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The Development of Hog Monitoring with Automated Feeding Machine and ventilation System using Mobile Application

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ABSTRACT

One of the pressing challenges faced by pig farm owners in the Philippines is the constant threat of swine flu, which can disrupt production and commercial operations of the domestic pigs. This study presents an automated smart pig farm system that includes key features such as feeding automation, waste management, and a water sprinkler system using mobile application. This technology integrates a comprehensive pig monitoring system, capable of tracking vital parameters such as temperature, weight, and ammonia content in feces. In contrast to traditional pig farming methods, this system introduces a cutting-edge approach to monitoring and control, facilitated through a user-friendly mobile application. The integration of the Internet of Things (IoT) in agriculture, specifically in hog monitoring, has demonstrated remarkable improvements in animal welfare and production efficiency. The study used an agile methodology to design and implement this smart pig farm system using mobile application. The study was evaluated using ISO25010 quality standards, ensuring that the system met the highest levels of performance, reliability, and user satisfaction. This rigorous evaluation process underlines the commitment to delivering a robust and dependable solution to the pig farming community. This not only enhances productivity but also contributes to the sustainability of pig farming in the Philippines, ultimately benefiting both the farmers and the industry.

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1. INTRODUCTION

Swine production is the largest livestock and poultry sector in the Philippines, with a substantial market value of P191 billion. It plays a vital role in ensuring food security by providing approximately 60% of the annual meat consumption for Filipinos. In global rankings, the Philippine swine industry stands at seventh place in terms of pork production and the number of breeding sows [1].

Nevertheless, piggery owners in the Philippines grapple with a significant challenge - the constant specter of swine flu, a respiratory disease caused by the type A influenza virus that periodically leads to pig influenza outbreaks. A recent incident in Sta. Maria, Sta. Ana, Pampanga, where 30 pigs succumbed to swine flu, serves as a stark reminder of the perilous combination of the Philippines' climate and the ease with which this virus can spread. The unfortunate consequence of insufficient monitoring and delayed care was an alarming increase

in pig mortality. The ripple effect of this loss extends to the potential infection of the surviving pigs, thus amplifying the crisis.

And in the tropical climate of the Philippines, characterized by humidity ranging from 71 to 85 percent and a consistent average temperature of 26.6 degrees Celsius throughout the year, a yearly increase of 0.65 degrees Celsius has been observed [2]. This warming trend exacerbates the susceptibility of pigs to heat stress, which compromises their internal defense mechanisms and heightens their vulnerability to infections. Furthermore, climate projections suggest that temperatures are expected to rise by 0.9 to 1.1 degrees Celsius in 2020 and 1.8 to 2.2 degrees Celsius in 2050, as per a study by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) on climate change in the Philippines [3].

The impact of this heat stress on pig production during the summer season is a significant challenge that affects various aspects such as growth rates and reproduction. In response to these challenges, our research aims to develop a comprehensive system that integrates real-time monitoring of pig health and environmental conditions to effectively prevent heat stress and improve overall piggery management. Here are the key components and features of the comprehensive system designed to address heat stress and enhance piggery management:

- The system incorporates sensors to monitor vital parameters such as pig body temperature, humidity levels, and air quality in the piggery environment. Real-time data collection allows continuous monitoring of potential heat stress indicators and environmental conditions that may impact pig health and well-being.
- The system is programmed to detect variations in pig body temperature that indicate potential heat stress. Upon detecting such variations, the system automatically alerts piggery owners or caretakers through a mobile application, providing timely notifications to take necessary actions.
- To mitigate heat stress, the system integrates with the piggery's ventilation system. Upon receiving an alert or detecting heat stress indicators, the system initiates the ventilation system to regulate temperature and improve airflow within the pig enclosures, creating a more comfortable environment for the pigs.
- The system includes a user-friendly mobile application that allows owners or caretakers to access real-time sensor data remotely. Through the mobile app, users can monitor pig health metrics, environmental conditions, and receive alerts or notifications regarding heat stress or other critical issues.
- In addition to monitoring and alerting functions, the system incorporates automation for pig feeding and waste management. Automated feeding systems ensure consistent and timely feeding schedules, promoting optimal nutrition management for the pigs. The system also includes mechanisms for automated removal of pig feces, enhancing hygiene and waste management practices within the piggery. The proposed system also includes a diary log feature for documenting pig information, including their names, genders, and ages. The system then automatically tracks the pigs' daily aging progression.

This overarching objective of this research is to introduce a smart piggery using mobile application, an innovative system integrating pig monitoring, automated feeding, and ventilation control, all accessible via a mobile application. Specific goals include monitoring pig weight, body temperature, environmental conditions, and ammonia levels in pig feces. The study also focuses on automating pig feeding, cage cleaning, and piggery ventilation while managing daily dietary requirements, treats, and supplements. The mobile application aims to provide control and access to sensor data, with a particular emphasis on assessing the system's performance and usability, aligned with ISO/IEC 25010 standards.

And the potential beneficiaries of this research are multifaceted. Piggery owners can expect improved monitoring capabilities and more efficient management, including real-time health and environmental data, automated feeding, and ventilation control [12]. Consumers, on the other hand, stand to gain from reduced risks associated with purchasing unhealthy pigs from piggery operations or markets [13]. Moreover, students can use this research as a practical case study of implementing a Smart Piggery with hog monitoring and ventilation systems using mobile application, deepening their understanding of IoT applications [14]. Finally, future researchers looking to advance this technology will find a valuable local review of related literature in this study [15].

The research's focus centers on piggery automation, particularly targeting feeding and ventilation processes and hog monitoring. It encompasses the development of a mobile application that permits users to manage individual hogs, offering detailed histories accessible through logs. The application facilitates setting feeding schedules and manual sprinkler control. The system incorporates ammonia gas sensors (MQ137) to monitor cage ammonia levels and Contactless Temperature Sensor Modules (MLX90614ESF) for tracking pig body temperature. Pig weight is monitored using load cells, while height is measured via ultrasonic sensors. Leveraging the Internet of Things (IoT), the system collects and relays data through a web server, rendering it accessible through the mobile application [23]. The system operates on a 220 AC power supply without backup power. The study focuses on selected piggeries in the Municipality of Sta. Ana and Candaba, Pampanga, which use cage-like housing. However, it does not encompass an accounting system for hog production and is exclusively designed for Android platform compatibility for mobile application access [24].

2. METHOD

This research project employed a quantitative research design to quantify responses from the study participants. A purposive sampling approach, which falls within the realm of non-probability sampling, was utilized to collect pertinent data from piggeries in the municipalities of Sta. Ana and Candaba in Pampanga. The primary objective was to elucidate the respondents' perspectives concerning the Functional Suitability, Reliability, Performance Efficiency, Usability, Security, Compatibility, Maintainability, and Portability of the Smart Piggery project using mobile application. The study's overarching aim was to demonstrate the tangible benefits of the Smart Piggery using mobile application, particularly for piggery farmers. To achieve this, data were gathered through surveys and questionnaires.

Using the mentioned statistical treatment, the use of Agile development methodology in the development process of the Smart Piggery system using mobile application played a crucial role in ensuring the systematic and functional integration of both the mobile application and the automated hardware components. This methodology is characterized by its iterative and incremental approach, which proved to be highly beneficial in achieving a constructive and advantageous outcome for the project.

Here are some key aspects and benefits of using Agile methodology in the development of the Smart Piggery system:

- Iterative Development: Agile methodology emphasizes iterative development cycles, where functionalities are developed, tested, and refined in short iterations known as sprints. This iterative approach allowed the development team to continuously improve and refine the system based on feedback and evolving requirements.
- Flexibility and Adaptability: Agile methodology promotes flexibility and adaptability to changing requirements and priorities. As the project progressed, adjustments and enhancements could be easily incorporated into the development process, ensuring that the final product met the stakeholders' needs effectively.
- Collaboration and Communication: Agile methodologies prioritize collaboration and communication within cross-functional teams. This facilitated close coordination between developers, designers, testers, and stakeholders, enabling rapid decision-making and alignment of objectives throughout the development lifecycle.
- User-Centric Design: Agile development places a strong emphasis on user feedback and involvement throughout the development process. This user-centric approach ensured that the Smart Piggery system's mobile application was designed and implemented with a focus on user experience, functionality, and usability.
- Continuous Integration and Testing: Agile methodologies promote continuous integration and testing practices, ensuring that new features and updates are integrated seamlessly into the system and thoroughly tested for functionality and quality. This helped in identifying and addressing issues early in the development process, reducing risks and enhancing overall system reliability.
- Incremental Delivery of Value: By breaking down the development process into manageable increments, Agile methodology enables the incremental delivery of value to stakeholders. This means that usable and functional features of the Smart Piggery system were delivered incrementally,

allowing stakeholders to start deriving benefits from the system sooner rather than waiting for a complete, but potentially delayed, release.

The adoption of Agile development methodology in developing the Smart Piggery system contributed significantly to its success by promoting iterative improvement, flexibility, collaboration, user-centric design, continuous integration, and incremental delivery of value. These aspects collectively ensured a systematic and functional integration of the mobile application and automated hardware, resulting in a constructive and advantageous outcome for the project [16]. This chapter provides an insight into the methods employed to obtain research data, detailing the instruments and strategies used in developing software and hardware that met the specific needs of piggery owners [17]. Additionally, it delves into the instruments and strategies implemented to assess the system's effectiveness in delivering the required features for the organization [18].

Using the Scrum Agile methodology, the research project necessitated extensive laboratory work, predominantly in the preparation and development of devices essential for its completion, in addition to hands-on activities conducted in a computer laboratory for mobile application development [19].

To conduct a comparative analysis, the researcher employed a comparative study approach, aimed at identifying, analyzing, and elucidating the similarities and disparities between manual processes and the utilization of a Smart Piggery system [20]. As a result, data were collected from piggery owners regarding different aspects of the processes involved in feeding, growing, and monitoring pigs.

The research design encompassed several stages, starting with the structural design of the project, determining the components essential for creating the hardware system, designing the mobile application software, and culminating in the evaluation of test results [21]. This comprehensive methodology was designed to ensure the seamless development and assessment of the Smart Piggery system.

Table1. Resondpondents

Piggery Farmers	Number of Respondents
Sta. Ana, Pampanga	5
Candaba, Pampanga	5
Total	10

Data collection for this study was conducted through surveys, with the primary data-gathering tool being questionnaires. These questionnaires were carefully designed to ensure the accurate acquisition of information from the respondents. The questions posed to participants focused on various aspects of the research project, including its functionality, reliability, user satisfaction, ease of use, and a comparative analysis of the manual processes versus the Smart Piggery system using mobile application.

The research instrument comprised two key questionnaires: an ISO 25010-adapted questionnaire and a computer system usability questionnaire. The Likert scale, a widely employed tool for ranking the level of agreement with a statement, was used to gauge participants' responses. This scale ranged from (1) "Very Poor" to (5) "Excellent," with (3) serving as the neutral or average option. This methodology allowed for a comprehensive assessment of the research project's various dimensions and provided valuable insights into the respondents' perceptions and experiences.

Table 2. Interpretation of Dichotomous Questions

Likert Scale Value	Interpretation
5	EXCELLENT
4	GOOD
3	AVERAGE
2	POOR
1	VERY POOR

To gather the essential data for this research project, the researchers conducted a comprehensive analysis of credible sources, including thesis papers, journals, articles, and research papers from both local and international publications. These sources served as a foundation for understanding the topic and framing the research within the existing body of knowledge.

In addition to the analysis of existing literature, the researchers followed a structured process for data collection from the Smart Piggery system. This process entailed several key steps:

- Formulation of Questionnaire: The first step involved creating a well-crafted questionnaire that included a range of technical and non-technical questions. These questions were designed to validate and substantiate the research findings.

- Validation of Questionnaires: In the second step, the questionnaires were subjected to a rigorous validation process. Experienced validators ensured that the questions were clear, pertinent, and capable of eliciting the desired information.
- Distribution to Respondents: The third step involved the dissemination of the questionnaires to the chosen respondents. This stage allowed the researchers to accumulate concrete evidence to support their study.
- Throughout the data collection process, the researchers adhered to ethical protocols, ensuring the confidentiality and protection of the respondents' data and privacy. This compliance with ethical standards aligns with the National Privacy Commission's R.A. 10173 Chapter 3-Section 11, which outlines the principles governing the processing of personal information, emphasizing transparency, legitimate purpose, and proportionality.

The collected data from the questionnaires was then analyzed using a combination of Frequency and weighted mean. These analytical tools allowed the researchers to derive meaningful insights from the responses. The findings were subsequently used to make descriptive assessments based on the Likert scale, which ranged from "excellent" to "very poor." This systematic approach aided in summarizing the survey questionnaire answers effectively.

The researchers employed the Likert Scale, utilizing a five-point format, to interpret the results of the survey questionnaire. This method provided a structured and reliable means of quantifying respondents' perceptions and opinions, contributing to the depth and rigor of the research project.

Weighted Mean:

$$\text{WM} = \frac{(E*5)+(G*4)+(A*3)+(P*2)+(VP*1)}{Total\ Respondents} \quad (1)$$

Where:

EXCELLENT, GOOD, AVERAGE, POOR, VERY POOR

Table 3. Likert Scale (Descriptive Evaluations Chart)

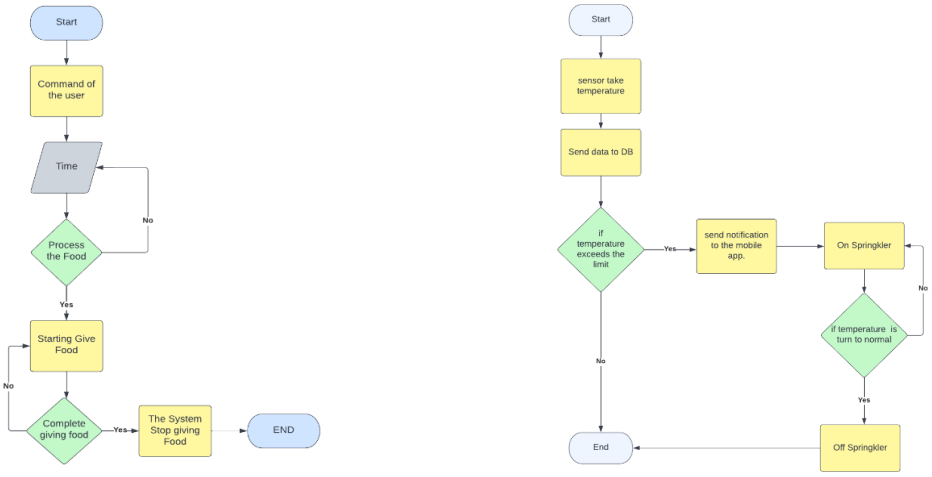
RATING	DESCRIPTION	LIMIT OF INDEX
5	EXCELLENT	4.01-5.00
4	GOOD	3.01-4.00
3	AVERAGE	2.01-3.00
2	POOR	1.01-2.00
1	VERY POOR	0.01-1.00

The weighted mean, which depicts the overall assessment and evaluation of the respondents, and statistical tests like the frequency of the replies were used by the researchers to examine the data they collected from the respondents.

To determine the system's level of utility, reliability, usability, and maintainability, the researchers computed the weighted mean and examined the findings. The weighted mean was then split into five categories by the researchers, with a weighted mean of 4.01 to 5.00 signifying "Excellent," which means that the respondents believed the system created was extremely acceptable. The respondents' "Good" response, which falls between the ranges of 3.01 to 4.00, shows that they believe the system to be in working order. The responses from the respondents fell between 2.01 to 3.00, which is the "Average" range. The "Poor" response, which has a range of 1.01 to 2.00, means that the respondents don't agree with the system's development since some of its elements are inconsistent. Finally, a score between 0.01 and 1.00 indicates "Very Poor," which means that the respondents disagree with certain aspects of the system.

The Agile approach is a style of project management that divides a project into stages. It entails ongoing engagement with stakeholders as well as continual development at each level [25]. When the job begins, teams go through a cycle of planning, execution, and evaluation [26].

Seven phases of Agile Designs were used by the researcher in developing the project “Smart Piggery Pig Monitoring with Automated Feeding and Ventilation System using Mobile Application”, Seven phases include the following: Planning, Design, Develop, Testing, Deployment of the system and hardware, Review, Maintenance, and execution of the project. This methodology is very easy to understand as this method can go back like a cycle for improvement and revisions of the project [27]. The system used a hardware and software for the sensors/modules to be automated.



(a) (b)

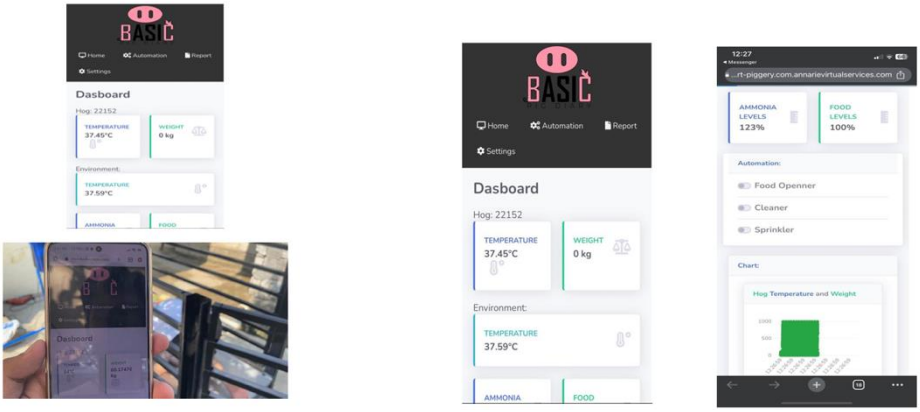
Figure 1. Flowchart

Figure 1(a) describes the Flowchart model, which depicts the flow of the feeding process and is ordered by the user to give time and how much food to supply.

Figure 1(b) describes the flowchart model, which shows how temperature monitoring for pigs works. When the device detects an inappropriate temperature, it alerts the user and requests that the water sprinkler be turned on to cool the pigs. If the temperature is normal, the sprinkler will be turned off.

Figure 2. System View

Figure 2 shows the final design of the system. The system measures 60.96 cm by height x 76.20 cm by length x 30.48 cm by width, and weighs 90kgs.



(a) (b) (c)

Figure 3. System Application

Figure 3(a), figure 3(b), and figure 3(c) displays the system application, showing the temperature, the level of ammonia, the weight of the hogs, and the automated feeding process.

The hogs should be fed once in the morning and once in the evening. However, in case the hogs need to be fed at any other time, there is a feed button on the application that can be used to automatically release the food.

3. RESULTS AND DISCUSSION

The Development of Pig Monitoring with Automated Feeding Machine and Ventilation System Using Mobile Application is a project that have a monitoring and automation, it is combined of a software and hardware. The automation consists of Feeding, Cleaning of pig feces, and Water Sprinkler. It has a monitoring for the pig, Temperature, Weight, and Ammonia level for the pig feces. Also with the environment, it also monitors its humidity and temperature to avoid the pigs from stress. The use of Internet of Things with the industry of agriculture have improved its production efficiency and animal welfare which can lead to increased productivity, and sustainability.

The researchers were able to monitor the progress of the hogs before and after implementing the system, and the results are as follows:

Table 4. Before Implementing Smart Piggery

Hog ID	Temperature (°C)	Weight (kg)	Ammonia Level	Humidity (%)
001	37.2	98	4.0 ppm	70
002	38.0	101	4.2 ppm	71
003	37.5	97	3.8 ppm	69
`004	36.8	94	4.1 ppm	68
005	37.9	100	4.3 ppm	72

Table 5. After Implementing Smart Piggery System using Mobile Application

Hog ID	Temperature (°C)	Weight (kg)	Ammonia Level	Humidity (%)
001	38.5	110	3.2 ppm	65
002	37.8	105	2.8 ppm	63
003	38.2	112	3.5 ppm	67
004	37.6	98	2.4 ppm	60
005	39.0	118	3.8 ppm	70

In the comparison of Table 4 and Table 5, there is a significant improvement in the hogs' living conditions and health after the implementation of the automated system. The system's automation and monitoring capabilities have led to more consistent temperature, weight, and ammonia level control, resulting in healthier and less stressed pigs. The humidity levels have also been better regulated, providing the animals with a more comfortable environment.

Table 6. ISO/IEC 25010

CRITERIA	WEIGHTED MEAN	DESCRIPTIVE RATING
Functional Suitability	3.83	Good
Reliability	3.65	Good
Performance Efficiency	4.07	Excellent
Usability	3.93	Good
Security	3.92	Good
Compatibility	4.00	Good
Maintainability	4.16	Excellent
Portability	4.26	Excellent
Overall Satisfaction	3.98	Good

A total of ten respondents completed the survey and selected respondents that have experience in taking care of pigs and have some knowledge on how a software and hardware works. Figure 5.1 shows the result of the test. Overall, the Development of Pig Monitoring with Automated Feeding Machine and Ventilation System

received a weighted mean of 3.98, which are classified into eight categories by the product quality model functional suitability, reliability, performance efficiency, usability, security, compatibility, maintainability, and Portability that is equivalent to a Good descriptive rating.

4. CONCLUSION

The Development of Pig Monitoring with Automated Feeding Machine and Ventilation System Using Mobile Application" is an innovative project that combines monitoring and automation, utilizing both software and hardware components. The automation features encompass feeding, cleaning of pig feces, and a water sprinkler system. The monitoring aspect covers critical parameters for the pigs, including temperature, weight, and ammonia levels in their feces. Environmental conditions such as humidity and temperature are also monitored to ensure the pigs' well-being. The integration of the Internet of Things (IoT) with the agriculture industry has significantly improved production efficiency and animal welfare, ultimately resulting in increased productivity and sustainability.

Among the various criteria evaluated, the factor with the highest mean value is "portability," which received an impressive overall rating of 4.26, corresponding to a descriptive rating of "Excellent." The engineering concept behind the cage design includes a dismantling element, allowing for easy disassembly and relocation of all automation components. The system's portability was highly commended by respondents.

Conversely, the criterion with the lowest mean value in the survey was "reliability," which received a rating of 3.65, indicating a "Good" rating. Respondents expressed the need for further testing and refinement to address hardware issues and enhance system reliability. Nonetheless, the overall assessment from respondents remained positive, emphasizing that the smart piggery using mobile application can be a valuable tool for piggery farmers, enhancing their success in pig farming through automation and monitoring systems.

The survey questionnaire results provide a comprehensive overview of the system's performance and its alignment with the researchers' objectives. The data indicates that the system is functioning well and effectively meeting its intended purposes.

The integration of the mobile application with the hardware has proven to be successful in providing real-time monitoring of pigs within their enclosures. This means that farmers or caretakers can access timely and accurate information about the pigs' conditions and activities through the mobile app.

One of the key strengths highlighted in the survey feedback is the seamless transmission of data from all sensors to the mobile application. This data transmission ensures that the automation features, such as feeding, cleaning, and water sprinkling, operate smoothly and in accordance with the sensor data. As a result, the system enhances efficiency and accuracy in managing the pigs' environment and needs.

Overall, the survey results confirm that the system is not only functioning well but also effectively contributing to the automation and optimization of pig farming processes. This feedback is valuable in validating the system's performance and its impact on improving operational processes in pig farming.

The smart piggery using mobile application has demonstrated its effectiveness in terms of functional suitability, reliability, performance efficiency, usability, security, compatibility, maintainability, and portability. Unlike traditional pig monitoring methods, this system serves as an advanced feature for convenient pig monitoring, promoting a technological approach with automation that can be controlled via a mobile application. The positive feedback from those who found the automation and monitoring functions beneficial underscores the potential value of this technology in pig farming.

5. RECOMMENDATIONS

The analysis and recommendations stemming from the assessment of survey respondents and the researchers' perspectives provide valuable guidance for future improvements to the smart piggery using mobile application system. These recommendations will aid future researchers in enhancing the project:

- Address hardware issues and conduct rigorous testing to enhance the system's reliability, ensuring consistent and dependable operation.
- Continue to refine the user interface of the mobile application to enhance user-friendliness and ensure it remains accessible and straightforward for piggery farmers.
- Implement additional security features to safeguard the system and its data, addressing potential vulnerabilities and ensuring data privacy.
- Develop a maintenance plan to ensure the long-term reliability and functionality of the system. This should include regular inspections and updates.
- Explore options to broaden the compatibility of the system, making it adaptable to a wider range of pig farming environments and practices.

- Conduct educational outreach programs to familiarize piggery farmers with the benefits of automation and monitoring in pig farming, encouraging adoption.
- By addressing these recommendations, future researchers can build on the smart piggery using mobile application system project's success and further advance the technology to benefit the pig farming industry.

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