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Auto-Feed. IoT-Enabled Chicken Feeder Using Raspberry Pi

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ABSTRACT

This research endeavor aimed to develop an Internet of Things (IoT)-enabled Chicken Feeder designed specifically for the needs of poultry farm operators and assess its usability. The study was conducted at Iloilo State University of Fisheries Science and Technology between December 2022 and March 2023, employing the descriptive developmental research method. The system's development utilized tools such as Arduino IDE, PyCharm, and Google Sites for software development, with hardware components including a Raspberry Pi 4b, Arduino UNO, Timer, Servomotor with a food level sensor, Water pump with a water level sensor, a pull-up button, and an LCD display. The development process followed the System Development Life Cycle-Rapid Application Development (SDLC-RAD) methodology, comprising the stages of Define, Design, Construct, and Implement. To assess the system's usability, an evaluation panel consisting of three small-scale poultry farm owners and thirty 4th-year students majoring in Animal Science and Agriculture was purposefully selected using quota sampling. Data collected from the respondents was tabulated and analyzed using the System Usability Scale (SUS). The developed IoT-based poultry feeding system achieved an impressive SUS score of 90.30, placing it in the "A+" grade within the 96-100 percentile range. This high score reflects a favorable evaluation of the system's usability, highlighting its potential to significantly improve poultry farm management and operational efficiency. In conclusion, the study demonstrates that the IoT-enabled chicken feeder is a practical and effective tool for optimizing poultry farm operations, with high usability as assessed by the respondents.

KEYWORDS

agriculture, internet-of-things, smart farming

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INTRODUCTION

This research explores the integration of Internet of Things (IoT) technology with a Raspberry Pi-based chicken feeder system, aiming to enhance the efficiency and automation of poultry feeding processes. The increasing demand for poultry products has driven the need for smarter farming solutions that can optimize operations and reduce manual labor. IoT-driven systems, including smart sensors and automated processes, offer promising advancements in poultry management by providing real-time monitoring and data-driven decision-making platforms.

Existing studies highlight the potential of IoT in this sector. For instance, Astill et al. (2020) emphasizes

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the importance of precision livestock farming (PLF) technologies, advocating for the adoption of smart sensors and automated processes to meet growing poultry production demands. Mitkari et al. (2019) developed an IoT-based automatic chicken feeding system, primarily targeting labor reduction in poultry farms through semi-automated feeding solutions. Similarly, Raynaldi (2017) and Mishra et al. (2019) highlight the efficiency gains of automated feeders, though many of these systems rely on simpler microcontrollers and lack comprehensive remote monitoring capabilities.

However, these studies often focus on partial automation or environmental monitoring, leaving a gap in the development of fully automated systems that integrate real-time monitoring and control in a user-friendly platform. To address this gap, the current study aims to develop an IoT-enabled chicken feeder using a Raspberry Pi 4b, incorporating water and feed level sensors. The system will provide real-time monitoring and control via a website, offering an efficient, fully automated solution for poultry farm management.

MATERIALS AND METHODS

Overview of the System

The system integrates a Raspberry Pi single-board computer and an Arduino microcontroller to automate chicken feeding and water distribution. The Arduino controls multiple sensors, including a servomotor, ultrasonic sensor, water pump, moisture sensor, timer, and override button, to manage feed and water levels. The system automatically dispenses feed and water based on sensor inputs and time-based triggers, with real-time monitoring provided through a website. This section outlines the methodology, from hardware and software setup to the system's development phases.

Hardware Requirements

Raspberry Pi 4b*.* Serves as the primary platform for integrating the hardware and software components. It powers the Arduino and logs sensor data to Google Sheets.

Arduino Uno. Controls the sensors, servomotor, water pump, and timer. It also displays system information on an LCD.

LCD Display. Shows real-time feed and water levels, as well as the current time.

Servomotor. Controls the feed dispenser, rotating to release feed at scheduled times.

Ultrasonic Sensor. Measures feed levels to determine whether they are high or low.

Water Pump. Pumps water into the reservoir when the moisture sensor detects low water levels.

Moisture Sensor. Detects the water level in the reservoir.

Timer. Manages time-based feed dispensing.

Override Button. Allows for manual feed and water dispensing outside of the scheduled times.

Software Requirements

Raspbian v11 Bullseye. The operating system for the Raspberry Pi.

Arduino IDE. Used to write and upload code to the Arduino to control sensors and actuators.

PyCharm. A Python IDE used for coding scripts that transfer sensor data to Google Sheets.

Google Sheets. Logs sensor data for real-time monitoring.

Google Sites. Hosts the monitoring webpage, allowing users to check feed and water levels remotely.

Phases of Development

The study adopted the **Rapid Application Development (RAD)** methodology, focusing on quick prototyping and iterative feedback. TeamGantt management tools helped structure the project timeline.

Flowchart of the System Development

The researcher used a flowchart as guide in the entire development of this study. The flowchart is visualized in Figure 1.

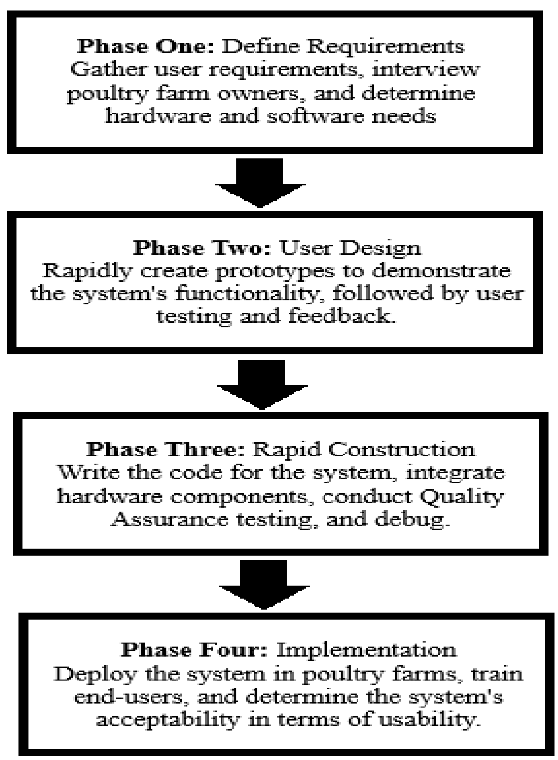

Figure 1. The flowchart used in system development.

Define Requirements. The first phase involved data gathering from small poultry farm owners and agricultural students. Interviews helped clarify the specific needs for a fully automated poultry feeding system. The researcher identified necessary hardware like Raspberry Pi, Arduino, sensors, and servomotors, along with software such as Raspbian and Google Sheets.

User Design. During the second phase, the system's initial prototypes were created, including a block diagram, connection diagram, data flow diagram, and use case diagram. The researcher worked with the respondents, testing the system's components and adjusting the design based on their feedback. This phase focused on creating an intuitive and user-friendly interface, as well as ensuring that the system meets all functional requirements.

Rapid Construction. The third phase involved coding and testing the hardware components. All connections were carefully integrated according to the system diagram. The researcher coded each component using the Arduino IDE and PyCharm to ensure the sensors, servomotor, and water pump worked in sync. The system underwent rigorous testing to ensure functionality, and feedback from users helped refine the system before final deployment.

Implementation. In the final phase, the system was deployed at the chosen study locations. The researcher trained poultry farm owners and agricultural students to use the system. User training included monitoring the system through Google Sheets and Google Sites and learning how to override the system manually when necessary. The system was continually tested for bugs, and the respondents provided feedback on its usability.

Locale of the Study. This study was conducted at Iloilo State University of Fisheries Science and Technology – San Enrique Campus.

Respondents of the Study. The respondents of the study were three (3) small poultry farm owners from Passi City, Iloilo and thirty (30) fourth year Bachelor of Science in Agriculture students majoring in Animal Science. The respondents evaluated the system in terms of its usability.

Sampling Technique. This study used purposive and quota sampling technique in determining the respondents. The poultry farm owners were chosen purposively while the agriculture students were chosen using quota sampling.

Research Instrument. A standardized questionnaire-checklist authored by John Brooke (196) was utilized in evaluating the system. This specific instrument was adopted as it is one of the most reliable and verified instruments in measure the usability of a developed software as set in the ISO 25010 standards. The questionnaire-checklist was composed of ten (10) statements. The system usability was evaluated with descriptive rating of Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree. On the rating scale for items 1, 3, 5, 7, and 9 the score contribution is the scale position minus 1. For items 2, 4, 6, 8, and 10, the contribution is 5 minus the scale position.

Data Gathering Procedure. During the conduct of the study, the researcher conducted interviews with the poultry farm owners. The information gathered during these interviews was recorded and used as valuable input for the system's design. In collaboration with the poultry farm owners, the researcher performed a logical design to make the system more applicable and advantageous. The system was designed based on the collected data. To evaluate the system's usability, three small poultry farm owners and thirty fourth-year Bachelor of Science in Agriculture students majoring in Animal Science were involved. The researcher demonstrated the system's functionality and distributed a standardized questionnaire checklist to the respondents for evaluation. The completed questionnaires were collected, and the data was tabulated.

Data Analysis Procedure. The data gathered was subjected to appropriate descriptive statistical tools. In evaluating the usability of the application, the gathered points were tabulated and analyzed using the System Usability Score.

The formula in computing the SUS is: SUS=(X+Y) x 2.5
Where: X= the points for odd-numbered questions – 5
Y= 25 - the points for even-numbered questions

In interpreting the result of the data gathered in evaluating the system's usability, the researcher solved for the average score and in interpreting the system's usability. The SUS interpretation table is shown in Table 1.

Table 1. SUS Interpretation Table

Grade	SUS	Percentile Range	Adjective	Acceptability	NPS
A+	84.1 – 100	96 – 100	Best Imaginable	Acceptable	Promoter
A	80.8 – 84.0	90 – 95	Excellent	Acceptable	Promoter
A-	78.9 – 80.9	85 – 89		Acceptable	Promoter
B+	77.2- 77.8	80 – 84		Acceptable	Promoter
B	74.1 – 77.1	70 – 79		Acceptable	Passive
B-	72.6 – 74.0	65 -49		Acceptable	Passive
C+	71.1 – 72.5	60 – 64	Good	Acceptable	Passive
C	65.0 – 71.0	41 – 59		Marginal	Passive
C-	62.7 – 64.9	35 – 40		Marginal	Passive
D	51.7 – 62.6	15 – 34	OK	Marginal	Detractor
E	25.1 – 51.6	2 – 14	Poor	Not Acceptable	Detractor
F	0 – 25	0 – 13		Not Acceptable	Detractor

RESULTS AND DISCUSSIONS

Design a hardware prototype for an IoT-Enabled Chicken feeder using Arduino Uno microcontroller. The IoT-enabled Chicken Feeder using Raspberry Pi was developed to automate the feeding of the chickens with feeds and water and with a website to monitor the real-time activity of the system using an Arduino Uno microcontroller. Figure 2 shows the prototype hardware of the system.

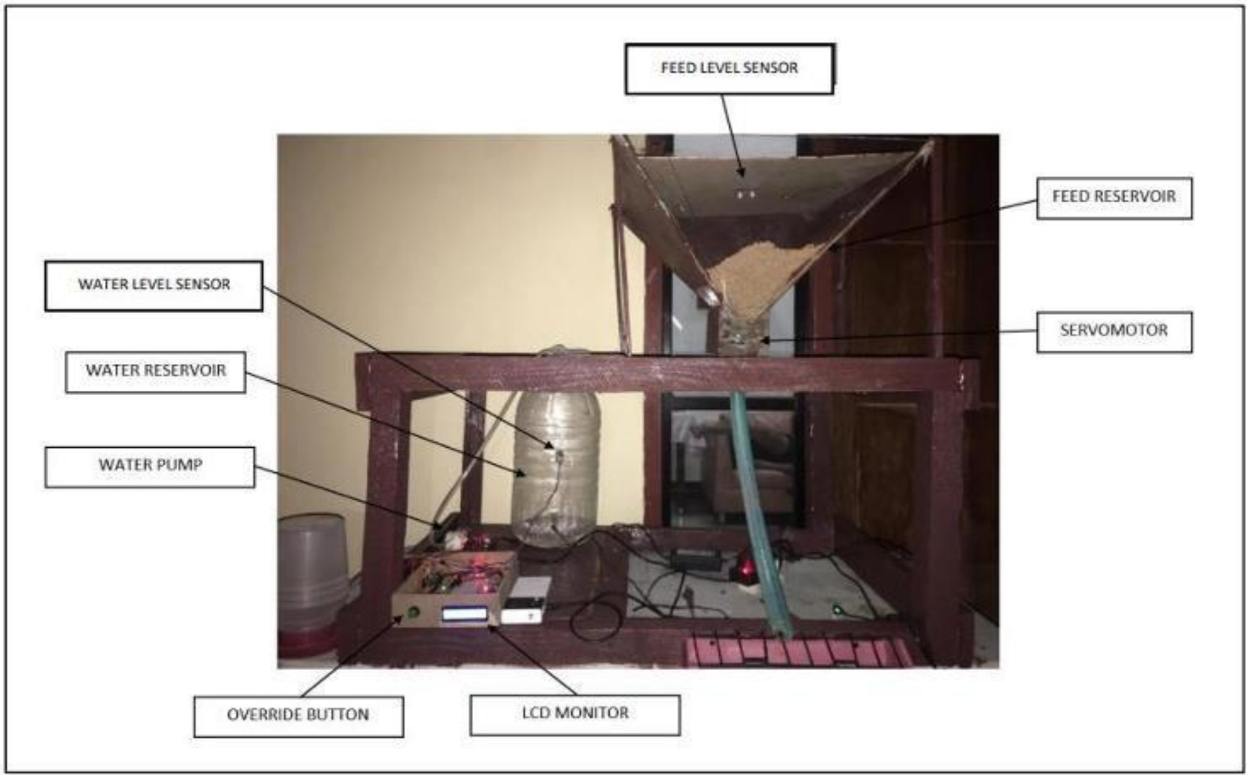

Figure 2. Hardware Prototype

IoT-enabled Working Prototype Model. After connecting all the hardware parts, uploading all the codes and modules on the Raspberry Pi, Arduino microcontroller, and creating an Auto–Feed monitoring website in the Rapid Construction phase of the SDLC.

Main Functionalities. The automatic chicken feed and water dispenser system is designed to automate feeding and watering processes using a Raspberry Pi and Arduino. A servomotor connected to the Arduino controls the feed reservoir valve, rotating to release food and then returning to close it once dispensing is complete. Water is dispensed through a pump controlled by a relay; it turns on at scheduled times, filling the chicken waterer and stopping once done. An override button allows manual activation of both the feed and water dispensers without waiting for the scheduled time. The system integrates sensors to monitor feed and water levels, using an ultrasonic sensor to measure feed levels and two moisture sensors to track water levels. Data from these sensors is processed by the Arduino and visualized on a 16x2 LCD display or uploaded to Google Sheets for online monitoring via Google Sites. The servomotor is connected to Digital Pin 9, while the ultrasonic sensor's ECHO and TRIG pins are connected to Digital Pins 2 and 3. The water level sensors are connected to Analog Pins A0 and A1. The system operates based on a real-time clock module, with SDA and SCL pins linked to A4 and A5. This setup ensures precise timing for feeding and watering, with data available for monitoring in real time.

Google Sheets and Google Sites. To automate data storage for water level, feed level, override status, and time, the developers used Google Sheets. Columns B, C, D, and E were designated for Time, H2O, Feeds, and Override data. The Google Sheets API key was embedded in the PyCharm code to update the sheet automatically. For real-time monitoring, Google Sites was used due to its flexibility and ease of use. The Google Sheet was embedded in the monitoring page by selecting it from recent spreadsheets using the insert feature, enabling users to view live updates on water, feed levels, and system overrides online. The Google Sites and Google Sheets are shown in Figure 3.

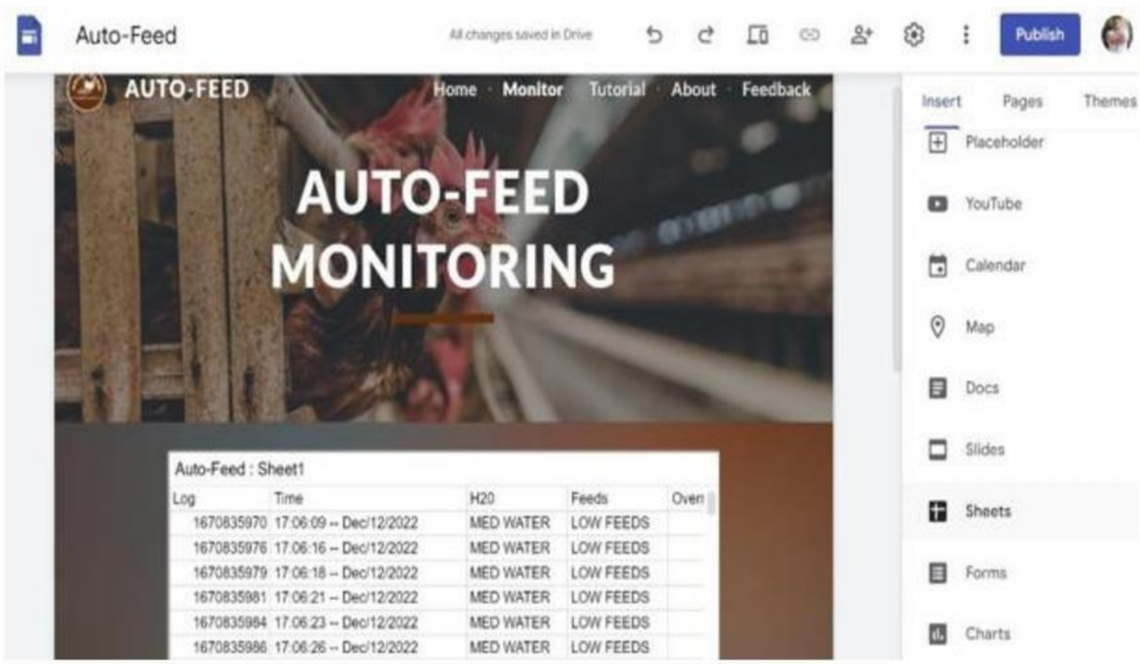

Figure 3. Google Sites and Google Sheets

Utilize the Raspberry Pi 4b single-board computer to upload data into the cloud and control the entire system. The Raspberry Pi is connected to the Arduino Uno via USB cable. The Arduino collects the data from the sensor and then relay it into the Raspberry Pi. The Raspberry Pi can be connected to the internet via WiFi or Ethernet. Once connected, the Raspberry Pi is programmed so that it can upload the data into Google Sheets which will then be

Determine the acceptability of the developed system in terms of its usability. The IoT-enabled Chicken Feeder using Raspberry Pi was evaluated by poultry farm owners and Bachelor of Science in Agriculture students majoring in Animal Science. Results showed that the system got a System Usability Scale Score of 90.30 which means it is graded A+, it is within the 96-100 Percentile Range, it is described as “Best Imaginable”, “Acceptable” as to Acceptability, and got a Net Promoter Score described as “Promoter” which means that the respondents promoted the evaluated System. Table 3 reflects the result of the system usability evaluation.

The IoT-enabled chicken feeder system successfully achieved its primary objectives of automating feeding and watering processes, providing real-time monitoring, and enhancing overall poultry farm management. The integration of Raspberry Pi and Arduino Uno effectively controlled the servomotor and relay for dispensing feed and water, respectively, based on scheduled times or manual overrides. The implementation of sensors for feed and water level monitoring ensured accurate and timely replenishment, reducing the risk of feed shortages or water contamination. The integration of Google Sheets and Google Sites provided a user- friendly platform for visualizing and analyzing data, enabling remote monitoring and timely intervention. The system's usability evaluation yielded positive results, with respondents rating it highly in terms of acceptability and promoting its use. This indicates that the developed system effectively addresses the needs of poultry farm operators and meets the desired levels of automation and efficiency.

Overall, the research demonstrates the successful application of IoT technology in poultry farming, providing a valuable solution for improving operational efficiency, reducing manual labor, and enhancing animal welfare. Future research could explore further advancements, such as integrating additional sensors for environmental monitoring or implementing predictive analytics to optimize feeding schedules based on animal behavior and growth patterns.

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

Summary

This descriptive-developmental research aimed to develop an automatic chicken feeder entitled IoT- enabled Chicken Feeder” and determine its usability. The SDLC Rapid Application Development method was adopted and guided the researches during its development. The researchers used the purposive sampling technique to choose their respondents specifically small poultry farm owners. Additionally, Bachelor of Science in Agriculture students majoring in Animal Science were selected using quota sampling technique. The respondents evaluated the system in terms of its usability. A System Usability Scale authored by John Brooke was utilized in determining the system usability.

The study was conducted at ISUFST - San Enrique campus located at San Enrique, Iloilo. From December 2022 to March 2023.

The findings of the study revealed that:

1. a hardware prototype of the IoT-Enabled Chicken Feeder was created using Arduino microcontroller;
2. multiple sensors were integrated into the microcontroller to gather and monitor data;
3. two user interfaces were developed to visualize data gathered by the system;
4. a Raspberry Pi 4 was integrated into the system to upload data into the cloud and control the entire system;
5. the system got a SUS score of 90.30 which means it was grade A+, within the 96-100 Percentile Range, described as “Best Imaginable”, “Acceptable” as to its acceptability, and got a Net Promoter Score described as Promoter.

Conclusion

Based on the result of the study, it is concluded that the IoT-enabled Chicken Feeder was developed using SDLC- Rapid Application Development Methodology and the target users found the system acceptable in terms of its usability.

Recommendation

The IoT-enabled Chicken Feeder using Raspberry Pi may be utilized by poultry farm owners and Bachelor of Science in Agriculture Major in Animal Science students in their research studies. Future researchers conducting a similar study could enhance the system's functionality by implementing an override button accessible through the website, enabling remote control over the internet. Furthermore, the integration of additional sensors into the Arduino and Raspberry Pi components can expand data collection capabilities, fostering a more comprehensive and efficient data-gathering process. Leveraging the wealth of data acquired, comprehensive data analysis can be conducted to formulate policies and guidelines, facilitating the development of an optimized farm feeding management system. This, in turn, promises increased yield and improved efficiency in poultry production.

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ETHICAL DECLARATION

This research project, "Autofeed: IoT-Enabled Chicken Feeder using Raspberry Pi," was conducted with full adherence to ethical guidelines governing technology research and development. The primary aim of this study was to design and develop an automated chicken feeding system, emphasizing technical innovation and functionality.

Key ethical considerations include:

1. Minimization of Risk: The development of the IoT-enabled feeder system was carried out in a controlled and safe environment. All experiments and tests involving the system were conducted to ensure safety for end-users, with no risks posed to humans or animals during the testing phase.
2. Data Privacy and Security: Throughout the development of the system, data collected by IoT devices, including sensor information related to feeding patterns and system usage, was handled with strict confidentiality. No personally identifiable information was collected or stored.
3. Environmental Responsibility: The system was designed with a focus on sustainability, incorporating energy-efficient components such as the Raspberry Pi. This minimizes the environmental impact and promotes the use of renewable and low-power technologies.
4. Transparency and Integrity: All stages of the research, from design to implementation, were conducted with transparency and in accordance with established research protocols. No conflicts of interest were present, and all findings were reported honestly and accurately.

5. Compliance with Regulations: The project adhered to all relevant regulations and ethical standards related to the development and use of IoT technologies. Where applicable, guidelines for safe and ethical use of electronic systems in agricultural environments were followed.

By signing below, the authors affirm that this research was carried out ethically, with full consideration for the safety, security, and integrity of the system and its intended use.

CONFLICT OF INTEREST

The author of the research project titled "Autofeed: IoT-Enabled Chicken Feeder using Raspberry Pi" declare that there are no conflicts of interest related to this study. The research was conducted independently, with no financial, personal, or professional relationships that could have inappropriately influenced the outcomes of this study.

The development and results of the project are solely intended for academic and practical contributions to the field of agricultural technology, with no external pressures or biases affecting the research process or its conclusions.

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