A Tactile Assistance for Improving Fingering Skill in Piano Performance

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***Abstract*—Playing a piano requires various techniques and properly acquiring fingering skills without expert's assistance is particularly difficult. While the expert tries to convey his skills through language and physical contacts to trainees, most ICT-based training systems visually present exercise information. We propose a method enabling trainees to easily improve their fingering skills via a tactile feedback technique. It indicates which finger to use by directly stimulating a target finger in parallel with presenting visual information. We made a tactile display for finely indicating fingering information and evaluated a prototype system to verify the effectiveness of the method.**

I. INTRODUCTION

Acquiring musical instrument playing skills is always a difficult task and playing a piano is one such example. Taking a one-to-one lesson with a teacher is an ideal situation for a student especially a beginner. Another choice is to use an ICT-based training system. Such a system graphically displays the order and timings of keystrokes, then the student should carefully watch the indicated keystroke pattern and repeatedly exercise until he can correctly reproduce the pattern by himself. It is, however, an inefficient performance training for the student because correctly performing the key hitting operations while looking at the graphical pattern is a difficult task. He should concentrate on hitting the keys by correct fingers through his vision. Also, numbers from 1 to 5 are generally used when presenting the fingering pattern, but it isn't intuitive to confirm the correct finger by its corresponding number.

Takekawa et al. proposed a method for projecting assistive information near keyboard and enabling a user to easily find it during practice [1]. However, it presents fingering pattern using numbers, so the user can't intuitively recognize it. In this paper, we propose a method for conveying the fingering pattern through tactile sensation to improve playing skill.

II. SYSTEM IMPLEMENTATION

Figure 1 shows the tactile display we made in this study. It consists of a glove worn by a user and five microcomputer-controlled vibration motors set at the base of each finger for generating stimuli. Arduino Uno is adopted as a controller. The tactile display worn the user's hand generates a tactile sensation to a specific finger by vibrating the target finger's motor. Because the tactile display directly stimulates a specific finger, the user immediately recognizes the finger for striking. The display generates tactile stimuli to the base of fingers for minimizing the interference of the user's natural fingering motions. It allows the user to concentrate on his performance without hindering his finger movements. The controller can separately activate each motor and flexibly convey any chord patterns by simultaneously vibrating multiple motors. The controller adjusts the vibration strength by changing the voltage applied to the motor. The user can appropriately sets the vibration strength in accordance with his preference for preventing him from disturbing his concentration. We made the display usable with the piano performance training system developed in our previous study [2].

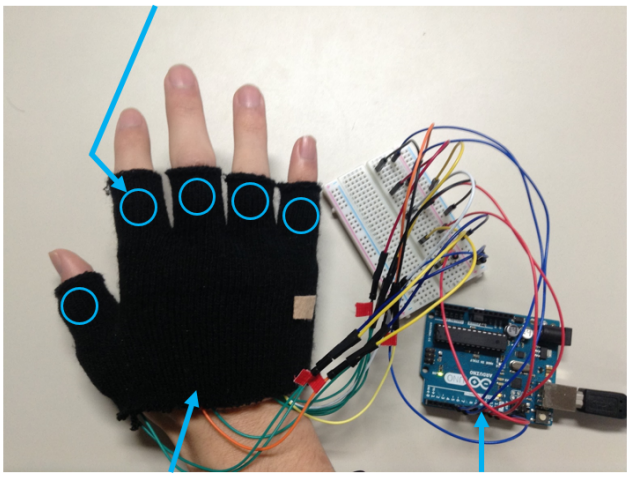

Figure 1. Handmade tactile display.

The system displays a series of numbers representing a specific fingering pattern in a graphical keyboard displayed on a monitor. The user can learn the fingering pattern by visually confirming the displayed numbers. The user, however, needed to follow the system's pace for presenting the pattern. Accurately confirming the continuing numbers with the system's presenting speed and striking the keyboard with the correct fingers is quite a difficult task for the user. We made the system to be adjustable for presenting the fingering pattern with the user's preferred pace for efficient training.

Figure 2 shows the system appearance with the tactile display. The system displays a number representing a specific finger to use in parallel with presenting a tactile stimulus to the finger via the tactile display. It enables the user to improve his fingering skill faster than the visual only training system.

III. EXPERIMENT

We conducted an experiment for verifying the effectiveness of the proposed method. We employed ten undergraduate students as subjects and asked them to wear the tactile display

The tactile display generates a vibration stimulus to the finger corresponding to the number.

The system indicates the number on the keyboard. "1" means a thumb to use.

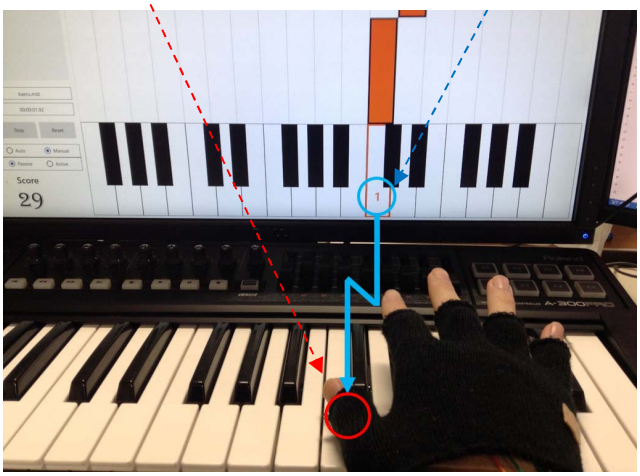

Figure 2. System appearance with tactile display.

and appropriately set the vibration strength based on their preference. Then, the system randomly presented a series of 20 keys as an experimental fingering pattern on the monitor and let the subjects to hit the pattern as presented. We requested the subjects to only use their right hand and perform the task twice, one trial without the tactile feedback (with visual information only) and with the tactile feedback to their fingers. Half of them firstly performed the trial without the tactile feedback and then with the tactile feedback, and another half performed in the reverse order. We measured the time to complete each task and counted the number of wrong finger usages in the task. We quantitatively evaluated whether the proposed method was effective for improving fingering skill based on these data. After they finished the tasks, we asked the following two questions and requested them to rate each of them in five ranks: (1) how about the proposed method's effectiveness for improving the fingering skill, and (2) how about the comfort of the tactile feedback presented in the task.

Table 1 shows the measurement results of the time to finish the task and the number of wrong finger usages. Since we observed the order effect in the second trial, we only shows the first measurement results in the table. Both average values are smaller when performed with the tactile feedback, meaning that they finished the task in a shorter time and reduced the number of wrong finger usages with the tactile stimuli. The average time to finish the task especially was 13 seconds faster than the trials without the tactile feedback. We confirmed that the system enables the subjects to promptly learn the fingering pattern and correctly striking the keys by directly stimulating their fingers.

Table 2 shows the evaluation results of two questions in five ranks (5 is "good" and 1 is "bad"). Both average values are above an intermediate value and the proposed method was highly evaluated. Many subjects stated that they were able to intuitively recognize target fingers to use with the tactile feedback. None of them stated the tactile feedback disturbed

Table 1. Measurement result.

(a) Without tactile feedback

Subject	Time to finish [mm:ss]	Wrong finger usages
a	01:12	3
b	00:56	0
c	00:52	1
d	00:48	2
e	01:05	0
Ave	00:59	1.2

(b) With tactile feedback

Subject	Time to finish [mm:ss]	Wrong finger usages
f	00:53	0
g	00:56	0
h	00:35	0
i	00:43	0
j	00:45	1
Ave	00:46	0.2

Ave: average value

Table 2. Evaluation result.

	Effectiveness for improving fingering	Comfort of tactile feedback
Ave	3.6	3.9

Ave: average value

Evaluation in five ranks (5: good - 3: neutral - 1: bad)

their concentration during the task. We confirmed that appropriately setting the vibration strength based on each subject's preference was a crucial factor. Some subjects had a difficult time to discriminate a stimulus whether it was given to their index or middle finger. Because the sensitivity at the base of a finger is lower than the ball of a finger or a fingertip, we would like to further improve the tactile feedback function by stimulating more sensitive parts in the user's hand.

IV. Conclusions

We proposed a method for effectively presenting a fingering pattern in the piano performance through a tactile feedback function. We designed and implemented a handmade tactile display that can separately stimulate a specific finger by vibrating the base of the finger. We conducted an experiment to verify the effectiveness of the system for improving the fingering skill and confirmed the results were promising. We would like to further sophisticate the tactile display function and evaluate it in a real piano training class.

Reference

[1] Y. Takekawa, T. Terada, and M. Tsukamoto, "Construction of a Piano Learning Support System Using a Real-time Fingering Recognition Technique," *IPSJ Journal*, Vol.52, No.2, pp.917-927, Feb. 2011. (in Japanese)

[2] Hokuto Tsutsumi, Hiroaki Nishino, Tsuneo Kagawa, "A Piano Performance Trainer with Tactile Guidance," *2017 IEEE International Conference on Consumer Electronics - Taiwan (ICCE-TW)*, pp.19-20, June. 2017.