

THE MEASUREMENT AND EVALUATION SYSTEM OF THE ENVIRONMENT SOUNDS

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Abstract - *We are surrounded by many various sounds every day. There are sounds as displeasing sound and there are pleasing sounds like music by the degree of the sounds to us. A sound is one of very important common means in man-machine interface. Some investigations of how human feel to the sounds such as music, ordinary sounds and noises. We try to construct a sound evaluation system using MTS (Mahalanobis-Taguchi System) in the paper. The aim of the study is to develop a system for evaluating various sounds to support the sound design like electric sound design. And the sounds such as noises are evaluated using the constructed sound evaluation system.*

Keywords - sounds evaluation system, MTS method, Quality Engineering,

1. INTRODUCTION

While the convenience of our life is improved and the life becomes rich, however, the noxious things for humans such as industrial waste, automotive exhaust gas, noises, food additives, etc., are increased. We are surrounded by many sounds like noises, human voices and music every day. We live in such environment. Whether what kind of sounds gives the discomfort to us and what kind of sounds gives us the comfort is not clear quantitatively till now. In this study, the measurement and evaluation system for the environment sounds is tried to construct using MTS (Mahalanobis-Taguchi System) method. MTS method is the technique that evaluates the parameters of many items using one measure. The measure is called Mahalanobis distance. The standard space of Mahalanobis is constructed on the data of white noise like running car sound. When the car runs on the road, car generates the sound like white noise. In general, we dislike this type of white noise sound. The white noise sound gives the discomfort to human. The evaluation of the various environment sound is tried using the constructed system. Many sounds in our surroundings are evaluated and the degrees of the discomfort and the comfort to us are shown. Mahalanobis distance in the constructed standard space shows the degrees of the discomfort and the comfort. The relation between the evaluated values and the human sensitivity is clarified by the experiment of paired comparison method and using the graph theory. Using the constructed sound evaluation system, the improvement of various sounds is possible. For example, the noisy uncomfortable sound is changed to the comfortable sound by overlapping some sounds to the noisy sound. The electric

sound of the portable telephone has given the uncomfortable sensitivity to us recently. The electric sound of telephone is evaluated and the sound is designed again, then, the electric sound gives us the comfortable sensitivity. Many kinds of the uncomfortable sounds are evaluated using the sound evaluation system and the uncomfortable degrees are improved. The improved level is shown numerically as Mahalanobis distance.

2. MAHALANOBIS STANDARD SPACE

2.1. Setting of Mahalanobis standard space

Sound intensity and tune give large effect at our psychological quantity. The phenomenon on the psychological effect is very complicated and the sufficient data have not been obtained till now. In the study, the relation between psychological quantity and frequency characteristics is examined by handling sound intensity and tune as frequency spectrum of the sound. There are following sounds that give comfort and discomfort to us. The comfortable sounds to us are the sounds with the fluctuation. They are called 1/f sound such as river flow, wave and wind. The uncomfortable sound to us is the white noise. Mahalanobis standard space is constructed using the uncomfortable noises like the white noise.

2.2. Standard data for standard space

How to set the Mahalanobis standard space is very important in the MTS method. It is said that the white noise gives the discomfort to us generally. The sound in which the car runs on the road shows the similar frequency spectrum to the white noise. The Mahalanobis standard space is set using the frequency spectrum of the running car sound. The frequency spectrums are shown in Fig. 1. Three kinds of sounds are shown. 1/f sound (wave sound on beach) gives the comfortable sensitivity to us. The frequency spectrums are measured with the noise meter. The noise level is measured every 1/3 octaves. The measured frequency band is from 10 Hz to 5 KHz and the measured data are standardized by 10 Hz noise level. 10 Hz noise level becomes 1.0 therefore.

The Mahalanobis distance handled in the study is shown in following equation, because the Mahalanobis distance becomes large value.

$$D_b = 10 \log D^2 \quad (1)$$

Where, D^2 is the Mahalanobis distance.

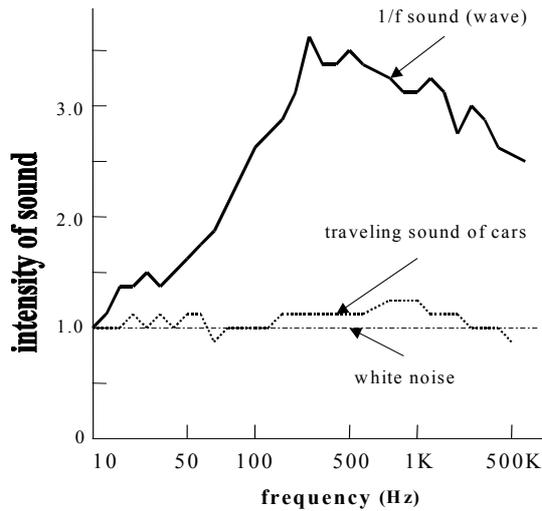


Fig. 1 - Frequency spectrum of sounds (noise level).

3. CONSTRUCTION OF SOUND EVALUATION SYSTEM

The sound evaluation system is shown in Fig.2. The evaluating sound is recorded and the noise level is measured by reproducing the recorded sound. Using the noise levels of running sounds of the various cars, Mahalanobis standard space is set. By the Mahalanobis distance calculated from the frequency spectrum of the evaluating sound, the decision of whether it is the comfortable sound and whether it is similar to the uncomfortable sound becomes possible. The

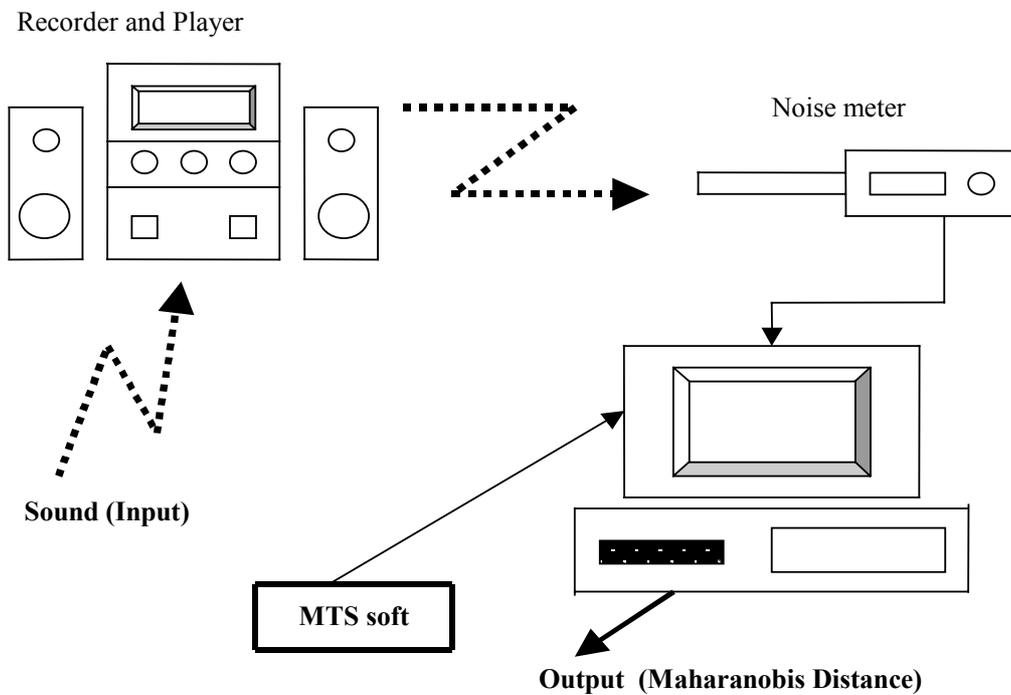


Fig. 2 - Evaluation system for various environment sounds.

Mahalanobis distances of various sounds are distributed between 1.0 and the Mahalanobis distance of 1/f sound in the set standard space. The distance of the uncomfortable sound is near 1.0 and the distance of the comfortable sound is located far from 1.0.

In this evaluation system, the input data is recorded sound with the microphone and the output evaluated data is Mahalanobis distance. If the Mahalanobis distance of the second product design is larger than the first product design, it can be judged that the second product design is improved. When the sounds in some group is evaluated, the difference of the Mahalanobis distance becomes a scale of the order of the discomfort or the comfort.

4. EVALUATION EXPERIMENTS OF MANY SOUNDS

4.1 Evaluation of music

The evaluation for various music is tried using the constructed sound evaluation system. There are three elements in music. They are rhythm, melody and harmony. Music as the evaluation objects are ① vocal music (winter journey), ② orchestra (fate), ③ piano (dream of love) and ④ electric music (kitaro). The evaluated result is shown in Fig.3. The order, ①→②→③→④ is obtained. The vocal music becomes the most comfortable music of four kinds of music. The vocal music is similar to 1/f fluctuation sound, because the noise level of vocal music is high in the frequency domain of the sound that is accustomed to our ears every day.

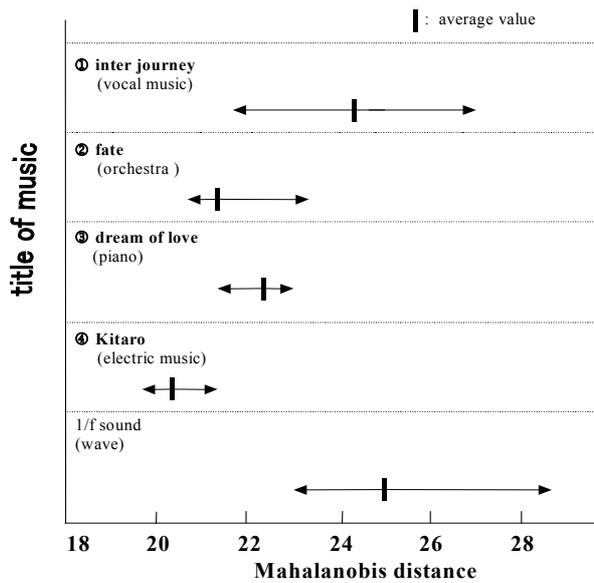


Fig. 3 - Mahalanobis distance of various music.

4.2. Evaluation experiment of various noises

Various noises are evaluated using the system. The noise level is measured with recording in each place and reproducing the noise. The result is shown in fig.4. The sounds are recorded in construction work field, railroad crossing, pachinko store and subway.

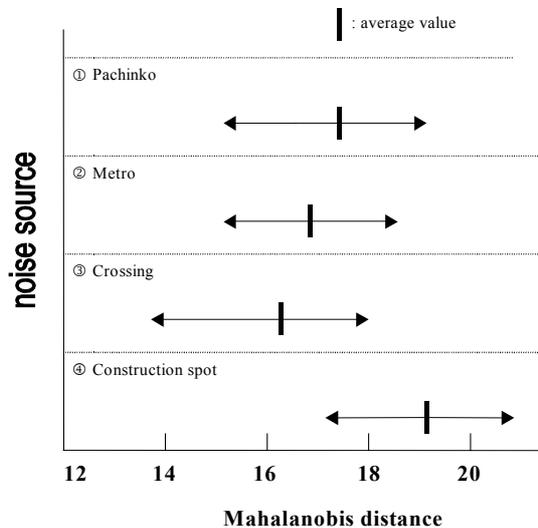


Fig.4 - Mahalanobis distance of various noisy sounds.

The clarification of the validity of the evaluation system is attempted using the research result. The pair comparison test and the analysis using the graph theory are practiced in order to confirm the contrast between the evaluation result and the human sense. The result is shown in Fig. 5. The evaluated result and the human sense show the same characteristic.

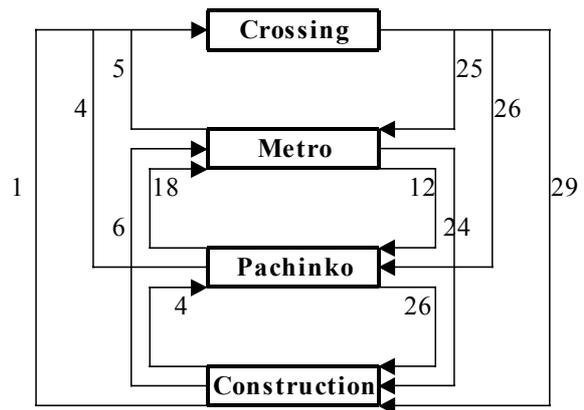


Fig. 5 - Noisy order of four sounds.

5. CONCLUSIONS

The evaluation system of the various surrounding sounds was realized using MTS method in the study. The noisy and uncomfortable degree of the various sounds was evaluated by the constructed system. It was shown that the evaluated result and the human sensitivity by pair comparison experiment and graph theory showed the same tendency to the uncomfortable and noisy sound. The effectiveness of the sound evaluation system was confirmed by the above experiment. The proposed evaluation system is improved further, then, the design of many sounds that gives the comfortable sounds and music to us becomes possible.

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