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# Stereohaptics: A Haptic Interaction Toolkit for Tangible Virtual Experiences

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## 1. Introduction

With a recent rise in the availability of affordable head mounted gear sets, various sensory stimulations (e.g., visual, auditory and haptics) are integrated to provide seamlessly embodied virtual experience in areas such as education, entertainment, therapy and social interactions. Currently, there is an abundance of available toolkits and application programming interfaces (APIs) for generating the visual and audio content. However, such richness in hardware technologies and software tools is missing in designing haptic experiences. Current solutions to integrate haptic effects are limited due to: i) a user's rigid adaptation to new hardware and software technologies, ii) limited scalability of the existing tools to incorporate haptic hardware and applications, iii) inflexible authoring capabilities, iv) missing infrastructure for storing, playback and distribution, and v) and unreliable hardware for long term usage.

We propose "Stereohaptics", a framework to create, record, modify, and playback rich and dynamic haptic media using audio based tools. These tools are well established, mainstream and familiar to a large population in entertainment, design, academic, and the DIY communities, and already available for sound synthesis, recording, and playback. We tune these audio-based tools to create haptic media on user's bodies, distribute it to multiple slave units, and share it over the Internet. Applicable to the framework, we introduce a toolkit, the Stereohaptics toolkit, which uses off-the-shelf speaker technologies (electromagnetics, piezoelectric, electrostatic) and audio software tools to generate and embed haptic media in a variety of multisensory settings. This way, designers, artists, students and other professionals who are already familiar with sound production processes can utilize their skills to contribute towards designing haptics experiences. Moreover, using the audio infrastructure, application designers and software developers can create new applications and distribute haptic content to everyday users on mobile devices, computers, toys, game controllers and so on.

## 2. Studio workshop

The goals of this studio is to educate and familiarize attendees (students, artists, designers and specifically the sound media workforce) with the technologies and tools common in the sound design settings, and utilize these techniques to create dynamic haptic experiences. Attendees will go through a number of hands-on activities to familiarize themselves with sound actuation technologies (such as voice coil speakers and subwoofers, piezo actuators, electrostatic speakers), audio interface tools (e.g. puredate, webaudio, Max/msp), sensors (accelerometers, potentiometers, etc) and hardware plugins (keyboard, joysticks, body trackers, etc.), generate haptic media and embed them in applications. For the purpose of this studio, we will focus on virtual and augmented reality scenarios. Attendees will add haptic feedback to events and activities in simple gameplay and educational settings.

### 2.1. Why Stereohaptics?

Many computing devices are already equipped with two (stereo) audio channels linked to the left and right side speakers. We utilize these two channels to excite two actuators. Therefore, the stereo channel of an attendee's computer (or laptop) is directly used for haptic generation. Two, recent research shows that two or more vibrating actuators create a variety of moving illusory percepts on and across the body [1, 2]. Moreover, these illusions are modeled parametrically to control varying the size, speed, direction and quality of haptic effects. We use these models in our toolkit and allow attendees to set attributes of sensation using sliders, knobs, dials, switches, and/or with an incoming data stream. These effects can be tuned to events, activities and audio-visual content of the games to produce coherent multisensory experience for users. Finally, the two-channel audio/haptic framework can be scaled up to accommodate multiple actuators, such as in a grid configuration of vibrating actuators, and allows users to create surround haptics experiences [4].

### 2.2. Architecture

The architecture of a typical audio framework and that of Stereohaptics is shown in Figure 1. A laptop computer runs an audio synthesizer tool that outputs analog waveform from the audio-output (speaker) channel and senses analog measurements through

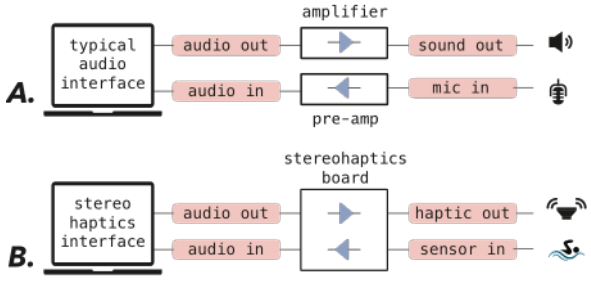


***Figure 1.*** *Architecture of a typical audio framework (top) and the Stereohaptics framework (bottom)*

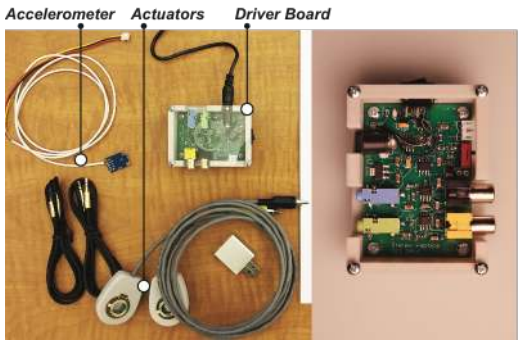


***Figure 2.*** *The Stereohaptics Toolkit used in workshop*

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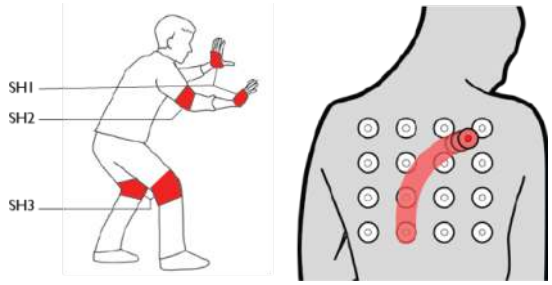


***Figure 3.*** *Scalability of the Stereohaptics Toolkit (a) multiple Stereohaptics units (left) and (b) Stereohaptics with multiple input-output.*

the audio input (microphone) channel. These input-output signals are conditioned through the Stereohaptics hardware board that comprises of common operational and audio amplifier circuitry. The output of the board is connected to off-the-shelf speakers mounted on a user's body, and the input to the board is connected to an analog sensor measuring the user's activity. The audio input channel can be stored, modified and routed to the audio output channel or to other communication channels connected to the laptop computer.

### 2.3. Schedule

The studio will host 16 attendees in two 1.5-hour sessions.

***Session 1: Introduction and familiarity (1 hours 30 min)***

- Introduction: Haptics perception and technologies. (15 min)
- Introduction of Stereohaptics toolkit, its main components, actuators and tools. (5 min)
- Hands on activity: setup audio systems on personal laptop and familiarity with various haptic technologies. (30 min)
- Introduction to haptic illusions and playing with its control parameters and exploring locations on the body (20 min.)
- Hands on activity: set up sensors and use them to control haptic effects. (20 min)

**Break (15 minutes)**

***Session 2: Creative gameplay (1 hours 30 min)***

- Group activity: Attendees are divided into groups of four with mix talent and background. Each group will be provided with a visual game, hardware and tools, and a computing platform with relevant software and plugins. Each group will add haptic media to the events and activities in the games. (65 min)
- Presentations: Each group will pitch the idea and present it to all attendees of the workshop, 5 min each. (20 min)
- Conclusion: Short survey and goodbye (5 min)

### 2.4. Use cases and applications

Stereohaptics toolkit allows haptic design more accessible to designers and artists. It reaches out to the population of people who already possesses skills to design audio and sound content. Without acquiring new skills, these folks will generate and design haptic feedback. Specifically, this will contextualize visual and auditory content in Virtual Reality. Furthermore, Stereohaptics opens up the possibility of easy distribution and broadcasting of haptic media. As all haptic content created with Stereohaptics is in the audio format, it allows users to playback and share haptic content on computing devices already equipped with the input-output audio channels.

***Possible use case applications of the toolkit feature***

Enhanced multimedia playback

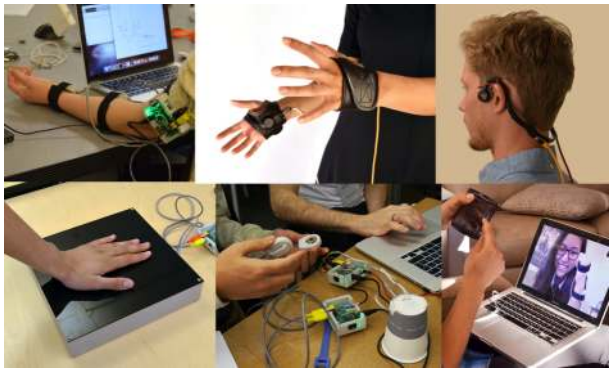

***Figure 4.*** *Applications of the Stereohaptics framework.*

Interactive gameplay

Bringing touch into audio-visual immersion

Social exchanged through networks (e.g. through Skype)

### 2.4 Learning goals

Participants will first learn *haptics by experience*: they will feel how it affects their sensations, rather than having to guess or imagine the effects of such stimuli by watching video tutorials, where haptics is transduced by audio or visual workarounds and artifacts. After the studio workshop, attendees will have gained experience on how to design and prototype haptic media using off-the-shelf hardware and software.

More about the toolkit, course material and up to date information on Stereohaptics, please visit: www.stereohaptics.com.

Our toolkit is scalable, 1) by utilizing multiple Stereohaptic units in a single framework (Fig 3, left) and 2) by using a multichannel I/O audio device supporting more audio inputs and outputs (Fig 3, right). The Stereohaptics framework is broad and used to create a wide variety of user experiences as shown in Figure 4.

## 3. Previous workshops and what's new in Siggraph

This studio workshop builds upon a series of previous iterations: the first installment of Stereohaptics has been hosted at the ACM TEI 2016 conference on February 14th 2016 [4]. A subsequent instance of Stereohaptics was hosted at the Web Audio Conference 2016 on April 6th 2016 [5], with a shift towards web audio technologies bridging designers from audio-, visual- and haptics-design communities through a shared web-based set of protocols and standards. In the Siggraph 2016 Studio, we extend the use of Stereohaptics in Virtual Reality and Augmented Reality settings, extend the library of actuators and sensors, and target the audience for Siggraph that are closely related to educational, gaming and entertainment industries.

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