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Development of a Learning Environment for Novices' Erhu Playings

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Abstract: In this paper, we describe the development of a learning environment for novices' erhu playings. In case of self-learning, the novices who want to learn playing bowed string instruments give up because they get into a wrong habit and don't understand how to play. Therefore, our goal is to develop a learning environment for novices. We focus on the erhu in bowed string instruments. The system we developed diagnoses finger positions and bow strokes by using magnetic position sensors and gives awareness of errors by showing finger positions and bow strokes on virtual 3D space. In case of bow strokes, the system shows how to improve bow strokes by using arrows. Moreover, the system shows how and where the errors occur on score. Accordingly, the novices can recognize and improve their errors by using this system. In future works, we will conduct evaluation experiments to disclose learning effects by using this system.

Keywords: Bowed string instruments, skill, learning environment, learning support, electro-magnetic field sensing device

1. Introduction

In this paper, we describe the development of a learning environment for novices' erhu playings. Because of the following backgrounds, we aimed to develop a learning environment for playing instruments.

Usually, to learn skills for playing instruments is achieved by means of taking a lesson, practicing by self-learning, referring to a study-aid book, and so on. In case of self-learning, the novices give up learning playing instruments because they get into a wrong habit, don't understand how to play instruments and don't make progress. Recently, there are many studies about analyses of skills and learning environments because of progress of sensors and computers performances. In case of the piano, there is an analysis of finger movements of a pianist (Rahman et al., 2010). Moreover, there is a learning environment regarding the piano (Takegawa et al., 2012). In case of the guitar, there are visual methods for the retrieval of the guitarist fingering as well (Burns et al., 2006). Furthermore, there is a learning environment of guitarist fingering (Tobise et al., 2013). In case of the drums, there is a motion analysis for emotional performance of snare drums as well (Miura et al., 2012). In addition, there is a learning environment of playing the drums (Iwami et al., 2007).

Particularly, the bowed string instruments (e.g. the violin, the cello, and the erhu) have many parameters to be adjusted. The parameters are the finger positions, the pressures by pressing strings, the gesture, the speed, the acceleration, and the angle of bow strokes. Accordingly, it is difficult for the novices to play with accurate pitches. Therefore, if we develop a learning environment for playing the bowed string instruments, these problems will be solved. As related works, there are many studies about analysis of playing the violin. Rasamimanana et al. (2005) analyzed the gesture of bow strokes by using augmented violin bow. Moreover, they analyzed bow and arm movements and bow pressure on strings by using 3D optical motion capture system and a custom pressure sensor (Rasamimanana et al., 2007). Furthermore, Carrillo (2013) characterized bow strokes by using audio and a motion capture system. In addition, Maestre et al. (2007) analyzed bow strokes by using electro-magnetic field sensing device. On the other hand, there are studies about learning environment of playing the violin. Wang et al. (2012) developed a real-time pitch training system for violin learners. However, this system does not diagnose learner's gesture parameters and pressure parameters, but diagnoses only sound pitches. Therefore, the novices cannot identify the cause of pitch errors. Thus, we aimed to develop learning environment for novices to understand why pitch errors were caused. Moreover, Ng (2009) developed 3D motion analysis and visualization system. This system visualize only bow stokes. Therefore, we aimed to develop learning environment for novices to understand bow strokes and finger position improvement simultaneously.

Although there are many studies about musical skills, there is no study about the erhu except for our studies. As our previous works, we describe following three studies. We have aimed to develop a learning environment for playing the bowed string instruments and have developed learning environment. Firstly, we have analyzed novices' parameters during playing a bowed string instrument (Soga et al., 2010). Specifically, we analyzed the erhu playing parameters by novices. As the results of the analyses, novices need supports of finger positions, bow motions, bow speeds, bow accelerations, and bow angles. The sounds depend on these parameters. A novice doesn't understand the reasons why the sounds aren't accurate because there are many parameters to be adjusted. Therefore, a novice needs a learning support environment for controlling each parameter. Secondly, we tried to assist novices' finger positions. We developed a learning environment regarding finger position on strings (Kikukawa et al., 2013). By conducting evaluation experiment, we found the system is useful for a novice to learn finger position on strings. Thirdly, we tried to assist novices' controls of bow strokes. We developed a gesture learning environment for novices' erhu bow strokes (Kikukawa et al., 2014). In this paper, we describe integration of previous two systems and improvement of the systems. By integrating previous two systems, the new system visualizes improvements of finger positions and bow strokes simultaneously and gives the novice learner feedback of diagnosed results of finger positions and bow strokes simultaneously for novices' understanding.

2. Instruments Choice

2.1 The Erhu

We have chosen the erhu in bowed string instruments. Figure 1 shows an erhu. There is a reason that we have chosen the erhu in bowed string instruments. It is a two-stringed instrument. Because of this feature, a learner only needs to judge which string s/he touches in those two strings with a bow. In case of the violin, a learner needs to judge which string s/he touches in four strings with a bow. Therefore, his/her hand and finger motions are very complicated when s/he learns the violin. It is comparatively easy for novices to learn how to play the erhu. Moreover, the erhu has the parameters that other bowed string instruments have (e.g. the finger positions, the gestures of bow strokes, the speed of bow strokes, the acceleration of bow strokes, the angle of bow strokes, and so on) in spite of only two strings. Therefore, to develop learning environment of playing the erhu is comparatively easy and can apply to other bowed string instruments.

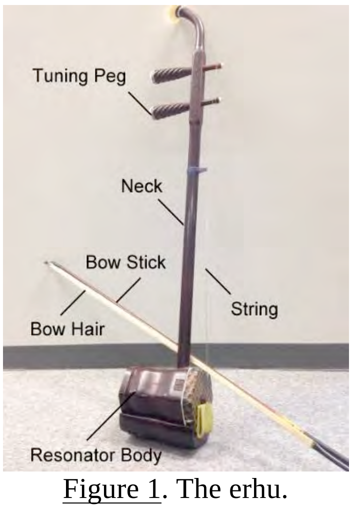

Figure 1. The erhu.

2.2 How to Play

Figure 2 shows how to play the erhu. How to play the erhu is as follows. Left fingers press strings with pitches as Figure 2(a). Then, it needs to press accurate finger positions. A pitch error reflects a finger position error directly because the erhu has no border between pitches. On the other hand, right hand holds a bow from underneath as Figure 2(b). Then, right index finger is attached to the wood part and right middle finger and ring finger control hair tension of the bow. A learner plays sounds by moving the bow between right and left, by the frictions between the bow and the strings. Loudness and expression of sounds depend on pressures between the bow and the strings, moving speed of the bow, and how to move the bow.

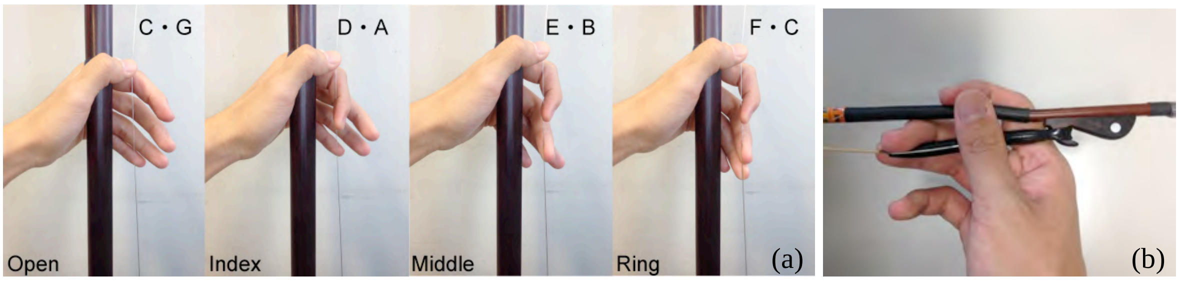

Figure 2. How to play the erhu.

2.3 Bad Example of Erhu Bow Strokes

Figure 3 shows bad examples of erhu bow strokes. The bow strokes should not leave the resonator body as Figure 3(a). Moreover, the gesture of erhu bow strokes should be parallel to the ground and parallel to the surface of the body. Therefore, Figure 3(b) and Figure 3(c) are bad examples. Based on the above, we aim to develop the system that makes the novice learner being aware of these bad examples and learning accurate gesture of erhu bow strokes.

Figure 3.Bad examples of erhu bow strokes.

3. System Design

3.1 Electro-magnetic Field Sensing Device LIBERTY

LIBERTY is an electro-magnetic field sensing device developed by Polhemus Inc. A transmitter and up to 16 receivers are connected to a main unit for use. Figure 4(a) shows LIBERTY. Figure 4(b) shows transmitter of LIBERTY. Figure 4(c) shows receivers of LIBERTY. A transmitter generates electro-magnetic fields which have three directions by passing an electric current in turn through coils around three axes. Receivers also have coils around three axes. When the transmitter generates an electro-magnetic field, induced electric currents are generated on the coils in the receiver. Then, position and orientation of the receiver are calculated by this amperage. These measured data are transmitted to a connected PC with ASCII or binary data format. LIBERTY is connected with PC through USB ports or serial ports. The accuracies are 0.03 inch RMS for X, Y or Z position and 0.15 degrees RMS for sensor orientation. The reason why we choose LIBERTY as a motion tracking sensor is that we need to use real-time accurate 3D tracking data for real-time visualization and real-time diagnosis of finer positions and bow strokes.

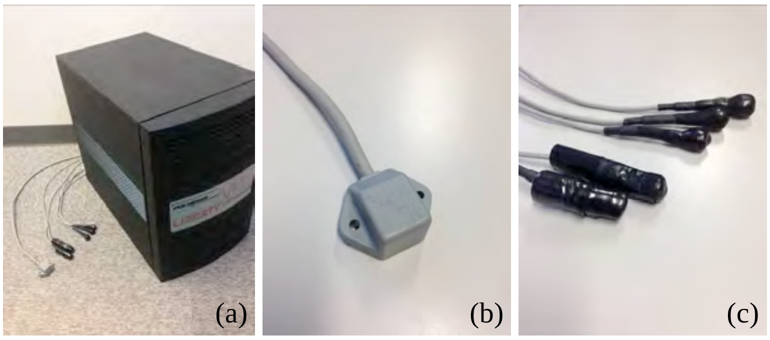

Figure 4. Electro-magnetic field sensing device LIBERTY.

3.2 System Composition

Figure 5 shows system composition. The system consists of a PC, an electro-magnetic field sensing device LIBERTY and an erhu. The erhu is equipped with a transmitter and receivers of LIBERTY. Figure 6(a) shows the erhu equipped with a transmitter and receivers of LIBERTY. Figure 6(b) shows left hand equipped with receivers. We equipped the erhu with a transmitter and receivers for measuring gesture of erhu bow strokes as Figure 6(a). Moreover, we equipped learner's index finger, middle finger, and ring finger of left hand with receivers for measuring learner's finger position on string as Figure 6(b). The system diagnoses learner’s gesture of erhu bow strokes and finger positions by using data measured by the receivers. The learner learns playing skills about bow strokes and finger positions by using this information.

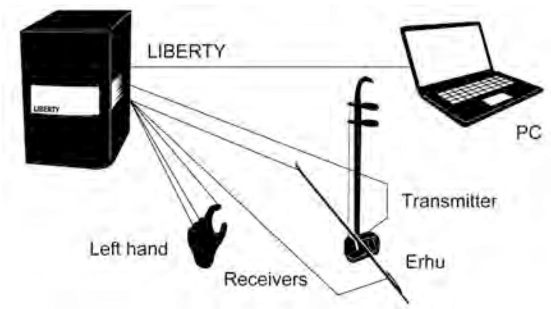

Figure 5. System composition.

Figure 6. The erhu and left hand equipped with LIBERTY.

3.3 Visualization Window

Figure 7 shows visualization window. It shows bow strokes and finger positions with virtual erhu model in the virtual 3D space. These bow strokes and finger positions represent learner’s bow strokes and finger positions measured by electro-magnetic field sensing device on real-time. The learner's playing is diagnosed by the system. Viewpoint in the virtual 3D space is changeable freely. The default viewpoint is matched with the real learner's viewpoint while playing the erhu.

The results of diagnosis about bow strokes are represented as follows. During accurate bow strokes, they are colored green as Figure 7. Figure 9 shows visualization window while playing bad examples. If bow strokes leave the resonator body (over 0.5 inch), they are colored black as Figure 9(a). If bow strokes are not parallel to the ground (over 10 degrees), they are colored red or blue as Figure 9(b) and Figure 9(c). If bow strokes are not parallel to the surface of the body (over 10 degrees), they are colored pink or orange as Figure 9(d) and Figure 9(e). Viewpoint in the virtual 3D space is changeable freely. Each feedback shows 3D arrows for indicating how to improve bow strokes. The learner can recognize bow strokes errors by watching visualization window.

The window shows totally six colored small spheres on the virtual erhu model's strings as Figure 7. Three spheres of them represent learner's left finger positions. The positions of index finger, middle finger, and ring finger are colored light red, light green, and light blue, respectively. The other three spheres represent correct finger positions. The correct positions of index finger, middle finger, and ring finger are colored red, green, and blue, respectively. The correct positions can be switched to display/non-display. If the learner's finger position is accurate, the light red sphere, the light green sphere, and the light blue sphere change the sky blue sphere. The learner can recognize finger positions errors by watching visualization window.

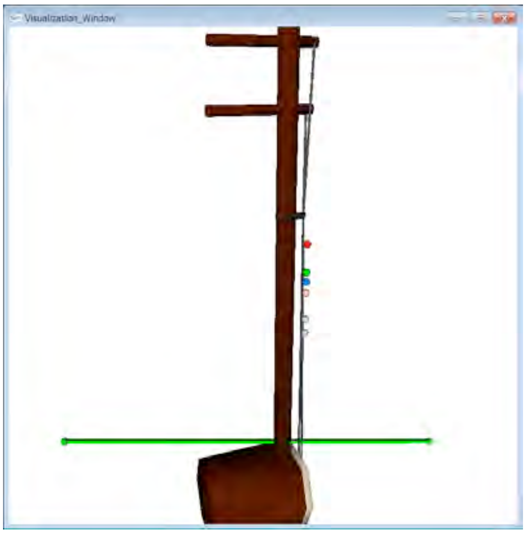

Figure 7. Visualization window.

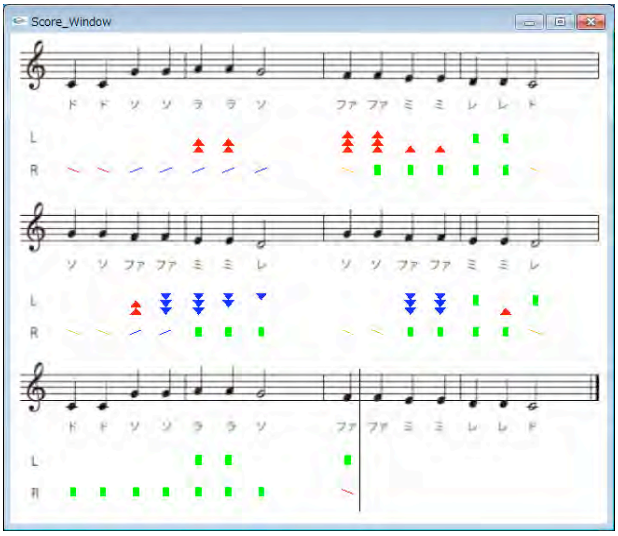

Figure 8. Score window.

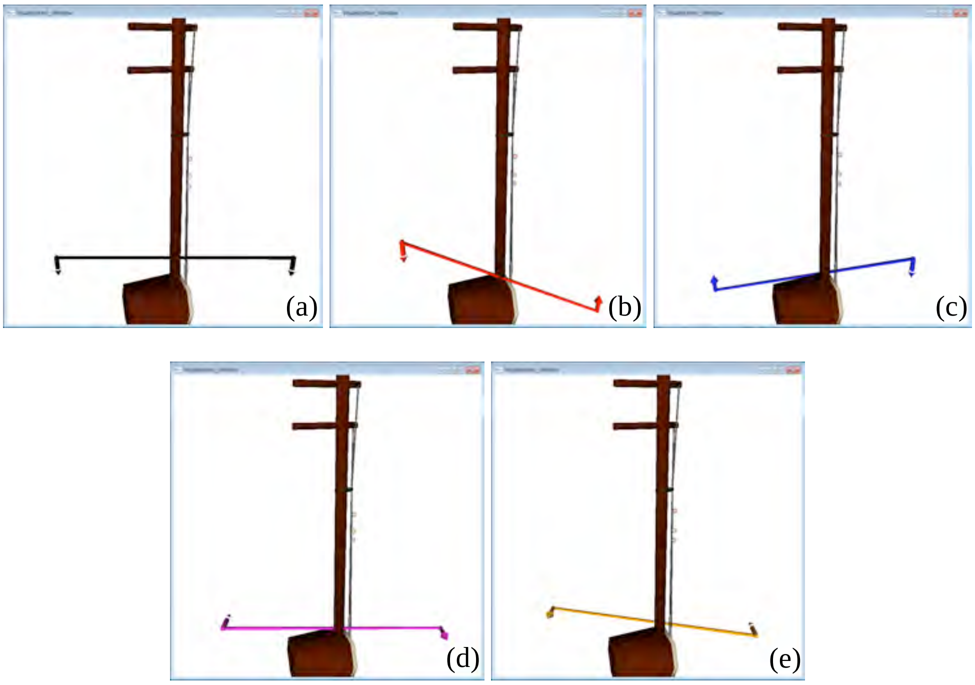

Figure 9. Visualization window while playing bad examples.

3.4 Score Window

Figure 8 shows score window. It shows score of the music, current diagnosing point on the score, and results of diagnosing. The current diagnosing point is shown by a black vertical line, and it moves along the score. A learner must play the erhu by synchronizing the current playing note with the current note on the black line. The results of diagnosis are indicated under the notes. 'L' in Figure 8 is results of diagnosis left finger positions. The red triangles represent that learner's finger position is upper than correct finger position. The blue triangles represent that learner's finger position is lower than correct finger position. The number of red/blue triangle represents the size of difference between learner's finger position and correct finger position. The green squares represent that learner's finger position is accurate. Moreover, 'R' in Figure 8 is results of diagnosis right hand bow strokes. The green squares represent that learner's bow stroke is accurate. The other colored figures that correspond to the representation of bow strokes in visualization window. The learner can recognize where s/he made errors of bow strokes and finger positions and how to improve his/her errors.

4. Conclusion and Future Works

In this paper, we designed and developed a learning environment for novices' erhu playings. The system diagnoses bow strokes and finger positions by using electro-magnetic field sensing device LIBERTY. The system has two windows, visualization window for visualization of bow strokes and finger positions on real-time, score window for showing the results of diagnosing bow strokes and finger positions along score. The novices can recognize and improve bow strokes and finger positions errors by using these functions. Therefore, we have achieved the aim.

In the future, we will conduct quantitative evaluation experiments for verifying learning effect during using the system by the data of electro-magnetic field sensing device.

Acknowledgements

We would like to thank all the people who cooperate with our studies.

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