Study on noise suppression method based on modulation perception mechanism

Yumiko Takahashi (1710109)

Graduate School of Advanced Science and Technology,
Japan Advanced Institute of Science and Technology

February 8, 2019

Keywords: discomfort of sound, physical characteristics, saliency.

In many years, there have been serious disasters as typhoon and earthquake. These disasters cause serious damage. In such cases, evacuation behavior is very important. Further, the call for emergency evacuation is the main way in evacuation behavior. These calls are important to protect everyone ' s safety. This is because about 80% of the people who heard the evacuation calls felt the necessity of evacuation. Nevertheless, the emergency evacuation calls often do not catch because there are many information such as when the disaster occurred. In fact, there are reports that only 56% of the people are able to clearly grasp the evacuation warnings from emergency broadcast system. Therefore, evacuation warnings must be made more prominent. It is necessary to improve salience of those calls to be able to hear them more clearly. The noticeable sound is said to be discomfort sound. Accordingly, it is effective to increase discomfort of the sound in order to make the calls salient. However, discomfort sound has not been quantified at present. Thus, studying discomfort sounds is challenging. If characteristics of the discomfort sounds are clearly known, salient sounds could be designed.

In previous studies, Aures proposed a scale for ' comfort ' using sound quality indices. The sound quality indices are index that associates psychological quantity with physical quantity according to human perception using psychoacoustic technology. Loudness, sharpness, roughness, tonality, etc. are present in this index. Watanabe et al. introduced that discomfort in tactile sense is closely related to phrases representing and roughness sharpness. From these studies, roughness and sharpness of sound quality indices seems to be related to sound discomfort. However, ' comfort ' is on the opposite direction of discomfort. Additionally, there are differences between touch and hearing. Thus, if we pay attention to the discomfort of sound, we must think from another point of view. In the present situation, relationships between discomfort sounds and acoustic features in sense of hearing are still not clear. Therefore, it is necessary to discuss physical correlates of discomfort sounds. Moreover, it is required to clarify what kind of physical quantity is related to sound discomfort. To answer the above question, we investigate correlations between degrees of discomfort sounds and acoustic features. However, discomfort sound has not been quantified. Therefore, it is necessary to know what type of sounds discomfort and the degree of discomfort of those sounds are. Hence listening test is carried out to collect scores for discomfort from sounds.

The system of listening test is constructed with a Windows-based PC, audio interface (Fireface UCX), headphone amplifier (STAX SRM-1/MK-2), and headphone (STAX SR-404). The experiment is conducted in a soundproof room. 25 types of sounds are used as stimuli. All these

stimuli sounds are electronic sounds. Also included are railroad crossing sounds and birdcall. Duration time of all stimuli was 5 seconds. Sampling frequency was 44.1 kHz. The average sound pressure level was 60 dB. The stimuli used for these experiments were actual warning sounds produced by Schneider Electric Japan Holdings Ltd. There is a previous study that frequency characteristics and time variation are related to sound discomfort. Therefore, we focused on these physical features. In order to study correlations between degrees of discomfort and features, we extract centroid, skewness and kurtosis of the modulation spectra and long-term amplitude spectra. Participants were seven male and seven female Japanese listeners in their twenties with normal hearing ability. here are sounds whose impressions change depending on the country. Hence, all the subjects are Japanese. In the experiment, participants were asked to listen to stimuli to score degrees of discomfort (not dis-comfort (0) - very discomfort (3)). One session includes 25 stimuli and 5 sections were presented to the participants. The evaluated values were averaged, and the extent of discomfort of the stimulation sound was calculated. The minimum value of the value is 0.543, and the maximum value is 2.314.

Using pearson product-moment correlation coefficient, correlation coefficient between the discomfort of the sound and the physical quantity was calculated. The correlation coefficient about centroid of the long-term spectra vs degrees of discomfort is 0.59. Therefore, it can be said that there is a positive correlation. The correlation coefficient about skewness of the long-term spectra vs degrees of discomfort is -0.56. Therefore, it can be said that there is a negative correlation. The correlation coefficient about kurtosis of the long-term spectra vs degrees of discomfort is -0.41. Therefore, it can be said that there is a low negative correlation. The correlation coefficient about centroid of the modulation spectra vs degrees of discomfort is -0.48. Therefore, it can be said that there is a low negative correlation. The correlation coefficient about skewness of the modulation spectra vs degrees of discomfort is 0.45. Therefore, it can be said that there is a low positive correlation. The correlation coefficient about kurtosis of the modulation spectra vs degrees of discomfort is 0.42. Therefore, it can be said that there is a low positive correlation.

From this result, it can be said that the sound concentrating at the high frequency component position and the sound concentrated at the low modulation frequency component are unpleasant. In other words, it feels unpleasant sounds that feel shrill and feel slowly fluctuating.

In order to clarify the physical characteristics of discomfort sounds, correlations between the evaluation values of discomfort obtained by the listening experiment and the estimated physical features were investigated. As a result, it was found that deviation of the spectra considered to be discomfort if the higher. The result of this research is considered to help research that considers the remarkable sound from physical properties.