Touch-typable VR piano that corrects positional deviation of fingering based on music theory

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Figure 1: Appearance of the system

ABSTRACT

In this paper, we propose a novel virtual piano system to assist composition, that corrects deviation of a position based on music theory when a user strikes a wrong key. It means that this system estimates a correct melody from deviated fingering due to the non-physical keyboard. When experienced performer comes up with a good melody, his hands usually move by themselves to play it. Our proposed VR piano does not have any physical keyboard; it estimates a correct key when user's fingering is deviated. Furthermore, if the weight of music theory is adjusted higher than the weight of the user's fingering position, this system changes to easy-playable VR piano. Even by hitting a key randomly, it will produce an appropriate melody based on music theory by taking a bit of fingering into account.

CCS CONCEPTS

• **Computer Applications → Art and Humanities**;

KEYWORDS

Capture/Scanning, Audio/Music

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1 INTRODUCTION

When an experienced performer comes up with a good melody, his hands play it by themselves on the keyboard. But it is obviously difficult to bring an instrument anytime, anywhere because an actual instrument is large. There are already some researches about virtual piano like, for example, its design via single-view video [Yeh et al. 2010]. There are also many piano applications for smartphone and tablet. Although you can see a keyboard, it is difficult to strike a key without any haptic feedback. Therefore, experienced performer's hands can not move to play the melody by themselves. On the other hand, many composition assistance systems are proposed, for example, songwriting support system [Iwata et al. 2012], that suggests a melody by a curve drawn on a card. However, this is not a traditional style to perform a melody. Our VR proposed piano does not have any physical keyboard either. When the user moves his hand on the table in such a way to play a melody with it, and the fingering is deviated from the key that the user wants to strike, it revises the deviation to a correct key based on music theory [Milne 2017]. This system obtains the user's fingering with a depth camera or a motion sensor, then it estimates the melody that the user wants to play. Furthermore, if the music theory weight is higher than the user's fingering position weight, this system changes to easy-playable VR piano. Even by hitting a key randomly, it will produce an appropriate melody based on music theory by taking a bit of fingering into account.

2 TOUCH-TYPABLE VR PIANO

To play the VR piano on a table, it is necessary to obtain the fingers motion. Although it is easy to get a hit on a tablet, the performance range is limited by the screen size. The player should drag the keyboard on the screen for example. Our proposed system obtains fingertip positions and joints of a hand through Leap Motion. No keyboard image is shown on the table, but an experienced pianist can move his fingers without seeing one. However, it is still difficult to recognize their actual finger position to strike a key for next note like there is no haptic feedback from physical key. Of course, just

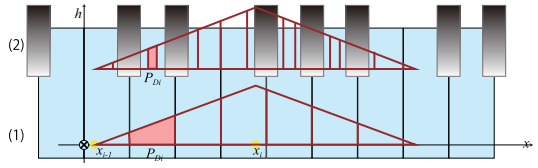

Figure 2: Probability for keystroke position

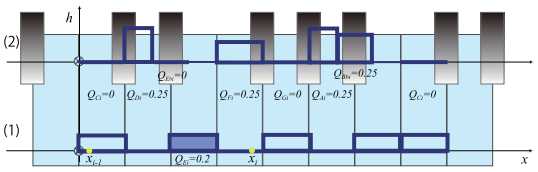

Figure 3: Probability based on music theory

by playing on a table and sounding notes in their mind, there is no problem. It means that the reliability of fingering data is not so high. Fingering is sometimes deviated from the wanted key to be played. Therefore, music theory supplements it on our system. The method to correct a fingering deviation using music theory is as followed:

- **Probability for keystroke position:** The key that the user wants to hit must be close to the stroke position, and the relation between it and the previous stroke is reliable. We consider an isosceles triangle with a base length of $2|x_{i-1} - x_i|$ and area of 1 (Fig. 2) for the keystroke position (x_i, y_i) obtained at time t_i. We define P_{ki} (k is a letter note as C, D, E, F, G, A, B, considered for three octaves) as the area shown in Fig. 2-(1). Then for example, P_{Di} is a probability to judge that the D key was struck at time t_i.
- **Probability based on music theory:** We consider a chord tone as music theory, a probability of a tone according to the chord should be higher at the stroke time or in the bar. When the code is CM7 for example, a probability Q_{ki} for each key is defined equally as shown in Fig. 3-(1). We consider just the keys that are covered in the triangle mentioned above, and sum of these areas at time t_i is 1. When the code is B^bM7 for another example, a probability Q_{ki} is defined as 0.25 or 0 as shown in Fig. 3-(2).
- **Determination of note:** Finally, the probability for each note is defined as $R_{ki} = w_P P_{ki} + w_Q Q_{ki}$, where w_P and w_Q are weights that satisfy $w_P + w_Q = 1$. The maximum R_{ki} for every k at time t_i is selected, then the letter note k is sounded. In addition, if $|x_{i-1} - x_i|$ is greater than a threshold, the center of the key position of note k is shifted to the striking position x_i every processing time, in other words, x axis origin is shifted to adjust x_i as the center of k. When the weight of music theory w_Q is 0 and the weight of user's fingering position w_P is 1, just the note at the stroke position is selected and sounded. When w_Q is adjusted larger than w_P, this system can be used as an easy-playable VR piano.

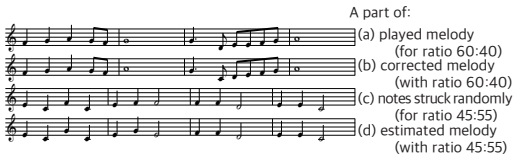

Figure 4: Experimental results

3 EXPERIMENT

We used Leap Motion and acrylic board to develop our new VR piano as shown in Fig. 1. Although we thought that a user plays this without seeing, keyboard CG and virtual hand were shown on a screen as shown in Fig. 1 (rights) to confirm deviation correction and keyboard shift according to the correction. This screen image was also used to decide initial hand position. In a first experiment, we assumed that a part of a melody of "Do Re Mi" was played, the chord progression was Dm7, Dm7, CM7, and then FM7 for 4 measures from diatonic chords of C major key. Diatonic chords are the chords that are derived from the notes of a key. Then this system corrected the fingering with the reliability ratio as fingering:theory = 60:40. If assuming that the center of a key is struck, when $|x_{i-1} - x_i|$ is 2 degrees, that means neighbor key, and when w_P is greater than or equal to 45 percent, fingering is adopted. When $|x_{i-1} - x_i|$ is 3 degrees, and when w_P is greater than 73 percent, fingering is also adopted certainly, however to adopt theory certainly, w_P should be less than 64 percent. Actually a hand was moved on this system slightly deviated form the melody (Fig. 4-(a)). In a second experiment, we assumed that a chord progression was the progression as CM7, CM7, G7, and then CM7 for 4 measures. The hand was moved almost randomly (Fig. 4-(c)), then it estimated the appropriate melody with the ratio 45:55. Fig. 4-(b) and (d) show the results. The melody that fingering was corrected was almost like the "Do Re Mi". And the melody that was estimated from random fingering felt us that it was not a random note sequence, but real music.

4 CONCLUSION

In this paper, we propose a novel virtual piano system that user can play without seeing keyboard. Now we are implementing next element of music theory as scale that is a specific set of notes, and transition of notes is sometimes according to the order in a scale. In the future, we should estimate a principal key and chord progression, it means the chord at stroke time or in that bar. This current system selects only note that is the key or the neighbor key. We should implement other elements such as tension note that is non-harmonic note added onto basic chord, etc. The initial position should be also estimated automatically from the very first strokes.

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