Tangibles within VR: Tracking, Augmenting, and Combining Fabricated and Commercially Available Commodity Devices

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Figure 1. a and b) Rod and reel tangible combining a Vive tracker, Microsoft Surface Dial and 3D printed elements for a fishing simulation. c) Student operating VR interface with the Microsoft Dial on top of a multi-touch display.

Abstract

Virtual Reality (VR) continues to provide an excellent alternative for users to experience diverse environments from the comfort of their home. The higher the level of immersion, the better the experience. However, the devices one can use to interact with objects in such environments are often restrictive and provide the same generic tactile feedback for contrasting objects, which may adversely affect immersion. One way to address this challenge is to use tangibles. Tangibles combined with tracking devices can provide alternative ways to increase immersion and catered tactile feedback. In this tutorial, we present simplified strategies that can be adopted to incorporate 3D printed and commercially available tangibles into VR applications using multi-touch displays and HTC Vive trackers. We showcase 3D printed prototypes that can be augmented with tangibles and trackers to interact in virtual environments. We also discuss multiple approaches that can reduce complexity further and help others incorporate tangibles into their VR simulations.

Index Terms: Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Virtual reality; Human-centered computing—Human computer interaction (HCI)— Interaction devices—Haptic devices;

1 Introduction

Current consumer virtual reality (VR) devices typically combine headsets, controllers, and other peripheral sensors for tracking users and other objects or tools that might be used in the virtual environment. Regardless, tangible interaction within VR is mostly limited to haptic feedback from tracked controllers like the Oculus Touch, HTC Vive controllers, etc. Higher fidelity tracking can be achieved with devices like the CyberGlove III, Manus VR, etc. but they can ramp-up production costs very quickly and still lack accurate virbrotactile feedback for complex objects. The lack of high fidelity interactions and engagement with tangibles in VR can also be attributed to the complexities added by incorporating tangibles, as solutions may involve building custom hardware and integrating additional layers of software (e.g. for communication and tracking).

Lessons learned in research which deals with fabrication approaches and augmentation of commercially available commodity devices for tangible and embodied interaction (complementary to custom-built solutions) may contribute to the current state of tangible interactions within VR. The combination of Microsoft Surface Dials, 3D printing, spatial trackers like the HTC Vive trackers, and the Unity 3D platform - both as particular products, and as representatives of broader classes of technology – can be utilized to overcome these challenges. Dials can be tracked in the virtual environment, and facilitate constrained parametric interaction with active haptic feedback; 3D printed (sometimes capacitive) elements can add physically-representational, evocative passive haptic feedback.

The tutorial falls under the input devices and haptics thematic categories, among others. The half-day tutorial begins by discussing techniques for instrumenting a specific type of VR application, built using the Unity 3D game engine, for tracking and communicating with tangibles using several commercially available devices and ad-hoc techniques. We will cover tracking strategies for tangibles in immersive and non-immersive virtual environments using spatial trackers and capacitive multi-touch displays. The tutorial will also discuss techniques and tools for designing and fabricating 3D printed objects, and approaches to physically attach 3D printed elements to commercially available devices. We will present several prototypes embodying the tangible interactions proposed which attendees will be invited to iteratively engage, manipulate, and examine.

2 Background

In the tangible, embodied, and embedded interfaces field, the subfield of tangible user interfaces is concerned with approaches that give material form to computational resources and data [7]. Several claims support these approaches:

- Two handed input may offer manual and cognitive advantages [10]. Two examples are time-motion efficiency and reduction of cognitive load in task composing and visualization.
- The level of control and understanding may be increased with

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the use of passive props when working with three-dimensional data visualization [8].

- Direct manipulation can be more satisfactory and enable people to better concentrate on their tasks [16].

Interaction with dials is a recurring trend in tangible user interfaces. For example, [12, 17, 18] structured dial interaction around fixed mechanical constraints, Sensetable and ReacTable allowed tangibles to be sensed and graphically mediated across interactive tabletops [9, 14]. In other variations, capacitive 3D printed objects have been created to interact with multi-touch devices [15]. Recently, smart dials such as the Microsoft Surface Dials [13], and Dell Totems [4] have become commercially-available.

Besides user interfaces, tangibles have been employed in interactions that engage the body with storytelling elements (e.g., plot, character, or setting), this sub-field is called tangible narratives [5]. In this context, the use of a tangible device might enhance interactivity by indicating how to interact, when to interact, and the result of interaction [1]. A controller may represent a flashlight in a dark room [2], or a tactile jacket might make movie viewing more emotionally immersive [11].

Others have combined research that deals with tangible and embodied interactions with the design challenges of Virtual Reality (VR). In one example, a plush animal, augmented with a custom-built tracking device, appeared as a companion character in a VR environment to help users solve problems [6].

3 Tutorial Description

The half-day tutorial will help students and VR practitioners extend their knowledge and skills in integrating tangibles within virtual environments. The tutorial is taught by two speakers, and will feature demonstrations that integrate and engage tangibles. The intended audience is expected to be familiar with VR concepts in general and have some experience with computer programming languages like Python, C/C++, or C#. Basic knowledge of the Unity game engine and 3D printing would also be helpful.

The tutorial will showcase two main applications, one that incorporates commodity, commercially available tangibles into VR to increase immersion and, another that extends an inherently tangible application, combining 3D printed dials, a multi-touch screen, and VR. The tutorial will demonstrate techniques to link tangibles with tracking devices and focus on how the communication between the Unity application and the tangible is handled. Specifically, attendees will be shown how to incorporate HTC Vive trackers into their Unity projects, and how to communicate with the Microsoft Surface Dial within the same application. The technical challenges of designing, fabricating and uniquely identifying 3D printed objects with multi-touch screens will also be addressed. Attendees will be introduced to Open Sound Control (OSC), a flexible networking protocol for gestural control, and TUIO, an open framework that defines a common protocol and API for tangible recognition on multi-touch surfaces. For connecting several physical elements, mechanical and magnetic approaches will be demonstrated.

The tutorial is an evolution from several previous efforts dealing with fabrication approaches for tangibles [3]. These efforts, however, did not include virtual reality dimensions. The tutorial will give attendees a good run down of how they can incorporate tangibles into VR to substantially increase immersion. No tutorial on the subject has been previously presented by the authors.

4 Biography

Alexandre G. de Siqueira holds a bachelor degree in computer science and an MBA, both from Brazilian institutions. Toward his Ph.D. degree, Alexandre has done extensive work with editions of interfaces that combine multi-touch and tangible interactions along with techniques for tracking, fabricating and augmenting tangibles.

Ayush Bhargava is a graduate student at Clemson University, working towards a PhD in Computer Science. He got his Undergraduate and Masters degree in Computer Science from Clemson University. His current research work is in perception action affordances, 3D interaction metaphors and Cybersickness.

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