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AN IOT BASED SMART BIRD CAGE WITH A WATER FILTERING AND MONITORING SYSTEM FOR BIRDS

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Abstract

At present, people have grown fond of raising birds. Birds require different and specialized habitats to cater to their unique needs, and cages that allow space for ample movement help promote their well-being. The study aims to address the challenge in ensuring optimal bird care by developing an IoT Based Smart Bird cage integrated with a water filtering and monitoring system. This includes automated bird feeding, water quality maintenance, waste processing, and temperature and humidity regulation. The system utilizes the ESP32, sensors and remote monitoring using the Blynk Application to enhance bird well-being and support bird owners in maintaining a healthy environment for their birds. ISO 25010 standard is utilized to ensure system quality. The Overall Mean for the system received an overall mean rating of 4.26, interpreted as Excellent. The criteria ratings evaluation scores started with the Functional Suitability with an evaluation of 4.41, the Performance Efficiency with 4.19 evaluation, Usability with 4.36 and Reliability with 4.17, and Security with a 4.17 rating based on the Likert Scale. The feedback from 62 bird owners, 33 bird breeders and 5 IT professionals, indicate that the overall mean evaluated criteria received an Excellent Rating.

Keywords: Internet of Things, Automated Smart Cage, ESP32, Internet of Things, Water Quality Monitoring.

Introduction

A March 2023 survey by the Social Weather Survey revealed that 64% of Filipino families have pets, with 3% owning pet birds (Marcelino, A. 2023). Birds require specialized habitats to support their unique needs for flying, perching, nesting, and breeding (Fahmi et al., 2019). Basic bird cages are becoming outdated, especially as lifestyles grow busier (Hakim et al., 2021). Proper care involves providing sufficient space for flight and exercise, which is crucial for their physical health and mental stimulation. Regular access to nutritious food and clean water is vital to prevent obesity and diseases, affecting their overall well-being (Petsmart, 2024) (Fahmi et al., 2019). Fresh water must be changed daily to prevent contamination, which can lead to health issues (Burns, K., 2021) (Perez, et.al, 2017).

Temperature and humidity are also critical for breeding, with optimal conditions around 25 to 30 degrees Celsius and humidity levels of 77% to 80% (Fahmi et al., 2019). A stable environment reduces stress and supports healthy breeding (Blancaflor et al., 2022).

To address the challenges of bird care, the study proposes an IoT Smart Bird Cage that integrates various sensors and devices, ensuring constant access to food and water, and maintaining appropriate environmental conditions. Currently, bird cages require manual feeding and cleaning, leading to unhealthy conditions for the birds.

The IoT Smart Bird Cage will utilize an ESP32 microcontroller and Wi-Fi module. An automated feeder will dispense bird seeds, and a DHT22 sensor will monitor temperature and humidity. A 5V fan will activate to cool the cage if conditions exceed optimal levels, while a heating lamp will maintain warmth if needed. A conveyor belt, operated by a 360-degree servo motor, will handle waste disposal. A water fountain with a pH sensor will monitor water quality, and a plastic faucet will facilitate waste disposal. The system connects to the Blynk application, allowing users to monitor sensor data and remotely control feeding, ventilation, and cleaning processes.

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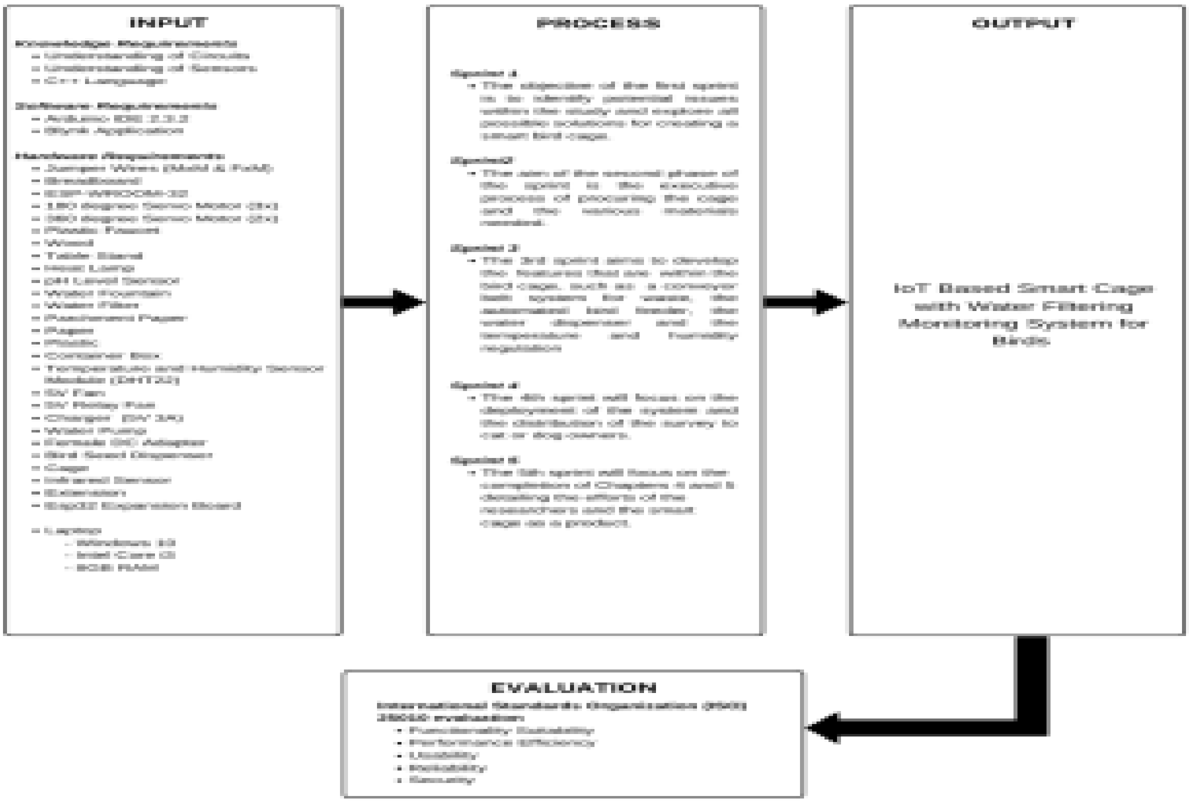
Objectives

a. By implementing an Automated Bird Feeder, the Smart Cage will help enhance bird care by ensuring that the pet bird will have constant access to food.
b. A Water Dispenser with Water Quality Monitoring and Water Filter integrated in the smart cage will help enhance bird care by ensuring that the pet bird will have constant access to clean water.
c. How to ensure the waste disposal of the birds when the owner is not present alongside the pet bird?

Conceptual Framework

Figure 1: Conceptual Framework



The figure shows the conceptual framework of the system which primarily focuses on developing a smart cage with a water-filtering and monitoring system for birds. The input includes the knowledge requirements, software requirements, and the hardware requirements of the system. The Process is shown in 5 sprints, with every sprint having an emphasis on the different focuses of development. The evaluation of the output, ISO/IEC 25010, will be the basis for a comprehensive evaluation of the proposed system.

Statement of the Problem

a. What would be the effects of a smart cage on automated bird feeder systems?
b. How will the cage address the issue of unmonitored water quality?
c. How to ensure the waste disposal of the birds when the owner is not present alongside the pet bird?

Scope and Delimitation

Scopes

The study aims to develop a comprehensive bird care solution using an integrated Internet of Things (IoT) system. This involves creating a smart cage with automated temperature and humidity monitoring, feeding, and waste disposal. A pH sensor will monitor water quality to ensure the birds' health. Key components include an ESP32 microcontroller with Wi-Fi for Blynk app connectivity, temperature and humidity sensors, a food dispenser with automated refill, a pH sensor in the water reservoir, a fan, heating lamp and a waste conveyor belt.

Limitations

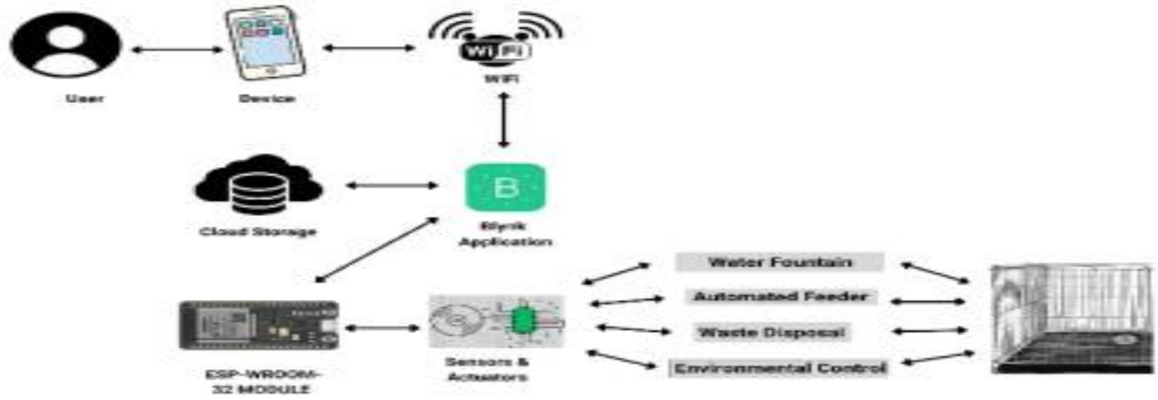
The study will focus on small birds like parakeets, finches, and lovebirds, excluding features such as built-in water filters and fixed water capacity. The automated feeder dispenses based on the available bird seeds in its reservoir. The prototype aims to be a small-scale solution for these birds. Environmental changes may affect sensor reliability, with factors like ambient conditions, complex bird behavior, and sensor accuracy impacting data interpretation. Additionally, scaling the prototype for commercial use may face regulatory challenges. These constraints are crucial for evaluating the smart cage's efficacy and feasibility.

Methodology

Research Design

a) System architecture

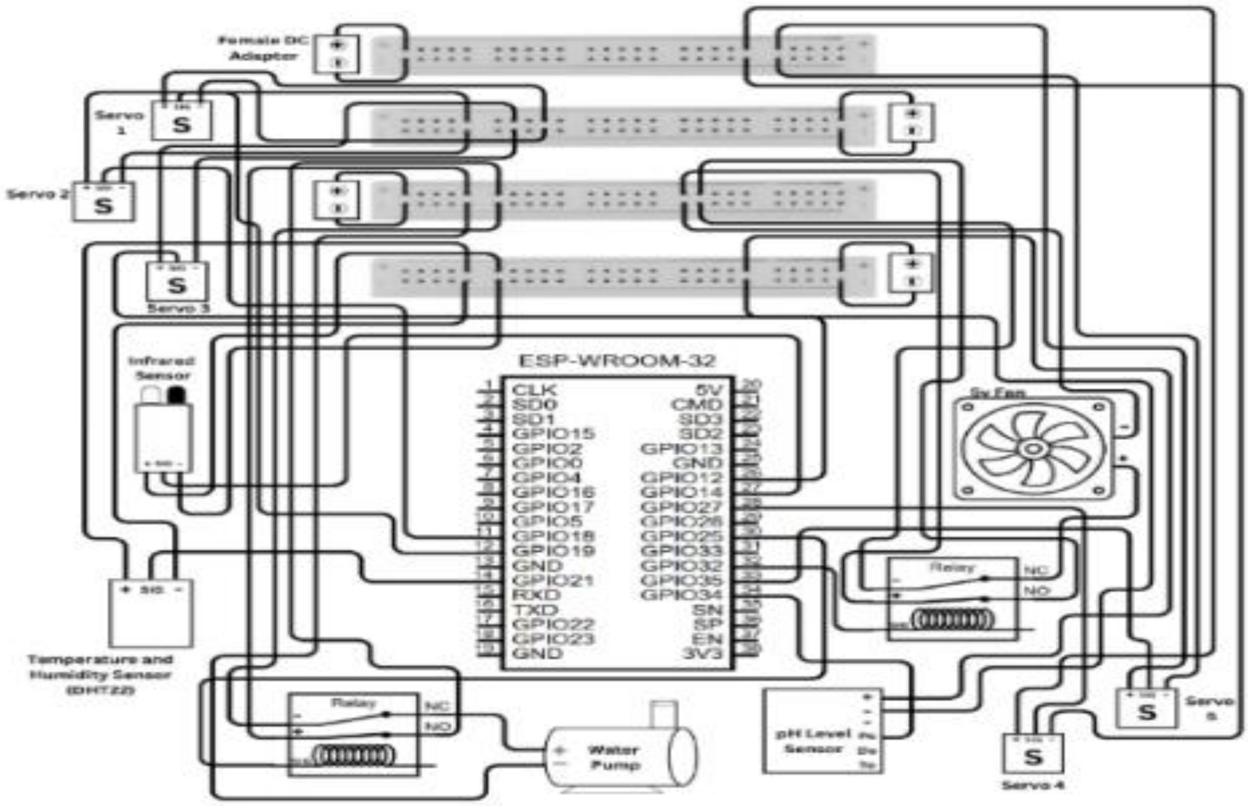
Figure 2: System Architecture



The System Architecture represents the interactions and functions of the different parts of the system. The user can access the Blynk Application with their device while connected to the Wi-Fi, and remotely monitor and control the system using the User Interface. The Blynk Application displays data from the different devices and data is stored in the Cloud Storage. The data is gathered by the various sensors and devices in the cage, and is connected by ESP32-WROOM-Module.

b) Block diagram

Figure 3: Block Diagram



The block diagram represents the overall structure of the system. It consists of Female DC Adapters that are attached to the power rails of the breadboards to supply power, sensors such as pH Sensor, DHT22 Temperature and Humidity Sensor, and Infrared Sensor, Servo Motors, Relays, a 5v Fan, a Water pump and the ESP WROOM 32 as the Microcontroller of the System.

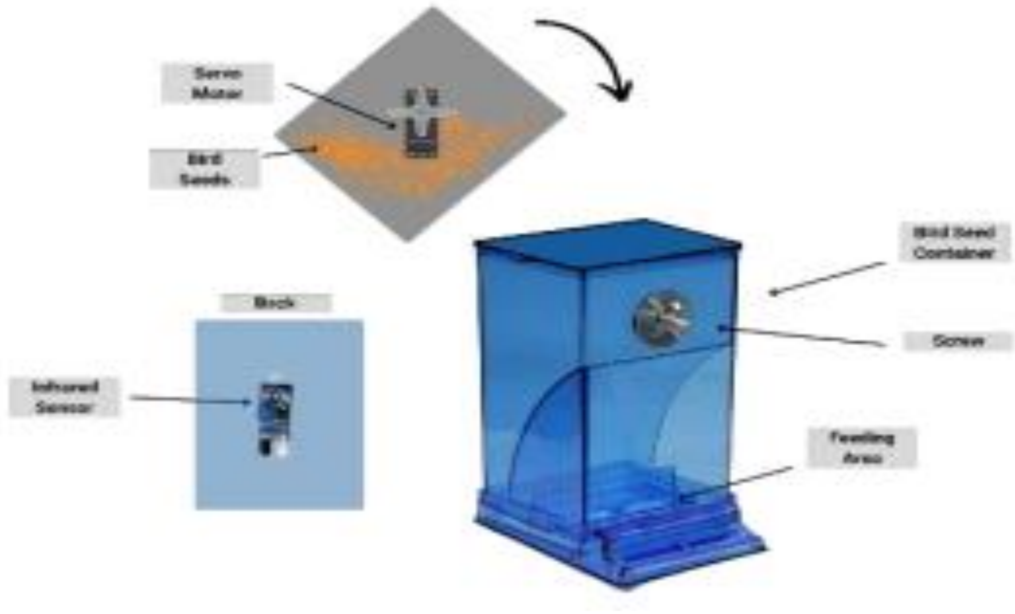
c) Prototype of the system

Figure 4: Smart Cage Prototype

The Design Prototype of the System illustrates the IoT Based Smart Cage with a Water Filtering and Monitoring System for Birds which features an Automated Feeding System, a Water Dispenser with a Water Filtering and Monitoring System, Waste Disposal and Environmental Control.

d) Automated feeder

Figure 5: Automated Feeder



The Automated Feeder features an Automated refill system. Using an Infrared Sensor, once the sensor detects low amounts of bird seeds in the feeder, the servo motor automatically rotates the seed dispenser and refills the feeder. Once full, the dispenser is returned to its initial position. The status of the food is also displayed on the Blynk IoT Application.

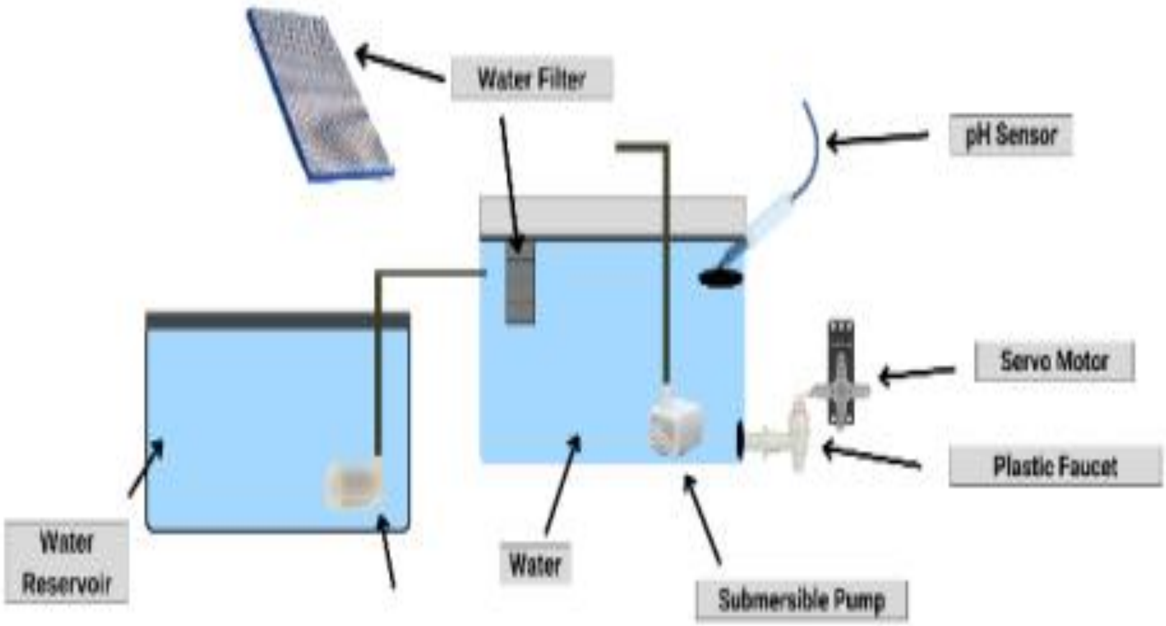
e) Waste disposal

Figure 6: Waste Disposal

The Waste Disposal features a conveyer belt underneath the Bird Cage. The conveyer belt is operated by two servo motors, and a scraper is placed underneath the conveyer belt to brush off any waste that sticks on the conveyer. Under the conveyer belt is a waste tray with plastic that catches the waste.

f) Water dispenser

Figure 7: Water Dispenser



The Water Dispenser features a Submersible Pump that pumps water to the surface of the Dispenser. The water then flows down to the container beneath, where the water will pass through a water filter. At the side of the dispenser, a pH sensor is placed to continuously monitor the pH level of the system. If the pH levels are not optimal, the water faucet will be automatically opened using a servo motor. After the dispenser is empty, the water pump can be activated by the user using the Blynk IoT Application to refill the container.

f) Environmental control

Figure 8: Environmental Control

The Cage Environmental Control features a DHT22 Temperature and Humidity Sensor, a Fan and a Heating Lamp. If the Temperature is above 32 degrees, the Fan Automatically opens. If the Temperature is below 32 degrees, the Heating lamp will open, and the fan will close. Additionally, the ESP32 with the Extension Board is positioned above the cage, as well as the 2 Relays that control the Fan and Pump, the PH4502C for the pH Sensor, the power rails and the Female DC Adapters connected to the 5V Chargers to supply power.

Participants/Respondents of the Study

The target respondents for the topic, “IoT Based Smart Cage with Water Filtering Monitoring System for Birds” would be people that own birds who are willing to take the time to provide information about what their pet birds need as well as provide any relevant information for the Smart Cage. A minimum sample of 100 respondents is and the method applied is the Purposive Sampling method.

Instrument/s of the Study

The ISO/IEC 25010 is a quality model that serves as the foundation of a product quality evaluation system and identifies which quality attributes are to be considered in assessing characteristics of a software product. To ensure that the system meets the quality standards the developers will utilize the ISO/IEC 25010 standard, with emphasis on the characteristics of Functionality, Performance Efficiency, Usability, Reliability and Security.

Table 1: ISO Characteristics Used for System Quality Evaluation

Characteristics		1	2	3	4	5
Functional Suitability	**Functional Completeness** - The IoT-Based Smart Bird Cage with a Water Filtering and Monitoring System for Birds encompasses all the essential functions and tasks outlined in the objectives. **Functional Correctness** - The IoT-Based Smart Bird Cage with a Water Filtering and Monitoring System for Birds produces accurate numerical data for detecting heat and humidity for the automation of the specific temperature regulating devices. **Functional Appropriateness** - The IoT-Based Smart Bird Cage with a Water Filtering and Monitoring System for Birds					

	has the ability to support and facilitate the owner’s bird/s.					
Performance Efficiency	**Time Behavior** - The IoT-Based Smart Bird Cage with a Water Filtering and Monitoring System for Birds meets the standard for appropriate response time in performing the action. **Resource Utilization -** The IoT-Based Smart Bird Cage with a Water Filtering and Monitoring System for Birds effectively utilizes the required resources to carry out its tasks. **Capacity** - The IoT-Based Smart Bird Cage with a Water Filtering and Monitoring System for Birds is capable of managing the anticipated defined constraints that meet the scopes.					
Usability	**Appropriateness Recognizability** - The overall system helps the users determine its suitability for easing the necessity of basic pet care such as feeding and waste disposal. **Learnability** - The system enables users to quickly learn the overall smart bird cage system. **Operability** - The IoT-Based Smart Bird Cage with a Water Filtering and Monitoring System for Birds is easy to operate and control for pet-care type of system. **User Interface Aesthetics** - The IoT-Based Smart Bird Cage with a Water Filtering and Monitoring System for Birds has a user-friendly third-party application that has easy to navigate function buttons. **Accessibility** - The IoT-Based Smart Bird Cage with a Water Filtering and Monitoring System for Birds is accessible to users with diverse characteristics and capabilities.					
Reliability	**Maturity -** The IoT-Based Smart Bird Cage with a Water Filtering and Monitoring System for Birds fulfills the reliability requirements for standard operation. **Availability** - The IoT-Based Smart Bird Cage with a Water Filtering and Monitoring System for Birds is functional and accessible as needed for helping the user to have an ease operation on pet-caring.					
Security	**Confidentiality -** The IoT Based Smart Bird Cage with a Water Filtering and Monitoring System for Birds ensures that only authorized users can access the data and control of the bird smart cage through Blynk application **Integrity -** The IoT Based Smart Bird Cage with a Water Filtering and Monitoring System for Birds ensures that the data collected, and the commands sent to the IoT					

	device are not tampered with or altered by unauthorized entities. **Authenticity-** The IoT Based Smart Bird Cage with a Water Filtering and Monitoring System for Birds ensures that only verified users can interact with the system, proving that the identity of the user accessing or controlling the cage through the Blynk application is legitimate.					

Data Collection and Analysis

The researchers will prioritize people who are bird owners, bird breeders, veterinarians and IT professionals. A live demonstration with the people answering the survey is implemented, allowing for on-site impressions and review of the system's functionalities. Additionally, a video demonstration for the convenience of other people, featuring system performance in real-time. The researchers will utilize Google Forms for the collection process and spreading it via message and social media.

Table 2: Likert Scale

Criteria	Score
Excellent	4.21 – 5.00
Very Good	3.41 – 4.20
Good	2.61 – 3.40
Fair	1.81 – 2.60
Poor	1.00 – 1.80

The five-point Likert Scale will be used to interpret the collected data. This ensures efficient data collection and analysis while providing a user-friendly experience for the students implementing the system.

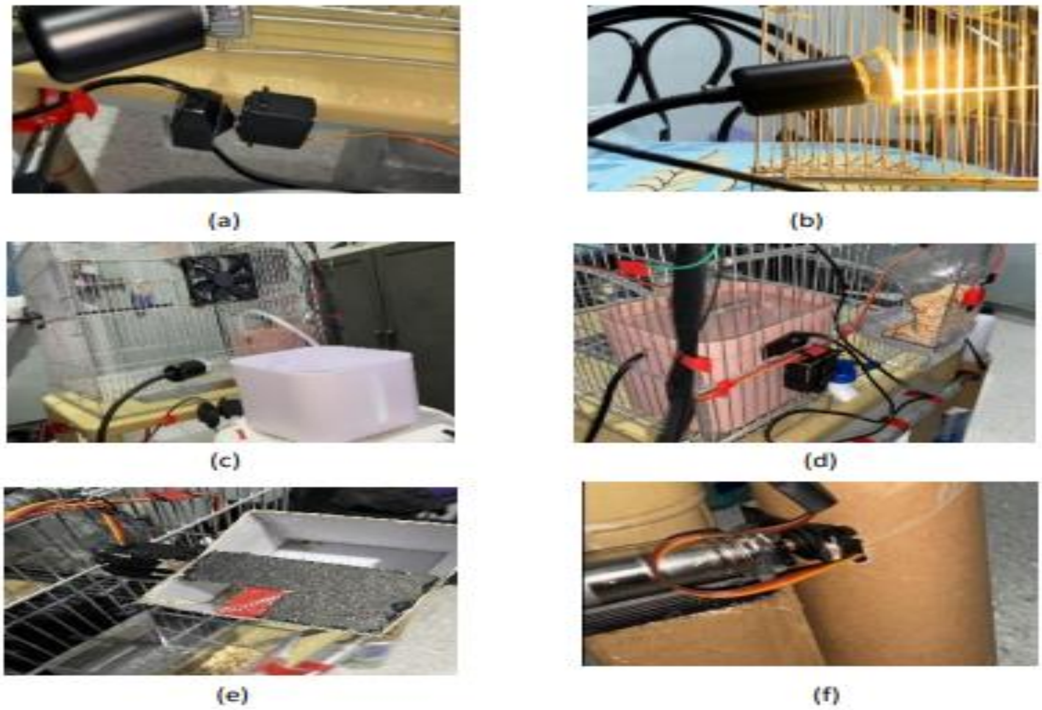
Ethical Considerations

In conducting this study, the well-being of the birds is prioritized by creating an environment that minimizes stress and encourages natural behaviors. The research will comply with relevant guidelines and regulations to ensure humane treatment and care for the birds involved. Participants will be asked for their informed consent, ensuring they understand the study's purpose and their right to withdraw at any time. All collected data will be treated confidentially and used solely for research purposes.

Results and Discussion

Device Prototype

Figure 9: Device Prototype



(g)

(h)

(i)

(j)

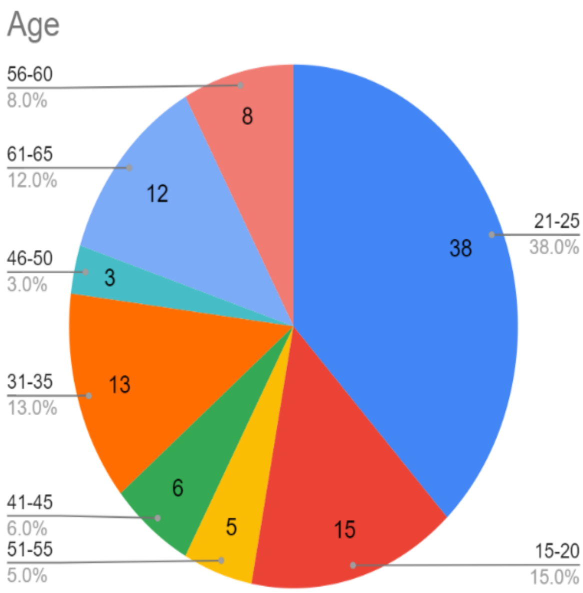
(k)

(l)

Device prototype shows combined features of the whole smart cage. Figure 9 (a) shows the white water reservoir, pumping to the pink water fountain found in the cage, connected via a plastic tube to transport water. Figure 9 (b) shows a close-up to the water fountain, as well as the servo-powered faucet for the water-disposal. The disposal of the water will be triggered whenever the attached pH Sensor detects it to be abnormal. The water fountain will be then refilled using the water reservoir. Figure 9 (c) shows the mechanism of how the servo motor works to turn on the attached heat lamp in Figure 9 (d) to function. Figure 9(e) shows the attached servo motor with the reserve bird seeds within, which will then be motorized to turn down for the bird seed dispenser shown in Figure 9 (b) with the infrared sensor on it. Figure 9 (f) and figure 9 (g) shows the two-conveyer belt stands with the attached servomotors inside with an external scraper beneath it, 9 while figure 9 (h) shows the actual conveyer belt material and process. Figure 9 (i) is the DHT-22 Temperature and Humidity sensor, which works in tandem with the heat lamp in Figure 9 (d) as well as the external fan in Figure 9(j). This sensor is the basis for the actuation programs of the heat lamp and fan, turning on the heat lamp at below 32 Celsius while turning off the fan and turning off the heat lamp above 32 Celsius and turning on the fan for cooling. Figure 9 (k) shows the complete wiring setup for the whole systems, featuring the ESP-32 module as well as the various relay modules and breadboards. Figure 9 (l) shows the Blynk application that is able to control all of the features.

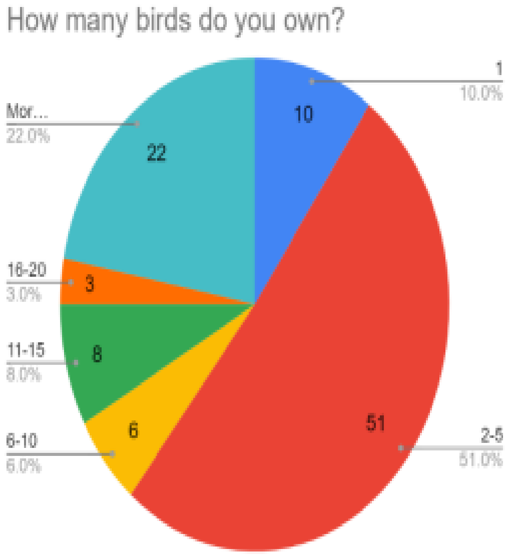
Result

Figure 10: Age of the Respondents



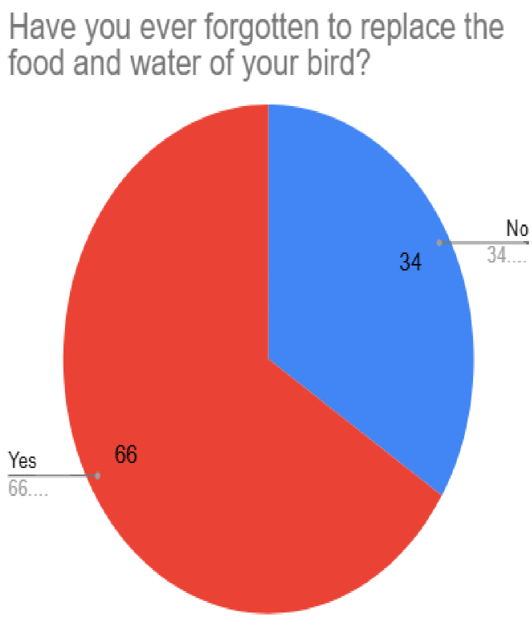
The graph shows the Age of the respondents. 38 of the respondents are 21-25 years old, 15 of the respondents are 15-20, 13 of the respondents are 31-35, 12 of the respondents are 61-65, 8 of the respondents are 56-60, 6 of the respondents are 41-45, 5 of the respondents are 51-55, and 3 of the respondents are 46-50.

Figure 11: Number of Birds Owned



The graph depicts the number of birds owned by respondents. The majority, 51 respondents, own 2-5 birds, while 22 own more than 20. Additionally, 10 respondents own 1 bird, 8 own 11-15 birds, 6 own 6-10 birds, and 3 own 16-20 birds.

Figure 12: Responses to the question.” you ever forgotten to replace the food and water of your bird?”



The data graph shows that 66 of the respondents have forgotten to replace their bird’s food and water at least once. The bird cage has no way of refilling the birds’ water and food. There is also no way of notifying the user if food is empty, or if water is empty or contaminated by internal or external factors.

Figure 13: Responses to the question, “Do you manually clean your bird’s waste tray?”

This data graph shows that 100% of the respondents manually clean their bird’s waste tray, frequently removing the waste tray under the bird cage to clean it when it is full of bird seeds and waste.

Evaluation

Table 3: Overall Mean Rating

Criteria	Score	Interpretation
Functional Suitability	4.41	Excellent
Performance Efficiency	4.19	Very Good
Usability	4.36	Excellent
Reliability	4.17	Very Good
Security	4.17	Very Good
Overall Mean	4.26	Excellent

The data shows that the Functional Suitability of the system achieved an average rating of 4.41 from the respondents, which indicates that most respondents deem the system’s functions to be “Excellent” in performing as intended. The Performance Efficiency of the system achieved an average rating of 4.19, which indicates that the system is "Very Good" in meeting appropriate response times, effectively utilizes required resources and very good in handling anticipated operational constraints within the defined scope. The characteristic, Usability achieved an Average rating of 4.36, which is interpreted as “Excellent”, indicating that the system is highly effective, easy to learn, and user-friendly. The Reliability characteristic received an average rating of 4.17 from the respondents, which is interpreted as Very Good, indicating that the system is stable and dependable for daily pet-care tasks. The Overall Computed Mean of 4.28 is interpreted as “Excellent” based on the Likert Scale with respect to Functional Suitability, Performance Efficiency, Usability, Reliability and Security.

Reliability Metric

Table 4: Reliability Metric

	DATE	OPERATING HOURS	DOWN TIME	NUMBER OF FAILURES
MEAN TIME TO REPAIR	October 8, 2024	24	9	3
3.375 HOURS	October 9, 2024	24	7	2
MEAN TIME BETWEEN REPAIRS	October 10, 2024	24	6	1
10.5 HOURS	October 11, 2024	24	9	3
MEAN TIME TO FAILURE	October 12, 2024	24	7	2
7.125 HOURS	October 13, 2024	24	8	2
	October 14, 2024	24	9	3

The data shows that the system achieved 3.375 for Mean Time to Repair, indicating that it takes an average of 3.375 hours to repair the system after each failure. The system achieved a 10.5 for Mean Time Between Repairs indicating that there is 10.5 hours of average operating time between repairs. Additionally, the Mean Time to Failure achieved a score of 7.125 indicating that there are 7.125 hours on of operation on average for each operation before the system failed.

Conclusion

In conclusion, after observing and testing the system, the evaluation results indicate that the system has met the required standards using the ISO/IEC 25010 Evaluation Tool, which assessed Functional Suitability, Performance Efficiency, Usability, and Reliability. The system's sensors and servos operate correctly, achieving an "Excellent" rating that confirms the accuracy and reliability of the collected data. The smart cage efficiently meets its objectives by implementing an automated feeder, water quality monitoring, and waste disposal management. Additionally, reliability testing showed that the system averages 10.5 hours between repairs, 7.125 hours of operation before failures, and a repair time of 3.375 hours, demonstrating its durability and responsiveness. Overall, the IoT-Based Smart Bird Cage effectively addresses pet owners' needs, enabling users to monitor and care for their birds remotely.

Recommendations

When conducting this type of research or pursuing the continuation of developing the bird cage, the researchers recommend the following:

1. Implement a Hatching Monitoring System which includes incubation, monitoring egg health, and the hatching time of the egg. A Hatching Monitoring System would help ensure that any eggs that the hen lays would hatch successfully.
2. Integrate a camera system to remotely monitor the birds with an algorithm to help detect a bird’s illnesses.
3. Add a health tracking system that could monitor the birds’ activities such as their sleeping and eating patterns, and their behaviors with real-time updates in the app.

Conflict of Interest

There is no conflict of interest between the authors in this manuscript. Results have been deduced objectively; nothing influenced this result by any individual, monetary, or institutional interests. In effect, utmost endeavors were in order to conduct a bias-free operation of gathering and analyzing the data into interpretation and producing a study based on merit, away from research inconsistencies.

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