home for the abandoned egg to survive, as well as the environment that the abandoned egg may require, which is far superior to the brooding hen, which frequently leaves its egg (not all), causing a delay in hatching or even the death of the embryo. Maintaining the temperature at 37.2 to 37.9 degrees Celsius and the humidity at 55 to 65 percent and not allowing it to increase or decrease above the predetermined threshold to avoid undeveloped chicks, abnormalities, or embryo death.

The project also included automatic detection and separation of rotten eggs from fertile eggs with 95% accuracy upon testing, wherein if it recognizes that the egg is rotten, it will swipe it. Furthermore, the project also had an application that can be installed on any Android phone. Through this, the owner and the assistant can monitor the temperature and humidity inside the incubator, even if they are outside, as long as they are connected to the internet.

This project serves as a valuable reference for future researchers with similar objectives. During the project's functional requirement phase, the project's functional requirements were meticulously ascertained by closely examining the functionalities depicted in the schematic diagram of the Automated Egg Incubator with Camera-Assisted Candling.

The first formula [1] is used for the assessment of the owner of the incubator and his/her assistant on the system. The second formula [2] is use to consolidate all the assessment of stakeholders on the efficiency of the system.

The proponents built an Automated Egg Incubator with Camera-Assisted Candling for abandoned chicken eggs, giving them a chance to hatch and live. The incubator acts as a home for the abandoned egg to survive, as well as the environment that the abandoned egg may require, which is far superior to the brooding hen, which frequently leaves its egg (not all), causing a delay in hatching or even the death of the embryo. Maintaining the temperature at 37.2 to 37.9 degrees Celsius and the humidity at 55 to 65 percent and not allowing it to increase or decrease above the predetermined threshold to avoid undeveloped chicks, abnormalities, or embryo death. Furthermore, it will be unable to produce chicks that are sensitive to diseases or weaker when they hatch.

The project also included automatic detection and separation of rotten eggs from fertile eggs with 95% accuracy upon testing, wherein if it recognizes that the egg is rotten, it will swipe it so that it is not passed on to the fertile egg, which may cause abnormalities and also prevent it from exploding which may cause a foul smell inside the incubator.

Furthermore, the project also had a mobile application that can be installed on any Android phone. Through this, the owner and the assistant can monitor the temperature and humidity inside the incubator, even if they are outside, as long as they are connected to the internet.

4. PRESENTATION OF ANALYSIS OF DATA

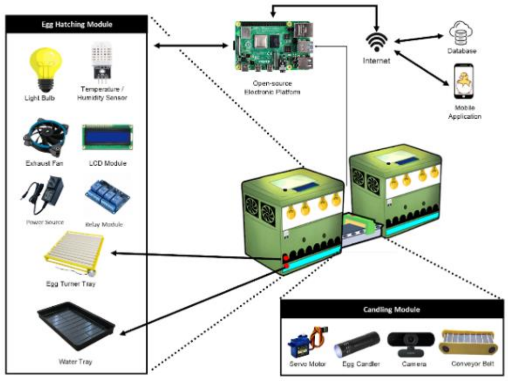

Figure 1. Operational Framework for the Proposed Project

To develop the proposed project (see figure 1), the Automated Egg Incubator with Camera-Assisted Candling, the proponents utilized an open-source electronic platform consisting of Raspberry Pi and ESP32, serving as a programmable microcontroller and the central hub for all connected components. The ESP32 oversaw the control of the DHT22 sensor, relay, and LCD module. The DHT22 sensor monitored the temperature and humidity conditions within the incubator. The relay module regulated the fan, bulb, and egg turner systems. Upon collecting temperature and humidity data, if the temperature fell below a set threshold, the bulb would be activated; conversely, if the temperature exceeded the threshold, the fan would be activated. The egg turner tray rotated the eggs periodically to ensure optimal temperature and humidity, preventing the developing chick from adhering to its shell. The LCD displayed the current status of the incubator.

On the other hand, the Raspberry Pi managed the webcam, IR sensor, servo motor, and relay module responsible for controlling the conveyor. The conveyor belt transported the eggs, halting automatically when an egg was detected by the IR sensor in front of the camera. The camera captured images used in the candling process to ascertain the fertility or viability of each egg. Following this determination, the eggs were sorted using the servo motor.

During the project’s system design phase, the functional requirements were defined. Functional requirements help identify missing requirements. It enables the proponents to determine the system’s intended service. The proposed project’s functionalities follow:

- The system could identify whether an egg was fertile or rotten the moment the camera captured the egg.
- The mobile application could monitor the temperature and humidity inside the incubator.
- The mobile application allowed users to configure the humidity and temperature thresholds.

- The system could separate the rotten egg after detection using the servo motor.
- The system could notify the client using a buzzer if the temperature was too high or low beyond a threshold.

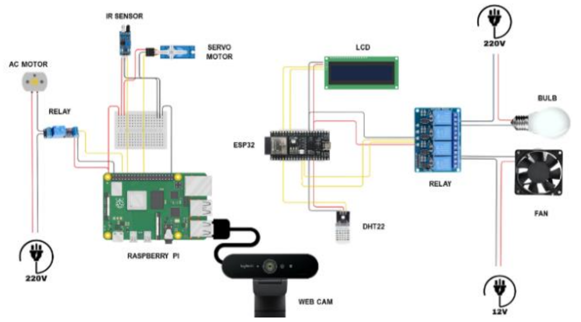

Figure 2. Schematic Diagram of Automated Incubation with Camera-Assisted Candling

The schematic diagram in (see Figure 2) shows the connections between the microcontroller and other components. The open-source electronic platform (Raspberry Pi) as the primary microcontroller, with an ESP32 serving as an additional microcontroller for the DHT22 and relay module. To effectively monitor incubation, a mobile application was integrated to track embryo growth. This mobile app connected to Firebase via the internet, enabling real-time monitoring of temperature and humidity. The system is usable if the user has a mobile application and access to the internet.

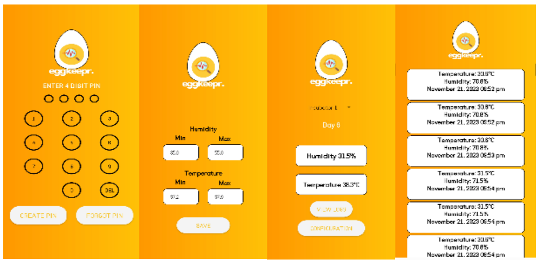

Figure 3. Mobile Application

The proponents designed the main screen or the first display of the mobile application (see in figure 3). This screen includes the PIN Screen, where users enter their PIN to access the incubation system. The user can also generate a new PIN on the and reset it if the user forgets their PIN. After entering the PIN, the Main Screen displays real-time humidity and temperature monitoring, along with buttons for configuration and viewing logs. Pressing the configuration button leads to the Configuration Screen, where users can set minimum and maximum humidity and temperature thresholds. Also, when the user clicks the logs button the Logs Screen will display which allows users to access a history of recorded humidity and temperature levels.

Figure 4. Connection of all modules in Raspberry Pi based on Schematic Diagrams

The Raspberry Pi 4 board served as the central processing unit. Its primary responsibilities in the proposed project included the intricate process of differentiating between fertile and rotten eggs, a critical aspect of the project's functionality. The webcam was used by the system's proponents to capture the eggs. The webcam also involved assessing the system's ability to accurately analyze captured images of eggs using visual cues and image processing techniques. The proponents also integrated a relay that was connected to Raspberry Pi 4; it was responsible for the conveyor system, governing the conveyor belt involved accurate evaluations to ensure its seamless operation, assessing its reliability in efficiently controlling the movement of eggs throughout the production line. IR sensor integration entailed fine-tuning the timing mechanism to halt the egg's movement upon detection by the IR sensor. This process aimed to optimize the sensor's functionality by ensuring precise timing for the conveyor belt to pause accurately when an egg was detected, allowing for efficient and accurate egg inspection. Furthermore, the integration of the servo motor included verifying its activation upon detection of a rotten egg by the system, facilitating the efficient separation and removal of the identified rotten eggs (see figure 4).

Figure 5. Connection of all modules in ESP32 based on Schematic Diagrams

The ESP32 was primarily responsible for controlling DHT22 sensors, which were in charge of accurately measuring internal temperature and humidity. The ESP32 was programmed to interact with the DHT22 sensors at predefined intervals by using appropriate libraries and programming techniques. Its function also included the integration of a relay module, which controlled the operation of both the bulb and fan systems. Furthermore, the egg turner was programmed to activate three times per day, ensuring regular and consistent egg rotation. Lastly, the ESP32 efficiently interfaced with an LCD display, allowing for manual monitoring of the incubator's environmental conditions (see figure 5).

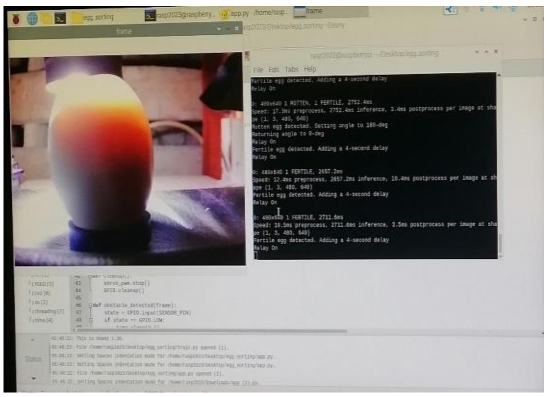

Figure 6. Proponents testing the Fertile and Rotten Egg Identification

The proponents had intended to program the project using the Thonny Python IDE. The focus was initially on developing the chicken egg detection functionality. The proponents initiated testing to distinguish between fertile and rotten eggs. They tested a variety of fertile and rotten eggs to confirm the accuracy of the used detection method. The testing phase (see figure 6) revealed the accurate detection of a rotten egg. The system successfully identified the presence of a rotten egg, showcasing its precision in distinguishing between fertile and rotten eggs.

Figure 7. Proponents presenting the Egg Candling Method to the Assistant

The proponents discussed to the owner on how the detection worked in recognizing fertile and rotten eggs. They demonstrated the system's functionalities through automated processes, such as the relay operates the conveyor until the IR sensor detects an object, identifying eggs using a webcam, and activating the servo for rotten eggs. Furthermore, the proponents explain how the system collects data with each detection, indicating whether the object is rotten or fertile (see figure 7).

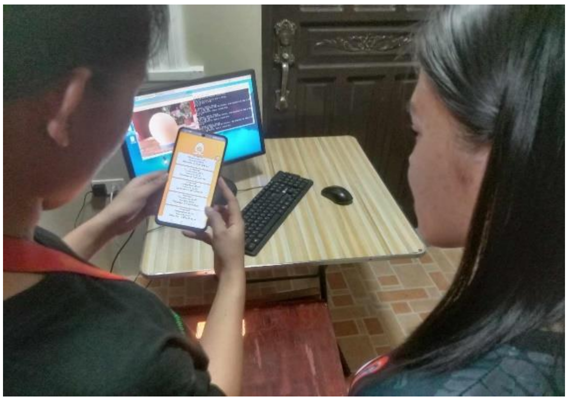

Figure 8. Proponents presenting the Mobile Application to the Owner

During testing (see figure 8), the proponents demonstrated the mobile application's functionalities to the incubator owner. The user-friendly app enabled the owner to monitor and visualize DHT22 sensor data, including humidity and temperature readings inside the incubator. Additionally, it provided a configuration option for users to specify humidity and temperature thresholds.

5. RESULT, CONCLUSIONS, AND RECOMMENDATIONS

Table 1. The owner and the assistant evaluation result

Owner	100 %
Assistant	100 %
Total	**100%**

The survey was conducted and the proponents calculated the survey findings using the survey forms that the owner and her assistant had completed and returned. According to the calculated final survey results, the project's effectiveness level is high, at 100% (see table 1). The survey's findings indicate that the project was efficient.

The Automated Egg Incubator with Camera-Assisted Candling assisted incubator owners in implementing a new method of incubating eggs that allowed abandoned eggs to hatch. The system displayed the exact temperature and humidity of the incubator, allowing owners to monitor the egg and improve the fertility rate of each egg inside the incubator. With the help of Camera-Assisted Candling, the system could also determine whether an egg was fertile or rotten. The proponents concluded that the detection captures detected fertile and rotten eggs with a 95% accuracy rate. It also could automatically separate rotten eggs from fertile eggs once they had been identified.

The Automated Egg Incubator with Camera-Assisted Candling stood out due to its numerous advantages, such as the ability to handle multiple eggs simultaneously and achieve faster hatch times compared to relying on a brooding hen. Additionally, this innovative system could detect and separate rotten eggs from fertile ones, contributing to the production of healthier hatchlings.

The mobile application demonstrated reliability in adjusting the temperature and humidity inside the incubator. It not only simplified the monitoring of egg conditions but also facilitated stakeholders in viewing historical logs of temperature and humidity changes. These logs provided insights into the evolving conditions inside the incubator, keeping stakeholders informed. The proponents concluded that the functions of the Automated Egg Incubator with Camera-Assisted Candling remained effective throughout the deployment phase.

The project was evaluated by the stakeholders, providing a 100% effectiveness rate. The proponents concluded that the project successfully identified fertile and rotten eggs. Moreover, the project proved highly efficient, offering significant assistance in giving abandoned eggs a chance to hatch and survive. It also played a crucial role in accurately distinguishing between fertile and rotten eggs, effectively separating the latter from the former. This functionality proved to be a substantial help for poultry industries, reducing the workload of poultry owners in the egg hatching process.

It is recommended that detection should begin on the 5th day and include the infertile egg detection on the system so that it could be immediately removed from the incubator. The proponents also recommended that the light used for egg candling be placed in the lower part where the egg is placed and that it be fixed, to facilitate the candle and avoid false detection. Furthermore, the incubator had to have no holes so that the heat inside it increased quickly and prevented it from coming out. Lastly, the proponents recommended further study to think of better components for the prototype so that the egg turner would not be removed when the conveyor belt started moving. The projects still had several flaws that allowed for future improvements by other researchers.

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