Study on Abnormal Sound Detection Using Sound Quality Metrics

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Machines require high reliability operating in factories, power stations, and transportation requires high reliability. If a machine or system malfunctions, it can lead to social disruption and economic loss. Furthermore, there is a risk of causing disasters and accidents due to aging of products and systems. In order to prevent these risks, daily maintenance and inspection work on the machines that make up to the mark the system is indispensable. In order to prevent these risks, daily maintenance and inspection work on the machines that make up to the mark the system is indispensable. It performs using human sense organs, in maintenance and inspection work. For example, we use the visual sense to observe the state of the machine, the auditory sense to listen to the operation sound of the machine, the tactile sense to touch the machine, and the smell to smell the odor emitted from the machine. The most frequently used sense is visual, and the next most used sense is hearing in maintenance and inspection work. Hearing is used to supplement visual information. For example, it is used as a black box when the structure of the machine cannot be seen or when it is difficult for humans to enter.

Skilled maintenance technicians can determine whether the machine is normal or abnormal based on the slight difference in the operation noise emitted from the machine. However, there is an individual difference in hearing, and even a skilled technician may make an incorrect judgment or disagree. In addition, no systematic training method has been established to bring engineers up to skill level. For this reason, training engineers are expected to take a lot of time and cost. There is a concern that maintenance know-how will be lost due to a decrease in the working population and a shortage of successors. From the background of these labors, practical application of abnormal sound detection by machines without human intervention is being studied. In recent years, with the improvement of computer performance, the study of abnormal sound detection by machine learning has been studied. However, it is not easy to create a model that distinguishes between normal and abnormal sounds, and there are few data sets to create the model.

It is considered that skilled engineers detect abnormal sounds based on timbre information, especially auditory impressions such as roughness, fluctuation, and sharpness. Among the timbres, there are sound quality metrics (roughness, fluctuation strength, sharpness) as objective evaluation indices related to the roughness, fluctuation, and metal factors of the sound. It is thought that abnormal sounds can be detected based on this sound quality

metrics. The purpose of this research is to examine what features appear in auditory impressions such as roughness, fluctuation, and instep height of machine operation sounds, and to clarify whether abnormal sounds can be detected based on the characteristics.

First, in order to clarify the auditory characteristics of normal or abnormal machine operation sound, the sound quality metrics of the database of normal sound and abnormal sound was analyzed. A toy motion sound database (ToyADMOS) was used in this analysis. The toy to be analyzed was a railway model (HO scale). There are various patterns of abnormalities in the operation sounds of railway models recorded in ToyADMOS. This database contains the sounds of broken wheels, broken rails, foreign objects on the rails, and loosened rail connections. In this analysis, the operation sound that matches the conditions when running on a damaged rail, running on a rail on which foreign matter is placed, or running on a rail with loose connections is used with broken wheels. There was a total of 14 operation sounds that matched this condition. The same number of normal sounds as the abnormal sounds were also used. The sound pressure level of the sound used in the analysis was set to 80 dB. These figures assume machines operating in factories and power plants. The sound quality metrics were used to analyze the toy train sounds. These metrics were derived by using OROS FFT analyzer (OR-34). The high-order statistics (mean, variance, skewness, and kurtosis) of the sound quality metrics were used to investigate whether differences between the characteristics of normal sound and abnormal sound can be appeared in the results of the sound quality metrics.

As a result of analysis, the average and variance of roughness and the variance of fluctuation strength for abnormal sounds were higher than those for normal sounds. In contrast, no difference between the normal and abnormal average sharpness could be confirmed. From these results, it was found that abnormal sounds have characteristics in the index related to sound fluctuation.

Next, the classification of normal sounds and abnormal sounds is performed using the statistics of roughness and fluctuation strength as thresholds, and the classification accuracy was evaluated. In addition to ToyADMOS, the classification accuracy was evaluated for a database of machine operation sounds (motor sounds) determined by a skilled engineer. A new database of machine operation sounds (motor sounds) determined by a skilled technician was prepared, and the classification accuracy was also evaluated for this database. There was a total of 37 motor sounds, of which 30 were determined to be normal and 7 were determined to be abnormal. In order to evaluate the classification accuracy, the database was divided for analysis and test. The normal sound and the abnormal sound were classified as

the roughness, the mean, the variance, and the variance of the fluctuation strength as thresholds.

In the ToyADMOS, the normal sound and the abnormal sound were classified using the average and variance of the roughness and the variance of the fluctuation strength as the threshold values. This result is equivalent to the result of classifying the same database by machine learning, and high accuracy was obtained. On the other hand, the classification results for the motor sound showed that the F-measures of mean, variance of the roughness , the F-measures of variance of the fluctuation strength ware 0.600, 0.632, and 0.667, respectively, which was lower accuracy than ToyADMOS.

From these results, it was suggested that abnormal sound detection can be realized by using the roughness and fluctuation strength, which are the sound quality evaluation indices, for the machine operation sound that is easy to discriminate.