Rapid-Prototype Robot Competition

Abstract

In this project, you are going to design, build, and prototype a working bridge-crossing robot. The robot design is under given constraint and will fulfill given tasks at the competition. Please read this document THOROUGHLY before starting on the project!!!

Design Constraints and Requirements

The basic function of your robot is to move along a “bridge” (Figure 1). The bridge is about 1 meter long and is wrapped with a layer of soft foam. You will try to move your robot from the start — one end of the tube to the other end, then come back. The bridge is installed in Sandbox and you are free to test your design any time before the competition day.

Figure 1: Bridge setup in Sandbox.
Robot Competition

Tube
Robot Competition

Motor
Vibration feedback

eccentric rotating mass motors (ERM)
Shaftless vibration motors

K. J. Kuchenbecker
Shaftless vibration motors

Frequency and magnitude are often coupled.
Linear resonant actuator (LRA)
Linear resonant actuator

**MagnetIO:** Passive yet Interactive Soft Haptic Patches Anywhere

Alex Mazursky, Shan-Yuan Teng, Romain Nith, Pedro Lopes
Haptics for VR
CMSC730 | Huaishu Peng | UMD CS
Small taste of VR
Haptics Research
Visual rendering is not enough to offer immersive experience
Sight vs Touch

Sight
- centralized
- broad
- passive
- cognitive

Touch
- distributed
- narrow
- active
- physical

Tom Igoe
Current VR Controllers

Vibration
How to add haptic feedback to VR systems

If you are going to design a system to offer full body physical feedback, how will you do it?
Pure vibrotactile stimulation ignores the role of sustained or distributed force in conveying realism.

In the real world, very few experiences are conveyed by vibration alone.
An alternative idea?
An alternative idea?

Offer both **vibration** and **variable force feedback** with pneumatic haptic wearable system.
How are you going to build such system? What are the possible hardware components?
Will it work? What would be the next step with the initial prototype?
Localization User Study

to determine users’ ability to perceive the location of the various inflatable compartments in the haptic pneumatic wearable.

There was a tendency to feel the lower arm location toward the wrist. Shoulder locations were biased toward the upper back rather than centered on top of the shoulders.

Free Magnitude User Study

to determine how perceived pressure magnitude was related to inflation magnitude of the various air compartments in the Jacket.
Haptic Effect Editor
to easily create and control haptic feedback sequences

Inflation Pressure [psi]
Target Force [N]
Feedback Duration [ms]
Target Frequency [Hz]
Bags To Inflate
Simulate impact in VR
Impacto: Simulating Physical Impact by Combining Tactile Stimulation with EMS

**ABSTRACT**
We present Impacto, a device designed to render the haptic sensation of hitting and being hit in virtual reality. The key idea that allows the small and light impact device to simulate a strong hit is that it decomposes the stimulus it renders the tactile aspect of being hit by tapping the skin using a solenoid. It adds impulse to the hit by thrusting the user's arm backwards using electrical muscle stimulation. The device is self-contained, wireless, and small enough to be wearable on the user's back, and it allows the user to experience the physical impact of virtual objects as if they were real. People are therefore able to walk around freely in a virtual environment. The device is of generic shape, allowing it to also be worn on kneecaps to enhance the experience of kicking, or strapped onto hips, such as a baseball bat. We demonstrate how to assemble multiple impact units into a single haptic suit. Participants of our study rated the suits we used with Impacto's combination of a solenoid hit and electrical muscle stimulation as more realistic than either technique in isolation.

**ACM Classification:** H.5.2 [Information interfaces and presentation]; User Interfaces: Input Devices and Strategies; Interaction Styles

**Keywords:** haptics, impact, virtual reality, mobile, wearable, electrical muscle stimulation, solenoid, force feedback

**INTRODUCTION**
The objective of virtual reality systems is to provide an immersive and realistic experience [20]. While research in virtual reality has traditionally focused on the visual and auditory senses, many researchers argue that the next step towards immersion must include haptics, i.e., to allow users to experience the physical aspect of the world [12, 23, 32]. In this paper, we focus on one specific category of haptic sensation, namely impact, i.e., the sensation of hitting or being hit by an object. Impact plays a key role in many sports simulations such as boxing, fencing, football, etc. The objective of Impacto is to decompose the impact stimulus into two sub-stimuli, each of which we can render effectively.

**Figure 1:** Impacto is designed to render the haptic sensation of hitting and being hit. The key idea that allows the small impact device to simulate a strong hit is that it decomposes the stimulus into the tactile aspect of being hit by tapping the skin using a solenoid, which adds impulse to the hit by thrusting the user's arm backwards using electrical muscle stimulation. Both techniques are small enough to be wearable on the user's back.

In this paper, we propose a different approach. The key idea is to decompose the impact stimulus into two sub-stimuli, each of which we can render effectively.

**UIST 2015**
Lopes et.al.
The sensation of impact can be decomposed to contact + impulse
The sensation of impact can be decomposed to contact + impulse
the **impulse** component is rendered using **electrical muscle stimulation**

it thrusts the arm backwards
the combination is perceived as the **impact** caused by a moving mass against the body

How can you build something like this?
User study to evaluate the core idea -> decomposing an impact’s haptic feedback into a tactile component (solenoid) and an impulse component (EMS)

VR view

With no EMS no Solenoid
With only EMS
With only Solenoid
With both
How to add physical feedback to VR systems
How to add physical feedback to VR systems
What do you see here? Any problem with exoskeleton hand solution?
DextrES: Wearable Haptic Feedback for Grasping in VR via a Thin Form-Factor Electrostatic Brake

Ronan Hinchet$^1$, Velko Vechev$^2$, Herbert Shea$^1$, Otmar Hilliges$^2$

$^1$EPFL, $^2$ETH Zurich
Electrostatic braking mechanisms

a) hand strip  

Top view  

Overlap area A  

Side view  

100 μm  

Dielectric film (PI)  

Back hand strip electrode + adhesive  

Finger strip electrode  

13 μm  

100 + 32 μm  

b) Free  

no charges  

very low friction  

sliding  

0V  

c) Locked  

electrostatic attraction  

very high friction  

no sliding
PuPoP: Pop-up Prop on Palm for Virtual Reality

always-available physical proxies for generating grasping haptic feedback in VR.

Also pneumatic system, but hands-worn
Pop-up Prop on Palm (PuPoP) is a pneumatic shape-proxy interface worn on the palm.

What problem does this paper trying to solve?
Pop-up Prop on Palm (PuPoP) is a pneumatic shape-proxy interface worn on the palm.

How does this paper solve it?
What are the potential challenges for this solution?
There will be limited shapes that can be rendered, how to decide what shape to generate?
# Identify Primitive Shapes

## VR Game Objects

111 hand-held objects found in 20 game trailers.

<table>
<thead>
<tr>
<th>Shape</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sphere</td>
<td>balls in sports, snowballs, bombs, and grenades, etc.</td>
</tr>
<tr>
<td>Cylinder</td>
<td>rackets, bottles, hammers, and swords, etc.</td>
</tr>
<tr>
<td>Box</td>
<td>sandwiches, books, milk package, and camera, etc.</td>
</tr>
<tr>
<td>Disk</td>
<td>Frisbee</td>
</tr>
<tr>
<td>Cone</td>
<td>carrot</td>
</tr>
<tr>
<td>Hemisphere</td>
<td>bowl</td>
</tr>
<tr>
<td>Others</td>
<td>scissors, clothes, chain, fish, cat, etc.</td>
</tr>
</tbody>
</table>
Props on Palm

Prop Stacking

Shape Stacking

Size Stacking
We demonstrate two fantasy VR applications using PuPoP
How to add physical feedback to VR systems
Sensory homunculus

mapping the human somatosensory cortex