Applying Haptic Touch Amplification in Virtual and Mixed Reality Environments

Erin Woo, Anzu Kawazoe, Yon Visell

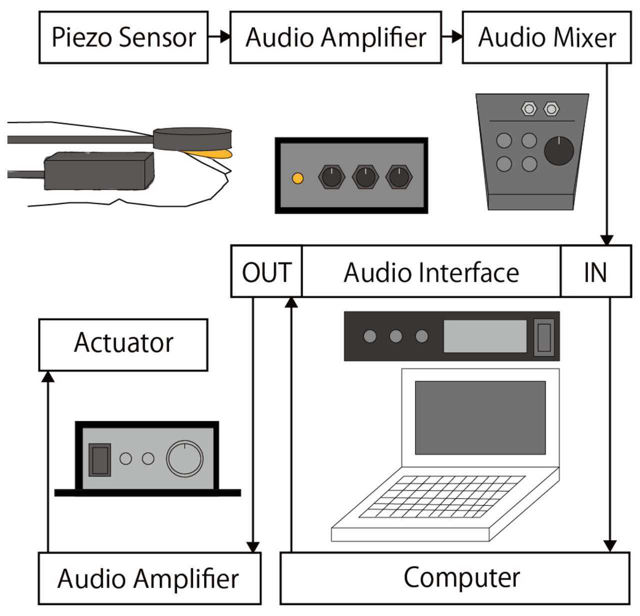
INTRO

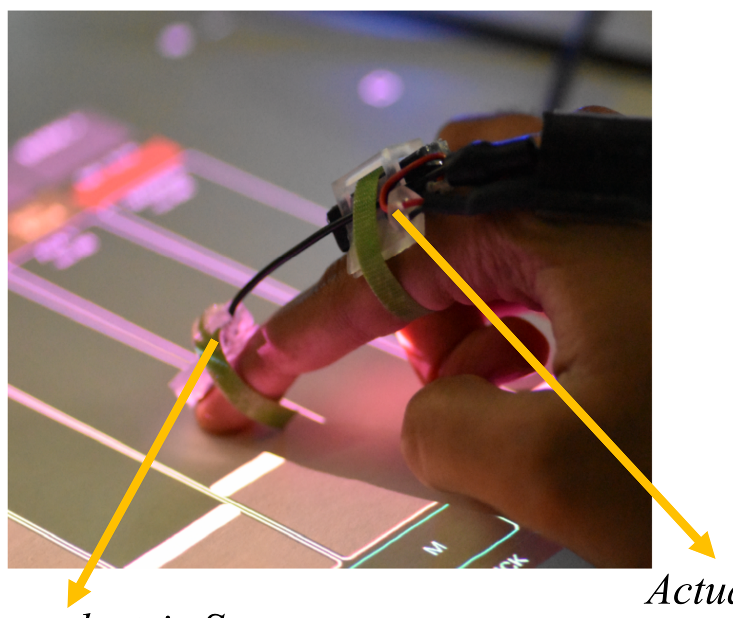
As technology becomes increasingly interactive, engineers are challenged with the task of making their products as intuitive and responsive as possible. Haptics poses as a solution to improving interactivity and feedback for products in a wide variety of fields such as biotechnology, audio/visual hardware, automobiles and more.

Haptics is a field that can be broadly defined as relating to the sense of touch. Touch amplification poses the solution of dynamic haptic feedback in the form of a finger-worn device.

The overarching goal of this project is to design and implement a device that is worn on the finger and consists of a cutaneous vibration sensor and an actuator that provides specific vibrotactile feedback to the user depending on the force and manner of their touch. When a user taps on a surface, the actuator provides feedback at the lower part of the finger that enhances the actual perceived sensation. The device uses audio mixing as an innovative approach to processing and producing haptic feedback. As a user touches a surface or object, the force signals produced by the touch are recorded at the tip of the finger by a piezoelectric sensor. The signals are then mixed, amplified and outputted as vibrations onto the proximal area of the finger by an actuator.

This type of feedback technology can be beneficial to many existing or emerging interfaces that we use or will use in our everyday lives.

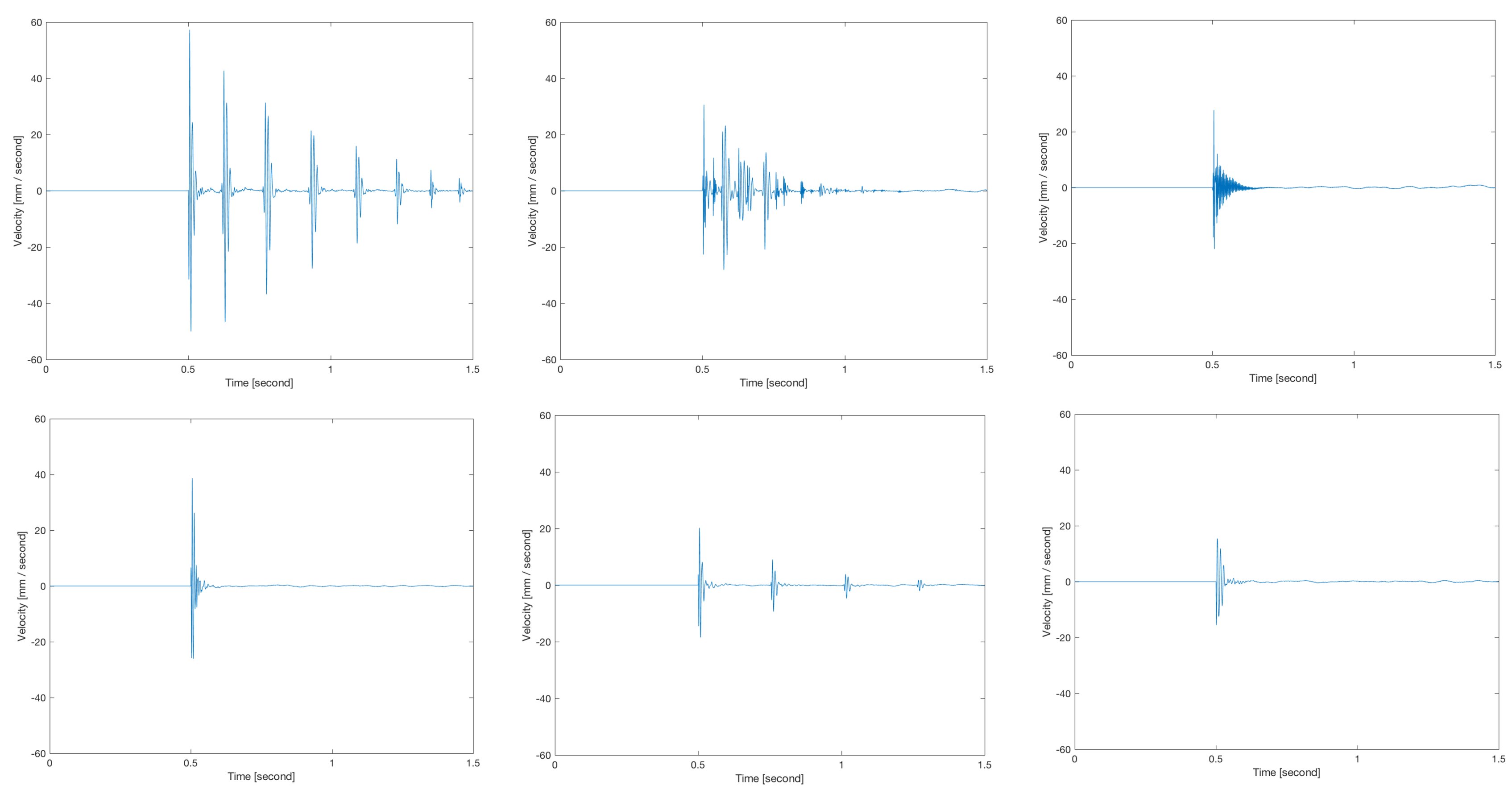




Actuator

Piezoelectric Sensor

Below are a few examples of the different preset tactile outputs, all from the same magnitude of input. The real-time amplitude of these outputs vary on the amplitude of the input. In other words, the more forceful the tap, the stronger the tactile sensation. The graphs relate the velocity of the actuator's vibration against time.



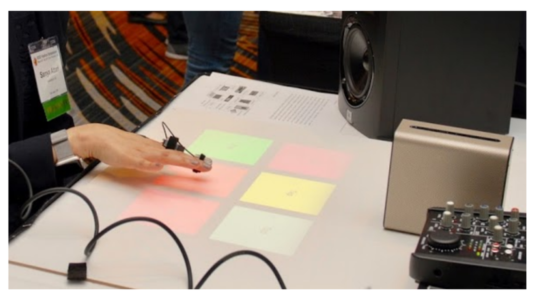
OVERVIEW

There is the question of whether or not dynamic haptics can be empirically advantageous in terms of user engagement and preference, based on the assumption that more senses are engaged in the process. In order to show the effectiveness of the device's implementation, it's necessary to show the scope of its possible usage in both 2D and 3D settings.

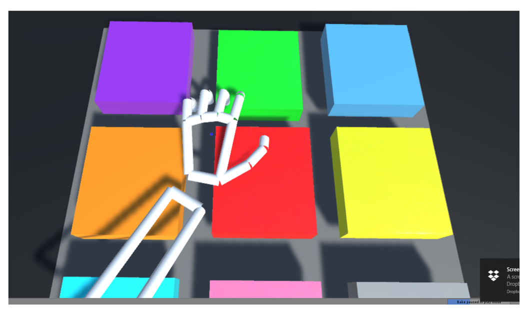
Touch amplification can be implemented in a virtual reality environment to enrich user experiences. Additionally, the use of proxy objects in digital spaces can give life to physically static objects in VR. This project will be focusing on the development of applications in virtual reality using Oculus Rift and Unity in C#, with an emphasis on touch amplification as a means of augmenting static proxy objects. The effectiveness of touch amplification in virtual reality can be investigated upon by extending the simple 3D button interface into the electronic handheld game Simon, where a pilot study is conducted to quantitatively measure the nature of the user's touch..

DEVELOPMENT

Oculus Rift, Leap Motion, and Touch Amplification Device



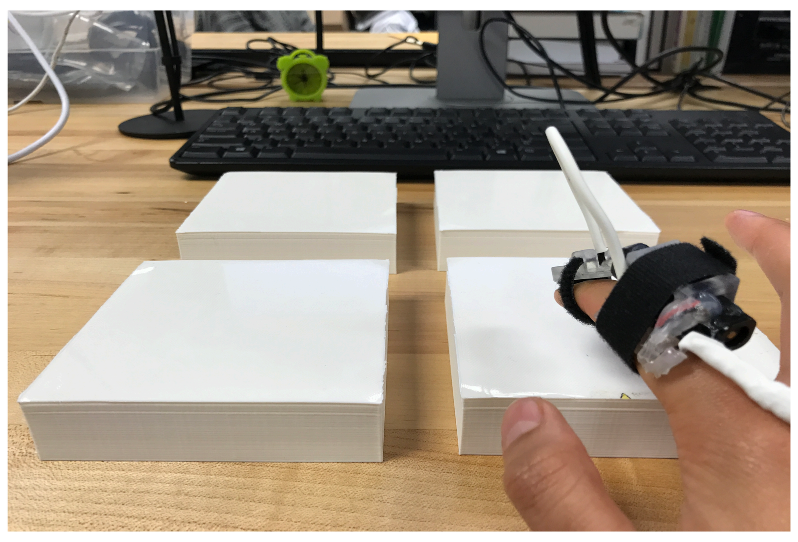
Original 2D Interface



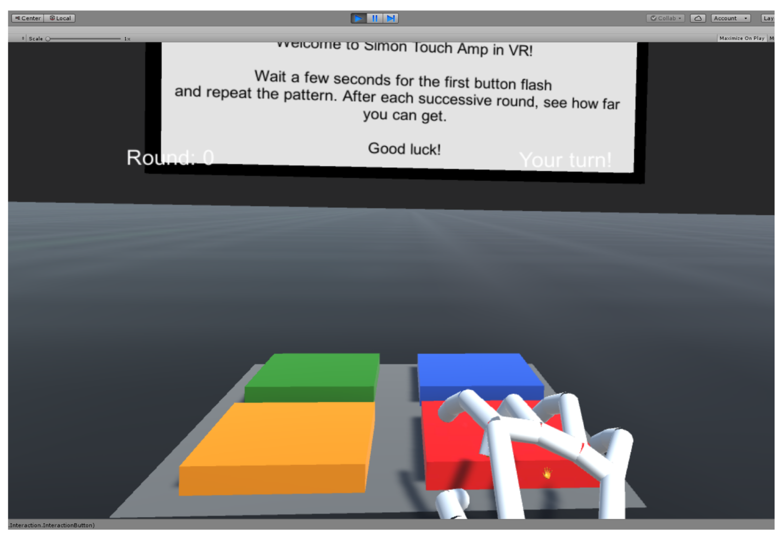
Virtual Reality Prototype

The virtual reality implementation can be described by its hardware and software components. The virtual reality hardware components consist of the Oculus Rift VR headset and a Leap Motion hand tracker rigged to the headset. The third component is, of course, the touch amplification finger-worn device.

The development environment was primarily Unity in C# with specific assets used from Leap Motion's Core and Interaction Engine assets. Additionally, 3D printed cubes acted as proxy objects representing buttons in virtual reality.



3D Printed Proxy Game Buttons

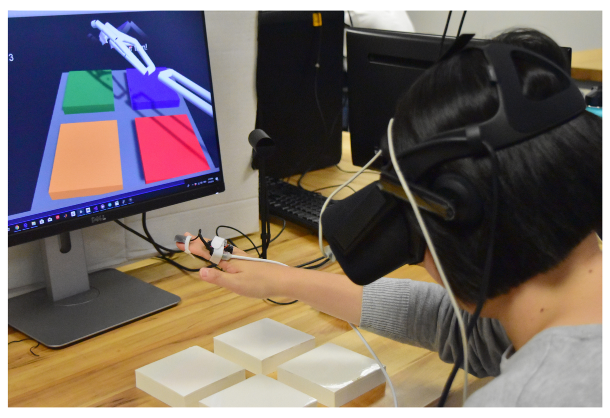


Simon Game VR Interface

PILOT USER STUDY

As we explore the possibilities of applying this technology in a 3D space, we must consider the impact of haptic touch amplification on user preference and performance. To quantitatively measure the user's application, an accelerometer on the finger-worn device records the displacement of the user's hand and the force of the input and output vibrations. We then compare the user's interaction playing Simon in VR with and without dynamic haptic feedback to see which interface the user interacts more naturally with, and ask the user to rate their preference for each.

We hypothesize that users will prefer interacting in a VR environment with multisensory tactile effects enabled over interacting in one without these effects. We will evaluate this based on an interactive 3D memory task, based on the handheld game *Simon*. We will also ask users to rate their experience using a selection of 7-point Likert scales drawn from standard "preference questionnaire" and "presence questionnaire" methods, measuring qualities such as interactivity, responsiveness, tangibility, accuracy, and entertainment. We will also record their performance in each condition.



Sample User Question:

Responsiveness:
How responsive was the environment to actions that you initiated (or performed)?

|_______|_______|_______|_______|_______|_______|_______|

NOT AT ALL SOMEWHAT COMPLETELY

CONCLUSIONS

The Simon VR game is only one of the limitless potential applications of the touch amplification system. Dynamic touch can change the way we interact with the digital world, and future studies can extend upon quantitative measures taken to assess the device's effectiveness and impact on users.

Additionally, we hope to optimize our current applications and think of more impactful ways we can implement the device into existing and emerging technologies.