Development of Voice Pitch Control System Using Two Dimensional Tactile Display for the Deafblind or the Hearing Impaired Persons

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Abstract: Deafblind or the hearing impaired persons have great difficulty with controlling their voice pitch because they cannot perceive own voice. In particular, when singing it is very difficult for them to control their voice pitch because they need take effort to maintain a stable tone. In this research, a voice pitch control system was developed to assist their singing by means of a two dimensional tactile display. The two dimensional tactile display which presents musical notes has 64 piezoelectric vibrators arranged in four rows (16 x 4 rows). A user rests the last joint of an index finger on the tactile display to receive tactile stimuli. The user can then control voice pitch using tactile feedback. In this study, data on the voice pitch of two subjects were measured to calculate interval deviation that was different from voice pitch to a target musical interval.
Keywords: deafblind, hearing impaired, singing, tactile display, voice pitch

Introduction

A tactile aid that presents vocal information as tactile stimulus is an assistive device for the hearing impaired [1],[2]. For the deafblind persons, who are totally blind and totally deaf and cannot use visual information, a tactile device is the only means through which they can perceive information. Voice pitch frequency is important information for recognizing a change in accent or intonation. Moreover, voice pitch frequency is also important for the recognition of a musical scale, when sing a song. Tactile aids that present voice pitch using tactile stimulus are used for understanding the context or assisting lip reading [3],[4]. However, only a few studies have been made on presenting a musical scale using a tactile display or voice training to adjust musical interval using tactile feedback. In light of this reality, we developed a voice pitch control system that uses a two-dimensional tactile display. In this paper, we discuss this newly developed system and show some examples of data.

Voice Pitch Control System

The voice pitch control system consists of a personal computer (PC), and the main unit of a tactile display shown in Fig. 1. When they use the system, the user places the ball of the first joint of the right index finger on the tactile display to perceive a stimulus. The size of the main unit of the tactile display is 180 mm × 95 mm × 35 mm, and weighs 180 g and it is connected to a USB connector of the PC. Electric supply is only from the USB connector.

A schematic diagram of the voice pitch control system is shown in Fig. 2. In this system, first, the target musical scale is set using a PC. Next, a deafblind person vocalizes so that this input can become the same musical scale as the target musical scale. The voice input from a microphone connected to the PC is taken in 10 kHz bands of sampling frequencies (Hanning window length: 51.2 ms.). The voice pitch frequency is calculated by a fast Fourier transform (FFT) cepstrum analysis. The musical scale corresponding to the calculated voice pitch frequency is displayed on the PC. Similarly, a vibrotactile stimulus is presented to the corresponding musical-scale position on the tactile display. The tactile display shown in Fig. 2 consists of 64 piezoelectric vibrators in four rows (16 x 4 rows). The diameter of each stimulus pin is 0.6 mm. The displacement of each pin can be changed from 0 mm to 0.1 mm (0 to peak), which corresponds to the sensation level of the vibration in the range of 12-16 dB (S.L.: Sensation Level). The two rows on the left side of the tactile display present the target musical scale, while the two rows on the right side present the musical scale corresponding to a voice pitch frequency of a user. When

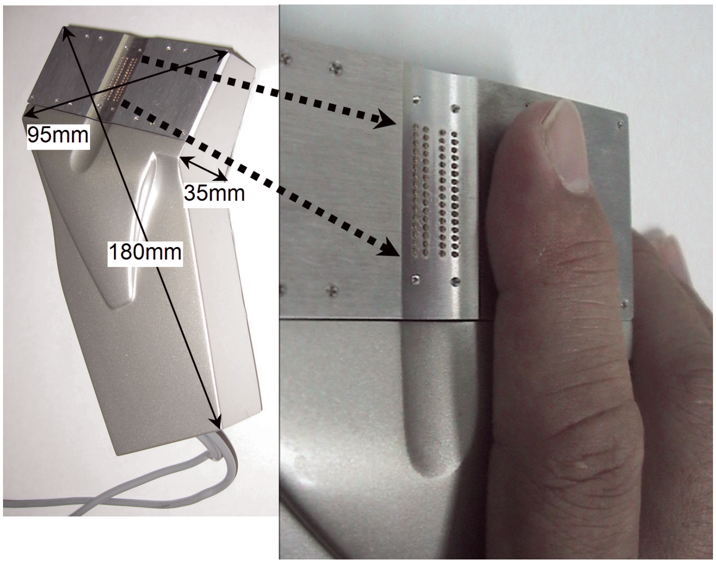

Fig. 1. Main unit of tactile display

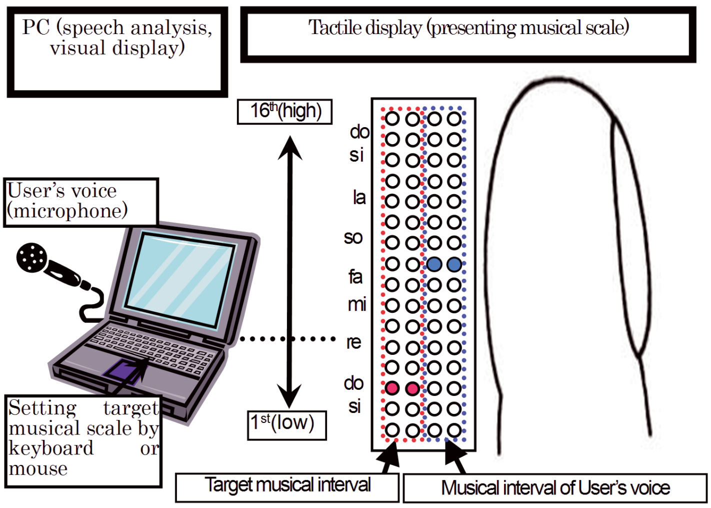

Fig. 2. Schematic diagram of the voice pitch control system

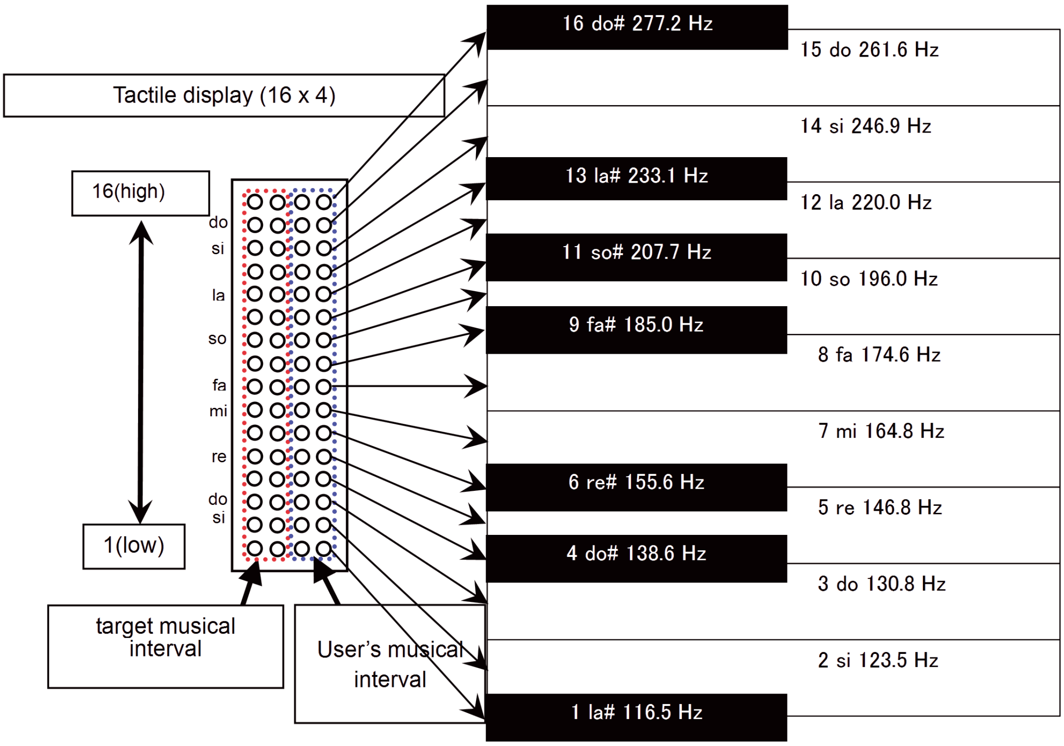

Fig. 3. Correspondence of musical scale and stimulus pins

the target musical interval (left side) and the musical interval of the user's voice (right side) is in the same position, the user's pitch stays on key.

The correspondence of musical scale and stimulus pin is shown in Fig. 3. The pin number is the stimulus pin of the tactile display. The musical scale uses an equal temperament of 12 degrees. One stimulus pin corresponds to a semitone with an equal temperament of 12 degrees. The male voice ranges from C4# to A2#, while the female voice is from C5# to A3#. The user is able to select one of these two modes by using a keyboard or a mouse. The frequency range of each musical scale is shown in Fig. 3. In addition, a cent is a value that converts a semitone with 100 calculated on the basis of C3 in the male voice and C4 in the female voice.

Examples of Data

The song called "Frog Round" (“Kaeru-no-uta” in Japanese) was used for our experiments. The musical notation for "Frog Round" is shown in Fig. 4.

A subject used in this study was a deafblind person who is a 69-year-old woman, who is totally blind and total deaf, having lost her vision and hearing 28 years ago. Before she became deafblind, she played the samisen, a traditional Japanese stringed instrument. Although she does not have the feedback of hearing, she continues to perform on the samisen at home and at concerts. As she had an experience as a musician, she had knowledge about the musical scale, and she was interested in the tone interval of the own voice. The main communication method for her is Finger Braille, which is one of the communication methods available to deafblind Japanese, and she also used Braille when she read. Although she lost her hearing 28 years ago, her pronunciation remains, by and large, as clear as that of a hearing person.

The procedure of data measurement was as follows. First, the target musical scale was fixed to C3 (do), which was the first note of this song. Second, the subject sung several times so that the voice pitch

Fig. 4. A musical score of “Frog round” (“Kaeru-no-uta” in Japanese)

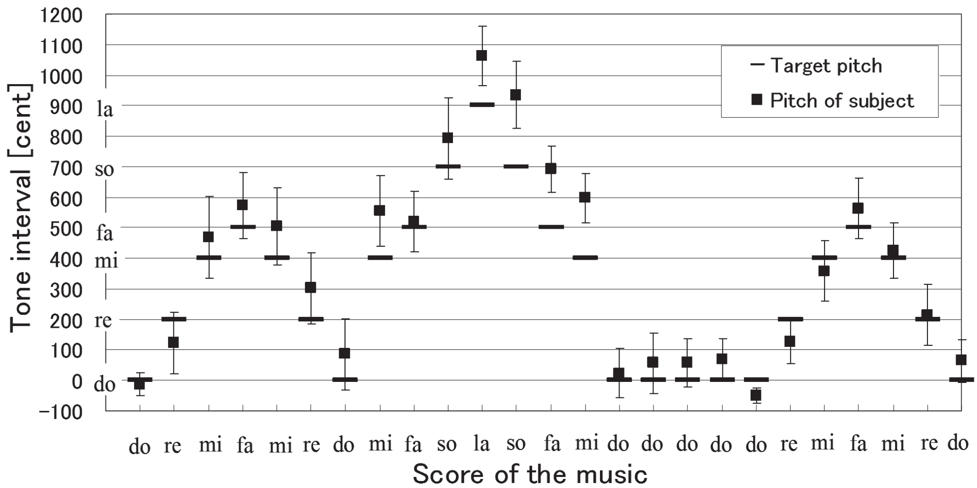

Fig. 5. Examples of average pitch and standard deviation of a deafblind subject

corresponded to C3 (do). Third, after the subject perceived that his/her voice pitch corresponded to C3, the subject sung the melody of "Frog Round" as shown in Fig. 4. This trial was repeated five times.

Fig.5 shows the average data of the subject. The horizontal axis of Fig. 5 is the musical scale corresponding to the notation shown in Fig. 4. The vertical axis is the musical interval with a cent value that is based on C3 (do). 1 semitone equals 100 [cent]. C3 (do) equals 0 [cent], D3 (re) equals 200 [cent], E3 (mi) equals 400 [cent], F3 (fa) equals 500 [cent] and so on. In Fig. 5, a horizontal line shows the target musical interval, and a black square shows the voice pitch of the subject. The error bar shows the standard deviation. Although there was a certain amount of deviation between target musical interval and voice pitch, the subject sung in time with the melody mostly. Details of our results of evaluation appeared in our previous study [5].

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