IoT- based Decision Support System for Poultry Care for Ilocos Sur Polytechnic State College

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The escalating global demand for high-quality agricultural products necessitates innovative approaches to meet future requirements sustainably. Poultry farming, a cornerstone of the agricultural sector, faces persistent challenges including disease outbreaks and environmental sustainability concerns. To address these challenges, stakeholders are increasingly turning to technological solutions such as the Internet of Things (IoT) for enhanced monitoring and management. This research focuses on designing and implementing an IoT-based Decision Support System for Poultry Care tailored to the needs of the Ilocos Sur Polytechnic State College (ISPSC) Sta. Maria Campus Egg Production Facility in the Philippines. Leveraging the Design Thinking framework and Agile Software Development Life Cycle, the system enables real-time monitoring of critical parameters such as temperature, humidity, and gas toxicity within poultry houses. The system aims to provide early warning mechanisms for proactive interventions, ensuring optimal conditions for poultry health and productivity. Usability evaluation results indicate strong agreement among users regarding the system's effectiveness, ease of use, and overall satisfaction. This study underscores the potential of IoT technologies to drive sustainable growth, improve productivity, and enhance decision-making in poultry farming operations.

Keywords: Poultry farming, Decision support system, Internet of Things (IoT), Environmental monitoring, Sustainable agriculture.

1. Introduction

The global demand for high-quality agricultural products, such as meat and eggs, is projected to surge by over 40% by 2050 compared to current levels. This increasing demand is primarily driven by factors like affordability and nutritional value. The poultry industry plays a pivotal role in meeting this growing demand, with the Food and Agriculture Organization (FAO) highlighting its importance in providing sustainable protein sources for populations worldwide [1].

The poultry industry also holds significant economic importance, with figures indicating its substantial contribution to national GDPs. For example, in the United States, the poultry production industry is estimated to be over $20 billion per year, while in Pakistan, the poultry sector contributes 1.3% of the country's national GDP [2].

However, despite its economic significance, the poultry industry faces persistent challenges, including disease outbreaks and environmental sustainability concerns. Diseases such as Highly Pathogenic Avian Influenza (HPAI) and Newcastle disease pose substantial threats to poultry health and production, particularly in regions like Vietnam [3]. Aside from these, manual monitoring of species in poultry farms has been identified as an area of concern [4]. This manual monitoring process is labor-intensive and time-consuming, particularly in large farms where multiple behaviors need to be monitored simultaneously.

To address these challenges and ensure sustainable growth, stakeholders are turning to technological solutions such as the Internet of Things (IoT). IoT technology enables the remote monitoring of critical parameters in poultry facilities, empowering farmers to make informed decisions and implement timely interventions to optimize conditions for their poultry flock [5].

In regions like the Philippines, poultry farming plays a vital role in the economy. For instance, the poultry subsector in the Philippines contributes 13% to agriculture's gross value added (GVA), with significant growth rates recorded in recent years [6].

However, poultry farming in the Philippines faces numerous challenges, including pests and diseases that can significantly impact poultry production. Avian Influenza (AI) and Newcastle disease (ND) are among the prevalent diseases that pose serious threats to poultry health and can result in substantial economic losses if not promptly addressed [7]. Prevention strategies involve implementing proper hygiene practices, utilizing respiratory protection, and euthanizing sick animals, but these processes are currently carried out manually, creating labor-intensive and time-consuming hurdles for farmers, especially in large-scale operations.

With these, research initiatives are underway to develop IoT-based decision support systems tailored to the needs of poultry farmers. These systems aim to provide early warning mechanisms for environmental monitoring in poultry houses, enabling proactive measures to ensure optimal conditions for poultry health and productivity [8].

The Ilocos region in the Northern part of the Philippines is recognized as one of the top producers of poultry products, contributing 25.53 thousand metric tons in 2023. The Ilocos Sur Polytechnic State College – Sta. Maria Campus, situated in the Municipality of Sta. Maria, Ilocos Sur, plays a significant role in the region's poultry production through its Egg Production Facility. However, despite its prominence, poultry farmers at the institution still rely on manual and traditional methods to monitor the facility's environment, encompassing factors like water temperature, humidity, gas toxicity, and disease presence that could impact poultry health.

To address this challenge, a research study aims to design and develop a Decision Support System for Poultry Care for ISPSC. This study aimed to fulfill the following objectives, to wit: 1) examine the information and technology requirements to design and develop a Decision Support System for Poultry care for ISPSC; 2) design the features that should be integrated Decision Support System for Poultry care for ISPSC; and 3) investigate the extent of usability of the Decision Support System for Poultry care for ISPSC.

This initiative aims to implement an early warning system using IoT sensors to monitor critical parameters such as temperature, humidity, and gas toxicity in the poultry houses. The collected data will ensure that the poultry animals are housed in a comfortable environment and receiving optimal care, enabling early identification and resolution of potential issues. This proactive approach provides farmers with the opportunity to take timely actions to safeguard their poultry effectively.

2. RELATED WORK

Recent studies from different countries have explored the design and development of Decision Support Poultry Care System . These studies are summarized in the following table:

TABLE I. SIMILAR STUDIES ABOUT DECISION SUPPORT POULTRY CARE SYSTEM

Year	***Place***	***Title of Study***	***Author/s***	***Acceptability/ Usability Rating***
2020	Spain	An IoT Platform towards the Enhancement of Poultry Production Chains	Gonzalez et al.	4.5
2020	Philippines	e-Poultry: An IoT Poultry Management System for Small Farms	Batuto et al.	4.0
2021	India	An IoT Poultry Management System for Small Farms	Priya et al.	4.0
2023	Philippines	Development of IoT-Based Decision Support System for Environmental Monitoring in Poultry Houses	Rogers et al.	4.2
2023	Nigeria	Smart Poultry Farming Using Internet of Things (IoT)	Dinrifo & Abatan	3.8

In 2020, researchers from Spain developed an IoT platform to enhance poultry production chains, achieving a high rating of 4.5. This highlights the significant potential of IoT in optimizing and improving efficiency within poultry production processes [9].

Additionally, a study in the Philippines by [10] in 2020 introduced an e-Poultry management system utilizing IoT technology for small poultry farms, receiving a commendable rating of 4.0, showcasing the effectiveness of IoT in enhancing management practices at a smaller scale.

Moving to India in 2021, researchers introduced an IoT-based system tailored for small poultry farms to enhance management practices and efficiency, earning a solid rating of 4.0. This emphasizes the importance of tailored IoT solutions in addressing specific needs and challenges faced by small-scale poultry operations [11].

In 2023, a study conducted in the Philippines focused on enhancing environmental monitoring in poultry houses through an IoT-based decision support system, receiving an acceptability/usability rating of 4.2. This underscores the value of IoT technologies in improving monitoring capabilities and overall environmental conditions within poultry facilities [8].

Similarly, in Nigeria, researchers explored the application of IoT in smart poultry farming practices, emphasizing improved poultry management with a rating of 3.8. While slightly lower than other studies, this rating still indicates the potential benefits of incorporating IoT technologies in enhancing efficiency and practices within the poultry farming industry [12].

These studies collectively showcase the global interest and advancements in integrating IoT technologies to optimize various aspects of poultry farming practices across different regions.

3. CONCEPTUAL FRAMEWORK

The researcher employed the Design Thinking framework to integrate and organize the concepts essential for conducting the study.

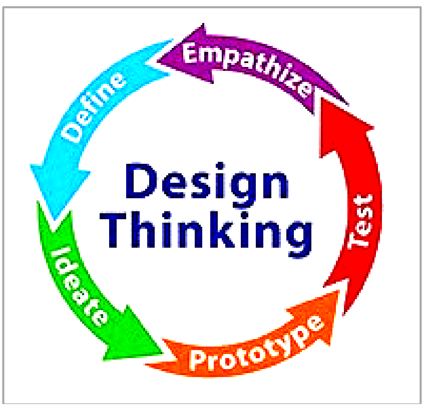

Fig. 1. Design Thinking Framework

Empathize. Understanding the needs in order to accurately address the challenges at hand, this phase encourages researchers and developers to observe and engage with customers, learn their expectations, and identify underlying challenges.

Under this stage, the researcher aimed to understand the problem prior to searching for solutions. To achieve this, the researcher conducted assessment on the current situation of poultry care and interviewed the farmers in the intended area of the study.

Define. The next step is to gather and analyze data from the 'empathize' stage so as to clearly define the core problem statement. This will help outline the real issue, before proceeding to the ideation stage.

In this stage, the researcher considered the process of figuring out the user's needs, motivations, and problems so that valuable insights can be gained that can be used to guide the development of a design strategy.

Ideate.This stage involves brainstorming and exploring creative solutions to potentially solve the problem statement.

The researcher developed solutions to the problem using the collected data from the assessment and interviews through comprehensive analysis and this begins with what most people know as brainstorming.

Prototype. This experimental phase aims to find the best solution for each identified problem. It is done by using scaled-down versions of the concept—also called prototypes—which are tested on users.

The researcher included the initial plan for the development of the system. A paper prototype was created to determine the flow and interactions involved in the system.

Test. Once the final prototype is ready, it is time to put it to the test by observing how the target audience interacts with the product and what their feedback is.

The researcher reviewed the system to see if all the necessary requirements and functionalities were included.

4. RESEARCH METHODOLOGY

In this study, the researcher utilized the Agile Software Development Life Cycle in the development of the system.

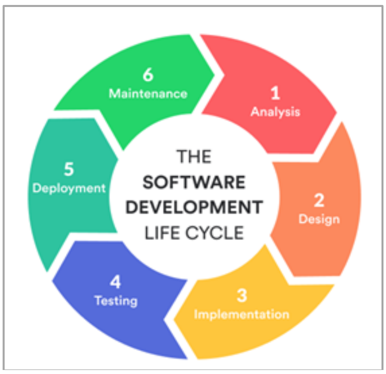

Fig. 2. Agile Software Methodology

Analysis. Defining the objectives and scope of the project is the main focus of this phase. It is also in this state where documents that outline the key requirements of the application are created.

In this stage, the researcher determined and defined the requirements and needs of the users, the information requirements needed by the system such as hardware and software requirements, the scope of the study, and the plan in the development of the system.

Design. The design phase is the stage where software developers define technical details of the application which includes screen designs, databases, sketches, system interfaces and prototypes.

In this phase, the researcher built a UML use case diagram and design a low fidelity prototype to show the system's architecture, features and flow. This will demonstrate the different ways that a user might interact with a system.

Implementation. This phase is initiated after the system has been tested and accepted by the user. In this stage, the system is installed to support the intended business functions. System performance is compared to performance objectives established during the planning phase.

After defining the requirements needed, the researcher started working in the study called construction. The system was constructed in this phase based from the requirements provided by the users, and needed by the system. Furthermore, the system went through various stages of enhancements in this phase which include simple and minimal functions. The researcher aimed to deploy the study within the estimated time.

Testing. The testing is done to ensure that the entire application works according to the customer requirements.

For the fourth phase, the researcher conducted a pilot testing in the Poultry Facility of ISPSC Sta. Maria Campus. Through farmers from the campus, the researcher conducted the test together with the system's usability assessment survey.

Deployment. In this phase the researcher will be delivering the final product to the customers in a live production environment.

After testing, the researcher deployed the constructed system to the intended location. This included the creation guides for installation, system operations, system administration and end-user functionality.

Maintenance. The software is monitored to ensure it continues to function as it was designed to, and repairs or upgrades are performed as needed.

Lastly, after deploying the system, monitoring the overall functionality and performance of the system will be in the following months and years to identify errors and to ensure that the system meets its functions.

5. RESULTS AND DISCUSSION

A. Variables Affecting the Health of the Chickens

Based on the conducted interview, the following results were gathered:

1) Temperature and Humidity: According to the poultry farmers, the temperature needs to be monitored during summer and cold weather. During summer, the poultry needs to continuously monitor the chickens to make sure that chickens survive during excessive heat. Usually, one intervention strategy of the poultry farmer when chickens are panting is that water is poured into the chicken's feathers to reduce the heat in the chicken's body. This strategy is to prevent heat stress caused by high temperature or death.

Furthermore, poultry farmers claimed that the most chicken has a higher mortality rate during cold weather or rainy season because chickens during these times are prone to colds, which if not immediately attended to, chickens might be from cold stress and might die. During this period, various challenges include reducing the amount of feed chickens consume, impacting their ability to maintain a healthy weight, and also spawning. To check the temperature inside the poultry house, some poultry farmers borrow temperature detectors and some are use their own experience to perform routine checks on the chickens instead of using temperature to measure humidity and temperature.

Their experience as poultry farmers is an aid in taking care of the chickens. Within the current practice of the poultry farmer, too much time is spent monitoring the chickens. The assurance of a proper temperature and humidity level is at stake that sometimes poultry farmers experience that chicks die, especially during the spawning period. It results in poultry owners losing profit if the chicken dies.

2) Ammonia or Gas Toxicity. The poultry owners do not have any devices to detect the ammonia level in the poultry farm. To avoid detrimental impacts on the chickens and the nearby community, it is imperative to monitor the level of ammonia in the poultry farm. The farmers claim that sometimes chickens die unexpectedly. This phenomenon occurs when it rains and a bad smell emanates from beneath the poultry house, which is where the chicken waste is kept. The poultry farmers thought it might have been ammonia. Almost all of the chickens eventually lost their appetite, were sick, and died away after a few days. In order to reduce the smell, the poultry farmer must clean the chicken dirt twice a day. Singh (2019) stated that ammonia irritates the eyes of the chicken and might be exposed to infections. Further, ammonia should not be above 25ppm.

B. Information and Technology Requirements for Poultry Care Data Analysis.

1) Information Requirements. The information requirements include temperature, humidity, ammonia or the gas toxicity.

a. Temperature. Monitoring temperature is essential to ensure the comfort of the poultry and optimize growth rates.

b. Humidity. Maintaining appropriate humidity levels is vital for the health and well-being of the birds.

c. Ammonia or Gas Toxicity. Monitoring ammonia or gas toxicity helps prevent respiratory issues and ensures a healthy environment for the poultry.

2) Technology Requirements. The technology requirements include Arduino Uno Microcontroller, DHT22 sensor, and MQ137 sensor.

a. Arduino Uno Microcontroller. The Arduino Uno microcontroller (Fig. 3) with its specifications serves as the central brain of the entire device. The Arduino Uno microcontroller processes all the detected values of the DHT22 temperature and humidity sensor and the MQ137 sensor for ammonia.

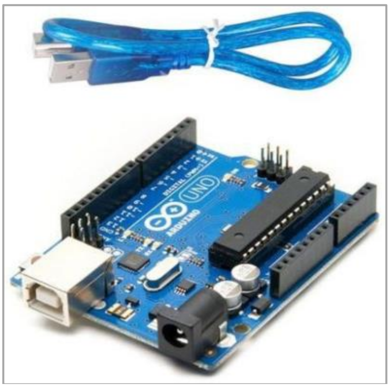

Fig. 3. Arduino Uno Microcontroller

Specifications

- Microcontroller: ATmega328P
- Operating Voltage: 5V
- Input Voltage (recommended): 7-12V
- Input Voltage (limit): 6-20V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- PWM Digital I/O Pins: 6
- Analog Input Pins: 6
- DC Current per I/O Pin: 20 mA
- DC current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB (ATmega328P) of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328P)
- EEPROM: 1 KB (ATmega328P)
- Clock Speed: 16 MHz
- LED_BUILTIN: 13
- Length: 68.6 mm

- Width: 58.4 mm
- Weight: 25 g

b. DHT22 Sensor. Fig. 4 shows the DHT22 sensor and its specifications that detects the level of temperature and humidity. It is connected to the Arduino Uno Microcontroller.

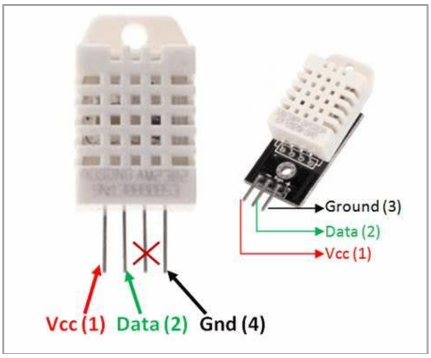

Fig. 4. DHT22 Sensor

Specifications

- Operating Voltage: 3.5V to 5.5V
- Operating current: 0.3mA (measuring) 60uA (standby)
- Output: Serial data
- Temperature Range: -40°C to 80°C
- Humidity Range: 0% to 100%
- Resolution: Temperature and Humidity both are 16-bit
- Accuracy: ±0.5°C and ±1%

c. MQ137 Sensor. MQ137 sensor (Fig. 5) plays a crucial role in monitoring air quality, particularly in industrial settings or agricultural environments where ammonia gas might be present. By detecting even minute levels of NH3, it helps identify potential hazards and enables prompt action to be taken. With this, the poultry farmer can monitor the ammonia level in the chicken cage through the Blynk framework using an Android phone and computer.

Fig. 5. MQ137 Sensor

d. Raspberry Pi 3 Model B. Raspberry Pi 3 Model B (Fig. 6) acts as the brains with its processing power ,internet connectivity and transmit the data.. It can handle complex tasks, data analysis, and communication with the cloud.

Fig.6. Raspberry Pi 3 Model B

Specifications

- Processor: 1.2 GHz quad-core ARM Cortex-A53 CPU
- RAM: 1 GB LPDDR2 SDRAM
- Graphics: VideoCore IV GPU with OpenGL ES 2.0 support
- Storage: MicroSD card slot
- Networking: 802.11n Wi-Fi, Bluetooth 4.1, and 10/100 Mbps Ethernet port
- Connectivity: 4x USB 2.0 ports, HDMI port, 3.5mm audio jack, and 40-pin GPIO header

C. Features of the System

The following are the features of the system:

1) Real-time Monitoring. The developed system allows continuous monitoring of critical parameters such as temperature, humidity, and gas toxicity within poultry houses to ensure optimal environmental conditions for poultry health.

2) Remote Access and Control. The system has the ability for farmers to access and control the system remotely through a web or mobile interface, enabling them to monitor and adjust conditions from anywhere.

3) Early Warning Alerts. The system has automated alerts and notifications to farmers in case of deviations from preset thresholds for temperature, humidity, or gas levels, allowing for proactive interventions to prevent potential issues.

4) Data Logging and Analytics. The system allows logging and analysis of historical data to identify trends, patterns, and potential correlations, providing insights for optimizing poultry care practices and decision-making.

5) Integration with Environmental Sensors. Environmental sensors such as temperature sensors, humidity sensors, ammonia sensors, and air quality sensors were integrated in the system to provide comprehensive monitoring capabilities.

6) User-friendly Interface. The system has Intuitive and user-friendly interface for easy system navigation, configuration, and monitoring by farmers and farm personnel.

D. Extent of Usability of the System

To determine the usability of the developed system, the researcher conducted system demonstration to the farmers in ISPSC Egg Production Facility in Sta. Maria, Ilocos Sur. The system was then evaluated using the Usefulness, Satisfaction, and Ease of use (USE) Questionnaire. The result of the evaluation is reflected on the following table:

TABLE II. SYSTEM EVALUATION RESULT

Indicators	***Mean***	***Descriptive Rating***	***Descriptive Interpretation***
Usefulness	6.45	Strongly Agree	Strongly Usable
Ease of Use	6.28	Strongly Agree	Strongly Usable
Ease of Learning	6.17	Strongly Agree	Strongly Usable
Satisfaction	6.30	Strongly Agree	Strongly Usable
Grand Mean	**6.30**	**Strongly Agree**	**Strongly Usable**

The results indicate high ratings across all indicators, with a mean score of 6.30, reflecting a "Strongly Agree" descriptive rating for each category - Usefulness, Ease of Use, Ease of Learning, and Satisfaction. These ratings suggest that the system is perceived as highly usable, effective, easy to learn, and satisfactory by the users. The strong agreement across all indicators highlights the positive reception and acceptance of the system among its users. This indicates that the system not only meets but exceeds user expectations in terms of functionality, usability, and overall satisfaction.

6. CONCLUSIONS AND FUTURE WORKS

This study has led to the development of an innovative Decision Support System for Poultry

Care tailored to address the specific needs of the poultry farming community at the Ilocos Sur Polytechnic State College (ISPSC) Sta. Maria Campus Egg Production Facility. By leveraging Internet of Things (IoT) technology, this system offered real-time monitoring of critical parameters such as temperature, humidity, and gas toxicity within poultry houses, enabling proactive interventions to ensure optimal conditions for poultry health and productivity.

The usability evaluation of the system revealed high ratings across all indicators, indicating strong agreement among users regarding its usefulness, ease of use, ease of learning, and overall satisfaction. This positive reception underscores the system's effectiveness in meeting the needs of poultry farmers, enhancing their capacity to make informed decisions and ensure the well-being of their flocks.

In conclusion, the Decision Support System for Poultry Care for ISPSC represents a significant advancement in poultry farming technology, offering a scalable and adaptable solution to address the persistent challenges faced by the industry. By empowering farmers with actionable data and insights, this system holds the potential to drive sustainable growth, improve productivity, and safeguard the economic viability of poultry farming operations in the Philippines and beyond.

However, the researcher recommends other researchers and developers to consider about expanding this system by leveraging Artificial Intelligence (AI) as well as using other IoT devices.

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