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A Basic Design of AR-supported System for Musical Instrument Learning

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1 Introduction

According to the statistics from the Japanese government, more and more people take music as their hobby [1]. Furthermore, about one tenth of them like playing musical instruments. In this paper, we focus on piano as the musical instrument. Unlike other musical instruments, face-to-face learning with a teacher plays a vital role in piano learning. Although numerous piano learning systems have been developed, to the best of our knowledge, none of them consider face-to-face piano learning. A student needs to pay attention to many things at once in this learning situation, such as teacher's fingering and music score, which may distract the student's attention, thus decreasing the learning effect. Using augmented reality (AR) technology, those information can be displayed in front of the student in real-time. In this paper, we aim to create a system that supports face-to-face piano learning using AR technology for beginner-level students.

2 Related Work

Many applications have been developed to support piano learning. Synthesia [2], a music game application, allows users to play a MIDI keyboard in time by following on-screen instructions based on the falling color bars corresponding to the key position and the pressing time. Beatmania [3] is basically the same as Synthesia, the only difference is that it was implemented using AR technology, where the users see the falling color bars on their HMD. In Music Everywhere [4], a piano learning system for Microsoft HoloLens [5], the proper piano fingerings are displayed as hands' animations captured from the performance of a real pianist.

Although the combination of the features of these applications will allow users to learn which keys to press, when, and how to press them, the usage of these self-study applications will be very limited in a face-to-face learning situation because they do not consider the interactions between the student and the teacher.

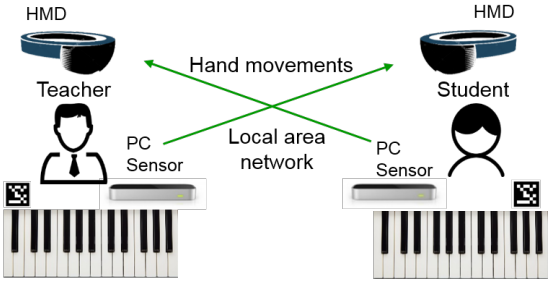

Fig. 1 System architecture

3 Face-to-face AR Piano Learning System

3.1 Architecture Overview

In order to solve the problem stated in Section 2, we propose to create a system that supports students on learning the correct key pressing and the proper piano fingering utilizing AR technology. In addition, the learning resources, such as music score, will be virtually displayed in front of both the teacher and the student to facilitate smooth communication between them.

The proposed system can be divided into two sides, the teacher-side and the student-side, as shown in Figure 1. Both sides have their own piano, each of which is equipped with a marker and a motion sensor. Furthermore, we assume that both sides wear an HMD.

3.2 Detailed design

We consider the situation where a student learns how to play the piano from a teacher by using a music score. Figure 2 illustrates the proposed learning system. In this figure, a pair of virtual 3D hands and a virtual music score will be displayed on the student's HMD. The hands'

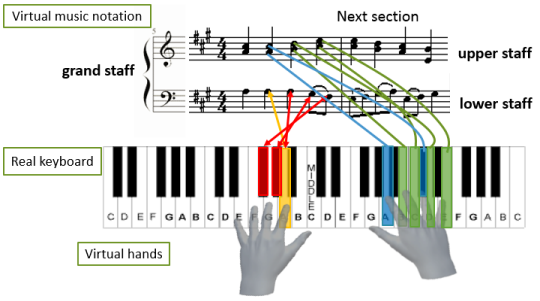

Fig. 2 Images displayed on the student's HMD

Fig. 3 A 3D virtual hand shown on the HMD

movements are captured by the motion sensor and then sent to the other-side through a local area network. Meanwhile, each note from the virtual music score is mapped to its corresponding key in the keyboard. To make it easier for the student to know the proper placement of his/her right and left hands, the upper staff notes (right hand) and the lower staff notes (left hand) are highlighted with two different colors, green and red, respectively. Moreover, it will be changed to blue and orange once the teacher pressed the keys. As time progresses, the music score will begin to roll and the key mapping is updated. This process repeats until the learning session ends.

4 Implementation

4.1 Environment

The experiments were conducted on a PC equipped with an Intel Core i7-4790 CPU, an AMD Radeon HD 7000 series GPU, a Unity engine (version 2017.4.1f1), and a Windows 10 OS. We used Leap Motion [6] as the motion sensor and Microsoft HoloLens as the HMD. The Leap Motion sensor is chosen due to its high precision and reliability for capturing the hands' movements. The sensor is placed on top of the HMD. A WiFi was used as the network to connect the PC and the HoloLens.

4.2 Visualization

In this experiment, three-dimensional coordinate, posture and gesture of a hand are obtained from the Leap Motion sensor and a virtual 3D hand is displayed on the HoloLens by a holographic remoting player. The visualization result is show in Figure 3. The number of frames displayed on HoloLens is approximately 30fps. Since the Leap Motion sensor is placed on top of the HMD, the hands' positions are limited within the field of view (FOV) of the HMD. Moreover, head movements may affect the stability of the displayed virtual 3D hand. Therefore, as the next step, we will consider placing the Leap Motion sensor at a fixed position over the piano. Furthermore, we will implement the virtual music score by mapping the keys to the music notes using the MIDI file which contains the information regarding the keys and their pressing timings.

5 Summary

In this paper, we present an idea to support face-to-face piano learning. The student can follow the teacher's virtual 3D hands and the highlighted keys mapped from the music score to understand the exact fingering, the pressing time and the key position. The teacher can hence give appropriate guidance according to the situation of the student.

In the future, we would like to consider to display other information such as the strength of the key pressing by showing it as the volume bar on the HMD. In addition, we will also consider to display the finger's shape during the key pressing.

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