A Study on the Estrus Detection System of the Sow Using the Wireless Sensor Network

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Abstract - *This paper proposed WSN-based estrus monitoring system for stalled sows, which detects estrus of a sows in real time using wireless sensor network and notifies optimum time of insemination to PC and smart device of a user. The need for detect the estrus cycle has been increased in pig industry as it has the direct effect on productivity and earnings. If failed to detect in timely manner, it may cause a huge loss. The proposed system is one that detects estrus by measuring sow's activity in real time with an accelerometer sensor to transmits it to the server, which analyzes the information received and then informs whether or not to be in heat to PC and smart devices of users. This system is expected to improve rate of return for livestock farms by detecting the exact optimum time of insemination of a sows and minimizing the number of non-production days.*

Keywords: Wireless Sensor Networks, Ubiquitous, Sow, Estrus, Agriculture

1 Introduction

The WSN is a technology that deploys sensor nodes with computing and wireless communication capabilities in a diversity of application environments, forms networks autonomously, and then utilizes information collected from the sensor nodes for the purpose of wireless monitoring and controlling etc[1,2,3]. This WSN technology is a core one to realize a ubiquitous society, and is applied to every field of our life, that is, a variety of industries including distribution, logistics, construction, transportation, defense and medicine etc. to implement advancement of productivity, safety and human living standard[4,5]. Recently, the WSN technology is also applied to the agriculture field to improve the working environment and to increase its productivity[6].

Domestic hog industry is recently having hardships caused by increased production costs, varied animal diseases, unsophisticated management technology, etc. The technology detecting estrus of sows among these pig-breeding management technologies is one to decide the right time to fertilize, which is directly connected to the earnings of livestock farms, if the right time to fertilize is missed, it results in an economic loss because the number of non-production days for the sows becomes longer to reduce the productivity[7]. At present, the sensing of estrus is inefficient because it is mainly carried out manually.

This paper proposes a system to sense estrus of sows and decide the right time to fertilize them in the livestock farms experiencing such damages. Based on the fact that the activity of the sow is more increased in heat than in non-heat, an accelerometer sensor is attached in the form of collar on the neck of the sow in the stall, and measures activity to detect its estrus. The existing systems generally use schemes to directly insert a sensor into the body of sows or to exploit a CCTV, however, the former has a disadvantage that produces damages such as injuries on the body of sows and stresses when inserting the sensor, and the latter has a disadvantage that is too expensive[8]. It is expected that could solve disadvantages of the existing system and minimize the number of non-production days to increase earnings of the livestock farms by understanding the right time to fertilize sows to maximize the fertility rate through the proposed system. In addition, it is expected that would have an effect on improving the working condition and reducing the labor force of the livestock farms because they do not need to visit the pig house frequently for checking estrus.

This paper is organized as follows. The related studies of Chap. 2 explain the estrus of sows and the stall that is a breeding space, and the system design of Chap. 3 describes the structure of the proposed system and the procedure to process services. Chap. 4 implements the final system and measures its performance after verifying the system through experiments, and Chap. 5 finishes with a conclusion.

2 Related research

2.1 Estrus of pigs and detection

In general, a weaning sow begins estrus around 4 to 7 days after weaning. As estrus period lasts 3 to 6 days for pigs, which is relatively longer comparing to other animals, it is not very easy to detect the exact optimum time of insemination[9]. Particularly for artificial insemination, much smaller number of sperms and smaller amount of seminal fluid are inserted comparing to natural breeding and the motility or surviving rate of sperms and surviving time in the

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reproductive organ of a sow are relatively low, so it is necessary to monitor estrus carefully for insemination at optimum time. However, due to difficulty with continued monitoring, a manager generally checks estrus of a sow two times a day through observation with a naked eye. This method requires much labor as well as high level of skills and rich experience, and has limitations in finding exactly when estrus began with only two checks a day and judging optimum time of insemination exactly because estrus begins mostly at dawn[10].

When artificial insemination takes place at optimum time even when detecting estrus, conception rate is low, which causes economic loss. Because of this problem, artificial insemination is conducted 2 to 3 times, but costs and labor involving this procedure are another factor of adding burden to livestock farms[11,12]

The system proposed in this paper decided the time between 26~34 hours after starting estrus reported at present as the right time to fertilize in order to solve such a problem.

2.2 Accelerometer sensor

Accelerometer sensor is for measuring the dynamic force such as the Acceleration, vibration and shock of object by processing output signal and it has a wide area of usage since it can detect motion status in details[13].

For the purpose of verifying the system proposed in this paper, Accelerometer Sensor of HBE-Zigbexll by HANBACK Electronics Ltd. was used.

Figure 1. Accelerometer sensor

3 System design

System of estrus detection of stalled sows employs a method of measuring activities using accelerometer sensor. For a sow reaching estrus time, activity of walking around with unique sound increases. However, the sows in the stall have a characteristic that the sitting/standing up movements are increased and the lying ones are decreased compared to the non-estrus due to the limitation on movements[14]. It is a system that attaches an accelerometer sensor on the neck of sows in the form of collar based on this characteristic, measures the activity, sends this value to the server to decide whether or not to be in heat, and then informs to PC and smart devices of users in real time. In addition, after detecting the estrus, it decides the right time to fertilize, and informs it, so it could fertilize at the exact time.

3.1 System structure

The proposed estrus detection system consists of physical layer, middle layer and application layer, as shown in Figure 2.

The physical layer consists of accelerometer sensor and sensor node for collecting sow activity.

The sensor manager stores the information collected through the accelerometer sensor in the livestock management server database through storable format processing, measurable unit conversion and update inquiry of processed data.

The management server plays the role of storing in each table the data collected through the accelerometer sensor, as well as the sow activity data collected through the standard values for status notification. And management server database store sow activity data and sow identification information.

The management server is located between the user and database, and periodically notifies the user the data stored in the database. It automatically controls the corresponding estrus notification upon comparing the estrus standard values stores in the table and the status notification table, or comparatively analyzes the existing sow estrus information stored in the database and the measured sow estrus information to notify the producer in real-time of any values that exceed or fall short of the standard values through web and SMS notification services.

The application layer consists of application services that support various platforms such as laptop, web, PAD and smart phone and provides to users livestock estrus detection information service, sow optimum time of insemination service.

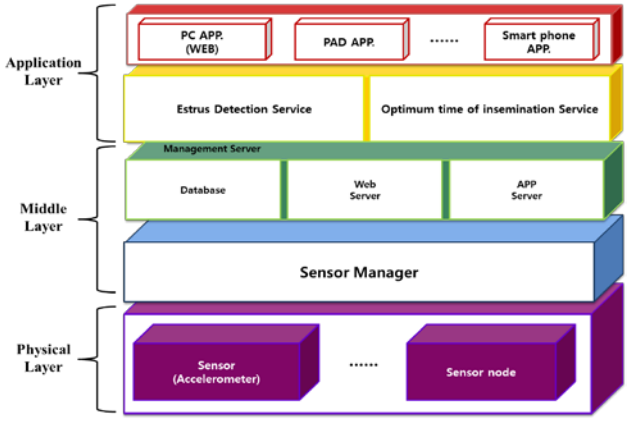

Figure 2. System structure

3.2 System configuration

The entire architecture of system of estrus detection of stalled sows based WSN is shown in figure 3.

This system consists of sensor of detecting estrus, server of storing and analyzing data transmitted from sensor and finally PC and smart device available to a user anywhere. Sensor used for monitoring judges whether or not a sow began estrus is accelerometer sensor. The sensor monitors activities of a sow, and stores and manages collected information in database. Server analyzes collected information, and notifies conditions of a sow to a user in real time after judging whether or not estrus began when the amount of activity exceeds the normal value.

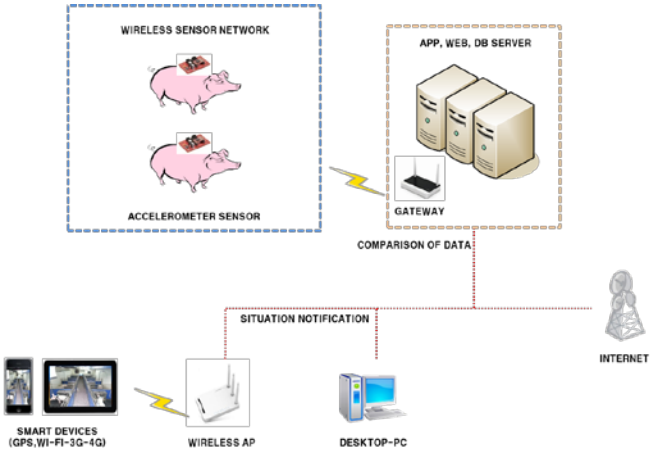

Figure 3. Proposed WSN based Estrus Detection System Configuration

3.3 System service

The proposed system provides information about estrus of a sow, and its operation is shown in figure 4.

Information measured through accelerometer sensor is transmitted to sensor manager, which stores processed data in database after processing transmitted data into format and converting units.

Management server requests sensor data of database on a regular basis, and compares transmitted data with data standard range of information; and when detecting estrus beyond the range, it analyzes information which took place to an individual sow and notifies it to a user.

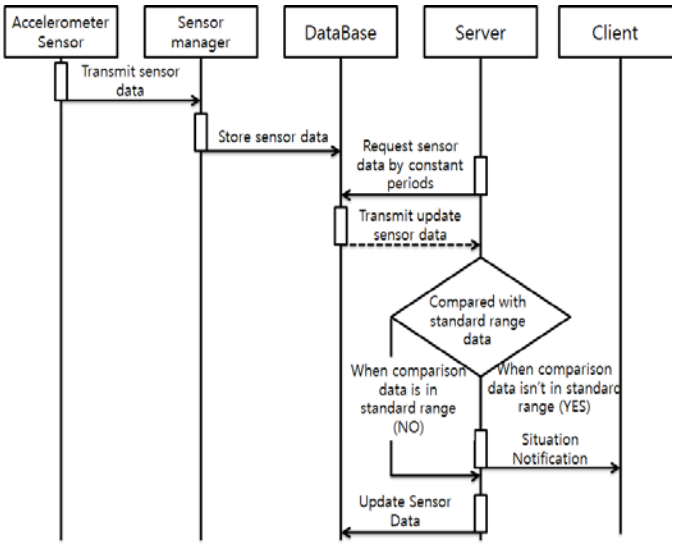

Figure 4. Service Process of Proposed WSN based Estrus Detection System

4 Implementation and result

The prototype model was tested by the method that persons wear accelerometer sensors fabricated in the form of collar to detect their movements. The reference scope was limited to measure activities by comparing with it, however, there were problems that the sensor in the form of collar dangled and there were noises. In order to solve these problems, it made the sensor in the form of collar could be adjust its size when applying it actually to the sow, values of the accelerometer sensor were passed through a LPF(Low Pass Filter) to remove noises and the required signals are obtained, so that the existing problems could be solved and the estrus of sows could be detected.

4.1 Prototype

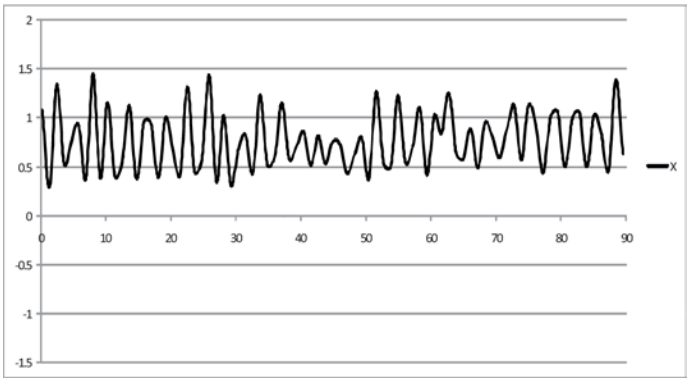

Figure 5. Accelerometer Result Values Graph of Test

Figure 5 is a graph showing acceleration result values of a test for the verification of system. As this system detects movement through accelerometer sensor attached to the neck of a sow, height variation value was used. This paper set a

standard range of data and detected estrus by comparing the amount of measured activity with the standard range. Through this experiment, this paper verified estrus detection system using accelerometer sensor.

The initial prototype of the WSN-based system to detect estrus of sows bred in the stall was fabricated with an accelerometer sensor in the form of collar, and its GUI was designed as figure 6. Comparing the graph of acceleration result values with the reference scope determined by counting movements during one minute, the estrus was detected.

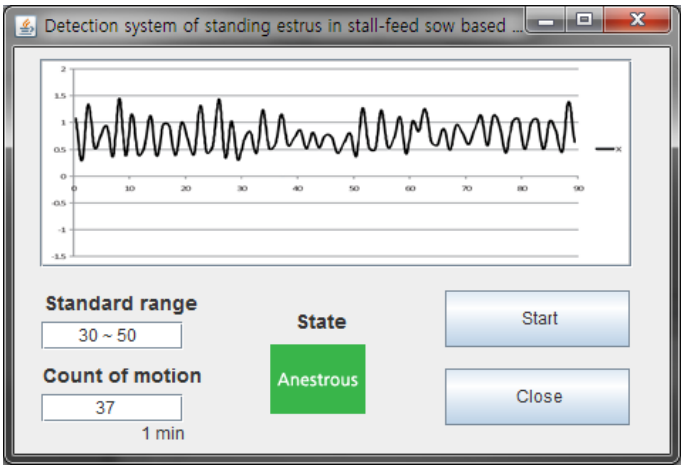

Figure 6. Estrus Detection System Prototype GUI

4.2 The Actual effect

Figure 7 is an image that applied actually to a sow bred in the stall. In order to solve the problem arisen in the prototype, when applying it actually to the sow, it made the size of the sensor in the form of collar could be adjusted, and the accelerometer sensor was intactly used.

Figure 7. Applied actually to a sow

Figure 8 is the GUI providing to users, where ① is the result of measuring activities by the accelerometer sensor, which is the result representing the hourly variation of activities. ② represents the sow's individual classification ID, its activity, the reference scope value of activities and whether or not to be in heat. ③ is the menu to set the reference scope of activities. ④ is the menu to inform the right time to fertilize by calculating time after detecting the estrus.

For the prototype, movements were measured during one minute, but the activities were measured for each time according to the sow's activity when implementing actually.

From the implementation result as above, it could verify the proposed WSN based estrus detection system, and it would like to advance it by developing continuously.

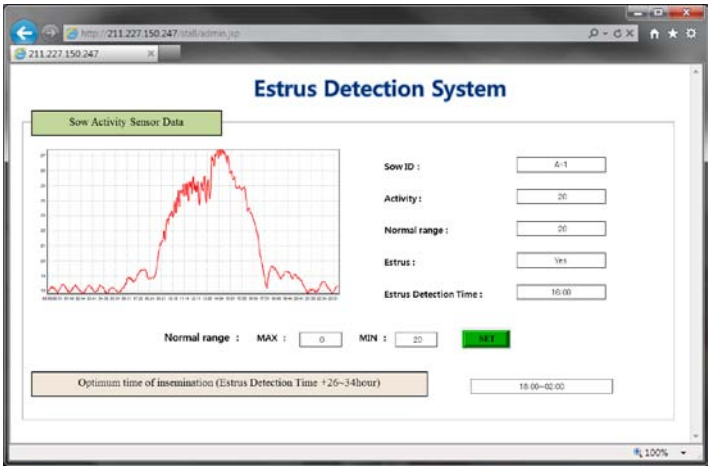

Figure 8. Estrus Detection System GUI

5 Conclusions

To maximize income, Livestock farms should increase reproduction rate by minimizing the number of non-production days for a sow. The system proposed in this paper has a purpose that detects estrus by measuring the sow's activity in real time with an accelerometer sensor, inform immediately the fact that the estrus is arisen and the calculated right time to fertilize to users, so that they could quickly deal with it. The existing method, which persons directly check estrus with their own eyes, is labor-intensive, and has a disadvantage that it has a lower chance of becoming pregnant even if detecting the estrus to make implantation and has much errors. The proposed system could solve problems of the existing method, improve the rate of detecting estrus of sows, and reduce labor force and production cost by deciding the right time to fertilize to increase the chance of artificial fertilization. In addition, it could get out of temporal confinement for detecting estrus to improve the quality of user's life and the working condition.

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