Piano Learning Application with Feedback Provided by an AR Virtual Character

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***Abstract*—This paper proposes a mobile application that uses Augmented Reality to enhance the experience of learning to play keyboard instruments. The proposed application uses Google Cardboard to let users visualize a virtual character and instructions. The character gives the user real-time visual feedback according to their music playing performance as evaluated by the system. This application lets users choose among pre-defined songs that can be learned and practiced by using a simplified notation that eliminates the barrier of using actual musical notation. Having in mind the psychological benefits of music learning, we aim to present a fun and easy way to learn music and keep the users' motivation during the process.**

Keywords—Augmented Reality; Computer-based instruction; music; visualization; character animation

I. INTRODUCTION

As the development of technologies related to Augmented Reality (AR) and Virtual Reality (VR) moves forward, developers have more opportunities to create interesting experiences for their users in. For instance, Google Cardboard[1] -an affordable VR headset for mobile devices- can be used for AR applications by using video input from a mobile phone camera.

Some work has already been done to use AR for assistance in music learning, a field that has acquired important significance for the health and well-being of the students due to recent evidence of the psychological and cognitive benefits that it presents [1]. Some examples of such applications are Cakmakci's work [2], which presents an application for learning bass, and Huang's AR piano-teaching software [3]. These proposals focus on the use of AR for displaying only current instructions directly above the instrument being played without scoring or providing feedback on the user's performance.

This kind of applications can accelerate the learning process of beginning music students, whose time with a teacher is often limited [4]. In particular, this work explores other possibilities of AR in music learning by proposing an application that lets users interact with a virtual character to further engage them into the experience (Fig. 1). The application takes input from a MIDI[2] keyboard and presents instructions to play a particular song. The virtual character, represented on the users' environment via AR, will change its behavior and presentation based on the performance of the user. The application is expected to present a fun way to learn music and keep students' motivation during the process.

II. PROPOSED SYSTEM

A. System Overview

As illustrated in Fig. 2, our system consists primarily of three main modules: instruction, evaluation and character display. The "pre-game" phase is currently managed during the development of the application, where the songs, characters and animations are packaged into the final product. Each module will be explained in detail in sub-section D.

B. Hardware Requirements

The input for this application can be either a computer keyboard or an electronic MIDI keyboard. Google Cardboard and a smartphone are used to display both instructions and the AR virtual character.

C. Pre-game

The songs can be fed into the application via MIDI (.mid) files.

[1] http://www,google.com/cardboard.

[2] https://en.wikipedia.org/wiki/MIDI.

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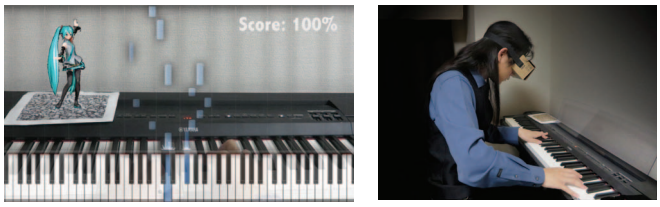

(a) (b)

Fig. 1. (a) Application preview. (b) Hardware involved.

At the same time, virtual character data and animations are required. For this particular implementation we will be using a rigged humanoid 3D model and animations found on Internet Motion Capture Data (Mocap) repositories. All this information will be packaged with the application.

D. Performance

1) ***Instruction****:* The instruction module will deal with displaying the instructions on the screen so the user can perform the song correctly. For simplicity, the user will receive graphical instructions on which keys to press. The songs will be introduced to the application in form of MIDI files, which will be interpreted for graphical display.

2) ***Evaluation****:* The evaluation module will compare the MIDI files with the user's input and provide a score. A description of a similar evaluation method can be found on Duval's work [4]. The calculated score will be sent to the character display module for further processing.

The following table is a representation of the evaluation data stream. Each column represents a time interval t of t = 60 / 64 BPM, where BPM represents the tempo (beats per minute) of a song. The first row represents the expected input (E: song in Figure 3), while the second represents user input (I).

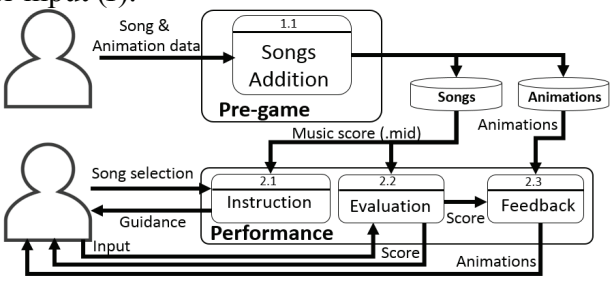

Fig. 2. Application Framework.

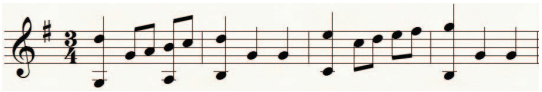

Fig. 3. Sample Musical Score

TABLE I DATA STREAM SAMPLE

t	1	9	17	25	33	41	49	57
E	G3,D5	G3,D5	G4	A4	A3,B4	C5	B3,D5	B3,D5
I	G3,D5	G3,D5	G4		B4	C5	B3,D5	B3,D5

The data will be compared at each interval to account for the number of correct notes given by:

$$S_t = \frac{\sum_{i=1}^{t} d(E_i, I_i)}{t} \quad (1)$$

Having

$$d(x,y) = \begin{cases} 1 \; E_i = I_i \\ 0 \; E_i \neq I_i \end{cases} \quad (2)$$

Based on this, the score (S) of the given example by time t would be 75%.

3) ***Feedback****:* Based on input from the evaluation module, the feedback module will render a 3D model of a virtual character and show it to the users on their real environment to give them feedback, while also pointing out mistakes during the performance. Based on the score, the character will be animated in a way which reflects whether the performance is good or bad. For example, the character will dance at higher scores and stop dancing at lower scores. The size and texture of the character can also be affected to reflect changes on the score. To achieve this result we will use, Unity's Mecanim[1] and Vuforia[2].

III. Conclusions and Future Work

This paper presented an application that helps to learn how to play keyboard instruments by presenting instructions and feedback using Augmented Reality. The interaction with an animated 3D character can help to keep the motivation in music learning. Further improvements can be made to this application in the future, such as working with other kind of musical instruments and allowing users to add their own songs and dance movements for the character.

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[1] http://docs.unity3d.com/Manual/AnimationOverview.html.

[2] http://www.vuforia.com.

DEMO VIDEO https://www.youtube.com/watch?v=YXnIEtnhamw.