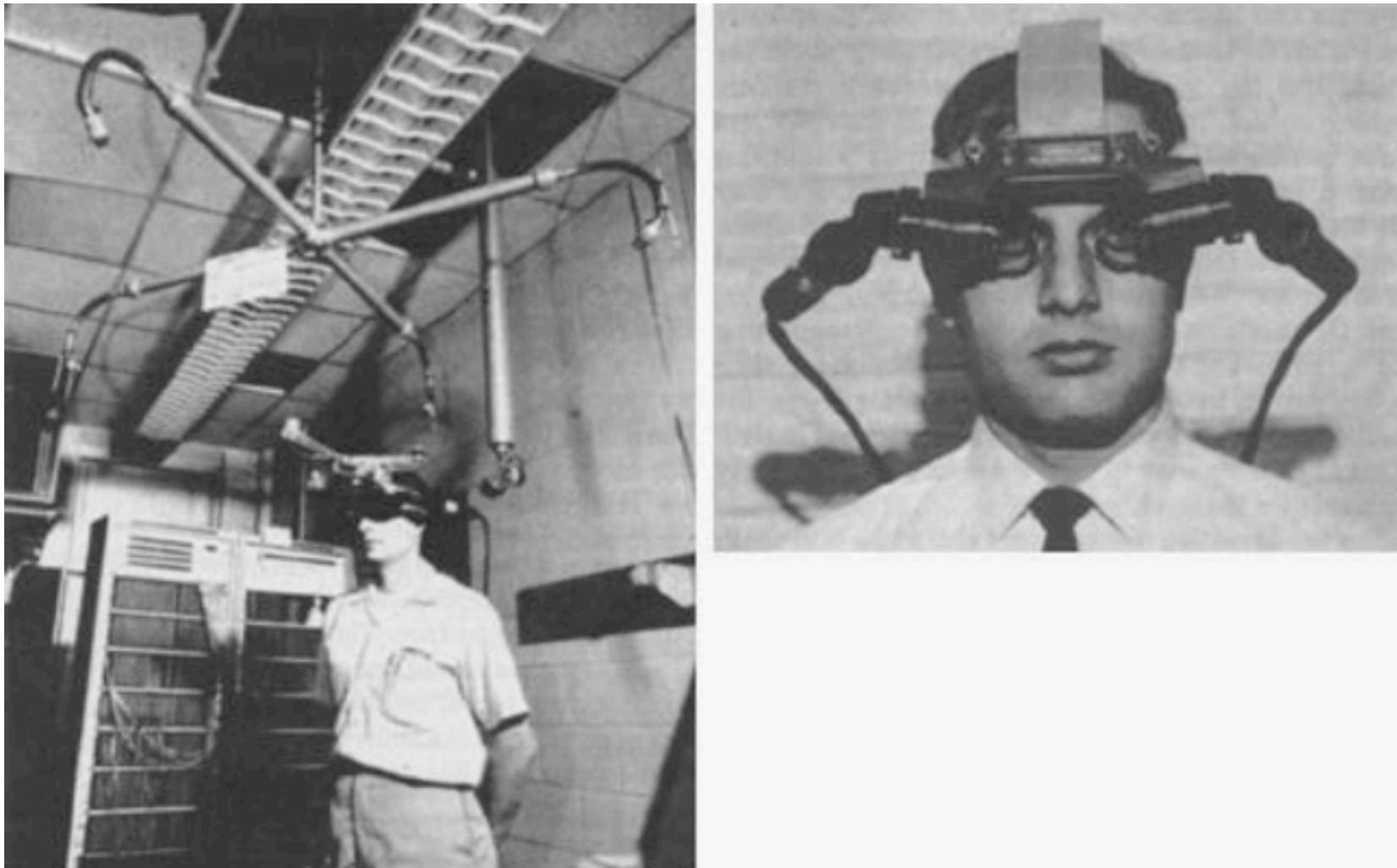


# **Interaction Design & Virtual Reality (IDVR)**

**Liwei CHAN 詹力韋**

haptics

**immersing** users in **graphics** is a huge factor in realism...



1968 head-mounted display  
**Ivan Sutherland**

# Ivan Sutherland: Ultimate Display (1965)

**Ultimate Display,  
1965**



**Ivan Sutherland**

(what else did he invent?)



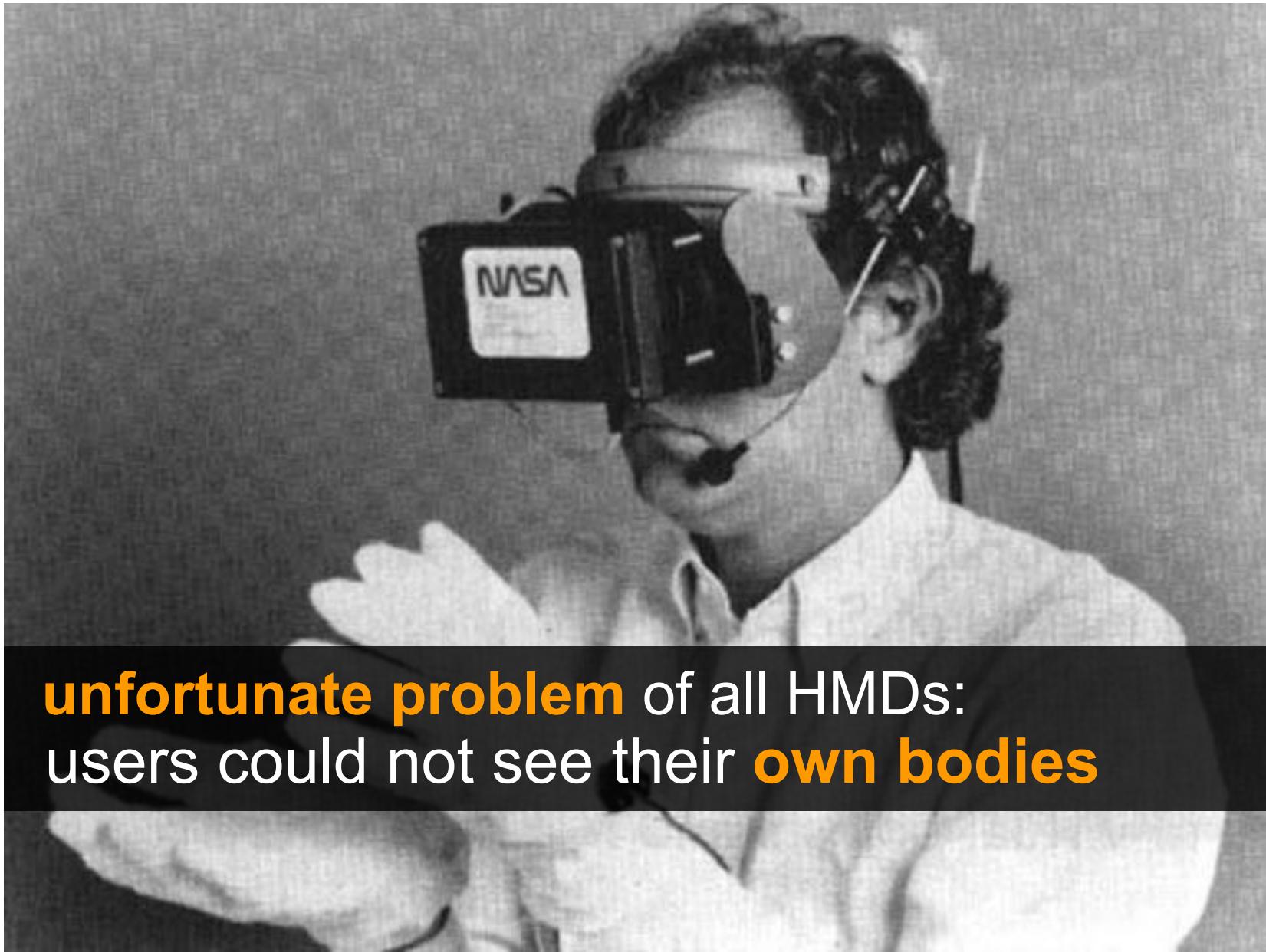
right, **interactive graphics** (sketchpad)

# Direct Manipulation





**1980s:** head-mounted VR hit “mainstream”



**unfortunate problem** of all HMDs:  
users could not see their **own bodies**



**#1 CAVE allows for (single-user) immersive view.  
And allows the user to see their own body.**



despite allowing users to see their own bodies,  
CAVEs had **two main limitations...**

#1 users can walk, but the virtual world is finite,  
soon users hit the **“end of the world”**

#2 when users try to touch the virtual objects their hands  
simply pass through → **no sense of touch**



#2 is more ubiquitous:  
as soon as we **touch**, it tells us **its not real**

→ objective: provide virtual objects  
with a **realistic sense of touch**



**force feedback** devices...

[CyberGrasp, Vrlogic]



**CyberGrasp**

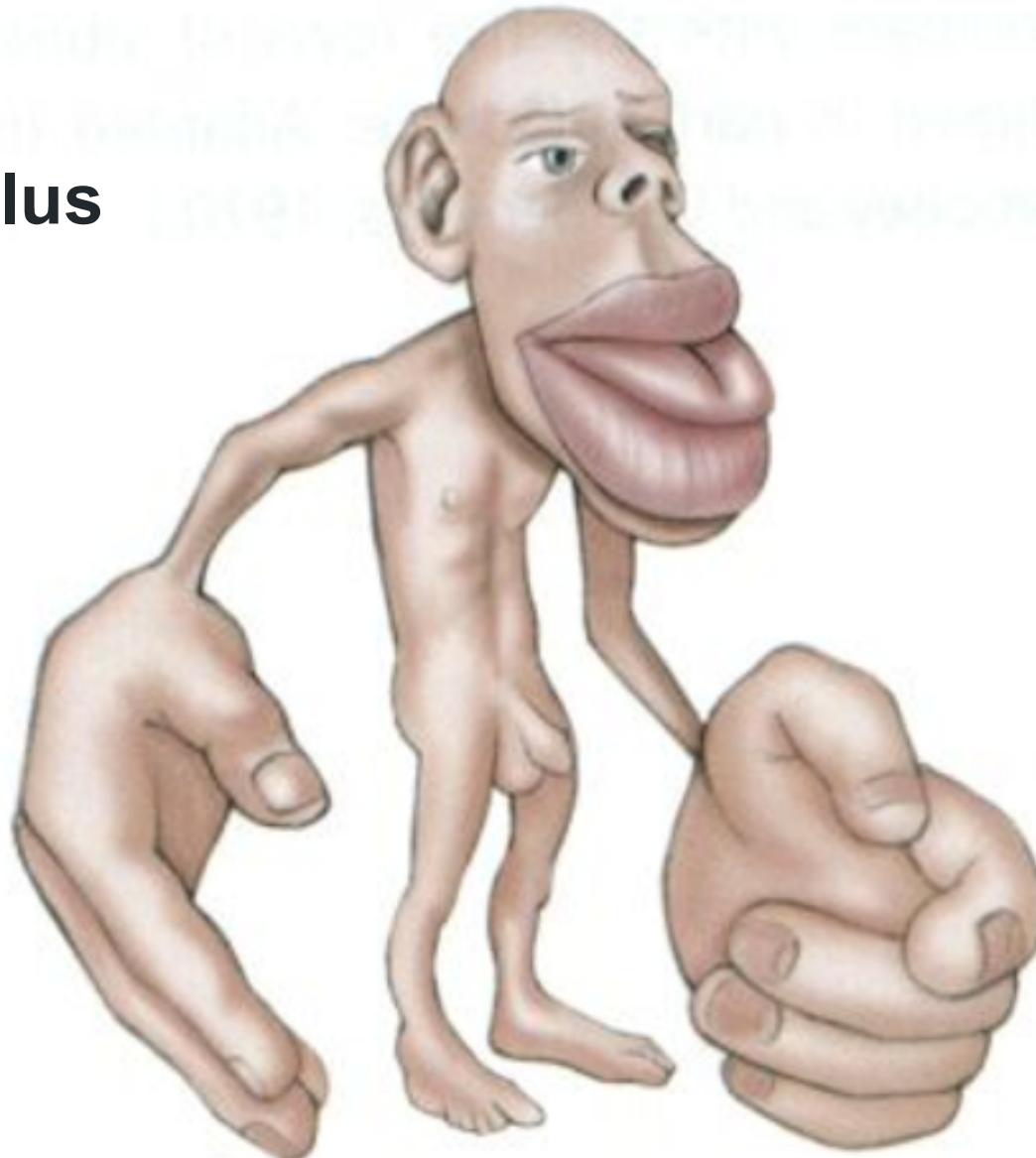


**force feedback** devices...

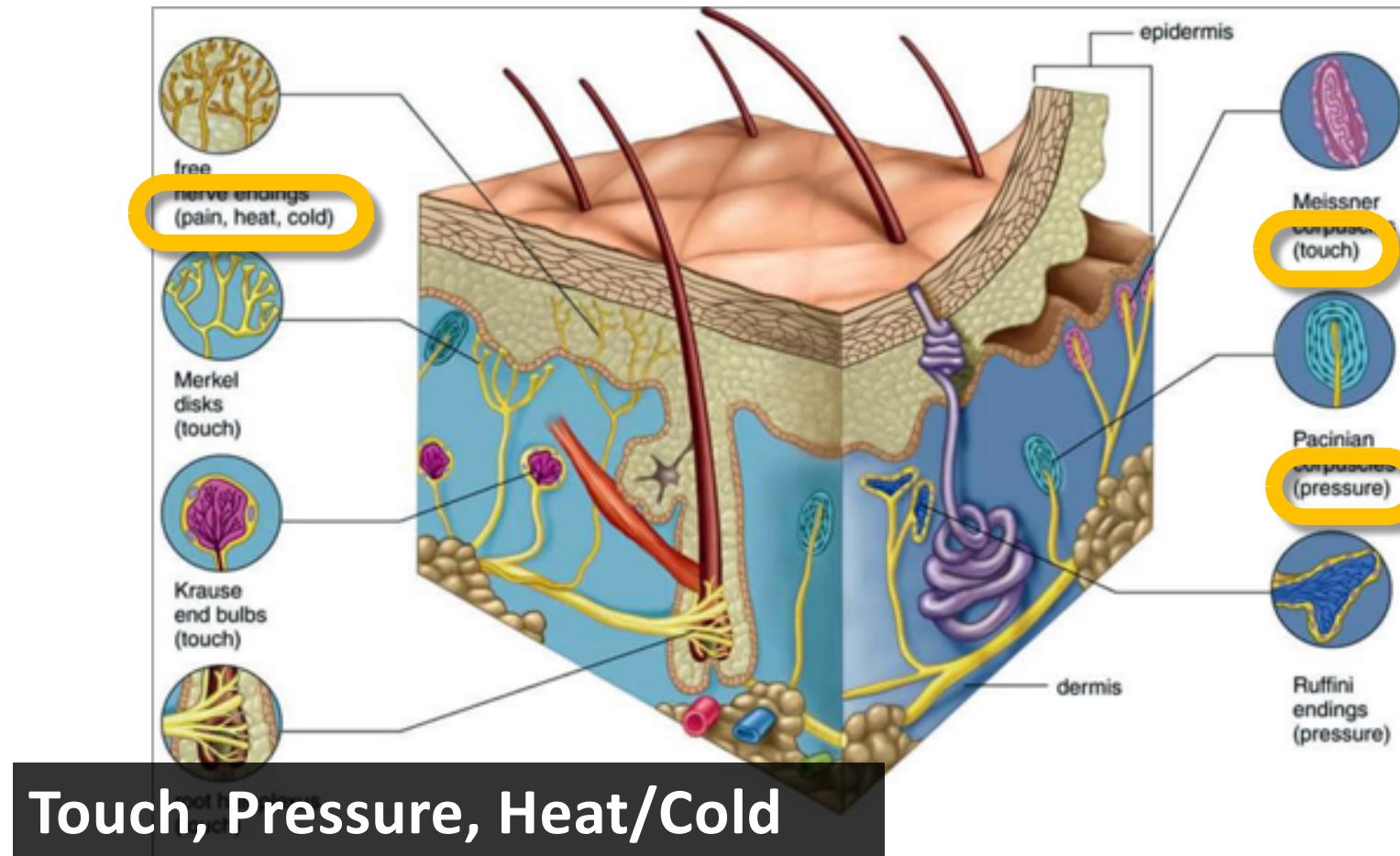
[PHANToM, senseable]

our haptic senses

## Homunculus of Touch



cortical sensory homunculus

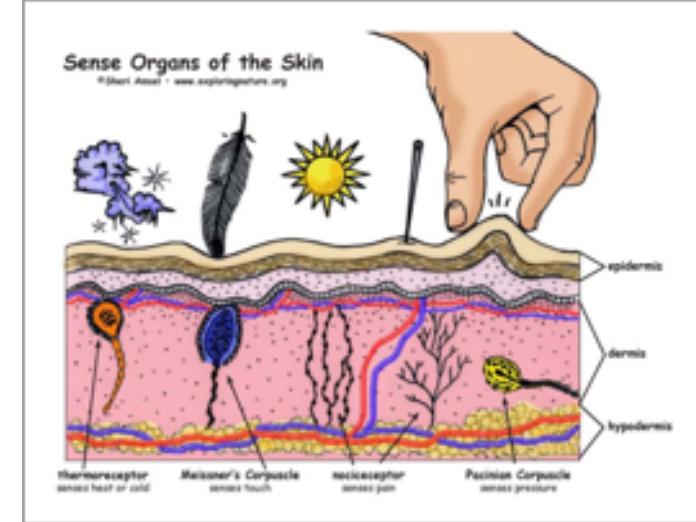
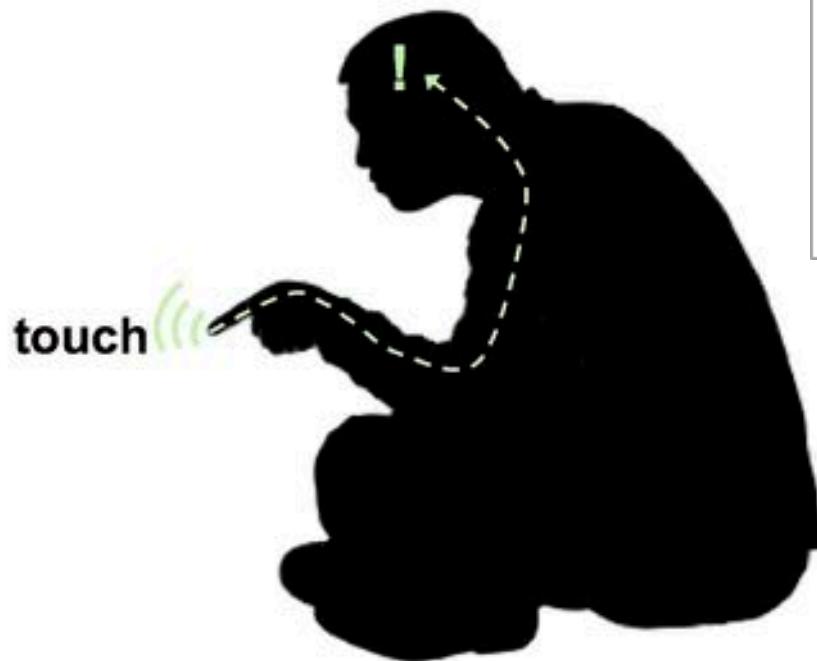


# **haptics ::**

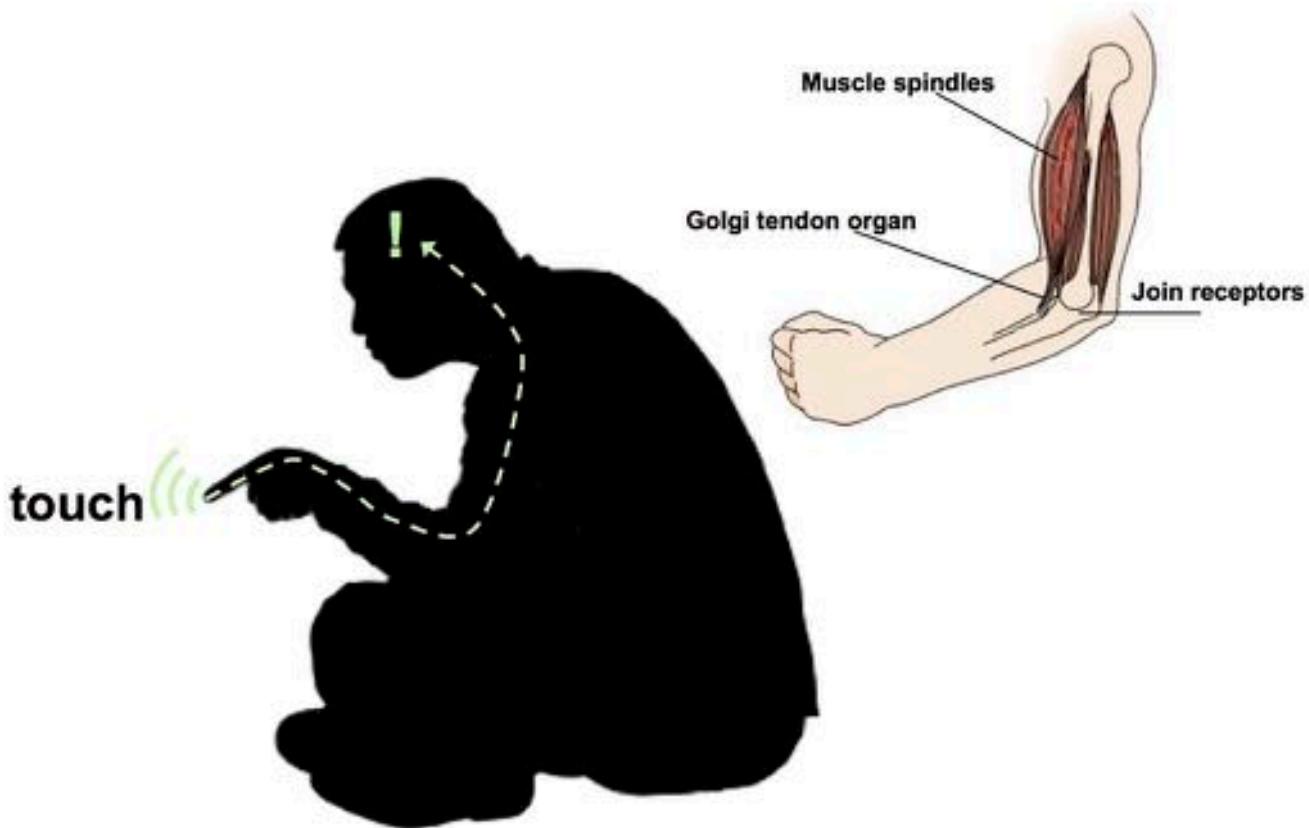
(or haptic technology) is a tactile feedback technology  
that **takes advantage of a user's sense of touch**

by applying **forces, vibrations, and/or motion to the user**

user's "sense of touch"... **what is that?**



#1 touch → tactile sensation **on skin**



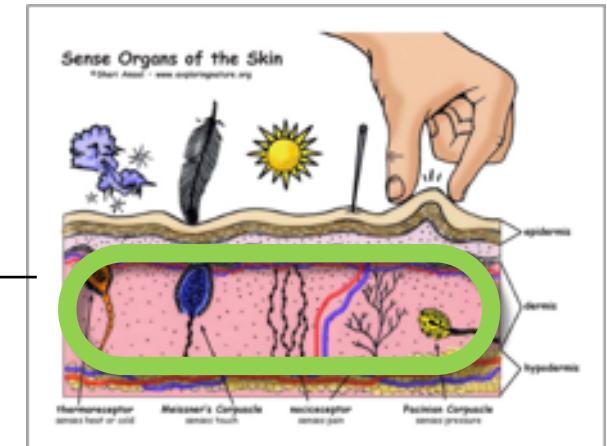
#2 force → **receptors on muscles/tendons**

Cutaneous sensations	皮膚感覺
Proprioception	本體感覺
Kinesthesia	動覺
Haptic Perception	觸覺
Somatosensory system	體覺

# Cutaneous sensations (皮膚感覺)

Sensations based on the stimulation of receptors in the skin.  
Including **Pressure, vibration, heating, cooling, and tissue damage.**

Mechanoreceptor



# Proprioception (本體感覺)

indicates where the various parts of the body are **located in relation to each other** (also whether the body is **moving**)

provides feedback solely on the status of the body  
**internally**

from Latin *proprius*, meaning "one's own"



# Kinesthesia (動覺)

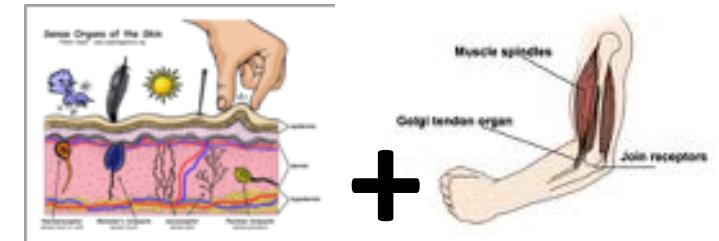
same thing (though some place extra emphasis on **motion**.  
some excluding the sense of equilibrium)



# Haptic Perception (觸覺)

the process of recognizing objects through touch

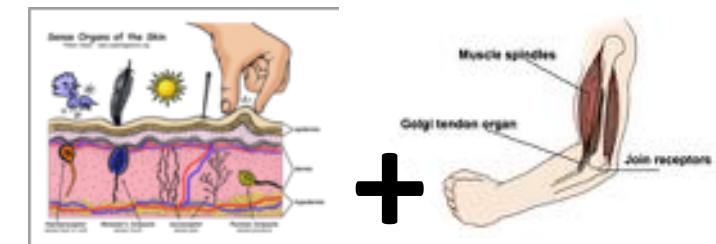
combination of somatosensory perception of patterns on the **skin surface** (e.g., edges, curvature, and texture) and **proprioception** of hand position and conformation



# Somatosensory system (體覺)

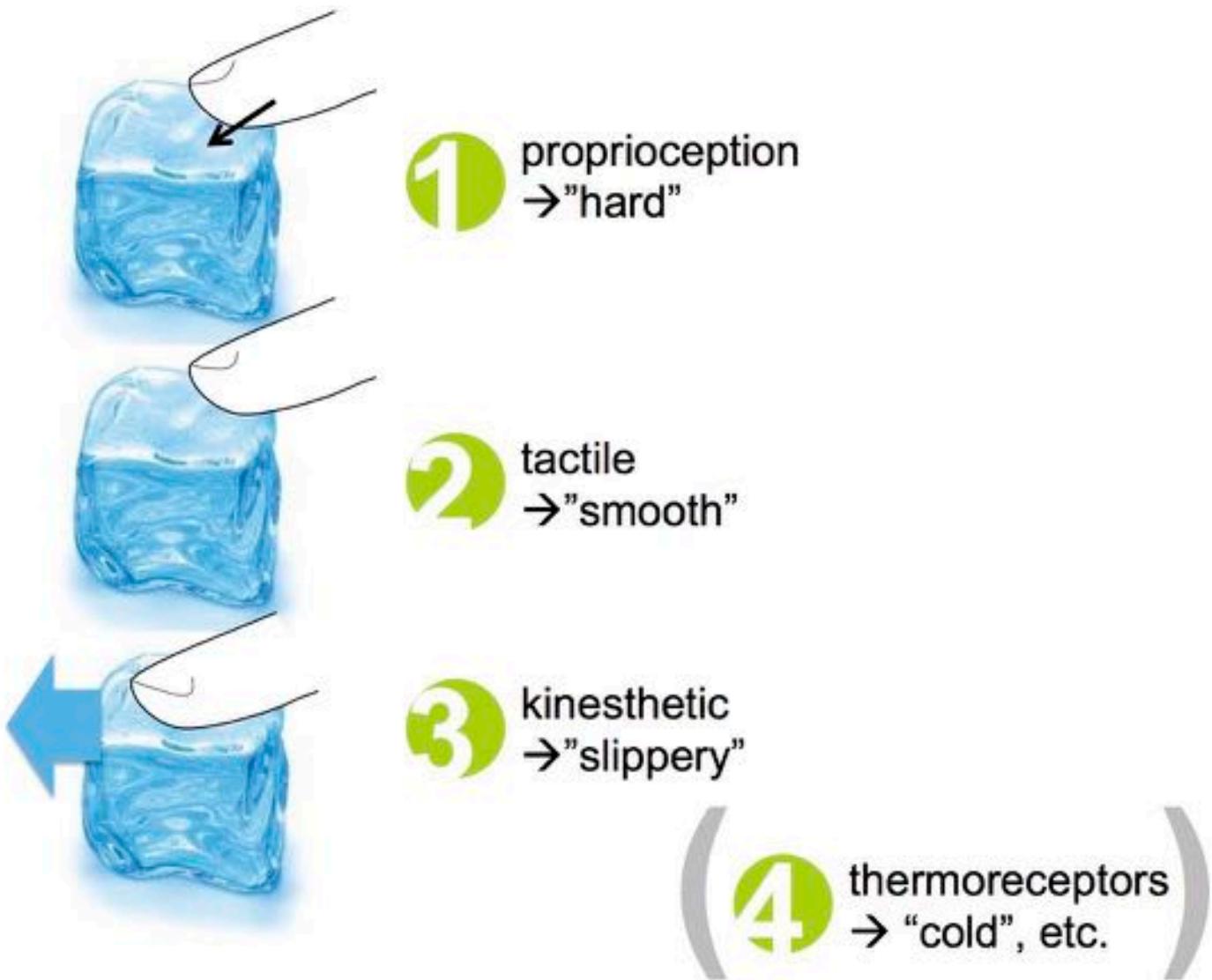
a diverse sensory system composed of the receptors and processing centers to produce the sensory modalities such as **touch, temperature, proprioception (body position), and nociception (pain)**.

The sensory receptors cover the skin and epithelia, skeletal muscles, bones and joints, internal organs, and the cardiovascular system.



if we want to create realism,  
we eventually need to **cater to all these (sub)senses**

that's why it's hard and that's why it's **hard to get started**



# NormalTouch and TextureTouch

High-fidelity 3D Haptic Shape Rendering on Virtual Reality Controllers

Hrvoje Benko, Christian Holz, Mike Sinclair, Eyal Ofek  
Microsoft Research, 2016



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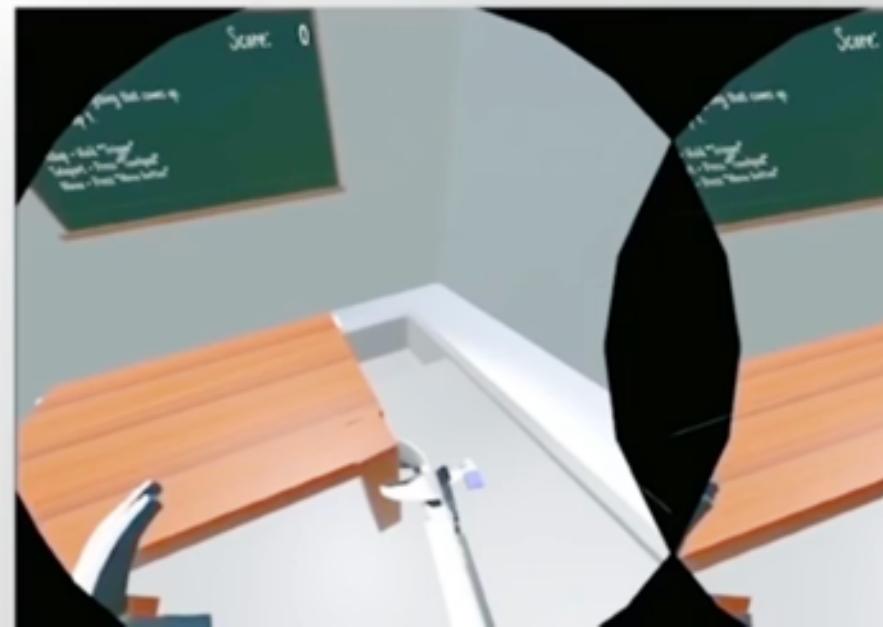
# CLAW: A Multifunctional Handheld Haptic Controller for Grasping, Touching, and Triggering in Virtual Reality

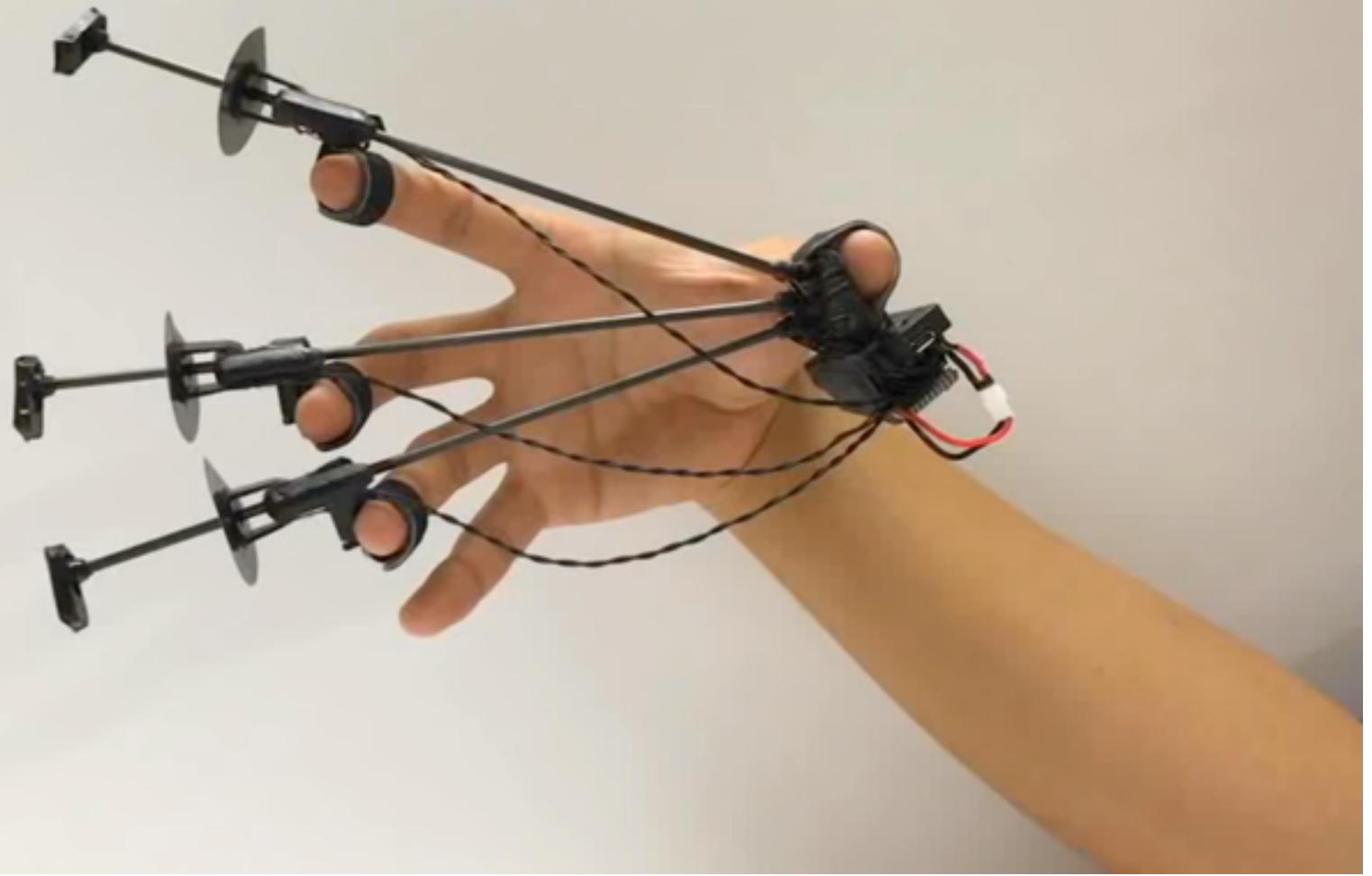
Inrak Choi<sup>1,2</sup>, Eyal Ofek<sup>1</sup>, Hrvoje Benko<sup>1</sup>, Mike Sinclair<sup>1</sup>, Christian Holz<sup>1</sup>

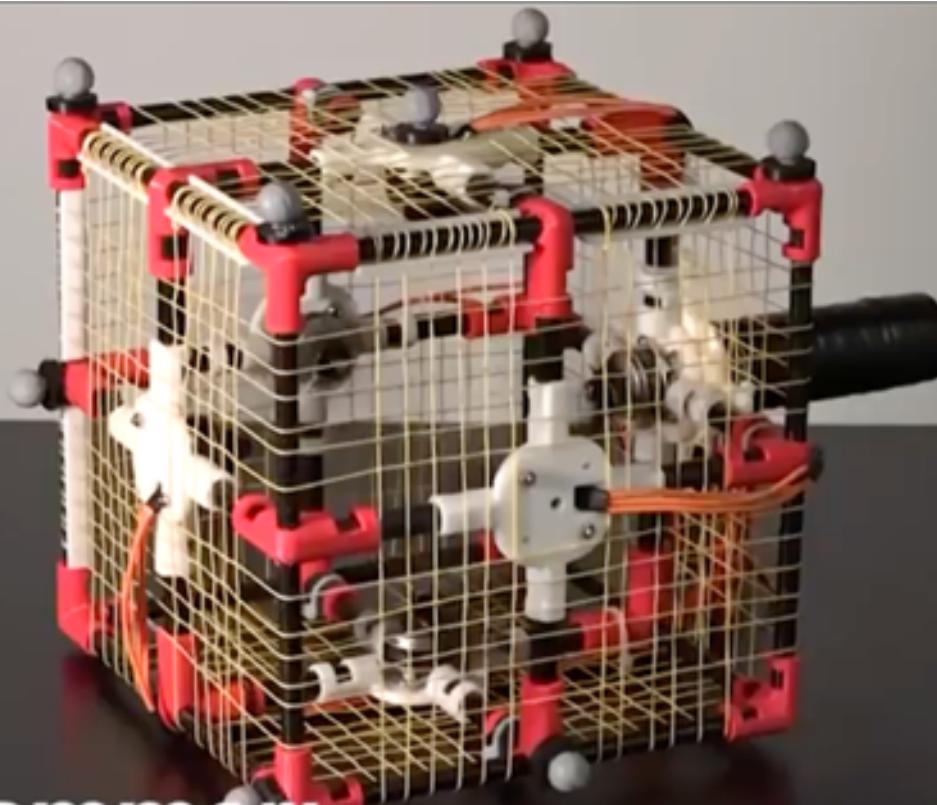
<sup>1</sup>Microsoft Research, Redmond, WA, USA

<sup>2</sup>Stanford University, Stanford, CA, USA

HAND







# Thor's Hammer:

An Ungrounded Force Feedback Device  
Utilizing Propeller-Induced Propulsive Force

Seongkook Heo

Christina Chung

Geehyuk Lee

Daniel Wigdor

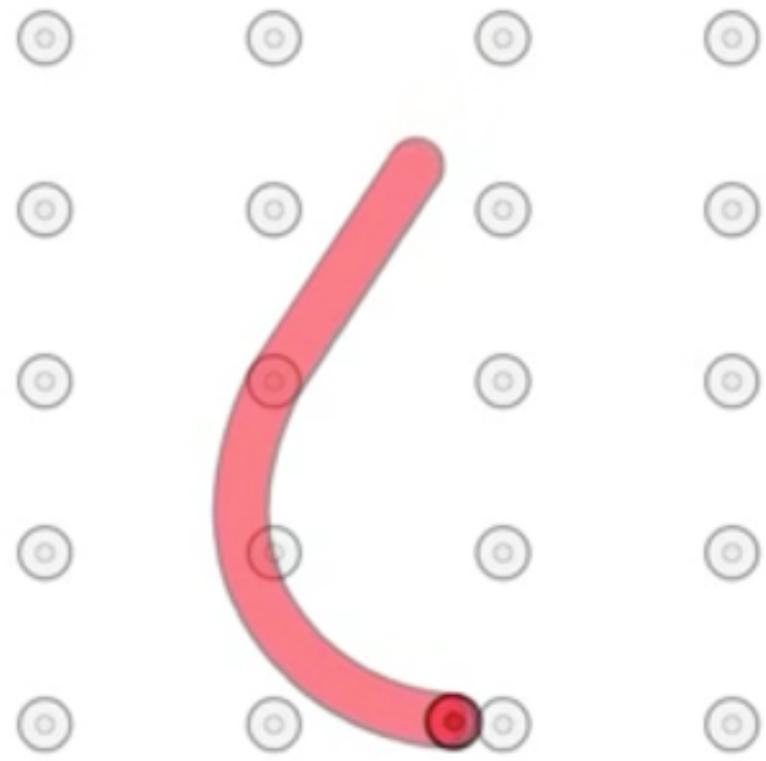


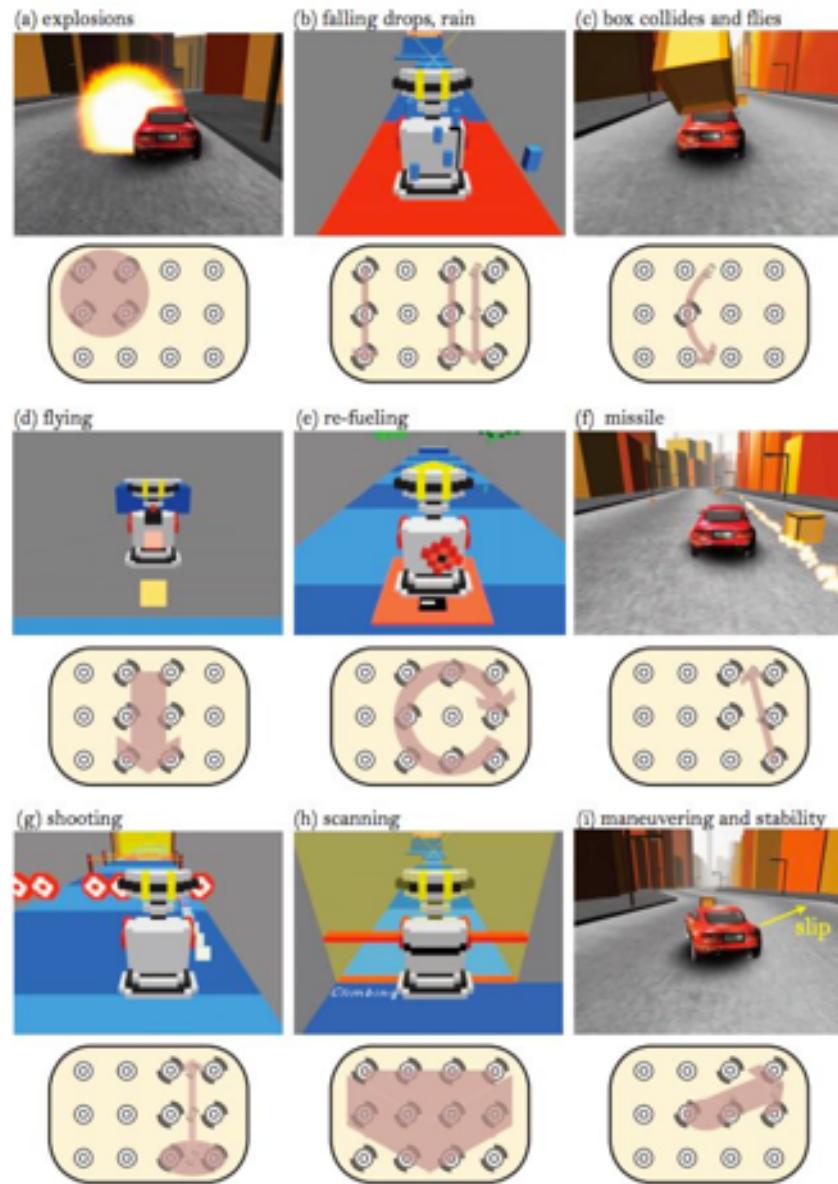
BODY

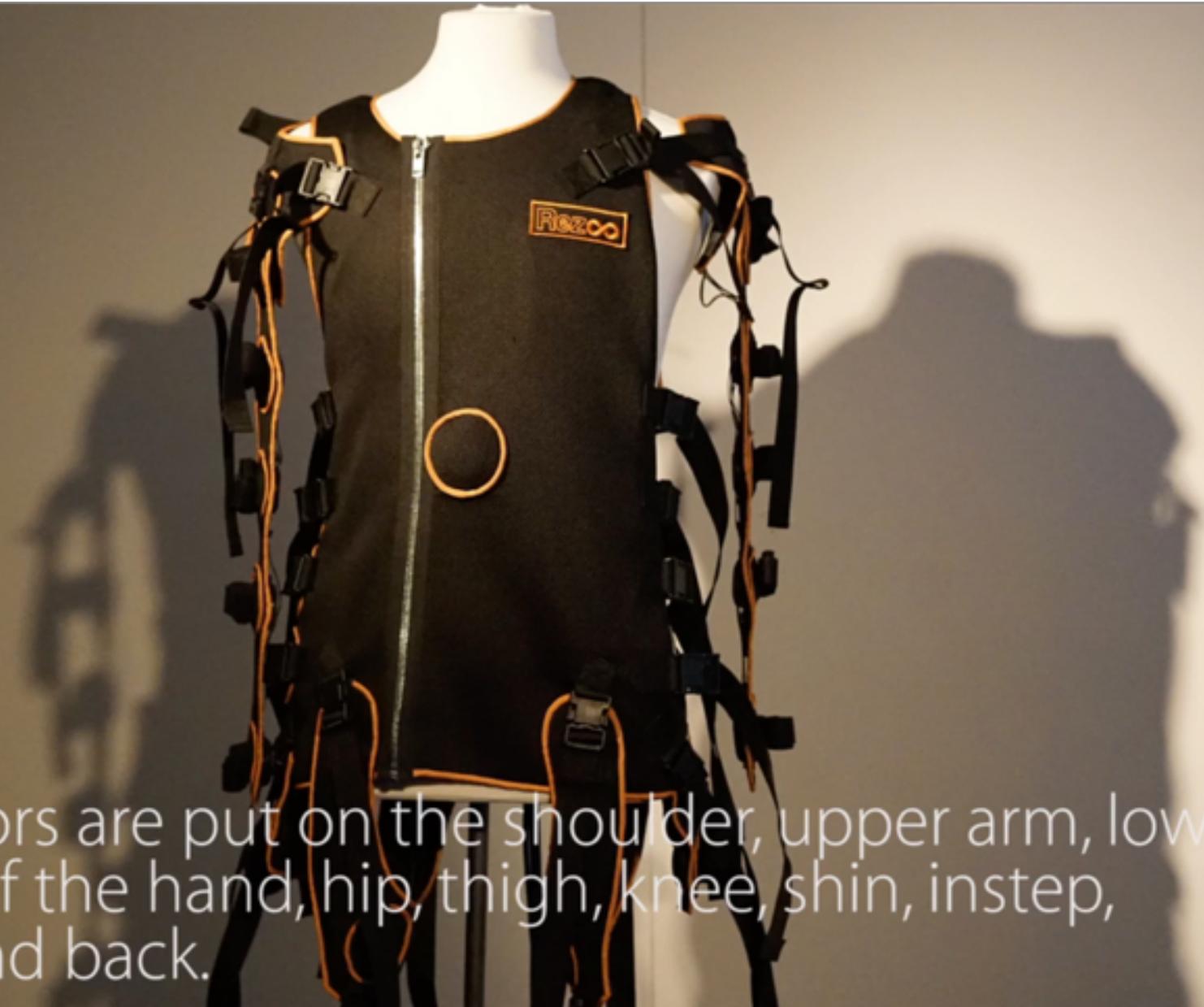


clever one : **appears spatial**

tactile brush [Israr CHI11]







The actuators are put on the shoulder, upper arm, lower arm, back of the hand, hip, thigh, knee, shin, instep, stomach and back.

---

# Force Jacket:

## Pneumatically-Actuated Jacket for Embodied Haptic Experiences

Alexandra Delazio\*, Ken Nakagaki†\*,  
Roberta Klatzky‡, Scott E. Hudson‡\*,  
Jill Fain Lehman\*, Alanson Sample\*

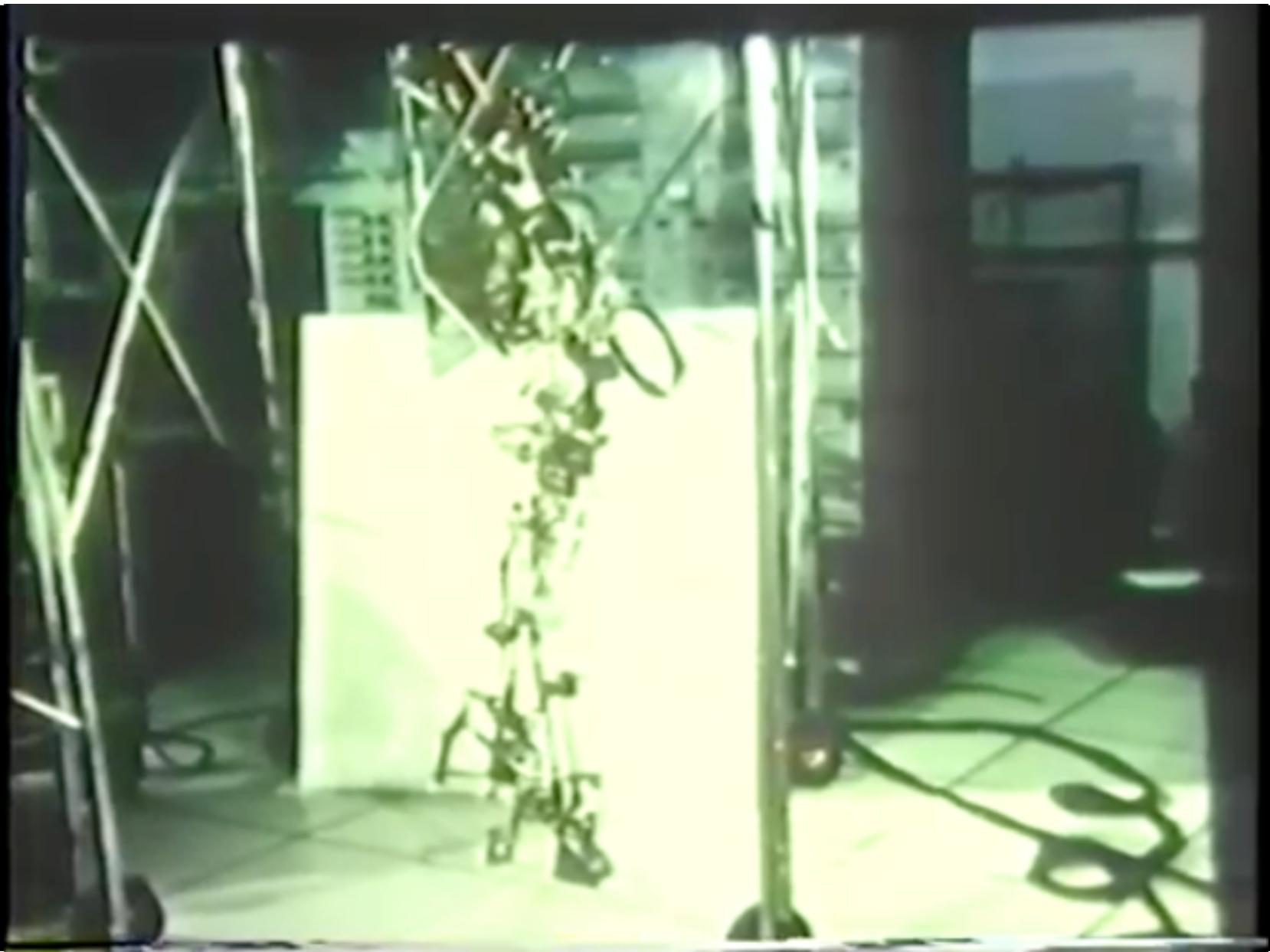
\*Disney Research  
†MIT Media Lab  
‡Carnegie Mellon University





1965-71 – G.E. Hardiman I Exoskeleton –  
Ralph Mosher (American)









can we borrow **active power** from the user's hands...

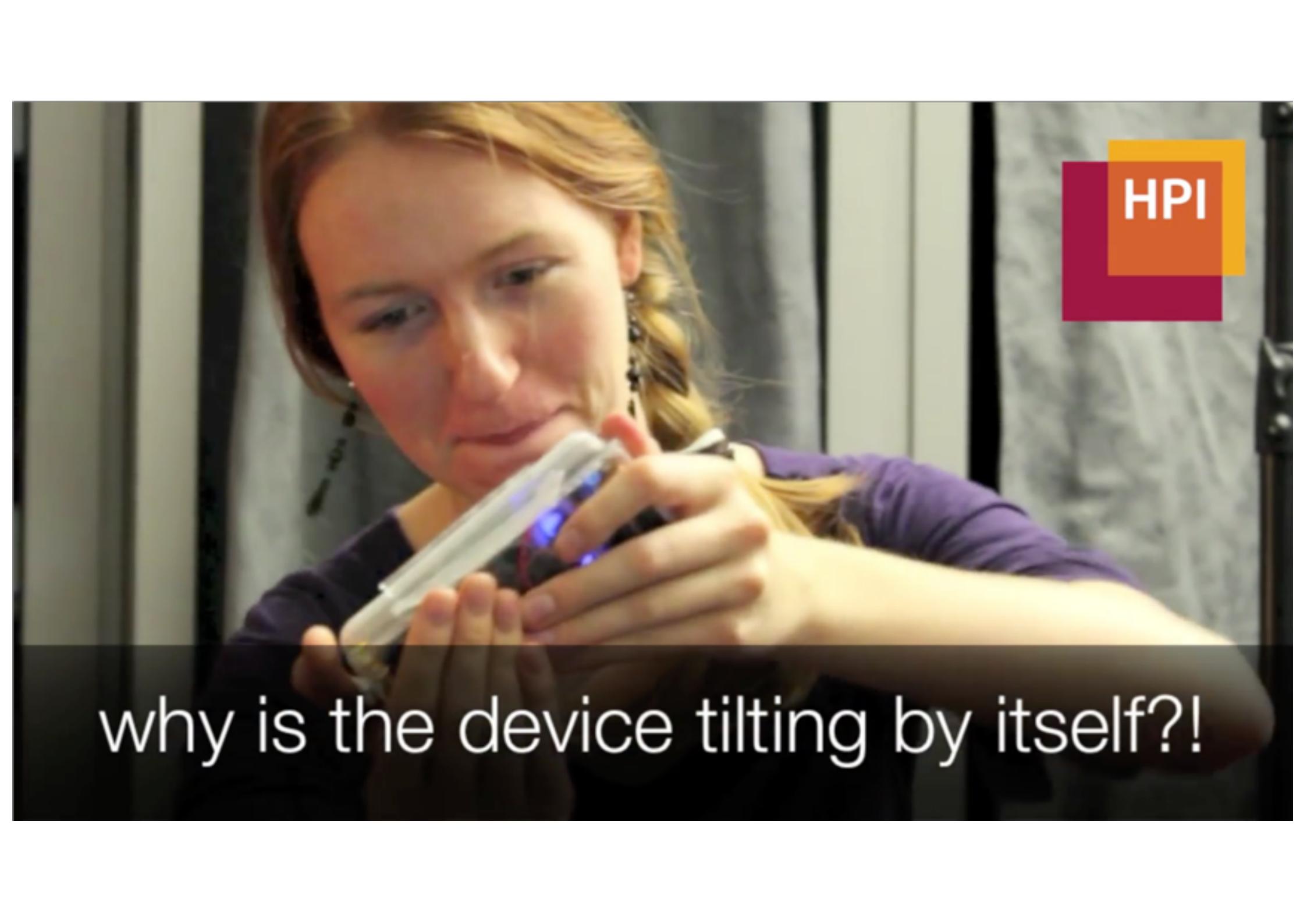


# electrical muscle stimulation ::

control body movements by directly sending electric charges in the nerves



**PossessedHand**

A close-up photograph of a young woman with blonde hair, wearing a purple long-sleeved shirt. She is holding a white, rectangular electronic device with two blue glowing lights on its front face. Her hands are positioned as if she is adjusting or examining the device. The background is slightly blurred, showing what appears to be a window with vertical blinds.

HPI

why is the device tilting by itself?!

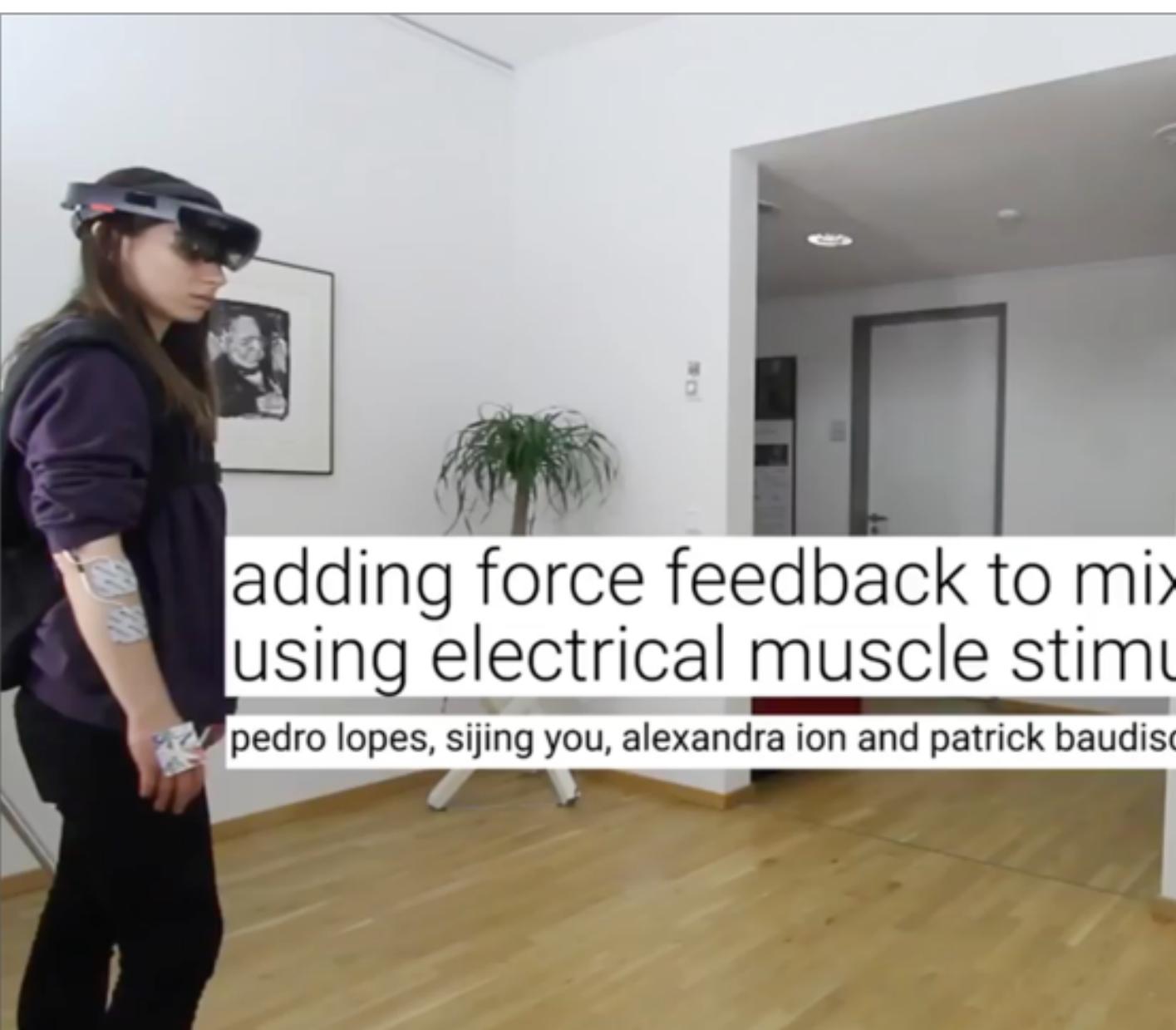
# impacto

Simulating Physical Impact by Combining  
Tactile with Electrical Muscle Stimulation



Pedro Lopes, Alexandra Ion, and Patrick Baudisch





# adding force feedback to mixed reality using electrical muscle stimulation

pedro lopes, sijing you, alexandra ion and patrick baudisch

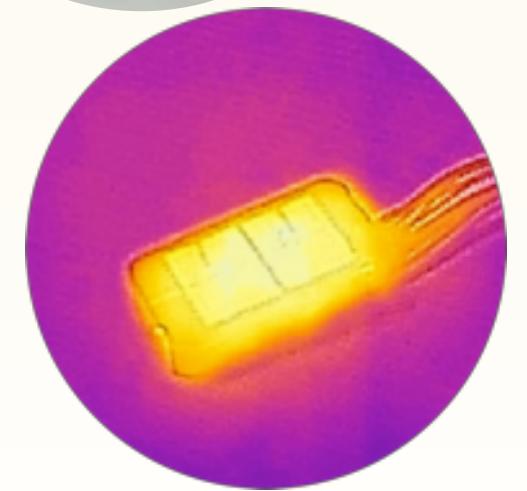
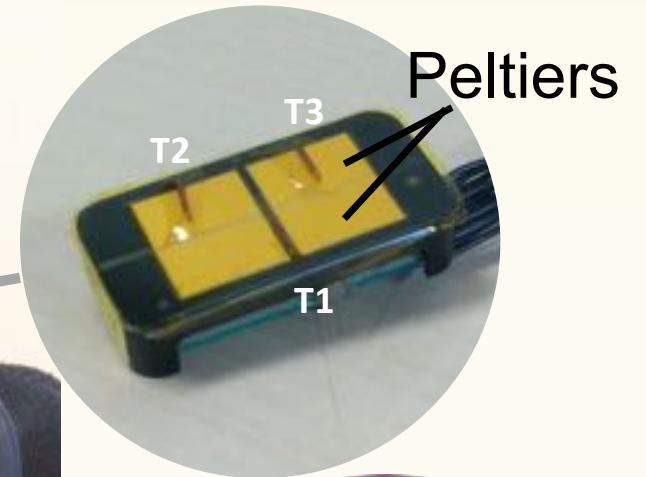
FACE



# On-Face Haptics

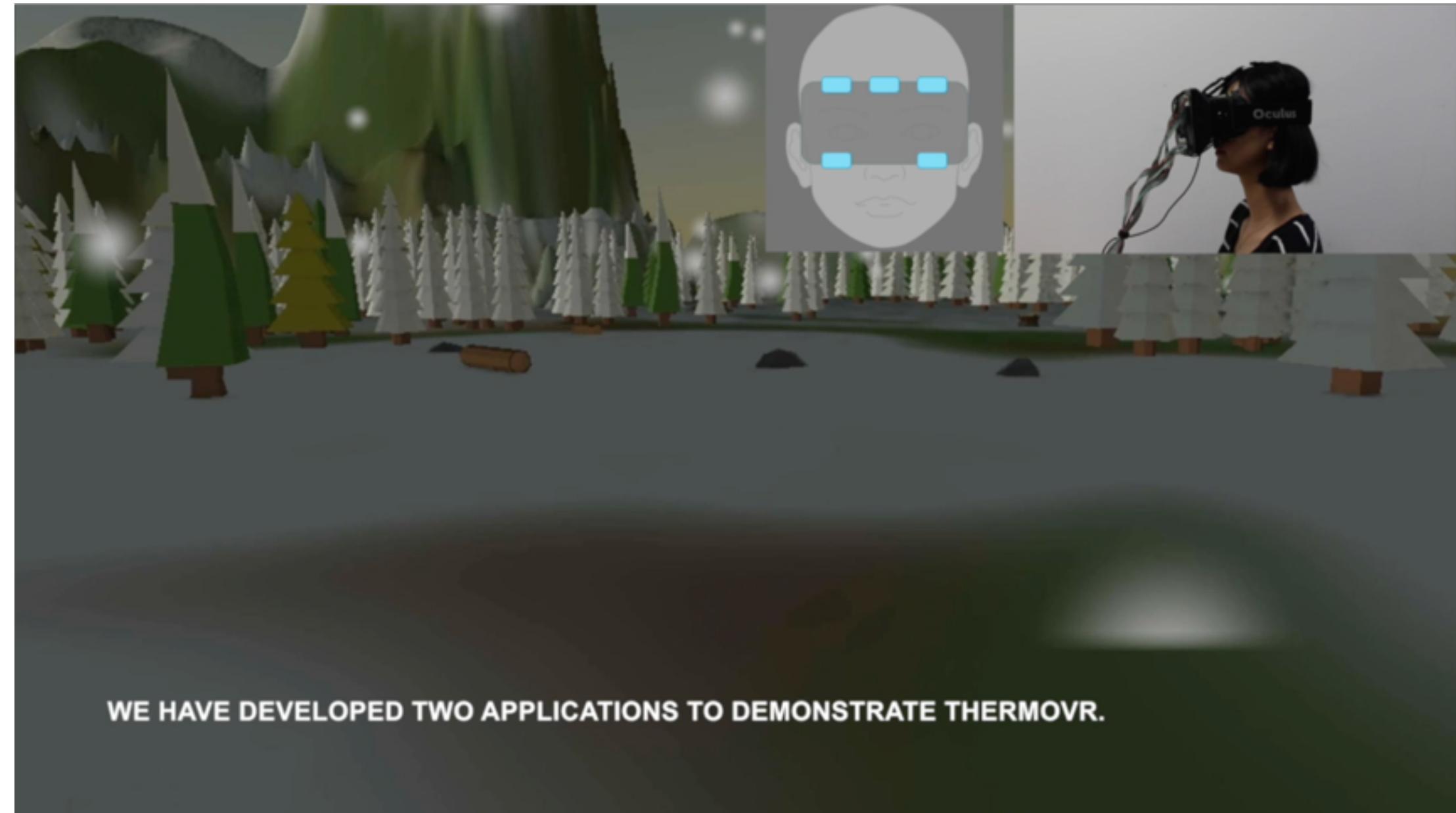
Dr. Liwei Chan  
Assistant Professor /  
National Chiao Tung University

# ThermoVR System Setup

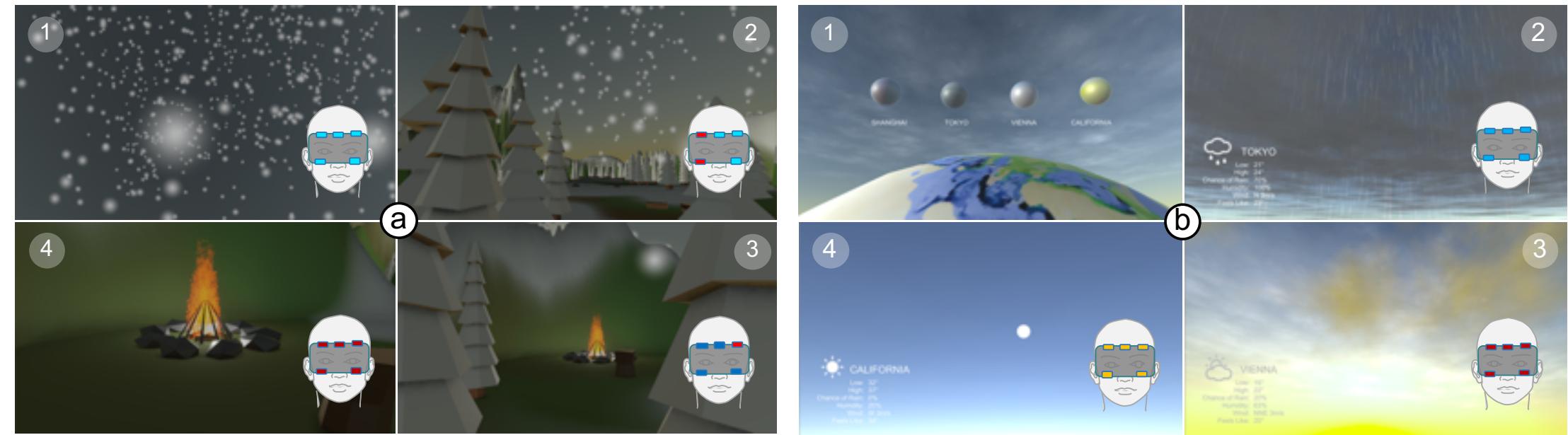


Katsunari Sato and Takashi Maeno: Presentation of Rapid Temperature Change using Spatially Divided Hot and Cold Stimuli, Journal of Robotics and Mechatronics, Vol.25, No.3, pp.497-505

Thermal Vision



WE HAVE DEVELOPED TWO APPLICATIONS TO DEMONSTRATE THERMOVR.



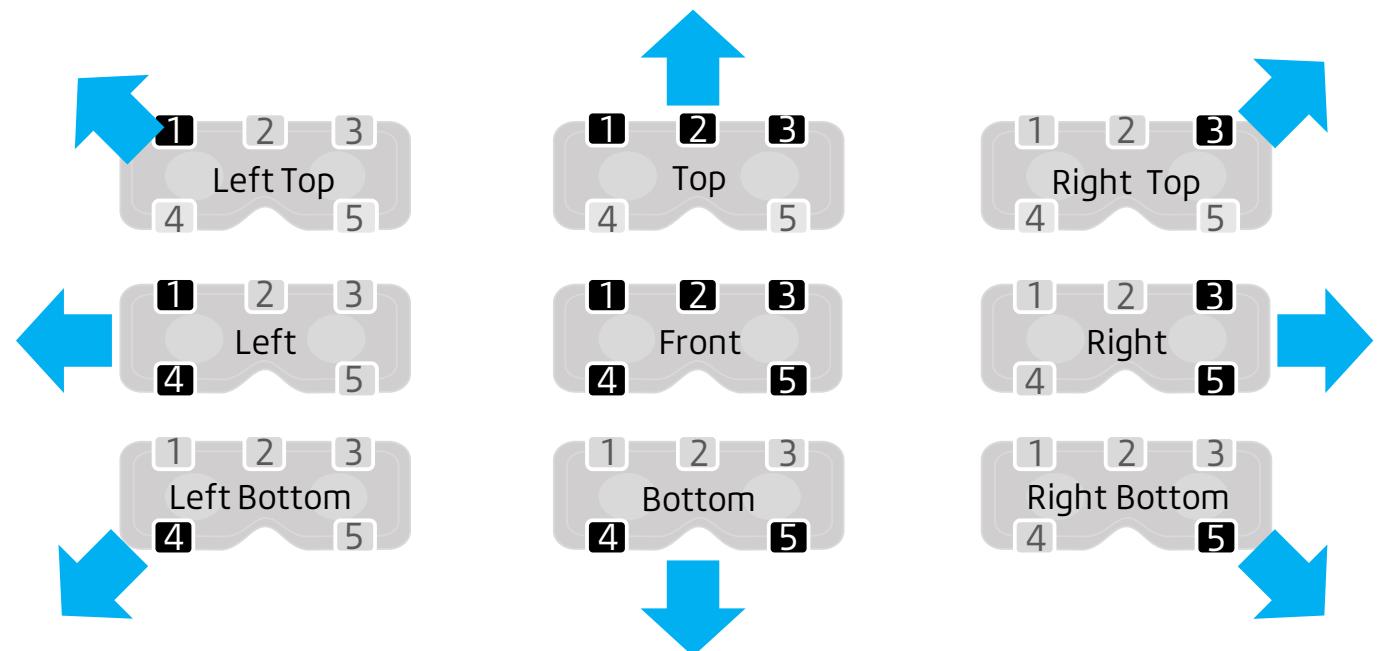
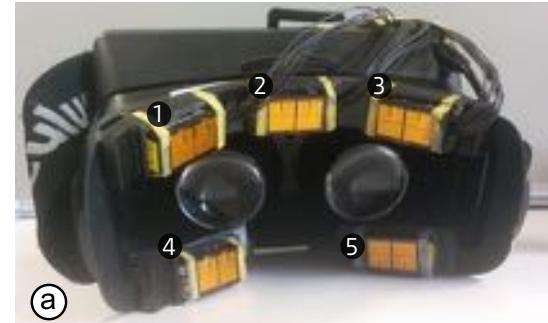
**experiment**

# Study 1 – Perception Accuracy

Accuracy of Perception of Spatial Cues  
9 cues x 2 types (hot/cold) x 5 repeats

From Skin Temperature:

- +3C - Hot
- 3C - Cold

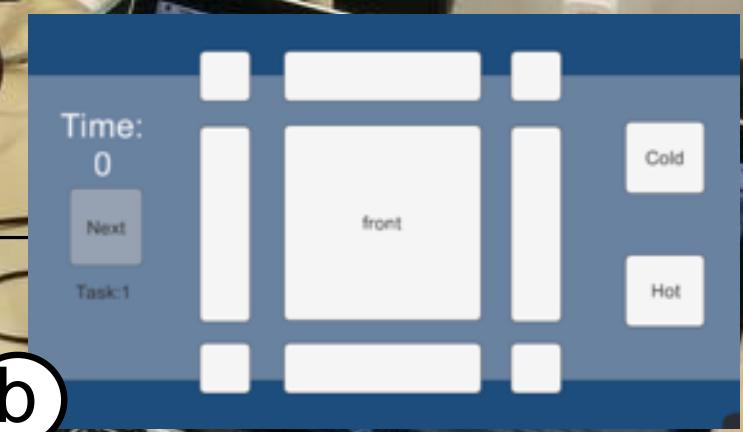


— HMD with Thermal Feedback

Temperature  
Controllers

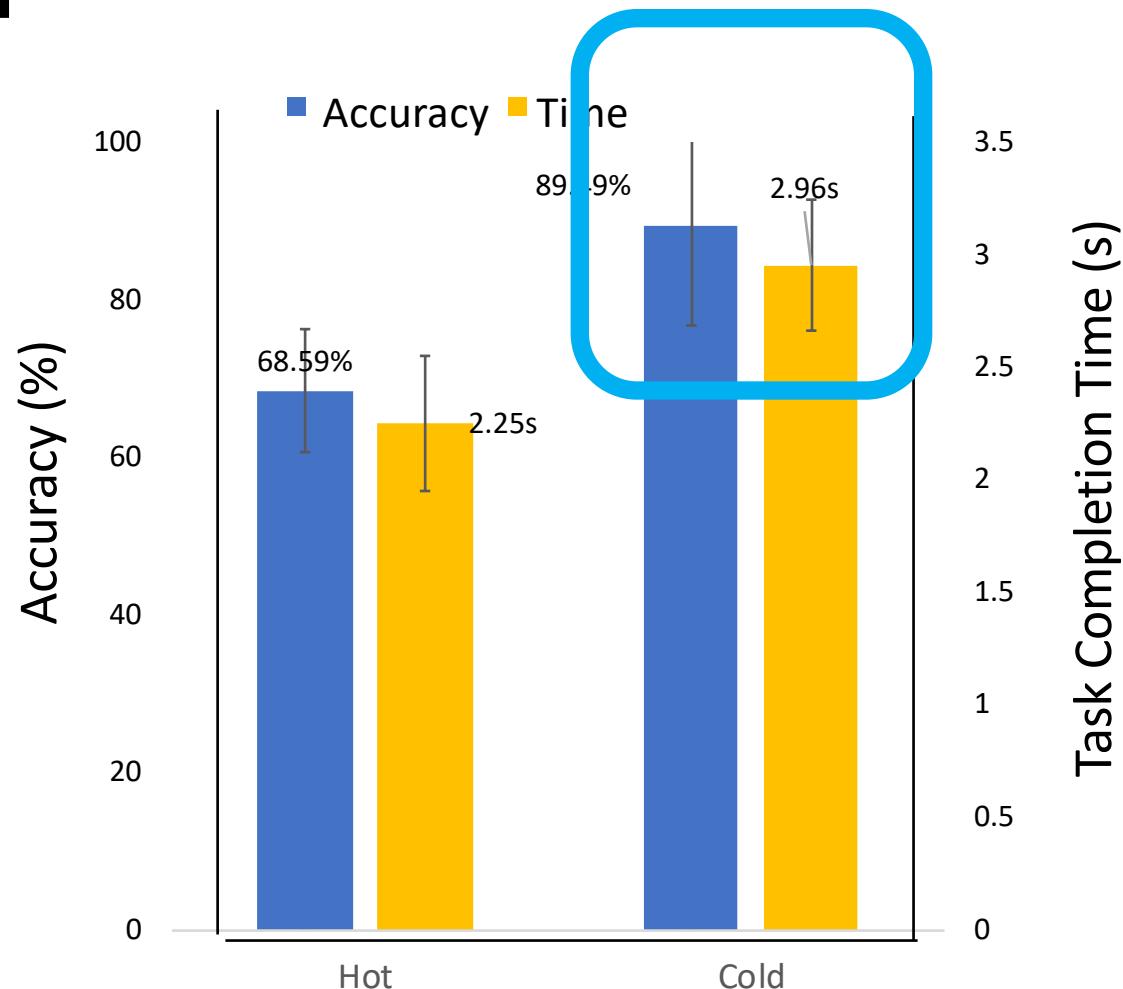
a

b



# Results: Study 1

Perception  
Accuracy  
Cold stimulations  
significantly better



# Feedback: Study 1

Perception Accuracy

Cold stimulations significantly better

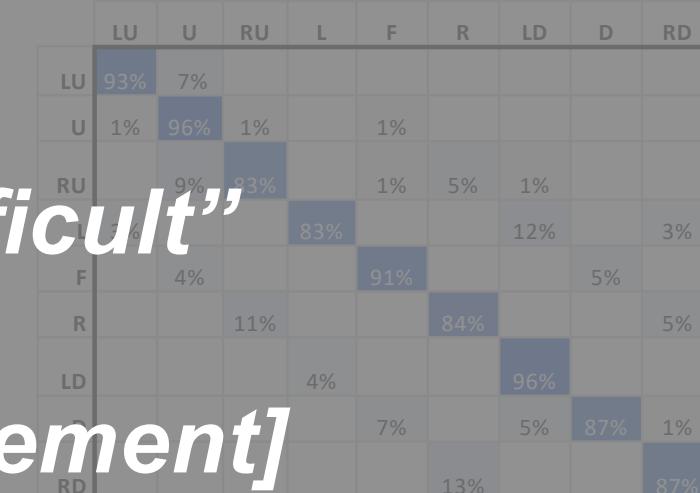
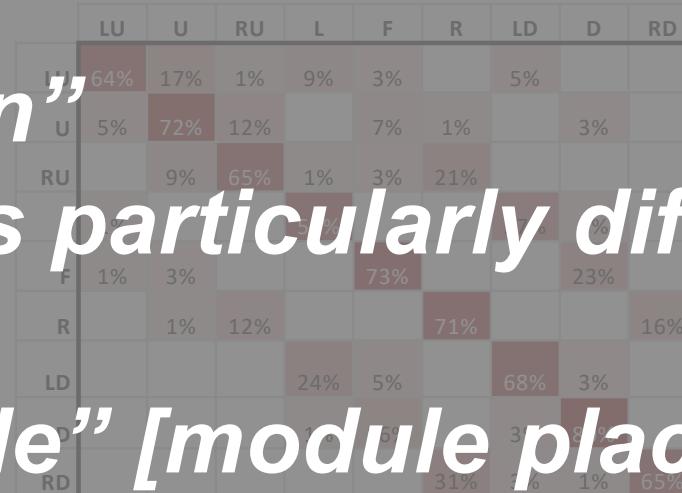
## Hot Stimulations

LU	U	RU
64%	72%	65%
L	F	R
58%	73%	70%
LD	D	RD
68%	80%	65%

## Cold Stimulations

LU	U	RU
93%	96%	83%
L	F	R
83%	91%	84%
LD	D	RD
96%	87%	87%

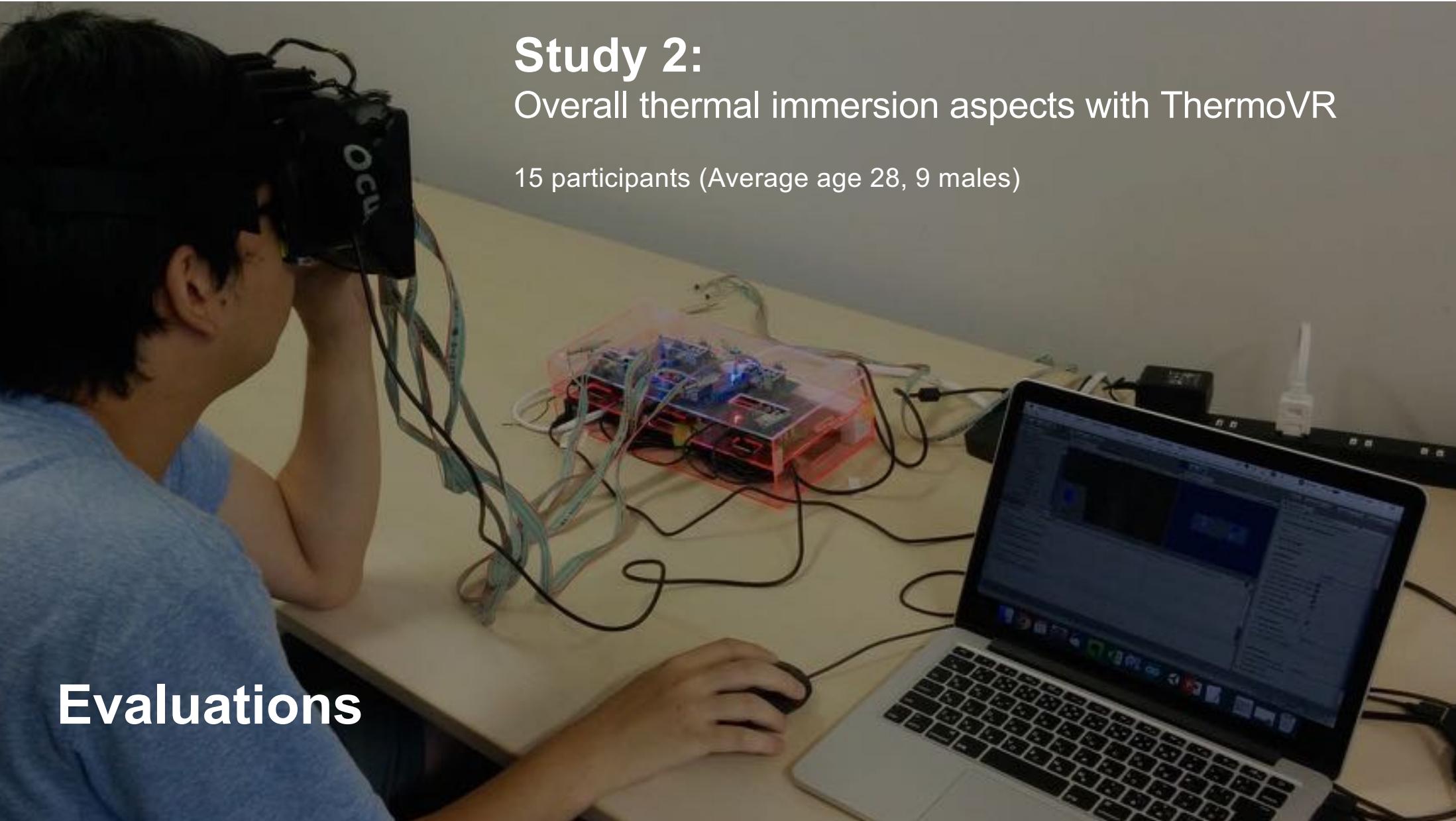
- *Cold was “Fun”*
- *“Forehead was particularly difficult”*
- *“Hot pinch”*
- *“Uncomfortable” [module placement]*



## **Study 2:** Overall thermal immersion aspects with ThermoVR

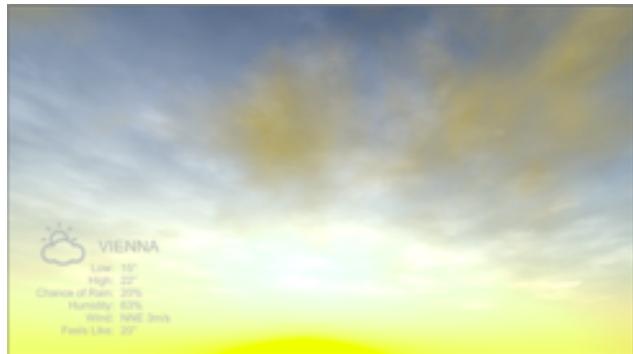
15 participants (Average age 28, 9 males)

**Evaluations**

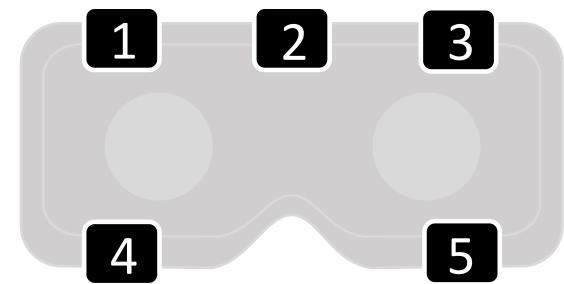


# Study 2 – Thermal Immersion

No Stimulation vs Hot Stimulation vs Cold Stimulation



Visuals



Stimuli

Modified Presence Questionnaire for Evaluation

$\pm 3^{\circ}\text{C}/\text{s}$  for 1s  
And maintain  
(from skin temperature)

# Feedback: Study 2

Thermal Immersion

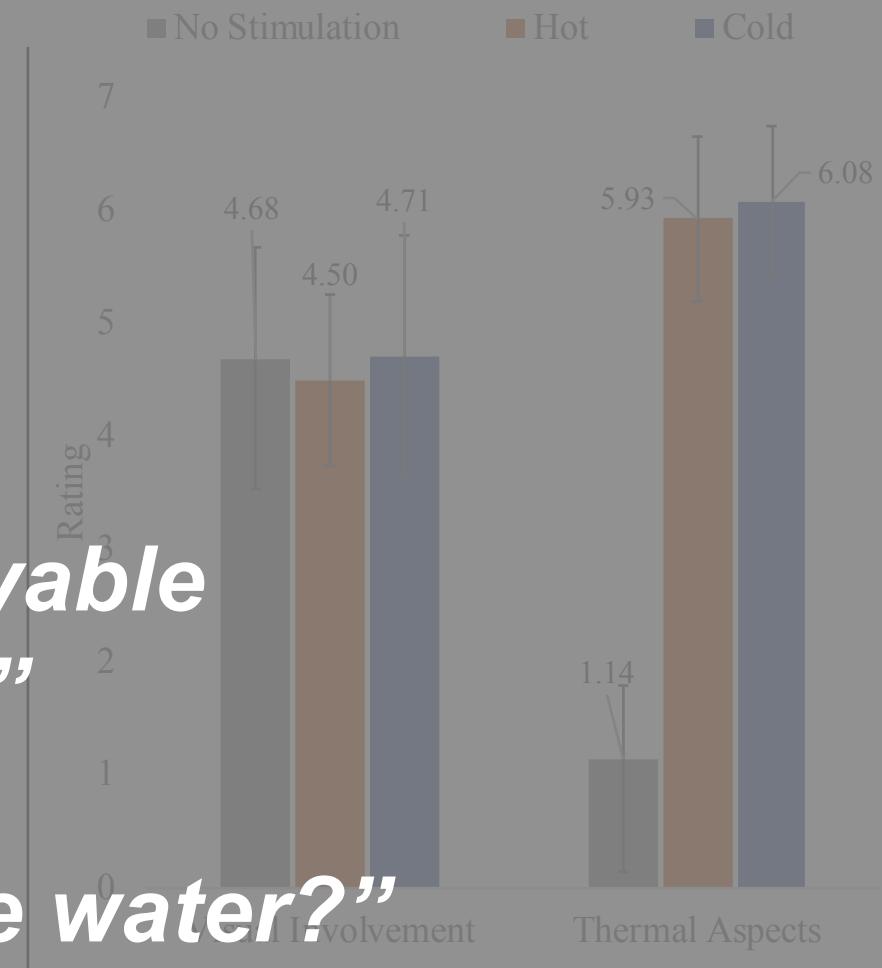
Significant improvement in thermal immersion

*Thermal immersion – enjoyable*

*“Like opening an oven”*

*“Feels like water”*

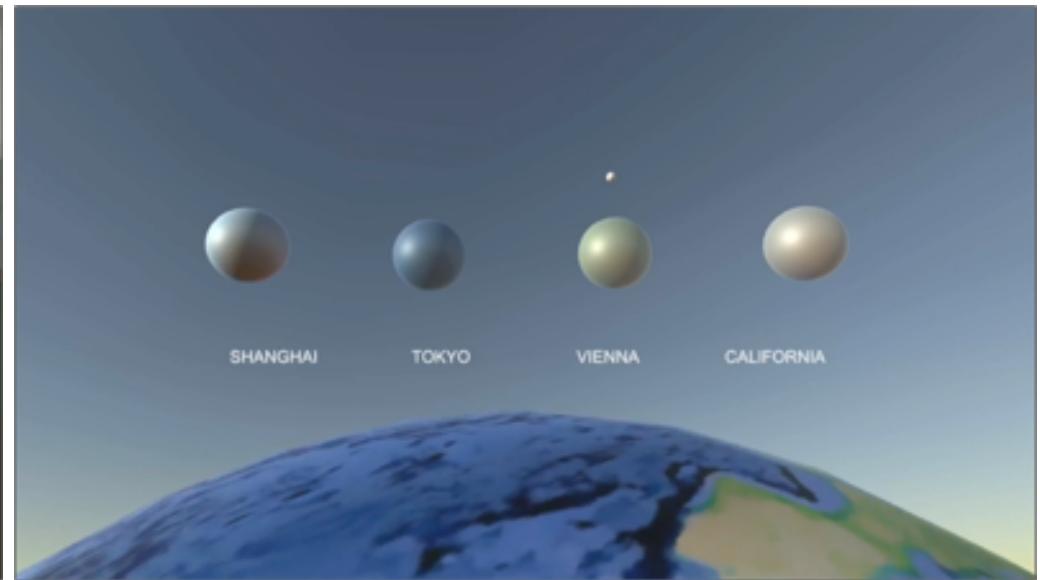
*“How did you spray the water?”*



# Applications



Where's my camp?



What's the weather?

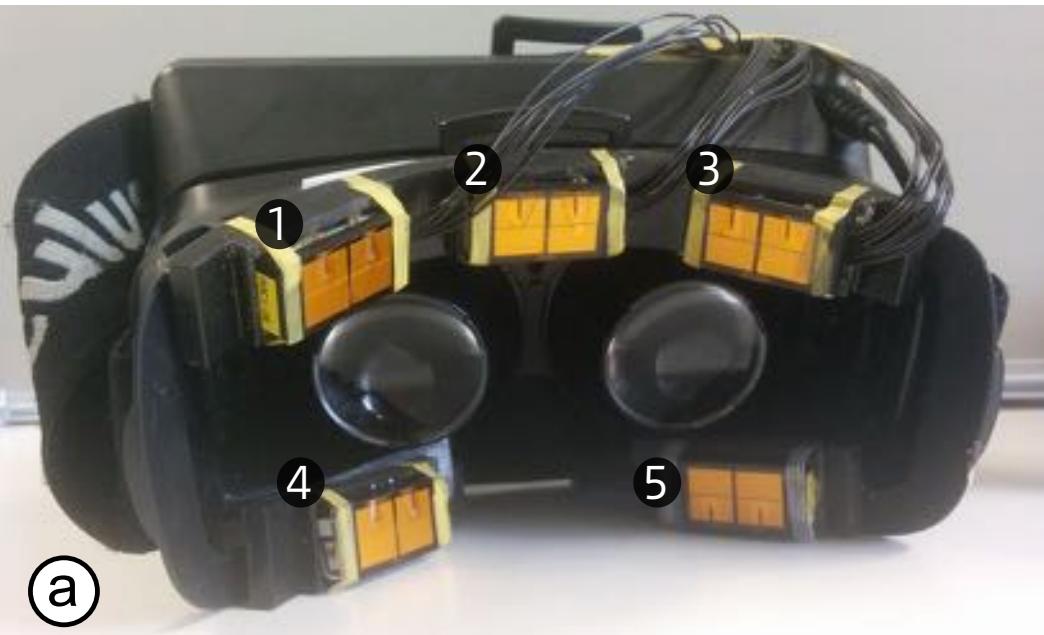


# **FacePush: Introducing Normal Force on Face with HMDs**



# **RELATED WORK**

# Thermal and Wind Feedbacks for directional cues and enhanced immersion.

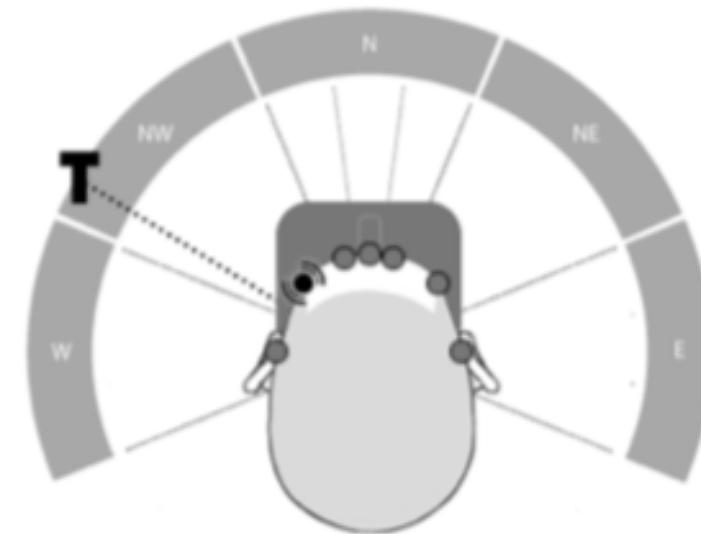
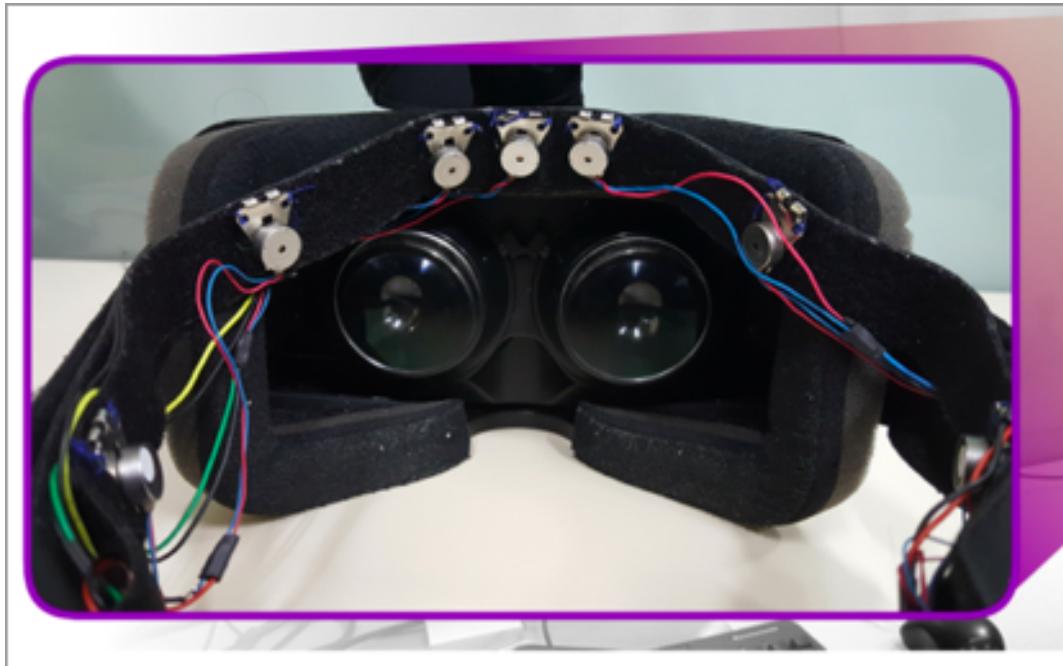


ThermoVR, CHI 17



Ambiotherm, CHI 17

# Tactile Feedbacks for **directional** cues

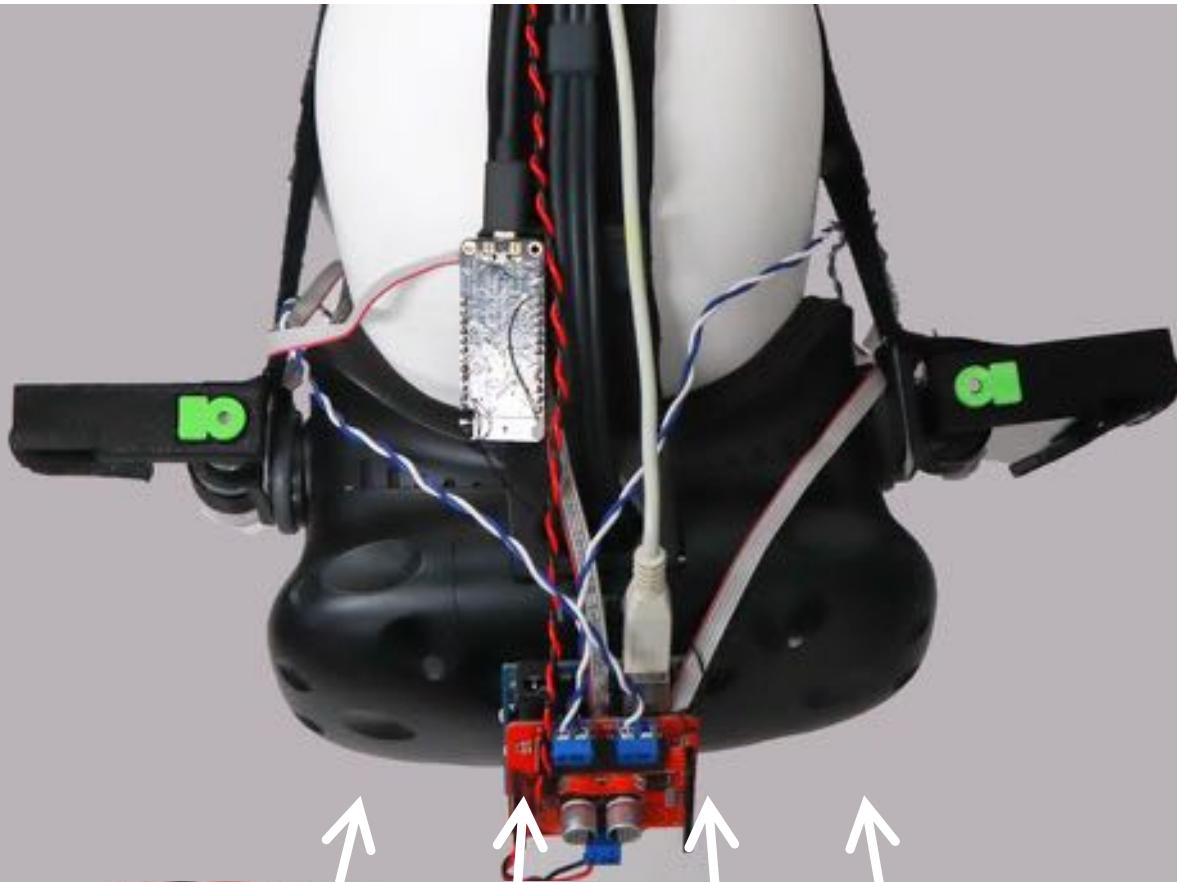


[IEEE VR 17]

# Tangential Force Feedbacks for enhanced immersion

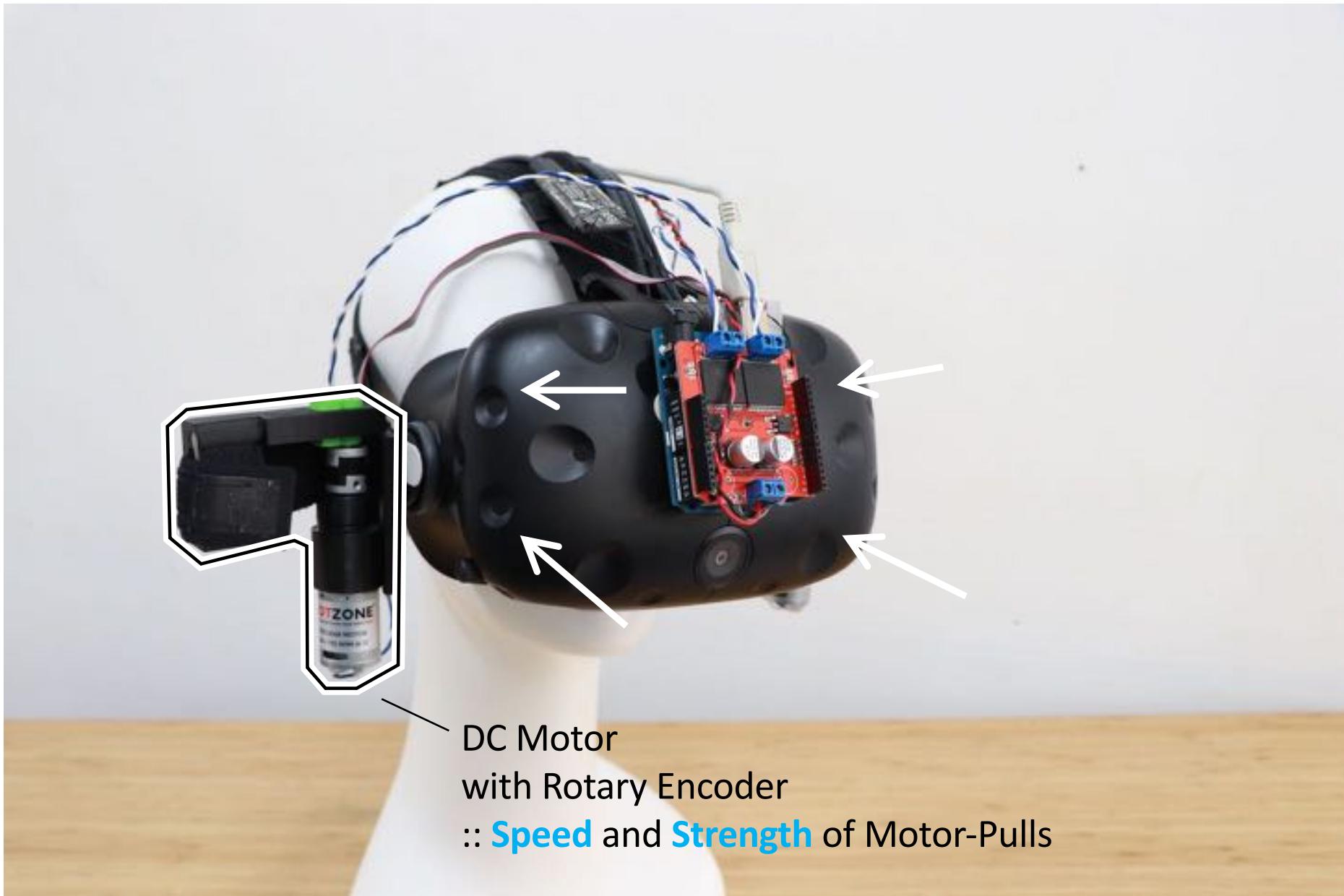


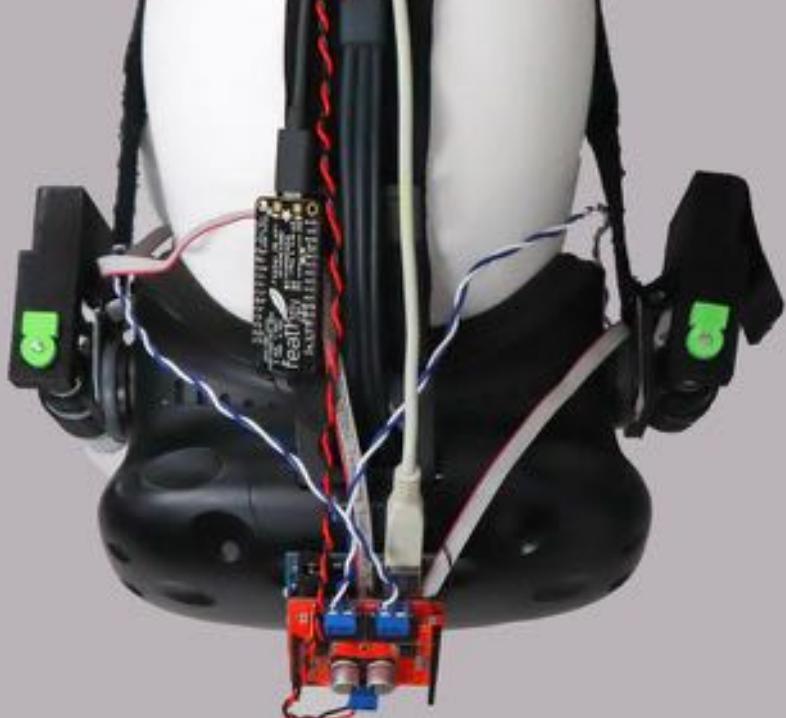
[GyroVR. CHI]



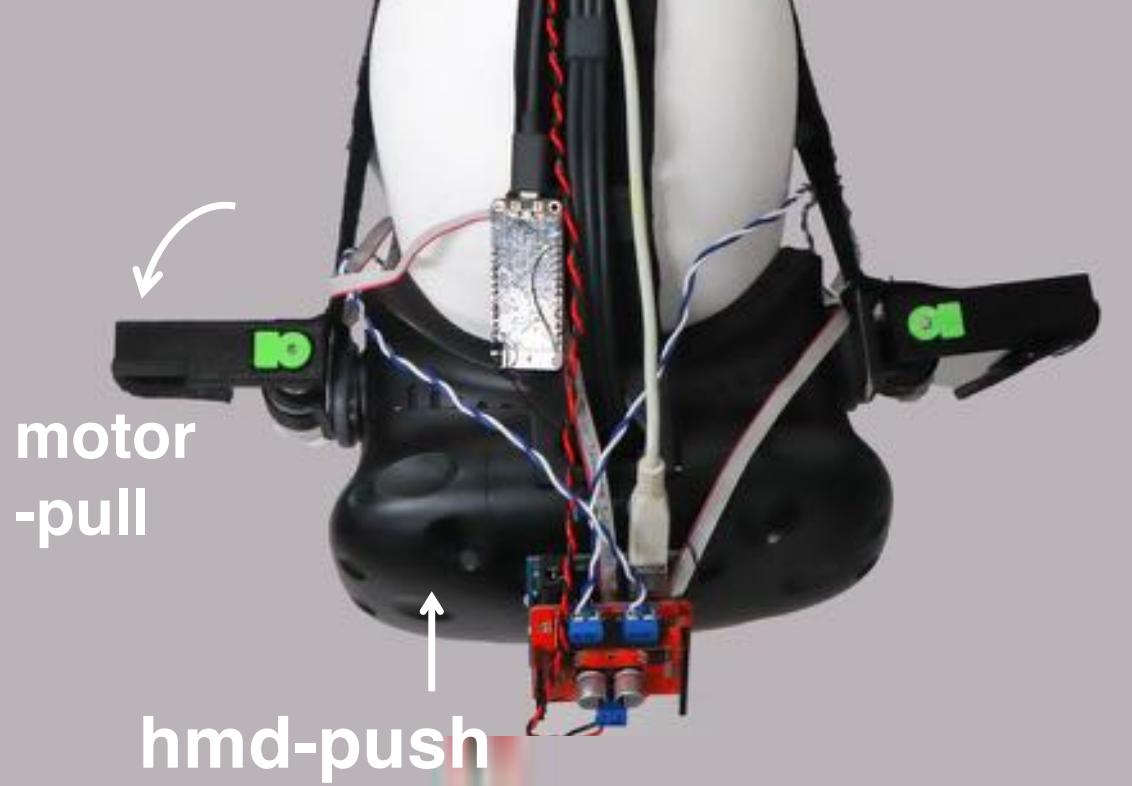
**FacePush::**  
**Normal Force** Feedbacks  
on Face for enhanced **immersion**

# Implementation





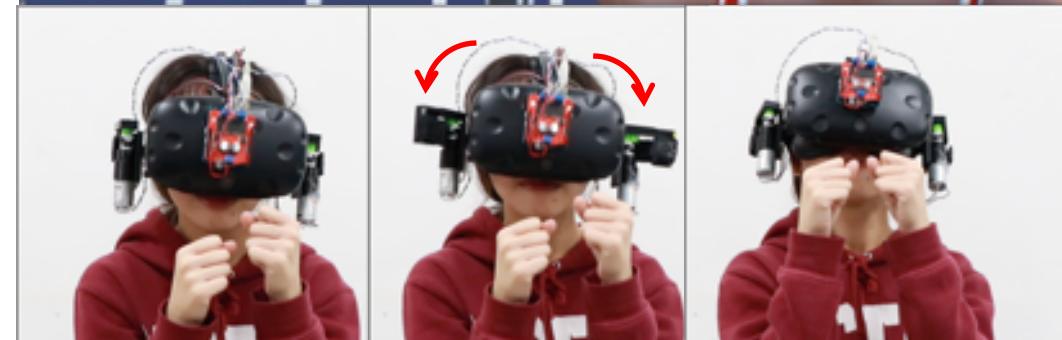
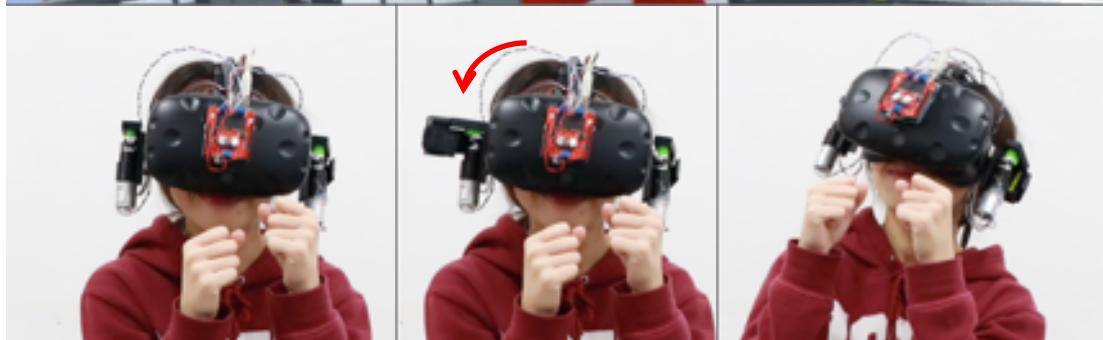
**neutral**



**pushed**

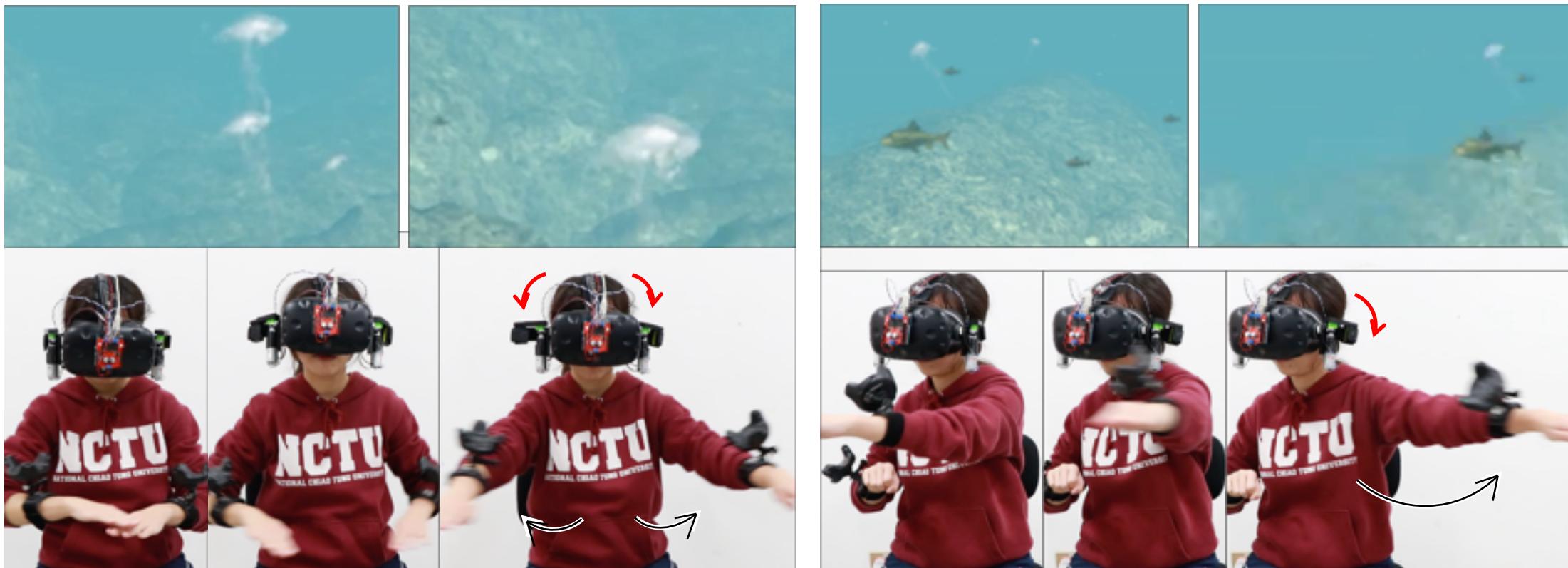
# Experience

# Boxing: Strong / Instant Push





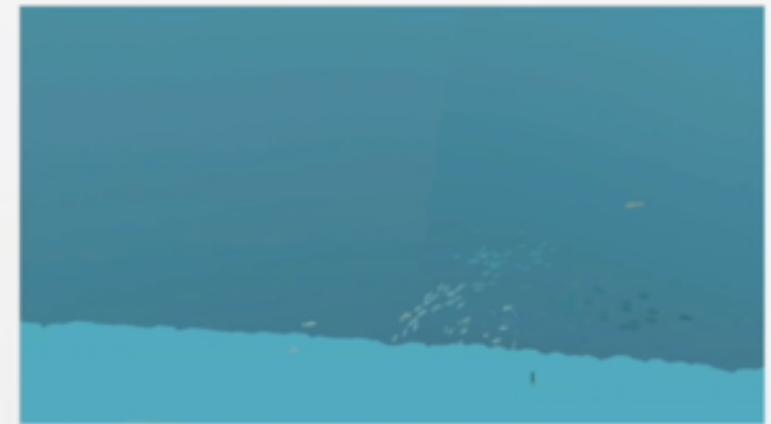
# Diving





Turn Right

# Fish Passing By



# Shark Approaching

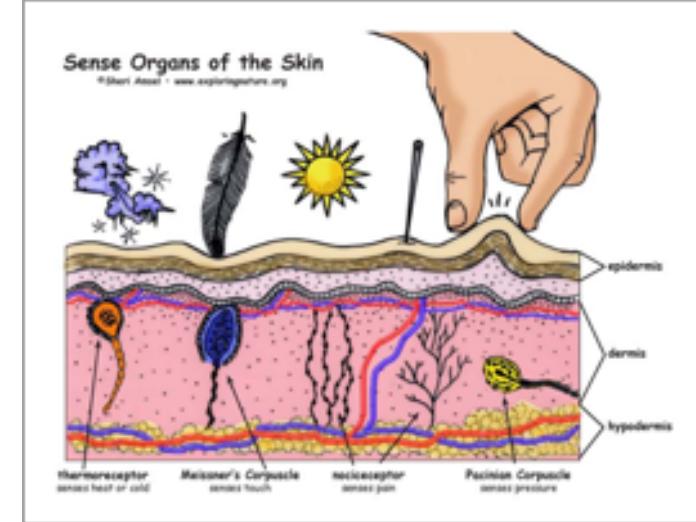
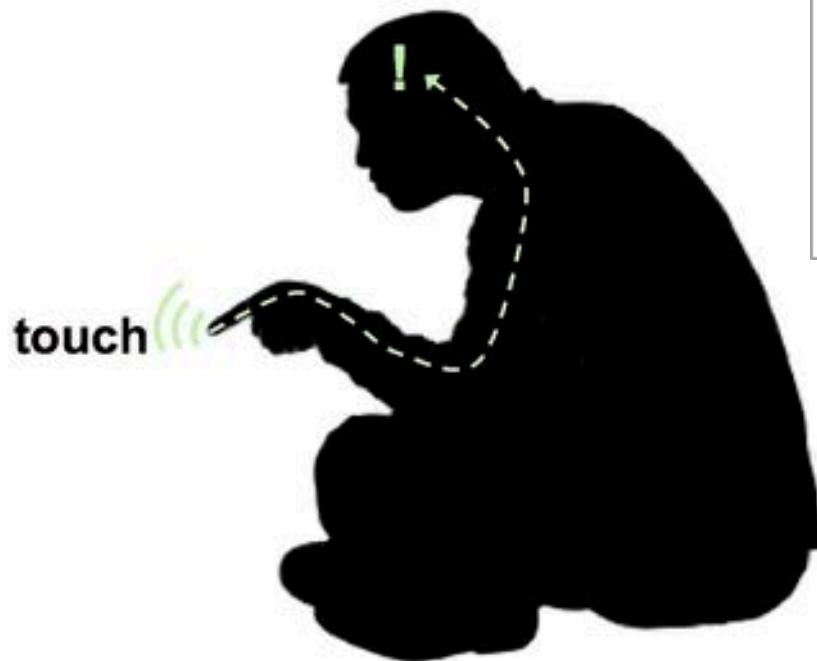


# Take-Away Message

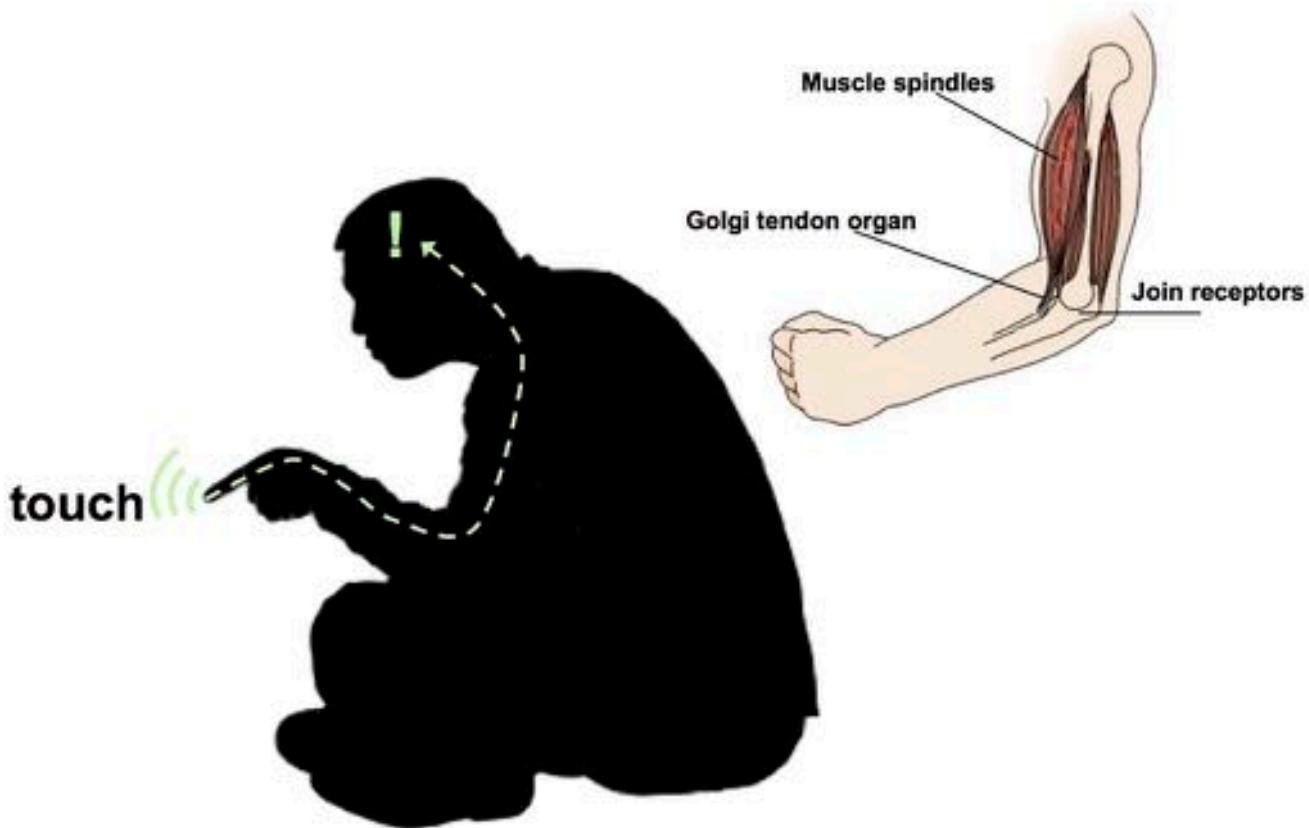
# **haptics ::**

(or haptic technology) is a tactile feedback technology  
that **takes advantage of a user's sense of touch**

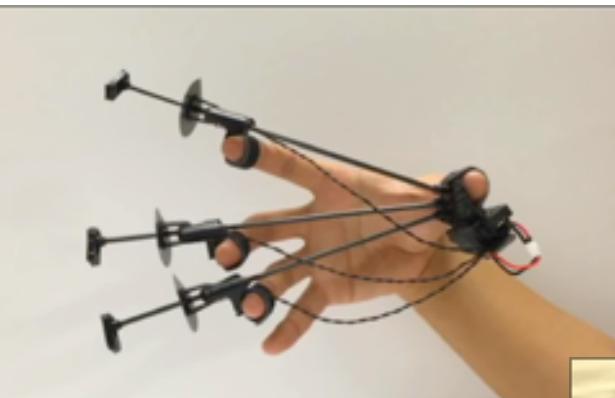
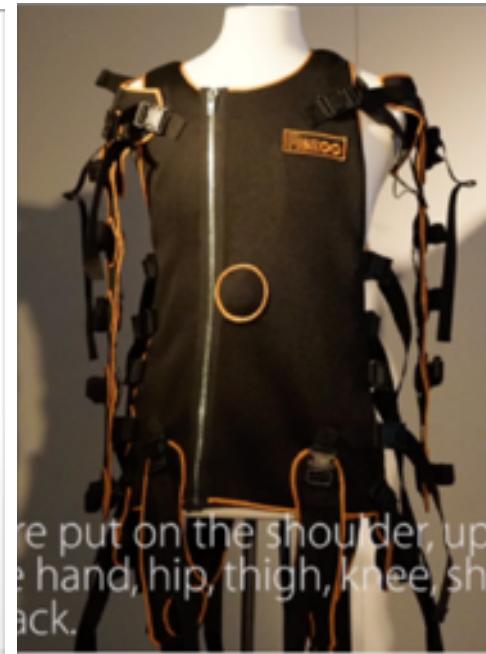
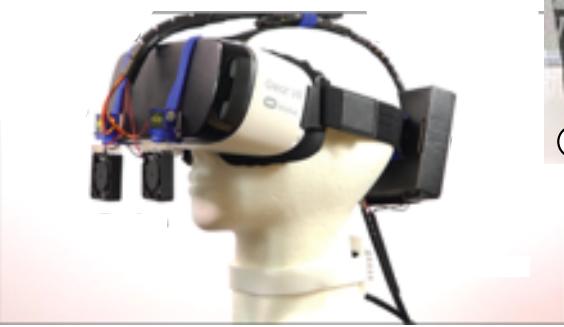
by applying **forces, vibrations, and/or motion to the user**



#1 touch → tactile sensation **on skin**



#2 force → **receptors on muscles/tendons**



# end

haptics has **many applications**  
including error prevention, eyes-free feedback...