TECHNICAL REPORT

Database of domestic sounds for evaluation of auditory-signal audibility: JIS/TR S 0001

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Abstract: A new Technical Report of Japanese Industrial Standard, JIS/TR S 0001, was made public in January 2002. This JIS/TR is a database for determining the acoustic properties of auditory signals used in consumer products; it consists of (1) graphical data of the frequency characteristics of domestic sounds, and (2) a library of recorded sounds on compact disc. The former can be used to graphically determine combinations of frequency and sound pressure level of auditory signals that are audible against domestic sounds. The latter is intended for use in a psychoacoustic experiment in which auditory signals are presented along with domestic sound(s) of the library; listeners are asked then to judge how they perceive the signals. The experiment can be carried out using either a loudspeaker or headphones. This JIS/TR will facilitate the development of suitable auditory signals for domestic appliances used under various noisy conditions and by a variety of users, including the elderly.

Keywords: Domestic sound, Auditory signal, Japanese Industrial Standard, Technical Report, Recorded library

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1. INTRODUCTION

Consumer products, such as domestic appliances, currently available on the market often adopt auditory signals in their user-interfaces. Such signals notify the user that the appliance has finished its function, such as cooking, or that it has some malfunction. Use of auditory signals has become popular along with full automation and the sophistication of appliance functions. The user can leave an appliance while it is working, but still remain informed of its progress. Sometimes the user must do something depending on what the appliance requires him/her to do. Auditory signals are expected to improve the usability of those appliances. Signals are also indispensable for the elderly, who are not accustomed to such products, and for the visually impaired, who need to manage appliances solely by hearing auditory signals.

One common criticism, however, is that signals cannot be heard distinctly enough or not at all in some cases. A major reason for this is that loud domestic sounds, such as noises from a vacuum cleaner or dish washing, might mask

signals and make them difficult to hear. Therefore, it is desirable that the signal level be carefully determined such that they can be clearly heard in noisy situations.

In order to determine suitable acoustic properties for auditory signals used in consumer products, a new Japanese Industrial Standard (JIS) [1] was established in January 2002. (It is actually a revised version of another standard [2] and was made separate to expand the contents of the first standard.) This standard is a guideline for product designers to develop auditory signals suitable for the elderly and the visually impaired, as well as young people with normal hearing. Items prescribed in this standard are as follows: (1) definitions and classifications of auditory signals, (2) recommended temporal patterns classified in terms of the signal purpose, (3) other notes on acoustical properties of auditory signals to make the signals clearly audible and understandable, such as fundamental frequencies and the number of sound components.

One issue that this standard does not fully address is the sound pressure level of auditory signals. The new standard does not specify what level is required for signals to be heard against background domestic noises. The working group of the standard was aware of the significance of the

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masking effect, but refrained from including definite descriptions on the sound level of signals in the standard. There are a variety of domestic sounds from different sources with different acoustic properties. They may also be different from room to room. Thus, it was not easy to propose a method for designing signals audible against domestic sounds and make some recommendations on necessary sound levels.

Although there may be large differences among domestic sounds, their characteristics can be determined statistically by collecting large quantities of measured data. If the average acoustic properties and statistical distribution of these sounds are made clear, it would be possible to estimate a sound level necessary for auditory signals to be discerned among background noises. The present authors have been engaged in building a domestic sound database for this purpose; the data corpus was made public in January 2002 as a JIS Technical Report, JIS/TR S 0001 [3].

The JIS/TR is open to any interested party, and any constructive comments on the JIS/TR regarding its future revision are welcome. The report is, however, written in Japanese and this may prevent broader access from areas outside of Japan. The following is a short introduction to the above-mentioned JIS/TR intended to help readers comprehend its outline.

2. OUTLINE OF JIS/TR S 0001

JIS/TR S 0001 consists of two kinds of data corpuses: (a) a set of graphical data of frequency characteristics of domestic sounds, and (b) a library of recorded domestic sounds that have median frequency characteristics shown in the corpus (a). The former can be used to find suitable combinations of frequency and sound pressure level of signals, or to evaluate whether a signal would be masked by background domestic sounds. The latter is contained on a compact disc attached to the main text of the JIS/TR. The library can be used in a psychoacoustic experiment in which the auditory signals being considered are presented along with the recorded sound(s); listeners can then judge, for example, whether they could hear signals against them. The experiment may be carried out using either a loudspeaker or headphones.

2.1. Graphical Data of Domestic Sounds

Recording of domestic sounds was conducted in 14 model or private houses. Recorded sounds were those generated by the following 11 appliances or by a person doing housework in one of four types of rooms. (1) In a kitchen: washing dishes, boiling water in a pot, a ventilation fan, and a microwave oven. (2) In a washroom: a washing machine, a clothes drier, washing hands, and a hair drier. (3) In a bathroom: running water from a faucet or a shower. (4) In a living room: a television and a vacuum

cleaner. For sounds with water such as the washing of dishes, the flux of water was set at three different levels. If the appliance power level was adjustable, as in the case of vacuum cleaners, the power levels were set to both *low* and *high*.

Sounds were recorded using a free-field microphone located at a position corresponding to the center of the head of a person using the appliance or doing housework. Thus, recorded sounds have characteristics that a person in each of the situations might typically perceive. An example of a microphone placement is shown in Fig. 1.

Recorded domestic sounds were fed into an analyzer to measure the one-third octave band levels, and their long-term average values were summarized in graphs, one for each kind of domestic sound. Figure 2 shows an example.

Fig.1 An example of a microphone placement [3].
(Recording of the sound of washing dishes.)

Fig.2 An example of graphical data showing the frequency characteristics of domestic sounds [3].
(Sound of washing dishes.)

Five curves appear in each graph, indicating the 5th percentile, the 25th percentile, the 50th percentile (median), the 75th percentile, and the 95th percentile levels of all data recorded under identical conditions for different rooms, respectively. These curves indicate, for example, that 90% of data around the median lie within the range between the 5th and 95th percentile levels; that 50% of data between the 25th and 75th percentile levels, etc.

When a pure tone is presented against broadband noise, one can just detect the tone if it has approximately the same power as that within the critical band with the same center frequency as the pure tone [4]. As the bandwidth of critical bands can be approximated by the one-third octave bandwidth when its center frequency is around 500 Hz and above, the one-third octave band levels of domestic sounds is a good measure for audibility of auditory signals presented against the domestic sounds; if a pure tone signal has a sound level sufficiently higher (e.g., 13 dB or more as prescribed in an ISO Standard [5]) than the one-third octave band level of a domestic sound at corresponding center frequency, the signal should be audible to the user in that situation.

As data appear with statistical distributions, one can also use them to determine a sound volume range of the auditory signals. For example, if the volume control of an appliance covers the range corresponding to that between the 5th and 95th percentile levels of a domestic sound in which the appliance would be used, one can expect the variable signal to be detectable in 90% of users' houses by adjusting the volume.

2.2. Library of Recorded Domestic Sounds

Although the one-third octave band levels can be used for rough estimation of audibility, some kinds of auditory signals may require further examination. For example, the detectability of a sound varying in amplitude or frequency, such as a "melody" signal, cannot be estimated based on its long-term average characteristics. This is also true for speech sounds that are occasionally used, and will likely be more frequently used, as auditory signals in consumer products for the elderly or the visually impaired.

Furthermore, users may have difficulty in hearing. Elderly people typically have some hearing loss and their hearing ability can be adversely affected by extraneous noise. Therefore, designers need to find a sound level that ensures signal reception for the elderly as well as for young people with normal hearing. The criterion of determining signal level is not restricted to whether the signal is detectable. For example, product designers may want to know what level is required for a signal to be heard "loudly enough."

Sounds in the library can be used in a psychoacoustic experiment to assess the audibility of complex signals or to

Fig. 3 An example of the placement of head-and-torso simulator [3]. (Recording of the sound of washing dishes.)

evaluate signals from these different aspects of audibility. Recording of domestic sounds was done with a microphone (Fig. 1) and a head and torso simulator (Fig. 3). The frequency characteristics of the sounds were then varied to have median values in the corresponding graphical data, as shown in Fig. 2. Thus, if one plays back sounds at a designated level, a domestic sound having typical frequency characteristics in each situation can be reproduced at the listener's position (via a loudspeaker) or at the listener's ears (via headphones).

The listening experiment may be conducted in the following way: the auditory signals of concern are presented with domestic sound(s) in which an appliance with the signals would be used. The experiment can be carried out with either a loudspeaker or headphones depending on the purpose of experiment. After listening to a signal along with the background sound(s), the listeners may be asked, for example, whether they could hear the signal or whether the signal was loud enough. Through such an experimental procedure, one can evaluate various aspects of audibility for any type of auditory signal.

3. CONCLUDING REMARKS

The authors are expecting several researchers to take interest in the area of auditory-signal design and to cooperatively develop a method for creating signals suitable for all users including the elderly. The JIS on auditory signals and the above-described JIS/TR on domestic sounds are not definite ones, but are subject to future revision according to the rules of the JIS. Research results will be reflected in the next version of the JIS and the JIS/TR.

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