Robot Competition

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.

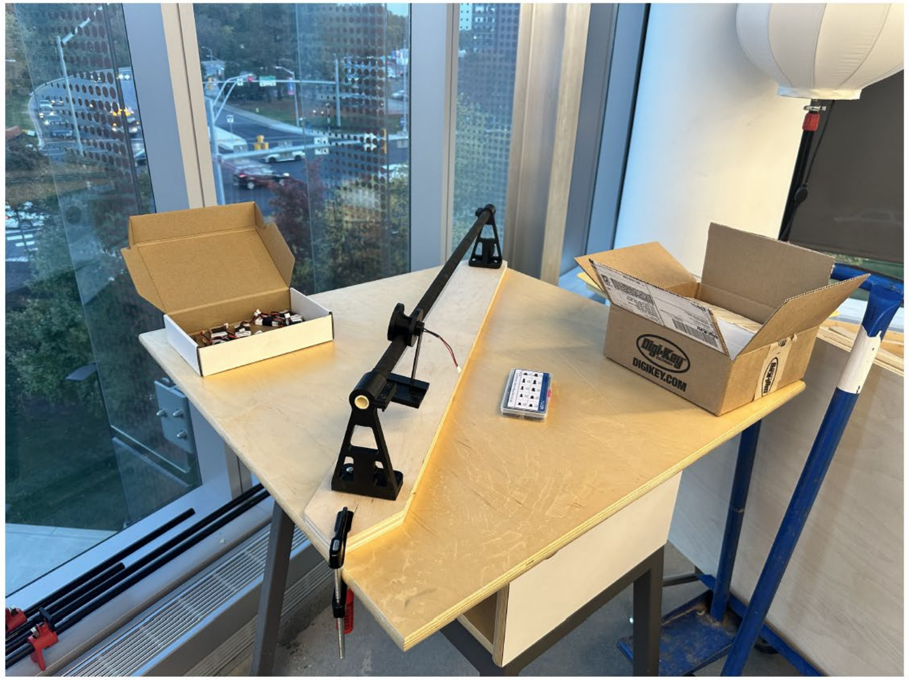


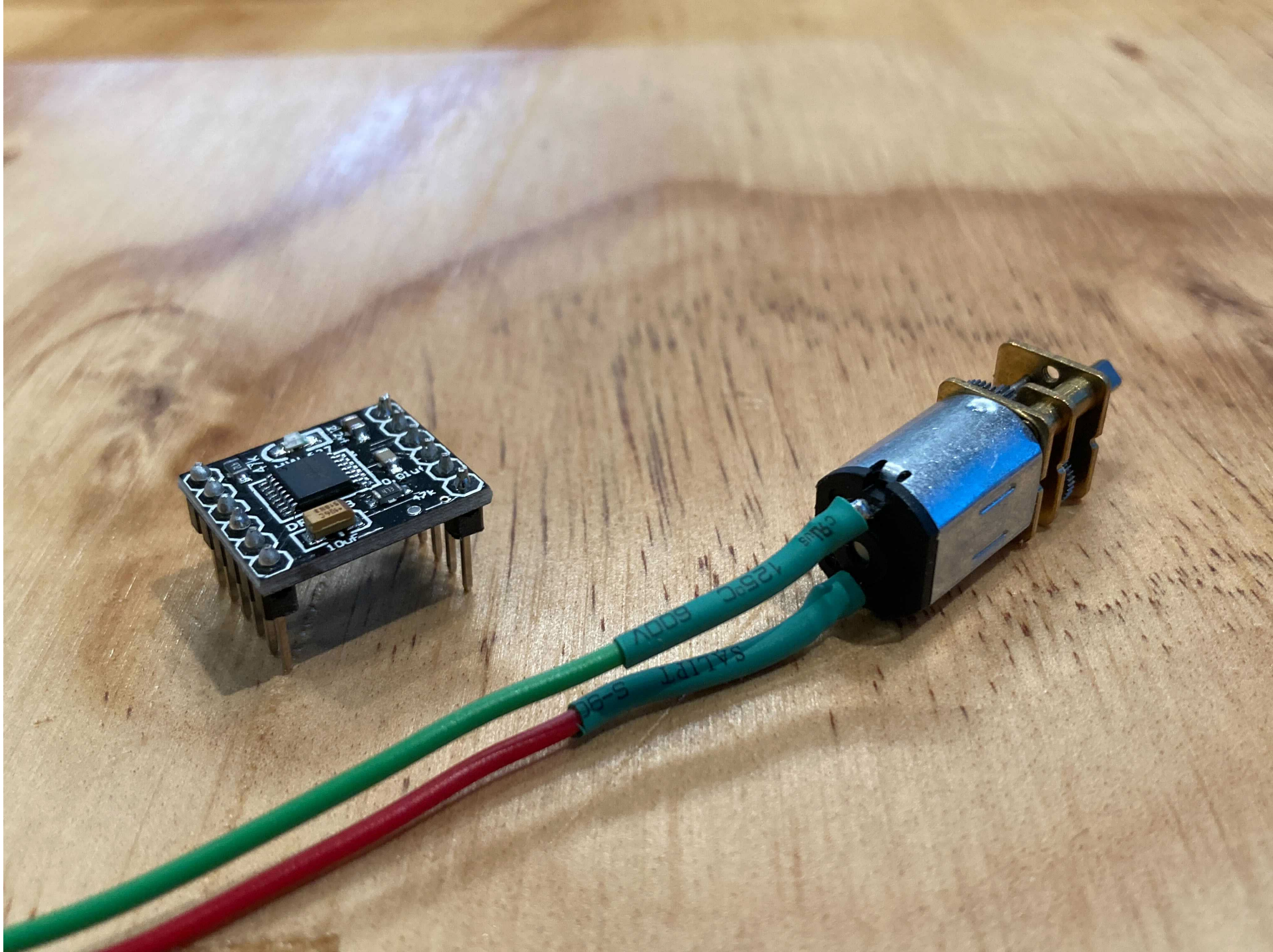
Figure 1: Bridge setup in Sandbox.

Robot Competition

Tube

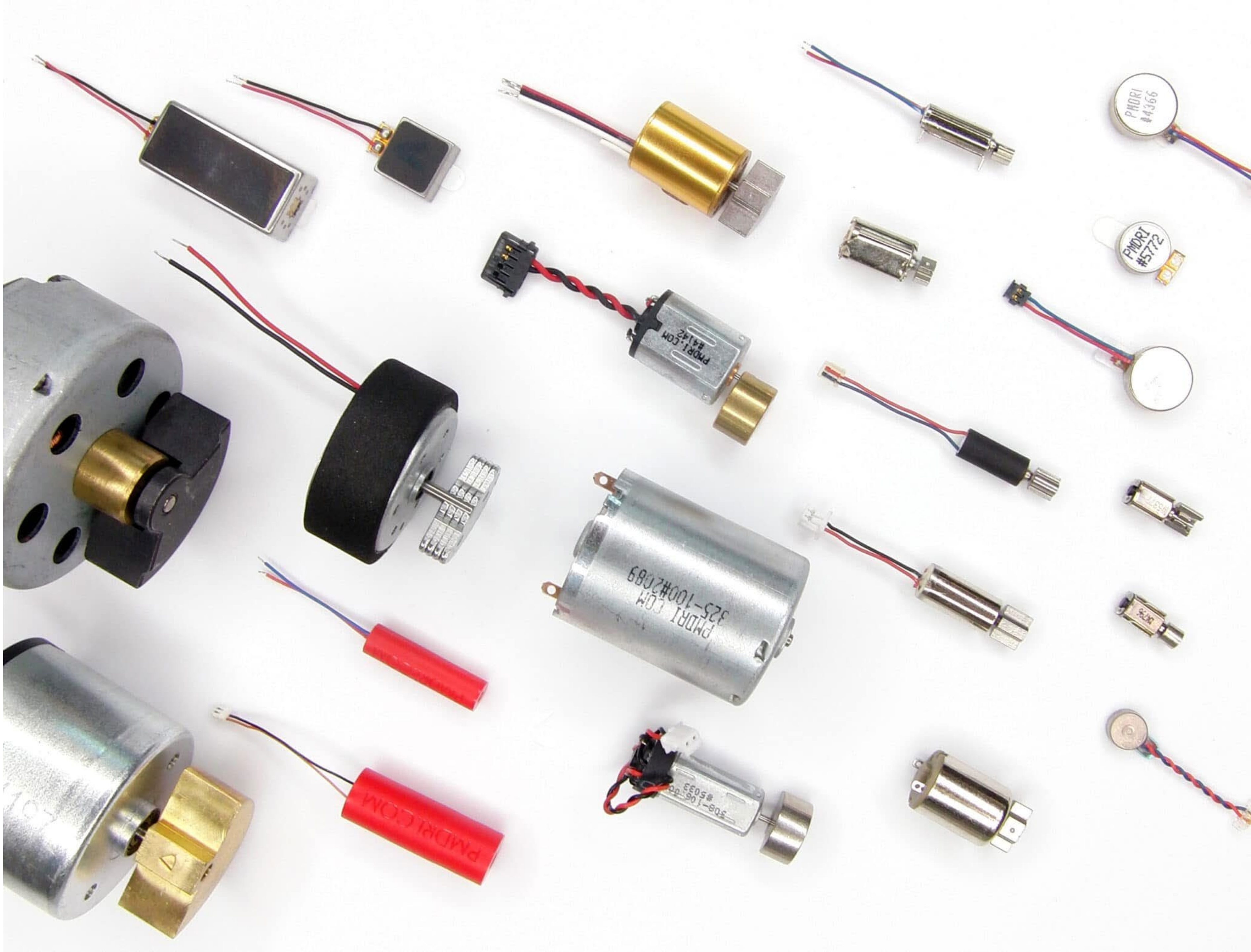
Robot Competition

Motor



Vibration feedback

eccentric rotating mass motors (ERM)



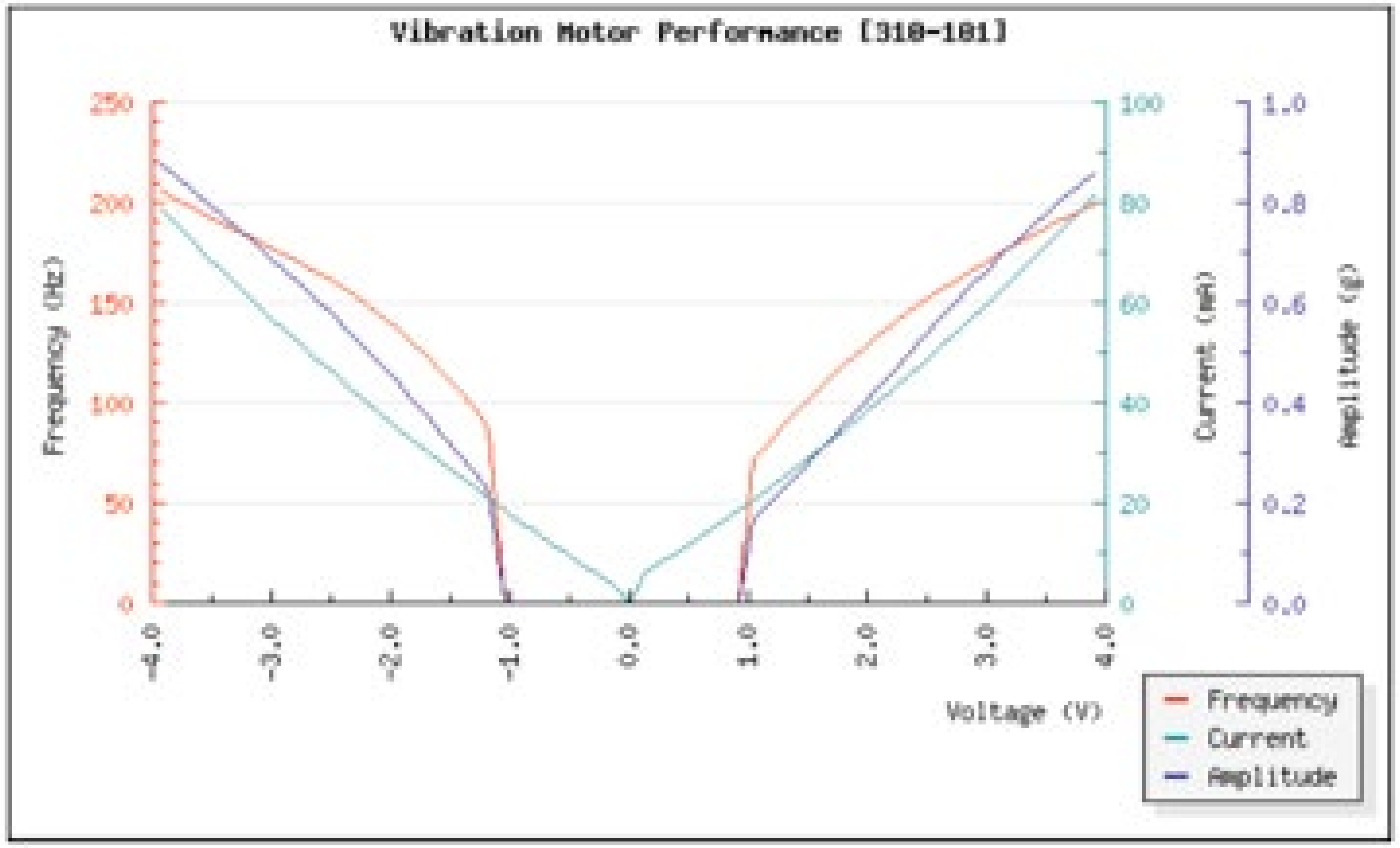
Shaftless vibration motors

www.precisionmicrodrives.com

Three pole DC motor
with eccentric coil

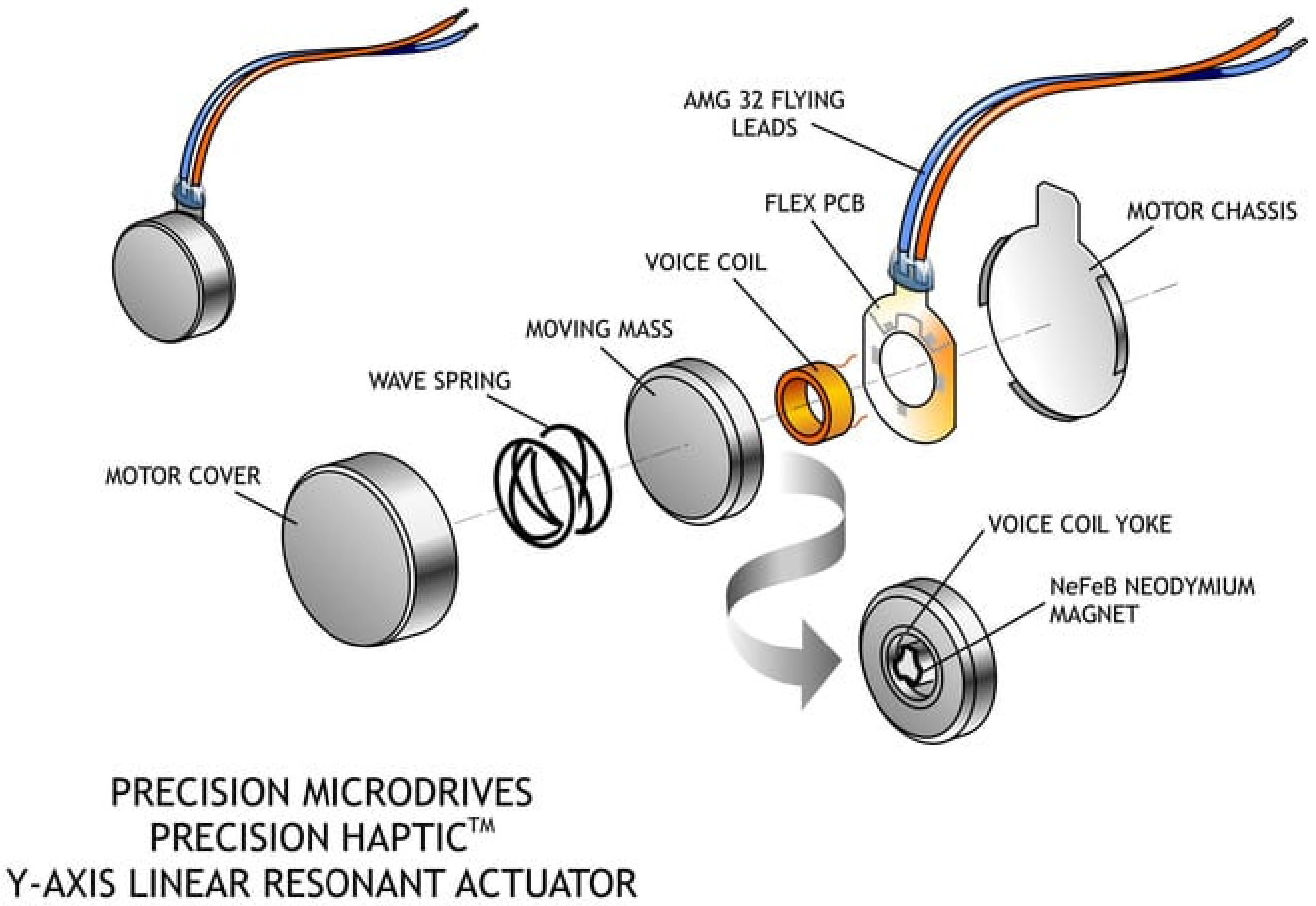
K. J. Kuchenbecker

Shaftless vibration motors



Frequency and magnitude are often coupled.

Linear resonant actuator (LRA)



Linear resonant actuator

CHI 21
Mazursky et.al.

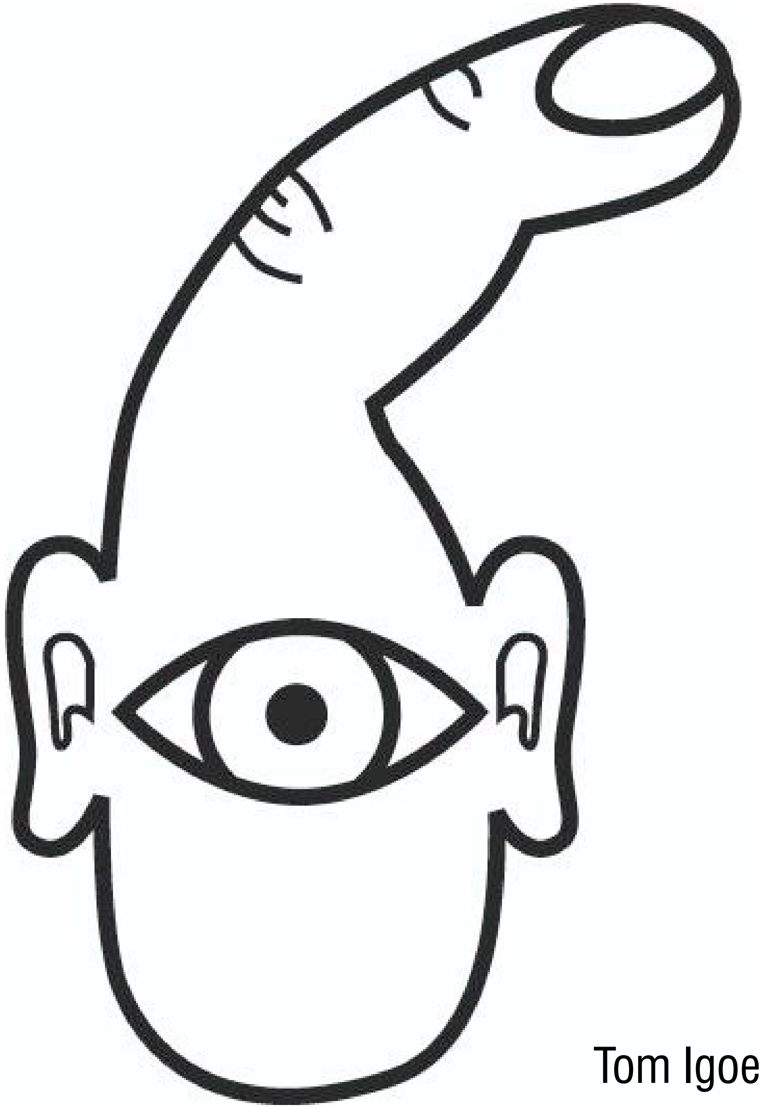
Haptics for VR

CMSC730 | Huaishu Peng | UMD CS


Small taste of VR
Haptics Research


Visual rendering is not enough to offer immersive experience

Sight vs Touch



Touch

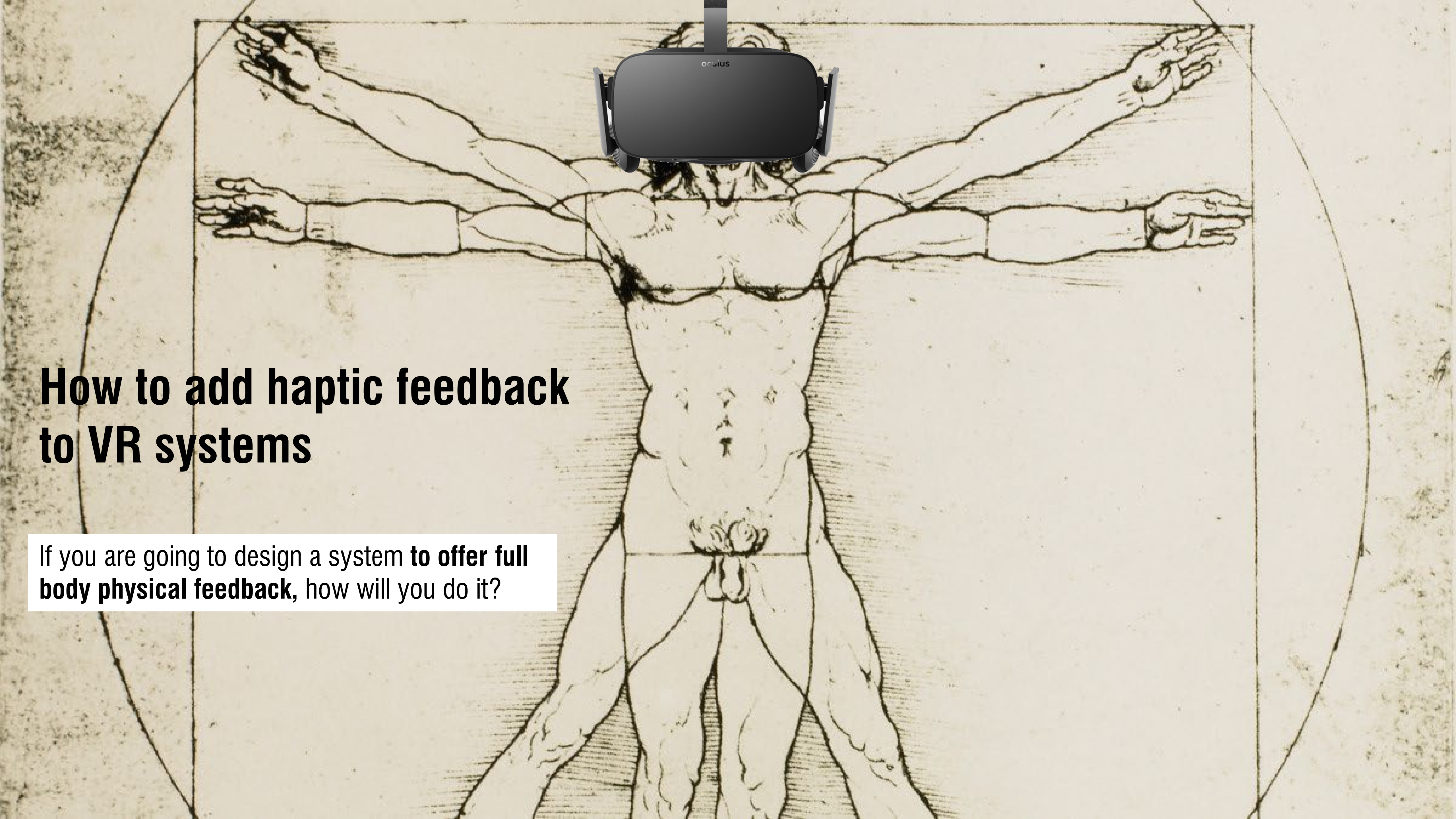
distributed
narrow
active
physical

Sight

centralized
broad
passive
cognitive

Tom Igoe


Current VR Controllers
Vibration
SONY
SONY
VIVE
VIVE
VR SOURCE



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.

Hardlight VR Suit

Failed Kickstarter Campaign

An alternative idea?

An alternative idea?

Offer both **vibration** and **variable force feedback** with pneumatic haptic wearable system

Force Jacket: Pneumatically-Actuated Jacket for Embodied Haptic Experiences

Force Jacket: Pneumatically-Actuated Jacket for Embodied Haptic Experiences

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ABSTRACT
Immersive experiences seek to engage the full sensory system in ways that words, pictures, or touch alone cannot. With respect to the haptic system, however, physical feedback has been provided primarily with handheld tactile experiences or vibration-based designs, largely ignoring both pressure receptors and the full upper-body area as conduits for expressing meaning that is consistent with sight and sound. We extend the potential for immersion along these dimensions with the Force Jacket, a novel array of pneumatically-actuated airbags and force sensors that provide precisely directed force and high frequency vibrations to the upper body. We describe the pneumatic hardware and force control algorithms, user studies to verify perception of airbag location and pressure magnitude, and subsequent studies to define full-torso, pressure and vibration-based feel effects such as punch, hug, and snake moving across the body. We also discuss the use of those effects in prototype virtual reality applications.

ACM Classification Keywords
H.5.2 User Interfaces: Haptic I/O, Interaction Styles

Author Keywords
Haptics; Pneumatic Actuation; Force Feedback; Vibrotactile; Wearable; Virtual Reality

INTRODUCTION
The creation of immersive virtual and augmented realities relies on engaging all of the senses. Although the fields of visual effects and sound effects have long histories and a wide variety of technologies to contribute, the inclusion of haptic feedback in such experiences is an area of recent growth. Many of the new haptic technologies being explored focus on feedback to the hand [4], fingertip[3], and hand-held tools[19]. However, as VR and AR applications increasingly expand to full-body spatial experiences, tactile sensation must expand with them. Similarly, most current approaches are limited to expressing motion and vibrational feedback through vibrotactile stimulation [11, 12, 13], ignoring the role of sustained or distributed force in conveying realism. Even in the real world, very few experiences are conveyed by vibration alone.

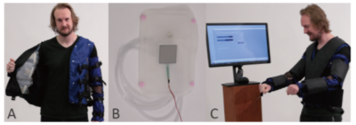


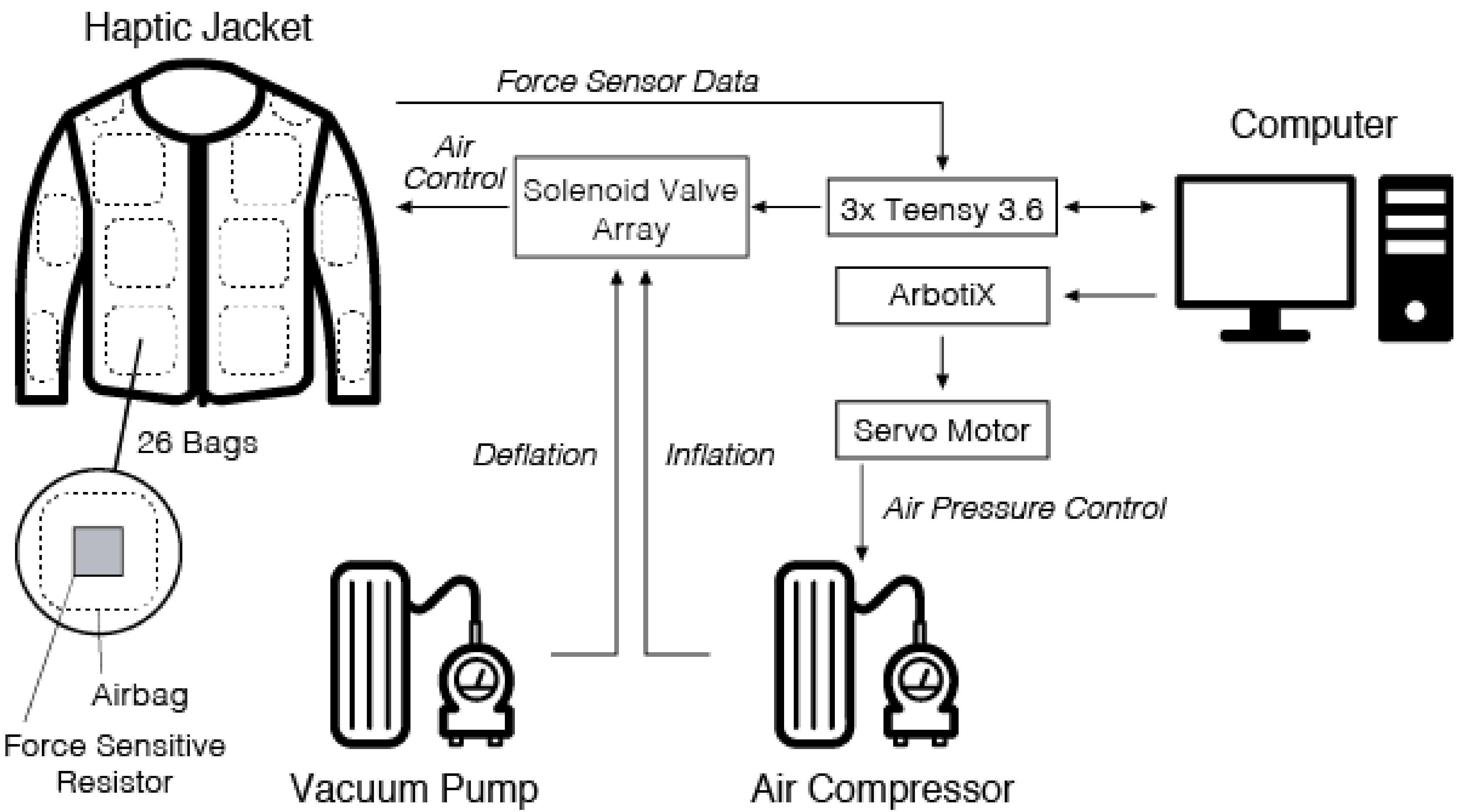
Figure 1. Force Jacket - A: Appearance of Force Jacket; B: Individual airbag with force sensitive resistor; C: User study set-up.

To move toward more expressive technology, a wearable haptic interface, the Force Jacket, that has both vibrotactile and variable force feedback for the upper body and arms was introduced (Figure 1A). A software-controlled valve system inflates and deflates each of 26 bags independently to provide targeted forces and vibrotactile stimulation against each part of the upper body relative to force sensitive resistors on each bag (Figure 1B). An initial user study evaluated users' perception of airbag localization and magnitude where users experienced seven levels of pressure (1.6 - 8.5 N) on 26 upper body locations, generating a perceptually reliable range of values (Figure 1C). The values formed the basis for a second study in which users authored *feel effects* such as punch, hug, and a snake moving across the body, based on the paradigm in [12]. Finally, we derive canonical values from the user-authored data for a subset of the feel effects to demonstrate the capability of the Force Jacket in several applications.

CHI 2018

Delazio et.al.

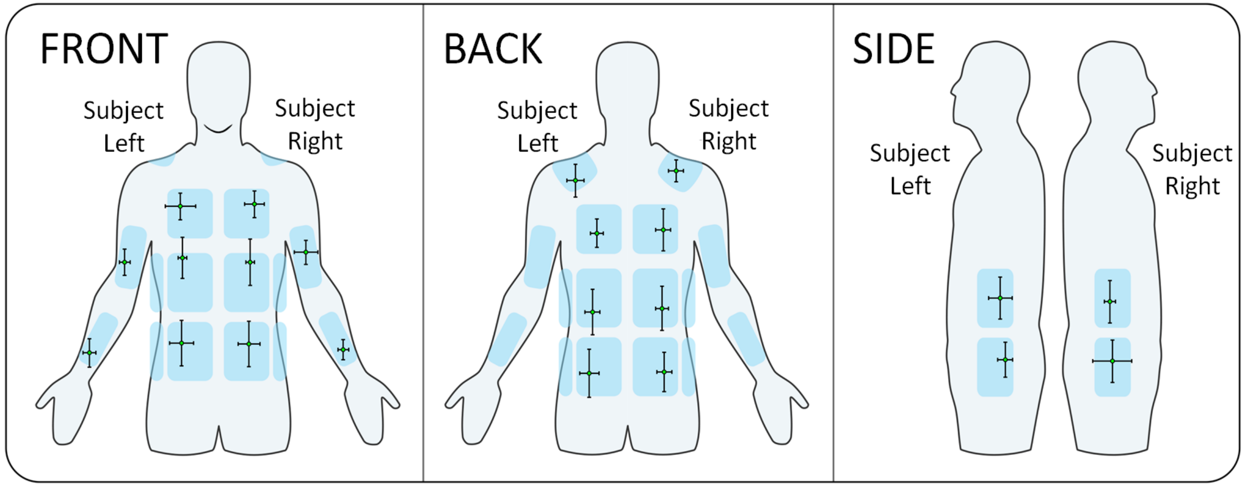
How are you going to build such system? What are the possible hardware components?


Haptic Jacket
Force Sensor Data
Computer
Air Control
Solenoid Valve Array
3x Teensy 3.6
ArbotiX
Servo Motor
26 Bags
Deflation
Inflation
Air Pressure Control
Airbag
Force Sensitive Resistor
Vacuum Pump
Air Compressor

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.



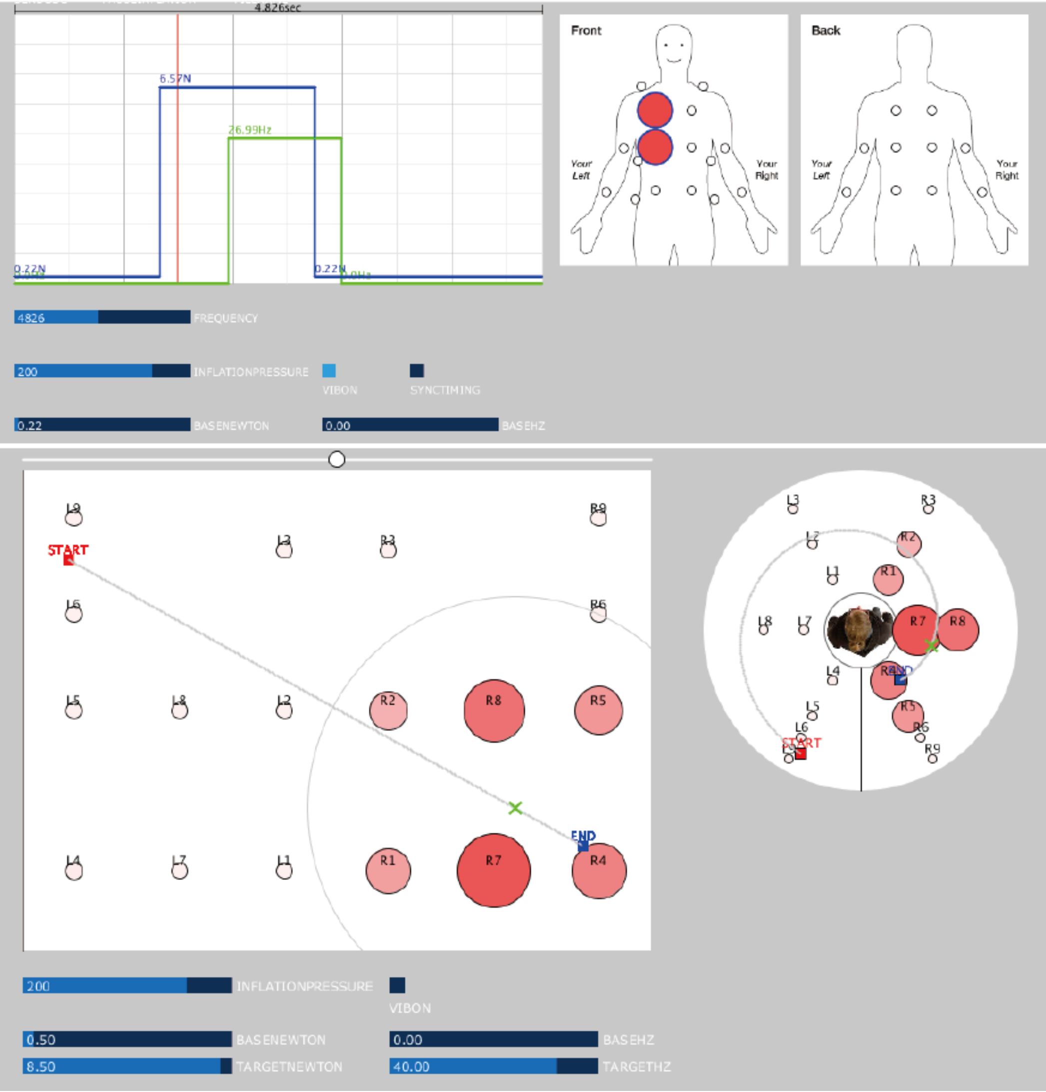
There was a tendency to feel the lower arm location toward the wrist. Shoulder locations were biased toward the upper back rather than centered on top of the shoulders.

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

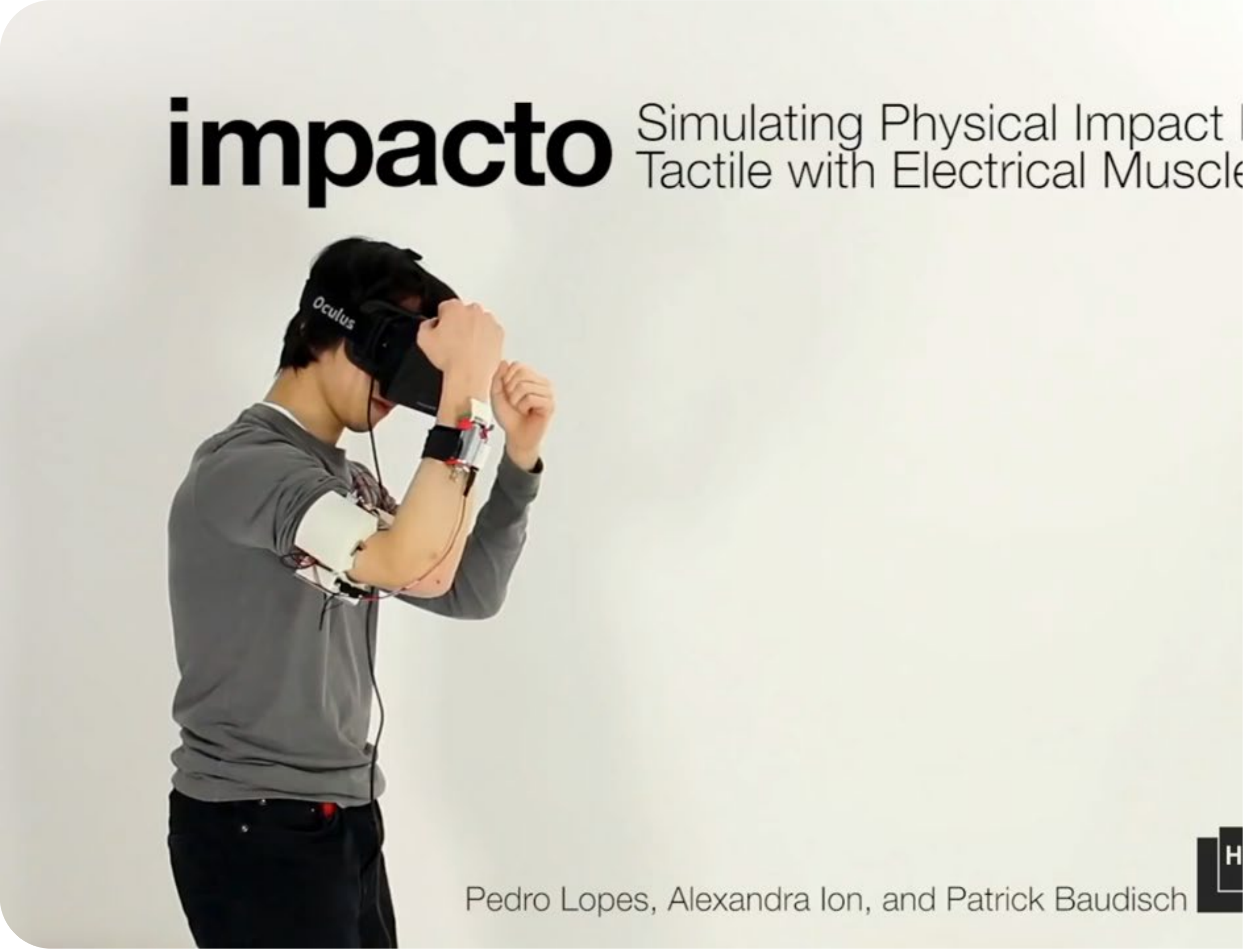


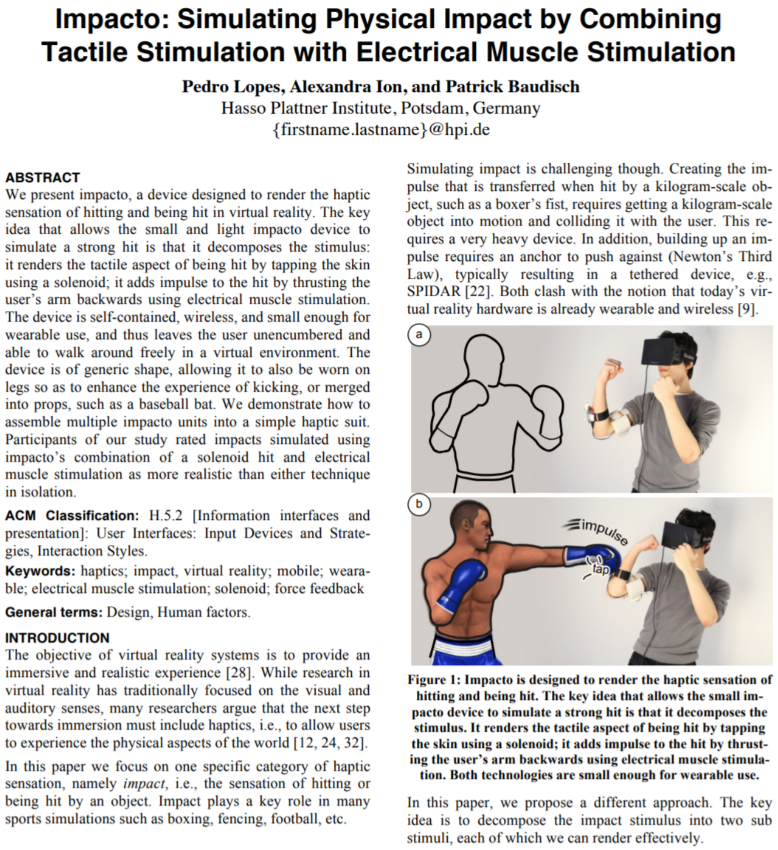
Inflation Pressure [psi]
Target Force [N]
Feedback Duration [ms]
Target Frequency [Hz]
Bags To Inflate

Applications


Oculus
Simulate **impact** in VR

Impacto: Simulating Physical Impact by Combining Tactile Stimulation with EMS





Impacto: Simulating Physical Impact by Combining Tactile Stimulation with Electrical Muscle Stimulation

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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 impacto 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 for wearable use, and thus leaves the user unencumbered and able to walk around freely in a virtual environment. The device is of generic shape, allowing it to also be worn on legs so as to enhance the experience of kicking, or merged into props, such as a baseball bat. We demonstrate how to assemble multiple impacto units into a simple haptic suit. Participants of our study rated impacts simulated using 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

General terms: Design, Human factors.

INTRODUCTION
The objective of virtual reality systems is to provide an immersive and realistic experience [28]. 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 aspects of the world [12, 24, 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.

Simulating impact is challenging though. Creating the impulse that is transferred when hit by a kilogram-scale object, such as a boxer's fist, requires getting a kilogram-scale object into motion and colliding it with the user. This requires a very heavy device. In addition, building up an impulse requires an anchor to push against (Newton's Third Law), typically resulting in a tethered device, e.g., SPIDAR [22]. Both clash with the notion that today's virtual reality hardware is already wearable and wireless [9].

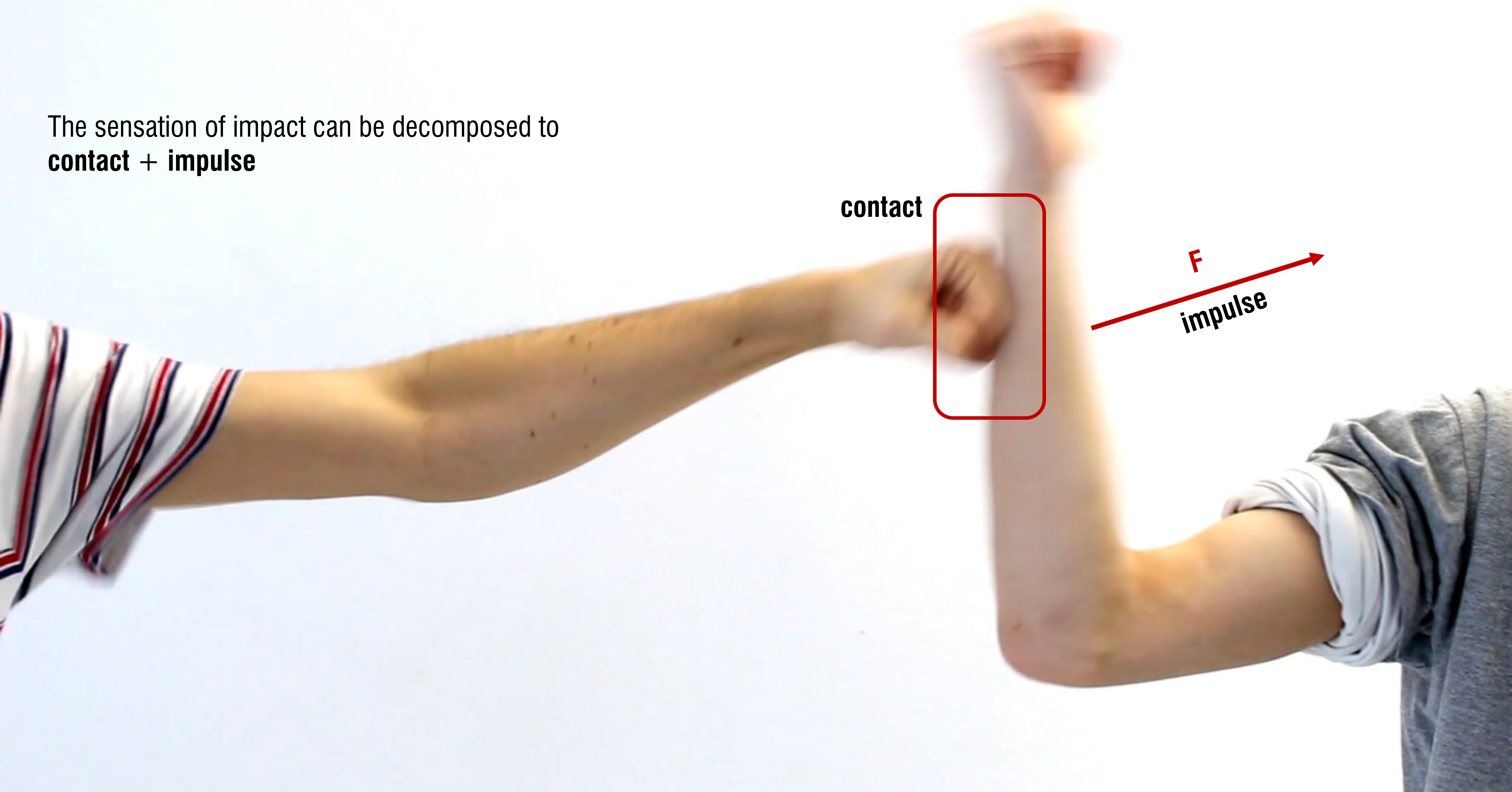
Figure 1: Impacto is designed to render the haptic sensation of hitting and being hit. The key idea that allows the small impacto device to simulate a strong hit is that it decomposes the stimulus. It renders the tactile aspect of being hit by tapping the skin using a solenoid; it adds impulse to the hit by thrusting the user's arm backwards using electrical muscle stimulation. Both technologies are small enough for wearable use.

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.

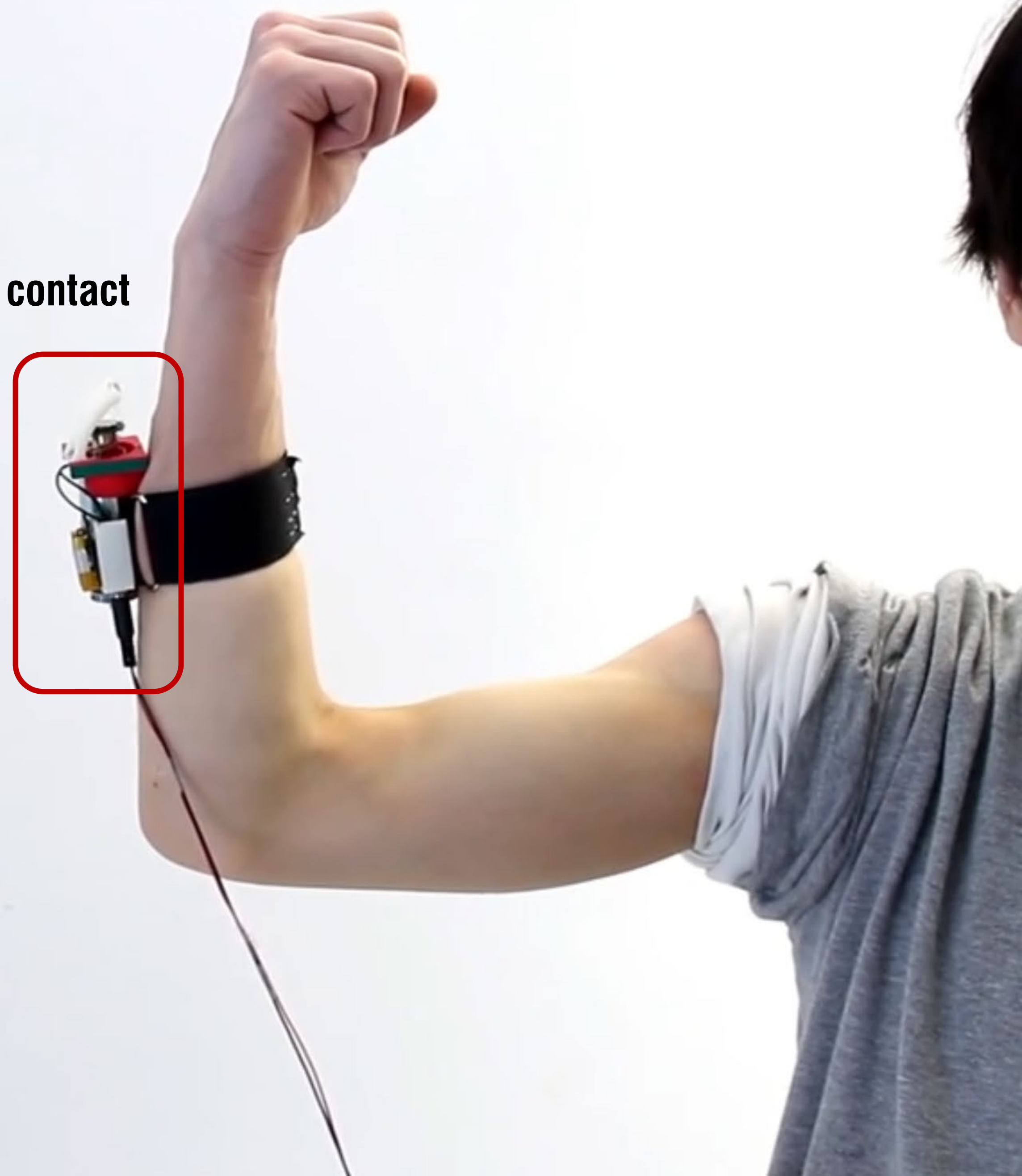
UIST 2015

Lopes et.al.

The sensation of impact can be decomposed to
contact + impulse

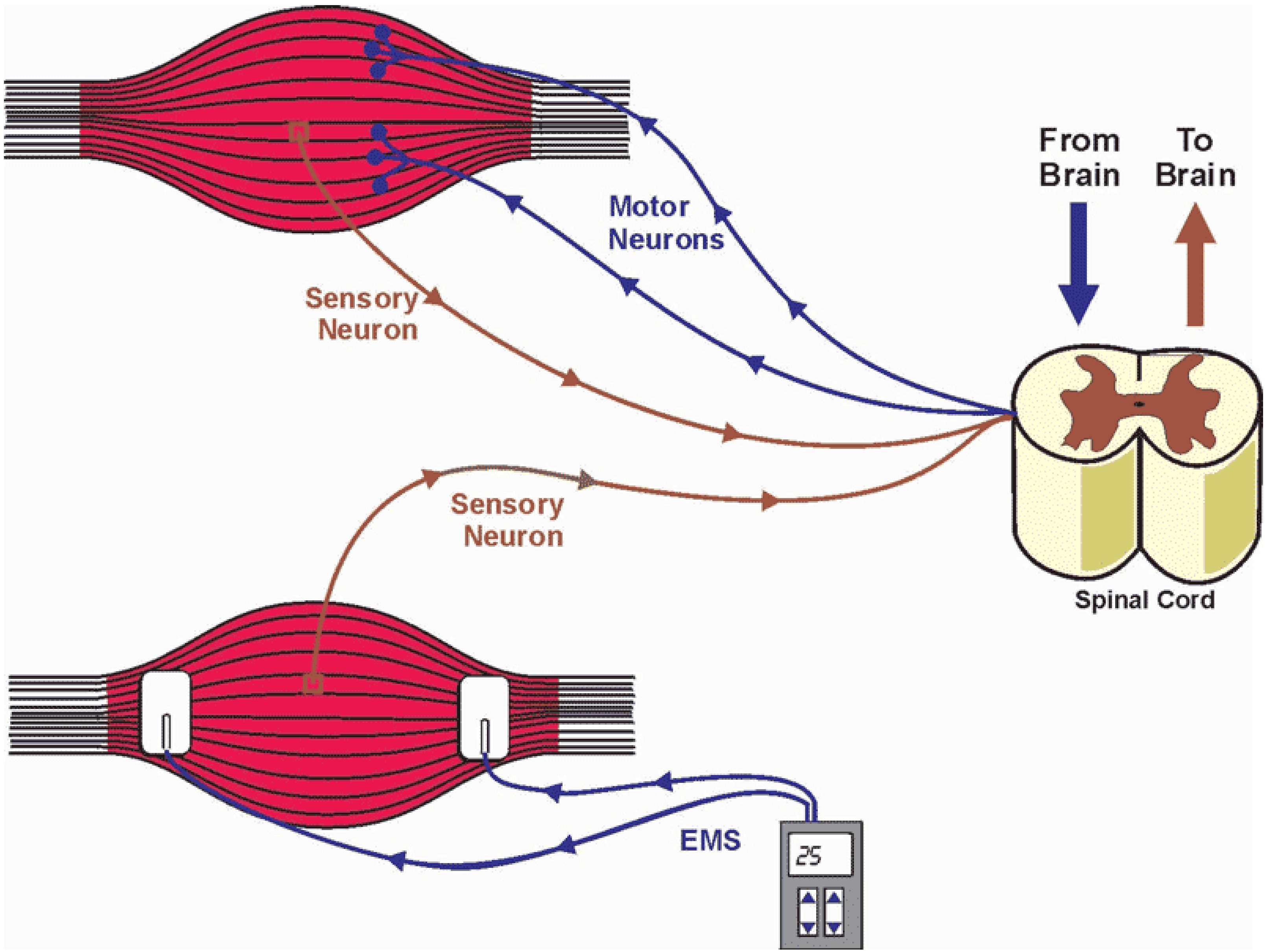


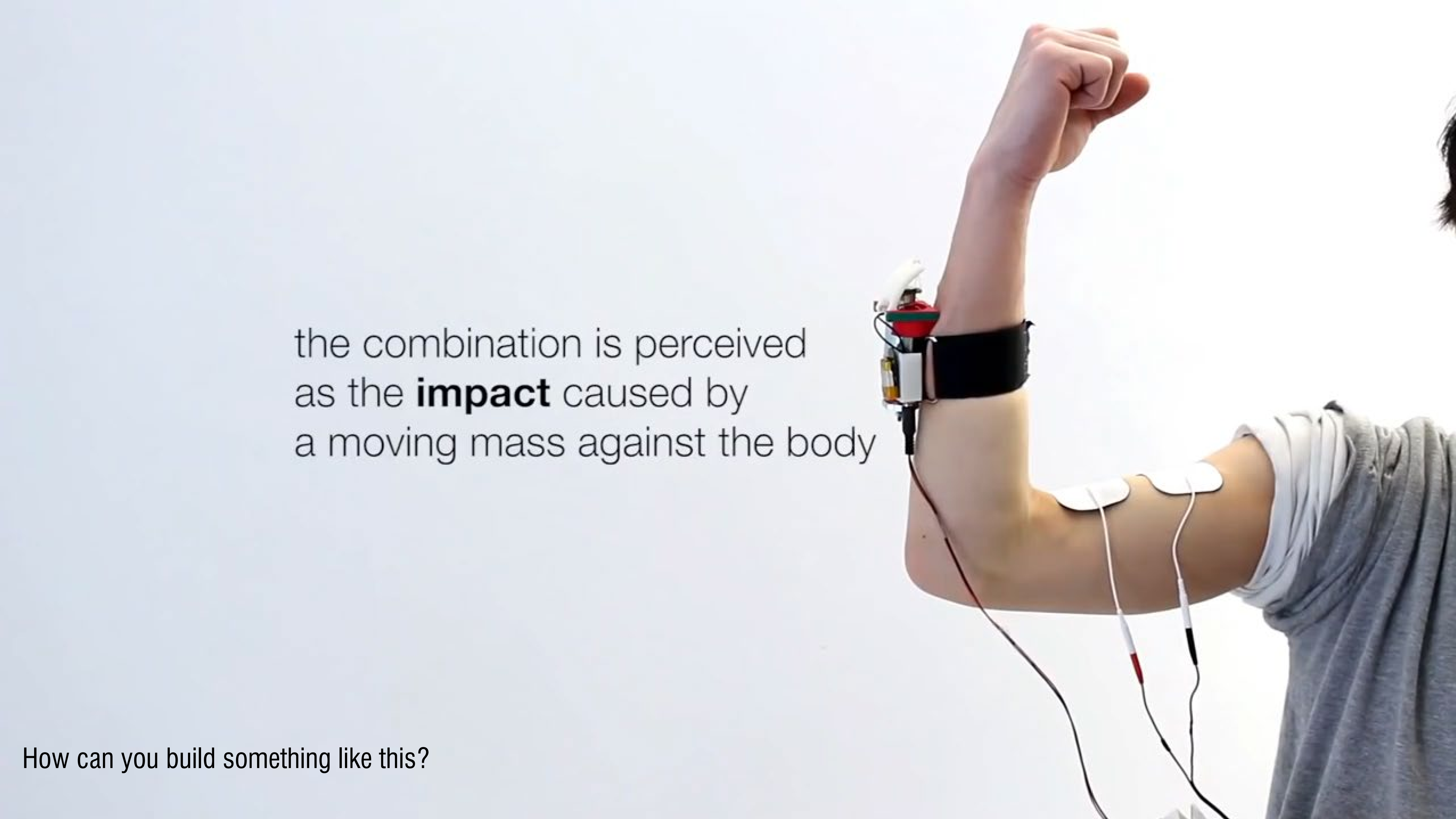
The sensation of impact can be decomposed to
contact + impulse



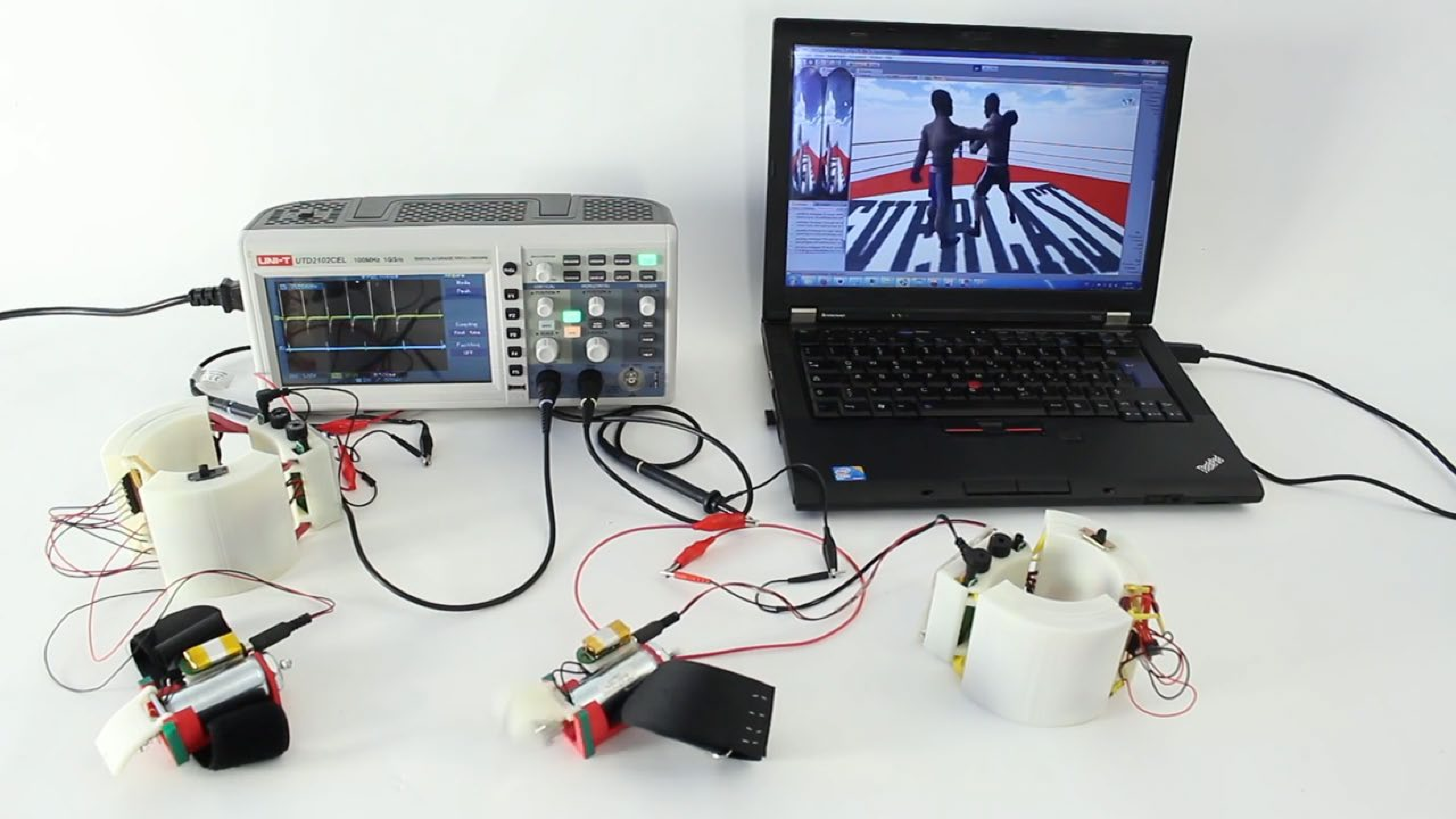
the **impulse** component
is rendered using
electrical muscle stimulation

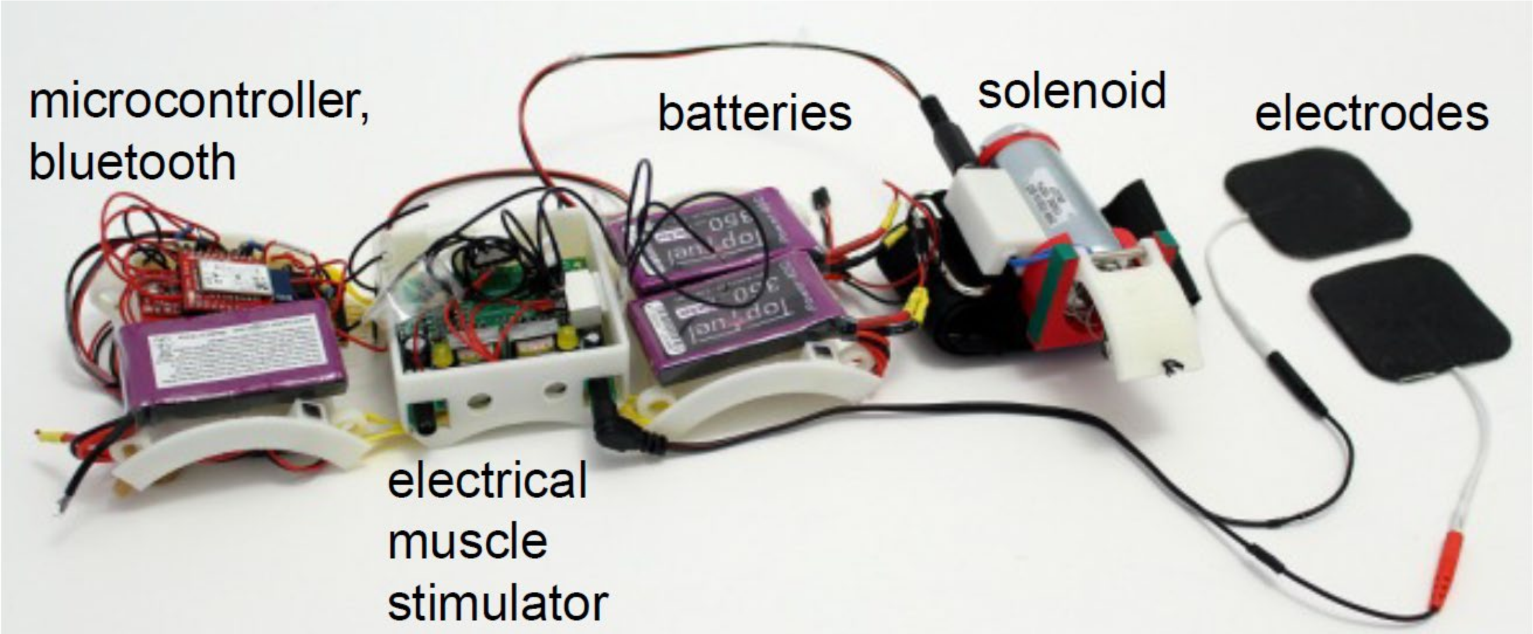
it thrusts the arm backwards

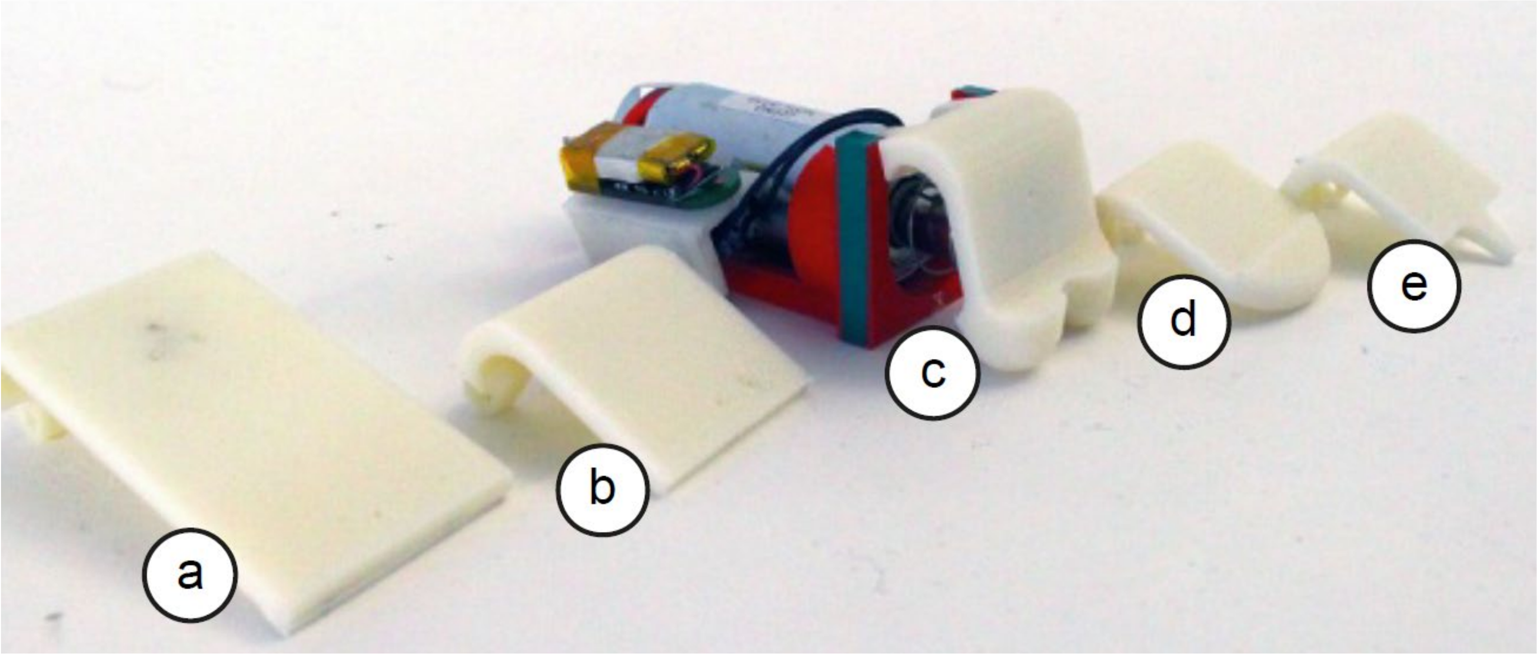

From Brain
To Brain
Motor Neurons
Sensory Neuron
Sensory Neuron
Spinal Cord
EMS
25



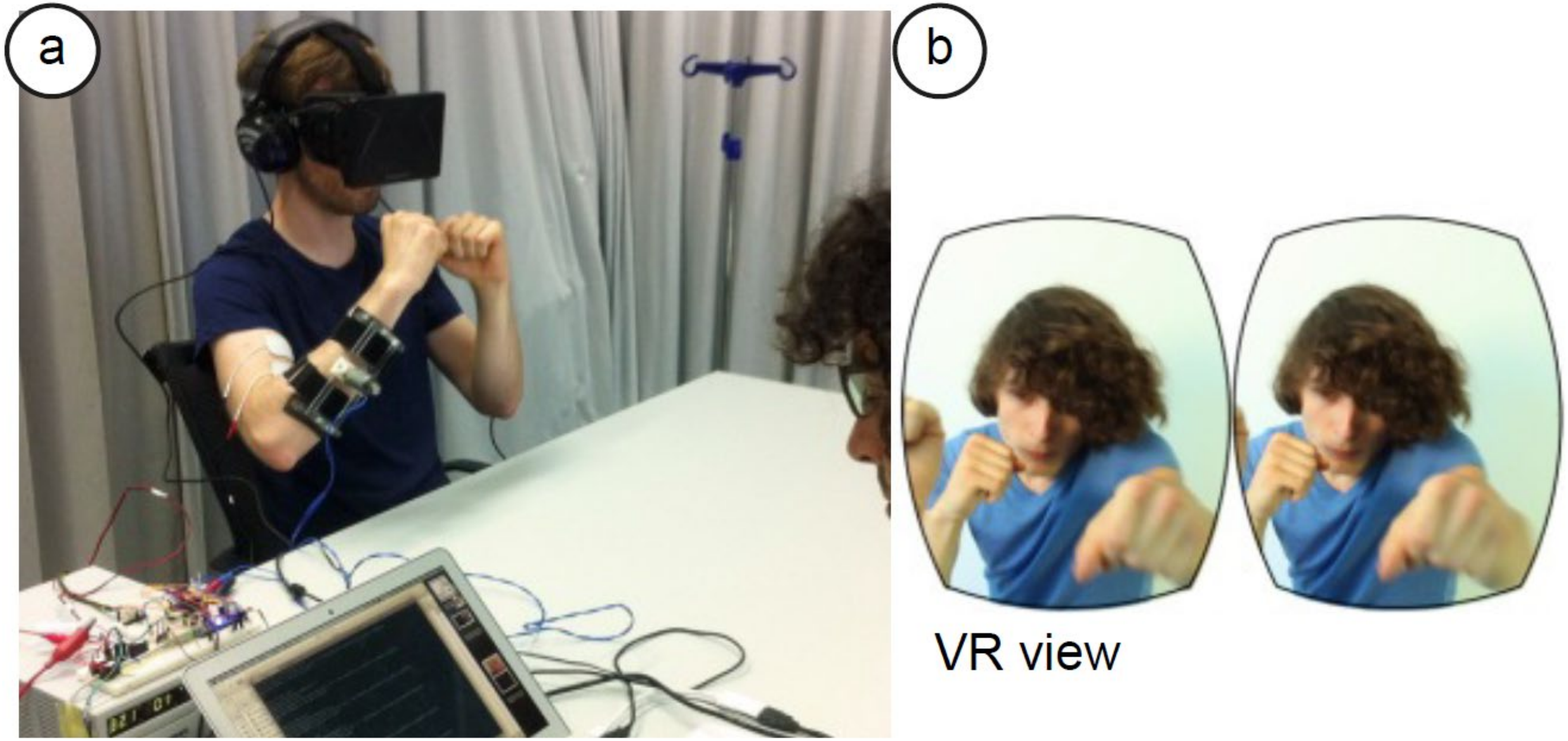
How can you build something like this?


UNI-T
UTD2102CEL
100MHz 1GS/s

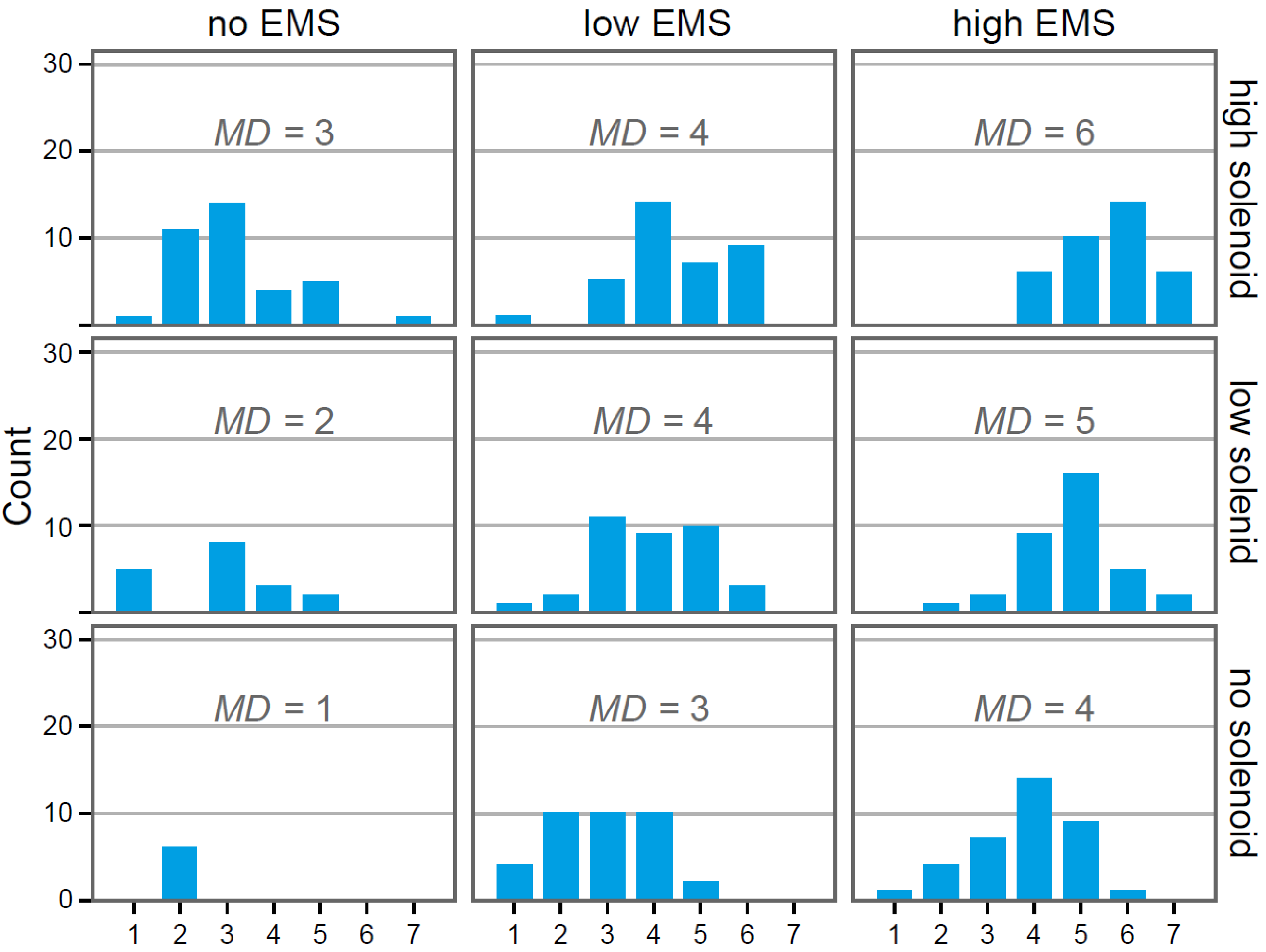

microcontroller,
bluetooth
batteries
solenoid
electrodes
electrical
muscle
stimulator


a
b
c
d
e

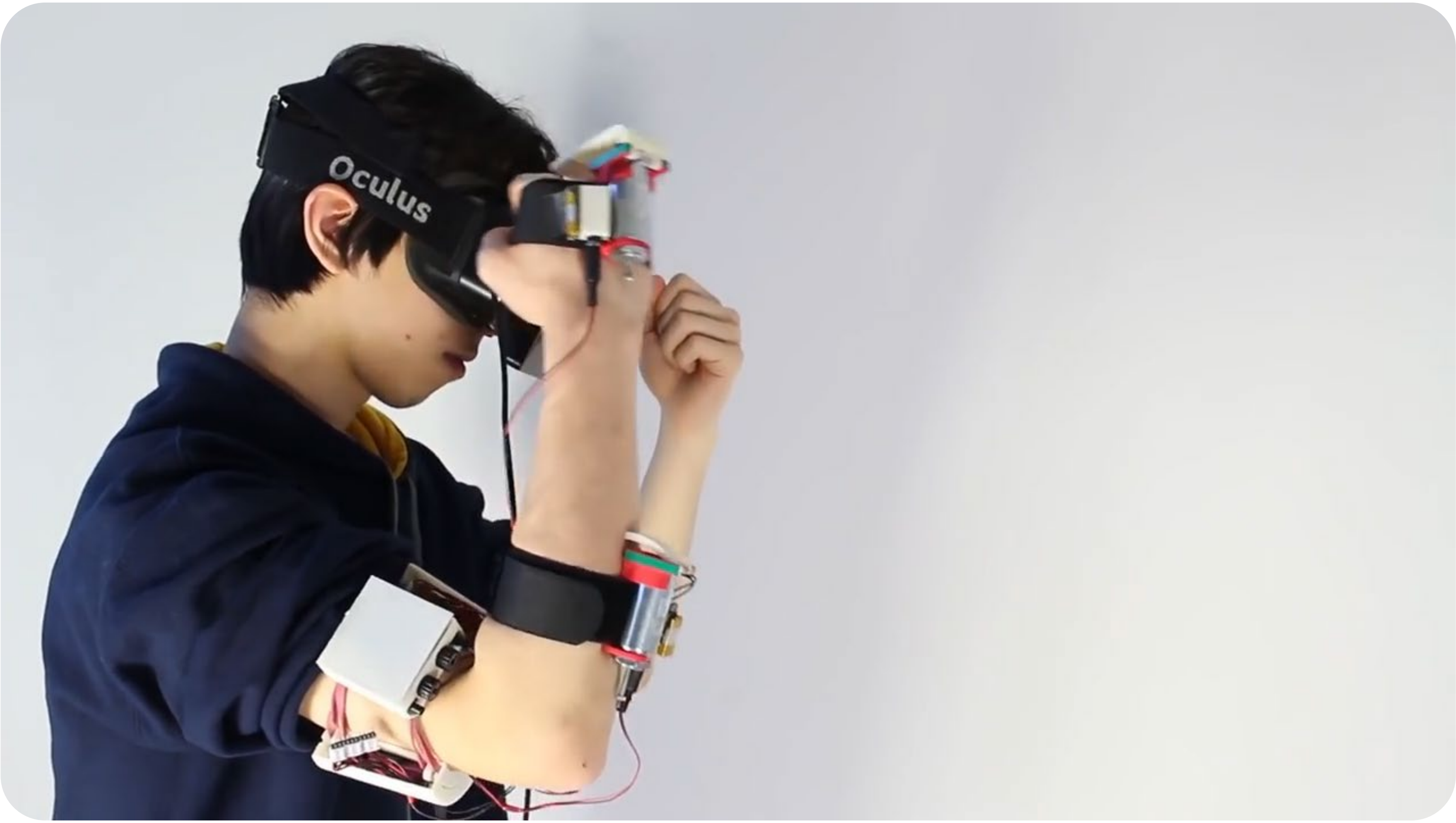
User study to evaluate the core idea ->decomposing an impact's haptic feedback into a tactile component (solenoid) and an impulse component (EMS)



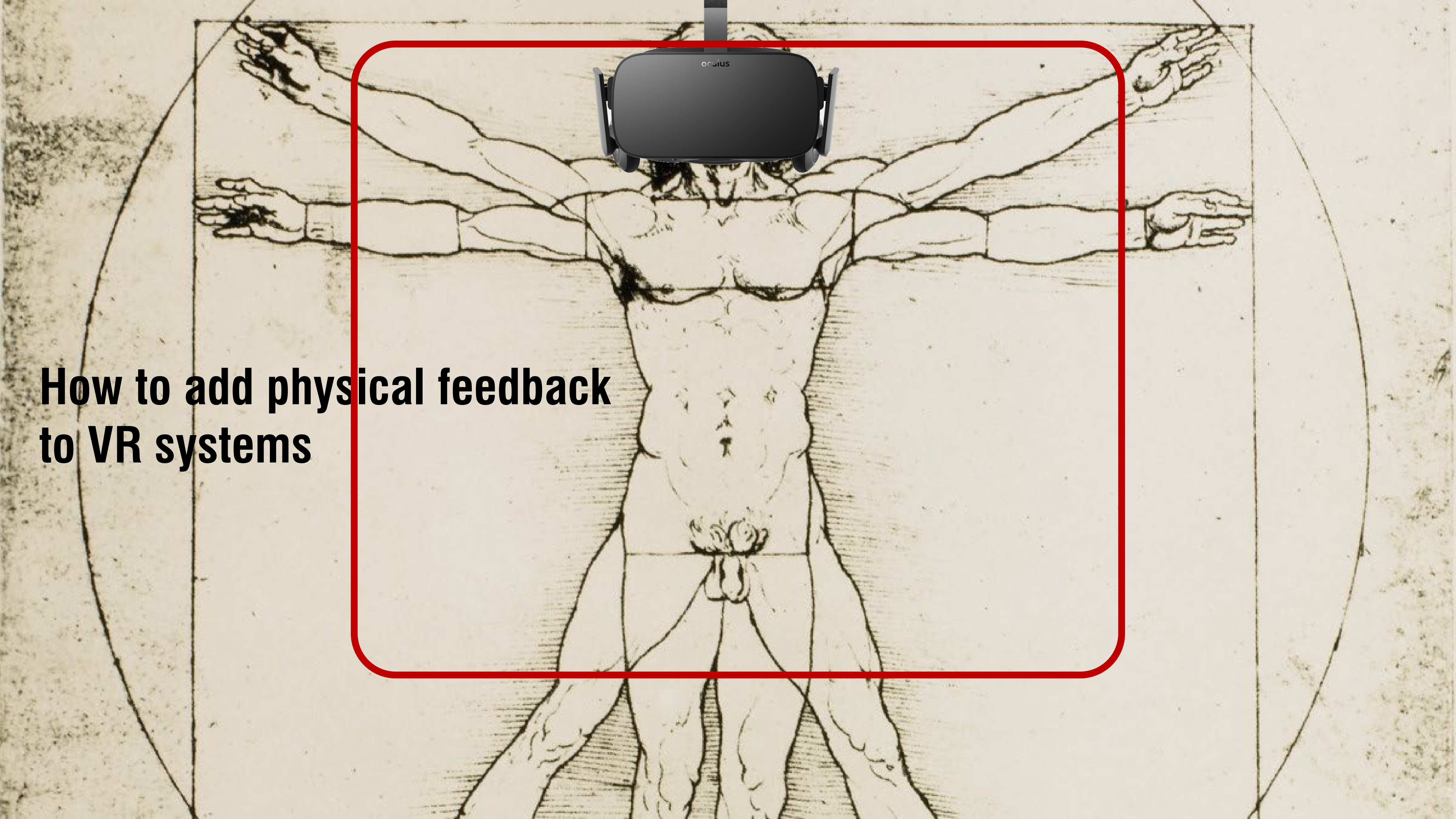
With no EMS no Solenoid
With only EMS
With only Solenoid
With both



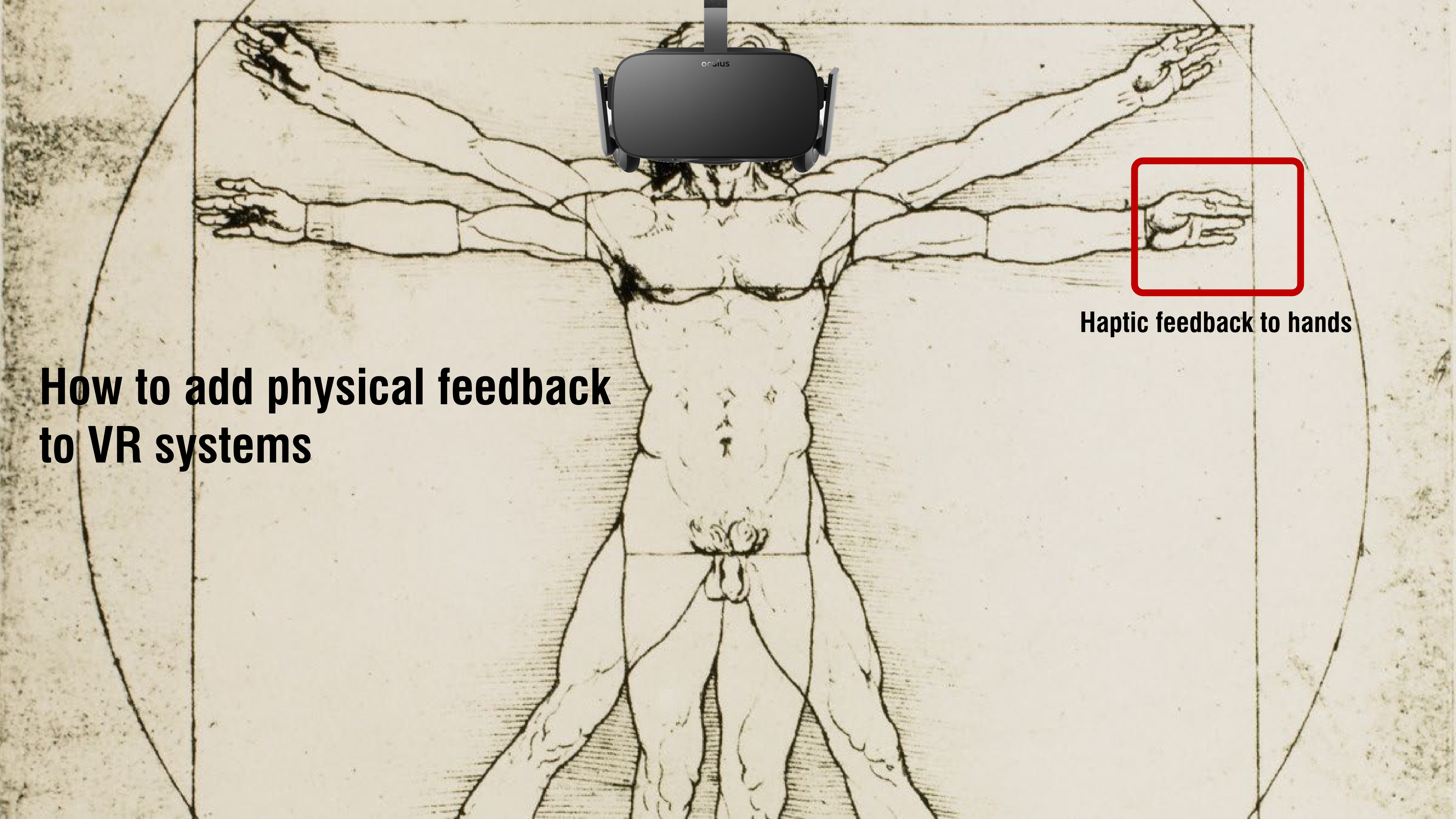
With no EMS no Solenoid
With only EMS
With only Solenoid
With both

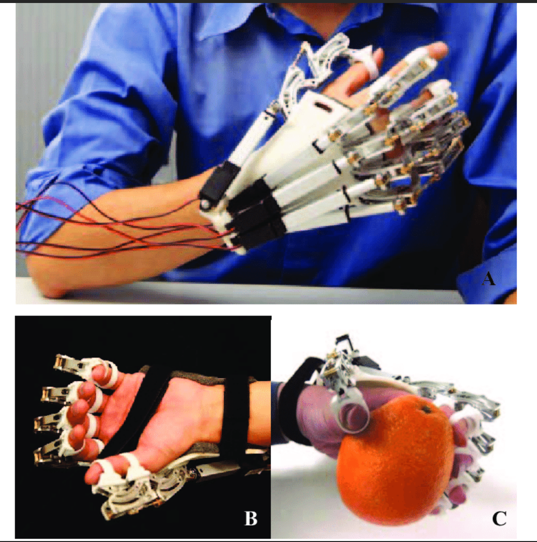

Oculus

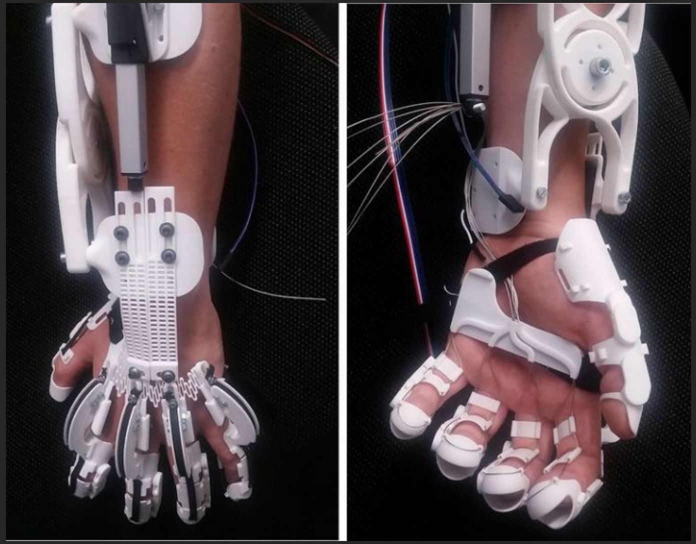
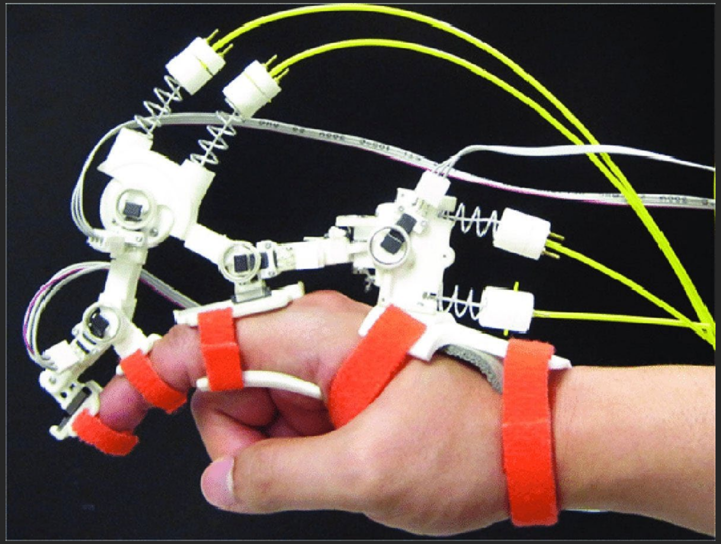
How to add physical feedback to VR systems



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

DextrES: Wearable Haptic Feedback for Grasping in VR via a Thin Form-Factor Electrostatic Brake

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[1]EPFL, [2]ETH Zurich
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Figure 1. DextrES is a flexible and thin form-factor haptic feedback mechanism for precise manipulation of virtual objects in VR and AR. a) Our approach provides kinesthetic feedback via electrostatic brakes and piezoelectric actuators for cutaneous feedback. b) We experimentally show that DextrES improves precision of virtual object manipulations in VR across c) a number of different types of grasps, each affording different hand poses.

ABSTRACT
We introduce DextrES, a flexible and wearable haptic glove which integrates both kinesthetic and cutaneous feedback in a thin and light form factor (weight is less than 8g). Our approach is based on an electrostatic clutch generating up to 20 N of holding force on each finger by modulating the electrostatic attraction between flexible elastic metal strips to generate an electrically-controlled friction force. We harness the resulting braking force to rapidly render on-demand kinesthetic feedback. The electrostatic brake is mounted onto the the index finger and thumb via modular 3D printed articulated guides which allow the metal strips to glide smoothly. Cutaneous feedback is provided via piezo actuators at the fingertips. We demonstrate that our approach can provide rich haptic feedback under dexterous articulation of the user's hands and provides effective haptic feedback across a variety of different grasps. A controlled experiment indicates that DextrES improves the grasping precision for different types of virtual objects. Finally, we report on results of a psychophysical study which identifies discrimination thresholds for different levels of holding force.

† Authors contributed equally to this work.

UIST '18, October 14–17, 2018, Berlin, Germany

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DOI: https://doi.org/10.1145/3242587.3242657

Author Keywords
Haptics; VR; electrostatic brake; dexterous interaction

INTRODUCTION
The dexterity of the human hand enables us to perform a number of useful everyday tasks such as actively exploring surfaces and grasping and moving objects [20, 16]. In Virtual Reality (VR), dexterous manipulation using the hand is a popular means of interaction. It allows us to leverage learned motor skills and vice versa, to train for real-world scenarios in VR [19]. While rapid progress has been made on the input side (display and sensing technologies), haptic interfaces providing physical feedback to the hand lag behind in their fidelity. In particular, the lack of appropriate kinesthetic feedback limit our ability to precisely steer and place grasped objects in 3D space [34].

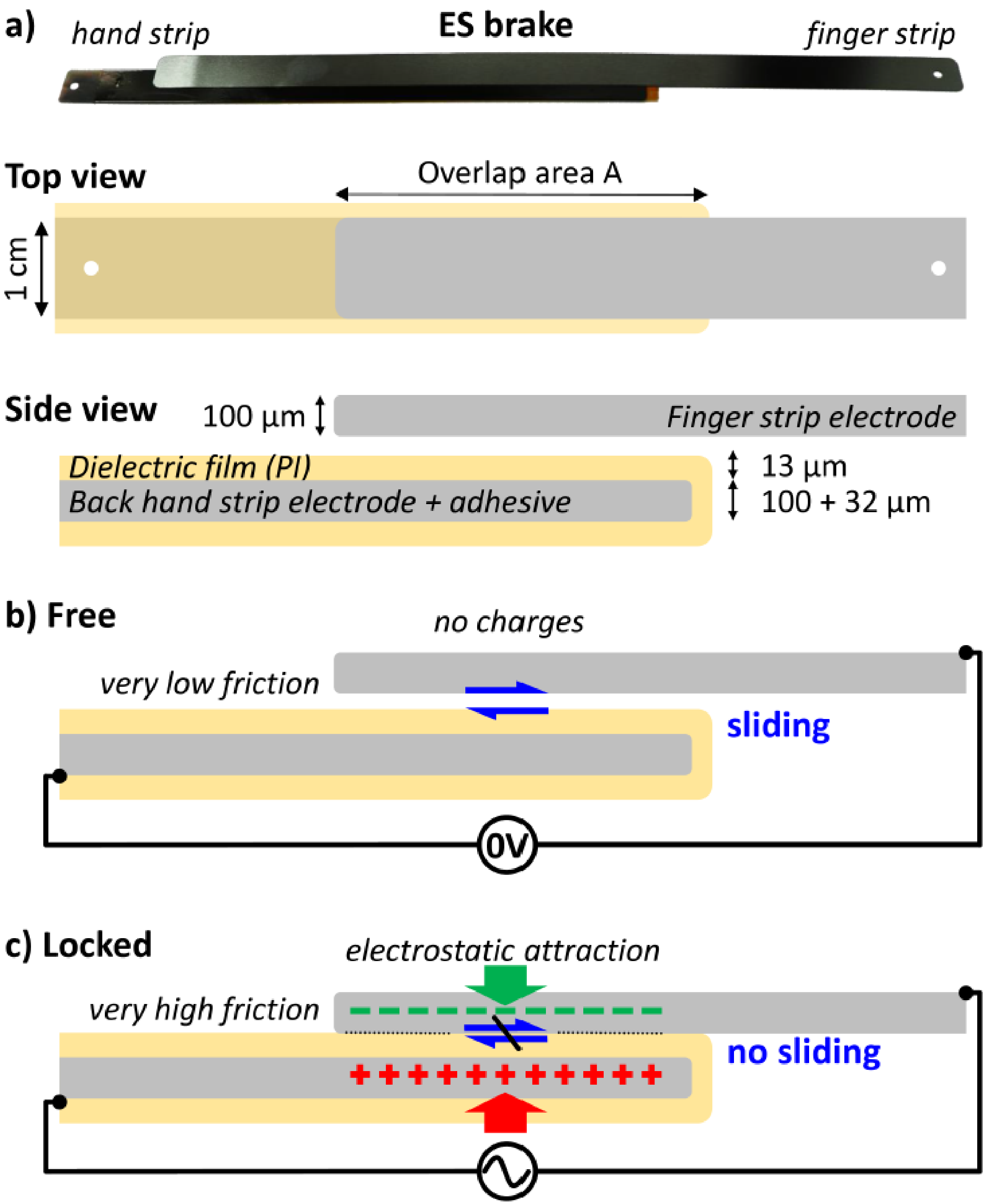
The ability to grasp objects is amongst the most useful skills we can perform in VR [8]. One challenging aspect is the wide array of possible grasps which require the fingers to be free to move into different configurations [16]. Traditionally, grasping feedback in VR has been supported via glove-based exoskeletons which create braking forces on the fingers [12, 21], render localized tactile feedback on the fingertips [13, 31], or combine aspects of both [10, 22]. These devices often employ complex mechanisms placed around the hand which may either add weight, constrain the movement of the fingers, or both. As a result, the full range of interaction capabilities of the human hand are under-utilized.

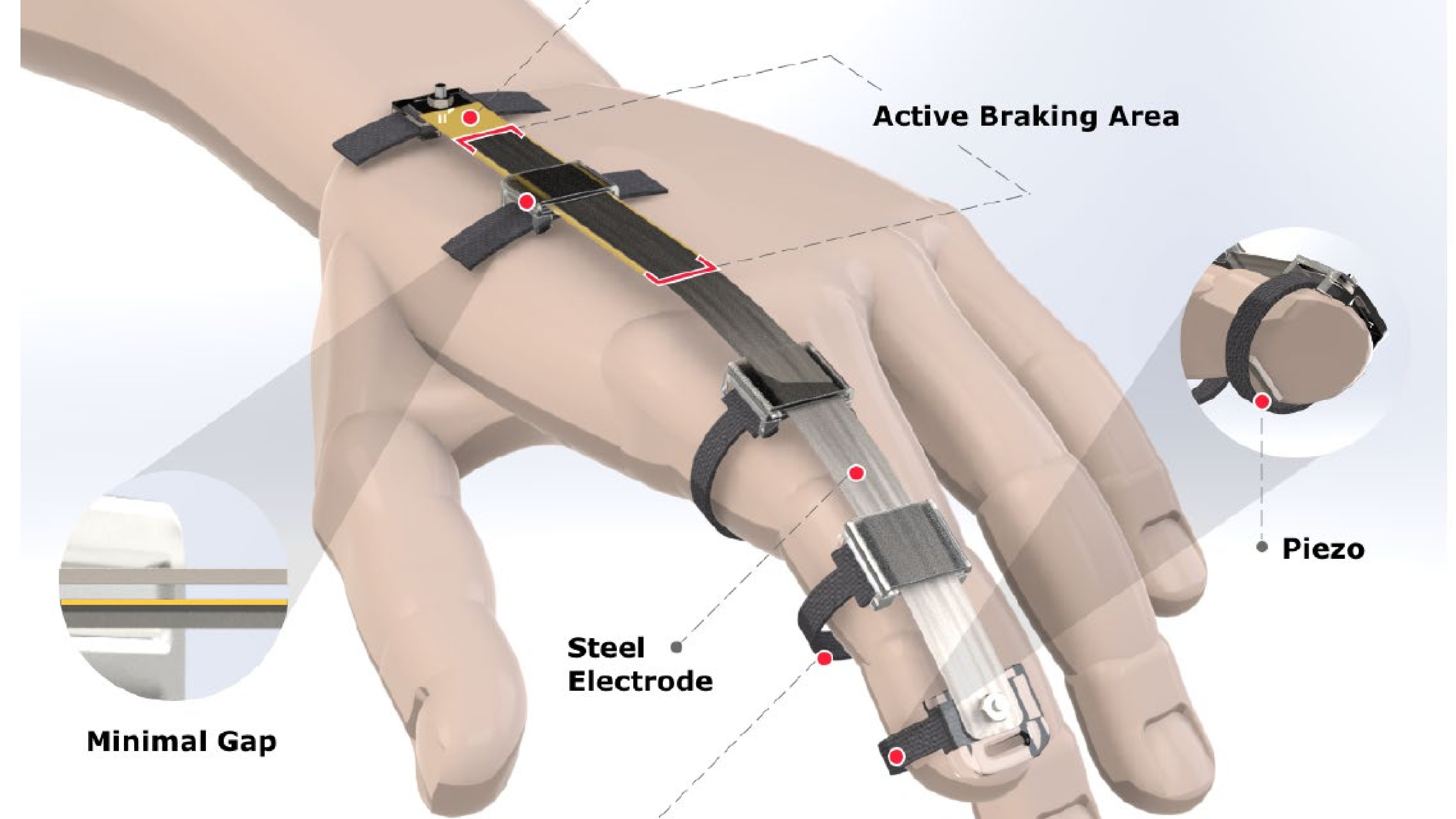
To address this challenge, we introduce DextrES, a finger-mounted haptic mechanism capable of achieving up to 20N of holding force on each finger when flexing inward. Our

UIST 2018

Hinchet et.al.

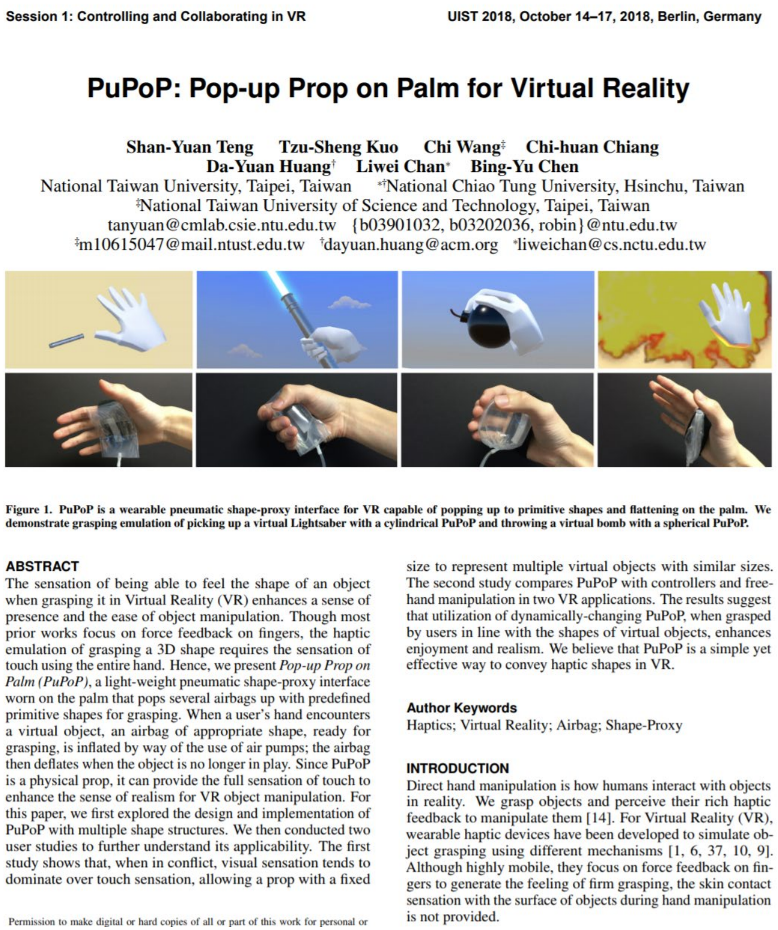
Electrostatic braking mechanisms




Active Braking Area
Piezo
Steel
Electrode
Minimal Gap

PuPoP: Pop-up Prop on Palm for Virtual Reality

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



Session 1: Controlling and Collaborating in VR — UIST 2018, October 14–17, 2018, Berlin, Germany

PuPoP: Pop-up Prop on Palm for Virtual Reality

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Figure 1. PuPoP is a wearable pneumatic shape-proxy interface for VR capable of popping up to primitive shapes and flattening on the palm. We demonstrate grasping emulation of picking up a virtual Lightsaber with a cylindrical PuPoP and throwing a virtual bomb with a spherical PuPoP.

ABSTRACT
The sensation of being able to feel the shape of an object when grasping it in Virtual Reality (VR) enhances a sense of presence and the ease of object manipulation. Though most prior works focus on force feedback on fingers, the haptic emulation of grasping a 3D shape requires the sensation of touch using the entire hand. Hence, we present *Pop-up Prop on Palm (PuPoP)*, a light-weight pneumatic shape-proxy interface worn on the palm that pops several airbags up with predefined primitive shapes for grasping. When a user's hand encounters a virtual object, an airbag of appropriate shape, ready for grasping, is inflated by way of the use of air pumps; the airbag then deflates when the object is no longer in play. Since PuPoP is a physical prop, it can provide the full sensation of touch to enhance the sense of realism for VR object manipulation. For this paper, we first explored the design and implementation of PuPoP with multiple shape structures. We then conducted two user studies to further understand its applicability. The first study shows that, when in conflict, visual sensation tends to dominate over touch sensation, allowing a prop with a fixed size to represent multiple virtual objects with similar sizes. The second study compares PuPoP with controllers and free-hand manipulation in two VR applications. The results suggest that utilization of dynamically-changing PuPoP, when grasped by users in line with the shapes of virtual objects, enhances enjoyment and realism. We believe that PuPoP is a simple yet effective way to convey haptic shapes in VR.

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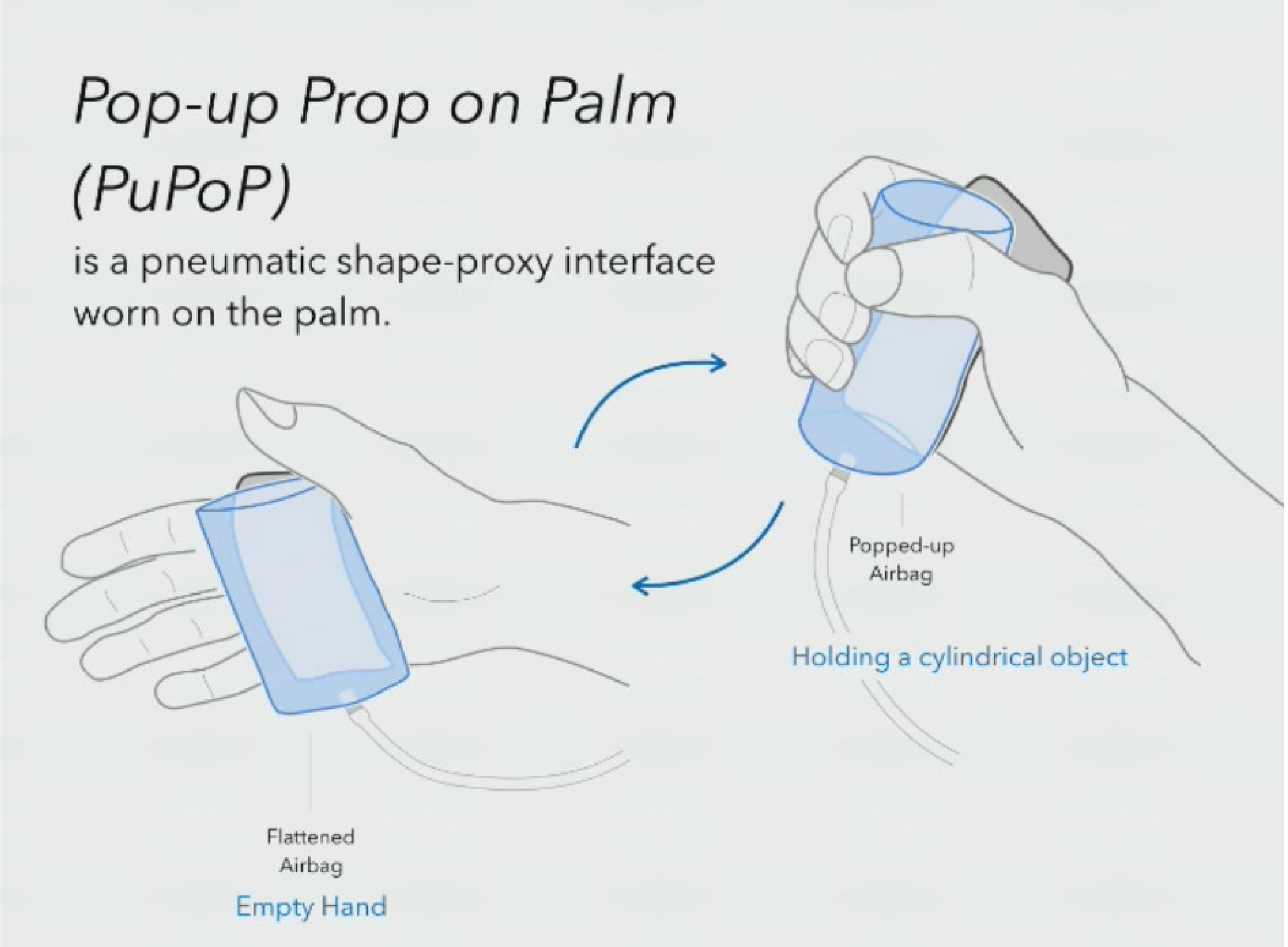
Author Keywords
Haptics; Virtual Reality; Airbag; Shape-Proxy

INTRODUCTION
Direct hand manipulation is how humans interact with objects in reality. We grasp objects and perceive their rich haptic feedback to manipulate them [14]. For Virtual Reality (VR), wearable haptic devices have been developed to simulate object grasping using different mechanisms [1, 6, 37, 10, 9]. Although highly mobile, they focus on force feedback on fingers to generate the feeling of firm grasping, the skin contact sensation with the surface of objects during hand manipulation is not provided.

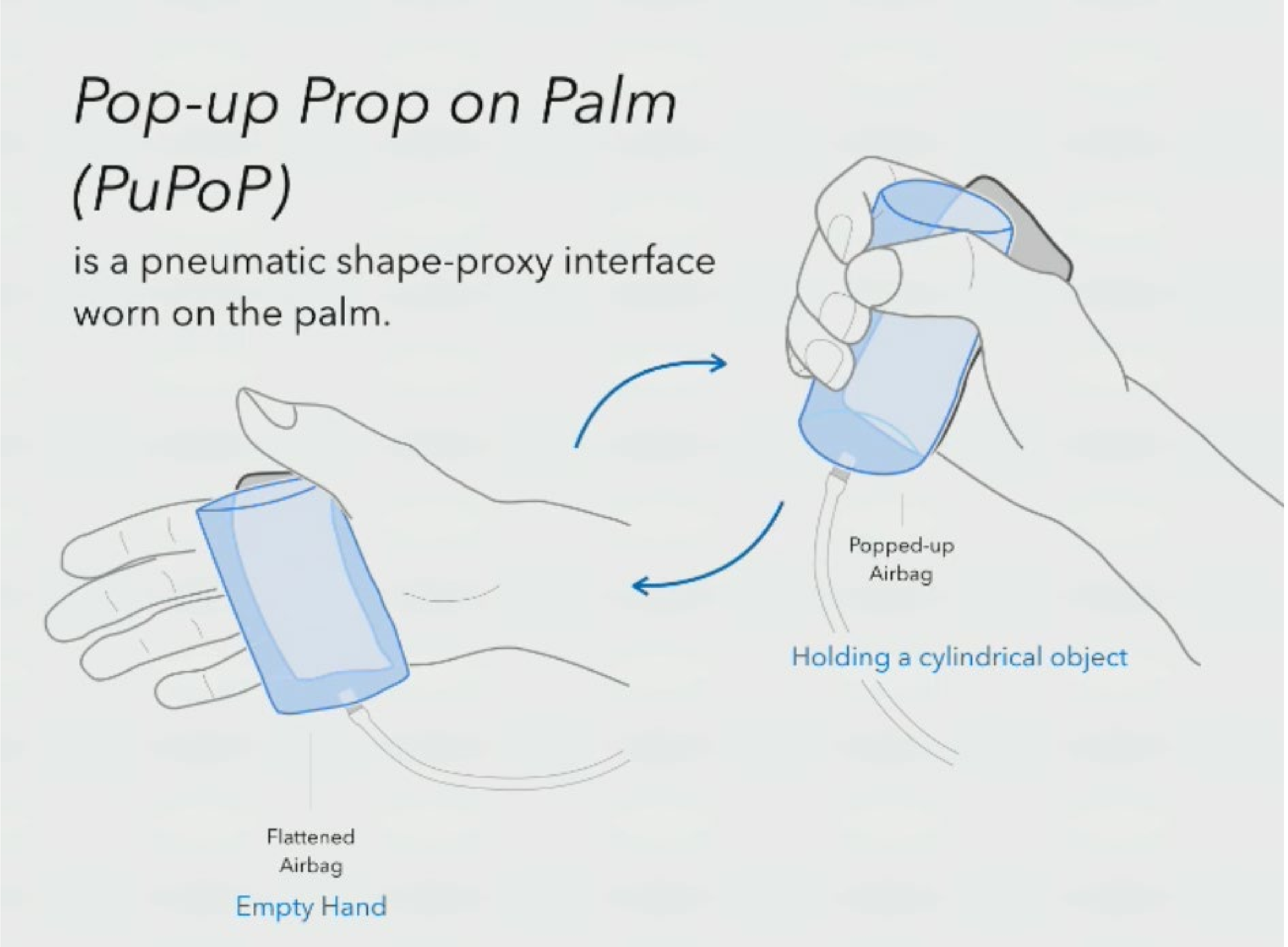
UIST 2018

Also pneumatic system, but hands-worn

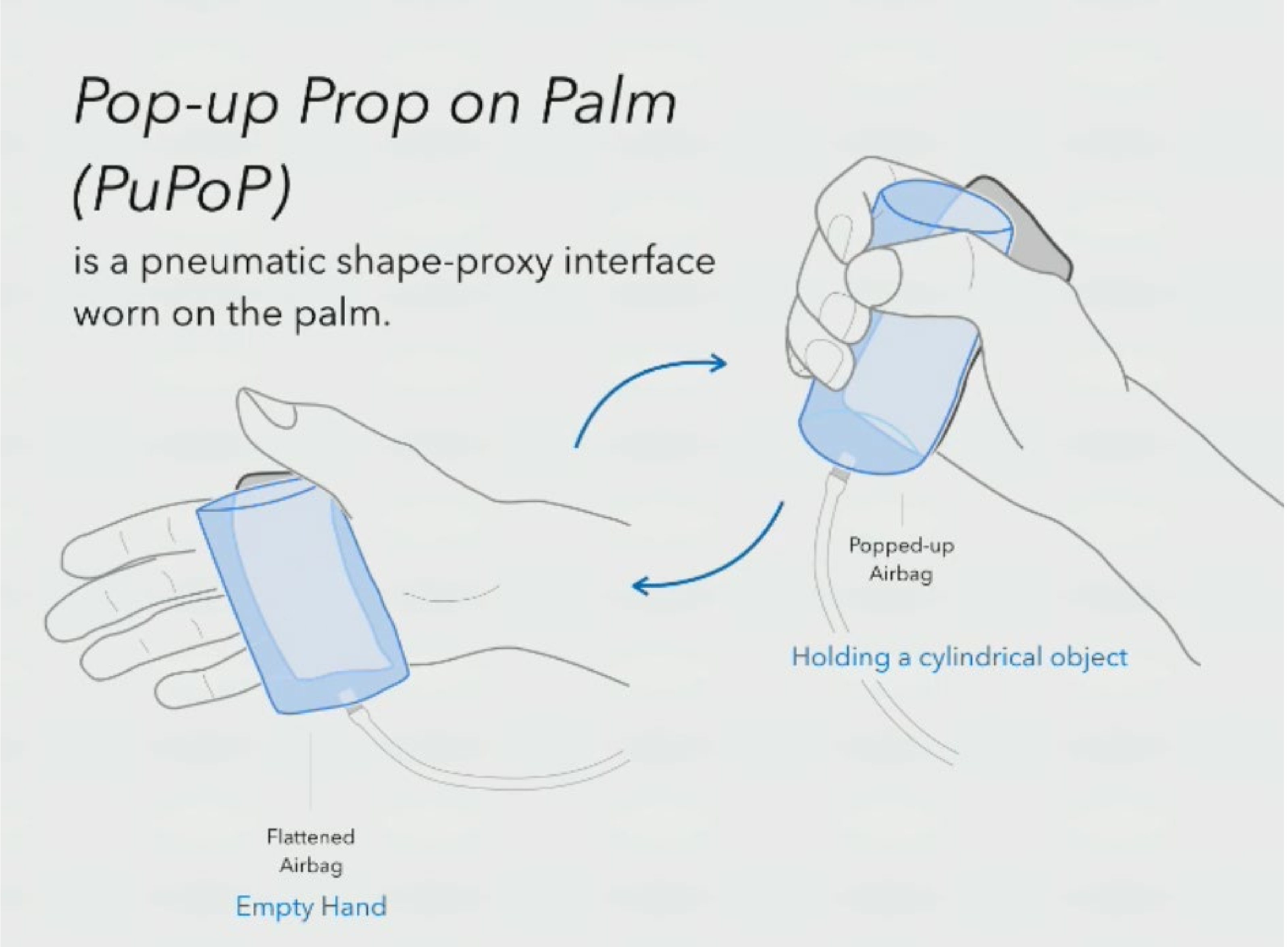
Teng et.al.



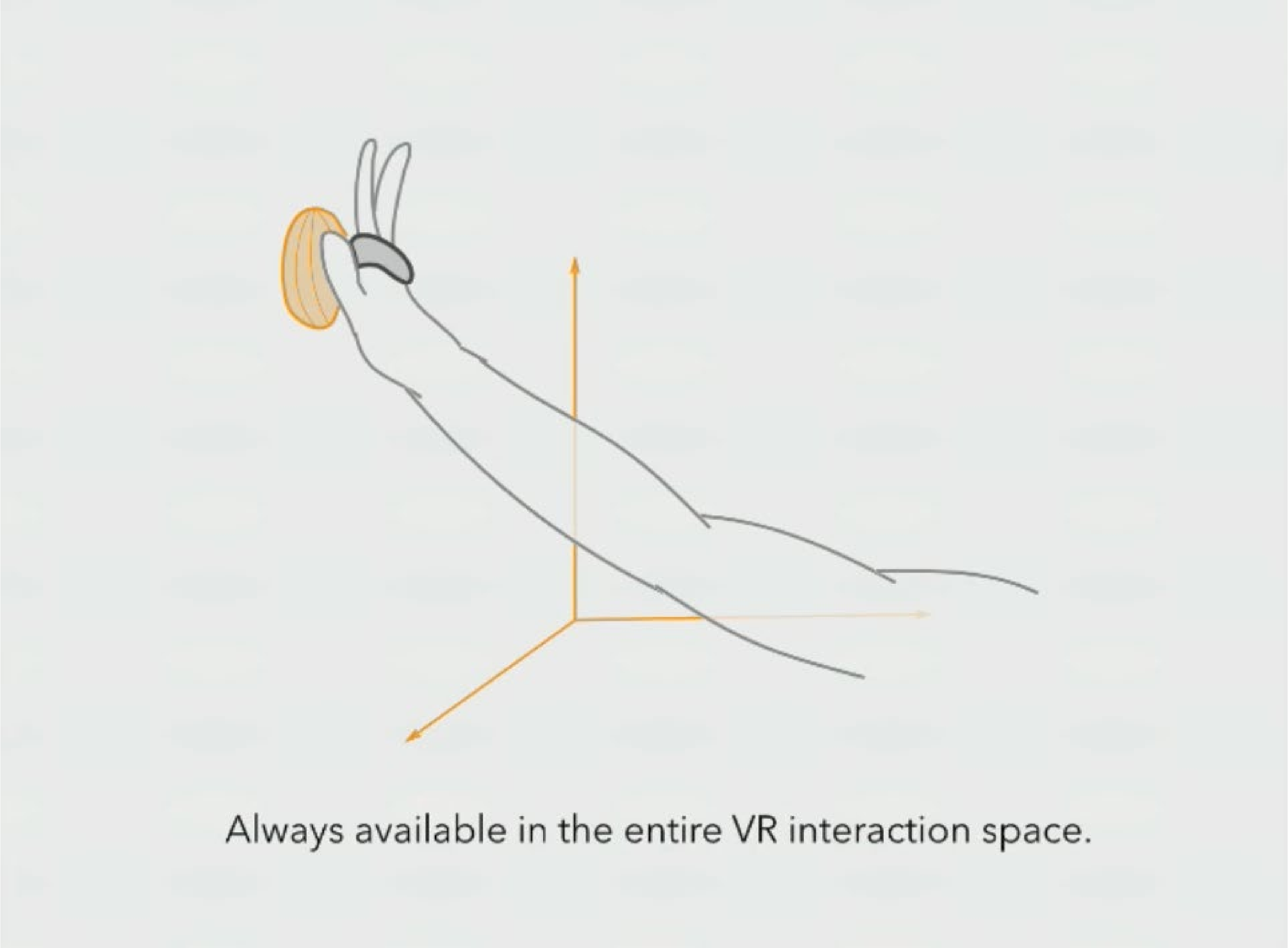
What problem does this paper trying to solve?



How does this paper solve it?



What are the potential challenges for this solution?



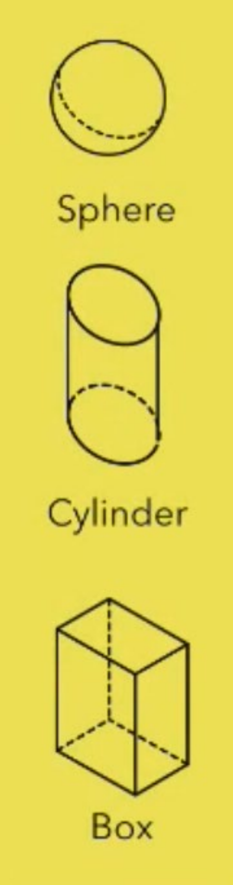
There will be limited shapes that can be rendered, how to decide what shape to generate?

Identify Primitive Shapes

VR Game Objects

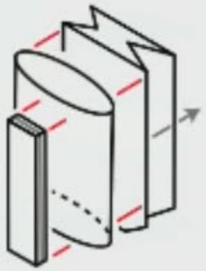
111 hand-held objects found in 20 game trailers.

Sphere	balls in sports, snowballs, bombs, and grenades, etc.
Cylinder	rackets, bottles, hammers, and swords, etc.
Box	sandwiches, books, milk package, and camera, etc.
Disk	Frisbee
Cone	carrot
Hemisphere	bowl
Others	scissors, clothes, chain, fish, cat, etc.

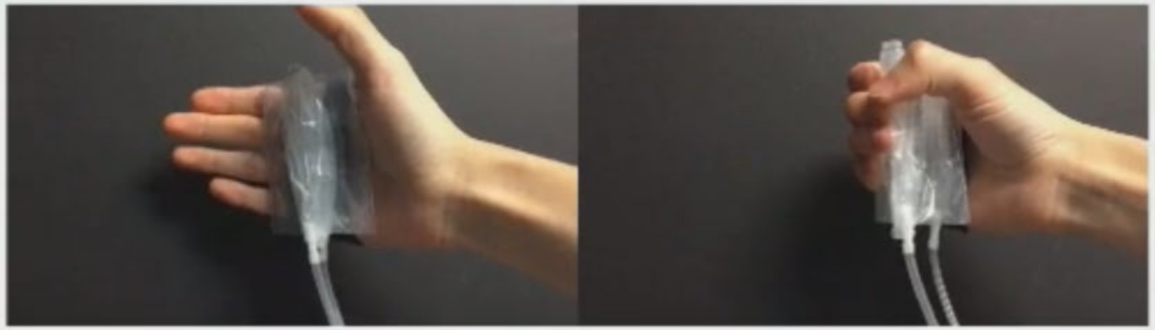


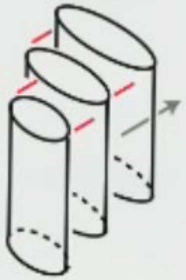
Props on Palm

Prop Stacking

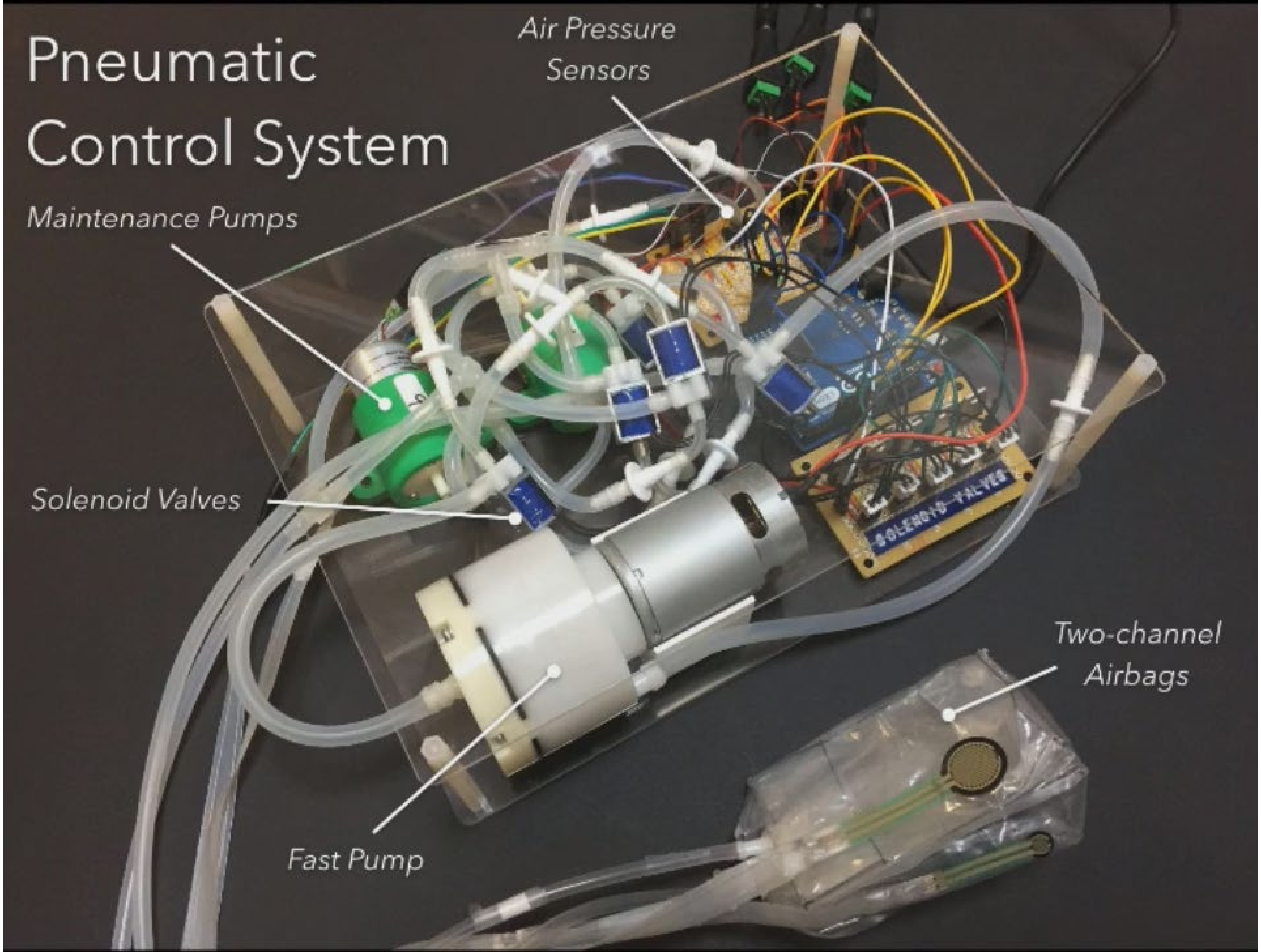


Shape Stacking

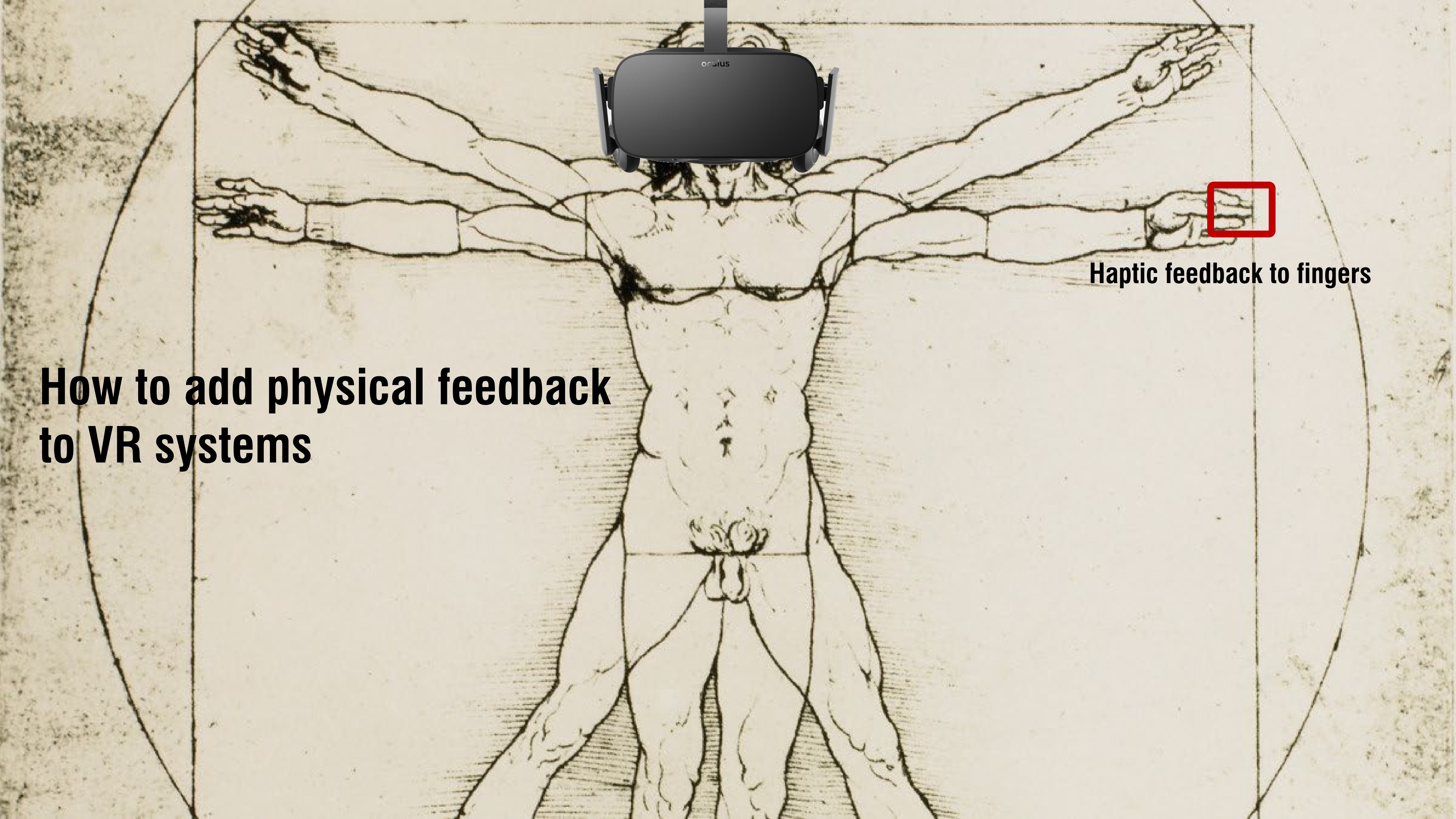




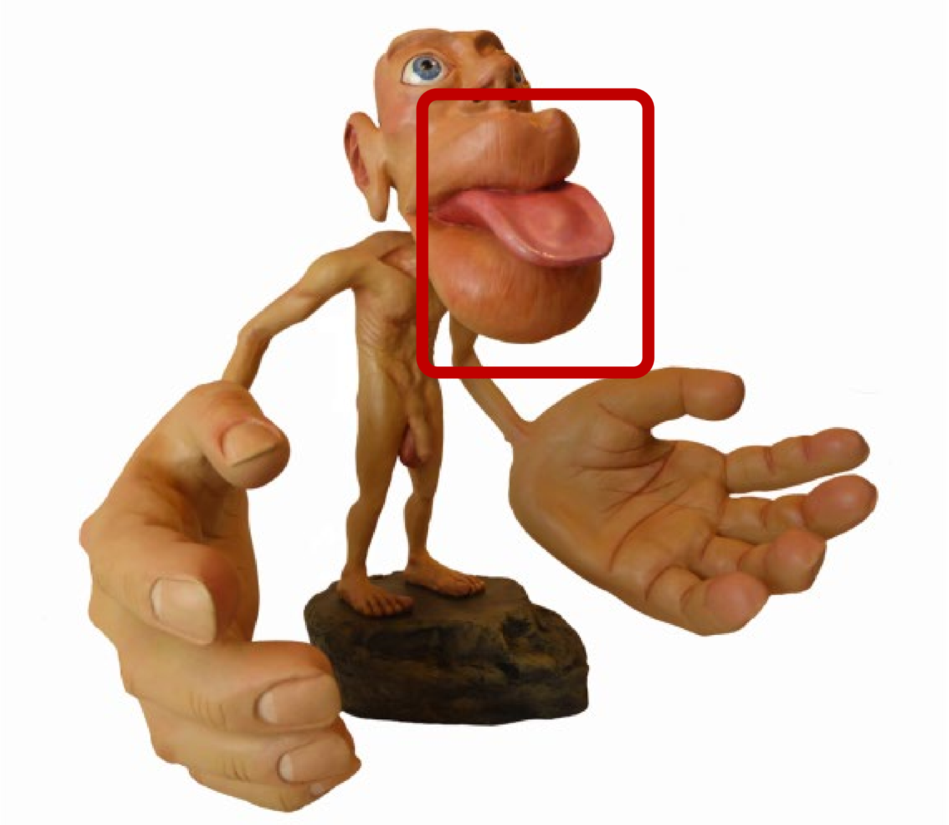
Size Stacking


Pneumatic
Control System
Air Pressure
Sensors
Maintenance Pumps
Solenoid Valves
SOLENOID VALVES
Fast Pump
Two-channel
Airbags


We demonstrate
two fantasy VR applications
using PuPoP


oculus
Haptic feedback to fingers
How to add physical feedback to VR systems

Sensory homunculus



mapping the human somatosensory cortex