Interaction Design & Virtual Reality

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Haptics

Content adapted from

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hciR
hasso-plattner institute

force feedback devices…

[CyberGrasp, Vrlogic]

CyberGrasp

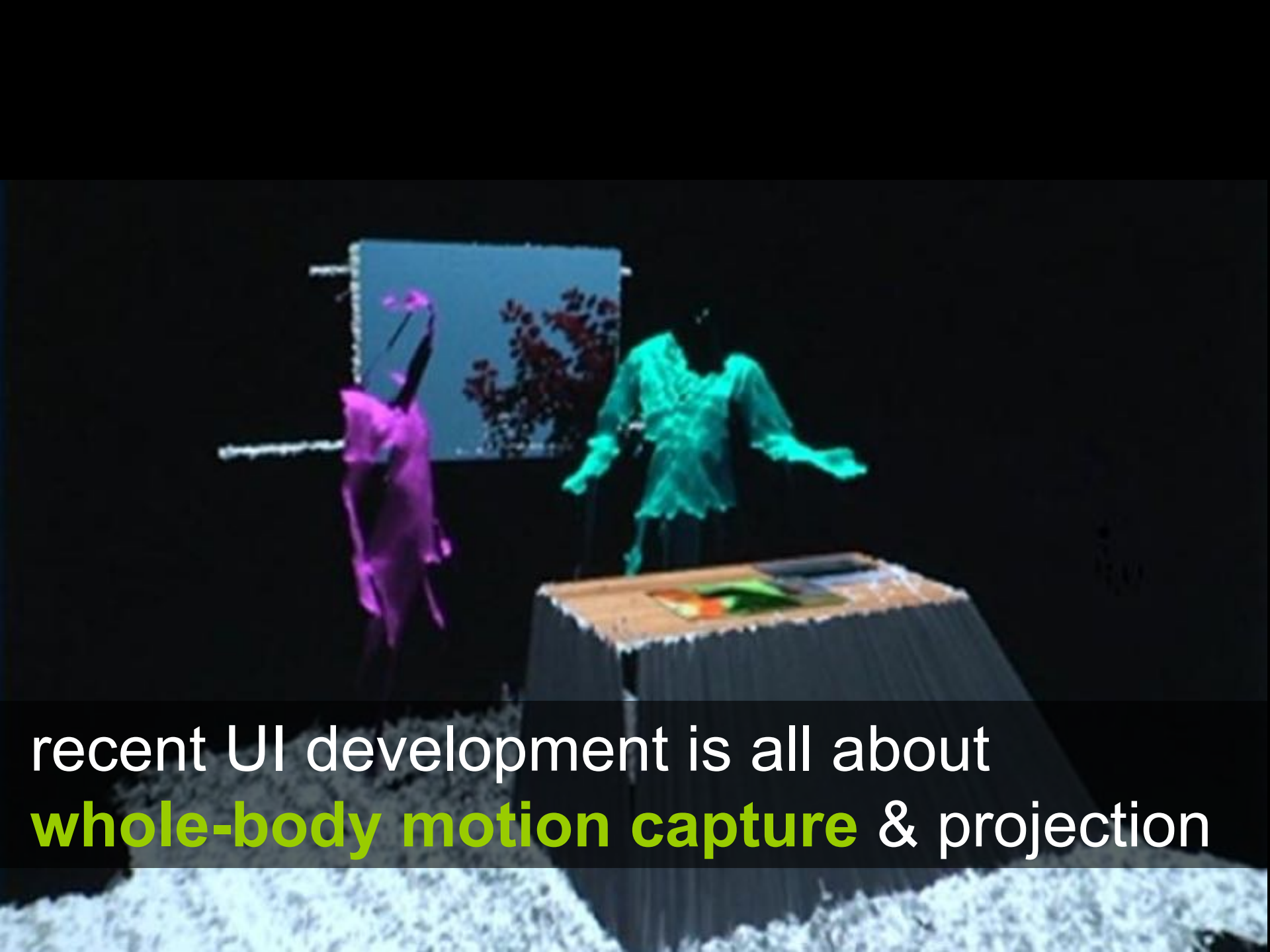
force feedback devices…

[PHANToM, senseable]

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

but let's start with…

motivation: the next step in immersion


recent UI development is all about
whole-body motion capture & projection

the level of interaction realism **people have been dreaming of** looks somewhat like this…

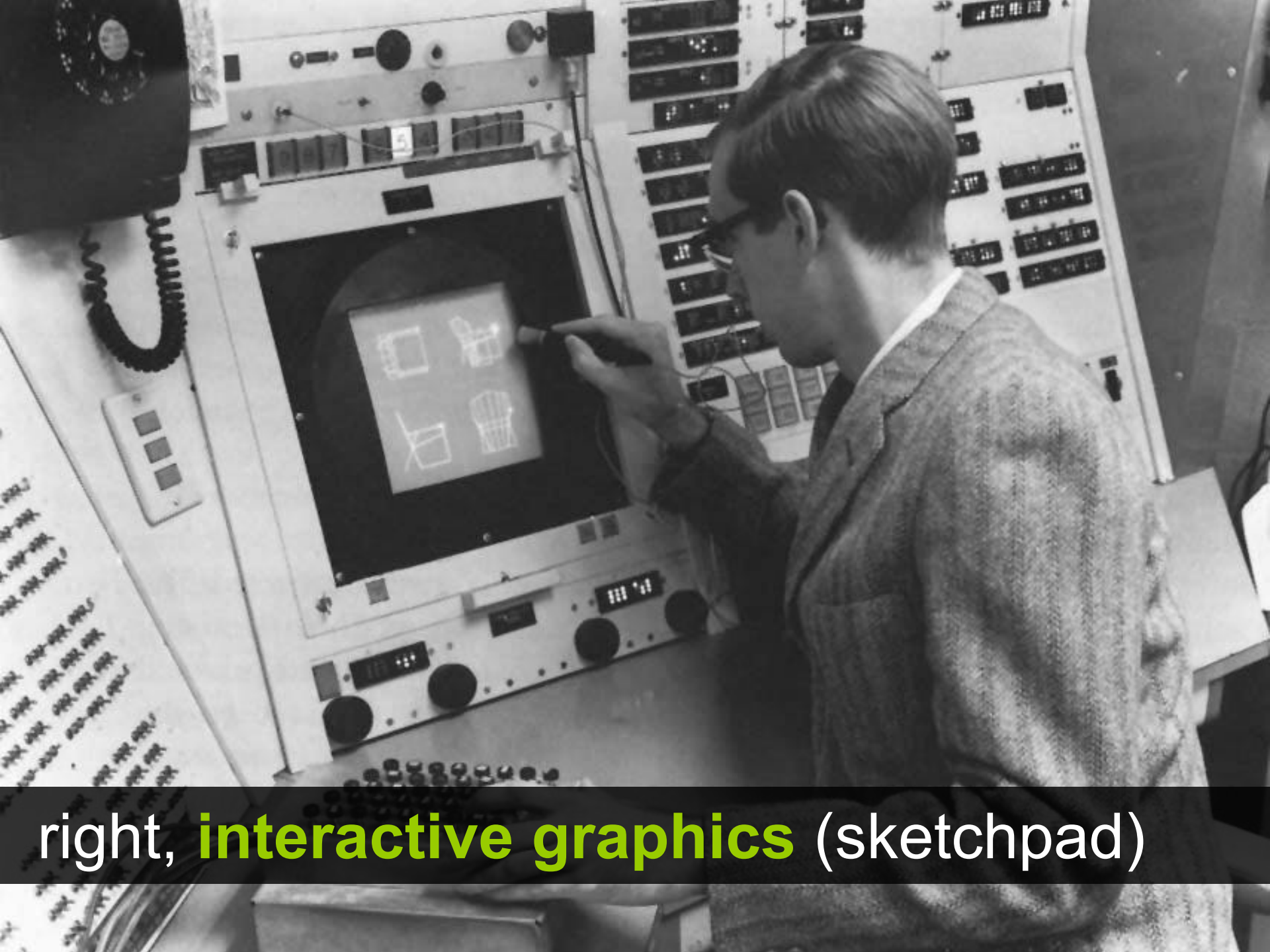
LightSpace

https://www.youtube.com/watch?v=gc_Xj7Z8aLU

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

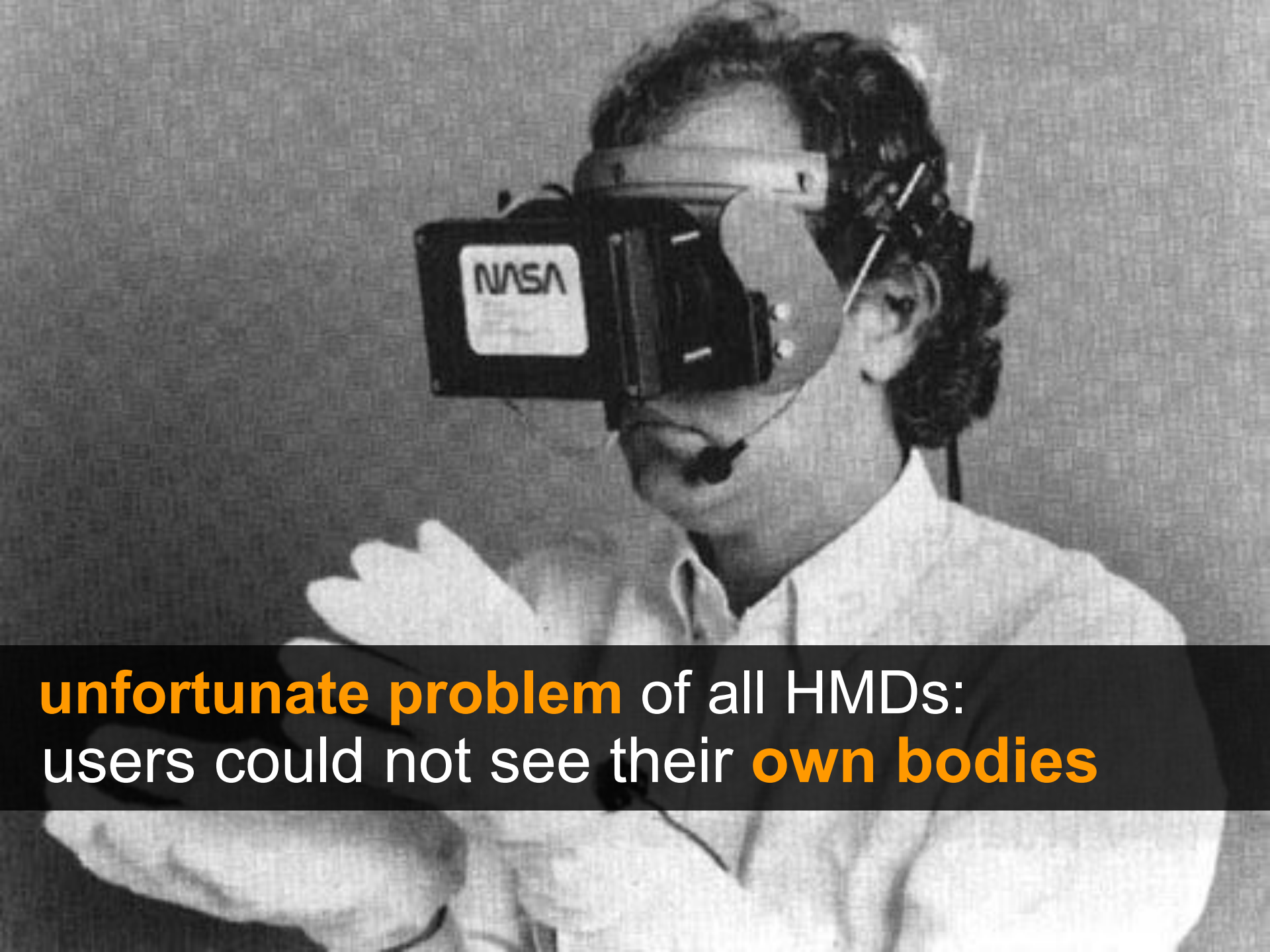
1968 head-mounted display

Ivan Sutherland (what else did he invent?)

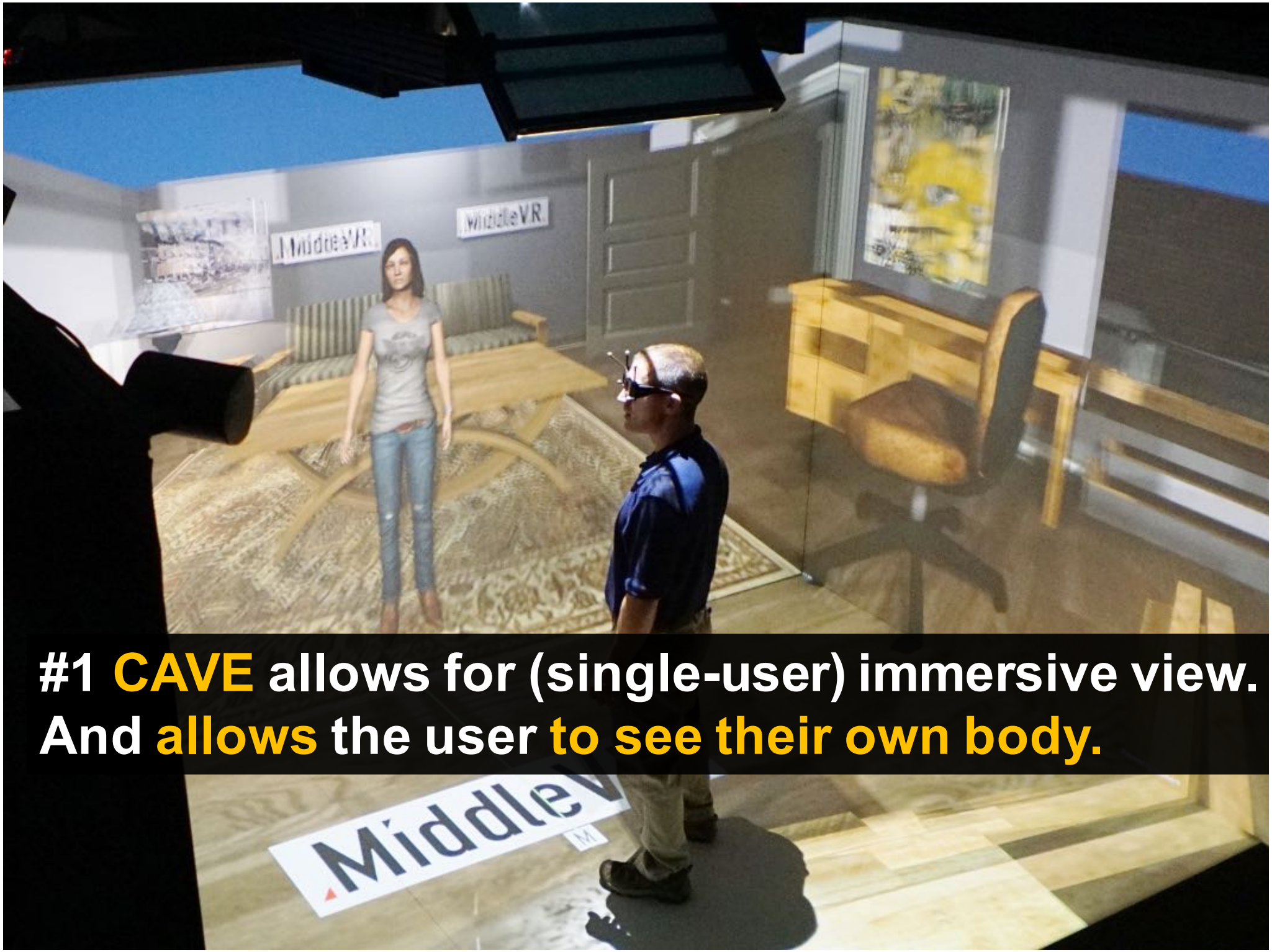


right, **interactive graphics** (sketchpad)

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**

(I will be giving an overview of research projects
if you want to make a realistic system, **borrow from these)**

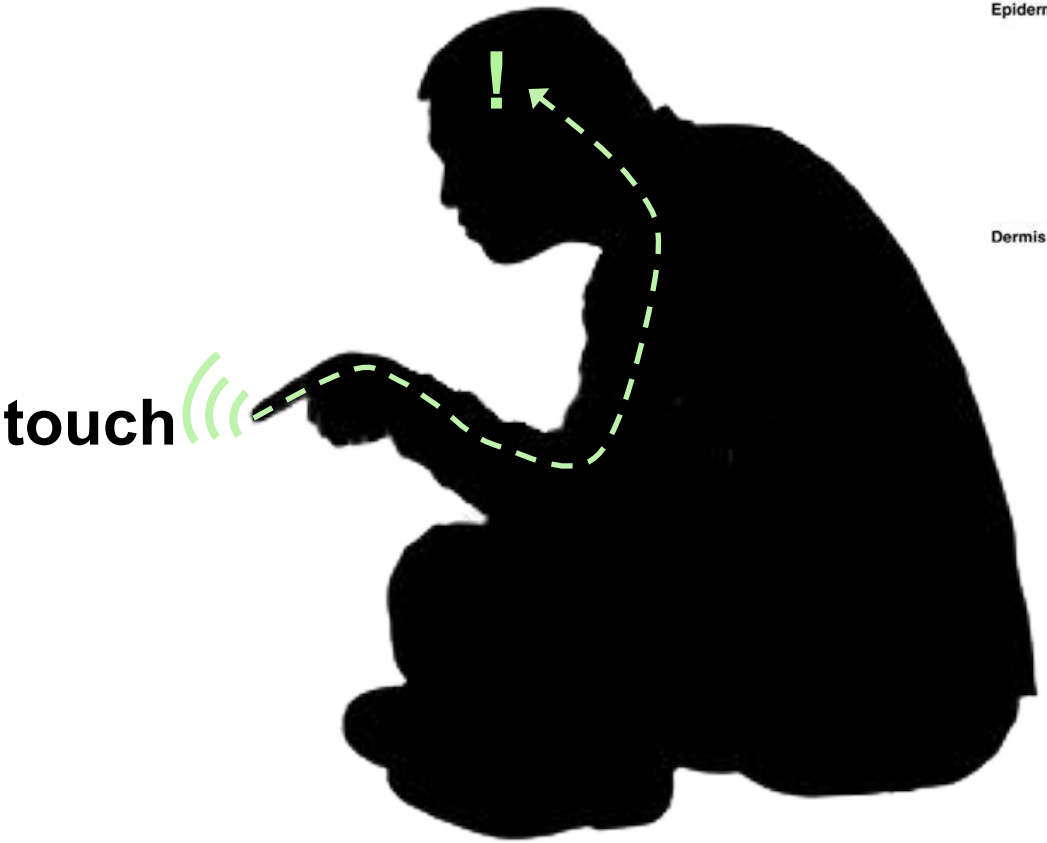
our haptic senses

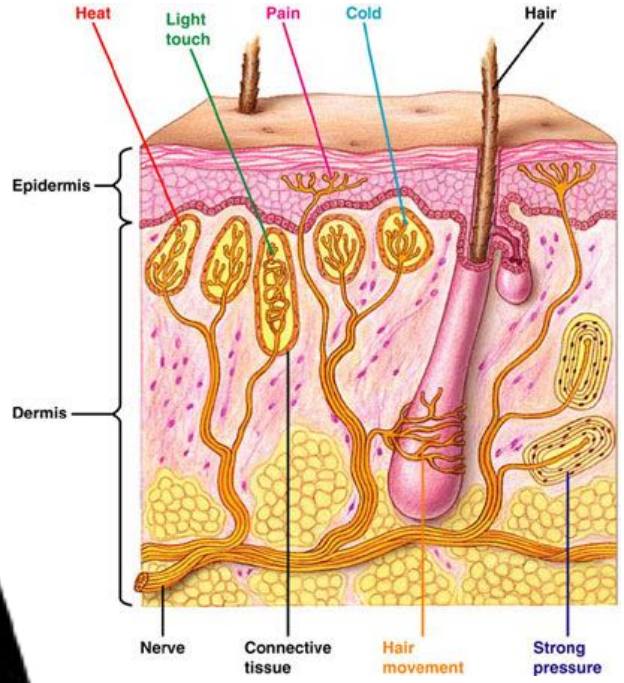
haptics ::

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

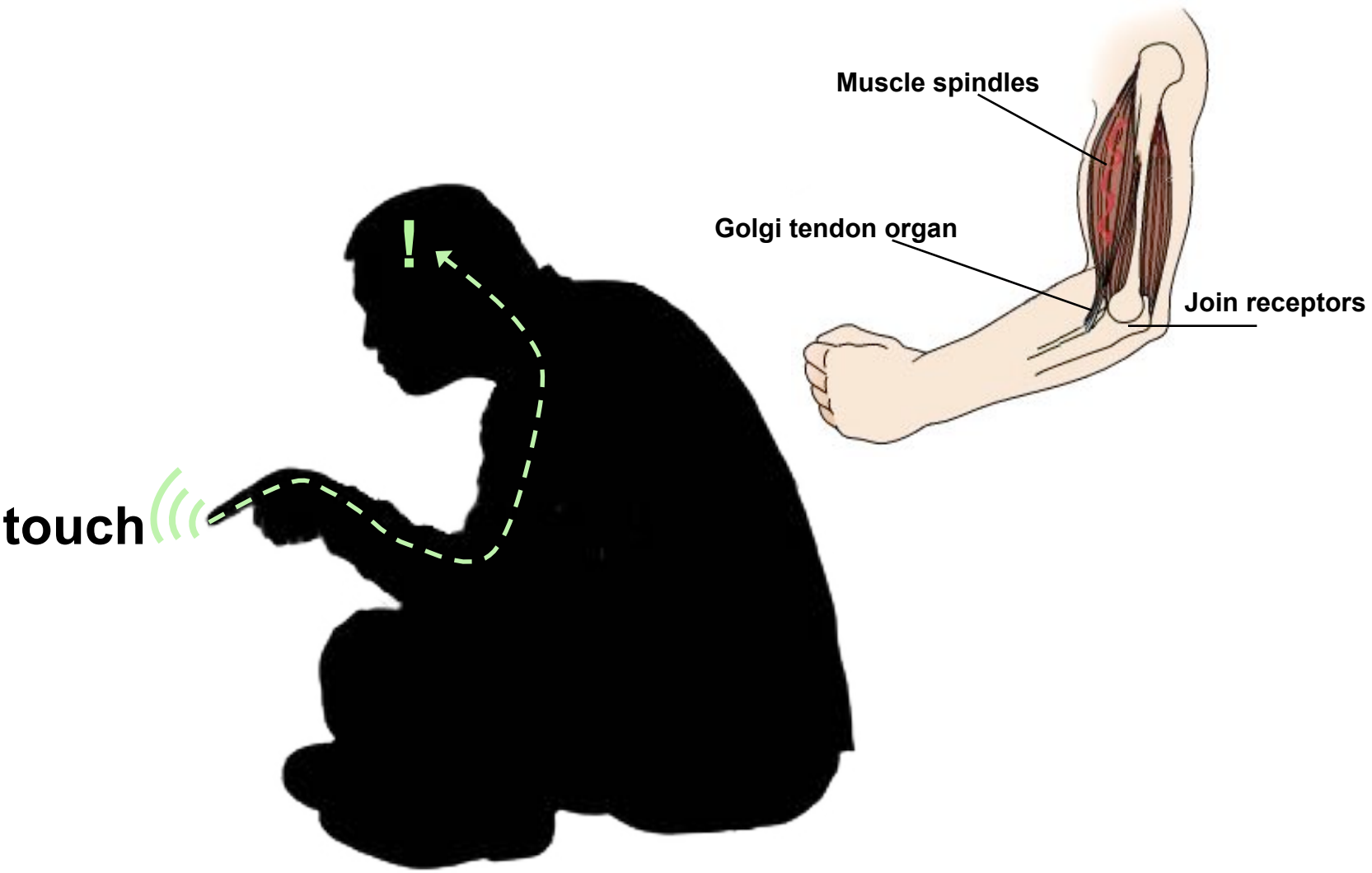
by applying **forces, vibrations, and/or motion to the user**

user’s “sense of touch”… **what is that?**





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



#2 force → receptors on muscles/tendons

proprioception ::

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" and perception

kinesthesia ::

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

haptic perception ::

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::

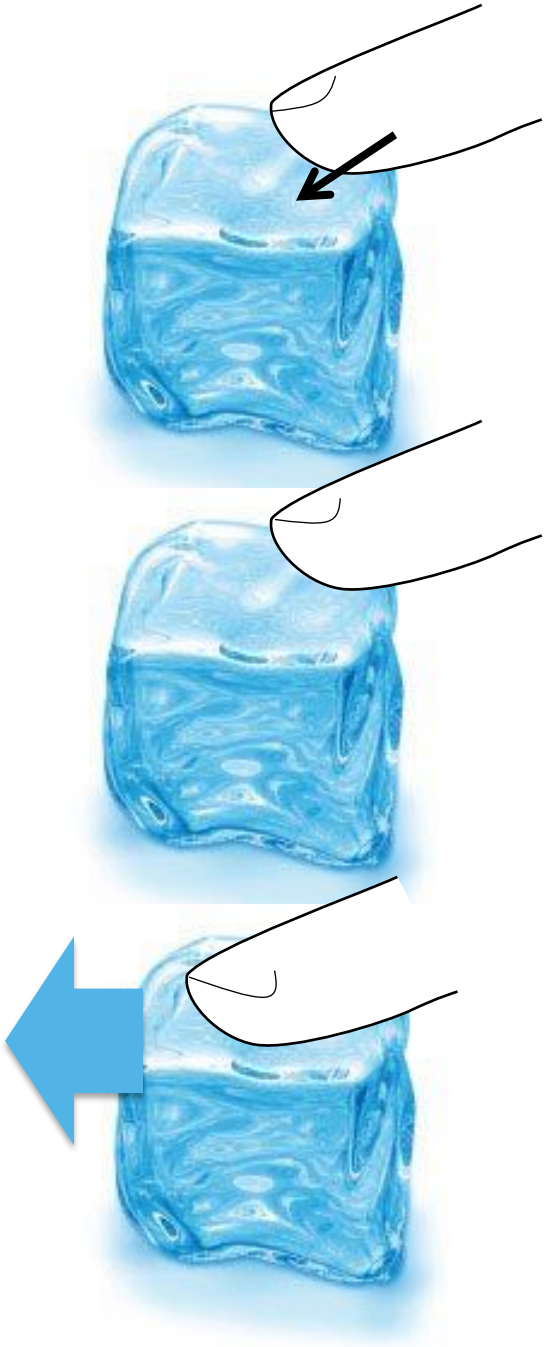
a diverse sensory system composed of the receptors and processing centers to produce the sensory modalities such as **touch, temperature, proprioception (body position), and nociception (pain).**

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

While touch is considered one of the five traditional senses, the impression of touch is **formed from several modalities.**

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

that’s why its hard and that’s why it’s **hard to get started**



1. proprioception
→”hard”

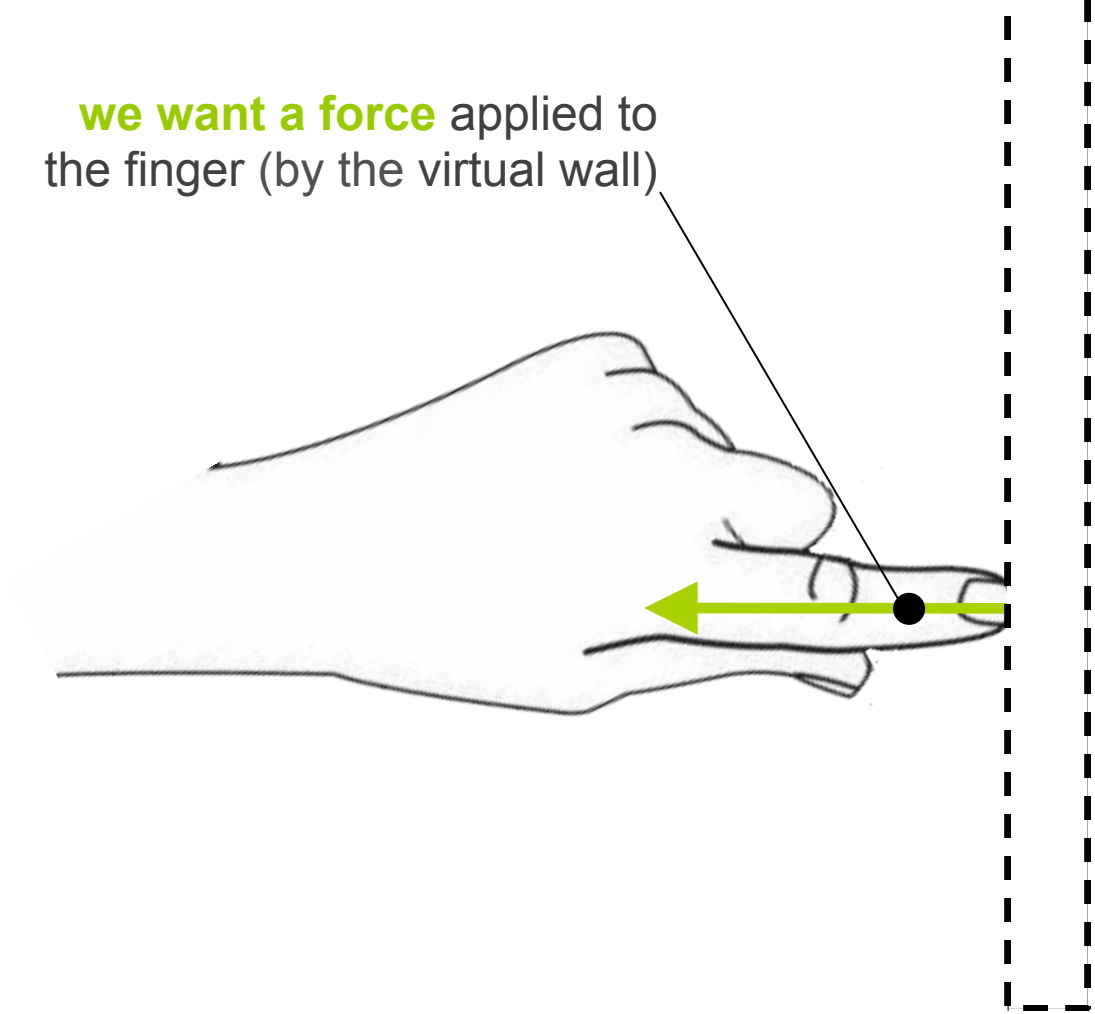
2. tactile
→”smooth”

3. kinesthetic
→”slippery”

(4. thermoreceptors
→ “cold”, etc.)

1. force feedback

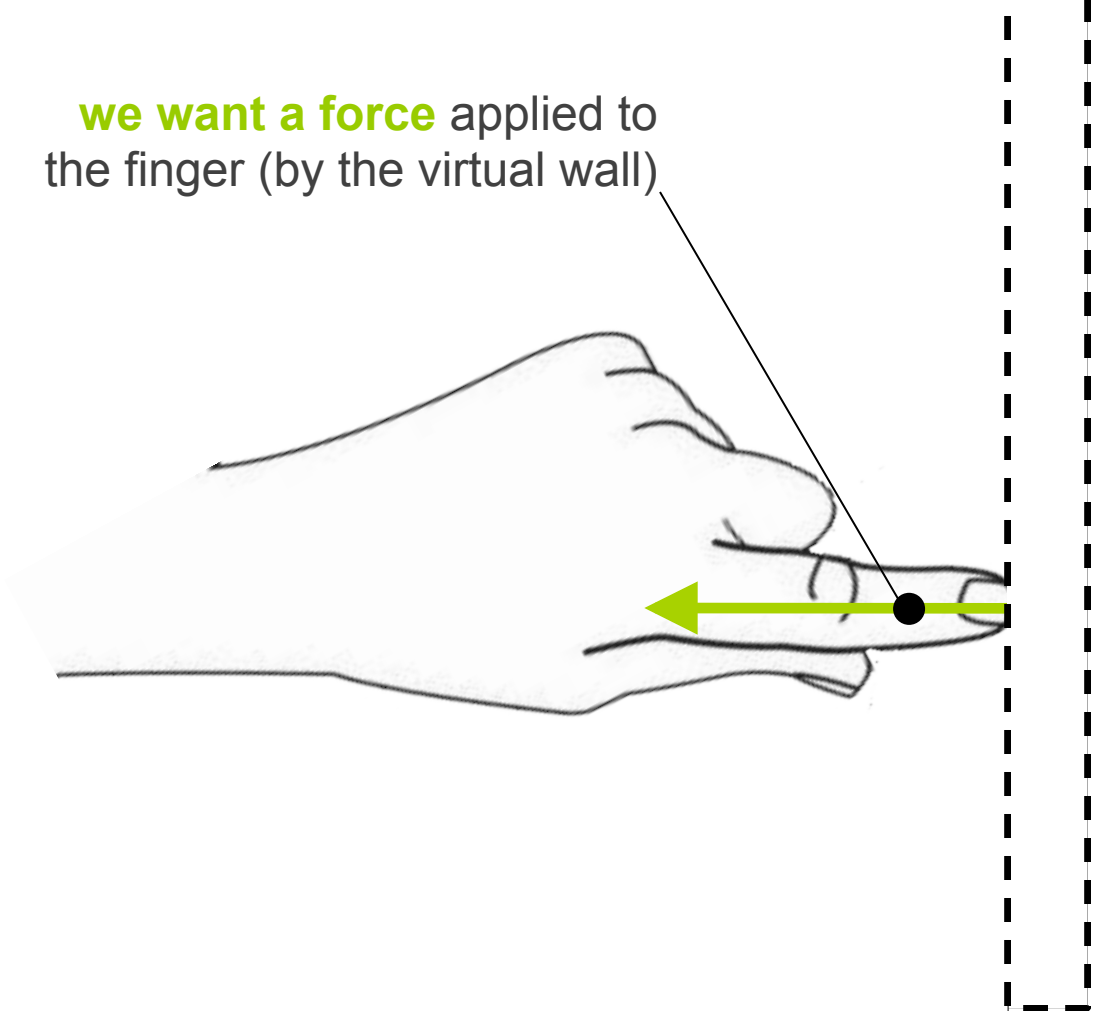
we want a force applied to the finger (by the virtual wall)



a common commercial solution ($1500)…

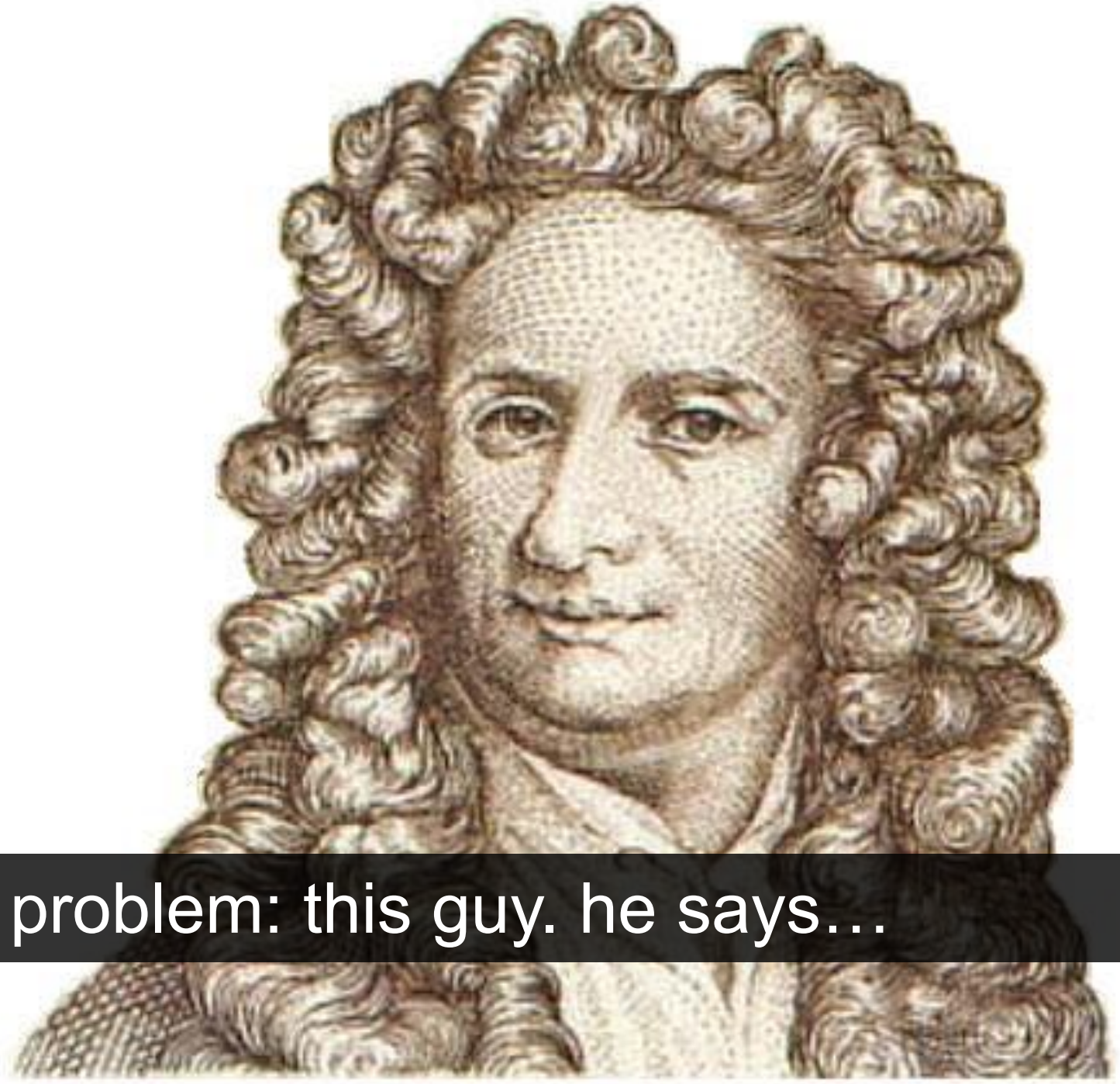
[PHANToM, senseable]


other vendor, same thing (cheaper = $250)
LIFE
[Falcon]



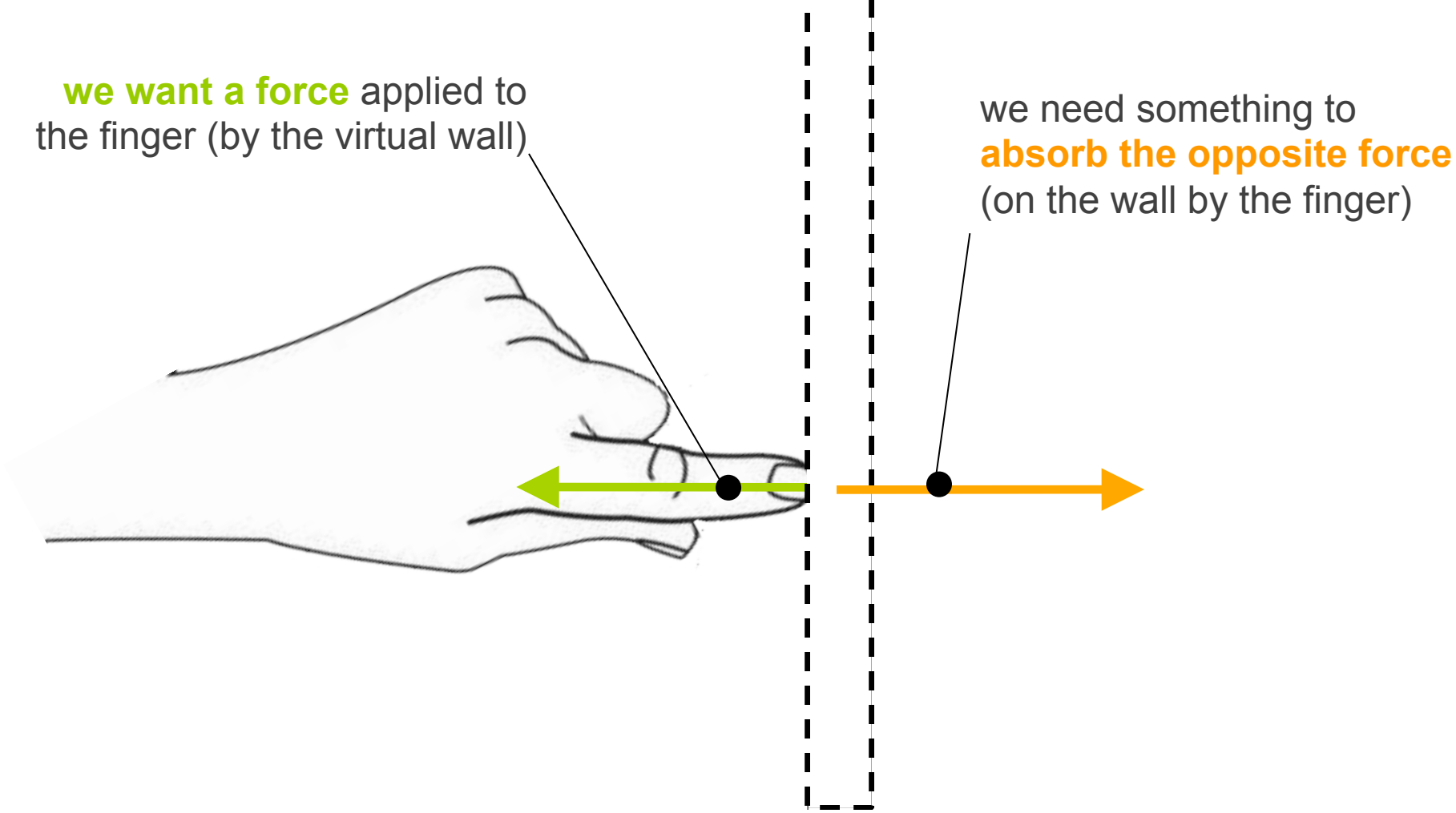
can we make this **mobile?**

<30sec brainstorming>

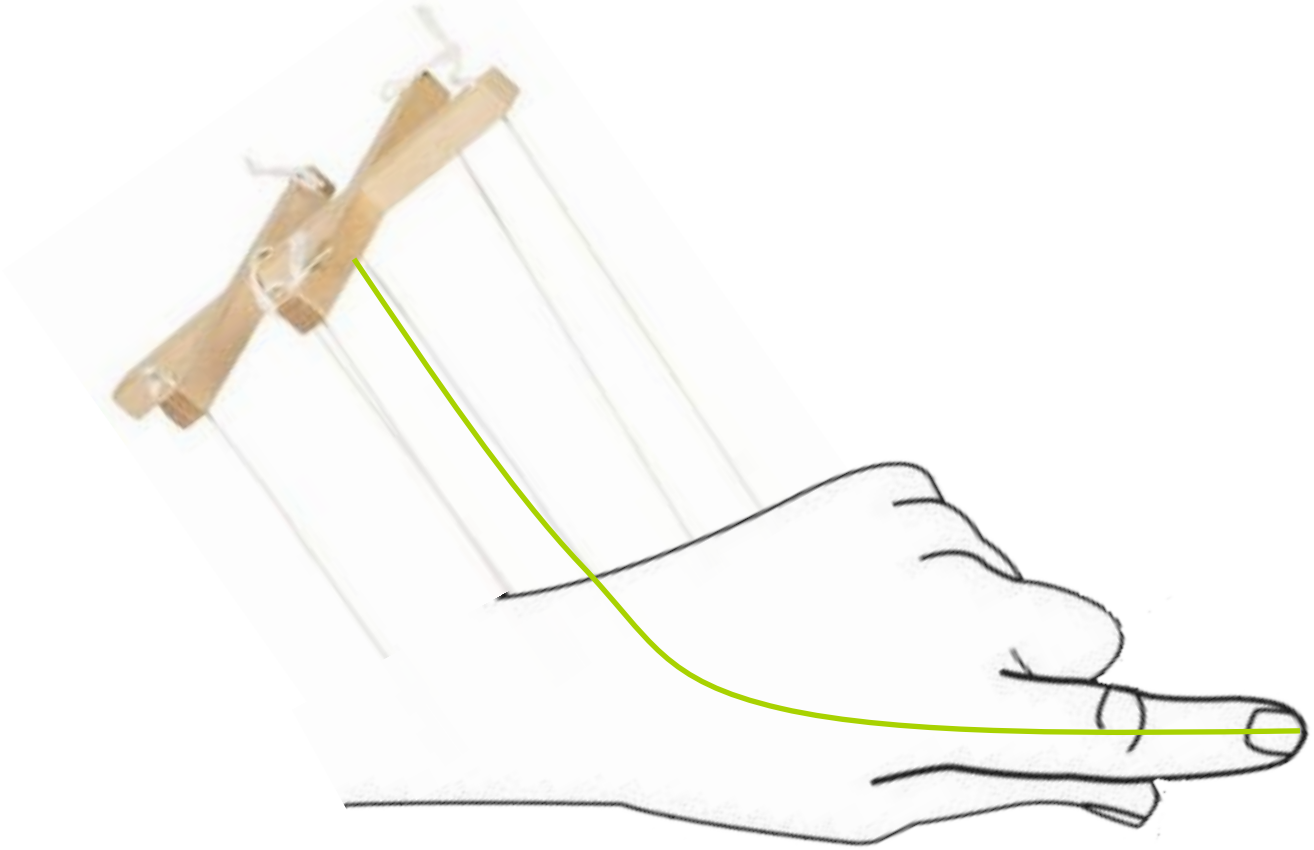


the problem: this guy. he says…


Newton’s laws #3
for every action there is an equal and
opposite reaction


we want a force applied to
the finger (by the virtual wall)
we need something to
absorb the opposite force
(on the wall by the finger)

the problem:



we can pull the finger back, but we need some anchor to **attach the wires to…**

a more convenient solution…

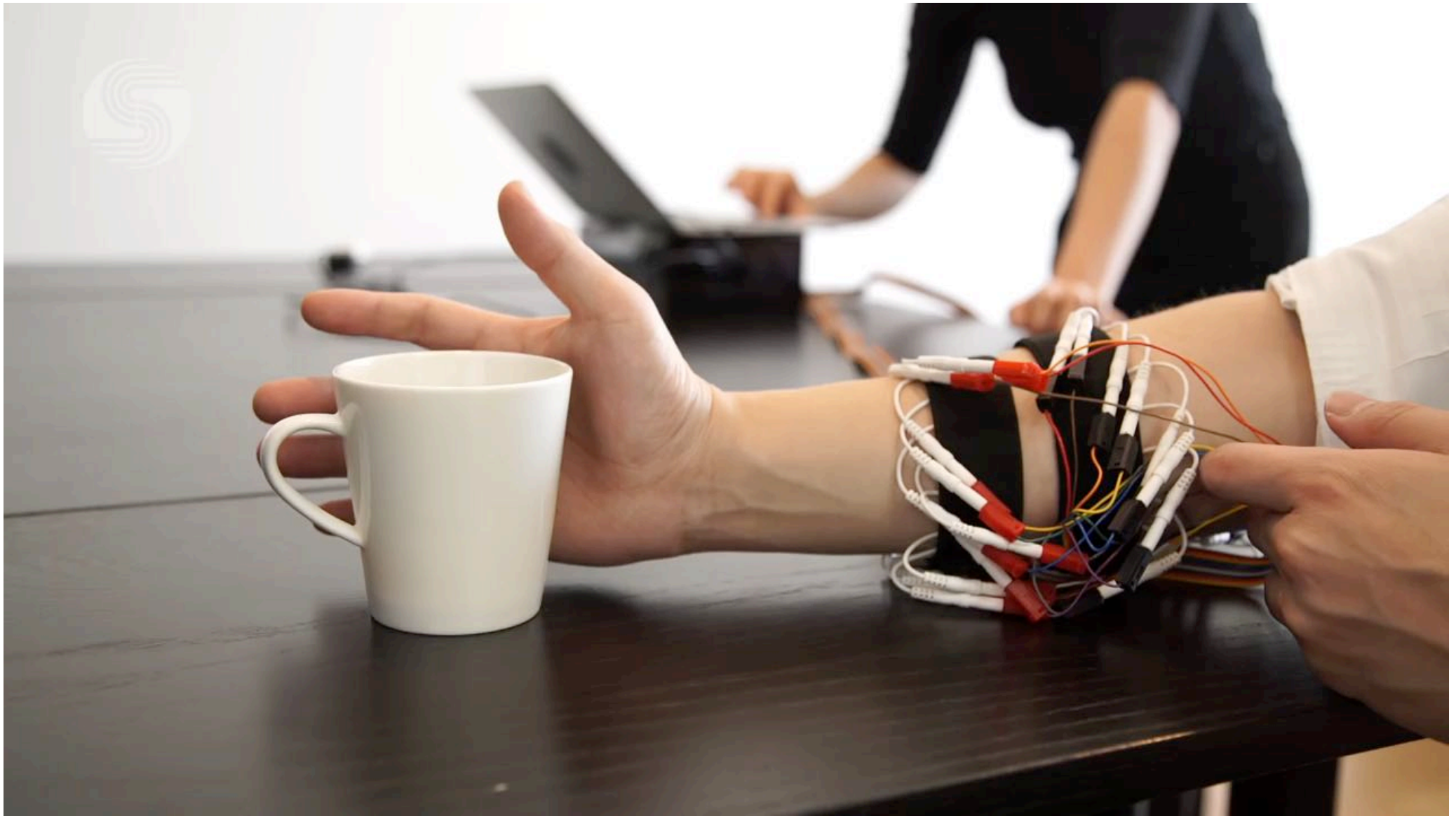
uthe user's **other hand** to provide this force…

haptic hand [kohli GI05]

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

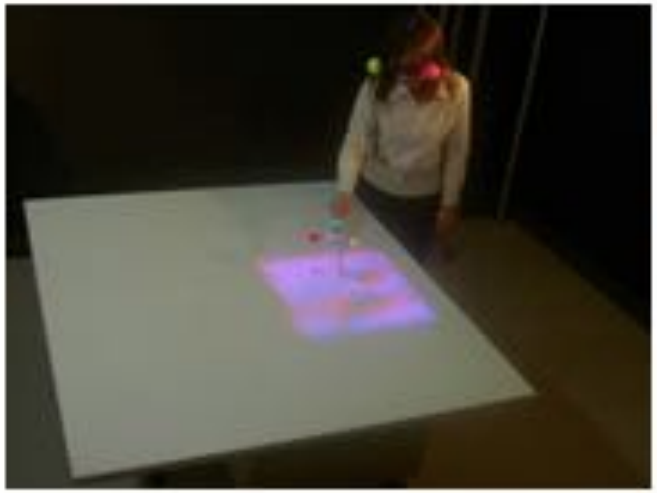
electrical muscle stimulation ::

control body movements by directly sending electric charges in the nerves



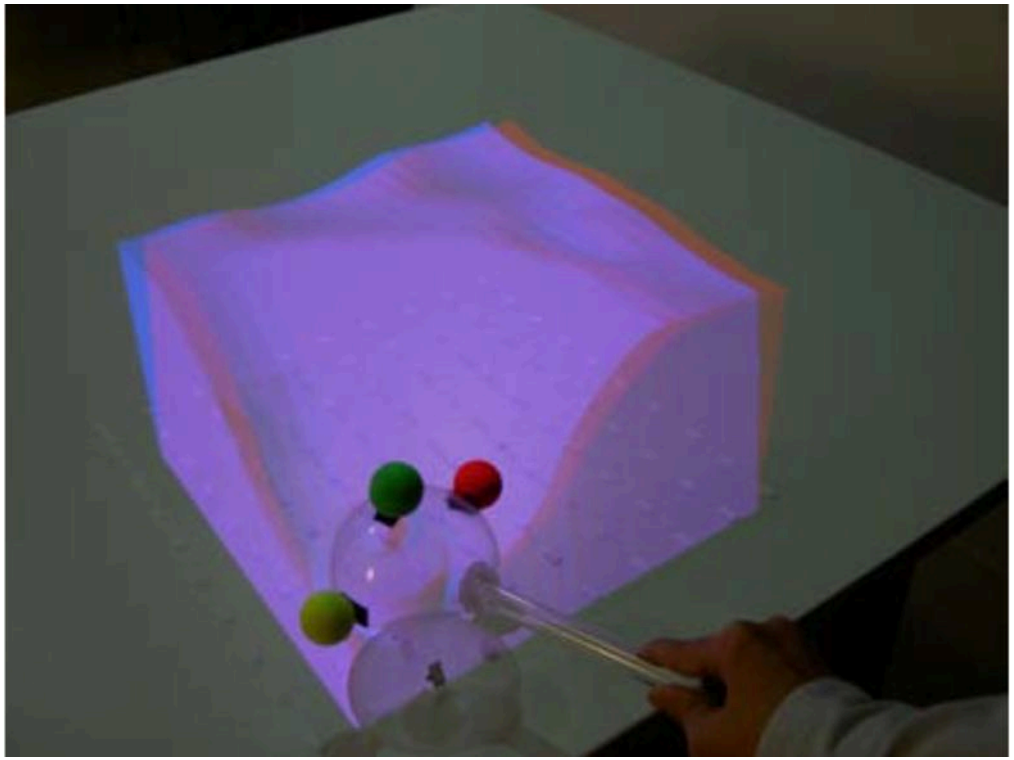
PossessedHand

emerging technologies:



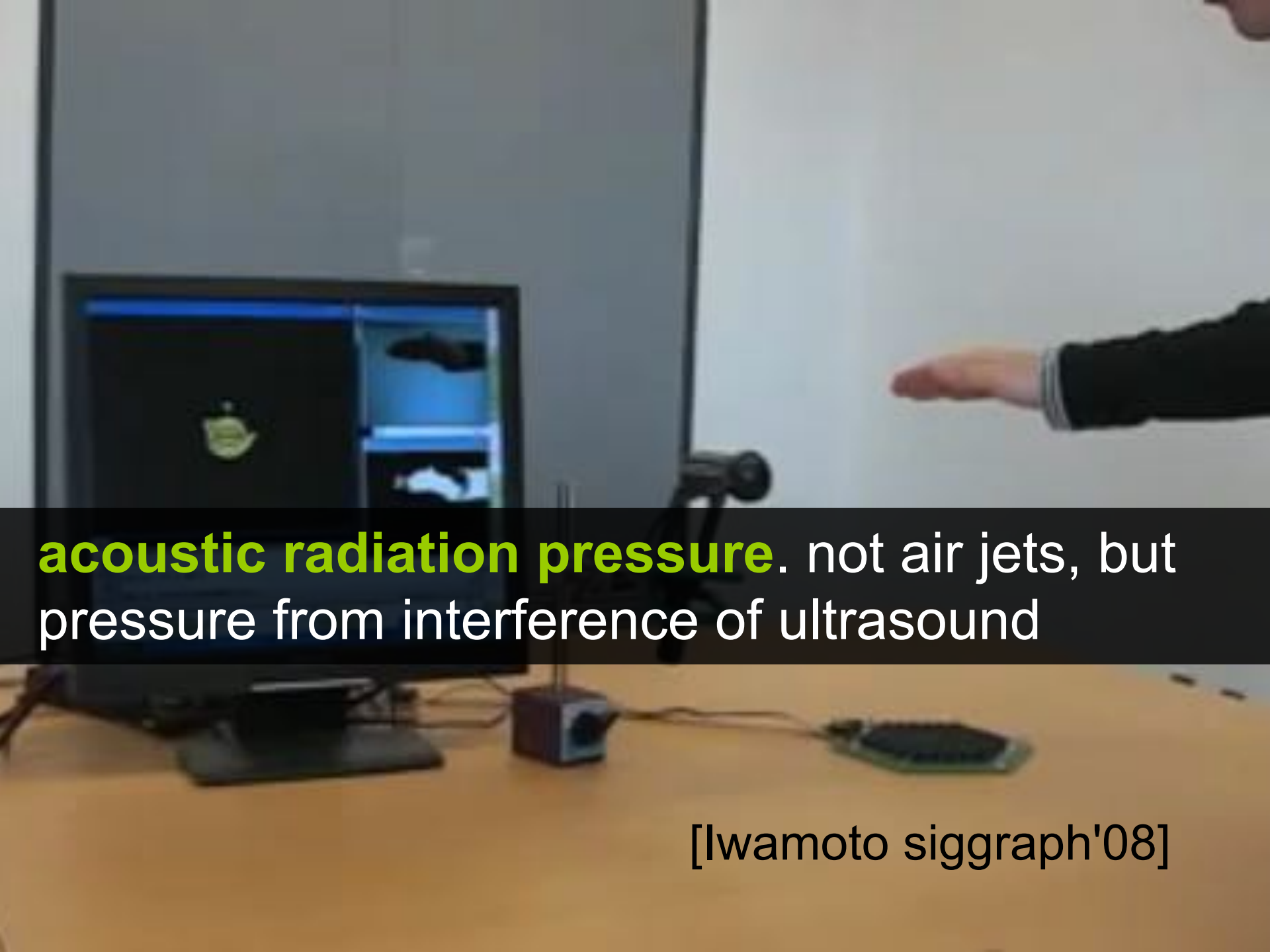
Untethered Force Feedback Interface That Uses Air Jets

This is an untethered interface that eliminates the annoyance of wires and other connectors by using air jets to establish force feedback. Attendees experience interaction with a virtual object that responds to being "touched." The sense of touch is provided by air jets, while visual clues are provided by a projection-based stereo display.



The virtual object

100 air-jet nozzles


acoustic radiation pressure. not air jets, but pressure from interference of ultrasound
[Iwamoto siggraph'08]

Rendering Volumetric Haptic Shapes in Mid-Air using Ultrasound

Benjamin Long, Sue Ann Seah, Tom Carter, Sriram Subramanian

Department of Computer Science, University of Bristol, UK

BIG
Bristol Interaction and Graphics

http://big.cs.bris.ac.uk
youtube.com/BristolIG
@BristolIG

UltraHaptics

https://www.youtube.com/watch?v=kaoO5cY1aHk

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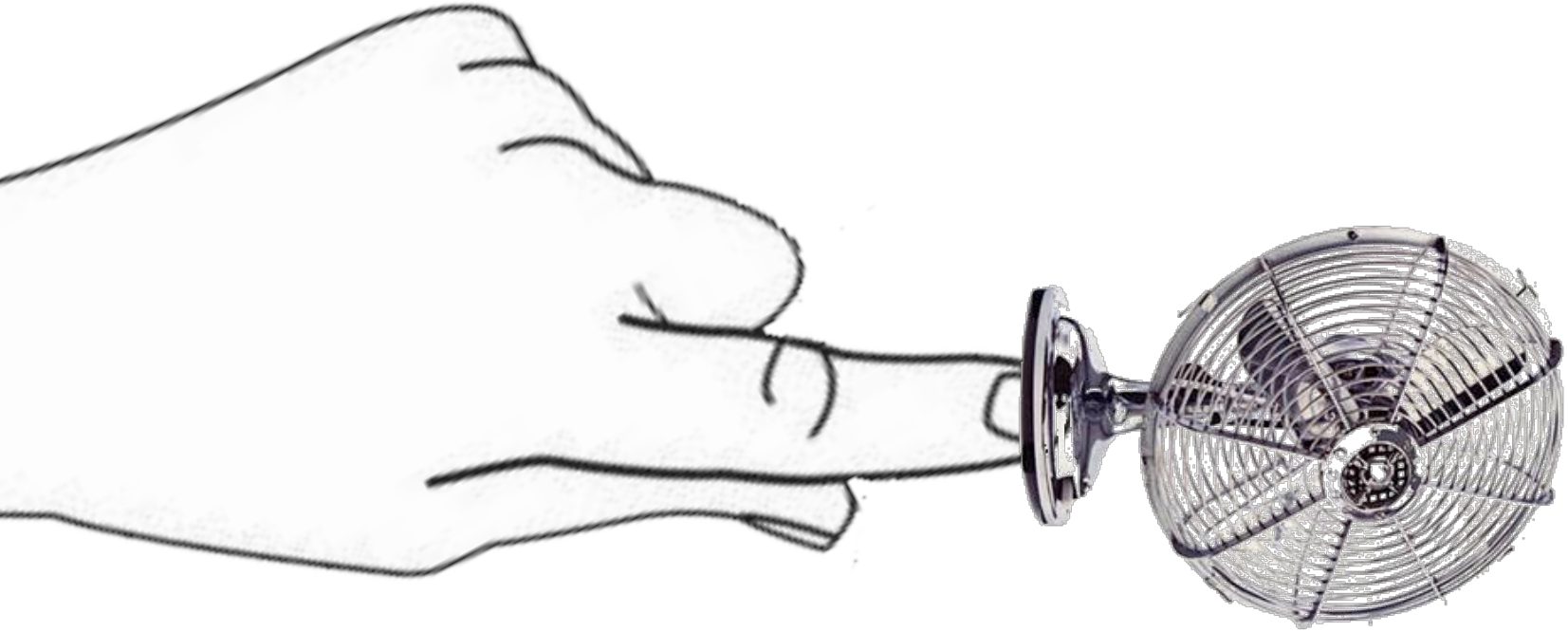
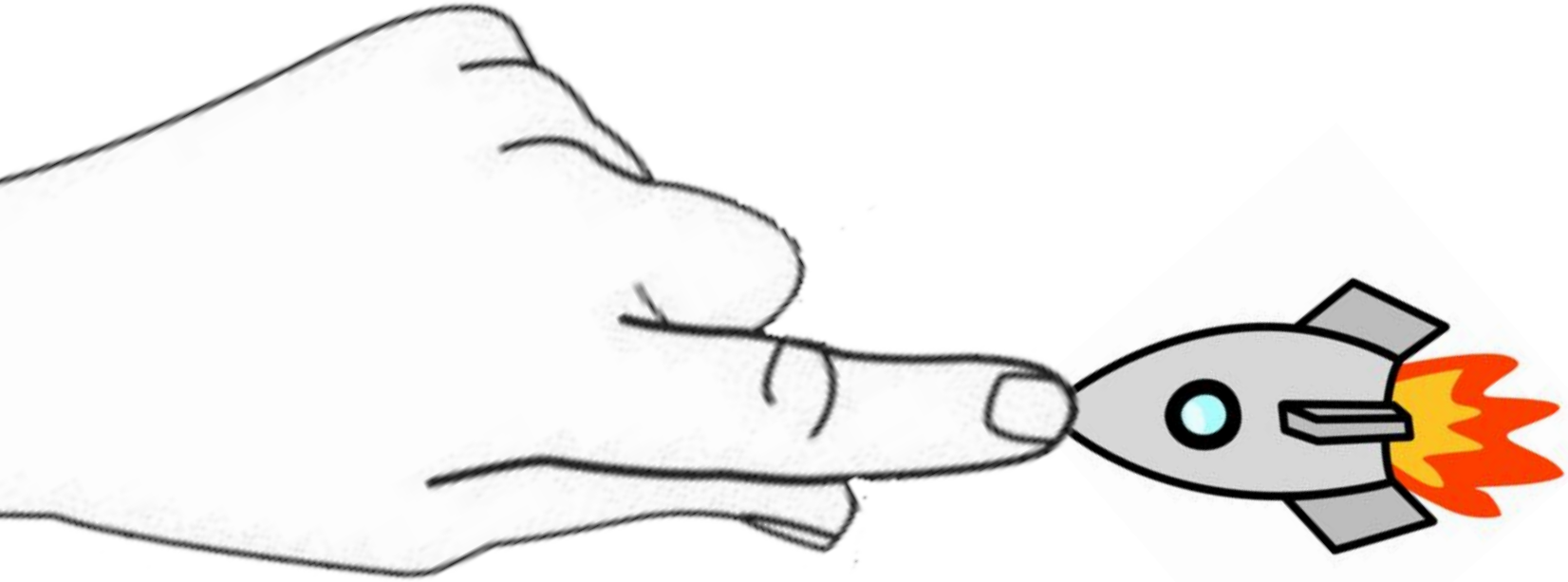
This article **may be confusing or unclear to readers**. Please help clarify the article; suggestions may be found on the talk page. *(August 2009)*

acoustic radiation pressure ::

is the apparent pressure difference between the average pressure at a surface moving with the sound displacements (the Lagrangian pressure) and the pressure that would have existed in the fluid of same mean density at rest.



who knows… maybe mount **fan** to the finger



… or a **rocket engine**


benefit: works also in space ;)

limitation:

ultra-sound, air jets, illusions… all of these are **super weak**

good enough to notify user, but not to simulate a physical reality → if you want that, have to **use strings**

summary:

force feedback is **difficult, expensive, and non-mobile**

force feedback in mid air is in its absolute infancy

one day it may come around.

in the meantime…

2. vibration

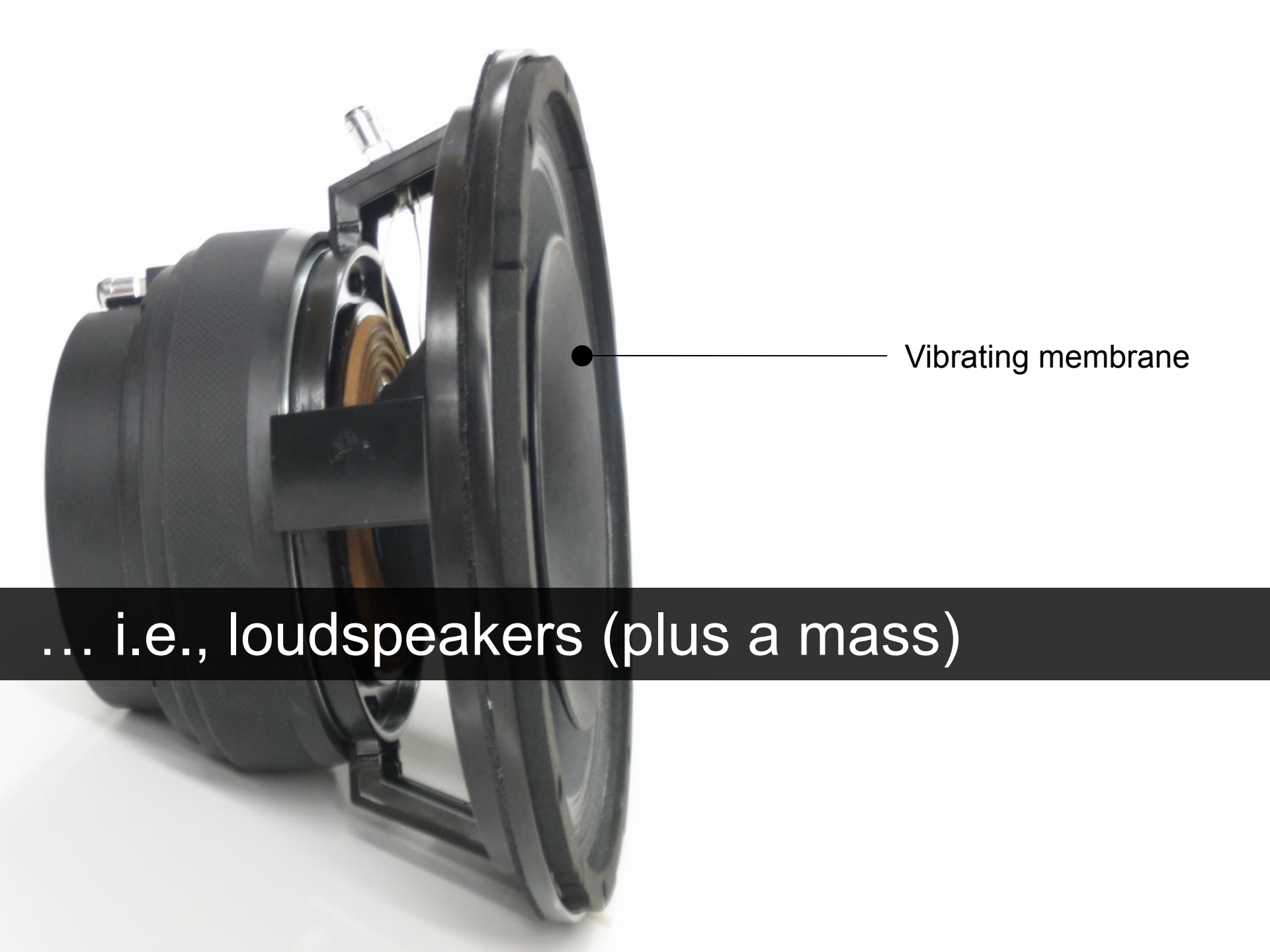
vibrotactile actuation ::

since we cannot move users anywhere,
let's move them **back and forth instead**

it is in most modern mobile phones…

…a motor spinning an **eccentric mass**

sound is vibration too → we can use sound equipment to generate vibration…



… i.e., loudspeakers (plus a mass)

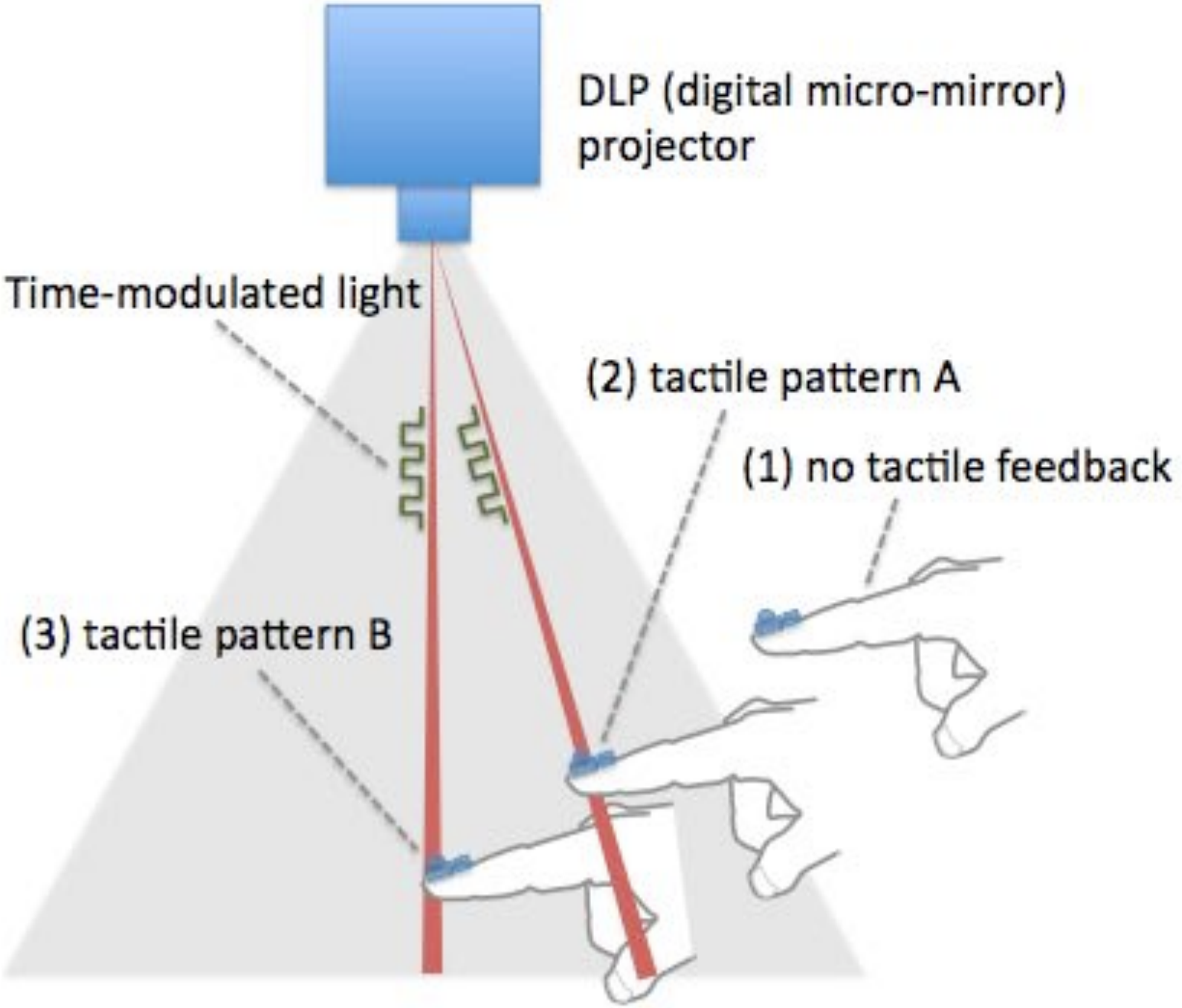
piezoelectricity ::

the charge that accumulates in certain solid materials in **response to applied mechanical stress.**

reverse piezoelectric effect = the internal generation of a mechanical strain resulting from an applied electrical field.

The word piezoelectricity means “electricity resulting from pressure” piezo (πιέζειν) = Greek for squeeze or press.


vibrotactile actuators are small, easy to use
senseableRays [Rekimoto chi09]

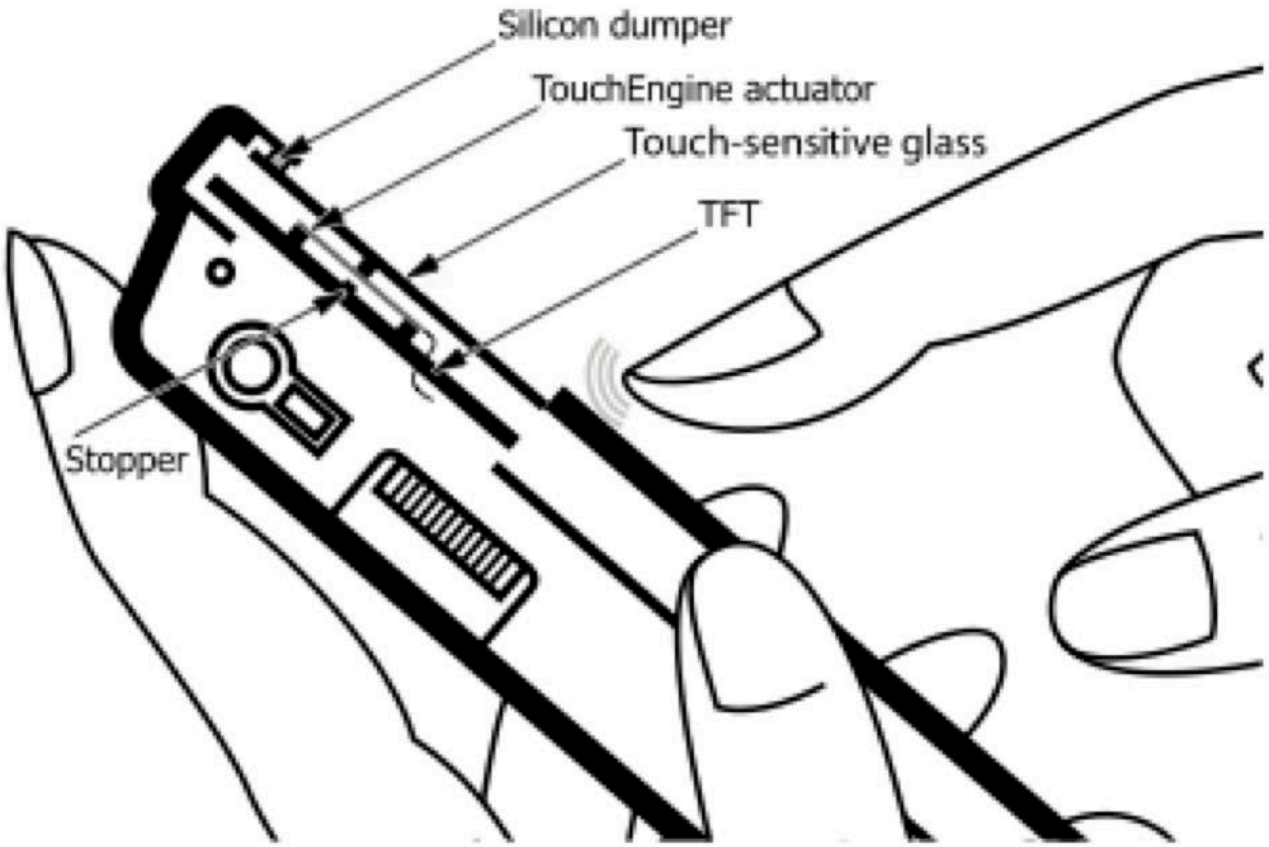

DLP (digital micro-mirror) projector
Time-modulated light
(2) tactile pattern A
(1) no tactile feedback
(3) tactile pattern B

can vibrotactile replace force feedback?

<30sec brainstorming>

my 2ct: **not really**

but it is so convenient, so people will keep using it

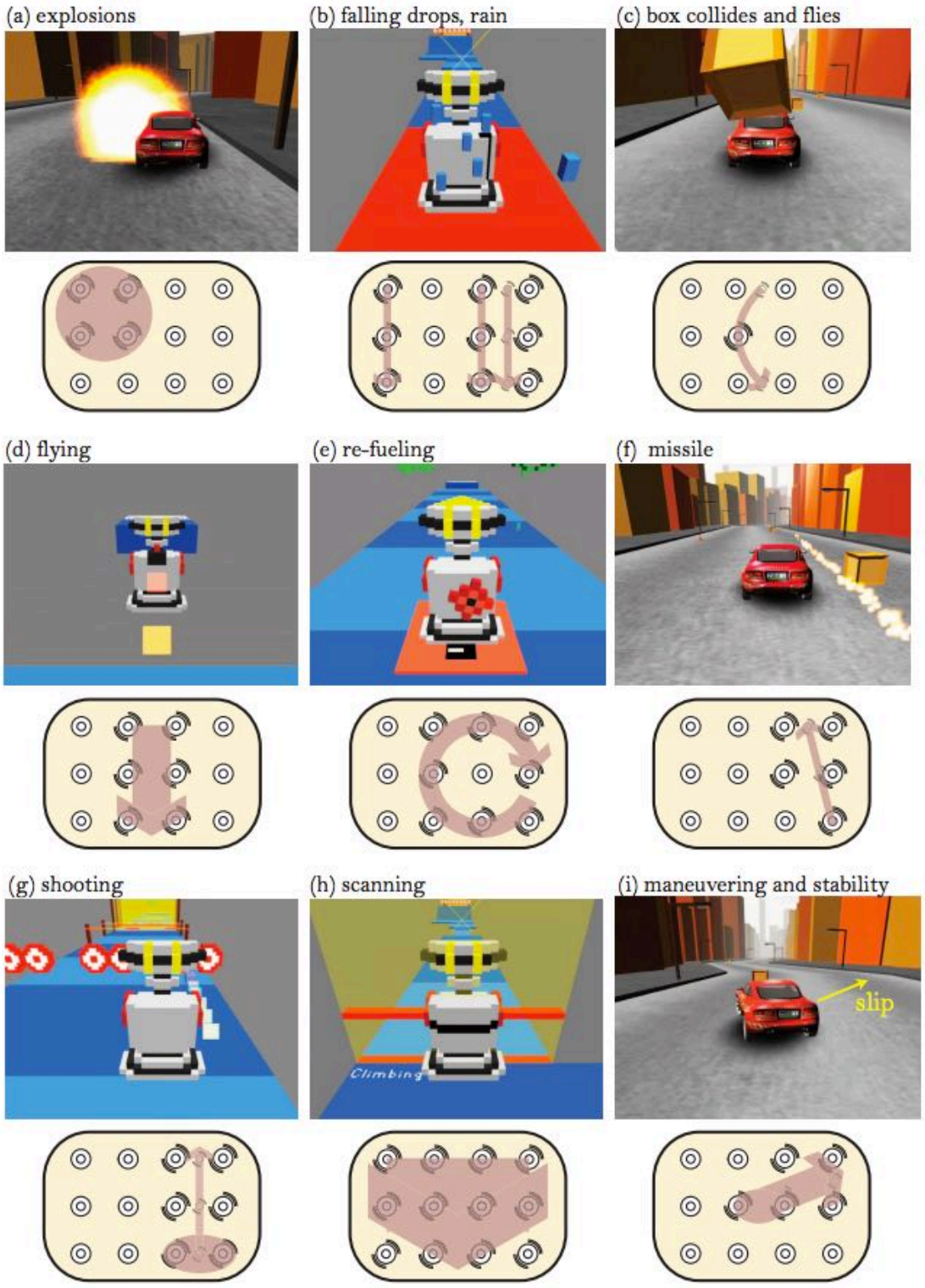


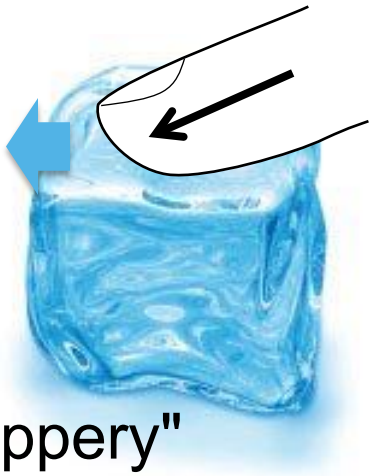
clever one : **appears spatial**

[Poupyrev UIST03, Brewster CHI07]

also spatial **using multiple actuators**

tactile brush [Israr CHI11]


(a) explosions
(b) falling drops, rain
(c) box collides and flies
(d) flying
(e) re-fueling
(f) missile
(g) shooting
(h) scanning
(i) maneuvering and stability
Climbing
slip



"slippery"

3. friction

friction: what can you do to a surface to (permanently) make it **sticky or slippery**

<30sec brainstorming>

coat with liquid lubricant

coat with low-friction materials
(e.g. teflon)

friction: rough solid > solid > liquid > gas

coat with air

polish

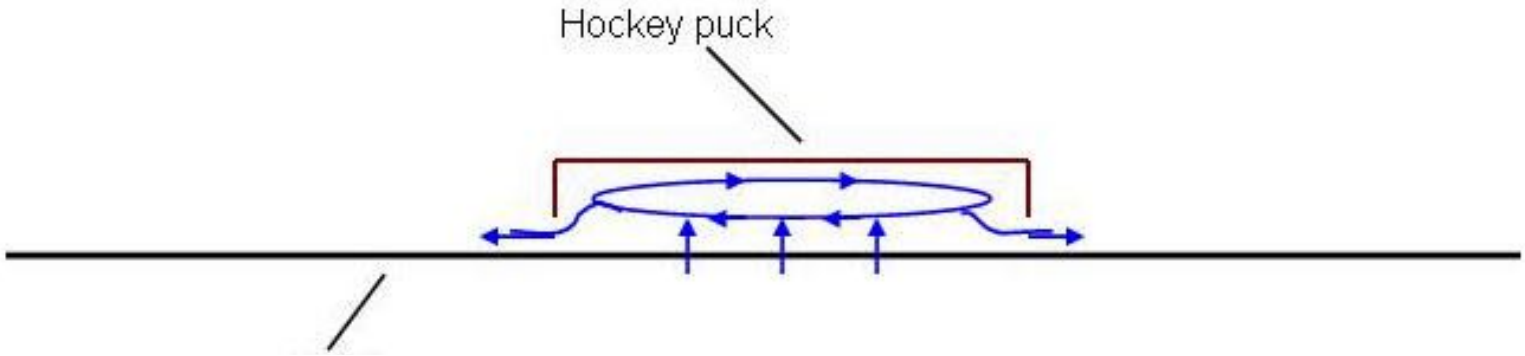
how Air Hockey Table works?

how Air Hockey Table works?

how Air Hockey Table works?

Air hockey **tables are built** using an extremely smooth surface perforated by thousands of **miniature air holes**

Underneath the table a fan is fitted that blows upwards into the table cavity and ultimately forces **jets of air** to **rush thought surface holes**.

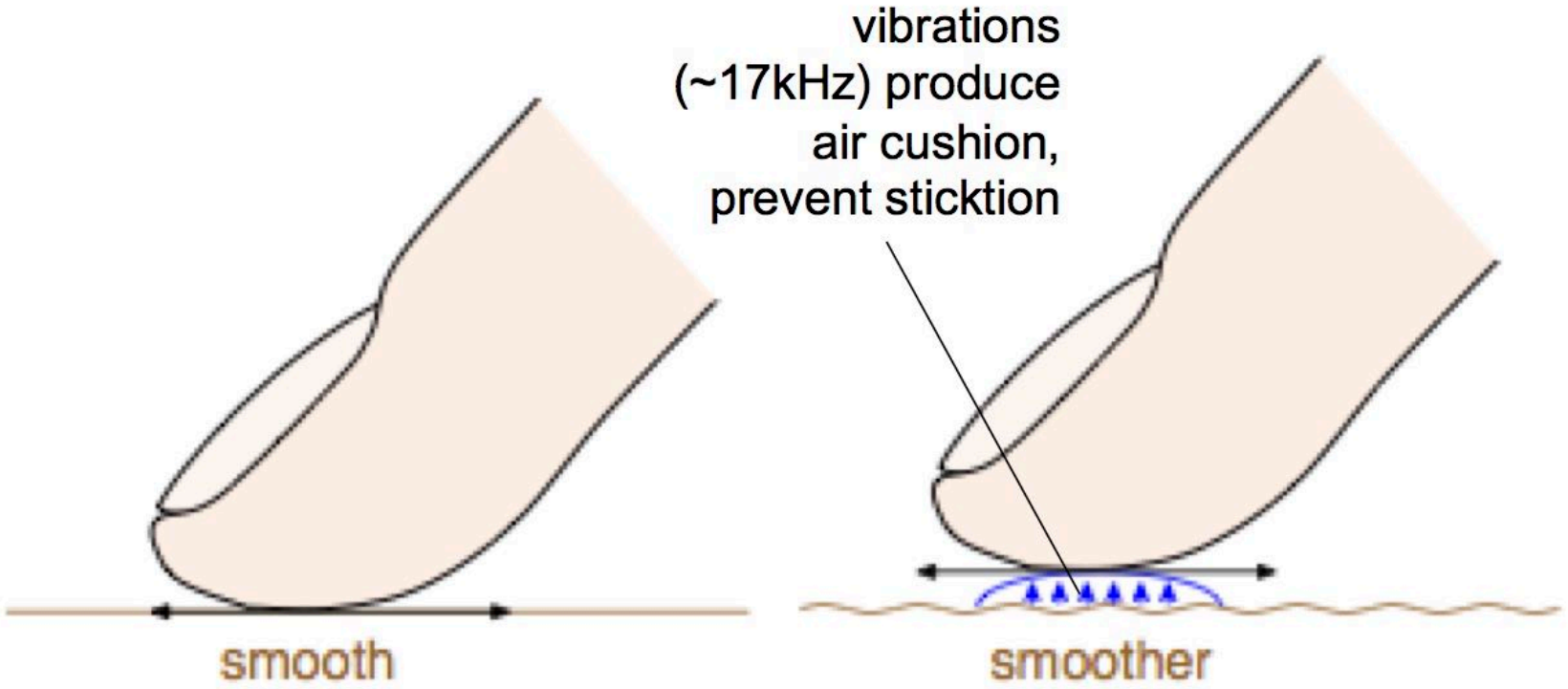


why do we slip on ice, again? **water cushion**

there are some devices in research that can change their surface properties between **sticky and slippery.**

how may they work?

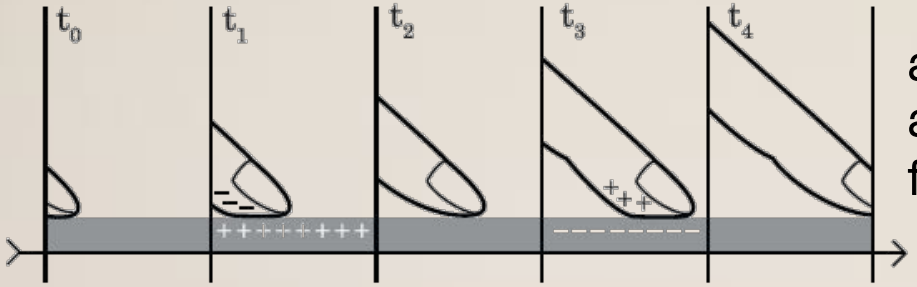
<30sec brainstorming>



vibrates the surface → "squeeze film"

stimtac [Biet 07, Watanabe ICRA'95, Winfield World Haptic 07]

[Levesque CHI11
Casiez CHI11]



attractive charge sucks finger against surface, thus increases friction

tesla touch pulls the finger against the surface

[Bau UIST10]

4. hardness

attempt to make surface hard and soft

mudpad [Jansen ITS10]

ferrofluid ::

a liquid which **becomes strongly magnetized** in the presence of a magnetic field

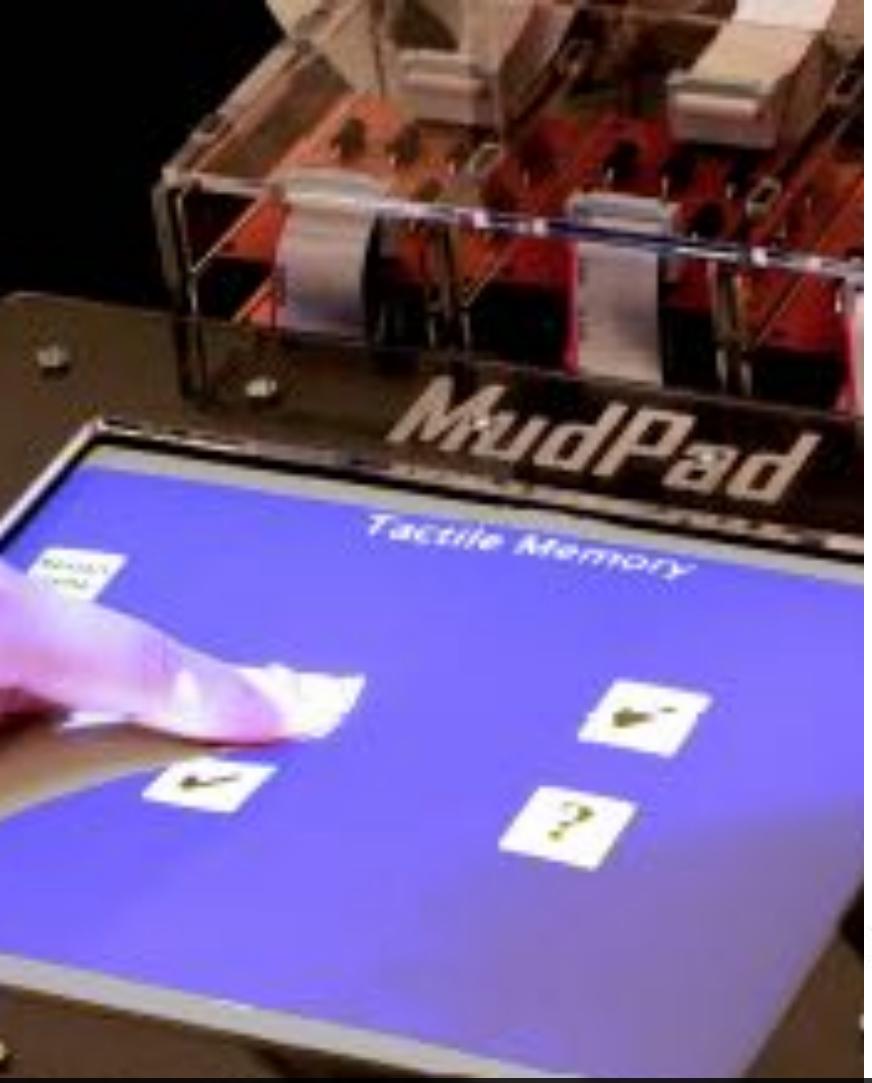
(compound of Latin ferrum, meaning iron, and fluid)

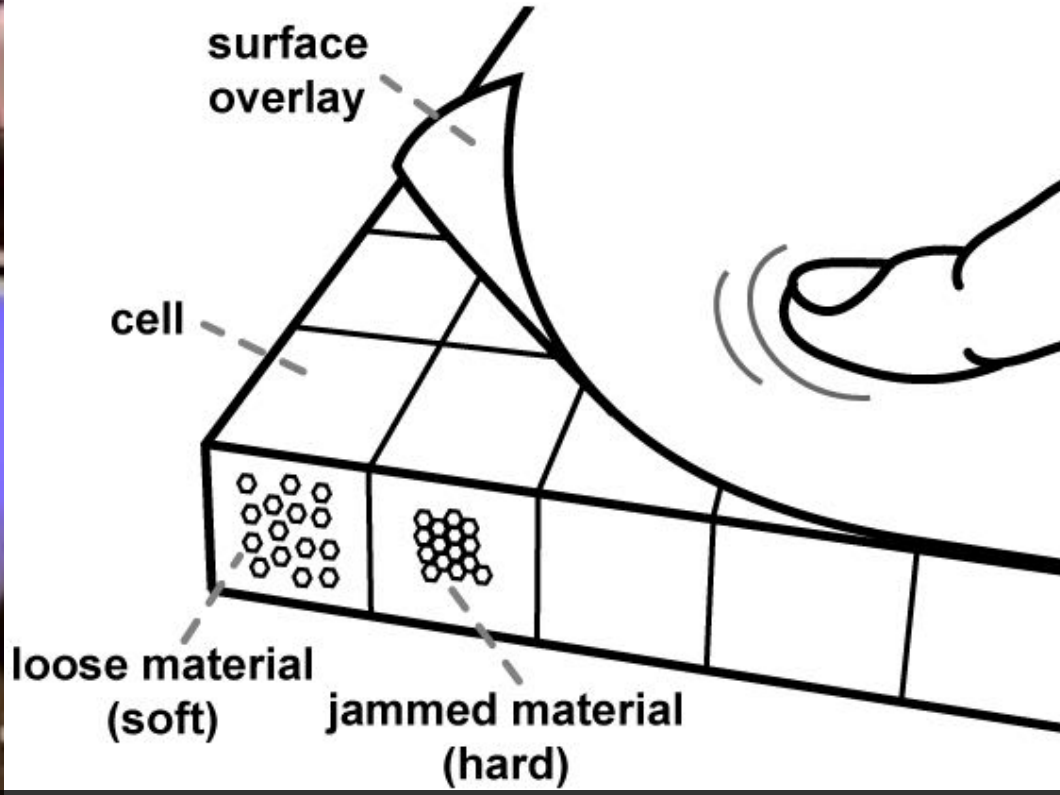
another approach to changing **the hardness…**

vacuum mattress ::

When the mattress is under pressure, the balls are free and the mattress can be molded. To use, the air is pumped out through the valve and the valve is closed. The atmospheric pressure presses the balls together and **the mattress becomes hard and rigid.** The straps are then tied to secure the patient.

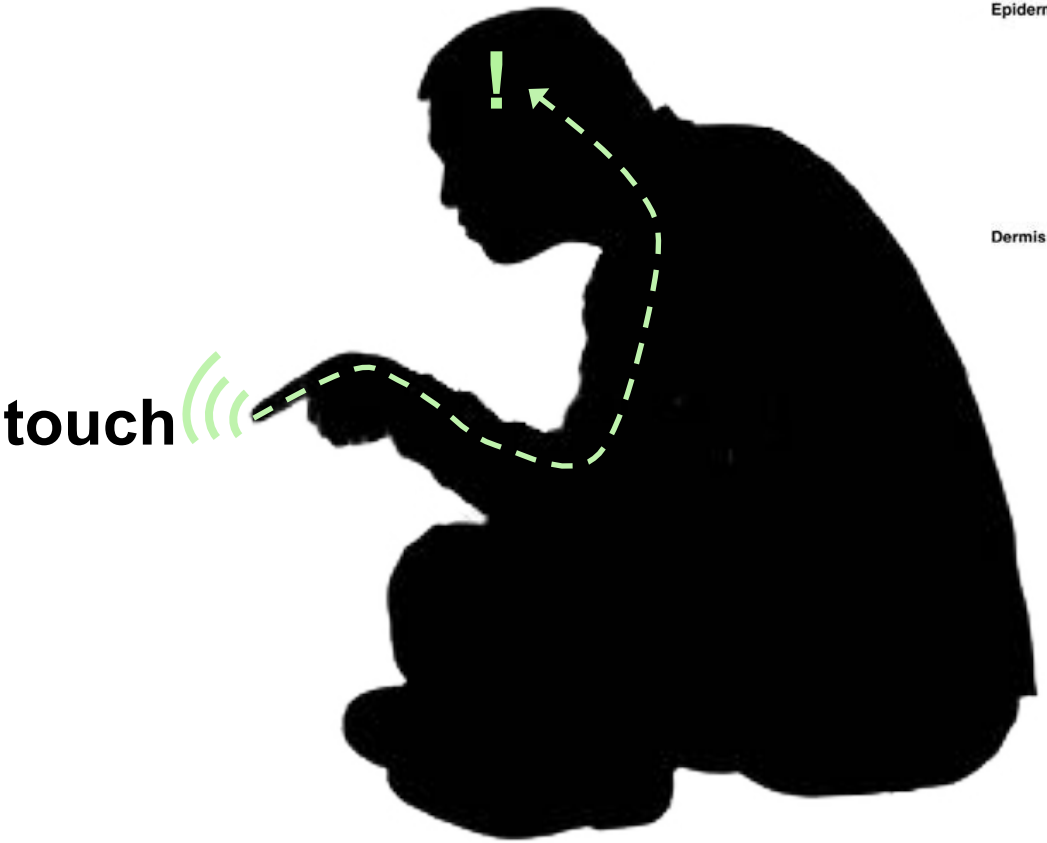

[Sean Follmer, UIST 2012]

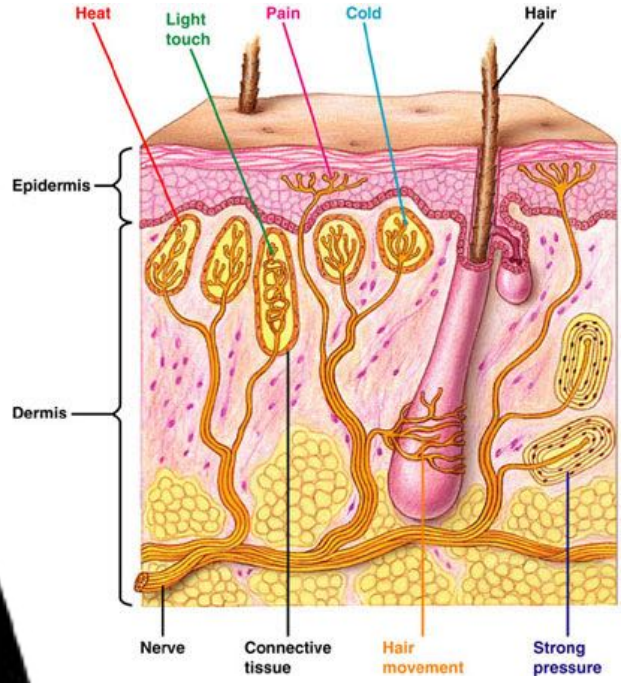




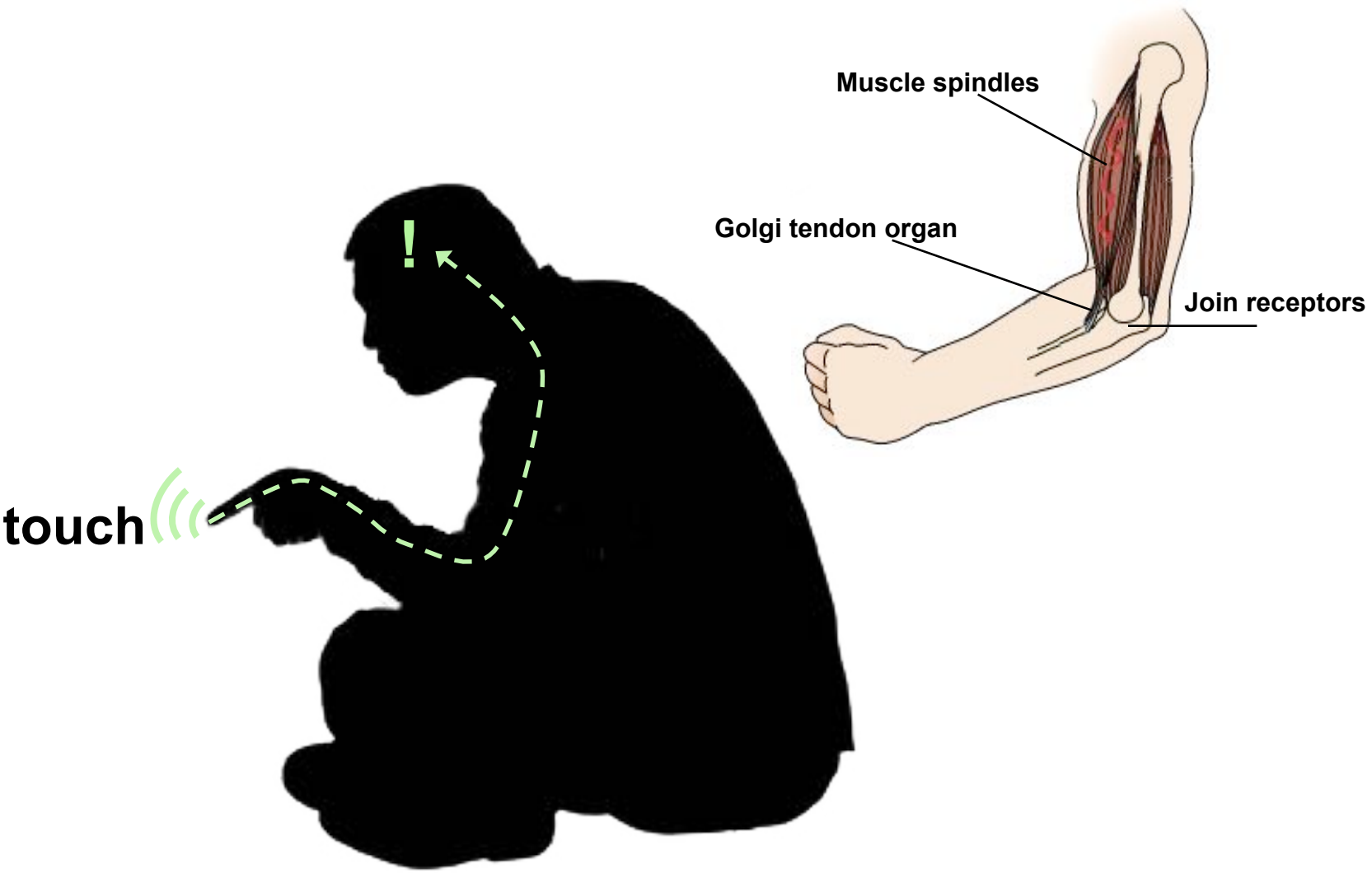
"passive" force feedback: mud pad and jamming require users to **exert a force** to feel

summary of techniques





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



#2 force → receptors on muscles/tendons

summary

all these techniques try to simulate just that:
their objective is so simulate physical objects realistically to **increase sense of realism**