It is important that farmers rearing livestock such as pigs in large groups detect diseases early. Respiratory disease is one of the most serious diseases that kill large number of pigs. Early detection can help minimize the loss of productivity in intensive pig farming. In the study presented here, we developed a recording system to detect respiratory diseases using a pig’s body-conducted sound. Body-conducted sound is used to identify biological signals, such as the heart sound of each pig, even if they are in a group. We used a piezoelectric sensor to extract the body-conducted sound and record signals from the sensor by transmitting the signals as waves in the FM band. With this system, we were able to separately record the sounds of several pigs from a distance. We verified that the recording system can record the body-conducted sounds of pigs.

Keywords: pig, body-conducted sound, respiratory disease, sensor

1. Introduction

Livestock such as pigs are reared intensively. Present trends in pig breeding in Japan show that the number of pigs per farm has been on the rise since the 1990s, making efficient livestock management a necessity in this regard[1]. Infectious diseases, especially respiratory diseases, are serious problems in intensive farming. Spreading of diseases in group-housed pigs can lead to death and loss of productivity. Therefore, it is important for pig breeders to detect diseases early. Detection methods for respiratory diseases in group-housed pigs have been reported in previous studies[2, 3]. J.-M. Aerts. et al. and C. Yongwha et al. recorded cough sounds group of piglets with wired microphone. However, it is difficult to individually detect pigs infected with diseases using this system, while moving pigs can easily damage the system. Therefore, we propose an early detection system for respiratory diseases in pigs. The system uses a piezoelectric sensor to record the body-conducted sound of the pigs wirelessly.
2. Propose system

In this paper, we propose an early detection system to identify pigs infected with respiratory diseases (Figure 1).

![Proposal system diagram](image)

Figure 1: Proposal system

This system is composed of a piezoelectric sensor, an FM transmitter, an li-ion battery, FM receiver, and a data recorder. The system can wirelessly record the body-conducted sound using a piezoelectric sensor. Biological data is needed to individually observe and detect the pigs that are infected with diseases. There is also a lot of noise such as the grunts of other pigs in the sty. Therefore, we decided to employ the body-conducted sound that is robust to noise. An accelerometer is generally used to record body-conducted sound in humans[4] but too expensive to use in pigs. The piezoelectric sensor is more affordable than the accelerometer. Moreover, we use an FM communication system that enables us to ignore the effects of the movement of the pigs. Near Field Communication(NFC) was used to configure the FM transmitter and receiver within a frequency range of 76.0 to 108.0 MHz in 0.05 MHz steps, to yield 640 bands (640 devices can be used simultaneously). The FM transmitter has a size equivalent to the ear tags that are used for livestock identification. This makes it easy to introduced this system to farmers. The amplification factor can be adjusted from 1 to 8 on the FM Transmitter board. Since the frequency range of body-conducted sound is low, the transmitter can emphasize low frequencies. The board can record using 2 channels while the amplification factor can be adjusted separately for each channel. Using the propose system, we aim to extract respiratory and heart sounds from biological signals.

3. Methods

As a preliminary experiment, we designed an experiment to verify that this system can record the body-conducted sound in humans.

3.1 Participants

A healthy male(35 years -old) participated in the experiment.
3.2 Apparatus

The proposed system uses a microphone (Ono Sokki, MI-1235), a piezoelectric sensor (Memory-Tech.) and a stethoscope (3M Littmann Select Stethoscope, 2301) attached to a microphone (Ono Sokki, MI-1235) at end of a tube. The microphone and stethoscope microphone were connected to a sensor amplifier (Ono Sokki, SR-2210) and all three devices connected to a LAN-XI module (Brüel & Kjær) to record the data.

3.3 Procedure

The microphone was set on a tripod about 15 cm from the mouth. The sensor and the stethoscope microphone were placed on the left chest of the participant and mounted on his skin with medical tape. The recording was done in a quiet room at Hiroshima City University with the research participant seated on a chair and breathing naturally. The recording lasted 1 minute.

4. Results

4.1 Respiratory sounds

We evaluated this system to compare signals from the microphone and the piezoelectric sensor. Figure 3 shows a waveform and a spectrogram recorded from the microphone. The spectrogram shows that the power gets stronger during inhalation. However, the power from the piezoelectric sensor cannot be shown on a spectrogram (Figure 4). Accordingly, we converted the waveform recorded from the sensor to power by squaring the absolute value, then extracted the peaks from the power. The result is as shown in Figure 5. We can observe fluctuations in the peak during inhalation. We hence confirmed that respiratory sounds can be recorded using piezoelectric sensors by extracting the peaks in the power.
Figure 3: The Waveform and Spectrogram recorded from the microphone

Figure 4: The Waveform and Spectrogram recorded by the piezoelectric sensor

Figure 5: Peaks in the power recorded by the piezoelectric sensor. The solid line shows a linear interpolation of the peaks.

4.2 Heart sounds

Figures 6 and 7 show the waveform and the power from the data recorded by the stethoscope microphone and the piezoelectric sensor. The waveform is shown in the upper row and the power in the lower row. We can see the peaks in power appearing at constant intervals in Figure 6. We believe that the peaks represent the heart sounds shown as white circles in Figure 6. Furthermore, similar peaks can be seen in the power recorded by the piezoelectric sensor. The lower section of Figure 7 shows the peaks from the stethoscope microphone and the piezoelectric sensor. The black asterisks indicate the power peaks from the piezoelectric sensor while the white circles indicate the intervals between the peaks in the power from the stethoscope microphone. We observe that the respective peaks are in agreement. This confirms our theory that the piezoelectric sensor can record heart sounds.

5. Conclusion

In this study, we developed a recording system for the early detection of respiratory diseases using the body-conducted sounds of pigs. The system uses FM communication system with independently adjustable frequency, making it possible to employ several recording devices simultaneously. The system can record body-conducted sounds individually. We verified that the propose system can wirelessly record body-conducted sounds through a preliminarily experiment on human being. We
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