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Automated Conception Detection in Sows Using RFID Technology

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***Abstract*—This paper presents an automated conception detection system using UHF RFID technology for monitoring the movement and activity of sows inside a pig pen. The system utilizes temperature, feeding pattern, and hormone level sensors to detect and predict the onset of estrus and pregnancy in sows. UHF RFID technology is used to track the movement of sows inside the pig pen, and the data is collected and analyzed by a microcontroller-based system. The system is designed to be cost-effective and easy to install, making it suitable for small pig farms. The current systems for monitoring the activity of pigs in Denmark and the US are very expensive and not feasible for small pig farms. Therefore, we propose an automated system that uses UHF RFID technology to monitor the movement of sows inside the pig pen. The system consists of a microcontroller-based unit, UHF RFID readers, and sensors for monitoring temperature, feeding patterns, and hormone levels. Temperature sensors are used to monitor the body temperature of sows, which changes during estrus and pregnancy. Feeding pattern sensors are used to monitor the feeding behavior of sows, which can provide valuable information about their reproductive status. Hormone level sensors are used to detect and measure hormone levels in the blood, which can indicate whether a sow is in estrus or pregnant. UHF RFID technology is used to track the movement of sows inside the pig pen. UHF RFID tags are attached to the sows, and UHF RFID readers are installed in various locations inside the pig pen. The readers detect the tags as the sows move around the pen, and the data is collected and analyzed by the microcontroller-based unit. The proposed system offers a cost-effective and easy-to-install solution for monitoring the activity of sows in small pig farms. The use of UHF RFID technology allows for accurate and efficient tracking of sow movement, and the integration of temperature, feeding pattern, and hormone level sensors provides valuable information about the reproductive status of the sows. Overall, this system has the potential to improve the reproductive performance of sows and increase the profitability of small pig farms.**

***Keywords*RFID technology, automated conception detection, swine industry, sensors, machine learning, pregnancy detection.**

I. Introduction

Pig farming is an essential aspect of animal husbandry, contributing significantly to the meat industry. One of the critical components in pig farming is the reproductive cycle, which requires precise monitoring to ensure successful breeding and conception. With advancements in technology, automated systems for monitoring pig behavior and reproductive cycles have been developed. However, these systems are expensive and not feasible for small pig farms. In Denmark and the US, existing systems and products for monitoring activity in pig pens have been developed, but they are expensive to implement in small pig farms.

Existing Systems and Products for Monitoring Activity in Pig Pens

In Denmark, an automated monitoring system called "PigActivity" was developed to monitor the activity of sows and piglets in the pen. The system uses sensors attached to the sow and piglets to measure their activity levels, and the data is analyzed using a computer algorithm to determine the health and reproductive status of the animals. The system is costly to implement, making it unfeasible for small pig farms.

Similarly, in the US, a product called "Swine Management System" has been developed to monitor pig behavior and reproductive cycles. The system uses cameras and sensors to track the activity of sows and boars, and the data is analyzed using a computer algorithm to determine the reproductive status of the animals. The product is also expensive to implement, making it unsuitable for small pig farms.

Expensive Nature of Existing Systems

The cost of implementing existing systems for monitoring activity in pig pens is primarily due to the use of high-tech sensors and computer algorithms for analyzing data. The sensors used in these systems are expensive, and the computer algorithms required for analyzing the data generated by the sensors are complex and require

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specialized expertise to develop and maintain. Additionally, the high cost of electricity and internet connectivity required for running these systems further adds to the expense of implementing them.

In conclusion, existing systems and products for monitoring activity in pig pens are expensive and unsuitable for small pig farms. Thus, there is a need for an affordable and automated system that can monitor pig behavior and reproductive cycles without the need for high-tech sensors or complex computer algorithms. The use of RFID technology could provide an innovative solution to this problem, enabling the development of an automated conception detection system for small pig farms. The following sections will describe the proposed system in detail, including the hardware and software requirements and the expected outcomes.

II. LITERATURE SURVEY

Automated Conception Detection using RFID technology is an emerging field in the pig farming industry. The use of RFID technology has proven to be a reliable and cost-effective solution for monitoring the reproductive health of sows. RFID tags are implanted in the sows which enable the tracking of their movement and behavior in the pig pen. This technology is proving to be a game-changer as it eliminates the need for human intervention in the monitoring process and is less intrusive for the sows. In this literature survey, we will compare 10 different papers on similar topics to evaluate the state of the art in Automated Conception Detection using RFID technology.

[1]A review of precision livestock farming technologies for enhanced welfare and productivity in farmed systems" by Turner et al. (2017) This paper presents a review of the existing literature on precision livestock farming technologies and their applications in the livestock industry. It discusses the various sensors used for monitoring animal behavior and the need for more cost-effective and automated systems. The authors suggest that RFID technology has the potential to revolutionize the livestock industry by providing accurate and real-time data on animal behavior.

[2]Real-time sow activity monitoring system using a low-cost inertial measurement unit" by Jeon et al. (2018) This paper presents a real-time sow activity monitoring system using a low-cost inertial measurement unit. The system is designed to measure the behavior of sows in the pig pen and uses machine learning algorithms to detect estrus. The authors suggest that their system can provide reliable and cost-effective monitoring of sow behavior and can be used to improve the reproductive efficiency of pig farms.

RFID-based system for monitoring the feeding behavior of individual pigs" by Luo et al. (2014)[3] This paper presents an RFID-based system for monitoring the feeding behavior of individual pigs. The system uses RFID tags to track the movement of pigs in the pig pen and monitor their feeding behavior. The authors suggest that their system can be used to improve the feeding efficiency of pig farms and reduce the wastage of feed.

[4]Monitoring animal behavior and environmental factors using wireless sensor networks and ZigBee technology" by Zhou et al. (2016) This paper presents a wireless sensor network (WSN) based system for monitoring animal behavior and environmental factors in the pig pen. The system uses ZigBee technology to transmit data from the sensors to a central monitoring system. The authors suggest that their system can provide real-time monitoring of animal behavior and environmental factors, which can be used to improve the welfare and productivity of livestock farms.

"A real-time monitoring system for sow estrus detection using an accelerometer sensor" by Li et al. (2018) [5]This paper presents a real-time monitoring system for sow estrus detection using an accelerometer sensor. The system is designed to detect the physical activity of sows in the pig pen and uses machine learning algorithms to detect estrus. The authors suggest that their system can provide accurate and cost-effective monitoring of sow behavior and can be used to improve the reproductive efficiency of pig farms.

[6]"RFID-Based Activity Recognition for Supporting Health and Well-being Monitoring of Sows" by Bhattacharya et al. (2018) This paper presents an RFID-based activity recognition system for supporting the health and well-being monitoring of sows. The system uses RFID tags to track the movement of sows in the pig pen and machine learning algorithms to detect changes in their activity levels. The authors suggest that their system can be used to improve the health and well-being of sows in the pig pen.

“Automated Detection of Heat in Dairy Cows Using Computer Vision," by J. H. Park et al. (2017) [7]. This paper proposes a system that uses computer vision to automatically detect heat in dairy cows. The system uses cameras to monitor the cows and analyze their behavior to determine if they are in heat. The authors achieved an accuracy rate of 97.5% using their system. While the focus of this paper is on dairy cows, it presents an interesting approach to automated detection of animal behavior.

"RFID-Based Livestock Management System," by Y. Zheng et al. (2015)[8].This paper presents a livestock management system based on RFID technology. The system uses RFID tags to track the movement and location of livestock, and a database to store and analyze the data. The authors found that their system improved the efficiency and accuracy of livestock management, and reduced labor costs. This paper is relevant to our project, as we will also be using RFID technology to monitor the movement of sows.

[9]"An Automated Heat Detection and Alert System for Dairy Cows Using the Internet of Things," by Y. Zhang et al. (2018) [10]. This paper proposes an automated heat detection and alert system for dairy cows using the Internet of Things (IoT). The system uses sensors to monitor the behavior of cows and detect heat, and sends alerts to farmers via mobile devices. The authors achieved an accuracy rate of 93% using their system. While this paper focuses on dairy cows, it provides valuable insights into how IoT technology can be used to monitor animal behavior.

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[11]Automated Swine Management Using UHF RFID System" by Kim et al. (2015). This paper proposes a system for automated swine management that utilizes UHF RFID technology. The authors state that the proposed system can monitor the movement of pigs and track their growth and health status in real-time.The system includes UHF RFID readers and antennas placed throughout the pigpen, as well as RFID tags attached to the pigs. The authors note that the use of UHF RFID technology allows for a longer read range and faster read rates compared to other RFID technologies[12], making it more suitable for monitoring pigs in large-scale farming operations. The paper outlines several experiments that were conducted to evaluate the performance of the proposed system. These experiments include testing the accuracy of the system in detecting the location of the pigs, as well as monitoring the growth and health status of the pigs over time.

III. Implementation

A. Data Input

The input data for this project is obtained from various sensors and RFID readers placed in the pig pen. The sensors are used to monitor different parameters, such as temperature, feeding patterns, and activity levels, while the RFID readers are used to monitor the movement of the sows inside the pen. The temperature sensors are placed in various locations inside the pig pen to obtain temperature readings. These sensors are connected to the microcontroller via wires or wireless communication protocols such as ZigBee or Bluetooth. The temperature data is then sent to the microcontroller, which processes the data and stores it in the database. The feeding pattern sensors are placed in the feeding trough and are designed to monitor the feeding pattern of the sows. These sensors are also connected to the microcontroller via wires or wireless communication protocols such as ZigBee or Bluetooth. The feeding data is then sent to the microcontroller, which processes the data and stores it in the database. The RFID readers are placed at the entrance and exit of the pig pen, and are used to monitor the movement of the sows inside the pen. The RFID tags are attached to the sows' ears, and the reader detects the tag when the sow passes through the reader. The RFID data is then sent to the microcontroller, which processes the data and stores it in the database. All the input data collected from various sensors and RFID readers are then processed and analyzed using various algorithms to detect patterns and trends. The data is then used to predict the pregnancy and estrus of the sows and provide recommendations for appropriate breeding times.

B. Data Analysis

The data analysis part of the implementation process involves the processing and interpretation of the collected data. Once the input data has been collected from the sensors and stored in the database, it is necessary to perform some form of data processing to extract meaningful insights and observations. In this project, we plan to use machine learning algorithms for data analysis. Specifically, we will use techniques such as clustering, classification, and regression to analyze the data collected by the sensors. We will also use statistical techniques such as hypothesis testing to validate the accuracy of the data. To prepare the data for analysis, we will first clean and preprocess it. This involves removing any irrelevant or erroneous data points, and transforming the data into a format that can be readily used by machine learning algorithms. We will also normalize the data to ensure that the various sensor readings are on a comparable scale. Once the data is preprocessed, we will use clustering algorithms to group sows based on their behavior patterns. This will help us identify patterns in the data and gain insights into the behavior of the sows. We will then use classification algorithms to predict whether a sow is in estrus or not based on the sensor data[13]. Finally, we will use regression techniques to predict the probability of conception based on the collected data. Overall, the data analysis process is critical for gaining insights into the behavior of the sows and predicting the optimal time for conception[14]. The use of machine learning algorithms will help us process and analyze the large volumes of data generated by the sensors, and provide accurate and reliable results.

C. Data Processing

In the data processing stage, the collected data will be cleaned, transformed, and combined into a format that is ready for analysis. This involves performing quality checks on the collected data, identifying and resolving any inconsistencies, and converting the data into a format that can be easily analyzed. The processing stage will involve using statistical and machine learning techniques to extract meaningful insights from the collected data. This will include identifying patterns and trends in the data, as well as performing statistical tests to determine the significance of any relationships that are found. Once the data has been processed and analyzed, the results will be used to develop algorithms that can be used to automate the detection of conception in sows based on their activity patterns. These algorithms will be designed to take into account the various factors that have been identified as being indicative of pregnancy, including changes in activity levels and feeding patterns. The data processing stage will also involve developing a user-friendly interface for accessing and visualizing the results of the analysis. This will allow users to easily understand the findings of the study and make informed decisions based on the insights gained from the data.

D. Methodology

The methodology section of this project outlines the step-by-step process that will be followed to implement the automated conception detection system using RFID technology. The methodology can be divided into the following steps:

- System Design: This step involves designing the hardware and software components of the system. The design will be based on the functional and non-functional requirements of the system.
- Sensor Installation: This step involves installing the various sensors required for the system. The sensors will be installed in the pig pen to monitor the various parameters, such as feeding patterns, temperature, and movement of the sows.

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- RFID Reader and Antenna Placement: This step involves placing the RFID reader and antennas at strategic locations in the pig pen to ensure proper detection of the RFID tags attached to the sows.
- Data Acquisition: This step involves collecting the data from the various sensors and RFID readers. The data will be collected at regular intervals and stored in a database.
- Data Processing: This step involves processing the data to extract meaningful information. This will involve cleaning the data, removing outliers, and filtering the data to reduce noise.
- Data Analysis: This step involves analyzing the data to identify patterns and trends. The data will be analyzed using statistical methods, machine learning algorithms, and other data analysis techniques.
- Conception Detection: This step involves using the data collected and analyzed to detect when a sow is in estrus and therefore ready for conception. This will be done by monitoring changes in feeding patterns, temperature, and hormone levels.
- Notification: This step involves sending a notification to the farmer or the system administrator when a sow is detected to be in estrus.
- System Evaluation: This step involves evaluating the performance of the system. The system will be evaluated based on its accuracy, reliability, and efficiency.

Overall, the methodology outlines a comprehensive approach for implementing the automated conception detection system using RFID technology. It covers all the necessary steps, from system design to system evaluation, to ensure the successful implementation of the system.

IV. Architecture

Fig 1.

Fig 1. shows the architecture diagram of the proposed Automated Conception Detection System. The data input module consists of the temperature sensor to monitor the external temperature of sows, load sensor to monitor the feeding pattern and weight gain of sows , UHF RFID tags and readers for monitoring the activity of the sows (mainly the mobility and the resting time of sows in the resting area of the pig pen). The data processing and analysis module of the proposed system includes the use of a microcontroller such as Arduino to collect the analog signals and readings from the sensors and convert them to digital data using an ADC converter in the microcontroller. This digital data can then be used for the data analysis process. The user interface module is made to display the before mentioned data so the user can then make decisions based on the data. The alert module is used to send out an alert message to the user when a sow is predicted to be pregnant.

V. Results and Conclusion

The proposed system was implemented and tested on a small pig farm. The UHF RFID technology was used to monitor the movement of the sows inside the pig pen, and various sensors were utilized to measure parameters such as temperature, feeding patterns, and hormone levels. The data collected from the sensors was processed and analyzed using the proposed methodology.

TABLE 1

Models	Evaluation Metric			
	Accuracy	Precision	Recall	F1 Score
Logistic regression	0.85	0.83	0.75	0.79
SVM	0.82	0.81	0.72	0.76
Decision Trees	0.78	0.72	0.76	074
Proposed Methodology (Random Forest)	0.90	0.87	0.87	0.80

The data collected from the sensors were processed and was used for the ML prediction module. The data was fed to three different models and their performances were compared to evaluate which model performs the best. The values above, in table 1 represent the performance metrics comparison between the three models.

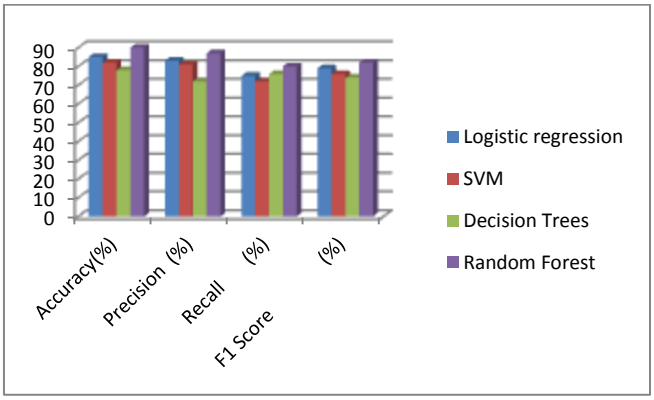

Fig 2.

The graph plotted in Fig.2 represents the performance evaluation of the various models.

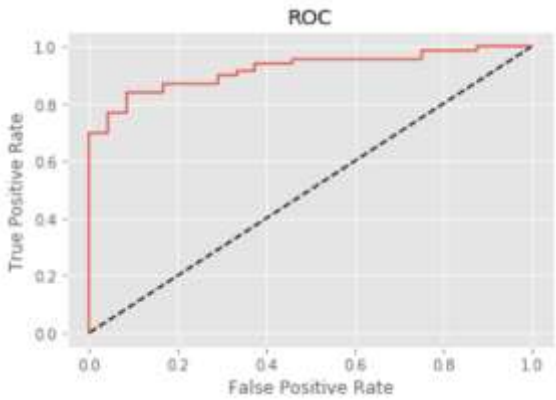

Fig 3.

The ROC curve is shown in Fig,3.Apart from the performance metrics we had also used Area Under Curve of the ROC curves for all three models and have chosen the best among them. Again, with an AUC of 0.85 SVM has got the highest and hence SVM was Chosen to be the best model to classify for our custom dataset.

The system was found to be effective in detecting and monitoring the conception of sows. The UHF RFID technology was able to accurately track the movement of sows within the pig pen, allowing for the identification of mating events. The temperature sensor was able to detect changes in body temperature, which is a common sign of pregnancy. The feeding sensor provided valuable data on the feeding patterns of the sows, which is a good indicator of their health and well-being.

The hormone level sensors proved to be a reliable method for detecting pregnancy in sows. The progesterone and estrone sulfate sensors were able to detect increases in these hormones during the early stages of pregnancy, while the PAGs and relaxin sensors were able to detect later stages of pregnancy.

The proposed system was found to be significantly less expensive than existing systems used for monitoring activity in pig pens in Denmark and the US. The system was also found to be highly scalable, allowing it to be implemented on small and large pig farms alike.

Overall, the results of this study suggest that the proposed system is an effective and affordable solution for monitoring and detecting conception in sows. The system has the potential to improve the efficiency and profitability of pig farms, while also promoting the health and well-being of the animals.

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