VibroPlay: Authoring Three-Dimensional Spatial-Temporal Tactile Effects with Direct Manipulation

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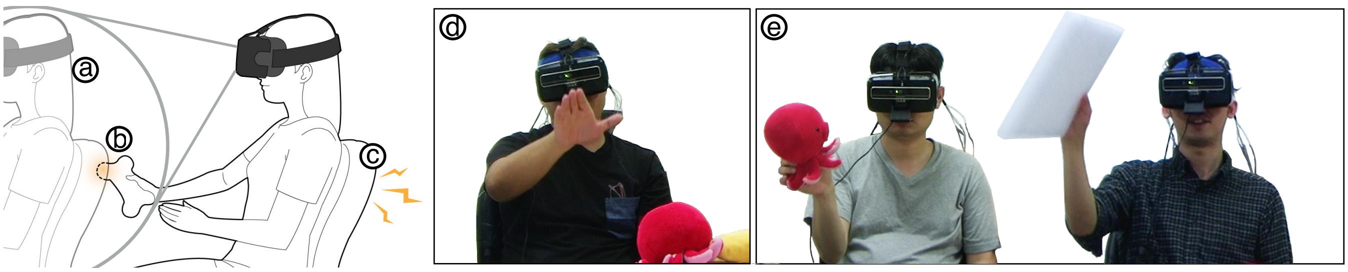

Figure 1: *The system shows (a) virtual replicas of the artifact and its actuators and (b) digitizes physical objects through a depth camera. Hence, the user can manipulate vibrotactile patterns by making the virtual objects collide the virtual actuators by using (d) bare hands or (e) digitized physical object accessible.*

Keywords: vibrotactile; haptics; authoring; virtual reality

Concepts: •**Software and its engineering** → **Virtual worlds software;** •**General and reference** → *Design;*

1 Introduction

Vibrotactile feedback provides immersive media experience. To facilitate the design of vibrotactile effects, an authoring system is essential. Soundtrack streamlined interfaces [Ryu and Choi 2008; Lee et al. 2009] were initially introduced to create temporal vibrotactile effects for individual actuators. Unfortunately, temporal effects designing with sound waves in temporal domain cannot well transfer to tactile sensations for designers without sufficient sound or haptic skills. More recent research [Schneider et al. 2015] designed spatial vibrotactile effects that involve multiple actuators by directly manipulating control points that specify spatial tactile paths. However, spatial effects designing with control points might be difficult to capture complex spatial behaviors.

We present *VibroPlay*, an authoring interface for three-dimensional temporal-spatial tactile effects using direct manipulation. As displayed in Figure 1, a designer wearing a head-mounted display (HMD) is sitting on a chair deployed with actuators. In his or her virtual reality (VR) view, an avatar sitting on a virtual chair is displayed in front of the designer. The avatar represents the designer, and the virtual chair stands for the replica of the physical one. This design helps the designer focus on the manipulation of tactile effects in the context. With direct manipulation through his or her VR view, the designer can create an effect by making contacts with the actuators in a spatial-temporal manner using bare hands or any physical object accessible. During the direct manipulation, the contacted virtual actuators switch their physical remote counterparts "on" such that the user can experience what is being designed in a streamlined manner.

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2 System Implementation

2.1 Hardware Design

To accept a wide range of design possibilities, we provide a depth-sensing volume which accommodates the virtual replica and allows any physical substance entering the volume becomes an effector to create contact behaviors with the virtual actuators. Here, a RealSense depth camera is adopted to create a depth map for our tasks of designing tactile effects happening on chair back, headband, and wristband.

Figure 2: *(a) A RealSense camera is used to capture the depth image and (b) duplicate it in the virtual space.*

The vibrotactile interfaces are made of Pico Vibe 310-103 motor vibrators; each measured 1cm in diameter and 2.7mm in height, allowing for 1.3g at its full strength. Three common vibrotactile interfaces, a chair, a wristband, and a headband, were created as the interactive artifacts in this study. The chair interface consists of a 4 x 3 actuator arrays attaching to the chair back. The wristband interface includes 2 x 6 actuators arranging in two circles side by side. Finally, the headband interface consists of 1 x 12 actuators arranging in a circle. These three interfaces are connecting to a PC through an Arduino Mega for communicating the interaction states.

To reduce the design parameter for users, we chose only use maximum and minimum intensities (*i.e.*, binary vibration). This decision also makes the interaction clear – vibrate on colliding.

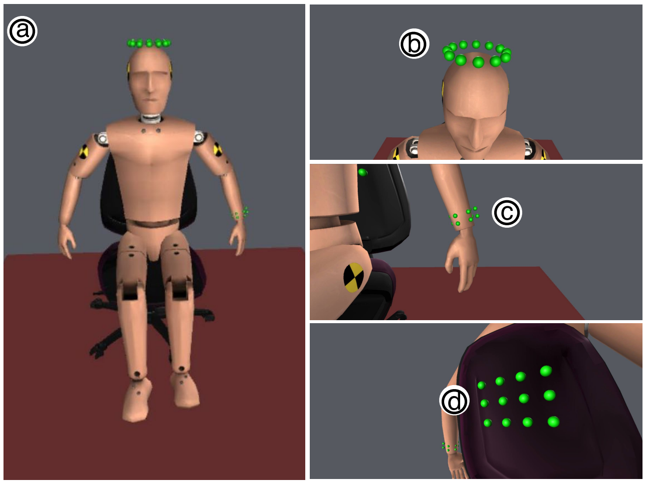

Figure 3: *(a) The overview of See-yourself interface. The (b) head, (c) wrist, and (d) chair cases.*

2.2 HMD Visual Design

To put the designer in context, we duplicate an identical setup of the physical interface in the designer's HMD view. For instance, to design effects for a vibrotacile headband, our design includes an human avatar (e.g., indicating the designer) wearing the headband sitting in front of the designer's HMD view, at a distance the designer can easily reach to the virtual actuators on the avatar. Same as the case for designing chair interface, the designer would see himself or herself sitting at the front, as shown in Figure 3. The green spheres in Figure 3a represents the actuators, and Figure 3b-d show each virtual vibrotactile interface.

This visual design includes two main benefits. First, the interface allows users be aware of the spatial associations of actuators. Second, designers can reach actuators which might be even inaccessible in the physical setup, such as to direct-touch an actuator on the chair back the designer is sitting on.

3 Authoring Tactile Effects for Videos

3.1 Authoring Interface and Procedures

The user task is to design vibrotactile effects on video segments. A movie player is added in the VR view for the participant to review the video content. The timeline, shown in Figure 4b, informs the participants the progress of the video segment. Virtual actuators turn red when colliding with any effectors, indicating they are functioning (Figure 4c).

The authoring process is designed based on the idea of mixing loops the generated tactile effects are recorded in realtime and looped playback in the corresponding video segment, such that tactile effects are designed and reviewed in repetitive manner and complex tactile effects can be built up increasingly over loops.

A three-button foot switch is provided to facilitate the operations during authoring, allowing users to fully use their hands while designing vibrotactile patterns. The first button switches the user's viewport in VR regarding different vibrotactile interfaces. The second button switches between reality and virtual scenes, allowing users to change physical tools with the real-world view. The third button starts design on next video segment.

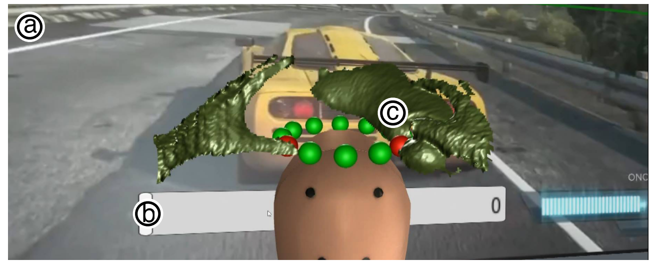

Figure 4: *In the virtual space, a user can (a) watch the continuous-looping video segment. (b) A timeline informs the user the frames. (c) The red spheres represent the virtual vibrators collided by depth maps.*

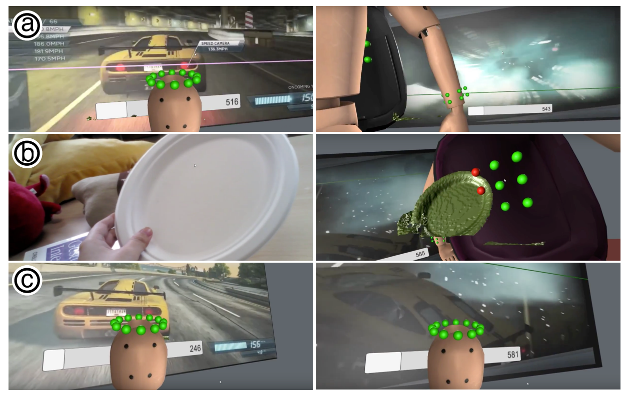

Figure 5: *A foot switch is used for viewport transitions during the authoring: (a) transiting between vibrotactile interfaces, (b) transiting the viewport between physical and virtual spaces, and (c) moving to the next video segment of interests.*

After introducing VibroPlay, the experimenter demonstrated how to operate the proposed interfaces. During the interaction, the user will be sitting on a chair. A set of physical tools are placed easily accessible at a second table on the left.These tools include *soft* and *rigid* objects that cover different physical properties, such as shape, size, deformability, etc., allowing to create colliding behaviors that are difficult to accomplish by bare hands. The participants will be then asked to design tactile effects for video segments, as mentioned above.

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