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CD of "Version 1.0" is a single size (8 cm) audio CD, and contains 42 tracks data. Total recording time is 21 minutes 49 seconds. We are now distribution it to the facilities of blind education or rehabilitation free of charge. We are also providing the free download site of the sound field data in WAVE file format on internet. The information about the training CD, the WAVE files, and the training manual are available on our web site : http://staff.aist.go.jp/yoshikazu-seki/ CD/CD10/

RESULTS

In this paper, we reported our training system or training CD for acquiring obstacle perception. Many O&M instructors and the people concerned with blind education or rehabilitation have tried our training system, and they reported that our system can reproduce the ideal sound variation that is easier to understand for beginners than conventional training. The simplified version of our training system is now working in the Coll e ge of National Rehabilitation Center for the Persons with Disab ilities , Japan for educational use. The latest version of our training CD "Version 1.0" has been distributed to over 15 0 blind facilities.

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AUDITORY OBSTACLE PERCEPTION TRAINING SYSTEM AND CD FOR THE BLIND

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Abstract:

Obstacle perception is a skill to detect presence of "silent" object, such as wall, pole, etc., by perceiving the acoustical cues, such as reflected sound, etc., through auditory sense. This skill is very important for orientation and mobility (O&M) of the blind. We are studying the training system for acquiring this skill in the blind education and rehabilitation by using acoustical technologies. Our training system consists of sound processors for making reflected sounds and several loudspeakers, and can reproduce ideal sound fields for learning the principle of obstacle perception. We are also distributing the audio CD that contains these sound fields to the people concerned with the blind education and rehabilitation. Our system is now used in the school for O&M instructor in Japan, and our CDs have been distributed to about 150 Japanese facilities concerned with the blind.

Keywords:

blind, O&M, obstacle perception, echolocation, auditory training

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Table of Contents

- 1. Introduction
- 2. Previous Training
- 3. Training System
- 4. Training CD
- 5. Evaluation
- 6. Conclusion
- References

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1. Introduction

Obstacle perception (or obstacle sense, human echolocation) is an experiential ability to detect presence of "silent" object, such as wall, pole, etc., which does not make any sounds, by perceiving the acoustical cues, such as reflection or diffraction of environmental or self-generated sounds, through auditory sense (Figure 1). This skill is very important for orientation and mobility (O&M) of the blind (Blasch, et al., 1997). Learning the relation between the existence of object and the variation of sound that is caused by the object enables to master the obstacle sense.

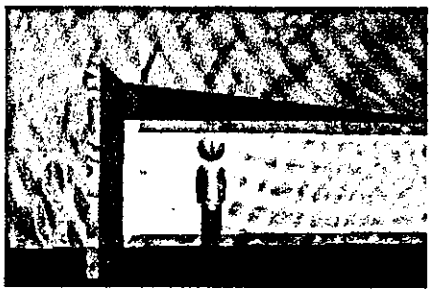

Figure 1, Schematic Explanation of "Obstacle Perception."
Blind person can detect presence of object, such as wall, by hearing reflection or diffraction of environmental or self-generated sounds through auditory sense. This ability is acquired by learning.

In this paper, we report our new training system or training CD for acquiring obstacle perception by using acoustical technologies.

* Back to Table of Contents.

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2. Previous Training

Conventional training for acquiring obstacle perception in the blind education or rehabilitation is usually performed in real environment. The O&M instructor instructs the blind trainee to approach the wall (Left panel of Figure 2), or brings a small board near to the trainee's face (Right panel of Figure 2), to show the sound variation that is caused by presence of object. The trainee should learn the cue of obstacle perception by hearing the shown sound variation experientially.

However, in the real environment, the sound variation caused by the object can hardly be heard, because of irregular variation of environmental sounds, attenuation of the reflected sounds, or being disturbed by other sounds. The conventional training in the real environment is sometimes difficult for beginners of obstacle perception. In order to provide the ideal training environment for the beginners, the new acoustical technologies that can reproduce an ideal sound field variation artificially should be introduced into the blind education or rehabilitation.

Figure 2, Schematic Explanation of Conventional Training of Obstacle Perception.
The blind trainee should learn the cue of obstacle perception by hearing the sound variation experientially with approaching wall or board.

* Back to Table of Contents.

3. Training System

As the first step of applying the acoustical technology to the training of obstacle perception, we developed a new acoustical training system (Seki, 1998). Our system consists of the signal processors and the loudspeakers that are arranged in a ring, and can reproduce the sound field variation by emitting the delayed sounds with respect to the direct sounds, which simulates reflected sounds from wall. Our system produces the ideal sound field variation by assuming that (i) the reflected sounds are perfectly (not attenuated) reflected at the surface of the object, (ii) the diffracted sounds are completely attenuated, and (iii) no other sound exists in the sound field.

The first model of our system had 8 digital delays (Roland SDE-330), and 16 loudspeakers (BOSE 111AD). The digital delays are controlled by the computer (NEC PC-9821Ap3), and make the reflected sounds by delaying the original sound signal. The delay time of the reflected sound ΔT is depending on both distance d and sound angle of incidence to the wall θ, and is found by Equation (1):

$$\Delta T = 2 d \cos\theta / c \quad \text{--- (1)}$$

where c is the sound velocity in the air (= 340 m/s). The delay times are calculated by the computer, and informed to the digital delays through MIDI. The original sound signal that simulates the environmental sound is white noise, pink noise, or true-recorded sound. The sound signal was recorded on multi track recorders (YAMAHA MT4X). (Figure 3, and 4)

The first system can emit up to 8 reflected sounds, and then project "virtual wall." The virtual wall can change distance, direction, and width. The distance is adjusted by the delay times. The direction and width are adjusted by assignment of the reflected sound loudspeakers.

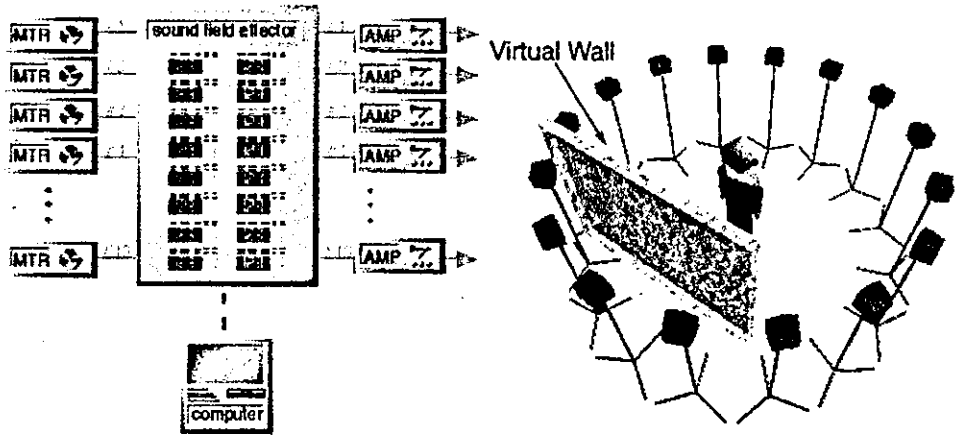

Figure 3, Outlook of Our Acoustical Training System for Obstacle Perception.
This system consists of signal processor (left panel) and loudspeakers (right panel). This system can reproduce ideal sound field variation for he beginners' training. The wall shown in right panel is "virtual wall" projected by our system.

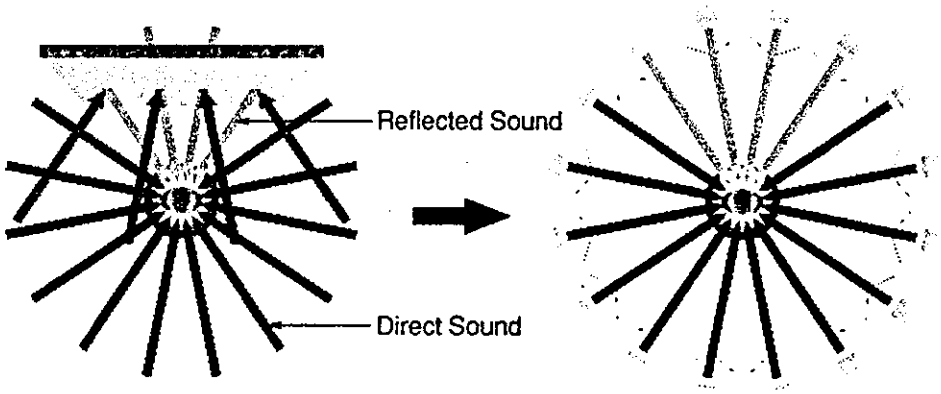

Figure 4, Principle of reproduction of sound field variation. Our system simulates reflected sounds that reflect at surface of wall. Delay time of each reflected sound is calculated by computer, and processed by digital delays. Left panel shows environmental sound field where some sounds reflect at wall, and right panel shows simulated sound field by our loudspeaker system.

Many O&M instructors and the people concerned with blind education or rehabilitation have tried this system, and they experienced that our system can reproduce the ideal sound variation that is easier to understand for beginners than conventional training.

However, our first system was too expensive and too large to be introduced into the facilities for blind education or rehabilitation. So we also developed the simplified version that consists of 1 or 2 digital delays and 2 or 4 loudspeakers. The simplified version is now working in the College of National Rehabilitation

Center for the Persons with Disabilities, Japan for educational use.

* Back to Table of Contents.

4. Training CD

Our training system, even if it is simplified, requires economic load and space to set its hardware, when it is introduced into the blind facilities. In order to reduce economic load and save space of the blind facilities, we developed the training audio CD that contains ideal sound field data, and are now distributing it free of charge.

Our training CD can be reproduced by general audio equipment for home use, and it can also generate the ideal sound field variation as well as the system. Our training CD contains one reflected sound in the right channel and one direct sound in the left channel. It is just the same as the simplified system of 1 delay and 2 loudspeakers.

When play this CD, the two stereophonic loudspeakers are arranged 2.4 - 3.0 m apart and facing each other. The listener's head is at the center of the two loudspeakers. The "virtual wall" appears in the direction of the right channel loudspeaker. (Right panel of Figure 5)

The sound field data were calculated by sound processing software (developed by REAL Software REALbasic) in computer (Apple PowerMac G4), and are recorded by CD burner (Apple iTunes & SuperDrive).

We first developed the trial version of the training CD, "Version 0.0" in 2001 and distributed it to over 50 facilities concerned with blind education or rehabilitation in Japan. Then we modified all data by their opinions, and developed the next version "Version 1.0" in 2002. (Left panel of Figure 5)

"Version 1.0" is focused on the usefulness in practical training scene, and contains various situations. The original sound signal that simulates the environmental sound is white noise, or true-recorded sound. The sound data simulate the wall movement in various ways. For example, wall approaches, approaches and goes away, jumps, and moves randomly. Total of 21 movement patterns are simulated. (Figure 6, Table 1)

CD of "Version 1.0" is a single size (8 cm) audio CD, and contains 42 tracks data. Total recording time is 21 minutes 49 seconds. We are now distributing it to the facilities of blind education or rehabilitation free of charge. We are also providing the free download site of the sound field data in WAVE file format on internet. The information about the training CD, the WAVE files, and the training manual are available on our web site: http://staff.aist.go.jp/yoshikazu-seki/CD/CD10/ (Seki, 2002).

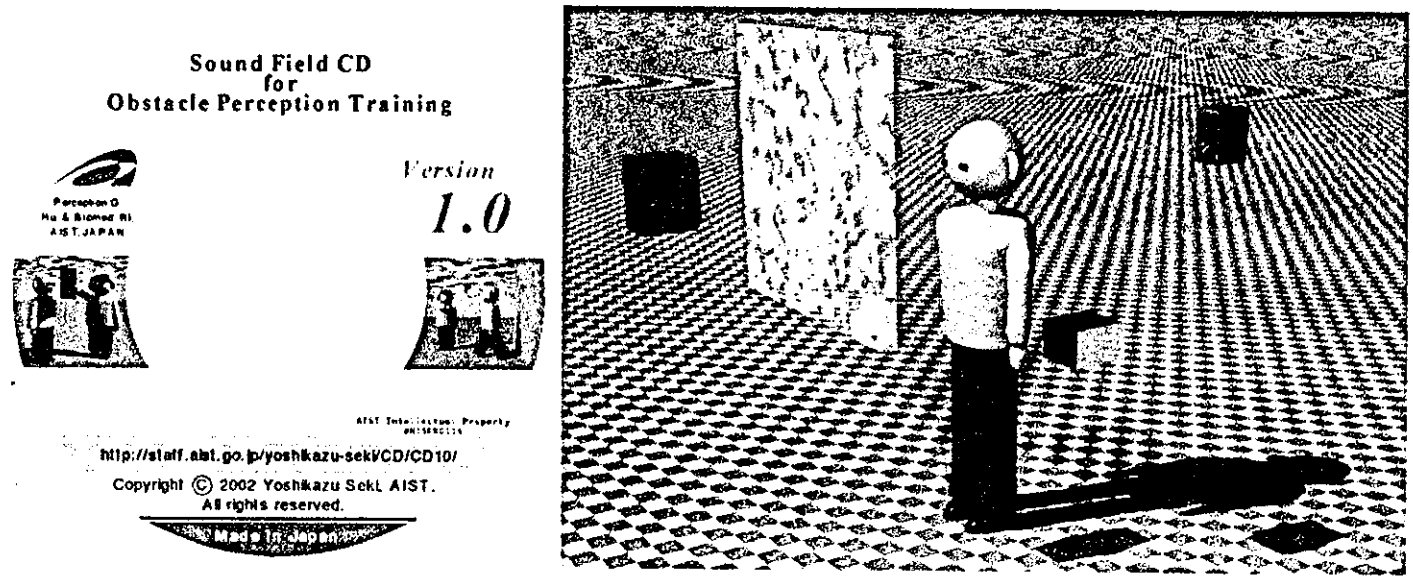

Figure 5, Outlook of Our Training CD "Sound Field CD for Obstacle Perception Training, Version 1.0," and Schematic Explanation of Reproduction of Sound Field.
This CD can be reproduced by home use audio equipment. Two stereophonic loudspeakers are arranged 2.4 - 3.0 m apart and facing each other. Listener's head is at center of two loudspeakers. "Virtual wall" appears in direction of right channel loudspeaker.

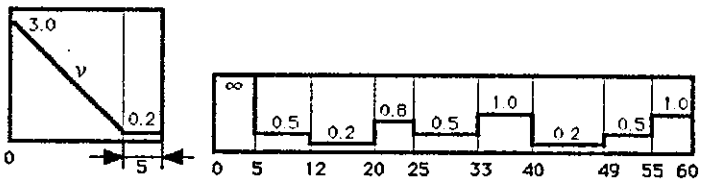

Figure 6, Examples of the Simulated Wall Movement in the Training CD "Version 1.0." Horizontal axis is time in second, and vertical axis is distance in meter. Left panel shows the approaching movement of the wall ("V" means constant velocity), and right panel shows one example of the random movements. Total of 21 movement patterns are simulated in "Version 1.0."

The following list shows the contents of "Version 1.0."

- 01 : White : Move from 3m to 0.2m in 0.7m/s : 9s
- 02 : White : Move from 3m to 0.2m in 0.4m/s : 12s
- 03 : White : Move from 3m to 0.2m in 0.2m/s : 19s
- 04 : White : Move between 3m and 0.2m in 0.7m/s : 56s
- 05 : White : Move between 3m and 0.2m in 0.4m/s : 56s
- 06 : White : Move between 3m and 0.2m in 0.2m/s : 56s
- 07 : White : Jump from infinity to 2.0m : 15s
- 08 : White : Jump from infinity to 1.5m : 15s
- 09 : White : Jump from infinity to 1.0m : 15s
- 10 : White : Jump from infinity to 0.9m : 15s
- 11 : White : Jump from infinity to 0.8m : 15s
- 12 : White : Jump from infinity to 0.7m : 15s
- 13 : White : Jump from infinity to 0.6m : 15s
- 14 : White : Jump from infinity to 0.5m : 15s
- 15 : White : Jump from infinity to 0.4m : 15s

- 16 : White : Jump from infinity to 0.3m : 15s
- 17 : White : Jump from infinity to 0.2m : 15s
- 18 : White : Random (Slant wall) : 60s
- 19 : White : Random (Rough wall) : 60s
- 20 : White : Random (Exits) : 60s
- 21 : White : Random (Poles) : 60s
- 22 : Environmental : Move from 3m to 0.2m in 0.7m/s : 9s
- 23 : Environmental : Move from 3m to 0.2m in 0.4m/s : 12s
- 24 : Environmental : Move from 3m to 0.2m in 0.2m/s : 19s
- 25 : Environmental : Move between 3m and 0.2m in 0.7m/s : 56s
- 26 : Environmental : Move between 3m and 0.2m in 0.4m/s : 56s
- 27 : Environmental : Move between 3m and 0.2m in 0.2m/s : 56s
- 28 : Environmental : Jump from infinity to 2.0m : 15s
- 29 : Environmental : Jump from infinity to 1.5m : 15s
- 30 : Environmental : Jump from infinity to 1.0m : 15s
- 31 : Environmental : Jump from infinity to 0.9m : 15s
- 32 : Environmental : Jump from infinity to 0.8m : 15s
- 33 : Environmental : Jump from infinity to 0.7m : 15s
- 34 : Environmental : Jump from infinity to 0.6m : 15s
- 35 : Environmental : Jump from infinity to 0.5m : 15s
- 36 : Environmental : Jump from infinity to 0.4m : 15s
- 37 : Environmental : Jump from infinity to 0.3m : 15s
- 38 : Environmental : Jump from infinity to 0.2m : 15s
- 39 : Environmental : Random (Slant wall) : 60s
- 40 : Environmental : Random (Rough wall) : 60s
- 41 : Environmental : Random (Exits) : 60s
- 42 : Environmental : Random (Poles) : 60s

* Back to Table of Contents.

5. Evaluation

Many O&M instructors and the people concerned with blind education or rehabilitation have tried this system and CD, and they reported that the sound field produced by our system or CD is easier to understand for beginners than conventional training. Qualitatively, efficiency of our system and CD have been given good evaluation from O&M instructors etc.

However, quantitative evaluation of this system and CD is not completed. We are now trying to develop the method to evaluate our training effect quantitatively.

* Back to Table of Contents.

6. Conclusion

In this paper, we reported our training system or training CD for acquiring obstacle perception. Many O&M instructors and the people concerned with blind education or rehabilitation have tried our training system, and they reported that our system can reproduce the ideal sound variation that is easier to understand for beginners than conventional training. The simplified version of our training system is now working in the College of National Rehabilitation Center for the Persons with Disabilities, Japan for educational use. The latest version of our training CD "Version 1.0" has been distributed to over 150 blind facilities (Figure 7).

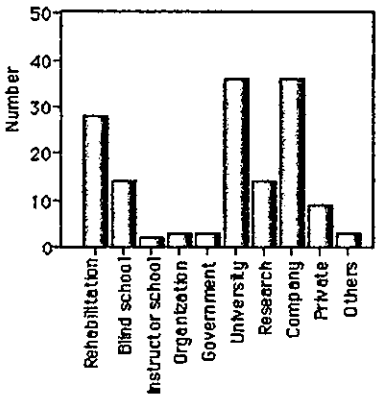

Figure 7, Distribution Statistics of CD "Version 1.0" (until Nov. 19, 2003).

* Back to Table of Contents.

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* Back to Table of Contents.