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RESEARCH PAPER

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Design and development of an arduino-based smart feeder system

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ABSTRACT

The Smart Feeder System is an autonomous feeder that is controlled by an Android and smartphone. This project allows owners to simply alter the feeding plan based on the appropriate feed dose, as well as providing Realtime feeding scheduling. The project is intended to provide an automation of feeding and watering system of the poultry. The Smart Feeder System includes a weight sensor that is used to manage the weight of chicken food. When the sensor detects that the amount of food in the container is running low, it will alert the user. NodeMCU is also included in this device, which will control the feeding. In addition, the system employs software that can design and produce a command for the devices, ensuring that they perform as intended. This system focuses on feeding and maintaining the poultry's essential diet, as well as providing water. Two testing strategies—acceptance testing and usability testing—were conducted to rigorously evaluate the application's quality. Each test involved distinct participants, ensuring a comprehensive assessment. The ISO/IEC software quality metrics framework was employed to objectively measure the application's acceptability and System Usability Scale (SUS) for usability testing. Notably, the acceptance test yielded exceptional results, with an overall mean of 4.95 and a remarkable usability score of 94. These outcomes indicate that the application has undergone continuous refinement and enhancement throughout the testing process. The application's user-friendliness and portability, including its offline functionality, are key strengths. It is now deemed ready for deployment to end-users.

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INTRODUCTION

Poultry farming in the Philippines is the keeping of chickens to produce eggs for home or commercial purposes. Because of the uncontrolled environmental conditions, the entire management is labor-intensive and difficult. Farmers must manually check environmental parameters and temperature. This would necessitate the farmer's experience in chicken farming, as well as the hiring of more assistants, which would just raise the expenditure.

Feeding is an important element of producing chickens; it accounts for the majority of production costs, and proper nutrition is reflected in the bird's performance and output. Chicken nutrition and feeding are critical components of productivity (Fanatico, 2023).

According to Imperial *et al.* (2022), the poultry business in the Philippines is a significant contribution to the economy, with rising gross production value and large chicken inventories in some areas. With 588 licensed poultry farms and around 175 meat processors, the Philippine broiler sector is made up of 20% small farms and 80% commercial farms.

As recorded by PSA (2023) total chicken production from July to September 2023 was 464.97 thousand metric tons, liveweight, representing a 2.3 percent increase over the 454.38 thousand metric tons, liveweight output in the same period in 2022. During the reference quarter, Central Luzon was the leading producer of chicken, accounting for 151.97 thousand metric tons, liveweight, or 32.7 percent of total chicken output. Nine areas reported gains in output during the reference quarter compared to the same quarter in 2022. CALABARZON saw the greatest increase in level, rising 7.76 thousand metric tons from 69.45 thousand metric tons in the third quarter of 2022 to 77.21 thousand metric tons in the same quarter of 2023.

When it comes to chicken farming, feeding is the most expensive and crucial element. As a result, when investing in a poultry feeding system, it is critical to guarantee that it will assist a farmer in running their enterprise properly and profitably. Poultry feeding systems decrease spillage, provide continuous feed availability, and eliminate fighting for food among chicks.

The mechanisms guarantee that all feed is consumed and that all birds have an opportunity to eat. The absence of hand feeding implies more time to devote to other critical duties (AgrifoodSA, 2021).

The trend toward automation will benefit today's poultry farming businesses by improving production, permitting better data collection, and making it easier for managers to oversee staff performance. Automated chicken farming systems are currently available at several levels. With a continuing shortage of personnel and rising labor costs, poultry automation is an urgent necessity. Automated feeding systems are appropriate for small to big farms (Rajput, 2021).

With the cheap cost of microcontrollers, automatic feeders remain the ideal alternative for feeding fish to replace the human technique. It is also the least expensive and most precise way. The user must be able to regulate or alter an automated system based on their demands and needs. The term "automatic" means that the feeder should be able to run without human supervision at least at specified intervals. There are several designs and brands of automatic fish feeders available on the market, but some limitations of existing fish feeders must be addressed. As a result, some sort of upgrade or new idea is required to tackle these challenges (Dada *et al.*, 2018).

Premise on the information mentioned above, this study was conducted in order to design, develop, and test a smart feeder system, an automated feeder to monitor the amount of food is managed. The goal is to create a low-cost, simple feeder that may be utilized by local chicken farmers. It intends to give precise motor rotation by utilizing a serve motor.

Objectives of the study

This study had the following objectives:

1. To design a smart feeder system that will automate the process of feeding.
2. To develop a smart feeder system that will automate the schedule of poultry feeding.
3. To test the smart feeder system in terms of functionality and general usability.

Significance of the study

The Internet of Things (IoT) based Automatic Poultry Feeder System would be beneficial for the following:

To poultry farmers: This initiative will assist poultry producers in improving and simplifying the monitoring of chicken feeding and save human resource expenses such as reducing one staff or worker.

To the researchers: This will provide fulfillment to the researchers by allowing them to acquire more knowledge and skills in information technology.

To future researchers: This will also assist students in developing their poultry-raising knowledge and skills. The system or prototype provides regular feeding which is crucial to the student if they have subjects relating to poultry.

Scope and delimitation of the study

The goal of this project is to design, develop and test the Arduino-based Smart Feeding System. It can send an alert to the user when the food supply is running low, as well as feed chickens and offer water. It includes a prototype that holds the other electronic components.

The user of this project will simply store food in a design tray, set the feeding time on a smartphone, and supply water in a container, and the prototype will deliver the feed weights message. The project is solely meant to feed the chickens and provide them with water.

MATERIALS AND METHODS

The flow of the smart feeder system is shown in Fig. 1. This presents how data flows across the whole network. There will be three major subsystems, including:

The Data Management Module requires an application that accesses the data storage environment and shows the same data to the end user.

The data transmission subsystem consists of a wireless communication interface with built-in security features that transmits data from the controller to the data storage server.

The data collection subsystem consists of multi-parameter sensors and an optional wireless communication unit for transmitting sensor information to the controller. The controller gathers the data, executes the same data.

Sensors form the bottom most part of the block diagram. Several sensors are available to monitor water quality parameters. These sensors are placed in the water to be tested which can be either stored water or running water. Sensors convert the physical parameter into equivalent measurable electrical quantity, which is given as input to controllers through an optional wireless communication device. Main function of the controller is to read the data from the sensor, optionally process it, and send the same to the application by using appropriate communication technology. Choice of the communication technology and the parameters to be monitored depends on the need of the application. Application includes the data management functions, data analysis and alert system based on the monitored parameters. This section further discusses the previous work carried out in each of the subsystems.

Based on the comprehensive tests performed by U.S. Environmental Protection Agency (USEPA), chemical and biological pollutants used have been found to have an effect on a broad variety of water parameters, including turbidity (TU), electrical conductivity (EC), dissolved oxygen (DO), temperature and the pH (Theofanis *et al.*, 2014).

Methodology

The flow of the smart feeder system is shown in Fig. 1. This presents how data flows across the whole network. There will be three major subsystems, including:

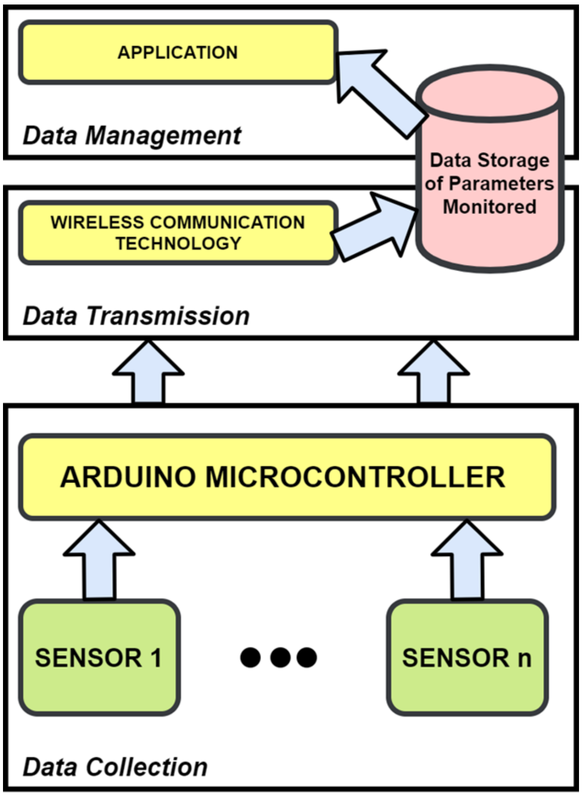

Fig. 1. Data flow diagram of the water quality monitoring system

The provided figure illustrates a general architecture for an automated feeding system, highlighting the key components and their interactions. At the core lies the Arduino microcontroller, which serves as the central processing unit. It collects data from various sensors and the collected data is then transmitted through a wireless communication technology, likely Wi-Fi or Bluetooth, to an application running on a device like a smartphone or computer.

This application is responsible for data management, including storage and visualization of the collected parameters. It may also incorporate features like remote control and automated decision-making based on the sensor data. For instance, the system could be programmed to automatically dispense feed when the weight sensor detects a low level or when the temperature drops below a certain threshold.

In the context of an automated feeding system, this architecture enables precise monitoring and control of feeding schedules, ensuring that animals receive the appropriate amount of food at optimal times. By integrating multiple sensors and leveraging wireless communication, the system can adapt to changing conditions and provide efficient and reliable feeding solutions.

Hardware specification

Table 1 outlines the essential hardware components required for the design and development of an automated feeding system. A laptop running Windows 7 or a later version serves as the central control unit, facilitating system operation and monitoring. A 9V 1A power adapter provides the necessary power supply for the system's electronic components. The NodeMCU/WiFi module, specifically the ESP8266MOD, enables wireless communication and remote control capabilities. The HC-SR04 ultrasonic distance sensor measures the distance to the feed dispenser, allowing for precise control of feed distribution. The load cell weight sensor, HX771, monitors the weight of the feed in the dispenser, ensuring accurate feed quantity delivery. Finally, the 6-volt DC motor powers the mechanism responsible for dispensing the feed. These hardware components, when integrated and programmed effectively, form the foundation of a reliable and efficient automated feeding system.

Table 1. Hardware specification

Hardware	Specification
Laptop	Any Laptop with Windows 7 or higher version
Power Supply	9V 1A power adaptor
NodeMCU/WIFI Module	ESP8266MOD
Ultrasonic Sensor	Hc-SR04 ultrasonic distance sensor
Weight Sensor	Load Cell Weight Sensor HX771
DC Motor	6 volts

Software specification

Table 2 outlines the key software components involved in the design and development of an automated feeding system. The system utilizes the Blynk mobile app as the user interface, enabling remote monitoring and control. C++ programming language is employed to code the underlying logic and functionality of the system. This integration of Blynk and C++ allows for a robust and user-friendly solution that can be tailored to specific feeding requirements.

Table 3. Software specification

Software	Specification
Mobile App	Blynk
C++ programming language	Programming Language to be used in coding

RESULTS AND DISCUSSION

Acceptance testing is a type of software testing in which a system is evaluated for usability.

The goal of this test is to determine whether the system meets the user requirements and whether it is suitable for delivery (Software Testing Fundamentals, 2022). The following five aspects of satisfaction are used to evaluate the performance of the HydroTech System using ISO 9126 quality standard:

1. The functionality characteristic enables judgments to be drawn about how well software performs intended functions.
2. The reliability property enables inferences to be drawn about how effectively software maintains the level of system performance when employed under specific situations.
3. The usability characteristic allows the developer to form judgments about how effectively software may be understood, learnt, used, and loved.
4. The efficiency property allows us to draw inferences about how effectively software performs in relation to the quantity of resources consumed.
5. The portability property enables inferences to be drawn about how effectively software may be moved from one environment to another.

The Benchmark Test was undertaken initially, followed by the Alpha Test and finally the Beta Test. The researchers analyzed the benchmark test, which was done in the third week of November 2023 using the ISO 9126 quality standard. The Alpha Test was reviewed by five (5) experts from Eastern Samar State University's College of Engineering using the same score card during the first week of December 2023. The Beta Test, held in the third week of December, had five (5) Salcedo Poultry Farmers evaluating the system using the same score card.

Benchmark test on the quality attributes of the Arduino-based smart feeder system evaluated by experts conducted on the first week of December 2023

Table 3 summarizes the benchmark test on an Arduino-based smart feeder system. The Benchmark Test's grand mean score was calculated by adding the entire results.

Table 3. Summary on Benchmark test for arduino-based smart feeder system

Criteria	Mean	Interpretation
Functionality	4.03	Very Good
Reliability	4.13	Very Good
Usability	4.15	Very Good
Efficiency	4.00	Very Good
Maintainability	4.07	Very Good
Portability	4.00	Very Good
Overall Mean	4.06	Very Good

In the Functionality category, it had a mean score of 4.03 and was classified as "Very Good". On the Reliability criterion, it had a mean score of 4.13 and is classified as "Very Good". On the Usability criterion, it had a mean score of 4.15 and is classified as "Very Good". On the Efficiency criterion, it had a mean score of 4.00, which is translated as "Very Good". Maintainability criterion yielded a mean score of 4.07, indicating "Very Good" performance. On the Portability criterion, it had a mean score of 4.00 and is classified as "Very Good". The benchmark test's grand mean score is 4.06, which is interpreted as "Very Good". This signifies that the constructed system is functioning as intended, but additional refinement is required.

Alpha test on the quality attributes of the Arduino-based smart feeder system evaluated by the expert, conducted on the second week of December 2023

Table 4 summarizes the Alpha Test on the smart feeder system. The Alpha Test's grand mean score was calculated by adding the entire results. It received an average score of 4.20 on the Functionality category and was classified as Excellent. On the reliability criterion, it had a mean score of 4.13 and was classified as Very Good. While on the Usability criterion, it had a mean score of 4.22 and is classified as Good. On the Efficiency criterion, it had a mean score of 4.20, which is considered Excellent. Maintainability criterion yielded a mean score of 4.20, indicating Excellent. And on the Portability criterion, it received a mean score of 4.13, which is considered as Very Good. The grand mean score of the Alpha Test is 4.18, which is considered Very Good. This signifies that the produced system is of high quality in terms of functionality, usability, efficiency, and maintainability, but requires additional development in terms of reliability and portability.

Table 4. Summary on alpha test for Arduino-based smart feeder system

Criteria		Mean	Interpretation
1.	Functionality	4.20	Excellent
2.	Reliability	4.13	Very Good
3.	Usability	4.22	Excellent
4.	Efficiency	4.20	Excellent
5.	Maintainability	4.20	Excellent
6.	Portability	4.13	Very Good
Overall Mean		4.18	Very Good

Beta test on the quality attributes of the Arduino-based smart feeder system evaluated by poultry farmers in salcedo, eastern samar, conducted on the third week of December 2023

Table 5 shows the results of the beta test for the Arduino-based smart feeder system. The grand mean score of the Beta Test was calculated by adding the total results of the Beta Test. It had an average score of 4.95 in the Functionality category, indicating that it was excellent.

Table 5. Summary on Beta test for arduino-based smart feeder system

Criteria		Mean	Interpretation
1.	Functionality	4.95	Excellent
2.	Reliability	4.90	Excellent
3.	Usability	5.00	Excellent
4.	Efficiency	4.97	Excellent
5.	Maintainability	4.96	Excellent
6.	Portability	4.70	Excellent
Overall Mean		4.91	Excellent

On the Reliability criterion, it had a mean score of 4.90 and was rated Excellent. It received an average score of 5.00 on the Usability criterion, indicating that it is excellent. On the Efficiency criterion, it had a mean score of 4.97, which is considered Excellent. When it comes to maintainability, it has a mean score of 4.96, which is considered excellent. And on the Portability criterion, it received a mean score of 4.70, which is considered as Excellent.

The Beta Test's grand mean score was 4.91, which is considered excellent. This refers to the developed system can now be utilized.

Usability testing

After the experimental testing, the usability test followed to guarantee that the developed device meets the requirements and is ready for implementation. The respondent used the System Usability Scale (SUS) by the (Digital Equipment Corporation, 1986), which measures how well a product allows users to accomplish their goals. The SUS Scale is generally used after the respondents had an opportunity to use the system being evaluated before any debriefing or discussions take place.

To calculate the SUS score, first sum the score contributions from each item. Each item's score contributions will range from 0 to 4. 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 score contribution is the scale position minus 5. Multiply the sum of the scores by 2.5 to obtain the overall value of the SUS. A SUS score of 68 is considered above average and anything below it is below average.

The evaluators of the system usability tests were three faculty members from Eastern Samar State University, College of Computer Studies and three farm operators in the Municipality of Salcedo.

Table 6 displays the summary for system usability on the quality of the Smart Feeder System that was done on the second week of last week of December 2023. It represents the overall score of the 10 item statements. It obtained an overall SUS score of 94. This is exceptionally high, indicating a very user-friendly and effective system. This score suggests that users found the system intuitive, easy to learn, and satisfying to use. It implies that the system's design and functionality are well-aligned with user needs and expectations, leading to a positive user experience. Such a high SUS score is a strong indicator of the system's success and potential for widespread adoption.

Table 6. System usability results on the quality attributes of the Arduino-based smart feeder system

Criteria	Mean	SUS Score
1. I think that I would like to use the device frequently	4.80	3.8
2. I found the device unnecessarily complex	1.00	4.0
3. I thought the device was easy to use	3.60	2.6
4. I think that I would need the support of a technical person to be able to use the device	0.80	4.2
5. I found that the various functions in this device were all integrated	4.20	3.2
6. I thought there was too much inconsistency in this device	0.60	4.4
7. I would imagine that most people would learn to use this device very quickly	4.60	3.6
8. I found the device very cumbersome to use	0.60	4.4
9. I felt very confident using the device	4.00	3.0
10. I needed to learn many things before I could get going with this device	0.60	4.4
SUS Score		37.6
Overall SUS Score (SUS Score x 2.5)		94

CONCLUSION

Based on the study's findings, the following conclusions were drawn:

1. The Arduino-Based Smart Feeder System is ideal for small poultry producers since it reduces farm workload.
2. The Arduino-Based Smart Feeder System was efficient and useful since it matched the requirements.

RECOMMENDATION

Based on the study findings, researchers propose the following:

1. Small poultry farms should employ an Arduino-based smart feeder system.
2. The Arduino-based smart feeder system should specify the exact weight of feed to be released for feeding.

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