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Evaluation of Trajectory Presentation of Conducting Motions Using Tactile Sensation for the Visually Impaired

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Abstract

Visually impaired people may have difficulty participating in orchestral or other performance activities because they cannot see the beat represented by the conductor's hand movements. Therefore, we proposed a method of presenting conducting motions tactilely using vibration actuators. By using tactile apparent movement, the trajectory of conducting motions can be presented. We conducted comparative experiments using the reaction time between the correct beat timing and the predicted beat timing.

CCS Concepts

• ***Human-centered computing*** → ***Haptic devices; Accessibility systems and tools;***

1. Introduction

Visually impaired people may have difficulty participating in orchestral performances because they cannot see the beat expressed by the conductor's hand movements. The visually impaired rely on sensory information, such as hearing and touch, in their daily lives [WWRW10], but in performance activities, it is difficult to use auditory feedback for performance assistance due to its nature. For this reason, methods using the tactile sensation have been considered for sharing conducting motions with visually impaired people. Asakawa et al. have studied an electronic conductor's baton system in which the movement of the conductor's baton is transmitted to the performer using a tactile interface device [AK12]. Turchet et al. have designed and evaluated a prototype tactile wearable device for synchronization through three workshops conducted with visually impaired performers [TBS21]. In these existing methods, a vibration actuator is attached to a part of the body and it vibrates in accordance with the timing of the beat expressed by the conducting motion. However, these methods present beats by using the presence or absence of vibration at the tactile presentation part, and the amount of information that can be presented is limited. Therefore, we proposed a method of presenting conducting motion tactilely using multiple vibration actuators [US22]. By using tactile apparent movement, it is possible to present the trajectory of conducting motion. In this study, we conduct comparative experiments using the reaction time.

2. Experiment

2.1. Experimental settings

To verify the effectiveness of the proposed method, we conducted a comparison experiment using reaction time as the evaluation metric. The reaction time is defined as

$$T_{reaction} = |T_{gt} - T_{pred}|,$$

where $T_{reaction}$ is the reaction time, T_{gt} is the correct beat timing indicated by the conductor, and T_{pred} is the beat timing predicted by the user based on the tactile presentation of the conducting motion. In this study, two kinds of experiments were conducted assuming performance activities: tempo changes and the timing of the start of the performance. In classical music, composers often intended tempo changes. In actual performance, the degree of tempo change is indicated by conducting motions, so the tempo must be captured by looking at the conductor. In addition, because the timing of the start of the performance is signaled by the conductor, it is necessary to capture the timing from the conducting motion. Table 1 shows the beats per minute (BPM) settings for each experiment. We set three different BPM settings for each experiment, based on 60, 80, and 100. In this experiment, we used the most typical conducting method, "tapping" [Sai99], where acceleration and deceleration are repeated evenly, just like a ball bouncing on the floor. We used a single beat, which is the simplest beat. To reproduce the conducting motion accurately, tactile sensations were presented based on the conducting motion calculated by the program. The subjects consisted of six persons aged between 21 and 25 (mean = 23.0, std = 1.41).

Table 1: *Beats per minute (BPM) settings*

Experimental settings		BPM
tempo changes	constant	60, 80, 100
	accel	60→80, 80→100, 100→120
	rit	60→40, 80→60, 100→80
the timing of the start of the performance		60–100

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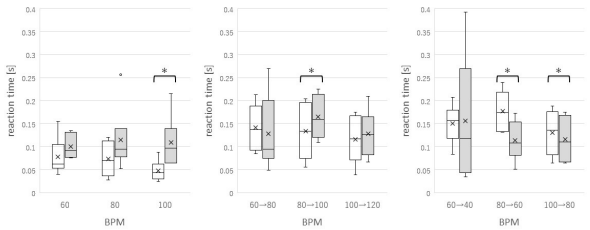

(a) (b) (c)

Figure 1: *Reaction time in tempo changes: (a) constant, (b) accel, (c) rit (white: point presentation, gray: trajectory presentation.)*

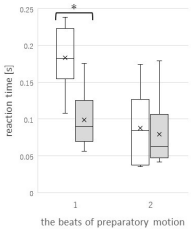

Figure 2: *Reaction time in the timing of the start of performance: (a) constant, (b) accel, (c) rit (white: point presentation, gray: trajectory presentation.)*

2.1.1. Tempo changes

Reaction times were measured for three types of tempo changes: constant, accel, and rit. Accel and rit are musical terms that indicate gradually faster and gradually slower tempo changes. In the constant tempo condition, 30 beats were presented at each BPM, and the reaction time was measured. In rit and accel, the tempo was changed for 10 seconds at each BPM, and the reaction time was measured during this time.

2.1.2. The timing of the start of the performance

In the timing for the start of the performance, two types of beats were set as the beats in the preparatory motions: one beat and two beats. The preparatory motions were presented, and the reaction time at start of the performance was measured for each. The preparatory motions are conducting motions presented by the conductor before the first beat to assist the start of the performance [Sai99]. In each preparatory motion, 20 sets of each were tested, and the reaction time was measured. In each trial, the BPM was randomly selected from 60 to 100, respectively.

2.1.3. Point and trajectory presentation in tactile presentation

To verify the effectiveness of the trajectory presentation of the conducting motion in the tactile presentation, experiments were conducted on two types of tactile presentations: point presentation and trajectory presentation (proposed method). Point presentation is a method in which a single vibration actuator is vibrated in accordance with the timing of beats. The distance between the vibration actuators was 10 mm, and the total area of the tactile display was 190 mm $\times$ 190 mm. The vibration frequency was set to 100 Hz. To remove the influence of the vibration sound, the subjects listened to white noise through headphones.

2.2. Results

2.2.1. Tempo changes

Figure 1 shows the experimental results. In constant tempo (BPM: 80), the mean reaction times for the point presentation and trajectory presentation were 0.072s and 0.114s, respectively. In accel (BPM:80→100), the mean reaction times for the point presentation and trajectory presentation were 0.133s and 0.164s, respectively. In rit (BPM:80→60), the mean reaction times for point presentation and trajectory presentation were 0.177 seconds and 0.113 seconds, respectively. The results of the t-test showed that the reaction time for point presentation was significantly shorter than that for trajectory presentation ($p < 0.05$) at a constant tempo (BPM: 100) and accel tempo (BPM: 80→100). On the other hand, in rit (BPM: 100→80), the reaction time was significantly shorter for trajectory than for point presentation ($p < 0.05$).

2.2.2. The timing of the start of the performance

Figure 2 shows the experimental results. When the preparatory motions were one beat, the mean reaction times in the point and trajectory presentations were 0.183s and 0.099s, respectively. When the preparatory motions were two beats, the mean reaction times in the point presentation and trajectory presentation were 0.088s and 0.079s, respectively. The t-test results showed that the reaction time was significantly shorter for the trajectory presentation than for the point presentation ($p < 0.05$) when the preparatory motions were one beat.

3. Conclusion

In this study, we evaluated a method of presenting conducting motions tactilely using vibration actuators to assist the visually impaired in their performance activities. The results showed that the reaction time for the trajectory presentation was significantly shorter than that for the point presentation in the timing of the start of the performance ($p < 0.05$) when the preparatory motions were one beat. For future work, we will make the tactile display wearable and measure the reaction time using actual conducting.

Acknowledgments

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