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Monitoring Pig Body Temperature Using Infrared Sensors

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Abstract

Purpose: The purpose of this study is to verify the feasibility of using an infrared sensor to measure the body temperature of a sow. We first conducted experiments on three pigs by using three infrared sensors and one indoor temperature sensor. **Methods:** The three infrared sensors were installed inside our model house and were used to take temperature measurements per second of the backs of the pigs. While feeding, the temperatures of the backs of the pigs were measured at distances of 10 cm, 20 cm, and 30 cm from the infrared sensors. **Results:** We concluded that the relation between the temperature of the pigs' backs and the indoor temperature was y =0.549x + 18.459 at a measuring distance of 30 cm. The relation was y = 0.645x + 15.461 for a distance of 20 cm and y = 0.760x + 11.913 for a distance of 10 cm. We found high correlation between the indoor temperature and the temperature of the pigs' backs. **Conclusions:** It is possible to use an infrared thermometer to monitor the temperature of pigs' backs. This system seems to be feasible and effective in monitoring pig temperature. The use of an infrared thermometer will also make daily monitoring easy. In later experiments, the possibility of developing a system that can determine if an error can be corrected by using infrared sensor is explored by considering humidity variables.

Keywords: Body temperature, Indoor temperature, Infrared sensor, Monitoring system, Pig

Introduction

The pork industry has been facing a number of difficulties in the recent times. The low-priced import volume of livestock products has gradually increased because of the conclusion of the Free Trade Agreement (FTA) with U.S.A., and as a result, the price are expected to decline. In addition, owing to the problem of disposal of livestock waste water, environmental problems, and the ban on ocean dumping, ground treatment has become a challenge. Owing to the improvements in and expansion of the swine wastewater treatment facilities, the cost of production, which is a major limiting factor, has reduced. Moreover, there exist other problems: the widening range of price range in the pork industry, labor shortage and rising labor costs, rising food prices, high dependence on import of raw materials, lack of breeding facilities, and so on (Kim et al., 1995). In order to solve these problems, the following steps can be taken: helping pig farmers to prevent qualitative and quantitative deterioration of agricultural labor, investing to ensure housing and parts for machinery and growth, controlling the increase in production costs, providing technology to livestock administrative tasks to streamline and maintain livestock, and improving productivity specification management technology system (Lee et al., 1991). Accordingly, the focus should be on achieving the maximum labor efficiency by building automated systems. Automated systems should also monitor pig body temperature, which is a very important factor because it can help determine the health of the animal. In view of this information on the temperature of pig grafting in an

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automated system it will be also effective. Rectal temperature measurement is the most widely used method to measure animals' temperature because the rectal temperature is an accurate measure of an animal's temperature. However, rectal temperature measurements of livestock animals sometimes needs to be corrected, and the measurement process takes 2–3 min, because of which most farmers try to avoid taking measurements. The farm level is almost without (Kim et al., 2003).

During estrus and the recent epidemics that occurred throughout the country, such as the foot-and-mouth disease, which is accompanied by high fever, and other conditions, the body temperature rises. Hence, animals' temperature can be used as basic data to identify the symptoms of the disease when it exceeds the normal temperature range (Yu, 2013).

Therefore, it is necessary to develop a non-contact thermometer to measure animals' temperature easily and quickly and without corrections. With the progress in Korean IT technologies, wireless transmission and sensing technologies have been developed and are used in the Korean livestock industry; such technologies have been actively studied because they combine the tasks of automation and feeding and management. In this study, the body temperature was monitored quickly and simply as by a non-contact temperature measuring method using an infrared sensor. In addition, the future, Temperature measurement system was developed in future, a basis study was performed for the diagnose symptoms of disease and estrus in sows.

Materials and Methods

Test animals

Three miniature pigs with an average weight of about 20 kg were used to test the proposed method. The test animals were self-made swine (3300 × 5400 × 2200 mm) that conformed to the specifications.

Location and duration of the experiment

This study was performed at Gyeongsang National University in the self-made model pig house from April 12 to June 24, 2014.

Feeding and management

Self-made pig housing comprised sandwich panel of thickness 50 mm. Feeding was limited to 500 g at 17:00–18:00 h once a day. Water was freely provided for the animal to consume.

Temperature measurement

The experiment was performed after giving the pigs an adaptation period of one week. The body temperature of the pigs at feeding time was recorded every second using an infrared sensor. The infrared sensor used was MI310LTSCB (Raytek, U.S.A), and its specifications are as follows: accuracy, ±1% of the reading or ±1°C, whichever was greater; temperature resolution, 0.1°C or 0.2°F. These infrared sensors were installed on the self-made stall (Figure 2) in such a manner as to face the pigs' backs

(a) A side view of the stall

(b) Locations of the infrared sensors

Figure 1. A photograph of the stall.

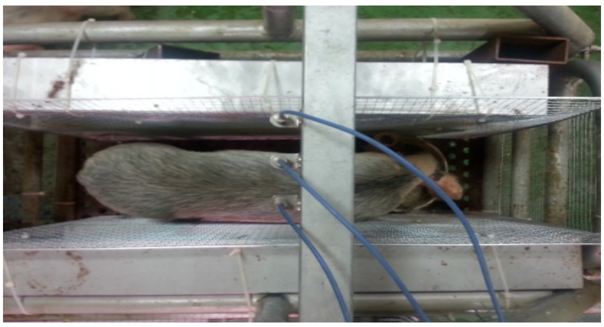

Figure 2. A photograph showing the experimental setup for pig temperature measurement.

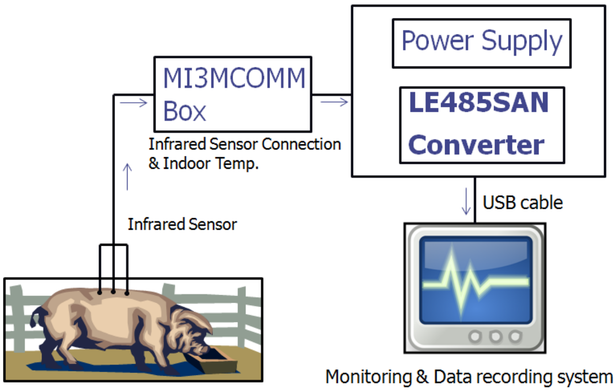

Figure 3. A schematic diagram of the measurement system for to measure pig body temperature.

when feeding. To measure the room temperature of the stall, MI3MCOMM Box (Raytek, U.S.A) was used. A bowl was installed inside the stall for feeding.

A schematic view of a temperature measurement system is shown in Figure 3. The infrared sensor was connected to a computer DataTempMultiDrop (Raytek, USA), and the measured data per second were stored in the computer. By means of the computer, the measured temperature information could be monitored.

Data acquisition

The body temperature of the three pigs per second during feeding time was recorded for 28 days using an infrared sensor. Data was collected during 28 days in 30 cm height body temperature and room temperature exception not stored due to an error in the program. Temperature was recorded at heights of 10 cm, 20 cm, and 30 cm for each additional week after the first 28 days. The collected data were averaged and analyzed. The room temperature when the pigs started feeding and the average temperature of the feed were collected. For each pig, the measured data were synthesized and that data compared. The room temperature and the temperature of the pigs' backs as measured by the infrared sensors were used as analysis data.

Statistical analysis

The temperature of the feed for each pig was measured every second; the average temperature of the collected data was used on analysis. The average data for each object collected daily was measured during the feeding time. By using SPSS software during feeding time, the room temperature was plotted on the x-axis, and the animals' temperature was plotted on the y-axis to obtain the primary regression equation. A linear trend line graph was obtained.

Results and Discussion

The body temperature of pigs measured from a height of 30 cm are listed in Table 1, and the each height temperature measurement results are listed in Table 2. Sometime, measurement of body temperature is not stored of program due to errors, so that data is excluded. During the experiment, the average temperature of the self-made pig housing was 25.97°C; the minimum temperature, 15.4°C; and the maximum temperature, 33.4°C. Using Excel, the correlation between the temperature of the pigs' backs and the room (environment) temperature measured at a height of 30 cm, a primary regression equation, and the R value were obtained. The first regression equation ($y = 0.549x + 18.459$) and R^2 value (0.843) were obtained, and the temperatures were found to be highly correlated ($p < 0.05$). Earned primary regression equation where x is the room temperature value, y the measured

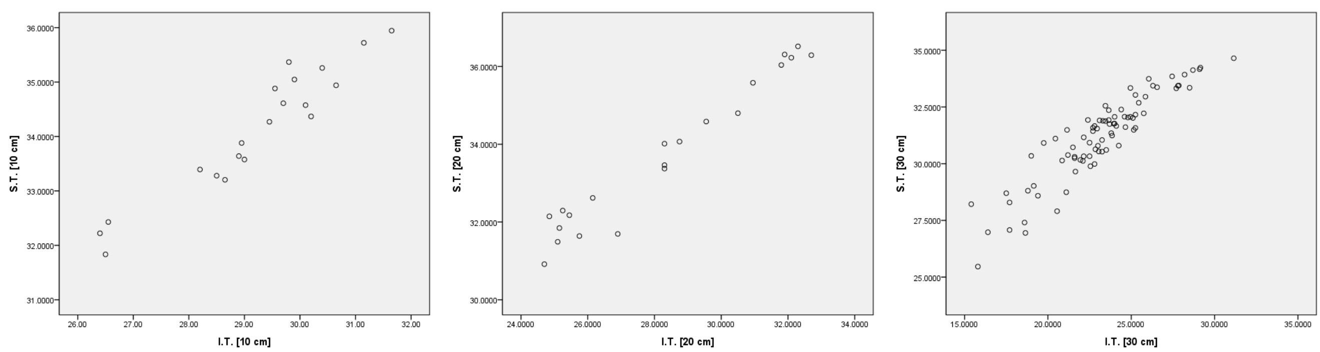

Figure 4. Correlation between indoor temperature and temperature measured by the infrared sensor.

Table 1. The calculated and measured temperatures and their errors

Temperature (°C)	Indoor air Temp.	Measured Temp.	Calculated Temp.	Error Average	Error Range
Maximum	31.15	34.64907563	35.551005	-	1.8281183
Minimum	15.40	25.46211765	26.90898	-	0.0048332
Mean	23.27	30.05559664	31.2299925	0.584973	-
Range	15.75	9.186957983	8.642025	-	1.8232851

Table 2. Errors by temperature measurement height

(°C)	Error Average	Error Max.	Error Min.	Max.-Min.
10 cm	.277	.797	.032	.765
20 cm	.314	1.107	.073	1.034
30 cm	.489	1.783	.002	1.781
Range	.212	.986	.071	-

Table 3. Statistical analysis between the temperature of pigs' backs and room temperature

	R square	Sig.	Beta
10 cm	.912	.000	.955
20 cm	.955	.000	.977
30 cm	.843	.000	.918

temperature value of the back part according to the room temperature able predict the temperature of the pig back part made algorithm. Comparison of the calculated temperature with the actual temperature of the pigs' backs showed that the average error was 0.48 appeared; the maximum error, 1.78; and the minimum error, 0.002. Similarly, primary regression equations and R values were obtained for the measurements made at each height. The primary regression equation for a measurement height of 10 cm was $y = 0.760x + 11.913$ with an R^2 value of 0.912, and those for a measurement height of 20 cm were $y = 0.645x + 15.461$ and 0.955. The measured temperature data for each height were variance analyzed and a significant correlation was obtained (Table 3).

Yu (2013) was found to be ear, head, neck, the surface temperature of the subcutaneous region affected by the environmental temperature and the ambient temperature is that the narrow width of the distribution range was increased to maintain the temperature will due to homeostasis according to the environmental temperature increases. Further, according to Soerensen et al. (2014), for the IRC, the following parameters are necessary to calculate the actual temperature of the an object: object emissivity, the temperature of the object surroundings (usually close to the ambient temperature), air temperature, distance between the object and IRC, and the relative humidity of the air.

Jeong et al. (2012) is observed a change of the body temperature in accordance with the momentum of the livestock but the variation is appeared insignificant that generally compared with body temperature changes under known disease conditions, and Ingram et al. (1973), It was 1°C higher than that did not consume the feed in the case of piglets when in feed intake, Henken et al. (1993), Heat production was affected pig depending on food intake and activity levels. The range of normal body temperature varies for each object, and a more accurate and effective database of the normal body temperature of a target object will need to be built. Only in this experiment, the feed intake measurements were analyzed by considering the temperature, and the feed intake was judged according to the increase in temperature. Therefore, the subsequent for actual application to sows housing development of the system may be considered as part of the determination.

Conclusions

The purpose of this study was to use an infrared sensor to measure the body temperature of a sow. For this purpose, we first experimented on three pigs. The measured temperature of the infrared sensor was stored in a computer. The temperature of the pigs' backs and the measured room temperature were correlated ($p < 0.05$) at a measurement height of 30 cm; the R^2 value (0.843) was obtained and analyzed. This indoor temperature is the action indicates that the important variable when measuring a back part temperature using an infrared sensor.

Using an algorithm, the temperature of the pigs' backs was predicted based on the room temperature. The average, maximum, and minimum errors in the predicted temperature as determined by comparison with the actual measured temperature were 0.48, 1.78, and 0.002, respectively. The R^2 values for the measurement heights of 10 cm and 20 cm were 0.912 ($p < 0.05$) and 0.955, respectively. The pigs' body temperature as predicted by the equation were compared with the temperature measured by the infrared sensor ($p<0.05$). For the measurement height of 10 cm, the average, maximum, and minimum errors were 0.28, 0.79, and 0.03, respectively; further, for the measurement height of 20 cm, the average, maximum, and minimum errors were 0.31, 1.107, and 0.073, respectively.

In this experiment, although there were no major differences between the predicted values for different heights, the measurement height of 20 cm yielded the best results.

The experimental error is attributed to the specifications of the infrared sensor, the variables, etc., and also to room temperature and humidity. The room temperature and humidity and the measured temperature also depend on whether the sow is in heat; a commercial body temperature monitoring system can be used to determine abnormalities. Back temperature was quickly and easily monitored using infrared sensors. Further, in the normal state, the correlation between the room temperature and the back temperature is very high. Hence, basic data including the room temperature can be used to estimate the temperature of the pig. Using the collected data, livestock diseases can be forecasted using the measured body temperature.

Conflict of Interest

The authors have no conflicting financial or other interests.

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