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CyARM
Interactive Device for Environment Recognition Using a Non-Visual Modality

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Abstract. The purpose of this research is to develop an interactive device for environment recognition, which uses senses other than vision. At present there is no interactive device with which a person who is visually handicapped can gain an intuitive impression of the external world. Our device, which we have named CyARM, has a mechanism that controls the motion of a visually impaired person's arm according to information about distance gathered by an ultrasonic sensor. We refined the features of CyARM through experimentation. The user can identify not only the existence of an object, but also its form.

1. Introduction

The many visual compensation devices for blind people are categorized into two groups from the viewpoint of sensory output. Devices in the first group use audition as the sensory modality of output; information is gathered from the surrounding environment via iconic or sonic sensors and transformed into audible frequencies of sound. Devices in the second group use haptic sense as

the output medium; information obtained by sensors is transferred into haptic stimuli (e.g.; vibrations). These types of output can provide blind users with information about distance and direction.

Some commercially available devices convey information about distance change by qualitative or quantitative modification of vibration. Blind users can easily detect a relative change of distance, but it is difficult for them to specify absolute distance. They must therefore improve their cognitive skills such as inference to identify the distance to objects. In other words, those devices can only be used successfully if the user has advanced cognitive skills.

In order for blind travelers to move about, it is important for them to obtain information about direction (spatial information). Sound output (e.g. Sonicguide) might be useful for providing spatial information, which is best conveyed by a binaural sound difference. However, artificial sounds generated by devices may mask natural sounds, making it difficult for blind users to hear sounds emitted by surrounding objects.

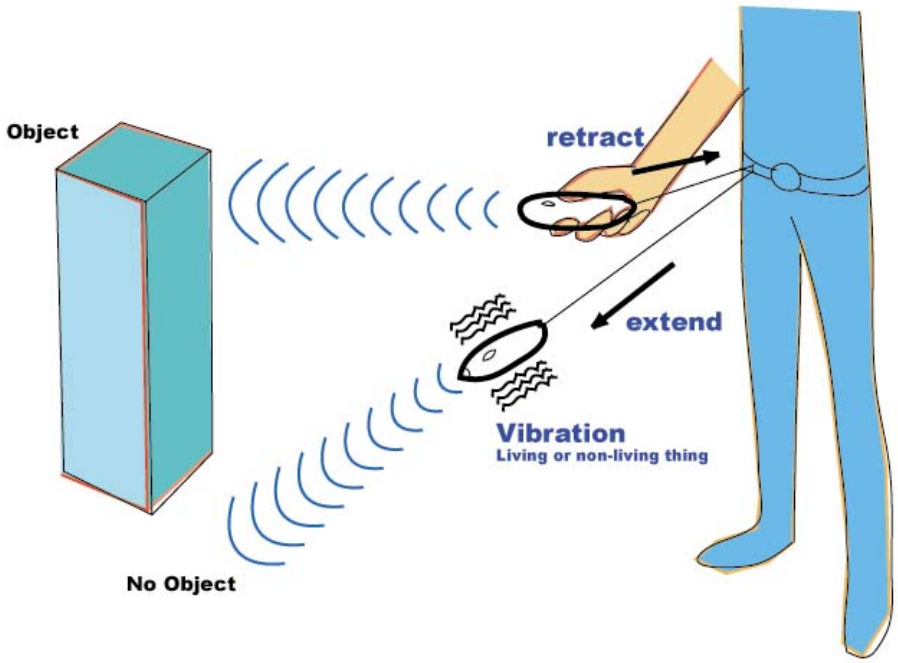
With the aim of solving the above-mentioned problems, we are designing a new sensory compensation device for the blind, by means of which they can perceive distance and other spatial information directly, with no need for inference.

The unique human-machine interface we are developing is designed to reduce the importance of the cognitive ability of the blind by specifying changes in distance and direction to objects. Consequently, our device is expected to be useful to the visually handicapped.

2. Concept

We propose CyARM, a sensing device with a unique, intuitive interface for assisting blind people with walking.

The user holds CyARM in their hand, and searches the environment by pointing and moving the device. CyARM is connected to the user's body by a wire and transmits ultrasonic waves to measure the distance to the obstacle. The tension of the wire is controlled according to the measured distance to the obstacle. If the obstacle is at a short distance, CyARM pulls the wire tightly so that the user feels that they could touch the obstacle by bending their arm. If the obstacle is at a long distance, CyARM pulls the wire loosely so that the user extends their arm and feels that they cannot touch the obstacle. The user can search for an obstacle in any direction by pointing the device, and this will give them the illusion that their hand is extended to reach the far obstacles. This output interface provides an intuitive interface for the user, who can recognize the environment as if walking around touching things.



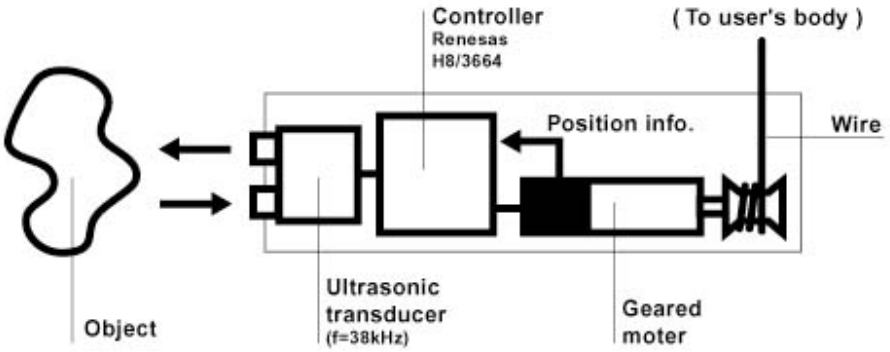
<**Fig. 1** Concept sketch of CyARM>

3. Development of the User Interface

3.1 Structure of the device

We designed the structure of the proposed sensing device, CyARM.

The ultrasonic sensor measures the distance to the obstacle, and the motor is controlled according to the measured distance. The wire position is controlled by PI control. The wire is rewound to the initial position at default, and the rewinding tension is controlled by the measured distance; high tension for short distance, and low tension for long distance. Tension or rewinding of the wire is represented by the P gain in motor control; high motor current for high tension. When the user tries to extend their arm, the device detects a small displacement of the reel caused by the wire tension. The characteristics of the CyARM prototype are as follows.

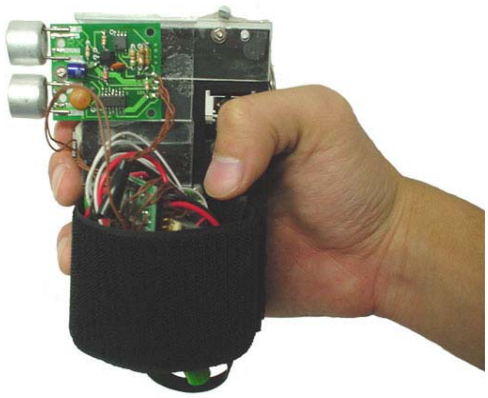


<**Fig. 2** Device structure>

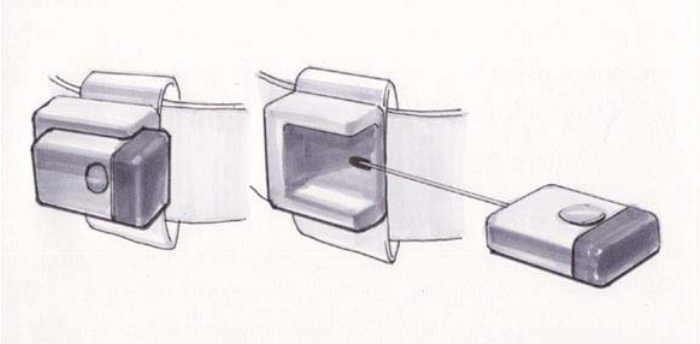
–Motor: Maxon GP16 (4.5W) with 29:1 gear head and magnetic rotary encoder.
–Motor Driver: iXs iMDs03-CL
–MPU: Renesas H8/3664
–Ultrasonic frequency: 38kHz

3.2 Package design

We also designed the package for CyARM. Fig.3 shows the built prototype package. Fig.4 shows a future model sketch of CyARM. The ultrasonic sensor is located at the front of CyARM, parallel to the user's fingers for easy aim at the targeted direction. We are trying to develop smaller, lighter, and easier-to-hold packages for CyARM.



< **Fig. 3** Built prototype package >



<**Fig. 4** Future model sketch >

4. Evaluation

We conducted two experiments in order to evaluate the usability of CyARM. One evaluates whether the user can identify the existence of an object using CyARM. The other consists of a comparison with another apparatus.

4.1 Experiment on identification of object existence

The first experiment investigated whether a user could identify objective existence. The subjects were five non-visually impaired people and one visually impaired person. The non-visually impaired people wore an eye mask, in order to impede vision, and all subjects wore stereo headphones to prevent them from judging the situation by means of external noise. All subjects had CyARM in hand and stood at a defined position<fig. 5>. A whiteboard was placed at a position 2m ahead of the subject. The subject tried to determine whether or not there was a whiteboard, and it was then removed.

4.2 Results of experiment on identification of object existence

Table 1 summarizes the results of the experiment on identification of object existence. Each subject tried to identify the state in which there was nothing and the state in which there was a whiteboard ten times, respectively. On average, the state in which an object existed was correctly identified 9.17 times out of 10, and the state in which an object did not exist was correctly identified 9.67 times out of 10; thus it was shown that identification is possible. However, it was pointed out in the interview after the experiment that the power to roll round is not enough for comfortable operation.

<**Fig. 5** Experiment on identification of object existence >

Table 1. Result of experiment on identification of object existence

	Existence (%)	Non existence (%)
Whiteboard	91.67	8.33
No whiteboard	3.33	96.67

4.3 Experiment involving comparison with another device

An evaluation experiment was carried out by four subjects, who used eye masks to impede their vision<Fig. 6>. The subjects were asked to pass between two walls using CyARM and Tri-sensor [1], and to make a comparison based on sound.

4.4 Results of experiment involving comparison with another device

We investigated issues of usability and user requirements by means of

interviews and video analysis. Our experiment showed that the subjects could determine the existence of an obstacle using both devices. It was also shown that CyARM has the advantages of enabling the user to find the end of a wall and the thickness of a wall, and to sense a person who is walking quickly.

<**Fig. 6** Evaluation experiment>

5.Conclusions and Future Work

We proposed CyARM, a new kind of sensing device for the visually impaired, to assist them in walking and recognizing objects around them. A wire is connected to the user's body, and controlled by CyARM according to the measured distance to the obstacle. This interface gives the user the impression of their arm being extended to an existing obstacle. We also discussed the implementation and package design of CyARM for building the prototype. Future CyARM research will be carried out through the gathering of more information on sensed obstacles, such as their texture (soft or hard, cold or hot) and whether they are living things or man-made objects. Other methods of gathering information will also be used, such as vibration and feeling with the fingers.

These extensions will be discussed in our future work. The device we propose, CyARM, gives new meaning to "sensing the environment". We are also planning to extend our research into joint attention or haptic joint attention feeling, which involves more than two people watching or feeling the same object.

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