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ACOUSTIC CHARACTERISTICS OF BIVALVE AND POSSIBILITY OF AUTOMATICALLY DISCRIMINATING DEFECTIVE BIVALVE USING ACOUSTIC SIGNAL

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Because of current health trends, health foods have recently begun gaining attention in Japan. Some types of bivalve are well known as health foods, and the bivalve native to certain areas of Japan are commonly used in Japanese cuisine. Typically, in such bivalve production areas, regulations for the catching of bivalve are in place to prevent excessive fishing and protect spawning grounds. The catch value is determined based on these regulations. A haul of bivalve will often contain both good and defective bivalve. In this paper, a defective bivalve is defined as a bivalve that is empty or full of mud or water. Because a defective bivalve has the same outward appearance as a good bivalve, it is difficult to visually distinguish between good and defective bivalve. Fishermen identify defective bivalve after fishing, but this identification involves difficult manual work. Discriminating between good and defective bivalve on the fishing boat would increase the ratio of good bivalve in the haul. Therefore, it would be beneficial to develop an automated discrimination method that can be implemented on the boat. Currently, fishermen gently tap the bivalve on a concrete or metal surface, roll the bivalve, and identify defective bivalve based on the sounds produced by these collisions. Previous studies have proposed discrimination methods using images or sound. The image-based method uses a transmission image obtained with near-infrared light; however, this method is very expensive. The sound-based method analyzes the sound produced by the collision of bivalve. In this study, in accordance with the previously proposed sound-based discrimination method, the sound produced by the collision of bivalve with a concrete surface was analyzed, and examined the difference between the collision sounds produced by good and defective bivalves. Finally, the possibility of automatically detecting defective bivalve using acoustic signals is discussed.
Keywords: Bivalve, automatic discrimination, acoustic characteristics, collision sound, frequency analysis

1. Introduction

Recently, health foods have begun attracting a lot of attention in Japan. For example, a type of pork rich in vitamin B1 has been promoted as a fatigue recovery food, and a red bell pepper rich in vitamin C is considered to strengthen the immune system. Several types of bivalve commonly used in Japanese cuisine are among these health foods garnering new interest and have been well known in Japan for a long time because Japanese cuisine uses many methods of cooking bivalve. One type of bivalve is known to aid in the recovery of liver function because it contains a lot of ornithine. Therefore, bivalve fishing is active in some areas, but regulations are in place to prevent excessive fishing and protect spawning grounds in bivalve production areas. For example, the catch value, delivery format, hours of operation, and days of moratorium on fishing are determined based on these regulations.

In a haul of bivalve, defective bivalve are mixed in with good bivalve. Here, a good bivalve is defined as a shippable bivalve, and a defective bivalve is defined as a bivalve shell that is empty or full of mud or water. Because the catch value is regulated, if defective bivalves are mixed with good bivalves, the ratio of good bivalve to defective bivalve is reduced. Because the outward appearance of a defective bivalve is the same as that of a good bivalve, it is difficult to identify defective bivalve only from their appearance. Fishermen must identify defective bivalve after fishing, but this identification involves difficult manual work. Discrimination between good and defective bivalves on the fishing boat enables the fishermen to increase the ratio of good bivalve in the haul. Furthermore, because current manual methods of discriminating between good and defective bivalves are time-consuming and labor-intensive, it would be beneficial to develop an automated discrimination method. Currently, fishermen gently tap the bivalve against a concrete or metal surface, roll the bivalve, and identify defective bivalve based on the sound of the collision. Using this method, fishermen can test approximately five bivalves per second. Previous studies have proposed discrimination methods using images [1] or sound [2, 3]. The image-based method involves the analysis of a transmission image obtained using near-infrared light; however, this method is expensive. The sound-based method involves the analysis of the sound produced when a bivalve collides with a known surface.

In this study, in accordance with the previously proposed method using sound, bivalves were dropped onto a concrete surface from a height of a few centimeters. The resulting collision sounds were analyzed in the frequency domain, and the difference between the collision sounds made by good and defective bivalves was examined. It was found that the collision sounds of the good and defective bivalves differ near a frequency of 900 Hz, as determined in the previous studies [2, 3]. In these previous studies, low-pass filters with cut-off frequencies of 3000 or 7500 Hz were applied to the collision sounds; however, in this study, a low-pass filter was not applied. Therefore, it was also found that there are differences in the collision sounds near frequencies of 9000 and 15000 Hz. From these results, it was demonstrated that it is possible to automatically distinguish between good and defective bivalves based on the differences between their collision sounds.

2. Frequency analysis of collision sounds

Bivalves were dropped onto a concrete surface from a height of a few centimeters, and the resulting collision sounds were recorded. These recorded sounds were extracted, normalized with 0 mean and unit variance in each time interval, and the Fourier transform was applied to the normalized signals to analyze them in the frequency domain. We grabbed about 10 bivalves and dropped bivalve one by one. This time, one set is about 10 bivalves, and we recorded many sets.

2.1 Recording apparatus and analysis conditions

Table 1 gives the sound and image recording apparatus. The image was recorded only for reference. The recorder (PCM-D50) used in this study has a 2-channel microphone, but only the L channel was used in the experiments. Figure 1 shows the recording setup. Collision sounds were totally recorded for approximately 6 min. Thereafter, the collision sounds were extracted for short time interval(4410 points) and the extracted sounds were normalized.

Table 1: Sound and image recording apparatus.

Sound recording apparatus	SONY, PCM-D50
Quantizing bit	24bit
Sampling frequency	44.1kHz
Image recording apparatus	SONY, HDR-CX170

Figure 1: Recording setup.

Table 2 gives the analysis conditions. The Fourier transform [4] was applied to the collision sounds. The frequency spectrum $X(k)$ of each collision sound is defined as

$$X(k) = \sum_{n=0}^{N-1} x(n)\mathrm{e}^{\frac{-j2\pi nk}{N}}, \tag{1}$$

where $x(n)$ is the collision sound and N is the number of data points. The power spectrum of each collision sound can be calculated as

$$P(k) = |X(k)|^2. \tag{2}$$

Table 2: Analysis conditions.

Sampling frequency	44.1kHz
Data points	4410
Kind of window	Rectangular window

2.2 Analysis results

Figure 2 shows an example of a series of recorded collision sounds. Figure 3 shows an example of the collision sound produced by a good bivalve. Figures 4 and 5 show collision sounds produced by defective bivalve. The power spectra of the collision sounds produced by the good and defective bivalve are shown in Figs. 6, 8, and 10, corresponding to the sounds in Figs. 3, 4, and 5, respectively. Figs. 6, 8 and 10 are enlarged in Figs.7, 9 and 11, respectively. The power spectrum of the collision sound of the good bivalve was found to have a large amplitude at approximately 900 Hz and at frequencies below 50 Hz. In previous studies [2, 3], the power spectra of the collision sounds of good bivalve were found to have a large amplitude from 900 to 1800 Hz. Therefore, the present results confirm that the recorded sounds have similar characteristics to those in previous related studies. In contrast, the power spectra of the collision sounds of the two defective bivalves have large amplitudes near 9000 and 15000 Hz. In the previous studies, because low-pass filters with cut-off frequencies of 3000 or 7500 Hz were applied to the collision sounds, this difference between the sounds produced by good and defective bivalves could not be found. However, because a low-pass filter was not applied in this study, the difference between the collision sounds of the good and defective bivalves were observable. From these results, there are detectable differences between the collision sounds of good and defective bivalves. Therefore, it might be possible to automatically discriminate between good and defective bivalves based on the differences between the collision sounds they produce.

Future work will focus on the following three tasks. First, a specific discrimination method must be established. Second, because discrimination between good and defective bivalves would ideally be conducted on the fishing boat, a method of noise countermeasure is necessary. Finally, collision surface materials should be investigated to find a good alternative to concrete.

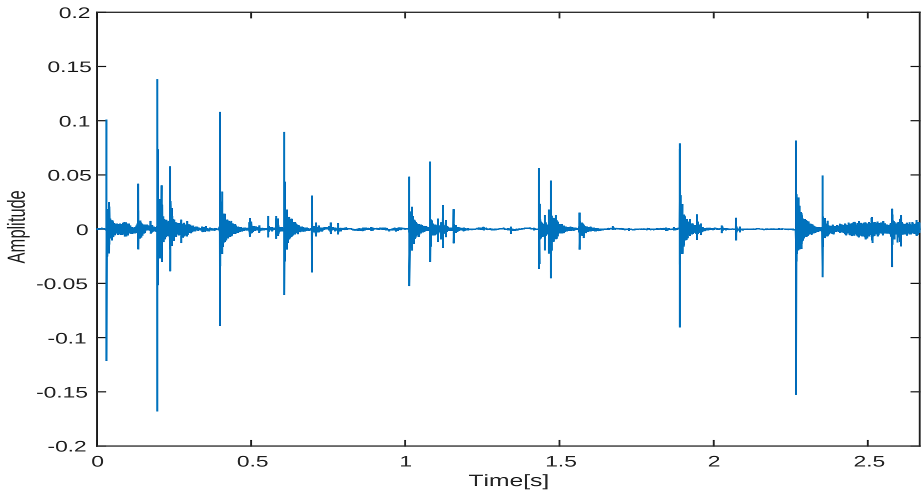

Figure 2: Example of recorded sound.

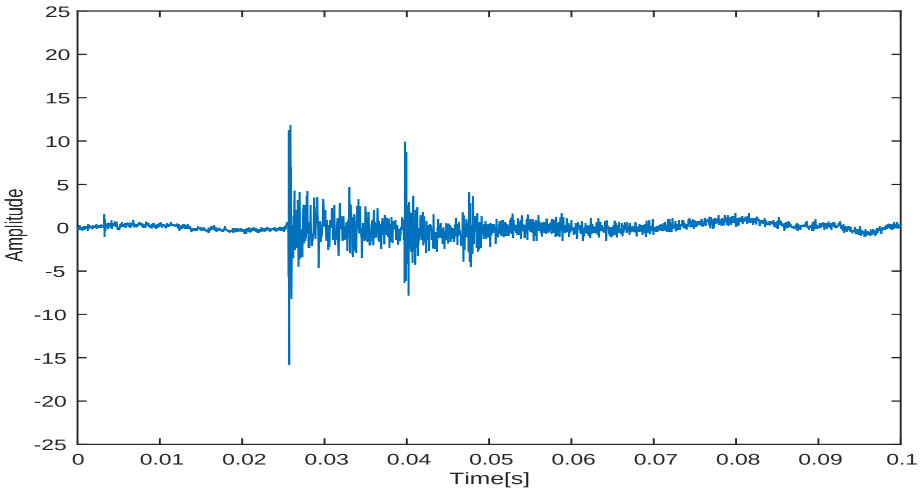

Figure 3: Example of a collision sound of a good bivalve.

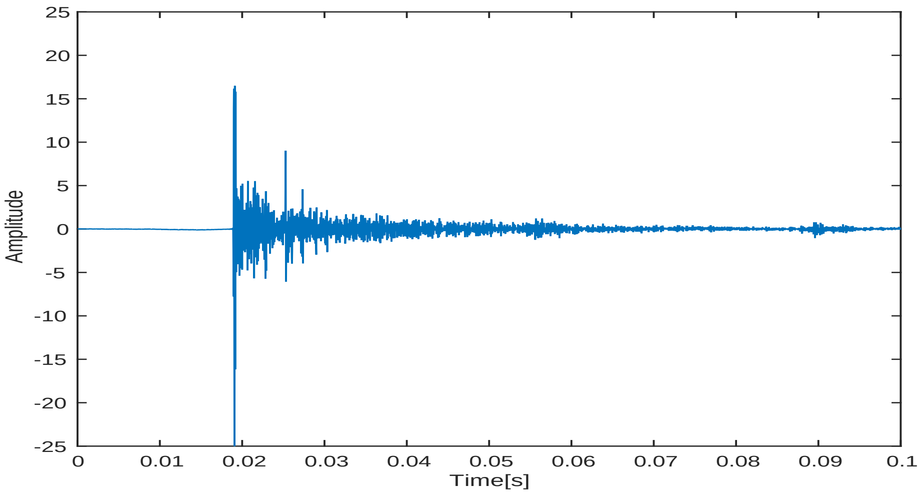

Figure 4: Collision sound of defective bivalve 1.

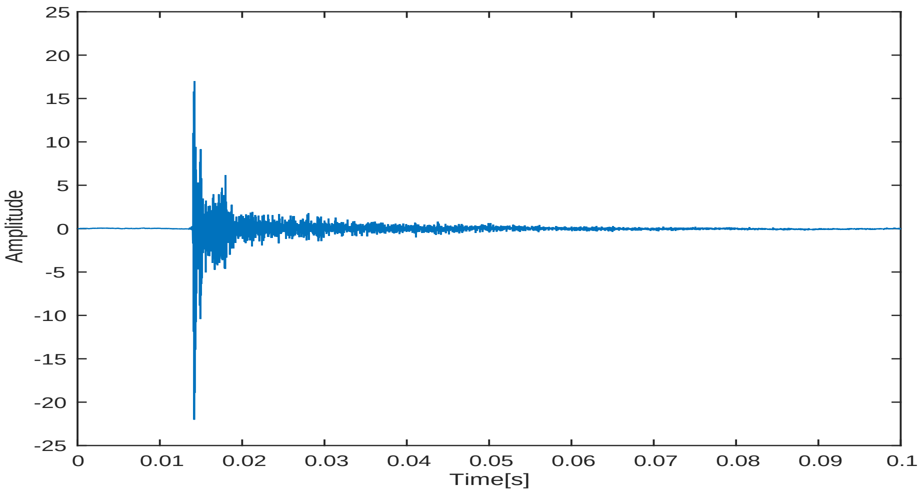

Figure 5: Collision sound of defective bivalve 2.

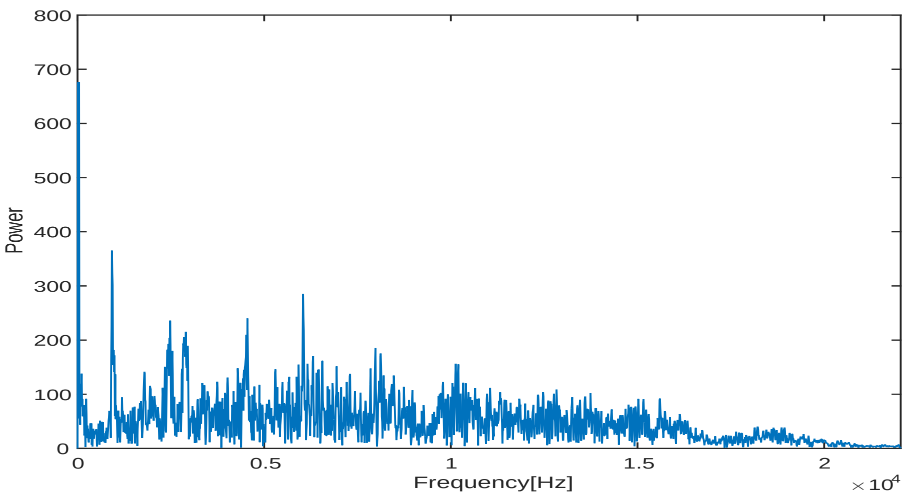

Figure 6: Power spectrum of the good bivalve.

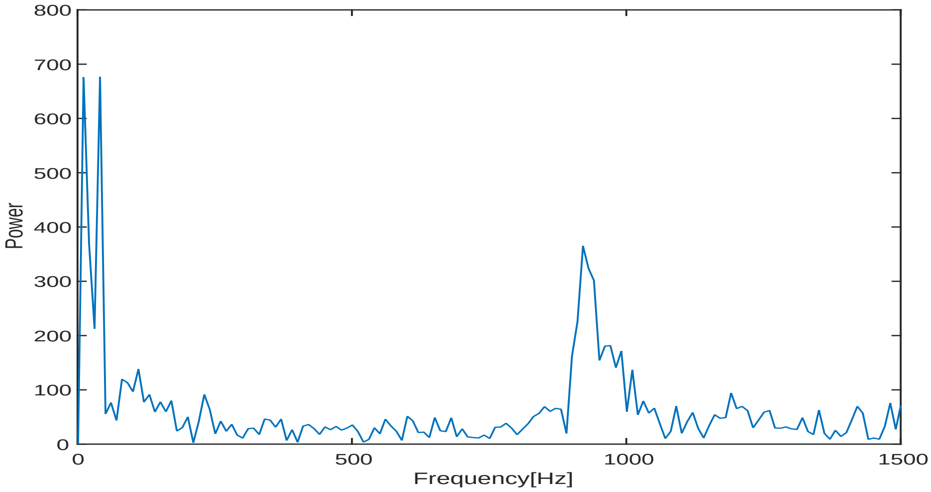

Figure 7: Enlarged power spectrum of the good bivalve.

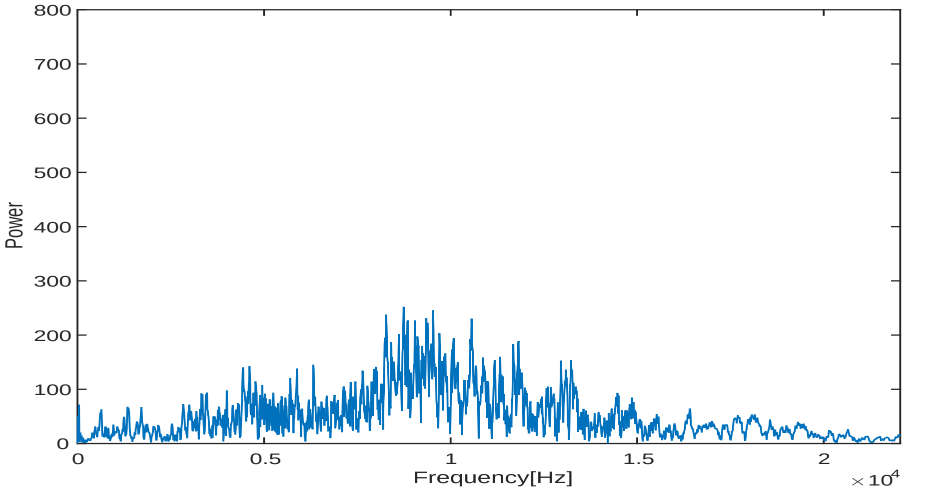

Figure 8: Power spectrum of defective bivalve 1.

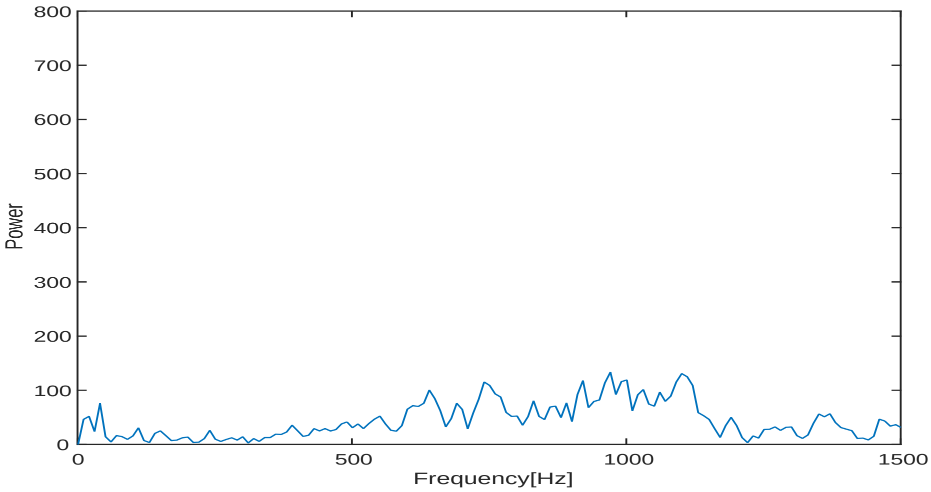

Figure 9: Enlarged power spectrum of defective bivalve 1.

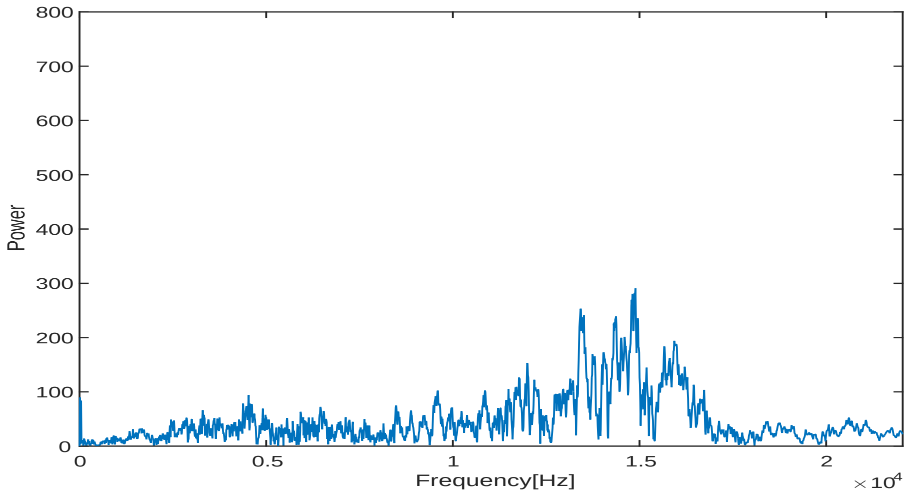

Figure 10: Power spectrum of defective bivalve 2.

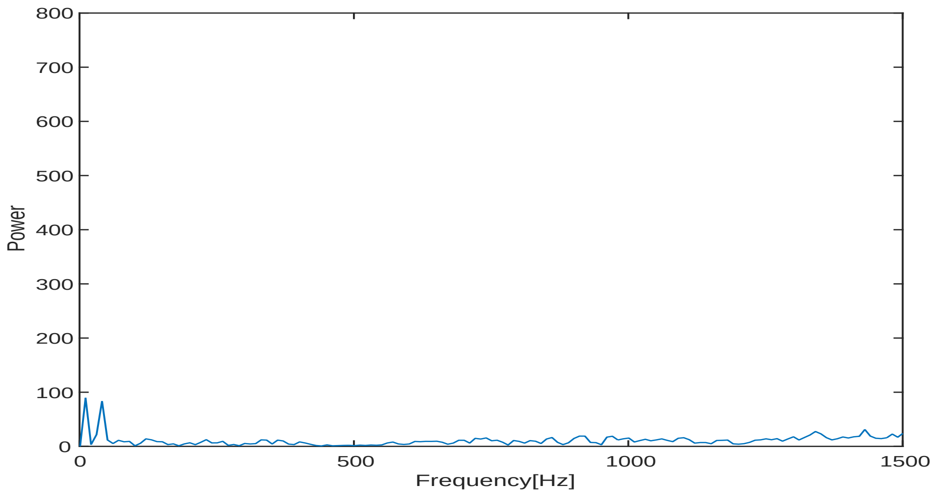

Figure 11: Enlarged power spectrum of defective bivalve 2.

3. Conclusion

Bivalves were dropped onto a concrete surface from a height of a few centimeters, and the resulting collision sounds were analyzed using the Fourier transform to examine the difference between the collision sounds produced by good and defective bivalves. In this experiment, the collision sounds produced by good bivalve were found to have a large amplitude near 900 Hz and below 50 Hz, whereas those produced by defective bivalve were found to have a large amplitude near 9000 and 15000 Hz. These results indicate that there are detectable differences between the collision sounds produced by good and defective bivalves. It may be possible to use this characteristic to automatically discriminate between good and defective bivalves.

This study is the first step in the creation of such an automatic discrimination method. Many problems remain to be solved in the near future, such as ensuring the speed and specificity of the discrimination method, developing noise countermeasures, and considering the effects of the collision surface on the sound.

Acknowledgments

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REFERENCES

1. Maruyama, N., Shellfish Sorting Method. Japanese Patent Number JP5126709, (2013).

2. Horiuchi, T., Beppu, T., Fujioka, Y. and Hara, M. Comparison of Pattern Classification Methods in Discrimination of Inferior Shijimi Clams Based on Acoustic Signals, *Japan Society for Fuzzy Theory and Intelligent Informatics*, **20**, (5), 817-822, (2008).

3. Beppu, T. The Discrimination Method of Defective Corbicula and Classification of Corbicula. Japanese Unexamined Patent Publication Number 2006-242800, (2006).

4. Ronald, B., *The Fourier Transform and Its Applications*, NewYork, McGraw-Hill(1999).