Experience Orchestra: Manipulating Musical Instruments in VR

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2022 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW) | 978-1-6654-8402-2/22/$31.00 ©2022 IEEE | DOI: 10.1109/VRW55335.2022.00310

Abstract

Fine-grained grasping and interaction can be frustrating and discouraging in a conventional virtual reality system with standard handheld controllers. *Experience Orchestra* is an immersive application in which users can experience playing orchestral instruments, either individually or in an ensemble, in realistic ways. We describe how conventional grasping methods were modified to make the experience more realistic.

Keywords: Virtual reality, 3DUI, Collaborative Experience

1 Introduction

Smooth interaction in virtual environments in the form of grasping and manipulating objects is necessary for a compelling immersive experience [2]. In this project, we use Oculus touch motion controllers to enable proper grasping and manipulation of musical instruments. One of the striking features of musical instruments is the position that each instrument must be held in so that it can be played effectively, e.g., compare a french horn with a violin. Our implementation of grasping and manipulation extends the simple distance grabbing technique [3] to employ collision snapping [1] with built-in markers so that each instrument is naturally positioned correctly.

The context in which these interactions take place is called *Experience Orchestra*. Whether pursuing it professionally or as a hobby, classical music can be incredibly expensive. From the cost of the instrument itself to maintenance to lessons, the barrier to enter the classical music world discriminates against those who are met with financial limitations. Therefore, while playing the violin may have been part of reality for centuries, it is important to ask — whose reality? Without sufficient support and resources, one can't even aspire to become a classical musician.

This problem is exactly what *Experience Orchestra* addresses. Its goals of are threefold: (1) to introduce western classical instruments in an approachable, user friendly, and interactable way; (2) to dismantle the glass ceiling and democratize the world of classical music; and (3) to give everyone, regardless of their background or socioeconomic status, a chance to dream.

Experience Orchestra is a virtual reality (VR) application implemented on the Oculus Quest 2 that provides a suite of orchestral instruments for exploration and use. It is a collaborative application, in that groups of users can form an ensemble using instruments of their choice. To play the instruments, users must *mimic* movements that would be required to play the instruments in the real world. The mimicry is a simplification of the actual motions required for a real instrument, but provides a virtual model that conveys an essential experience for that instrument. This 3DUI abstract focuses on the object manipulation component, which was a focus of the design process. Our object manipulation method extends a well-known snapping algorithm to make it suitable for handling musical instruments.

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Figure 1: Screenshot of application with violin on table

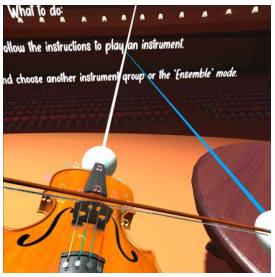

Figure 2: Screenshot of a user playing the violin

2 Design of Application

The application allows users to play instruments from the string, woodwind, brass, and percussion families in a single player environment. The user can play four different instruments in each of these families for a total of sixteen playable instruments in total.

For each instrument, the user must first grab the instrument using the snap grab mechanism (see Figure 1). This mechanism allows the user to properly position the instrument for play in order to emulate the playing of these instruments in the real world (see Figure 2). Then, the user plays the virtual instrument similarly to how it would be played in the physical world. For string instruments, the user holds the bow perpendicularly along the waist of the instrument. For brass and woodwind instruments, the user positions the mouthpiece near their head and presses on the valves using Oculus controller buttons. Playing percussion instruments involves grabbing a percussion stick using the snapping mechanism and hitting the instrument. When a user plays an instrument, an audio clip of a performance with that instrument is played. So, if the user mimics the motions of the violin in the application, the violin plays pre-recorded violin music as long as the user imitates the motion. Users can manipulate the tempo of the music played from the instrument by changing how they play the instrument. For instance, they can change the tempo of the violin music they are playing by moving the bow faster or slower. For brass and woodwinds, the user can change how fast they press the controller buttons to manipulate tempo. The application employs 3D spatial audio in order to localize the sounds of the instruments and simulate the orchestra experience.

The application also allows users to play a single musical piece together in a multiplayer mode called ensemble. In this mode, each user picks an instrument to play and they play their part of the piece together. The goal of this experience is to have users correctly play a musical piece by synchronizing their performance of the virtual

978-1-6654-8402-2/22/$31.00 ©2022 IEEE
DOI 10.1109/VRW55335.2022.00310

instruments with other users.

2.1 Equipment

The application is built for an Oculus Quest 2 headset. The Quest 2 headset supports six degrees of freedom head and hand tracking without the use of a wired tether to a computer or additional sensors by using four built-in cameras on the headset. The Quest 2 runs on an Android-based operating system. The application was developed using Unity 2020.3.17f1.

A user will need to load a provided apk for the Oculus Quest 2 and have two hand controllers. Wifi networking is required. In application instructions are provided, and either individual or ensemble (multi-user) mode can be selected.

2.2 Interaction Method

Basic 3D manipulation tasks involve selection, positioning, and rotation of virtual objects [2]. The basic distance grabbing approach implemented on Oculus touch controllers is limited when applied to musical instruments, if proper form is to be enforced. Most orchestral instruments need to be held in particular ways. For example, with the french horn the left hand accesses the levers and right hand is placed inside the bell; for the flute, the left hand is place closest to the embouchure and right hand nearest the foot. An unconstrained grasping and manipulation technique makes it difficult for novice users and learners to grasp the object properly, and default rotation techniques result in the object frequently dropping, causing a frustrating user experience. As a result, a modified form of collision snapping [1] was adopted which put each instrument in the correct position with minimal effort on the part of the user.

Our application employs two snapping methods: snapping to dynamic objects and snapping to static objects. We employ snapping to dynamic objects in the application when the user attempts to grab an instrument. Specifically, when a user grabs an instrument, the snapping mechanism causes the grabbed instrument to snap into its proper holding position. Once the instrument is snapped into place, the instrument will follow the hand that grabbed that instrument. We call this method dynamic since the instrument position is continuously modified based on the dynamic object to which it is snapped. The dynamic object in this case is the user's hand which is almost always in motion. For instance, if the user grabs a violin, the snapping mechanic forces the user to grab the violin by the neck and position it appropriately, aligning the violin neck with the user's hand (see Figure 3). This method allows us to emulate proper holding and performance of instruments in the application by making the positioning of instruments in the application as realistic as possible.

In our application, we implement snapping to static objects in the application to snap instruments back to their original positions in the VR scene. When the user releases an instrument after having finished their interaction, the snapping mechanism snaps the instrument back to the static table object in the VR from which the instrument was grabbed. We call the table static as it is not changed over the course of the application run-time with respect to its attributes like position and rotation. The static snapping method allows us to maintain consistency and minimize chaos in the scene by allowing the users to consistently access instruments from designated locations without having to worry about remembering where the instrument was previously left.

2.3 Design Process

Initially, we intended on creating a skeuomorphic instrument performance experience, where users could play individual notes of an instrument by changing how they held the instrument or pressing specific buttons. For example, we initially designed the violin so that finger positions on the violin could be emulated by pressing controller buttons and hand positions could be manipulated by the joystick on the Quest 2 controller. However, we found that this method introduced complications related to resource usage. For instance, in a violin implemented using this method, the application must support the user playing notes concurrently and playing various notes along the length of the violin for each of the strings. To support this sort of performance, the application would require many audio clips of various notes being playing in different variations. Due to technical feasibility problems and time constraints, we modified this approach to make it far simpler to play an instrument in VR.

Figure 3: Illustration of snapping behavior, before, during and after.

To this end, we created a simpler method where a user plays the instrument by imitating the motion of playing the instrument. For string instruments, this would be moving the bow back and forth across the body. For woodwinds and brass, this method would be putting the mouthpiece near the head and press on the controller buttons to simulate the pressing of valves. For percussion instruments, this method is hitting the instrument with a stick object. We found that this mechanically simple method aligns closely with the goals of our project of allowing users to experience playing instruments without any physical barriers. We essentially removed the individual notes aspect from the previous method to develop this method. So, we do not need individual note audio samples for each instrument using this method. Instead, for each instrument, we use a pre-recorded performance of the instrument playing a musical piece and play the audio whenever the user plays the instrument. The audio will start playing once the user starts performing the motions. The audio will continue to play as long the user performs the correct motions of playing the instrument. Finally, the audio will stop playing once the user stops performing the proper playing motions. The tempo of the music in the audio will change based on how fast or how slow the user performs the instrument performance motions.

Snapping is limited in that it properly positions the instrument only if picked up by the correct hand (left hand for all instruments except the french horn). If a user picks up an instrument with the incorrect hand, the instrument will not be properly positioned. Because of this, many left-handed users might be uncomfortable since the right hand does most of the playing. This limitation could be improved so that each hand has a different snapping method for each instrument, which would properly position an instrument regardless of which hand is used to pick up the instrument.

3 Conclusion

Experience Orchestra allows users exposure to instruments in VR without requiring the knowledge of how to truly play the instruments. A novel snapping interface allows users to easily interact with instruments and correctly manipulate them to produce music. The application thus accomplishes its main goal of giving users the experience of playing in an orchestra.

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