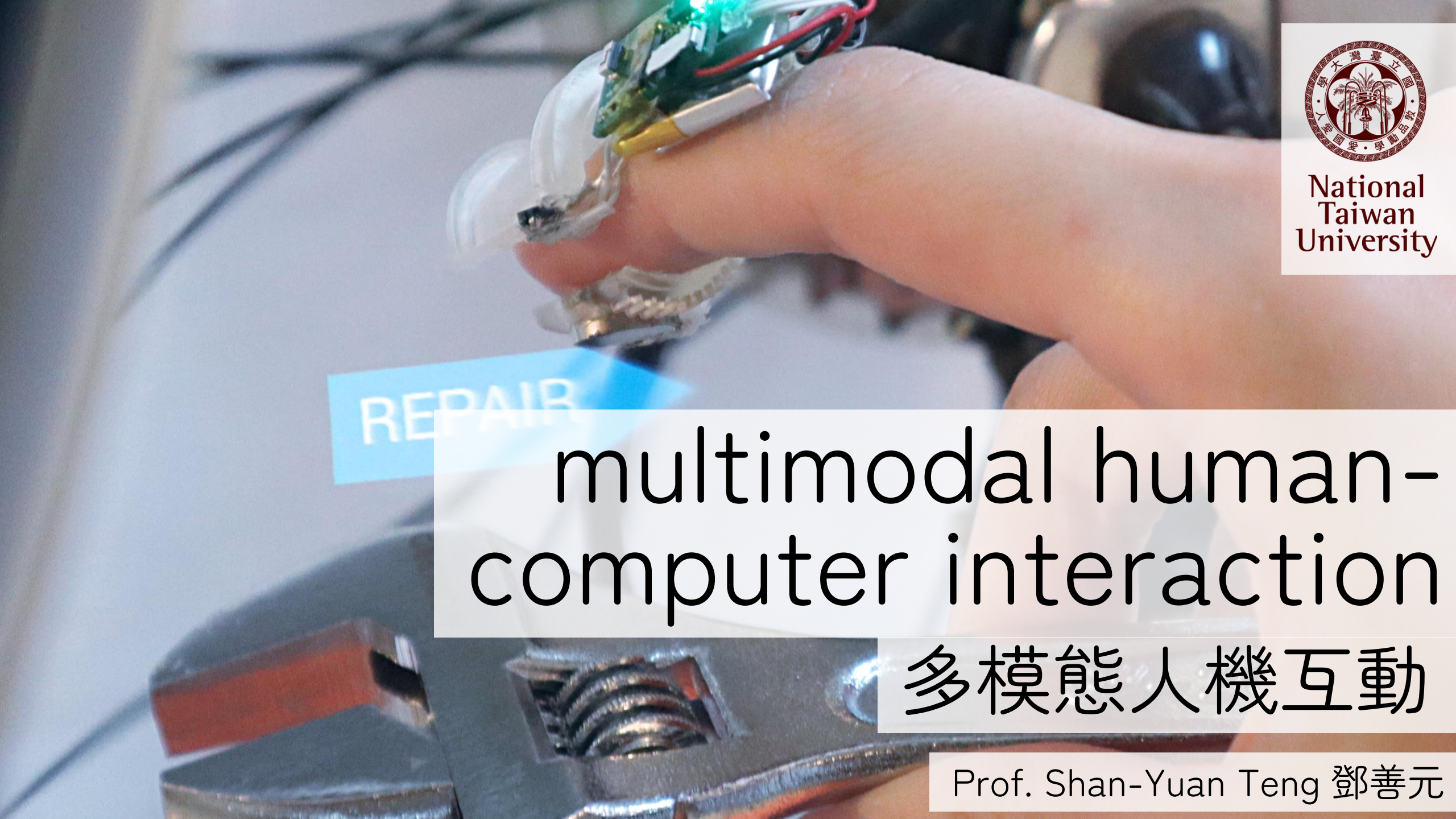


National Taiwan University

multimodal human-computer interaction

多模態人機互動

Prof. Shan-Yuan Teng 鄧善元

self intro

Shan-Yuan Teng
Assistant Professor, NTU CSIE
PhD, University of Chicago
MS/BS, National Taiwan University

dexterous interaction lab

靈 巧 互 動 實 驗 室

done with mental or physical skill, quickness, or grace

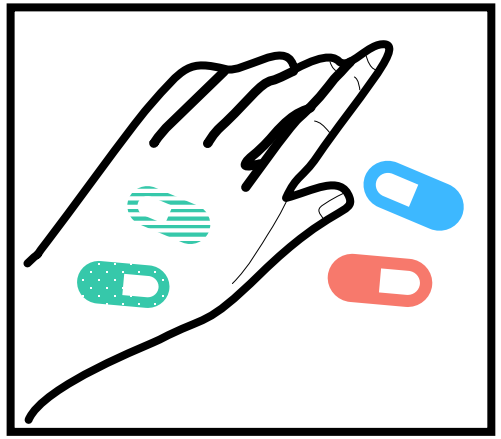
dexterous interaction lab

靈 巧 互 動 實 驗 室

done with mental or physical skill, quickness, or grace

dexterous interaction lab

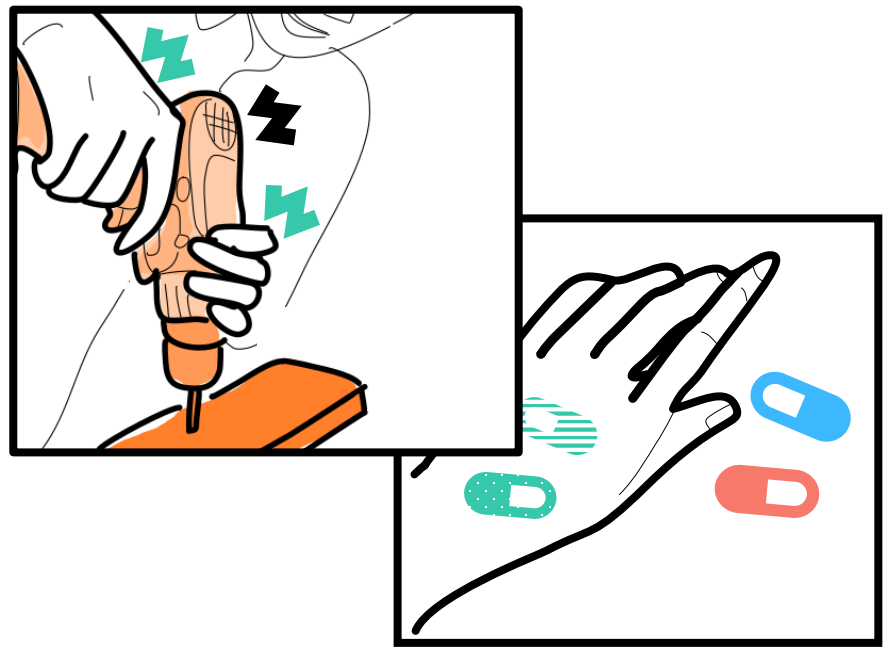
靈 巧 互 動 實 驗 室



done with mental or physical skill, quickness, or grace

dexterous interaction lab

靈 巧 互 動 實 驗 室



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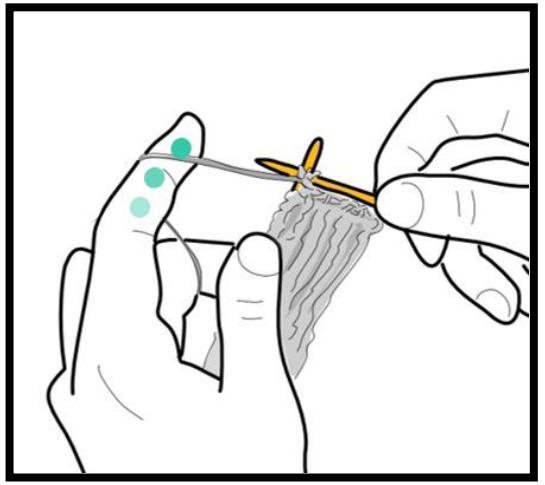
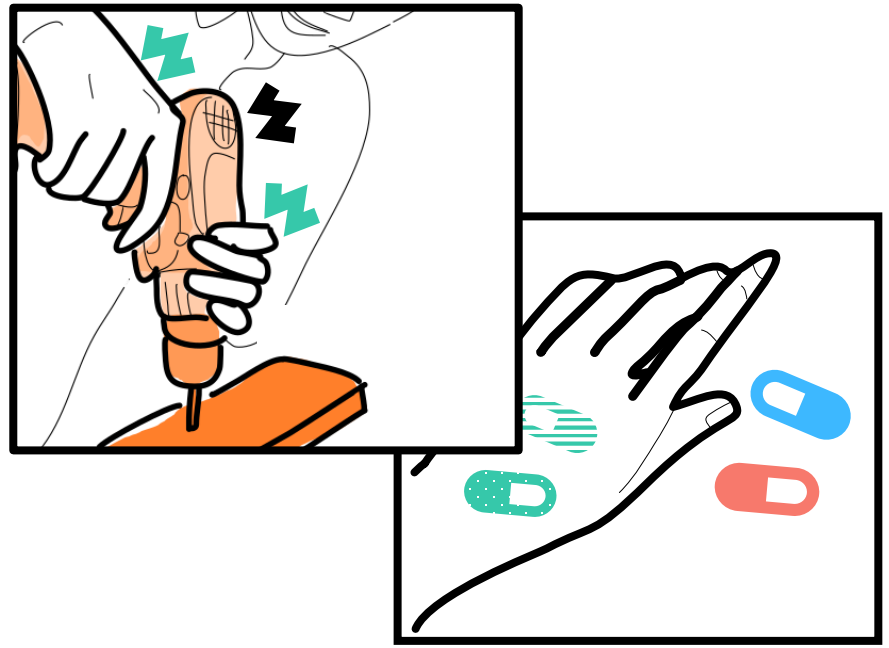
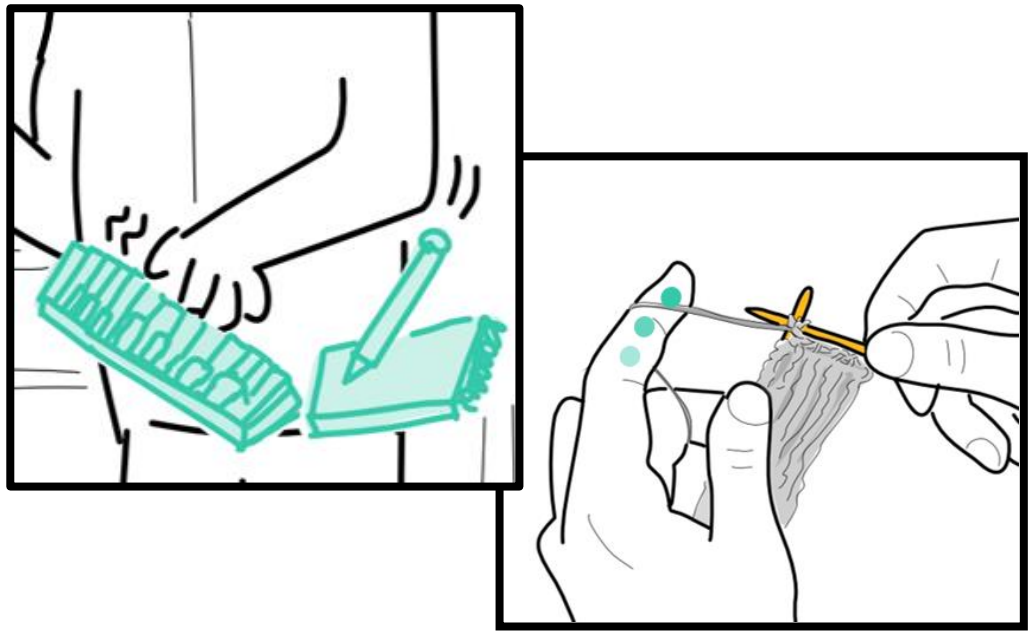
dexterous interaction lab

靈 巧 互 動 實 驗 室







done with mental or physical skill, quickness, or grace

dexterous interaction lab

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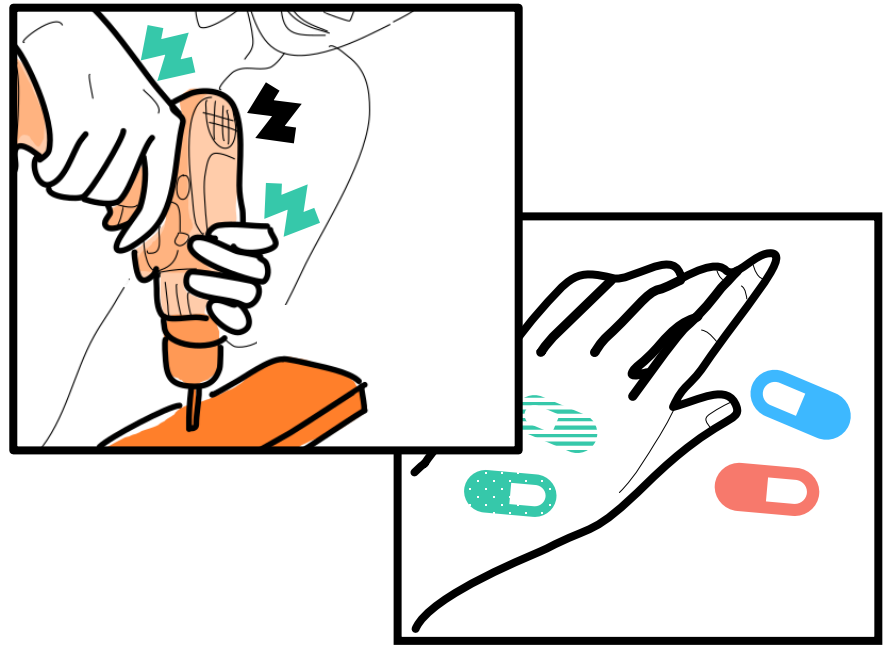


research focus:
how can we make humans more dexterous in future interactions?

done with mental or physical skill, quickness, or grace

dexterous interaction lab

靈 巧 互 動 實 驗 室

insight:
multimodal interaction

research focus:
how can we make humans more dexterous in future interactions?

done with mental or physical skill, quickness, or grace

dexterous interaction lab

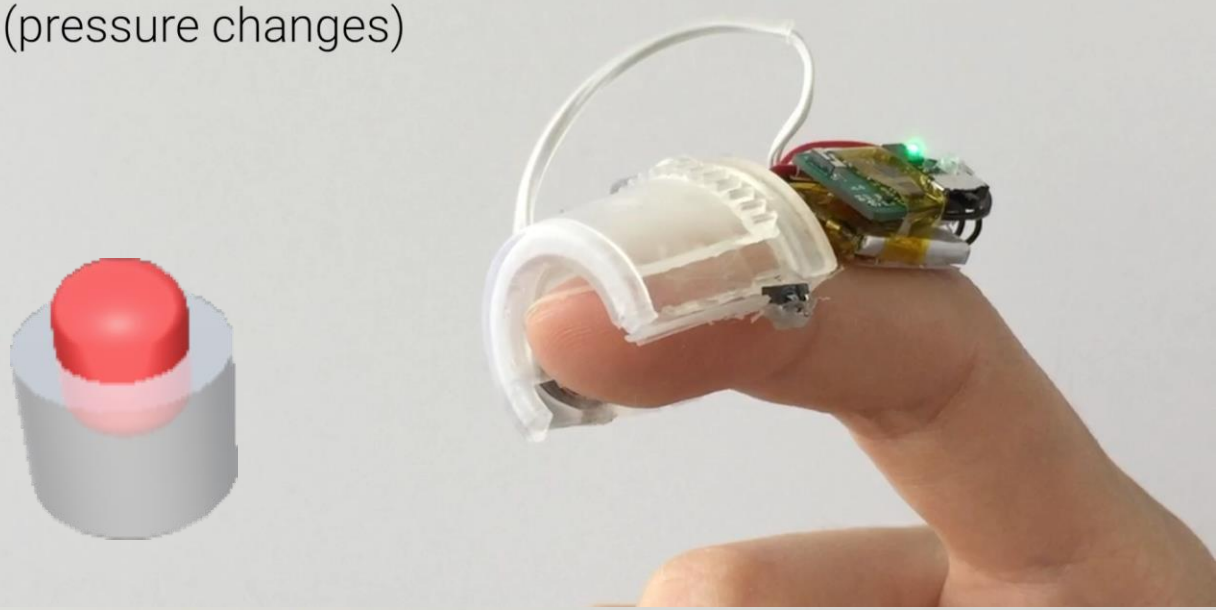
靈 巧 互 動 實 驗 室

we engineered a foldable nail-mounted haptic device for mixed reality (MR)

[CHI ‘21]

1. contact with virtual surface (pressure)

2. contact with variable forces (pressure changes)



3. low-frequency texture
such as corrugated cardboard

4. high-frequency texture
such as sand paper

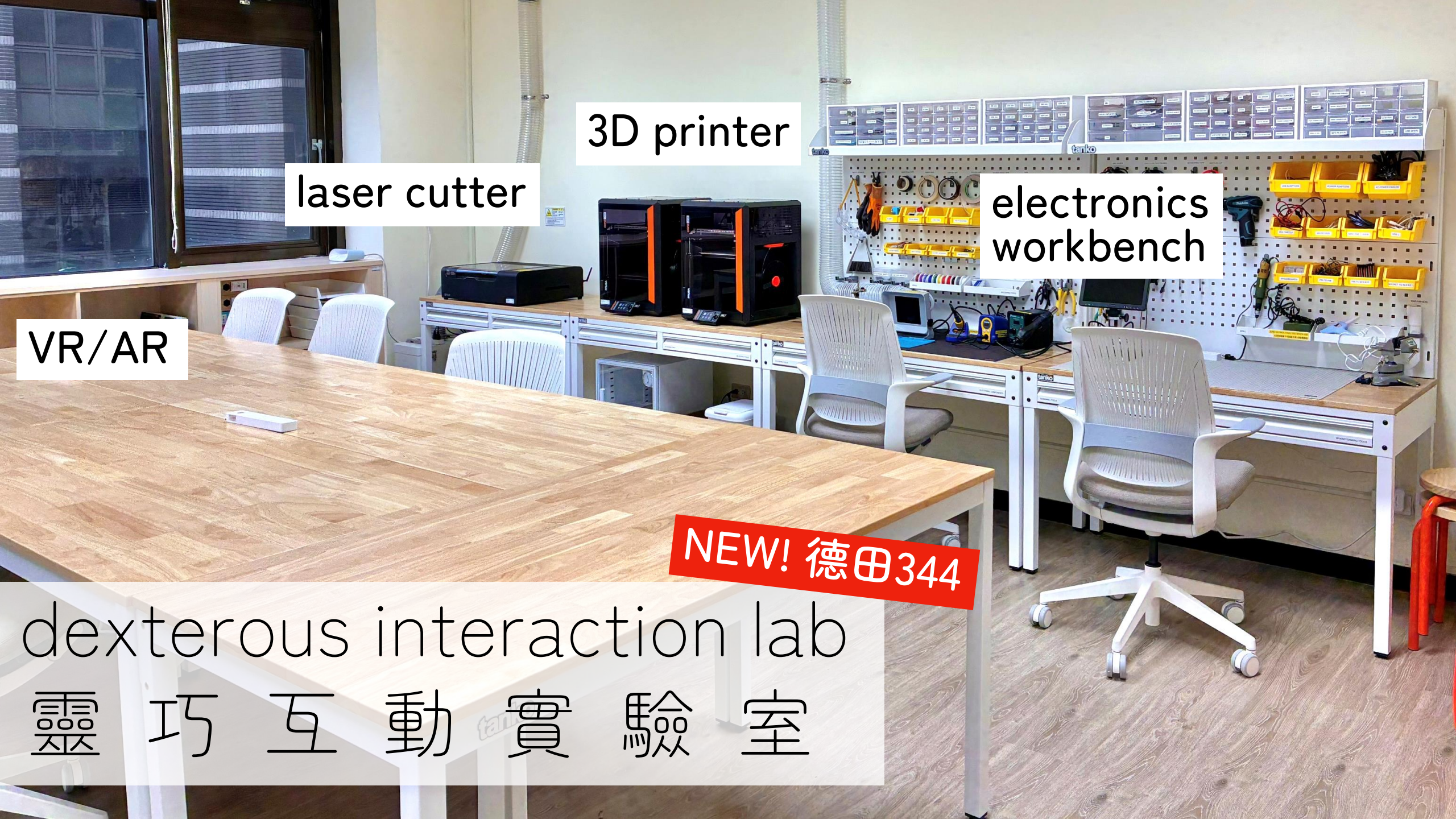
Guinness World Records
Most precise bionic hand controller

[UIST '21]

this **blind user** wants to use a **hot kettle**

[CHI ‘25]


NEW! 德田344
dexterous interaction lab
靈 巧 互 動 實 驗 室



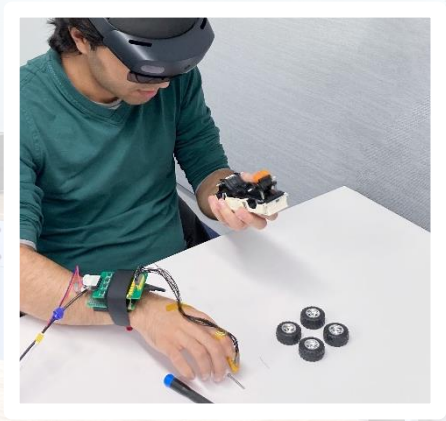
dexterous interaction lab

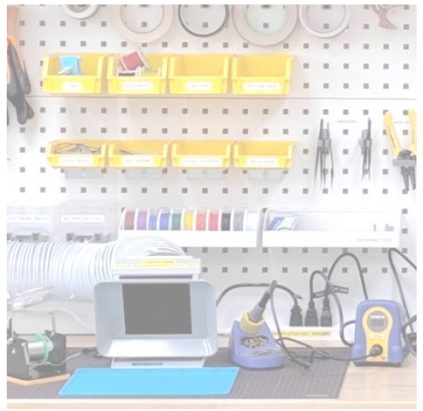
靈 巧 互 動 實 驗 室

prototype

dexterous interaction lab

靈 巧 互 動 實 驗 室



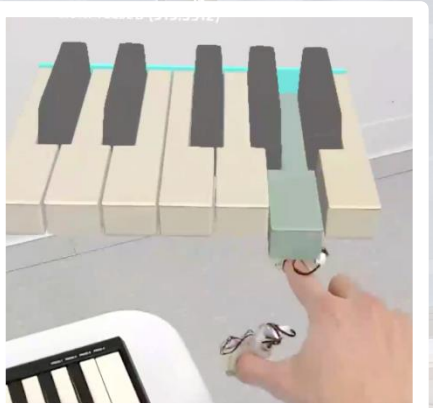


prototype

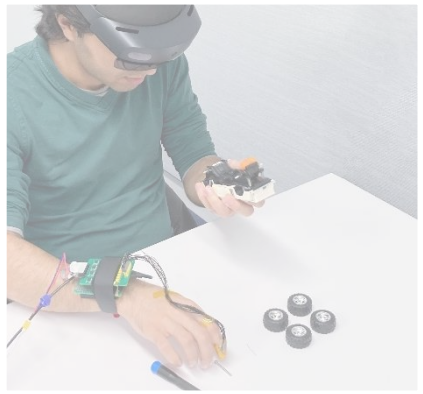
studying users

dexterous interaction lab

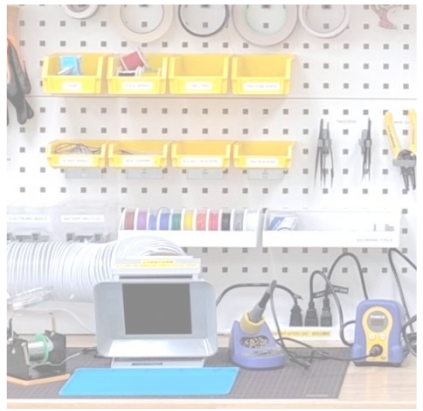
靈 巧 互 動 實 驗 室



building applications



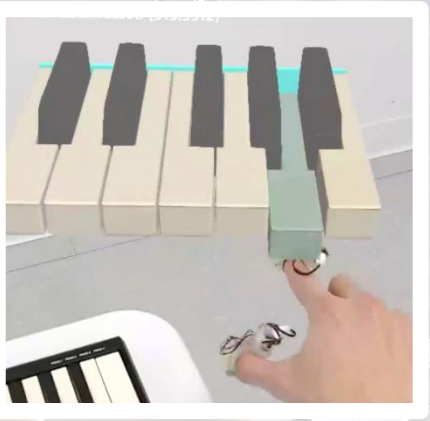
studying users



prototype

dexterous interaction lab

靈 巧 互 動 實 驗 室



building applications

studying users

prototype

dexterous interaction lab

靈 巧 互 動 實 驗 室

dexterous interaction lab

靈 巧 互 動 實 驗 室

recruiting students!

https://lab.tengshanyuan.info/

two-week's class:

1. computing going multimodal
2. benefits of multimodal systems
3. technologies enabling multimodal interactions

two-week's class:

1. computing going multimodal
2. benefits of multimodal systems
3. technologies enabling multimodal interactions

an assignment will be announced at the end of the class (no coding)

what are modalities*?

what are modalities*?

*field dependent

what are modalities*?

*field dependent

neuroscience

sensory
channels

what are modalities*?

*field dependent

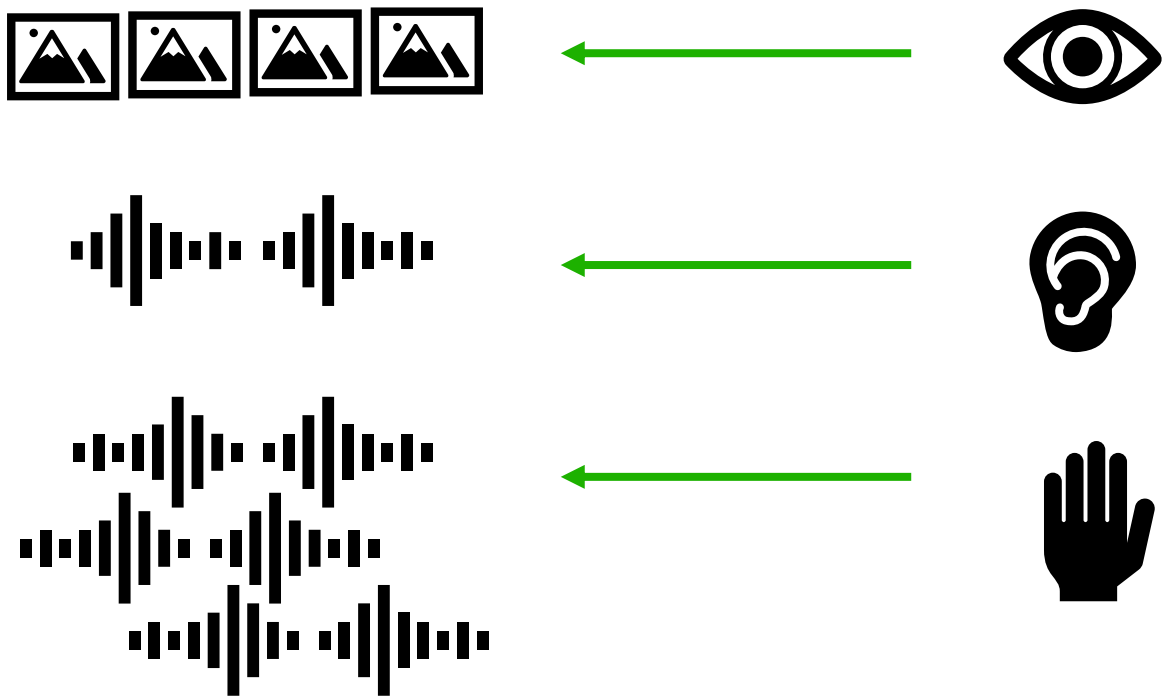
multimodal AI

data types regarding sensory channels

neuroscience

sensory channels

data



what are modalities*?

*field dependent

multimodal AI

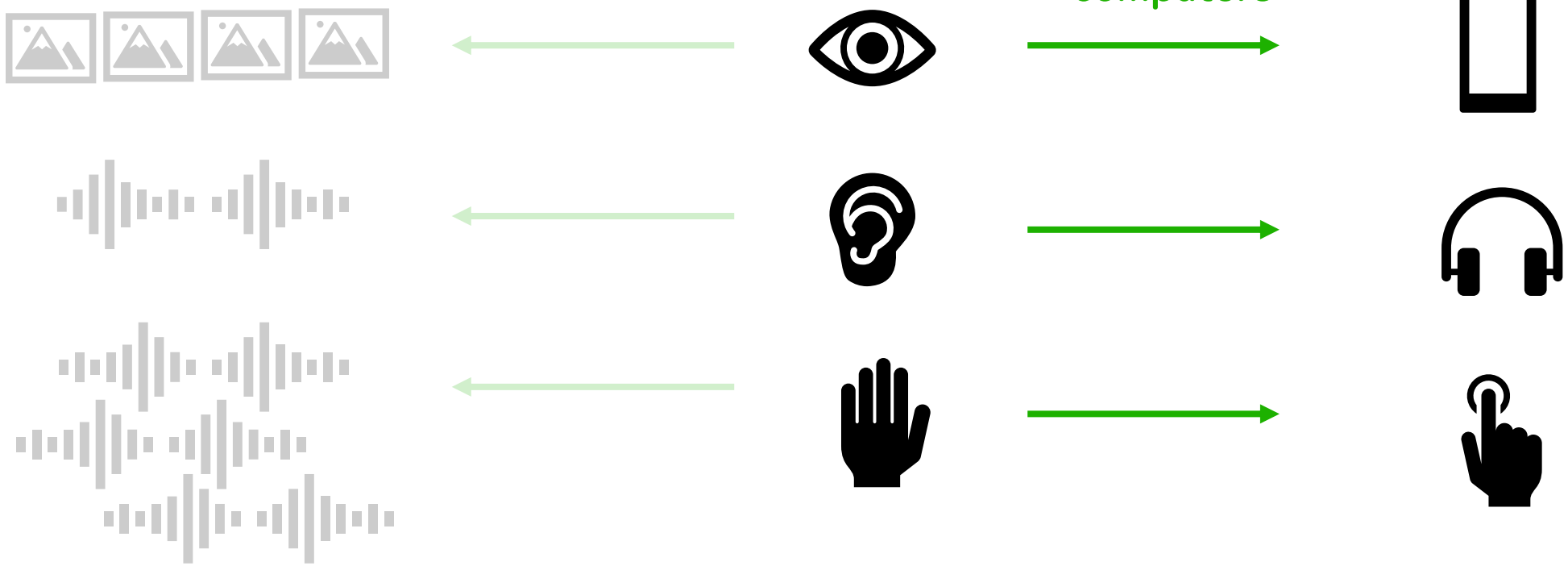
data types regarding sensory channels

neuroscience

sensory channels

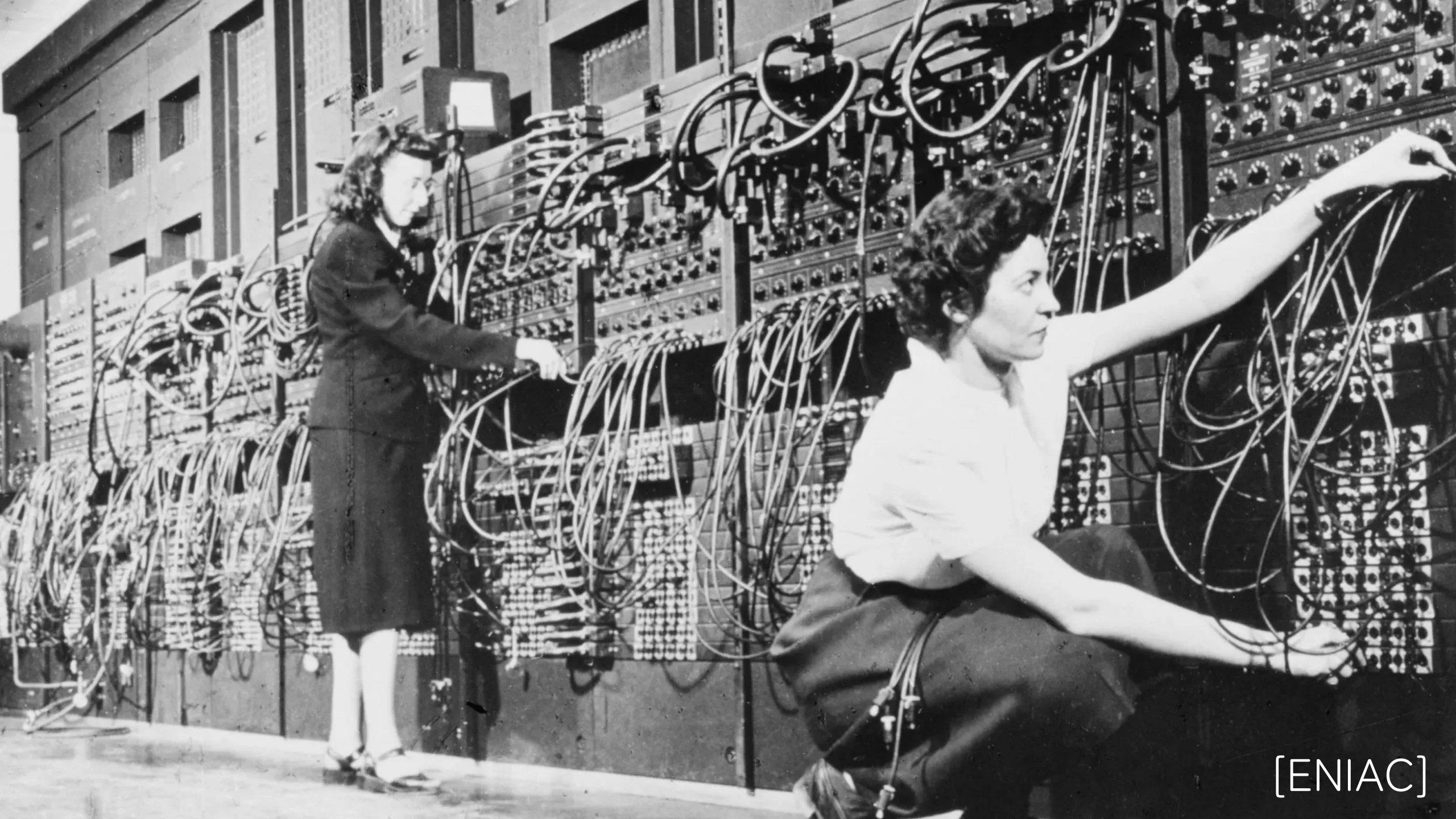
Human-Computer Interaction (HCI)

input & output modes using computing systems



1945

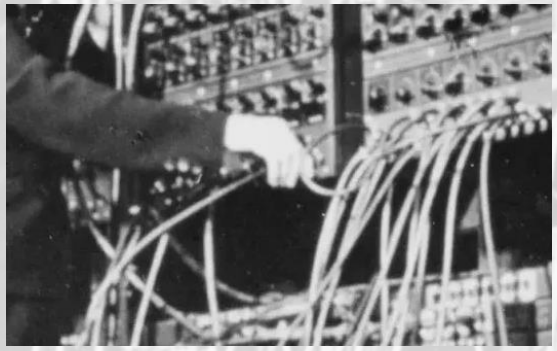
[ENIAC]



[ENIAC]

input

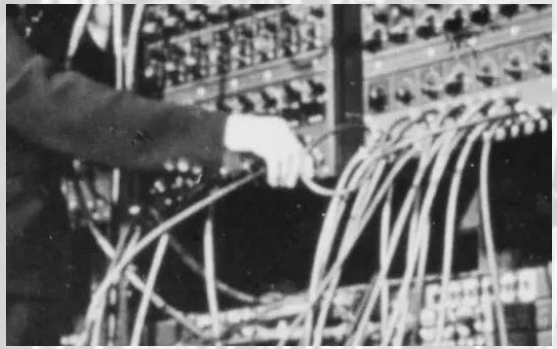
plugging wires



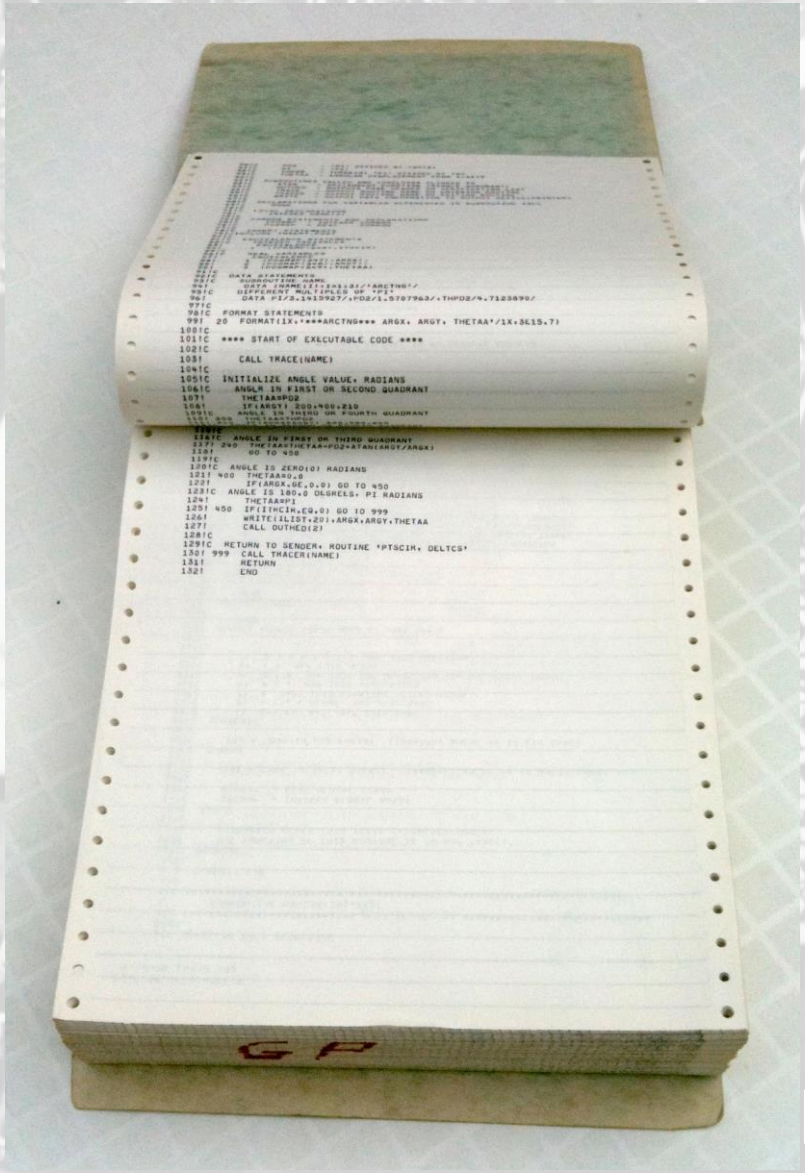
[ENIAC]

input

plugging wires



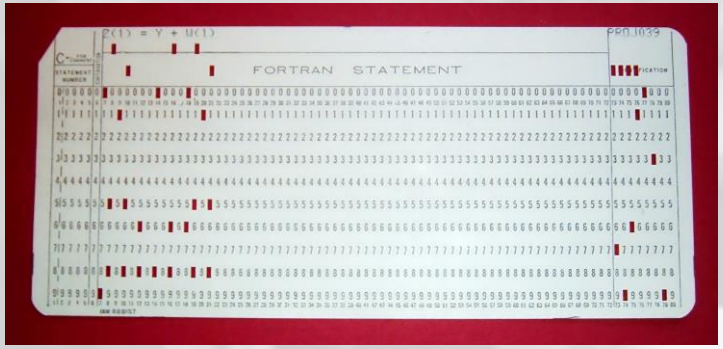
output



IAC]


FORTRAN STATEMENT
punched cards
keyboards
[IBM 026]

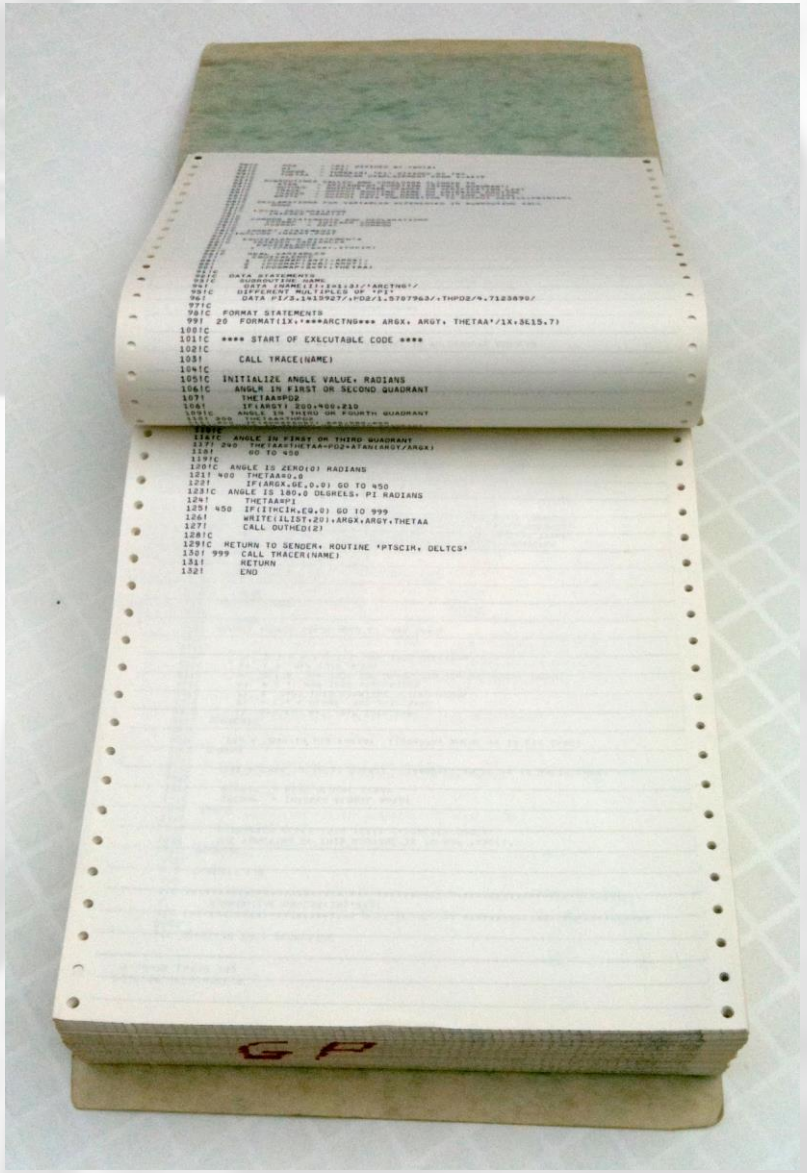
input

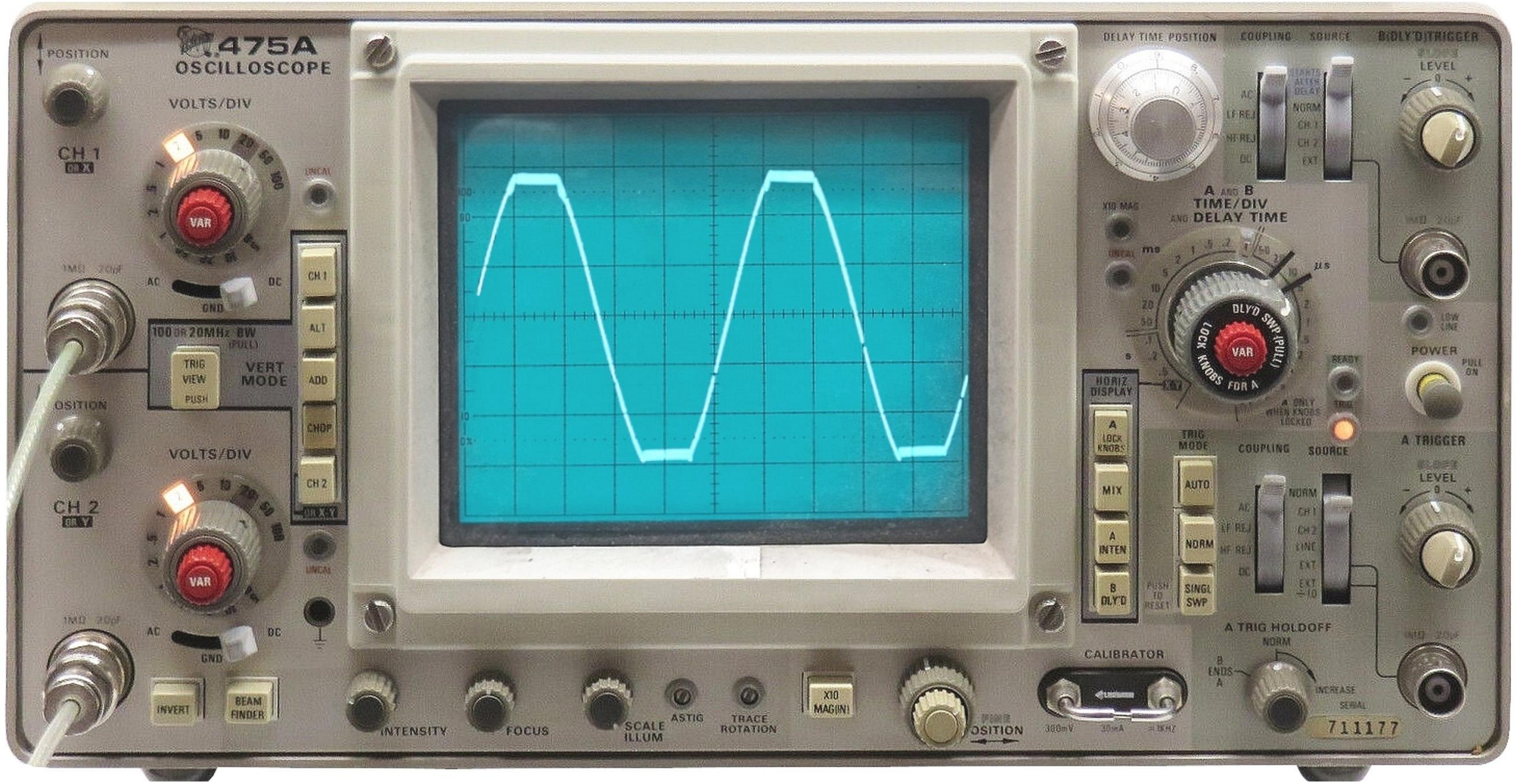


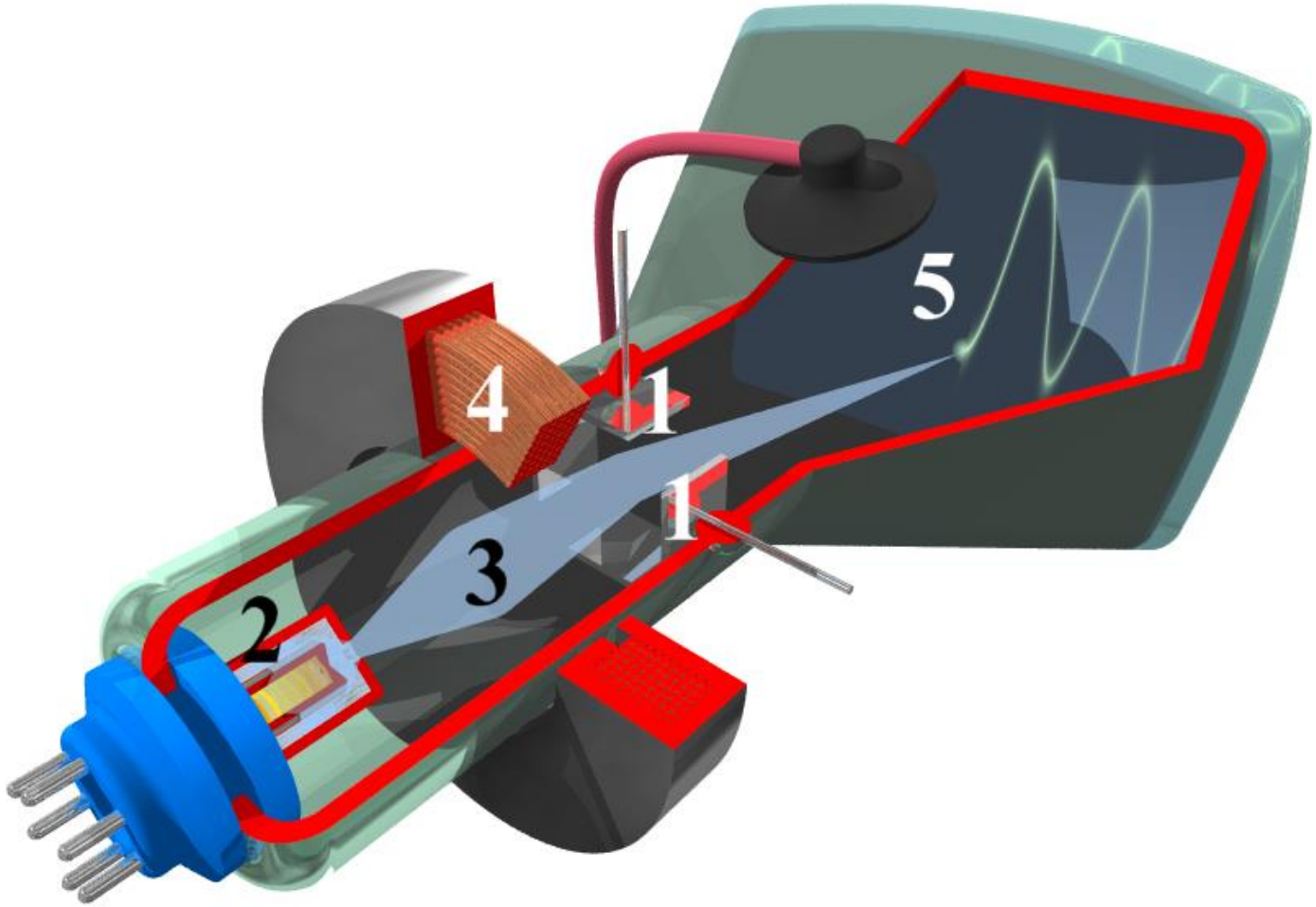
punched cards

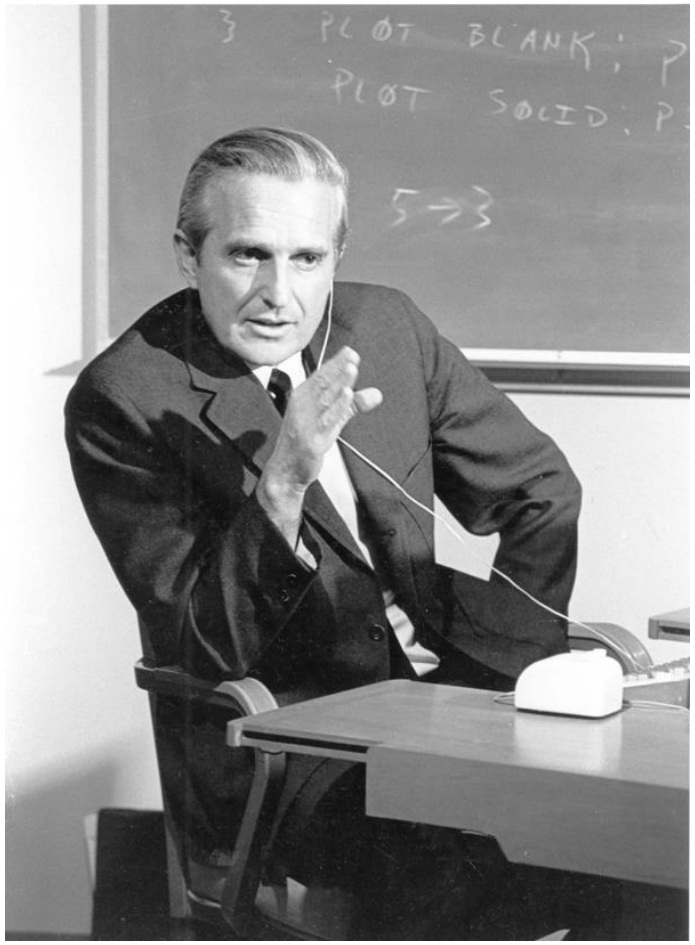
keyboards

output




475A
OSCILLOSCOPE
POSITION
VOLTS/DIV
CH 1
OR X
VAR
AC
GND
DC
CH 1
ALT
ADD
CHOP
CH 2
100 OR 20MHz BW
(PULL)
TRIG VIEW
PUSH
VERT MODE
VOLTS/DIV
CH 2
OR Y
INVERT
BEAM FINDER
INTENSITY
FOCUS
SCALE ILLUM
ASTIG
TRACE ROTATION
X10 MAG(IN)
POSITION
CALIBRATOR
DELAY TIME POSITION
COUPLING
SOURCE
B DLY'D TRIGGER
LEVEL
A AND B
TIME/DIV
AND DELAY TIME
X10 MAG
DLY'D SWP (PULL)
LOCK KNOBS FOR A
READY
POWER
HORIZ DISPLAY
A
LOCK KNOBS
MIX
A INTEN
B DLY'D
TRIG MODE
AUTO
NORM
SINGL SWP
A TRIGGER
A TRIG HOLDOFF
B ENDS A
INCREASE
711177


5
4
1
1
3
2



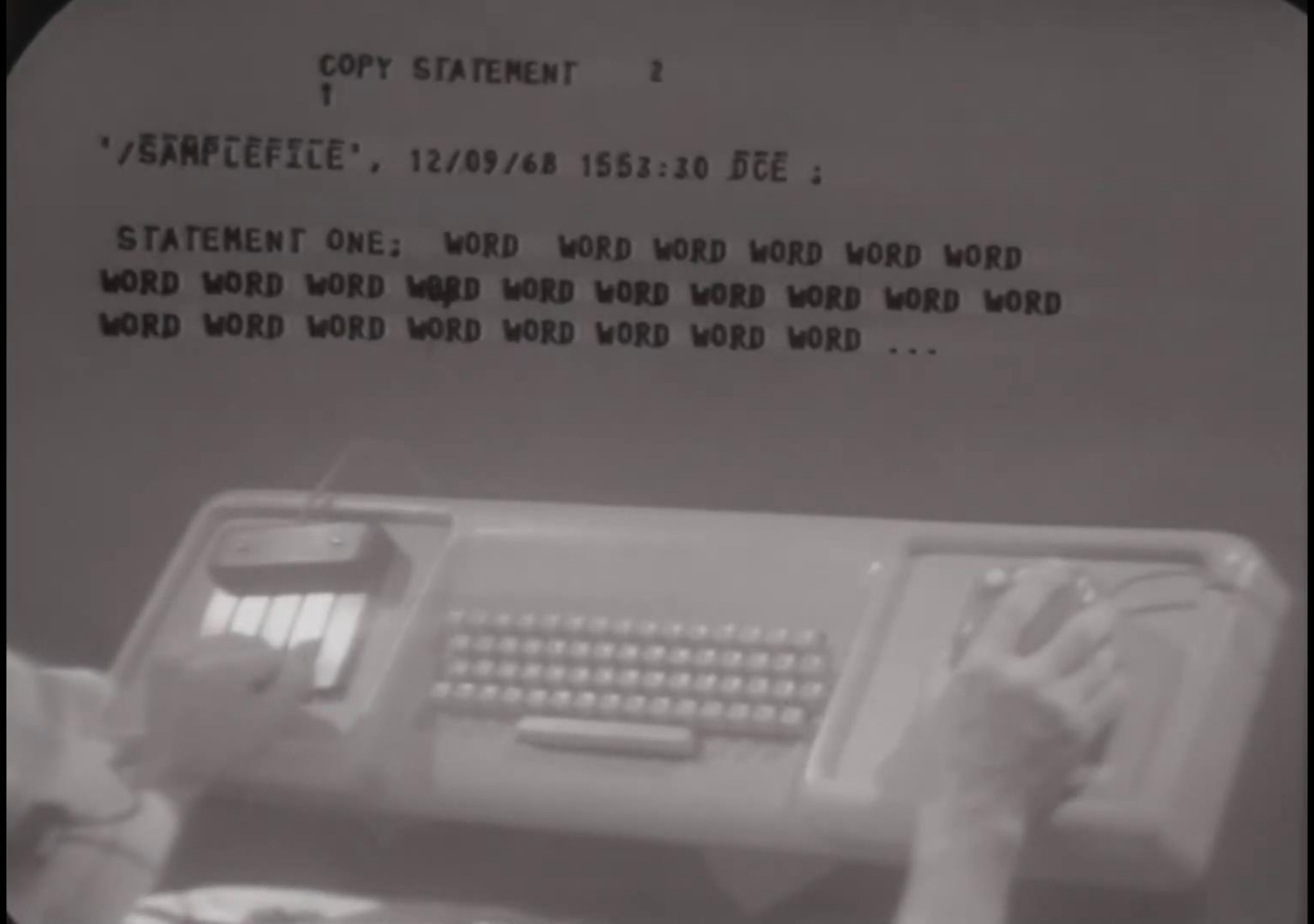
Douglas Engelbart

(Turing Award, 1997)

1968

“The Mother of All Demos”

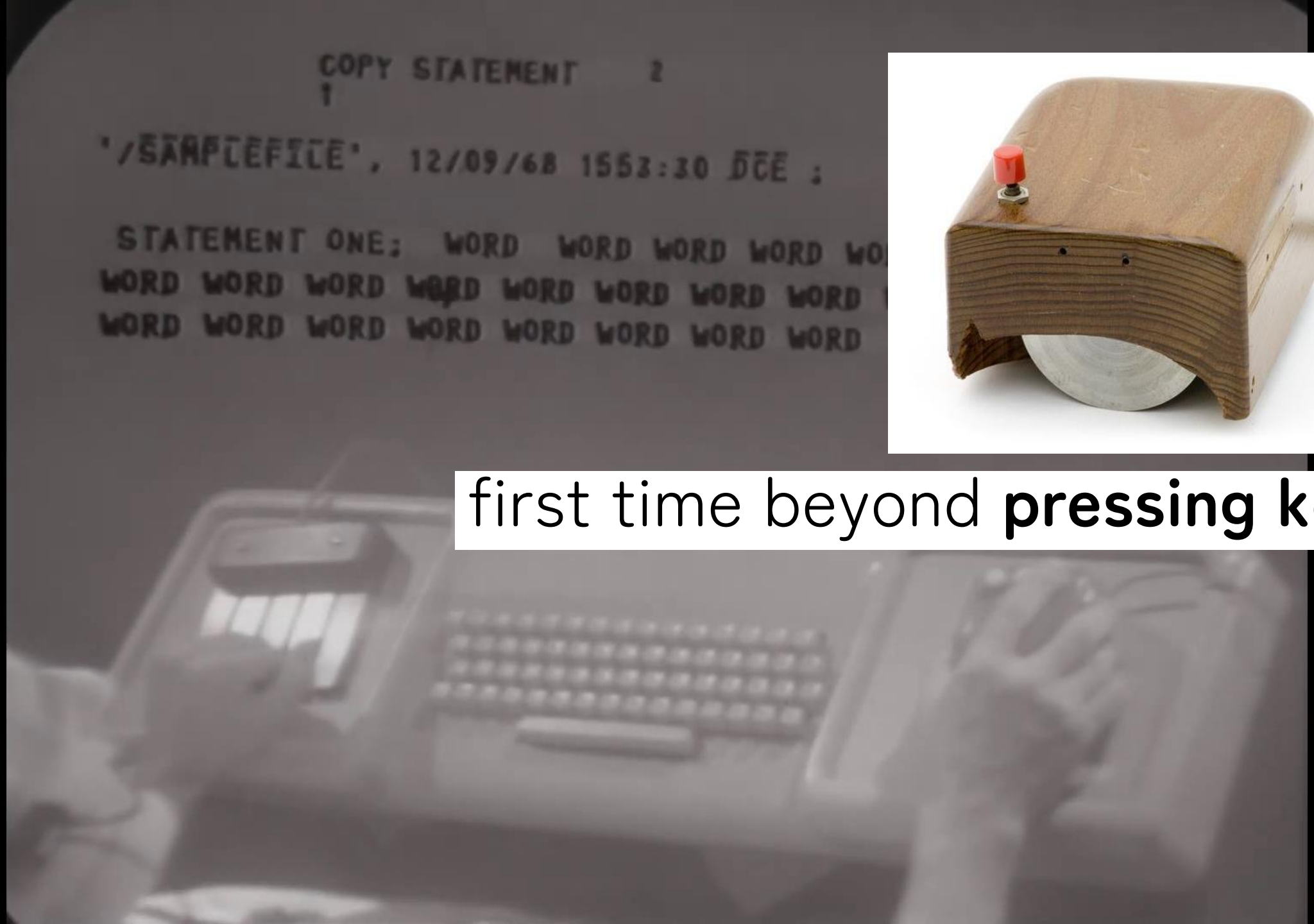
90-minute live demonstration of windows, hypertext, graphics, efficient navigation and command input, video conferencing, word processing, dynamic file linking, revision control, and a collaborative real-time editor…


COPY STATEMENT 2
1
'/SAMPLEFILE', 12/09/68 1553:30 DCE ;
STATEMENT ONE; WORD WORD WORD WORD WORD WORD
WORD WORD WORD WORD WORD WORD WORD WORD WORD WORD
WORD WORD WORD WORD WORD WORD WORD WORD ...

COPY STATEMENT 2
1

'/SAMPLEFILE', 12/09/68 1553:30 DCE ;

STATEMENT ONE: WORD WORD WORD WORD WO
WORD WORD WORD WORD WORD WORD WORD WORD
WORD WORD WORD WORD WORD WORD WORD WORD



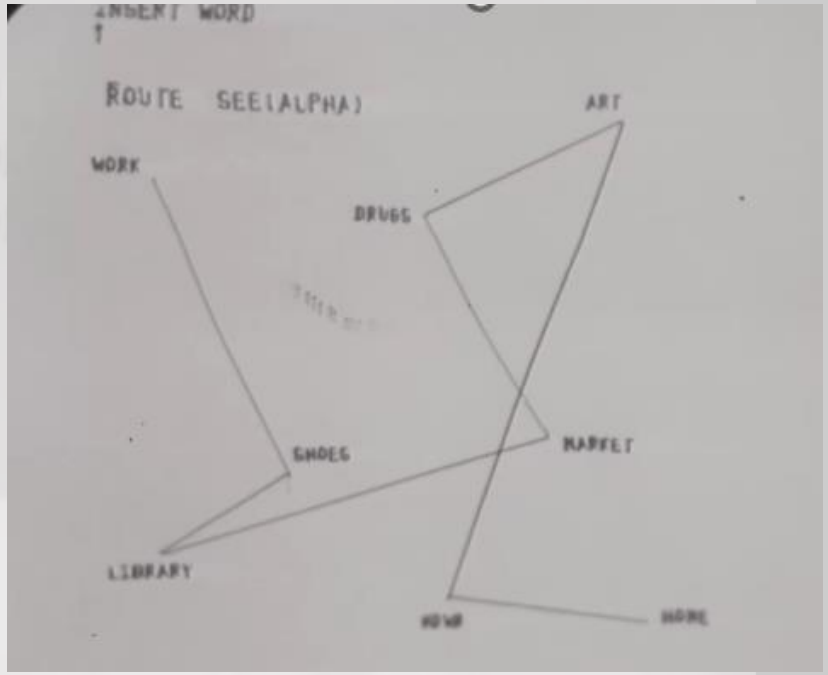
first time beyond **pressing keys**

input

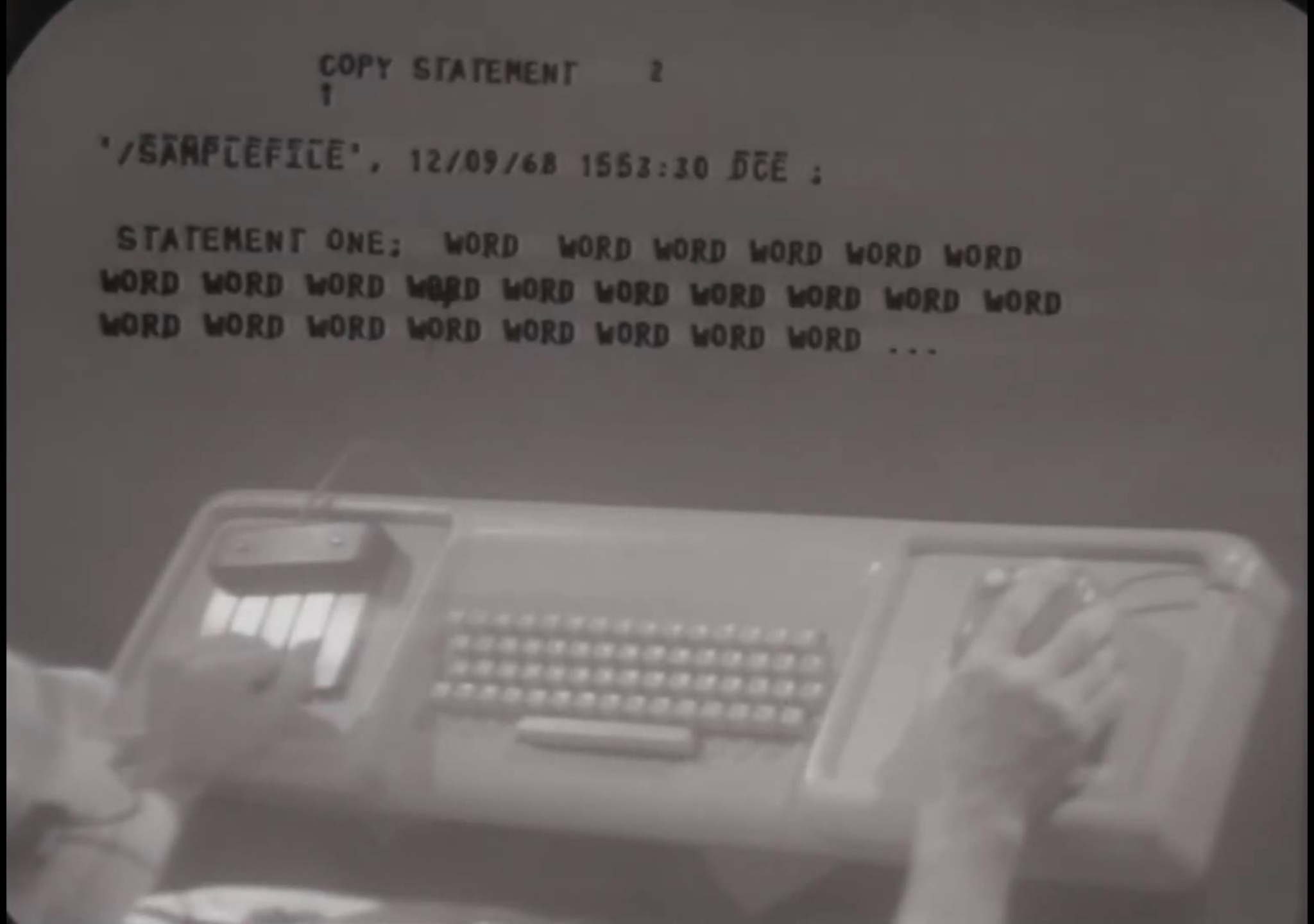
mouse

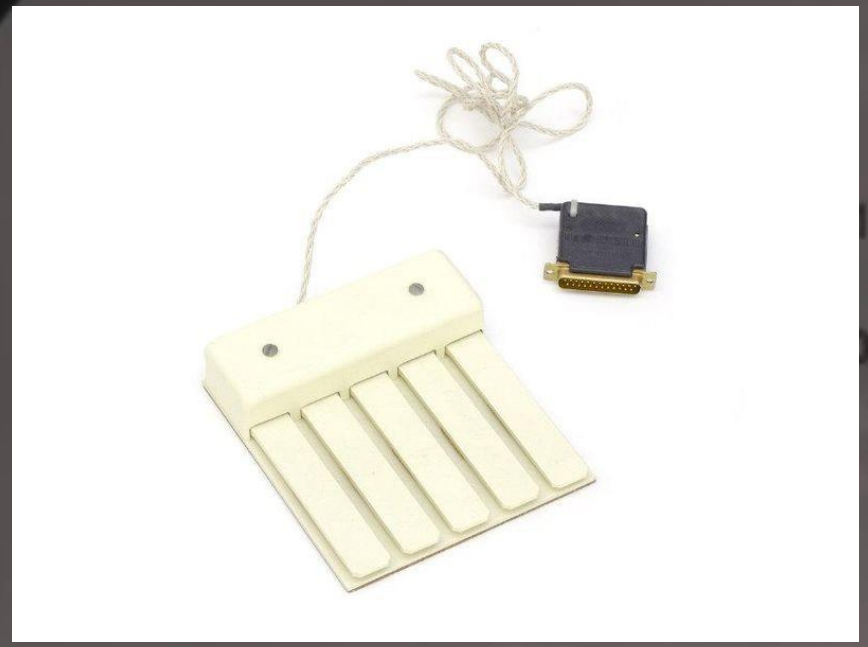
keyboard

output



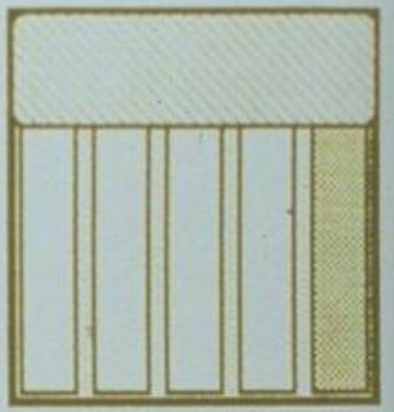
2D real-time screen


COPY STATEMENT 2
1
'/SAMPLEFILE', 12/09/68 1553:30 DCE ;
STATEMENT ONE; WORD WORD WORD WORD WORD WORD
WORD WORD WORD WORD WORD WORD WORD WORD WORD WORD
WORD WORD WORD WORD WORD WORD WORD WORD ...

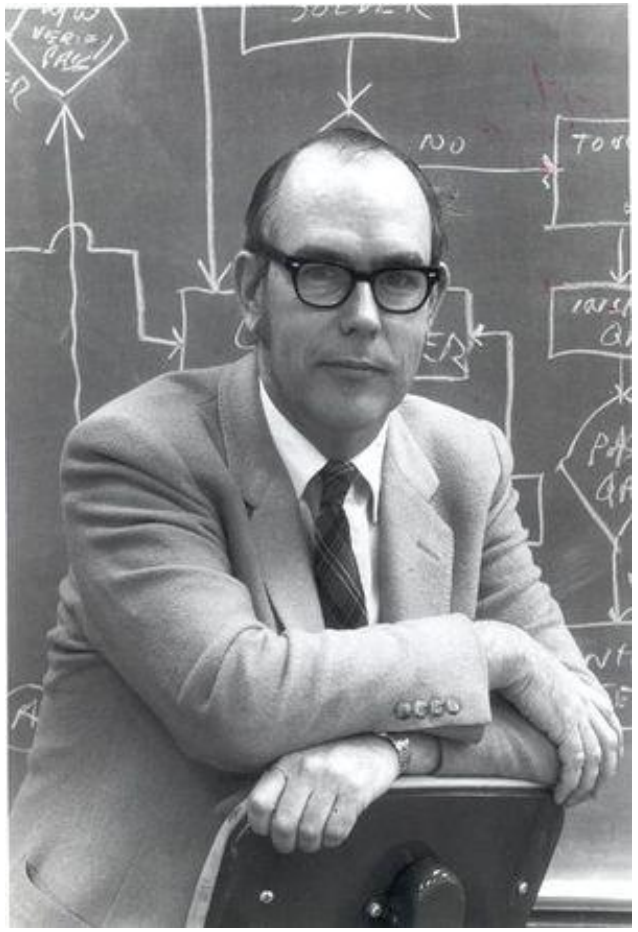


One-Handed,
Chord Keyset:

Code for "a" →

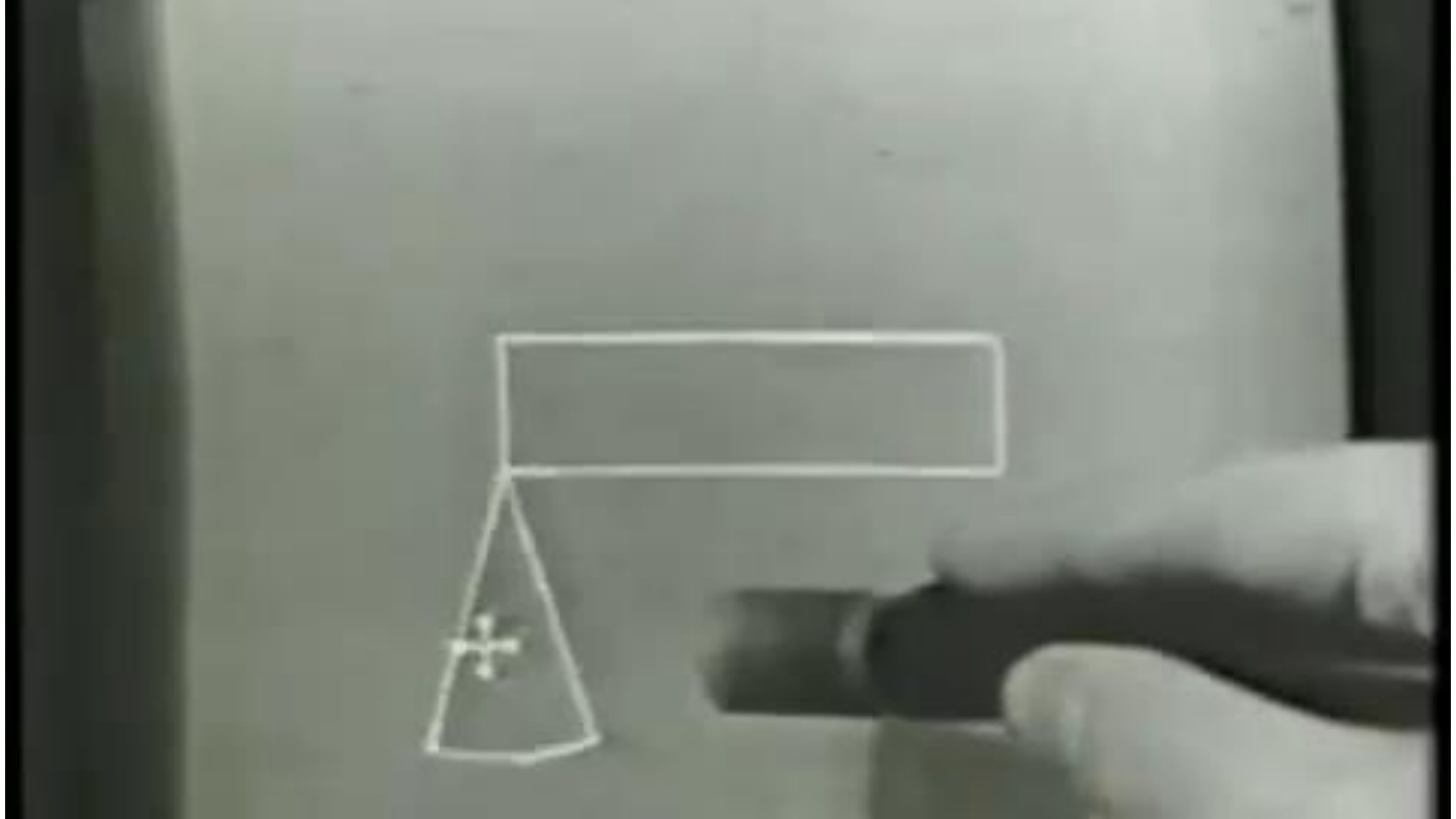


b
c
d
e
f
g
h
x
y
z



Ivan Sutherland
(Turing Award, 1988)

1963
Sketchpad

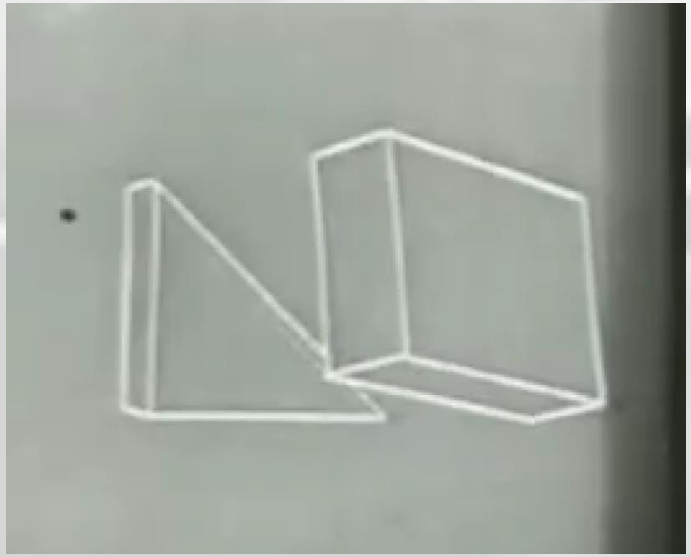


first time we can **point with our body directly** to a real-time output

input

stylus (direct input)

output



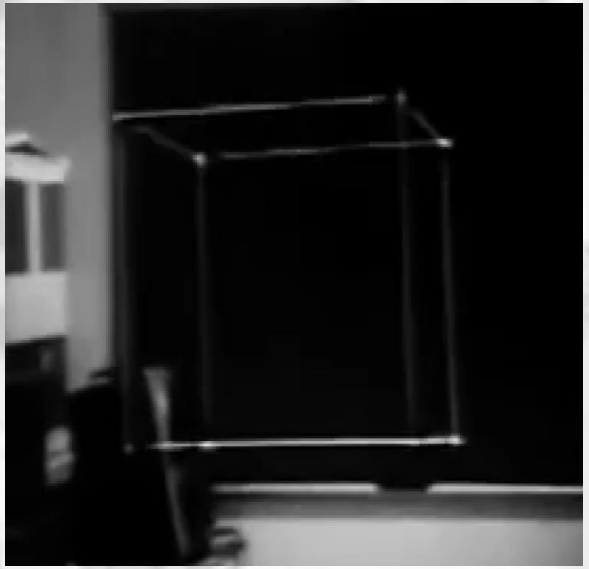
2D screen (render 3D shapes)

The first Head-Mounted Display

input

output

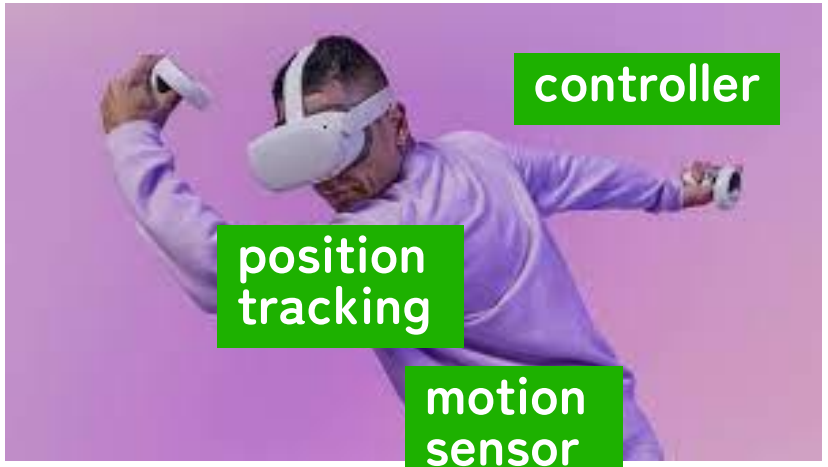
head movement



3D graphic

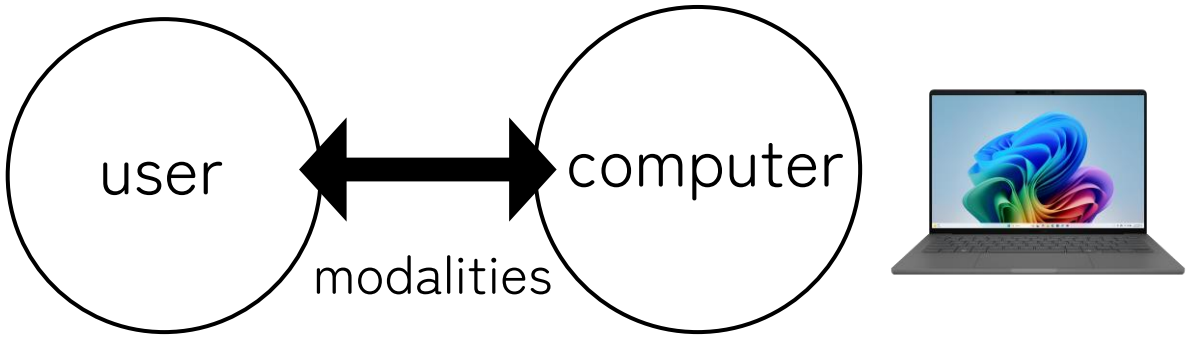
today’s interfaces

today's interfaces

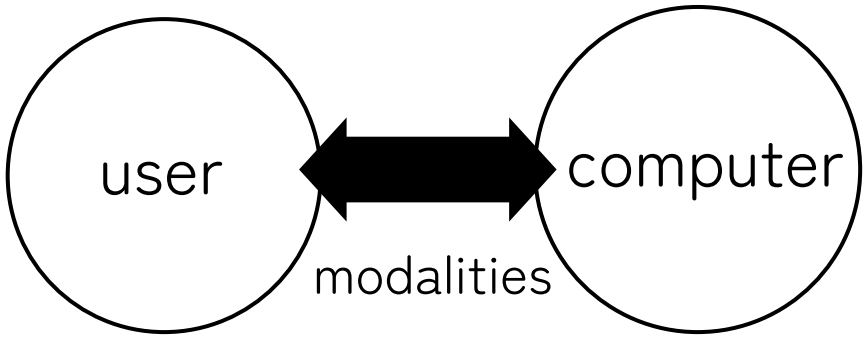


what’s next

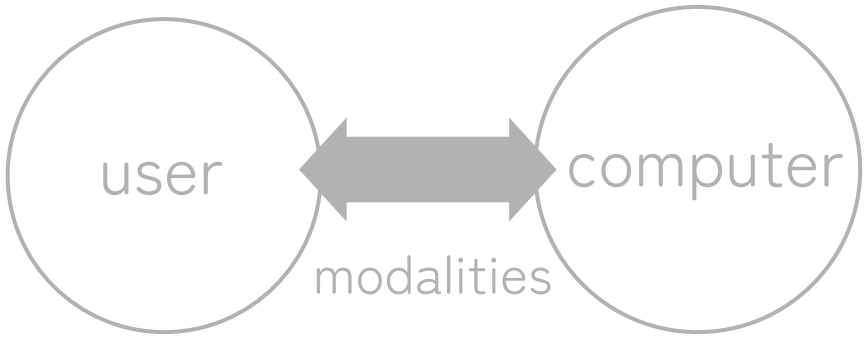
what's next

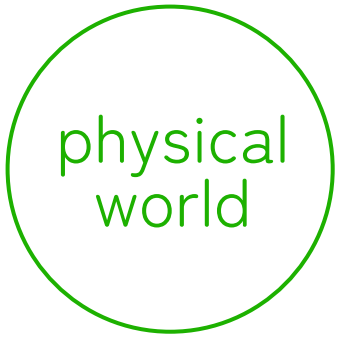


what's next

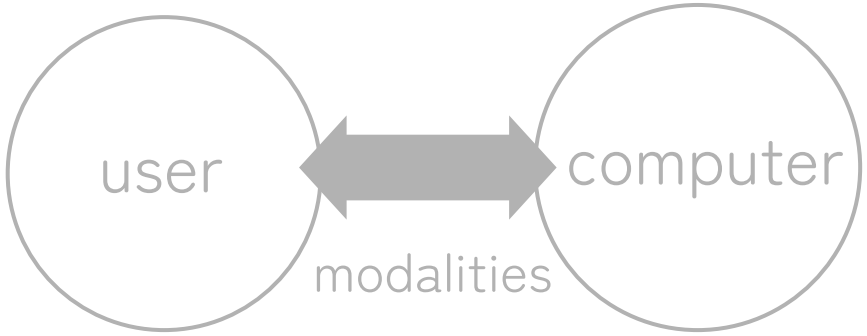


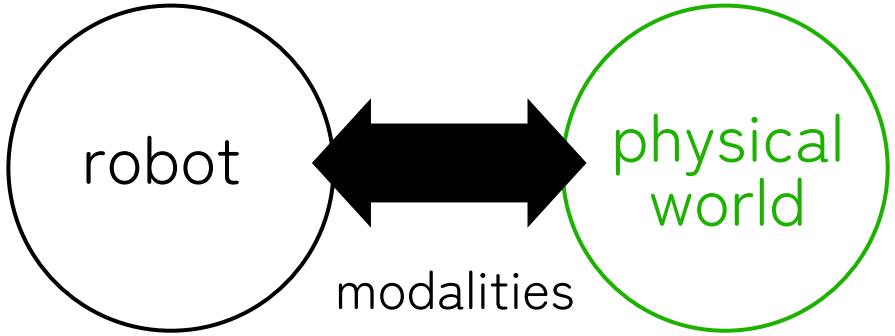
what's next



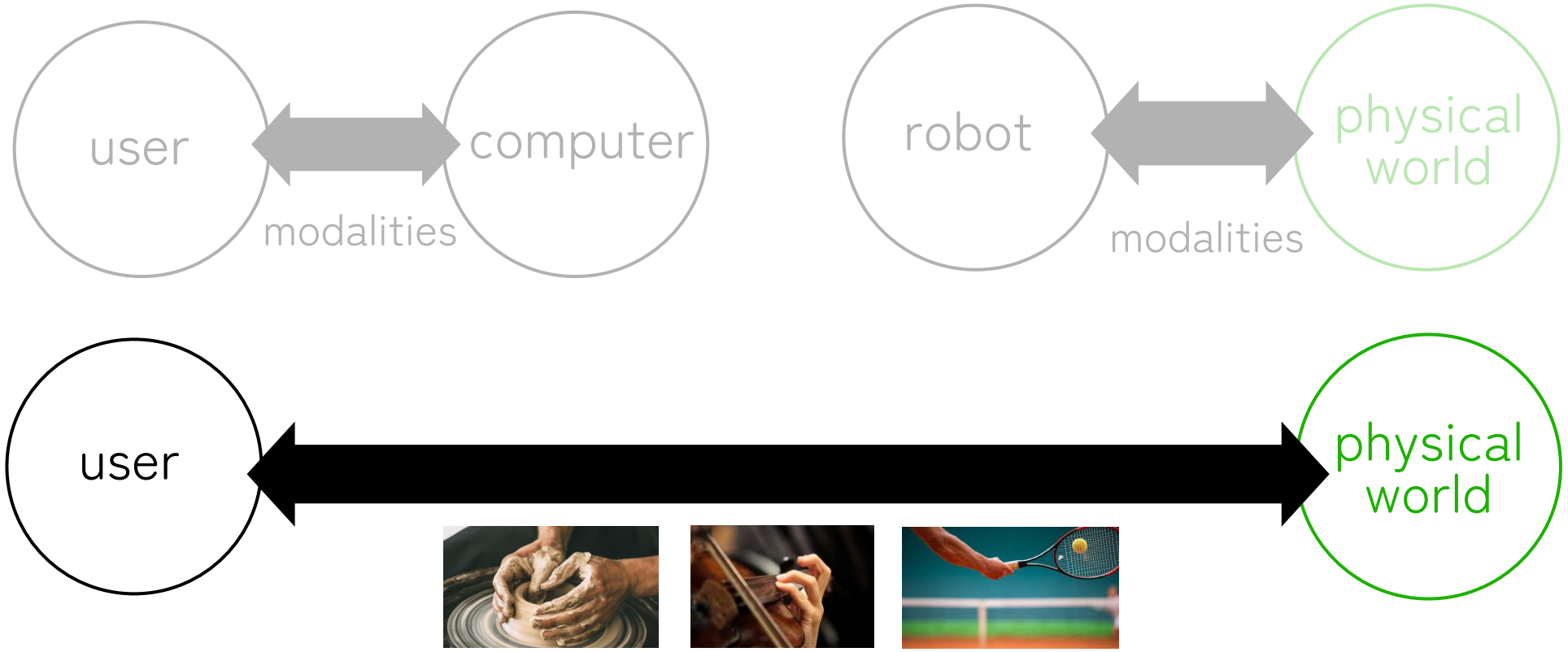


what's next

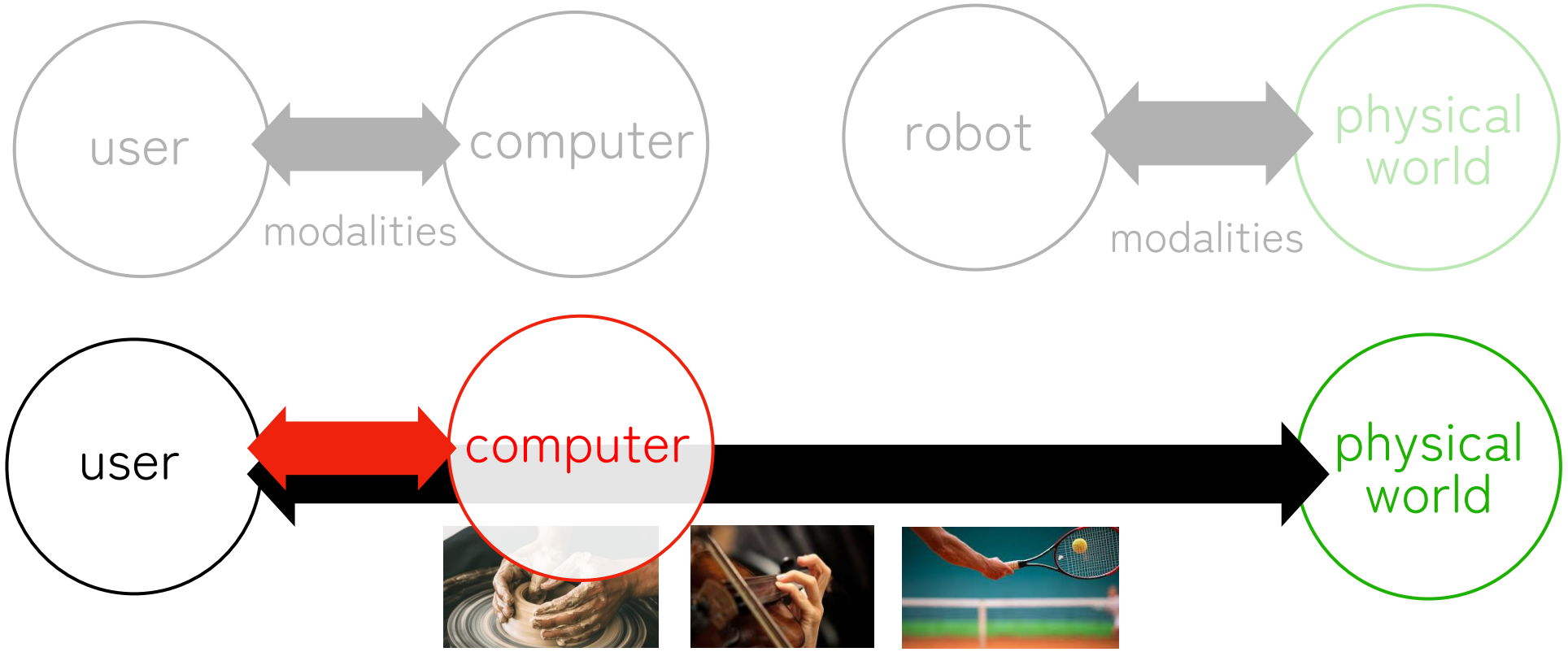

user
computer
modalities


robot
physical world
modalities

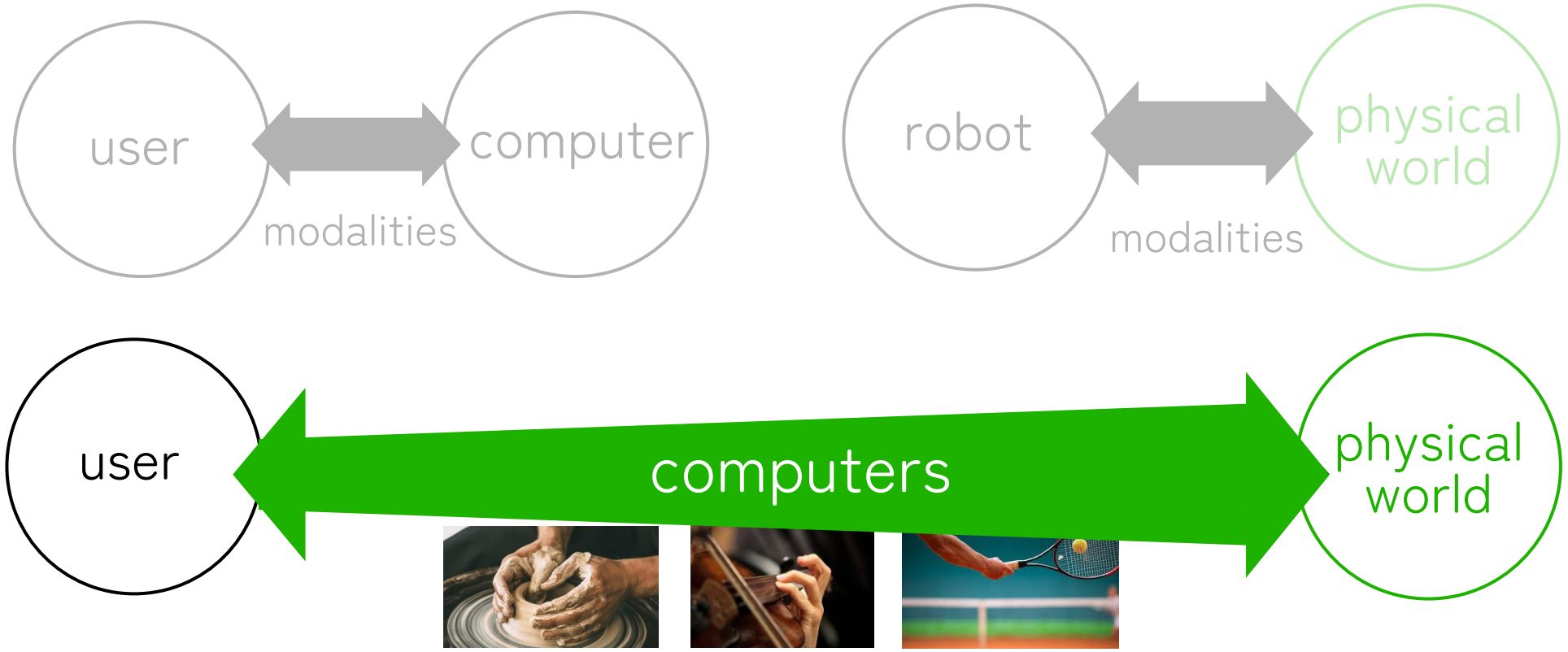
what's next


user
computer
modalities
robot
physical world
modalities
user
physical world

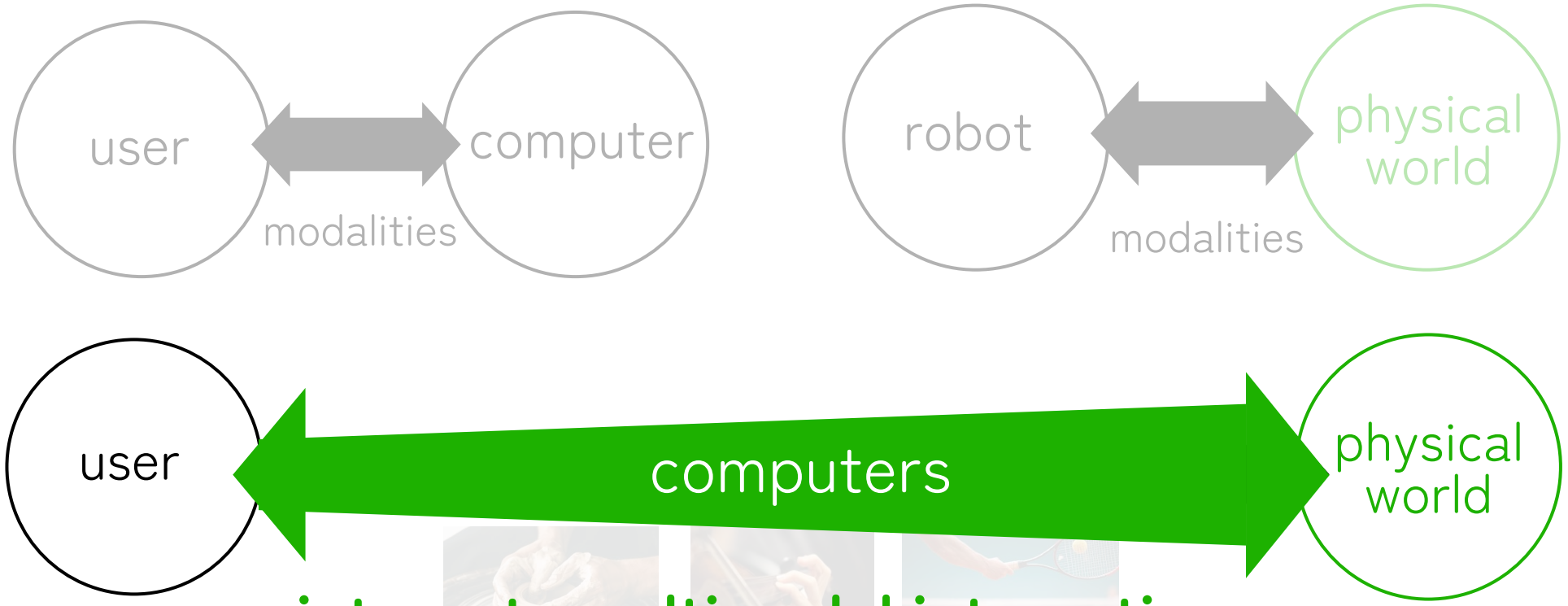
what's next


user
computer
modalities
robot
physical world
modalities
user
computer
physical world

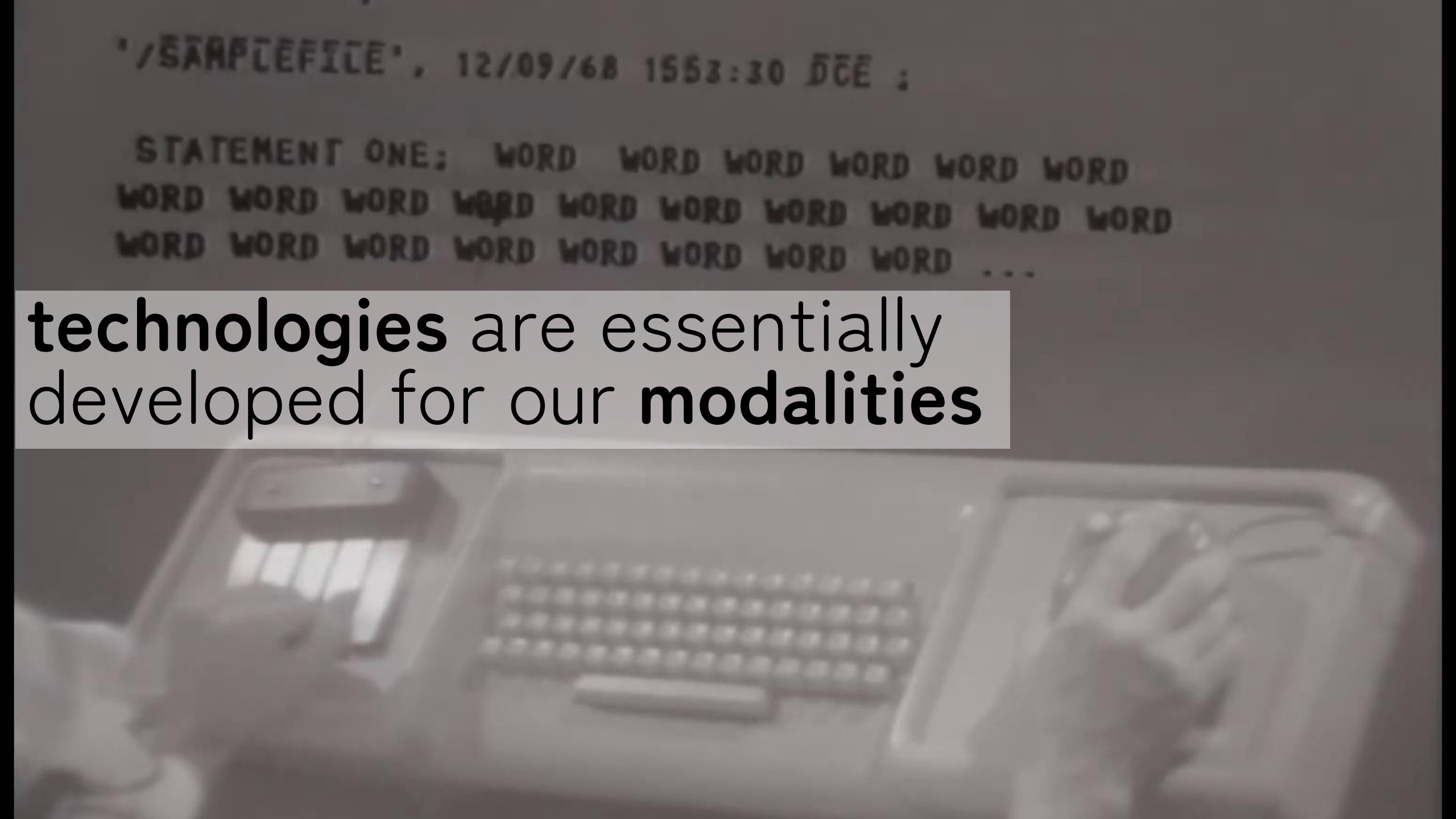
what's next


user
computer
modalities
robot
physical world
modalities
user
computers
physical world

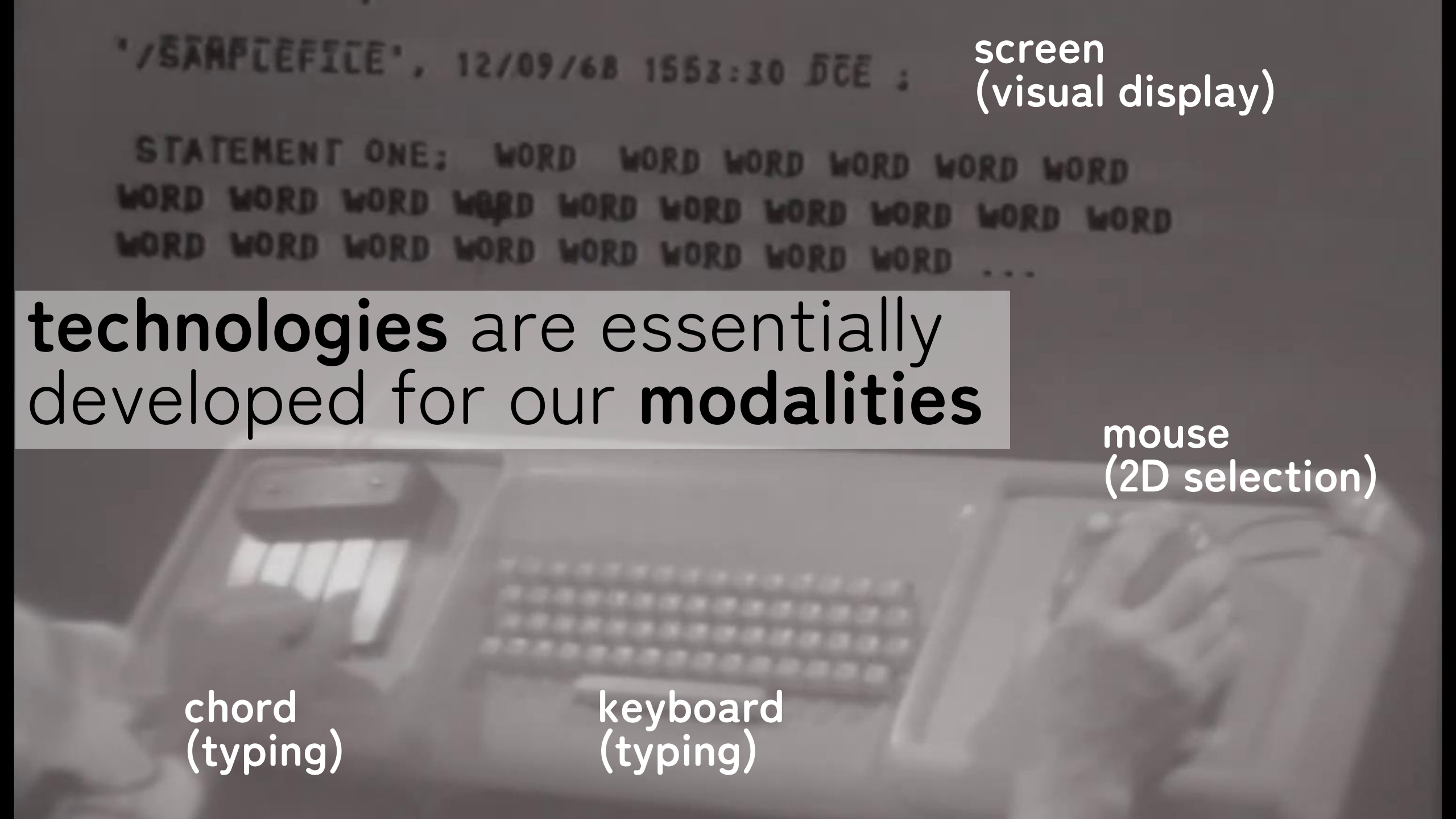
what's next



integrate multimodal interactions into the real world



technologies are essentially developed for our **modalities**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STATEMENT ONE: WORD WORD WORD WORD WORD WORD
WORD WORD WORD WORD WORD WORD WORD WORD WORD WORD
WORD WORD WORD WORD WORD WORD WORD WORD ...
technologies are essentially developed for our modalities
screen (visual display)
mouse (2D selection)
chord (typing)
keyboard (typing)

benefits of multimodal HCI:

1. efficiency
   make computers more efficient

2. usability
   make computers easier to use

3. fidelity
   make computers feel more realistic

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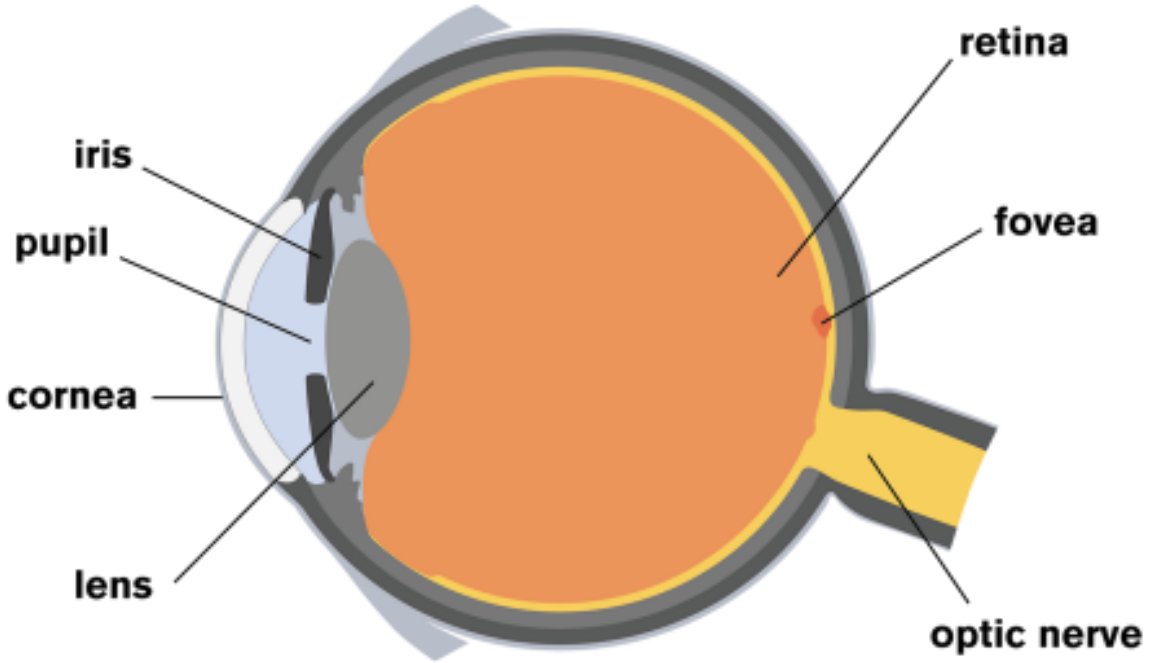
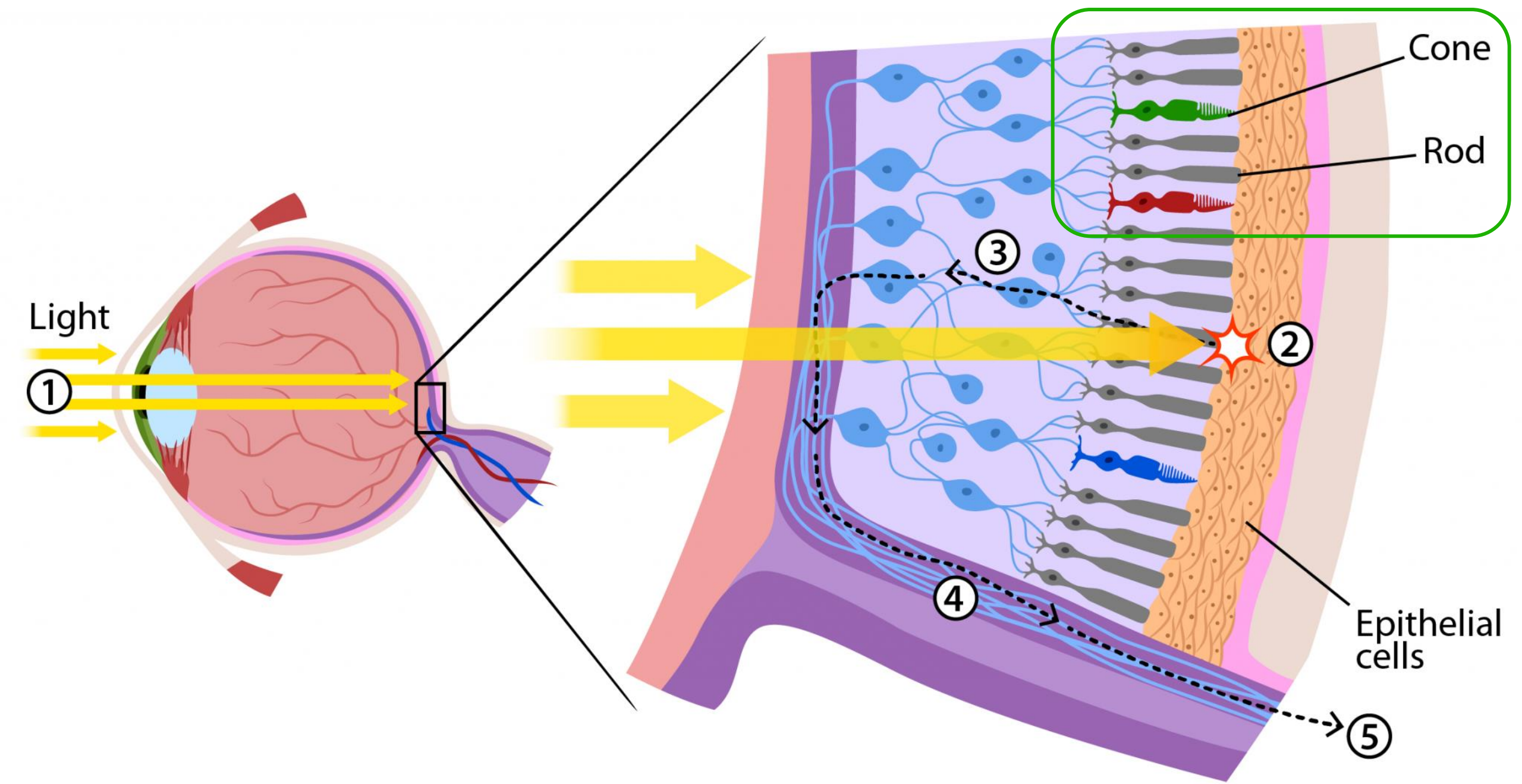
visual perception

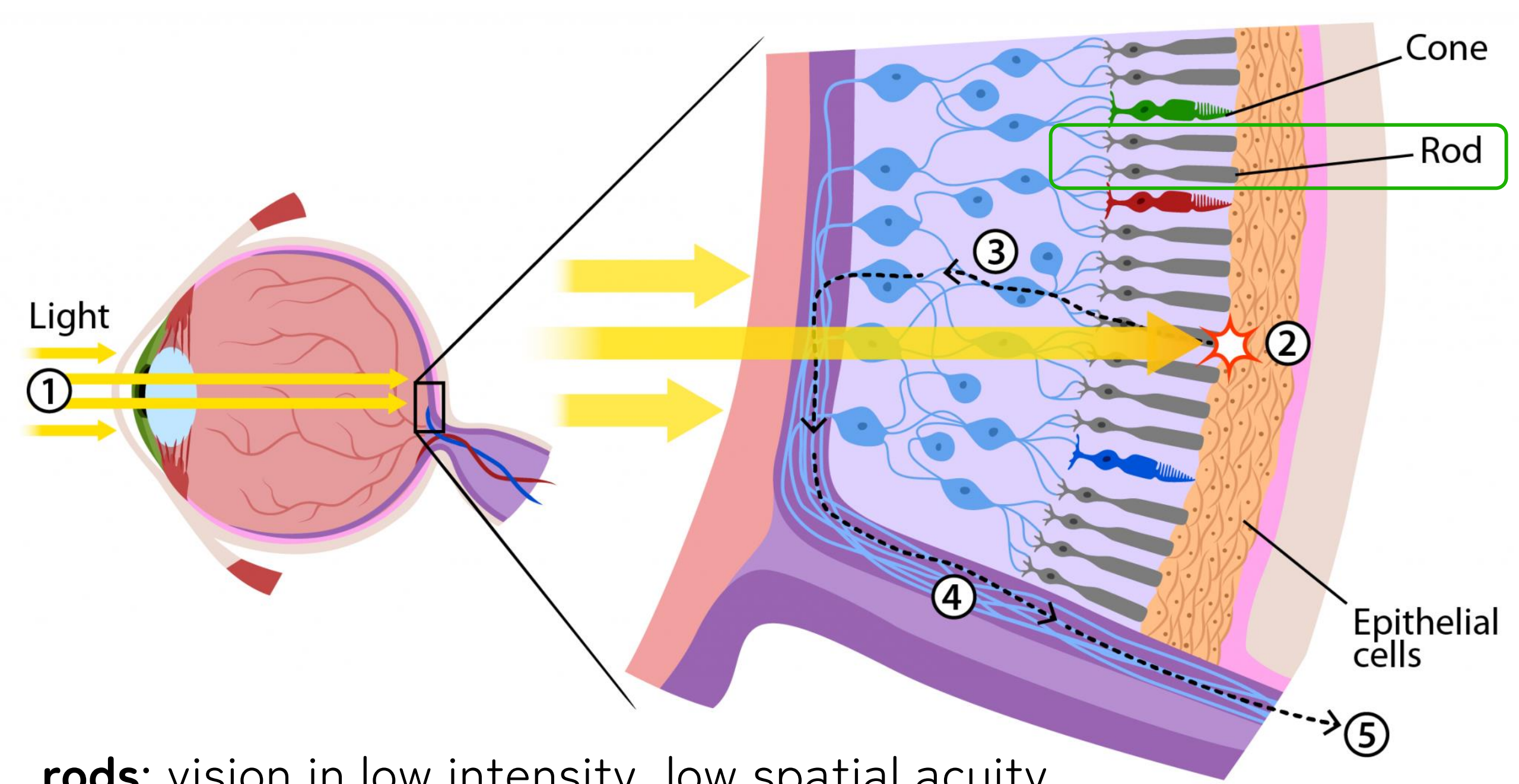
1. light enters and gets focused by cornea
2. the pupil contracts/expands to change aperture
3. the lens does the focus and inversion
4. the retina has photo-receptors



[slide from Pedro Lopes, University of Chicago]

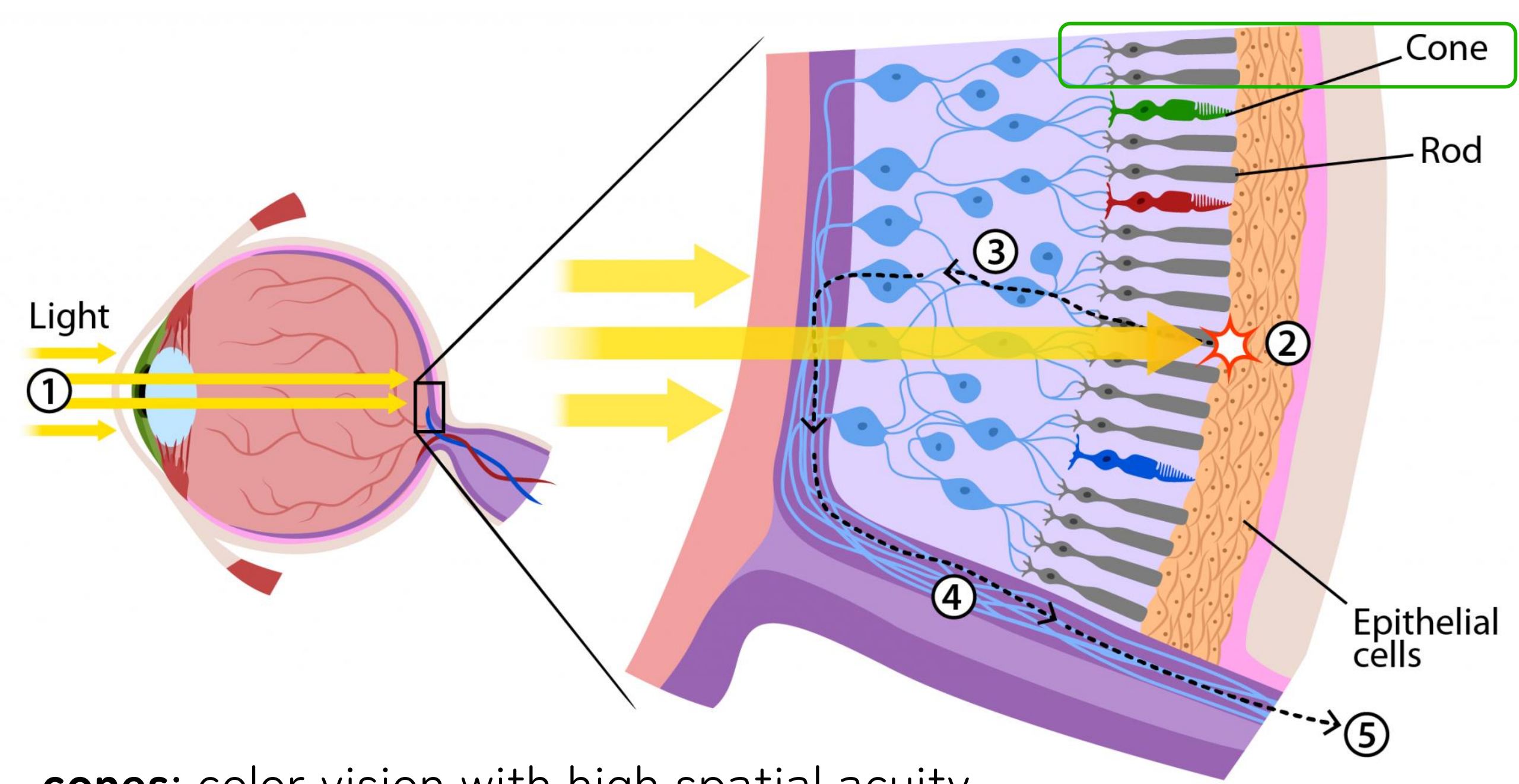


[slide from Pedro Lopes, University of Chicago]



rods: vision in low intensity, low spatial acuity

[slide from Pedro Lopes, University of Chicago]

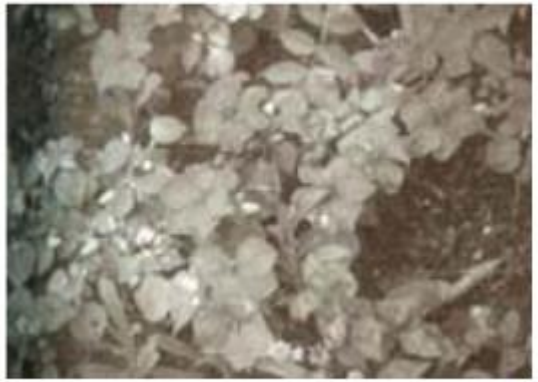


cones: color vision with high spatial acuity

[slide from Pedro Lopes, University of Chicago]

rods and cones **work together** to produce an image

(this is an analogy, not taken from our brains, because we can't do that easily)

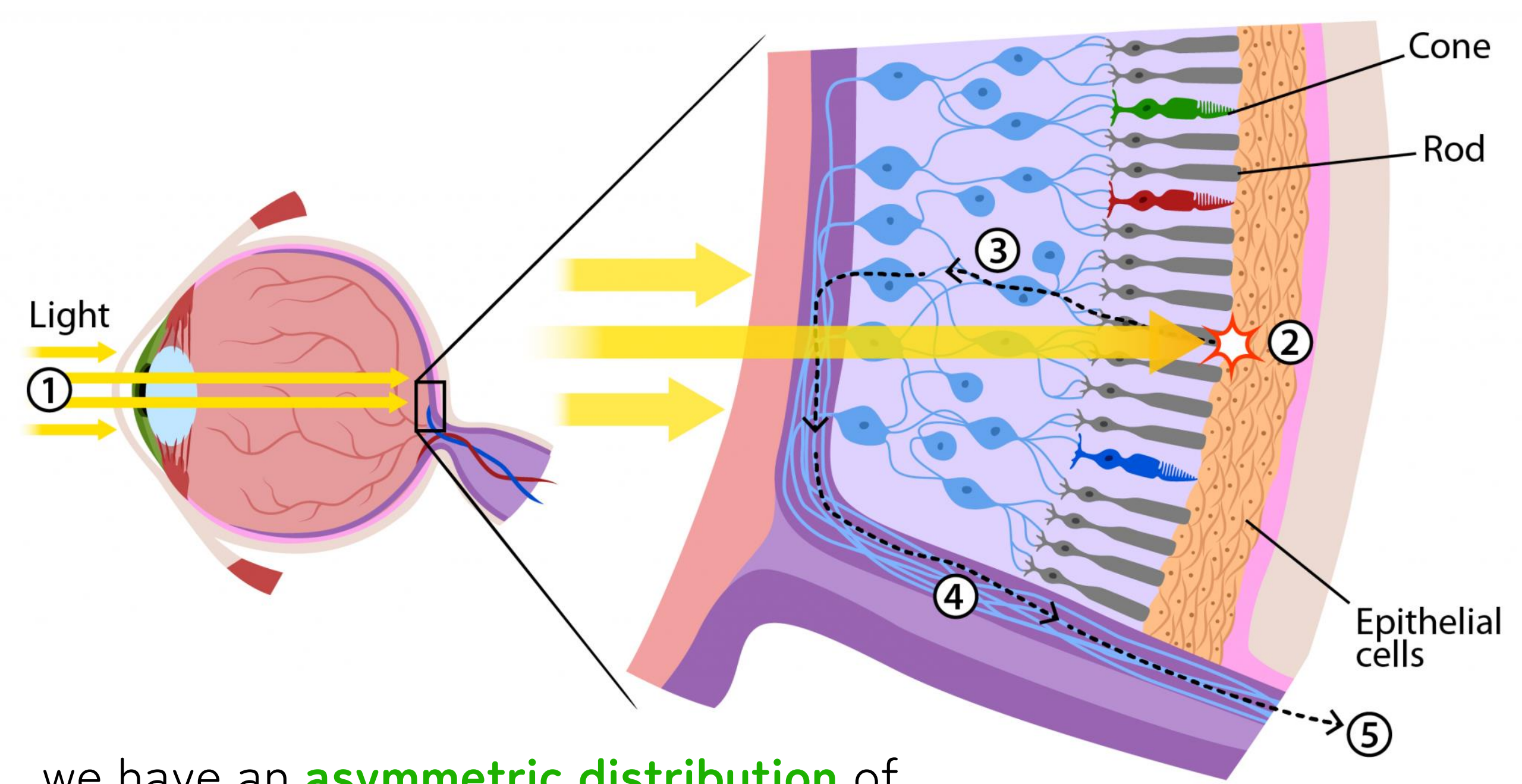


Black And White Only

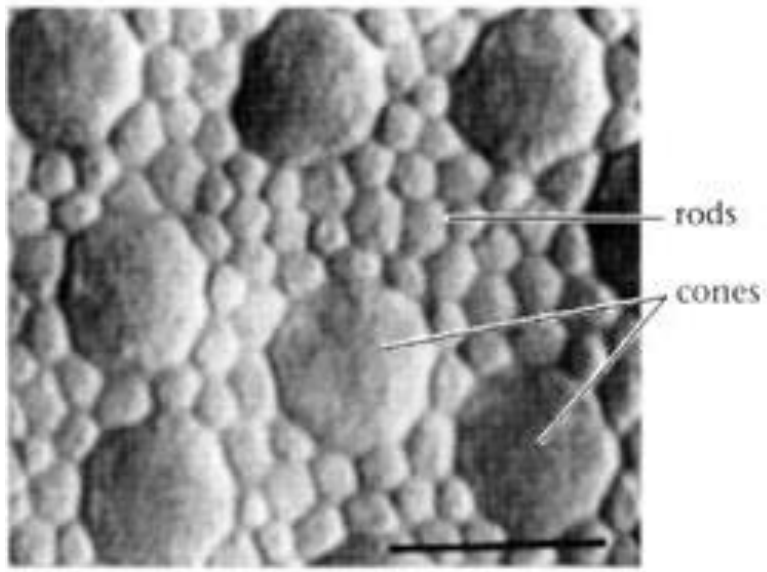
Color Only

Full Color

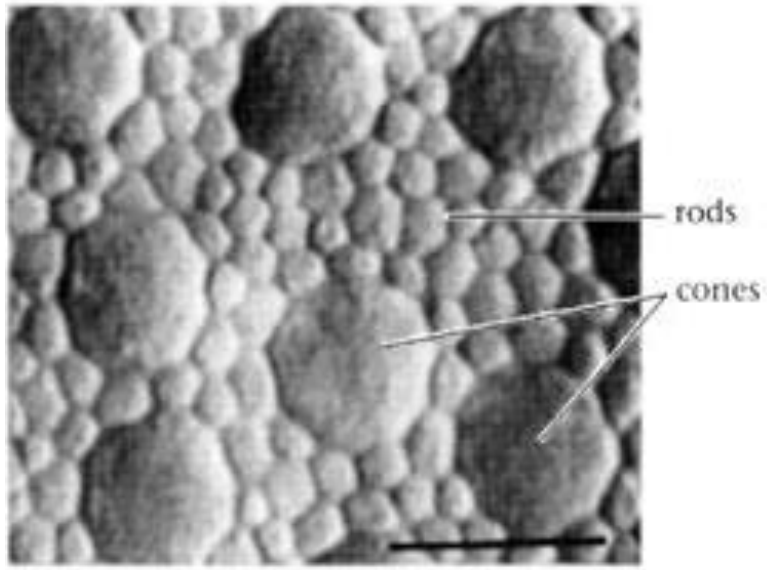
[slide from Pedro Lopes, University of Chicago]

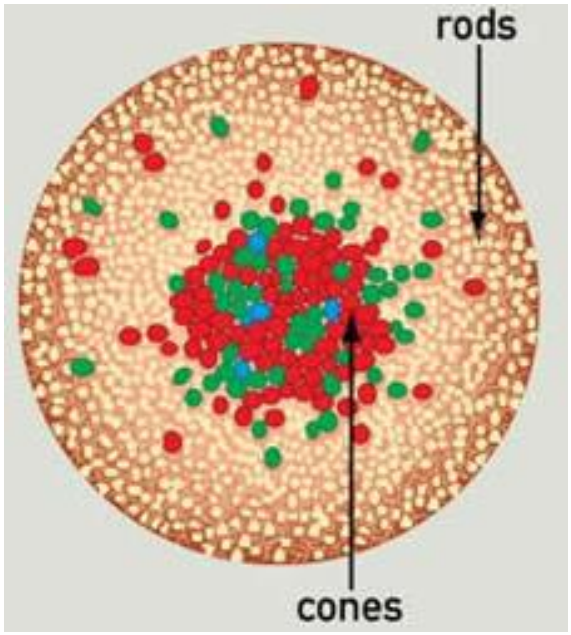


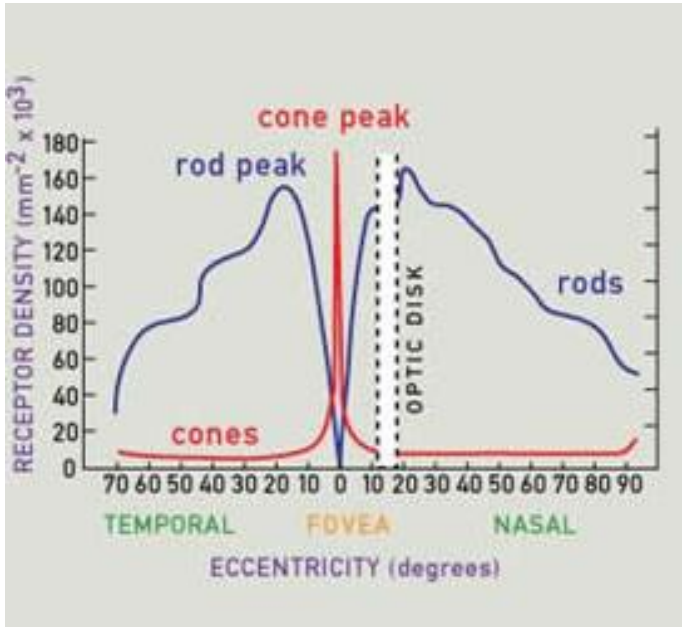
we have an **asymmetric distribution** of color sensing cells to intensity sensing cells [slide from Pedro Lopes, University of Chicago]



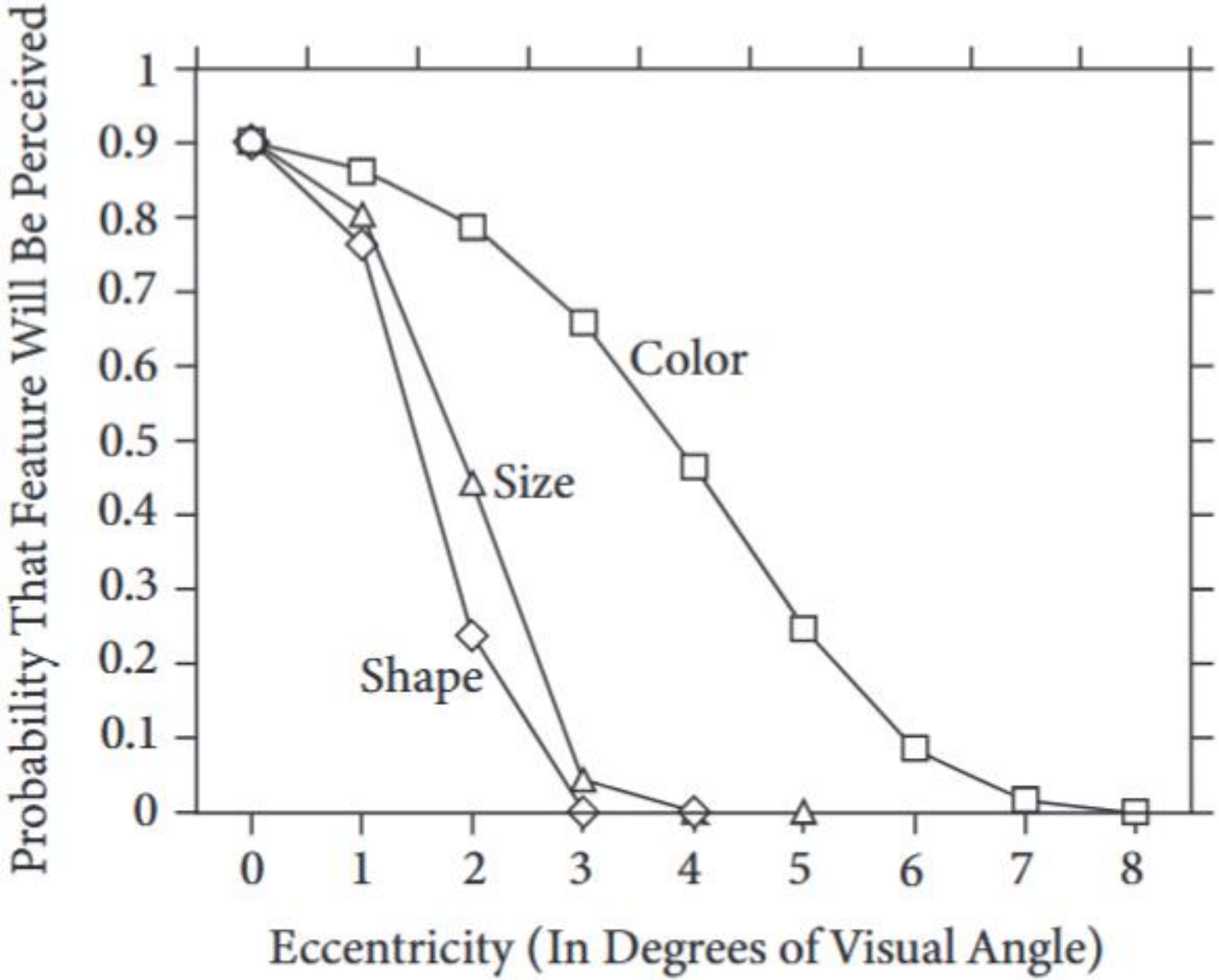
[slide from Pedro Lopes, University of Chicago]







[slide from Pedro Lopes, University of Chicago]


Probability That Feature Will Be Perceived
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Color
Size
Shape
0
1
2
3
4
5
6
7
8
Eccentricity (In Degrees of Visual Angle)

implications:

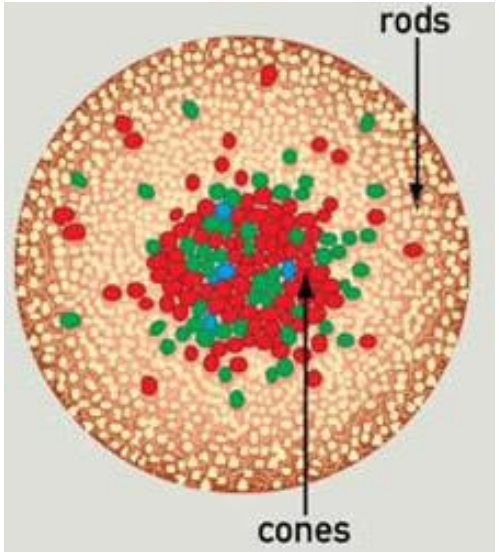
1. we don’t see in color in all regions (periphery, not color)
2. we don’t see all colors the same

[slide from Pedro Lopes, University of Chicago]

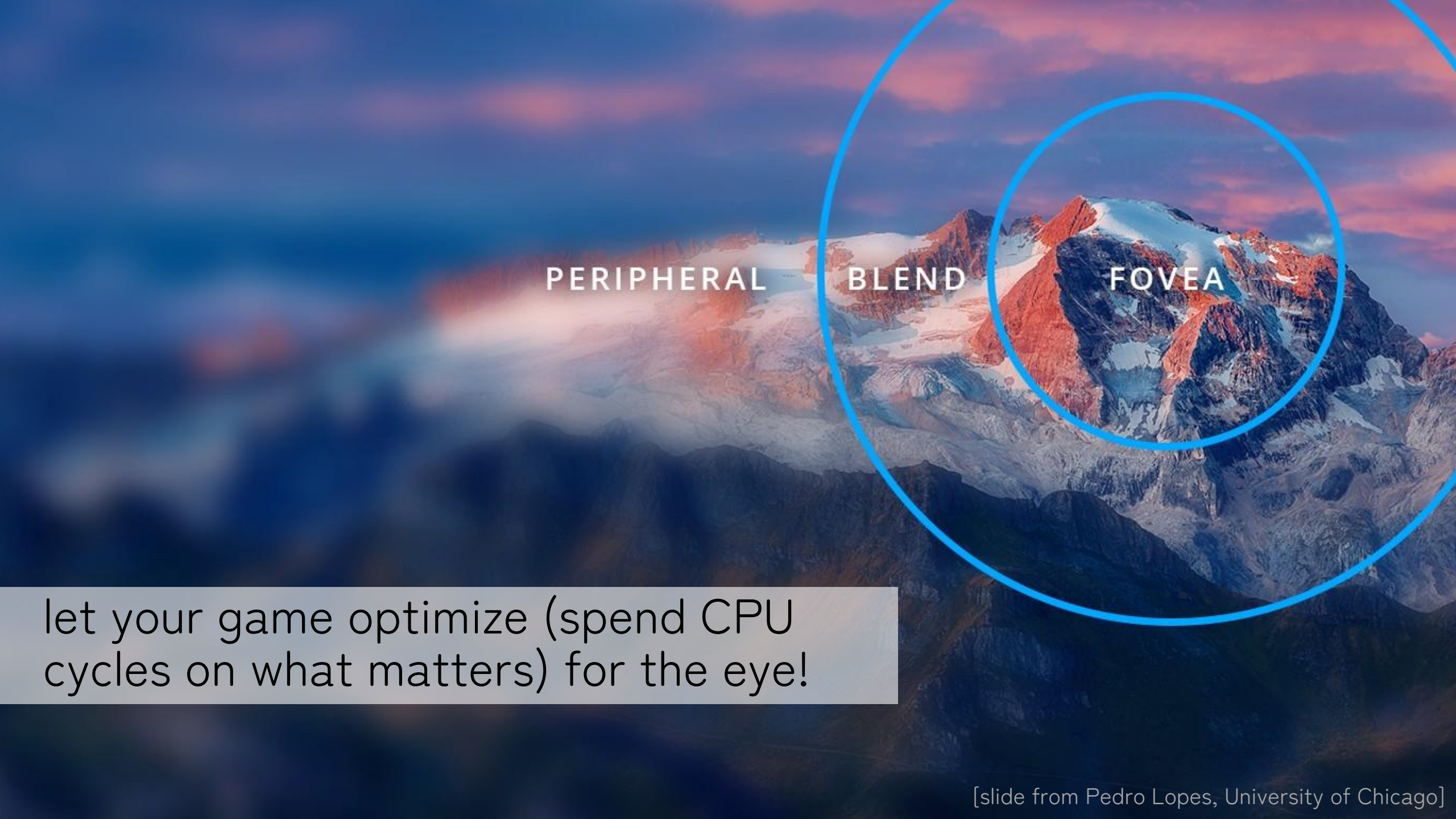
implications:

1. we don’t see in color in all regions (periphery, not color)
2. we don’t see all colors the same

… using these insights to **improve virtual reality**



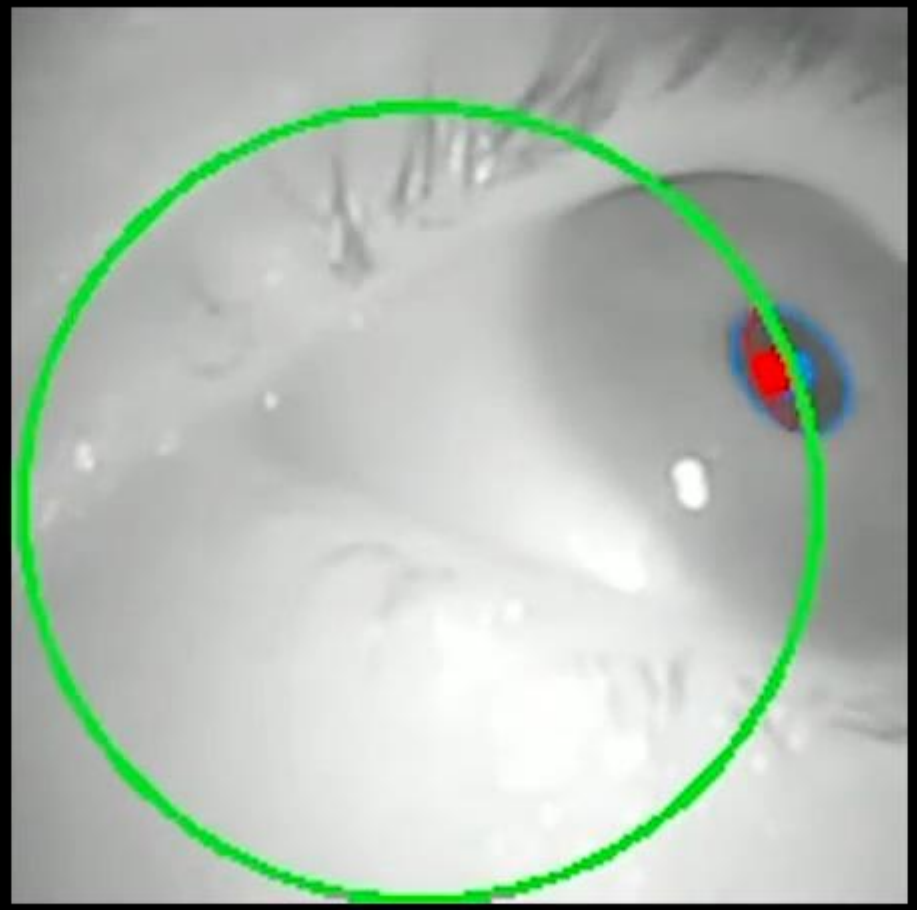
[slide from Pedro Lopes, University of Chicago]



let your game optimize (spend CPU cycles on what matters) for the eye!

[slide from Pedro Lopes, University of Chicago]

eye tracking



[Pupil Lab]


[slide from Pedro Lopes, University of Chicago]

[slide from Pedro Lopes, University of Chicago]


ORIGINAL
00:00
OUR

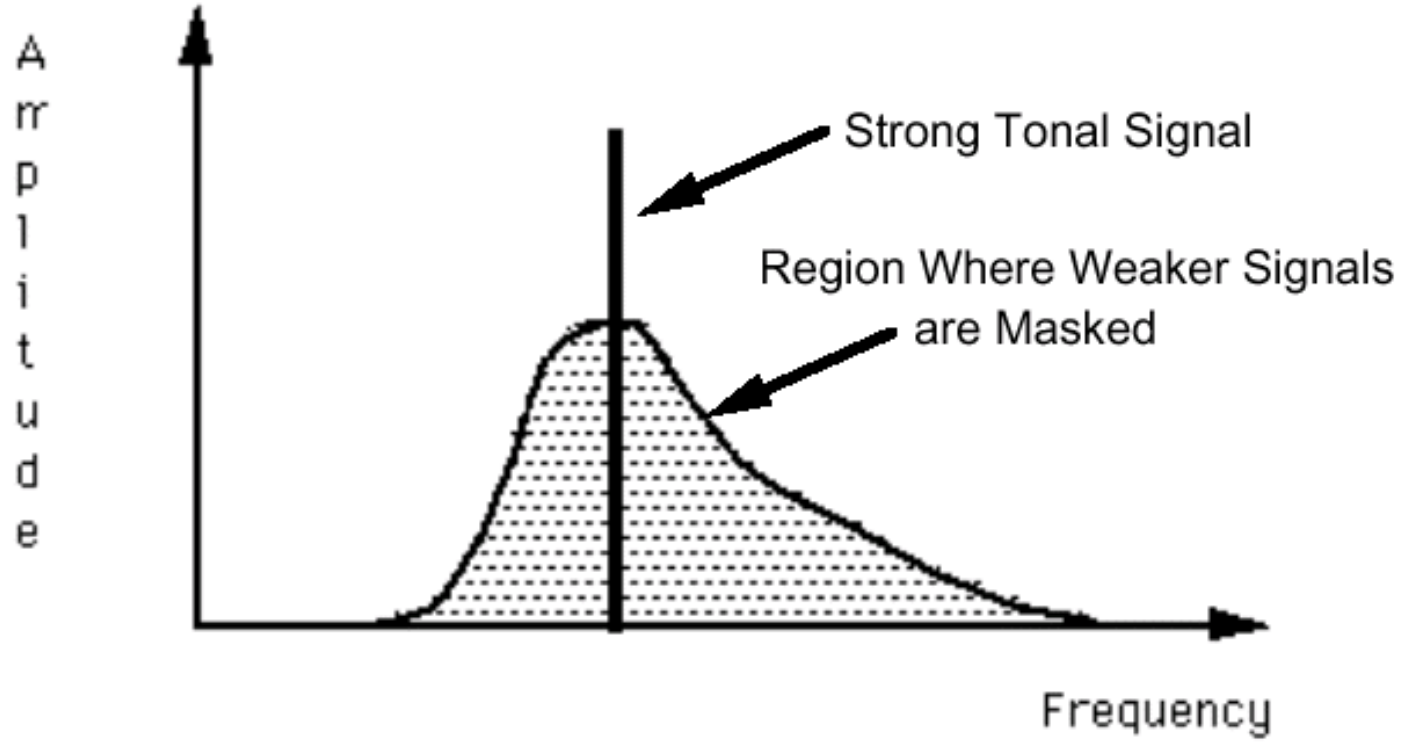
understand human modalities can
improve computer efficiency

understand human modalities can
improve computer efficiency

- graphic rendering (e.g., VR)
- audio compressing (e.g., MP3)

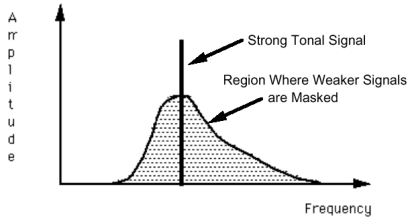
understand human modalities can
improve computer efficiency

- graphic rendering (e.g., VR)
- audio compressing (e.g., **MP3**)



benefits of multimodal HCI:

1. efficiency
   make computers more efficient



2. usability
   make computers easier to use

3. fidelity
   make computers feel more realistic

benefits of multimodal HCI:

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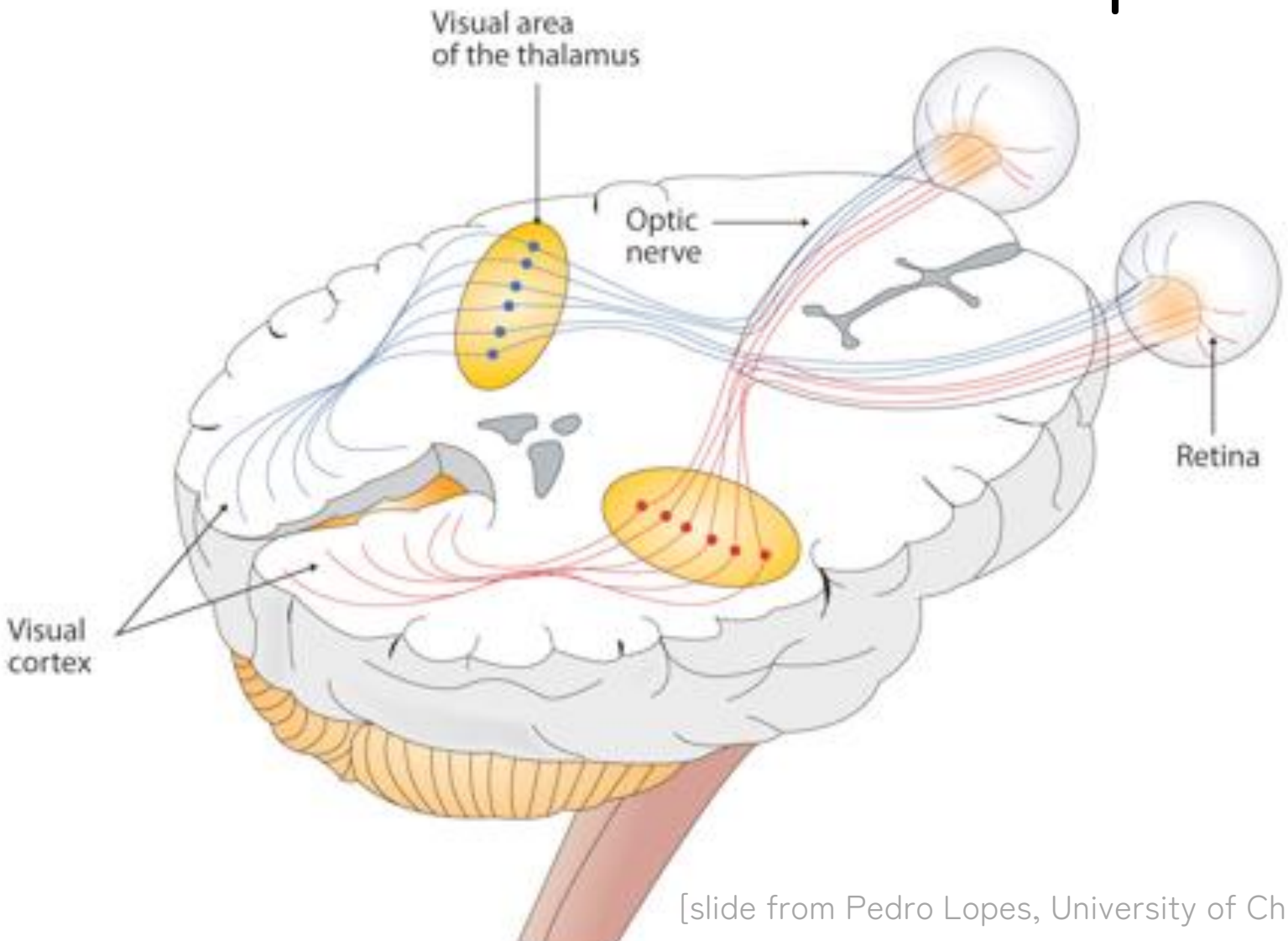
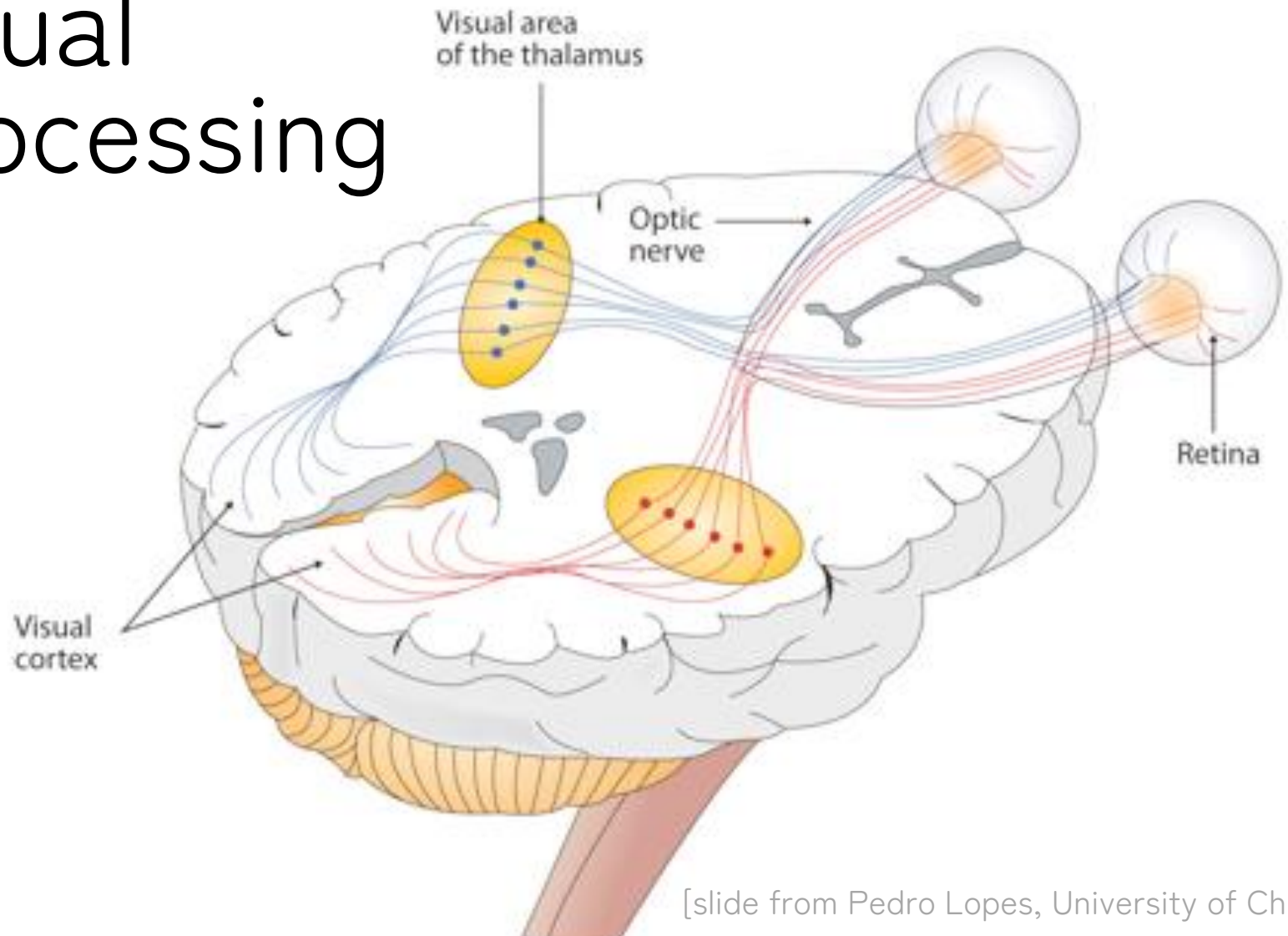
visual receptors



[slide from Pedro Lopes, University of Chicago]

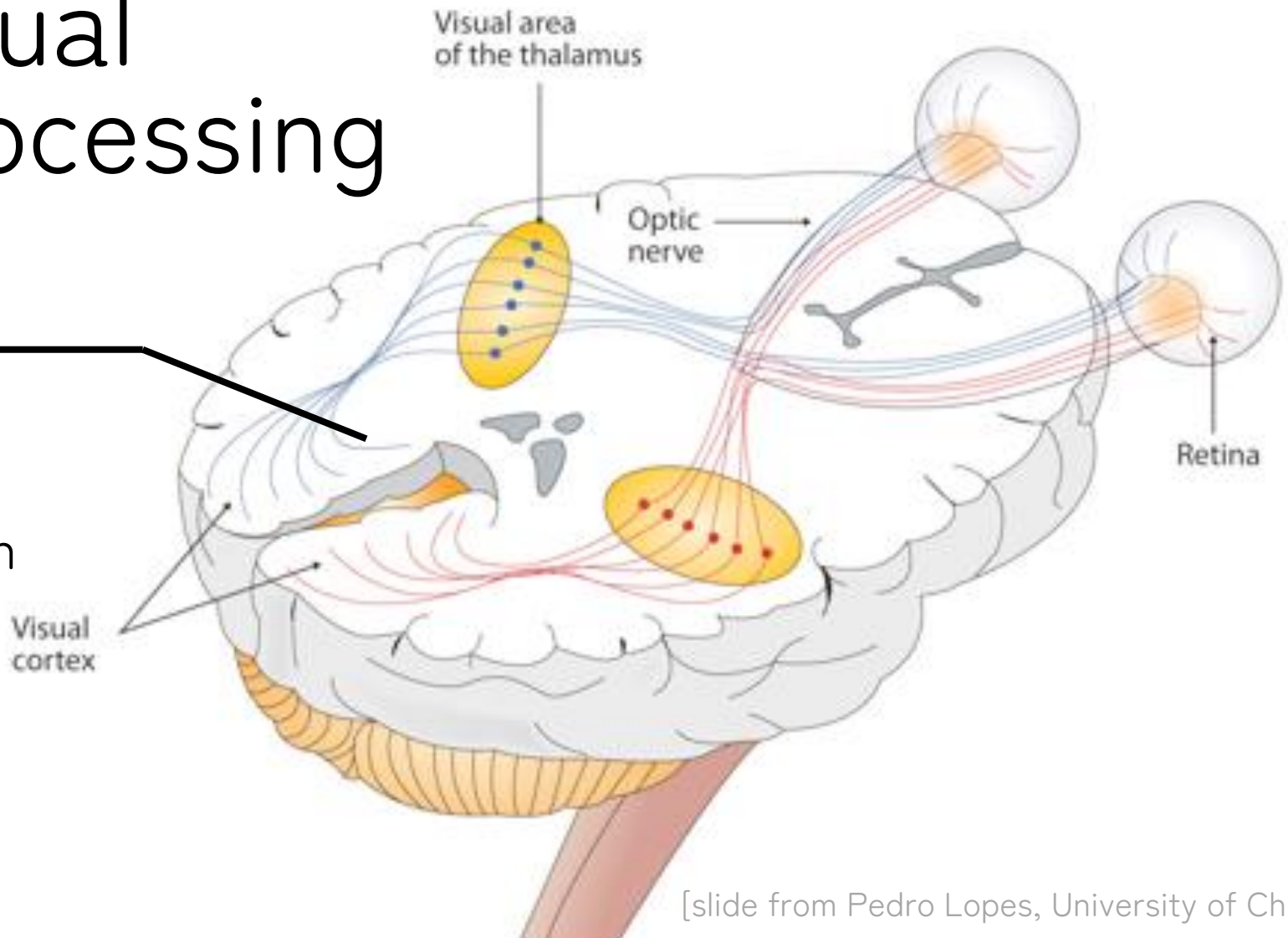
visual processing



[slide from Pedro Lopes, University of Chicago]

visual processing

how important is vision as a modality?
check out how much space this takes in your brain



[slide from Pedro Lopes, University of Chicago]

when we look at an object we need to quickly detect:

1. color
2. shape
3. motion

... the human visual system has low-level "hardware" to accomplish all of these!

[slide from Pedro Lopes, University of Chicago]

when we look at an object we need to quickly detect:

1. **color = cones (we saw already)**

[slide from Pedro Lopes, University of Chicago]

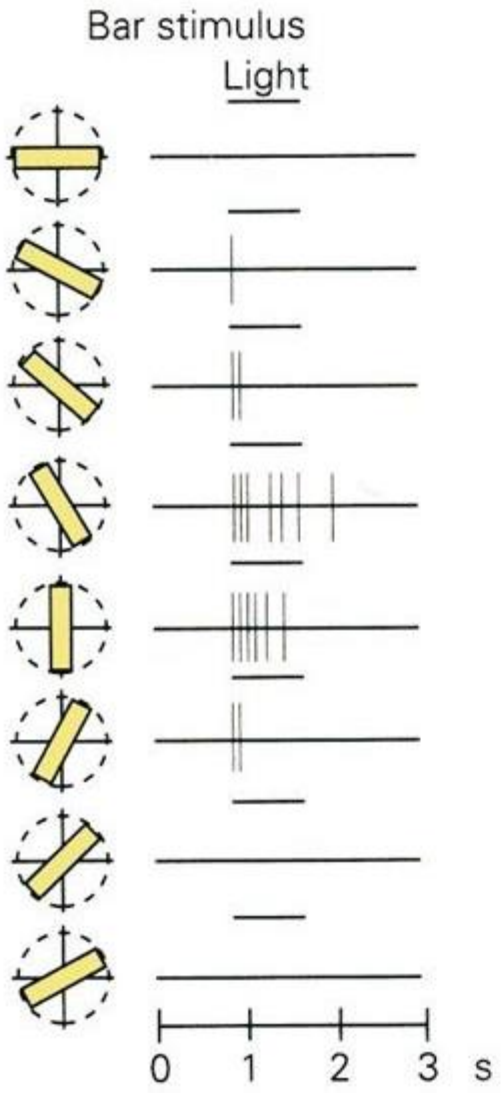
when we look at an object we need to quickly detect:

1. color = cones
2. shape: **how do we distinguish the boundaries of the flower from the background?**

there's an entire system comprised of slightly more complex cells that sense **edges** (quick dark>light transitions)

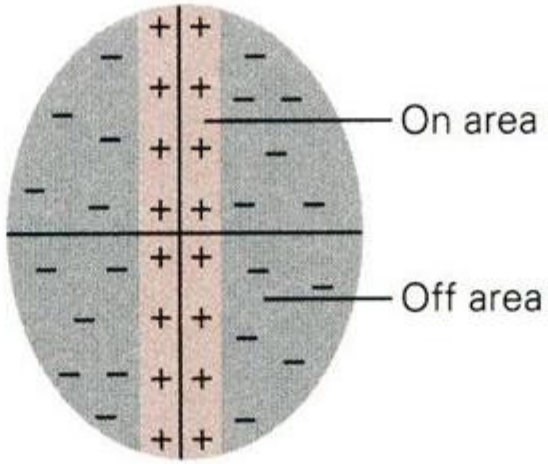
[slide from Pedro Lopes, University of Chicago]

an example of an “edge detector” cell



A simple cell:

- responds to a straight edge
- at a specific angle
- in a specific position in the visual field



(Kandel et al)

[slide from Pedro Lopes, University of Chicago]

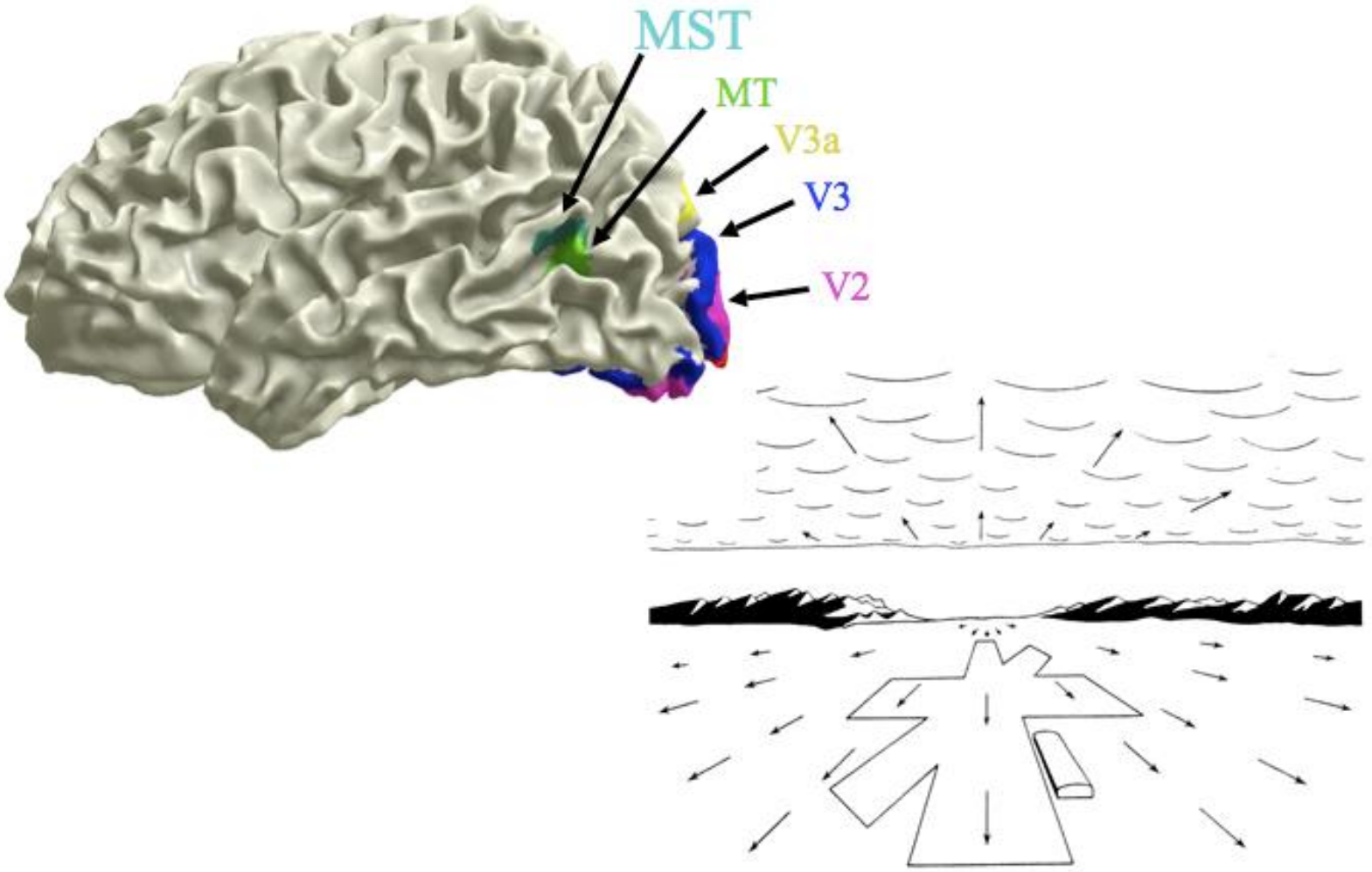
when we look at an object we need to quickly detect:

1. color = cones
2. shape: networks of edge detection cells (and more)
3. **motion:**

there's another system comprised of slightly more complex cells that sense **slower changes** (movement), less accurate than the shape (no detail)

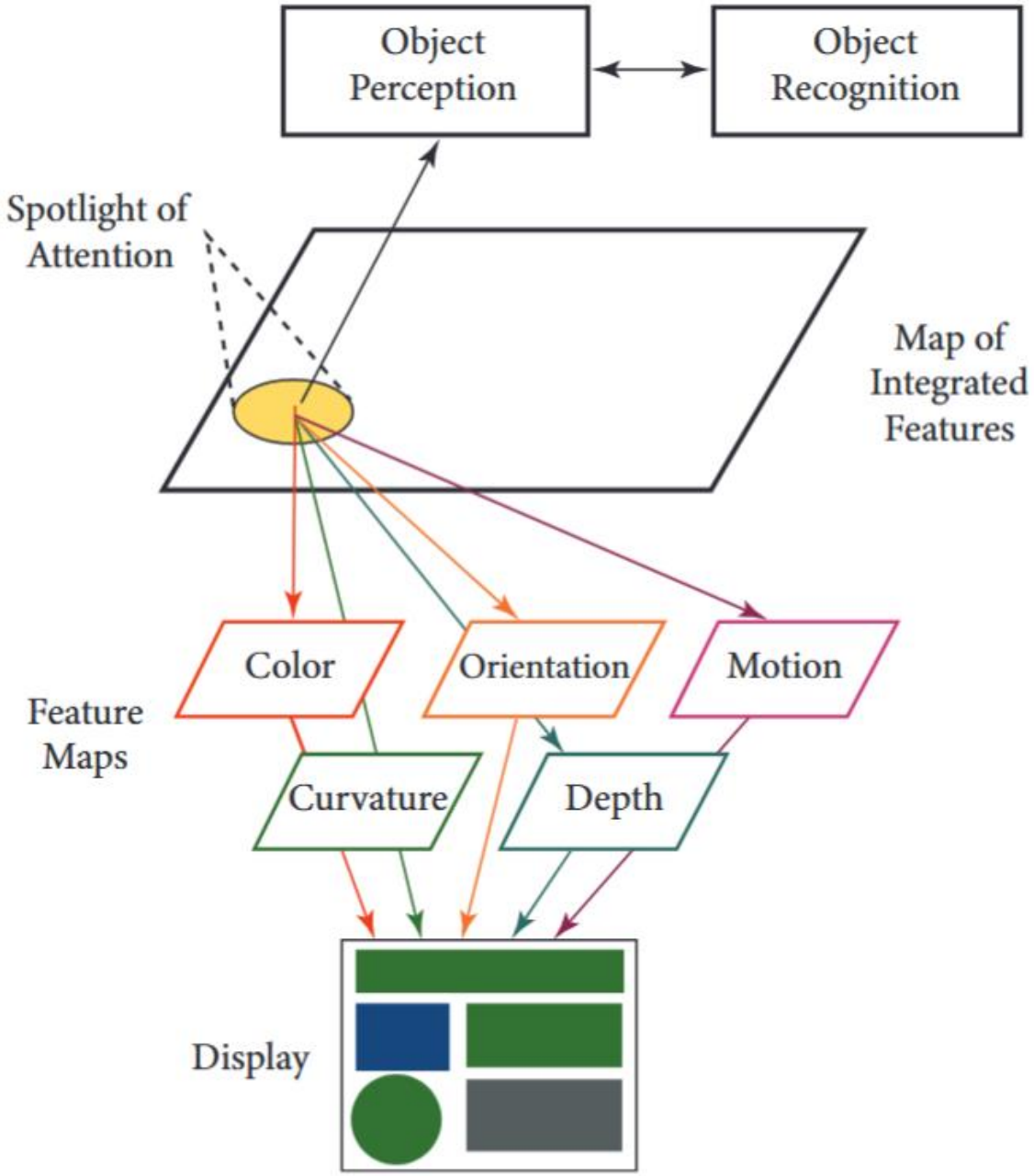
[slide from Pedro Lopes, University of Chicago]

it (very very roughly) does this by calculating the **optical flow**, i.e., the changes in direction for each small area of the field

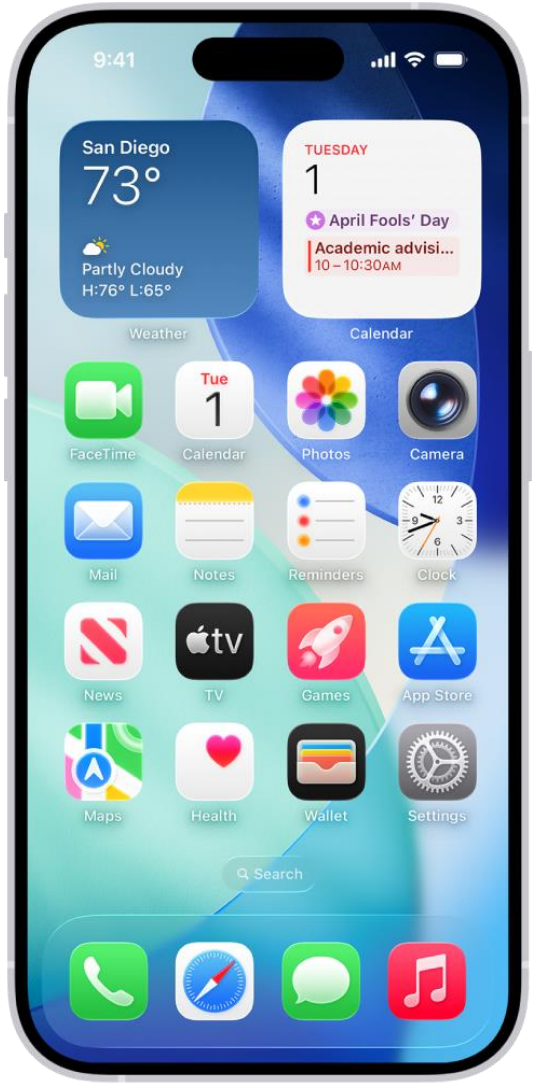


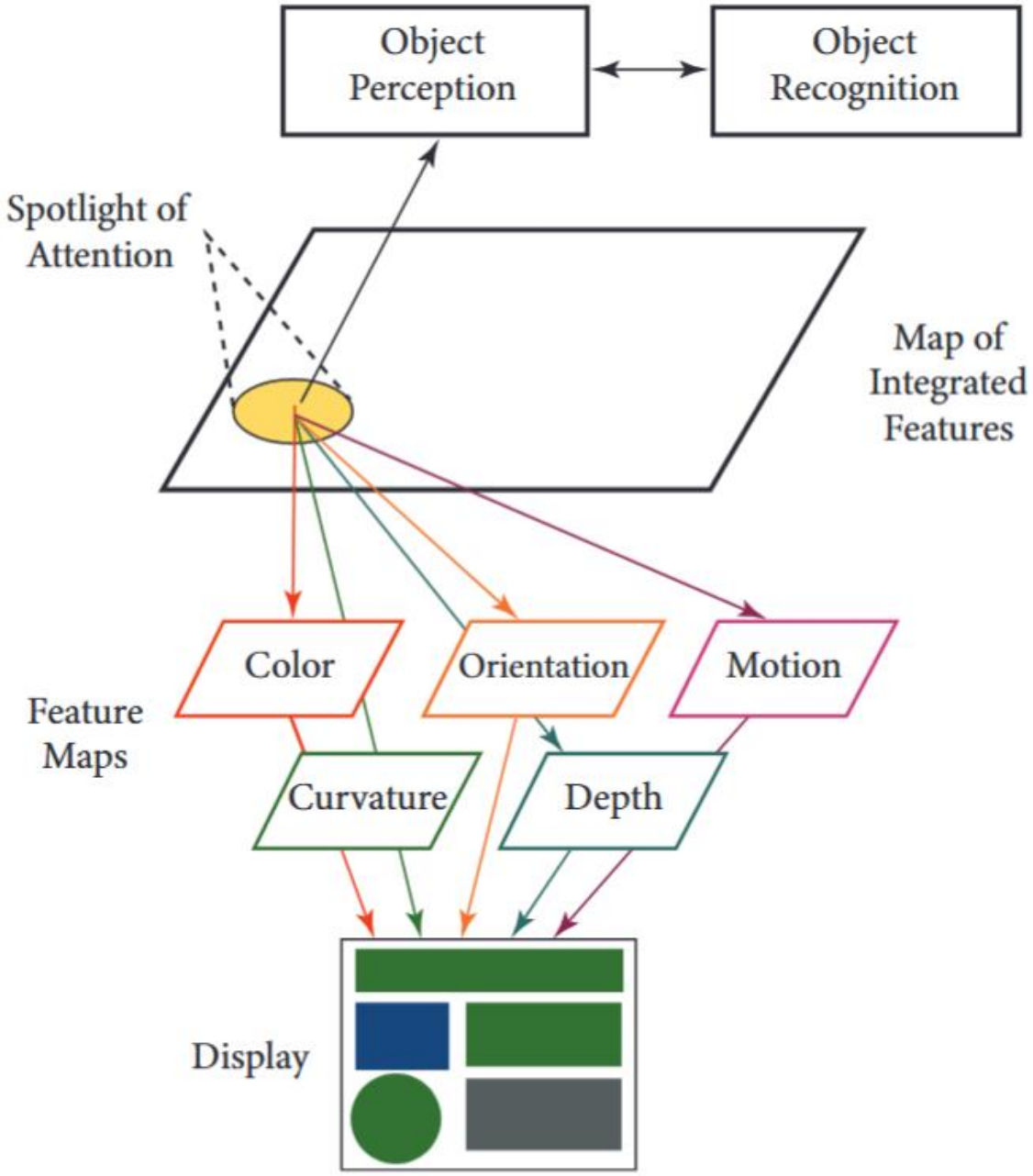
[slide from Pedro Lopes, University of Chicago]

visual search



visual search





leveraging these low-level processing, useful design principles: **gestalt laws**

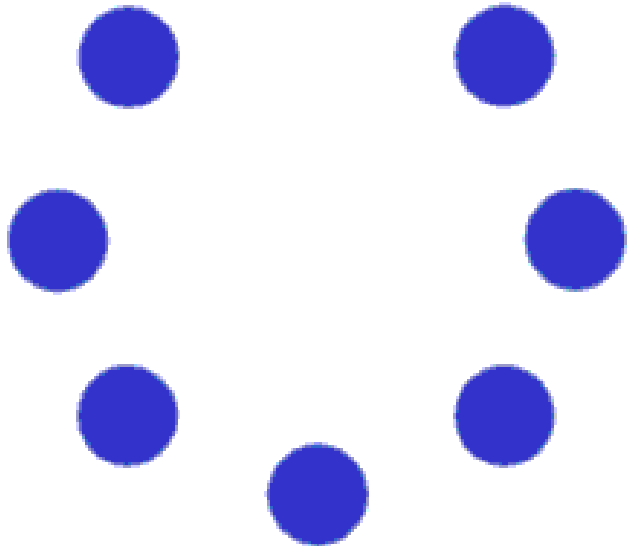
Gestalt is a school of psychology created by **Max Wertheimer**, Wolfgang Köhler, and Kurt Koffka in 1920s.

Gestalt school is based on **understanding and perceiving the whole sum of an object** rather than its components

what triggered Max to start the Gestalt school?

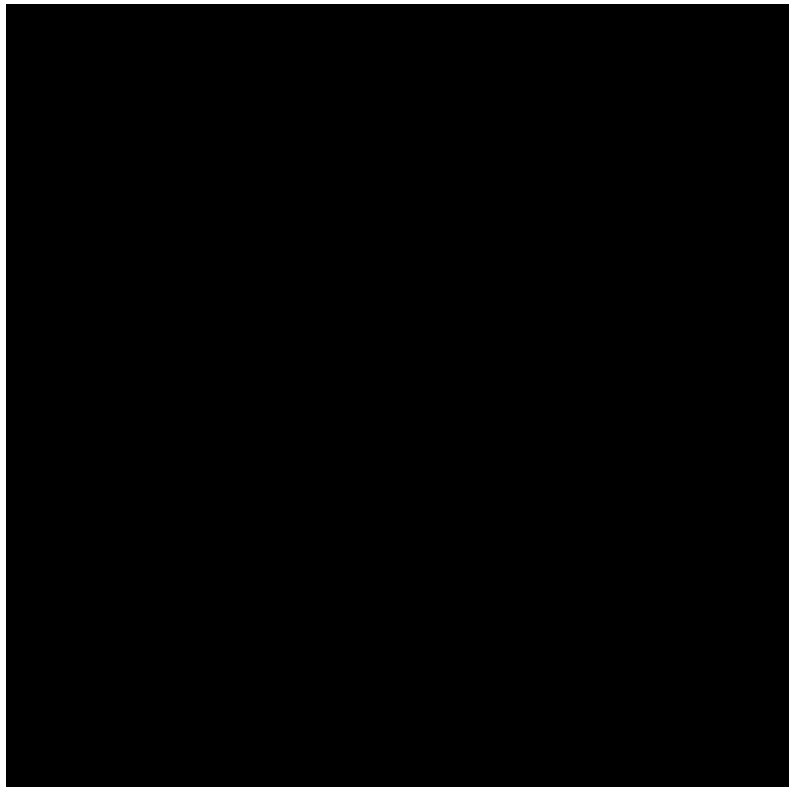
his discovery of the **phi-phenomena**

[slide from Pedro Lopes, University of Chicago]



phi-phenomena: you are seeing a **white rotating circle** but in fact this is **just a sequence of still images**

[slide from Pedro Lopes, University of Chicago]



a variant of it for lower frequencies still works and
is called **beta movement**
(snake game)

[slide from Pedro Lopes, University of Chicago]

the key principles of **gestalt**:

emergence, reification, multistability, and invariance.

[slide from Pedro Lopes, University of Chicago]

gestalt laws

emergence

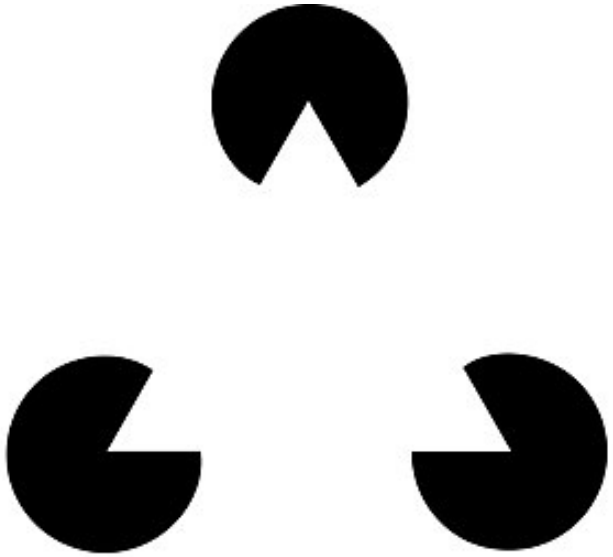
that our experience emerges **from what we perceive** (not necessarily from what is out there but how we feel it)

[slide from Pedro Lopes, University of Chicago]

gestalt laws

reification

the constructive aspect of perception by which the experienced percept **contains more explicit spatial information** than the sensory stimulus on which it is based.



[slide from Pedro Lopes, University of Chicago]

gestalt laws

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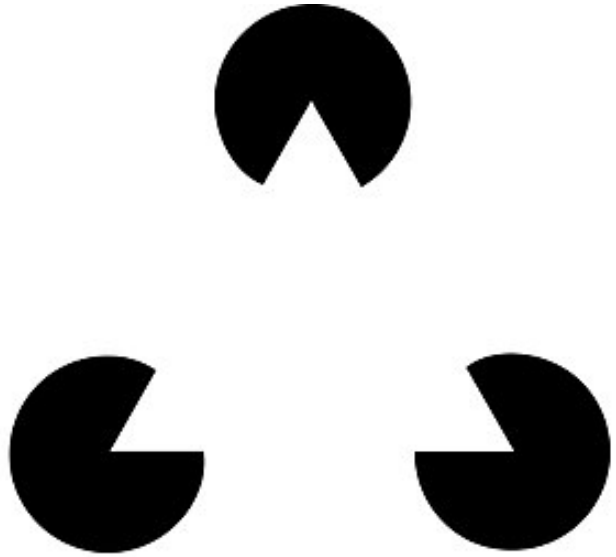
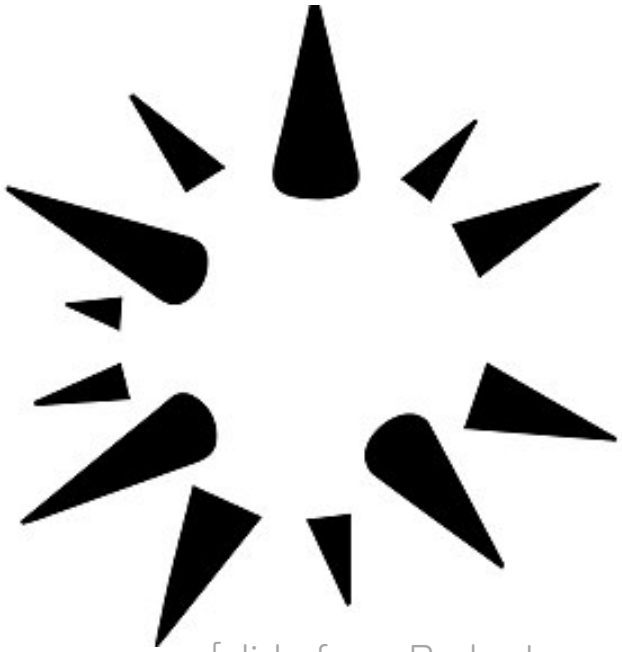


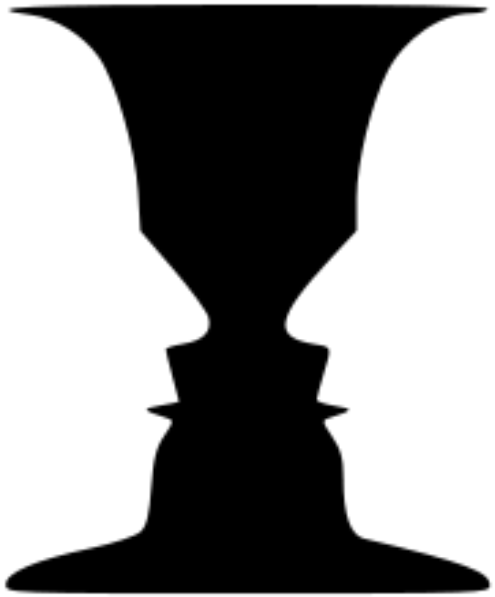


[slide from Pedro Lopes, University of Chicago]

gestalt laws

multistability

tendency of **ambiguous perceptual experiences** to pop back and forth unstably between two or more alternative interpretations.



[slide from Pedro Lopes, University of Chicago]

gestalt laws

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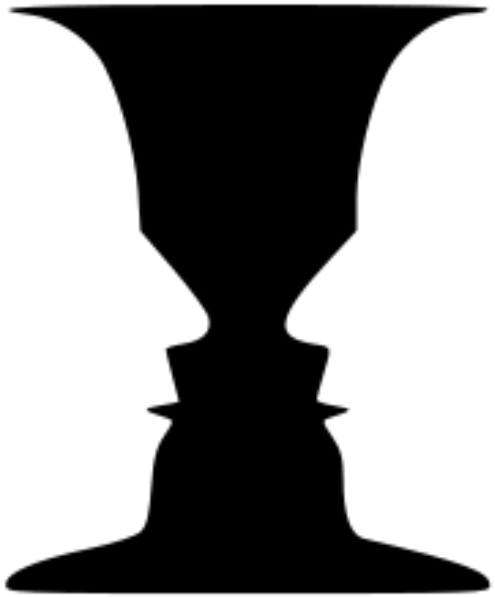
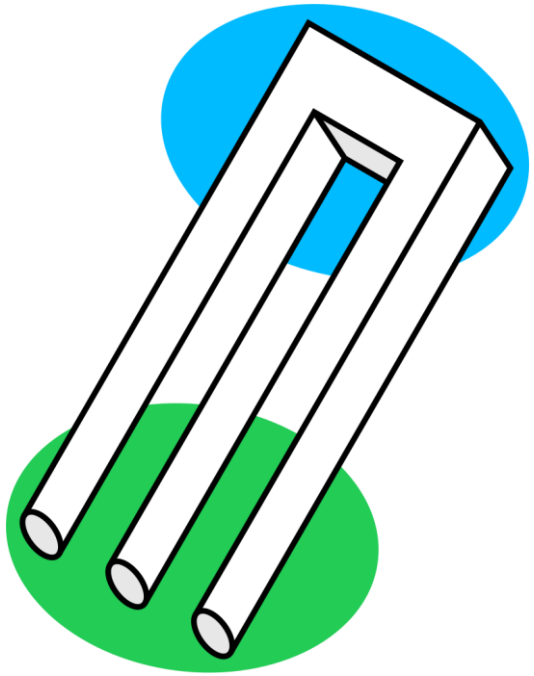


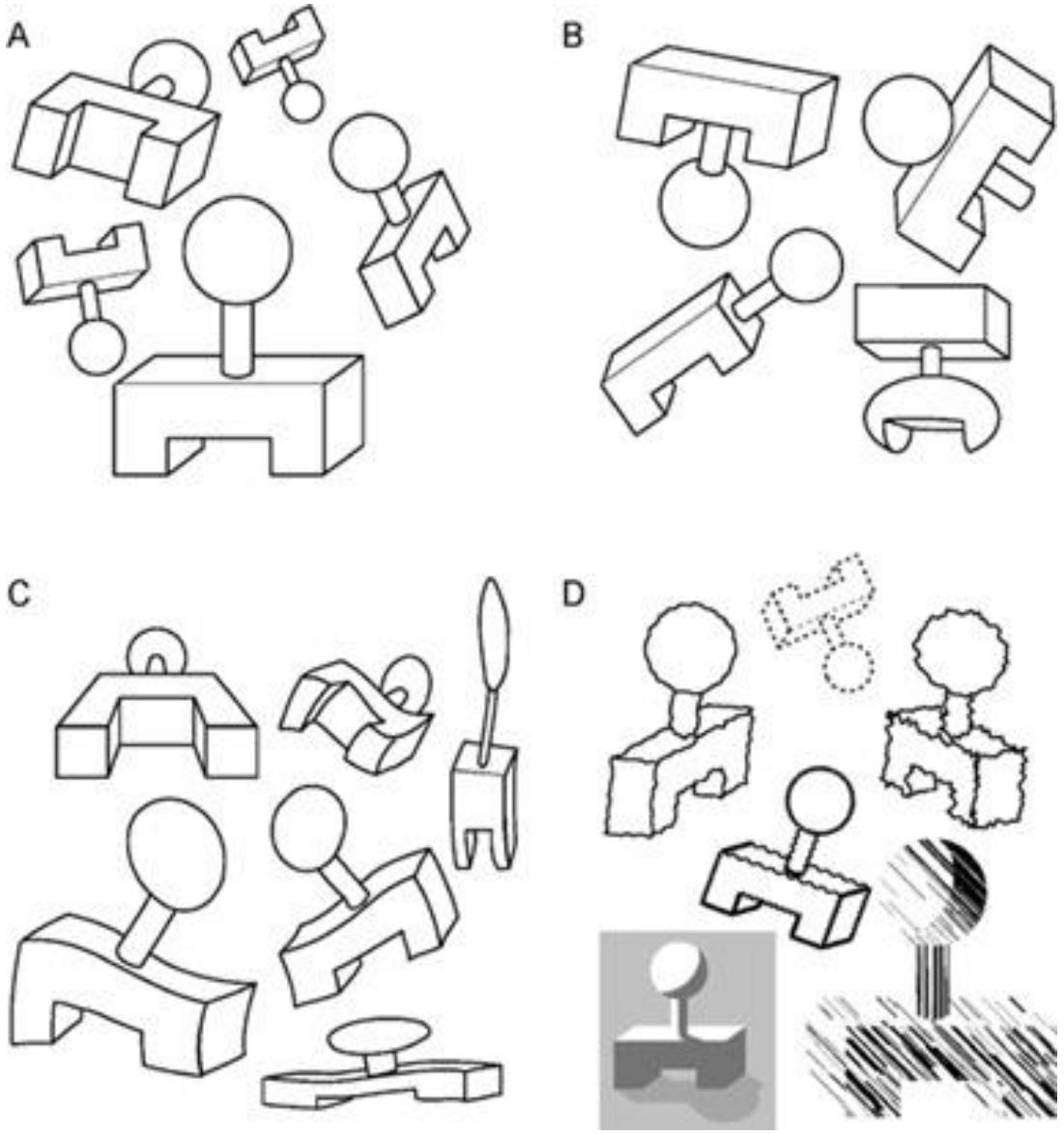


[slide from Pedro Lopes, University of Chicago]

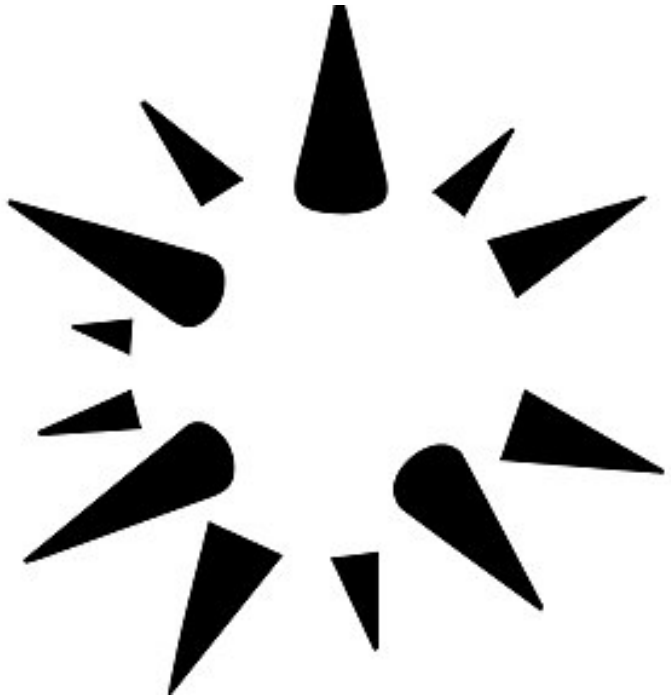
gestalt laws

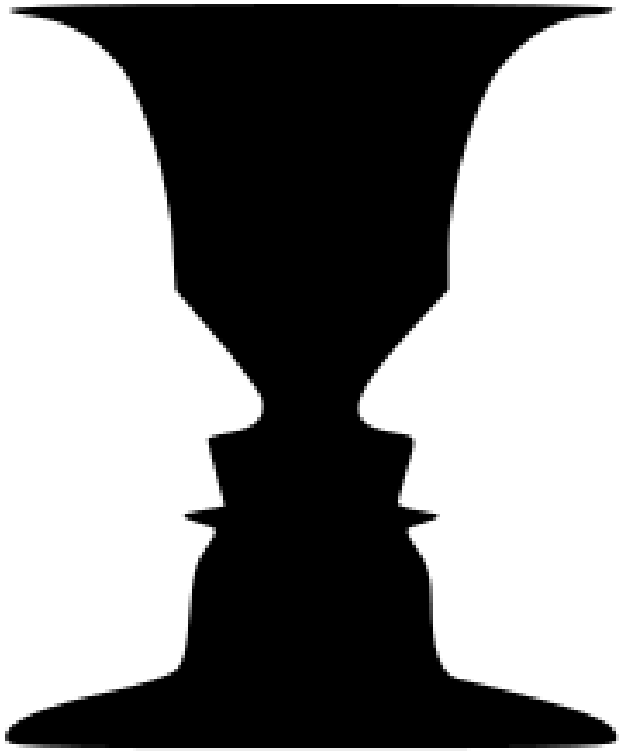
invariance

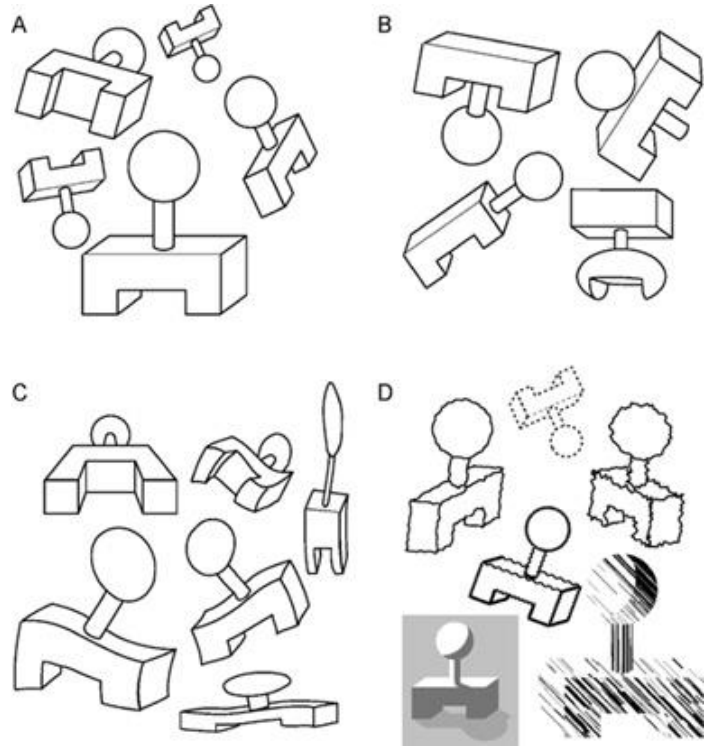
the property of perception whereby simple geometrical objects are recognized **independent of rotation, translation, and scale**; as well as several other variations such as elastic deformations, different lighting, and different component features.



[slide from Pedro Lopes, University of Chicago]







using these principles Gestalt psychologists observed how humans attribute relations between things, **often putting more weight into the relation** than into the things themselves (remember: “whole > parts”).

these are so-called **Gestalt Laws (designers use them often!)**

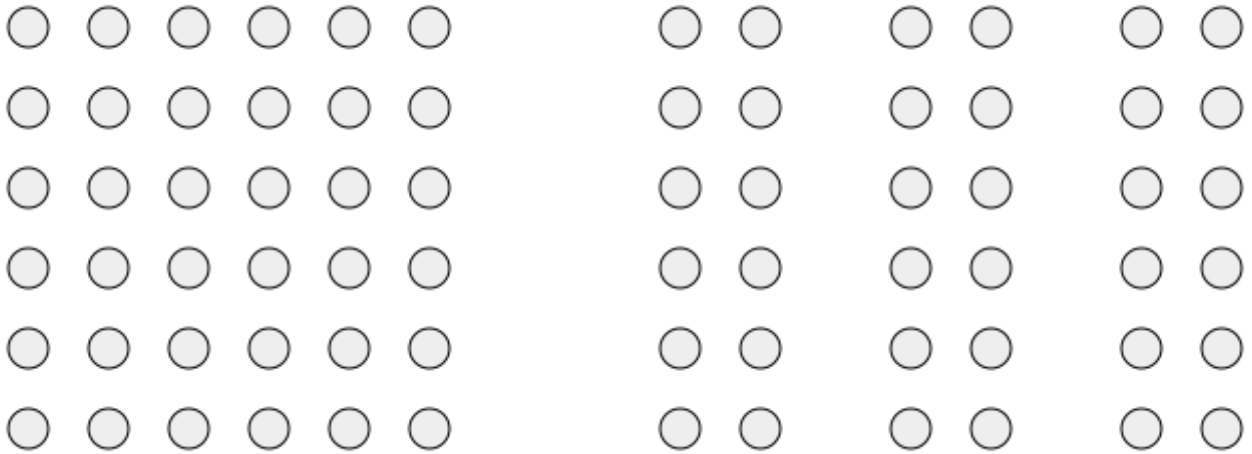
[slide from Pedro Lopes, University of Chicago]

gestalt laws of grouping

proximity, similarity, closure, symmetry,
common fate, continuity

[slide from Pedro Lopes, University of Chicago]

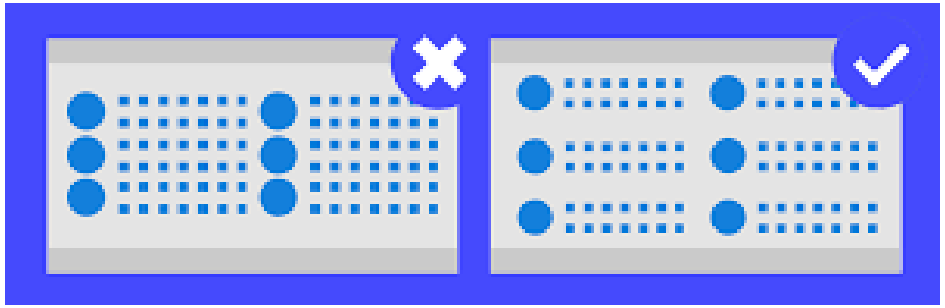
gestalt grouping
proximity



objects that are close to one another **appear to form groups**.
even if the shapes, sizes, and objects are radically different,
they will appear as a group if they are close.

[slide from Pedro Lopes, University of Chicago]

gestalt grouping
proximity



Good

Introduction
xkdkdkdkdkd

Body
kdkdkdkd

Conclusion
kdkdkdkd

Bad

Introduction

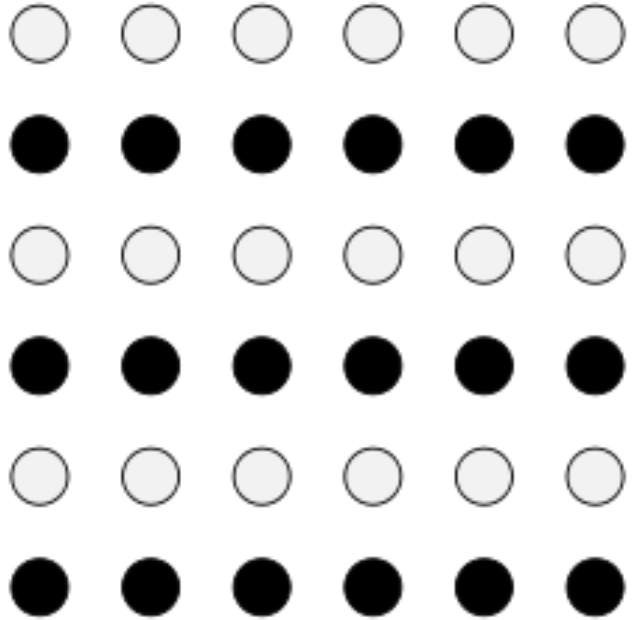
xkdkdkdkdkd

Body

kdkdkdkd

[slide from Pedro Lopes, University of Chicago]

gestalt grouping
similarity



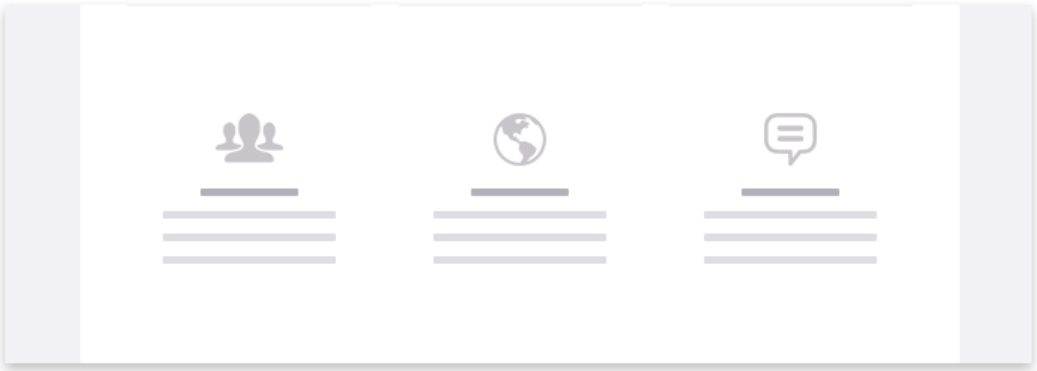
all else equal, **perception lends itself to seeing stimuli that physically resemble each other as part of the same object**, and stimuli that are different as part of a different object.

[slide from Pedro Lopes, University of Chicago]

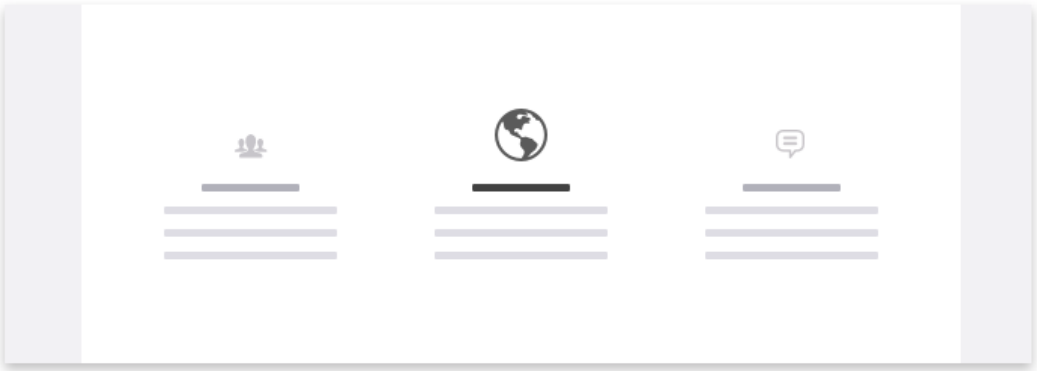
gestalt grouping
similarity

be intentional when highlighting something:

good: icons all similar



bad: one icon stands out



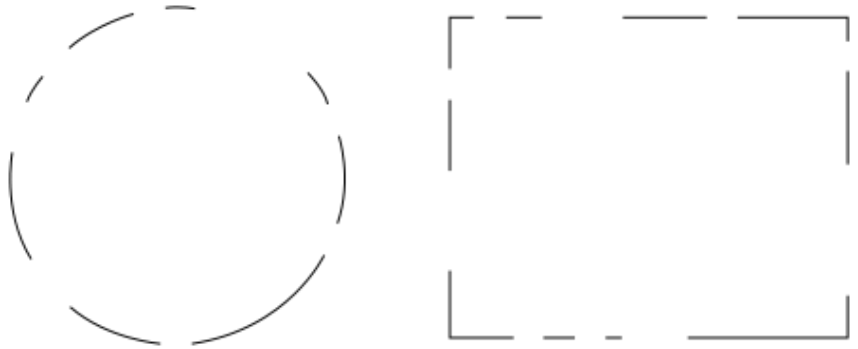
[slide from Pedro Lopes, University of Chicago]

gestalt grouping
similarity

similarity works with many properties: shape, color, etc.

[slide from Pedro Lopes, University of Chicago]

gestalt grouping
closure

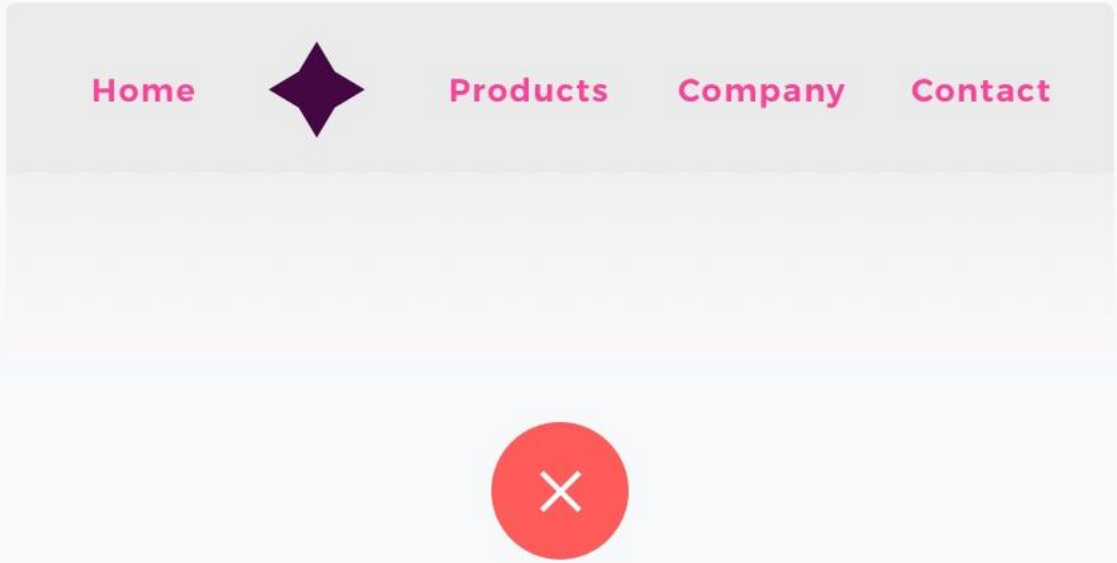


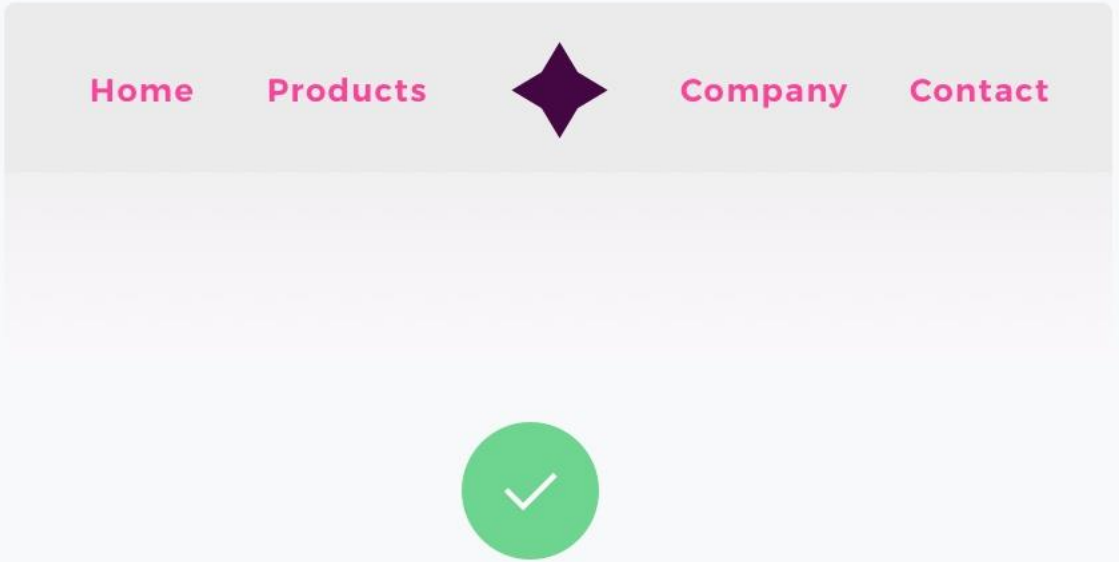
closure refers to the **mind's tendency to see complete figures or forms even if a picture is incomplete**.

[slide from Pedro Lopes, University of Chicago]

[slide from Pedro Lopes, University of Chicago]

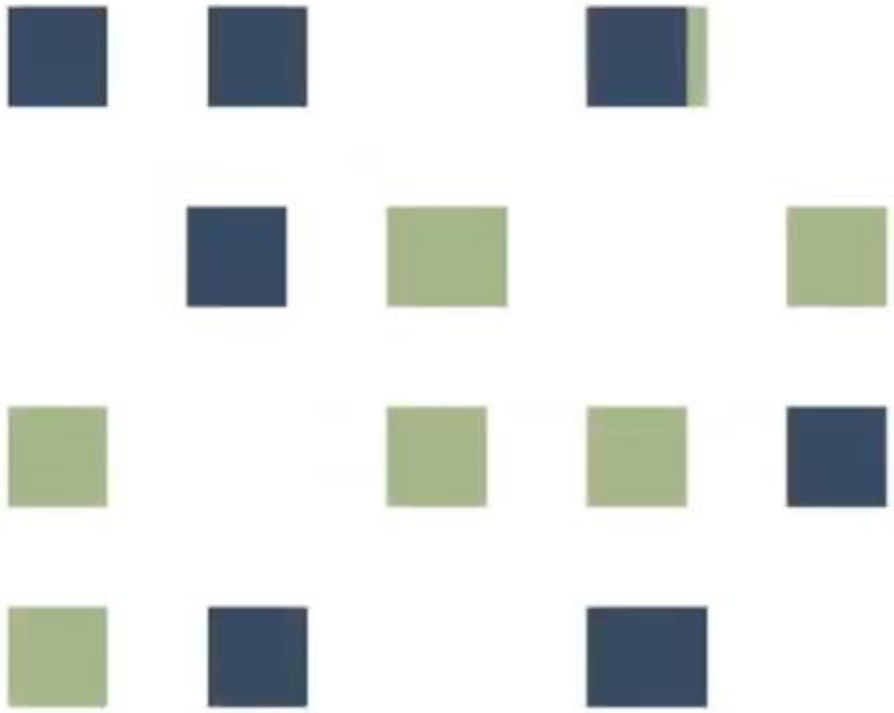
gestalt grouping
symmetry





[slide from Pedro Lopes, University of Chicago]

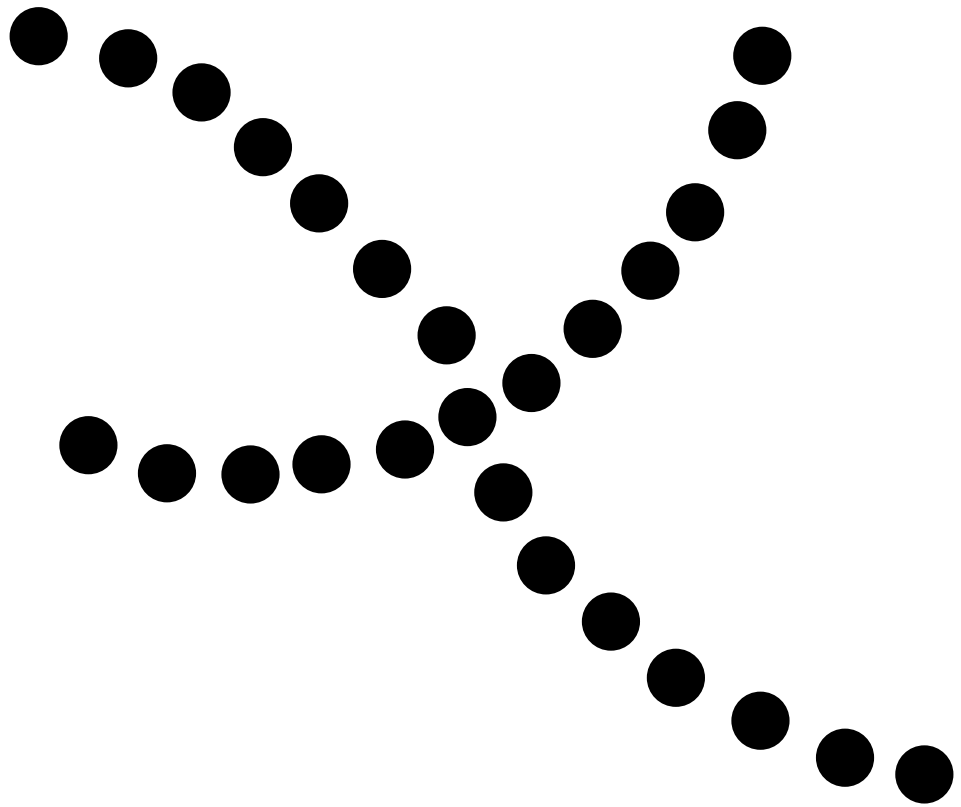
gestalt grouping
common fate



[slide from Pedro Lopes, University of Chicago]

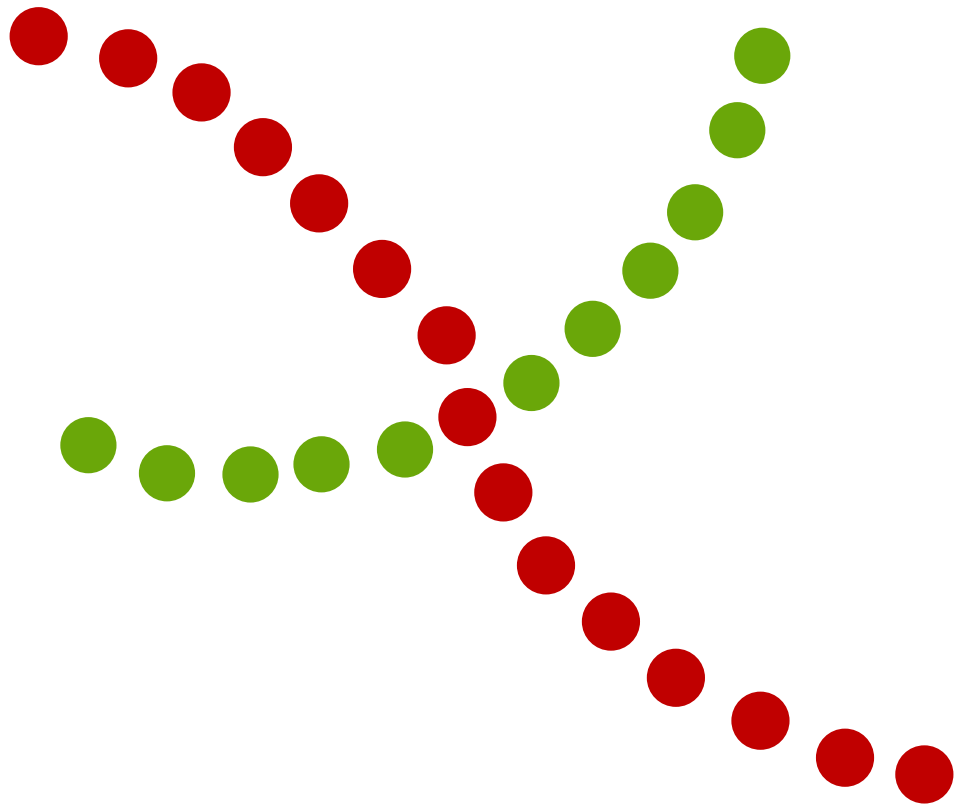
gestalt grouping

continuity



how many groups?

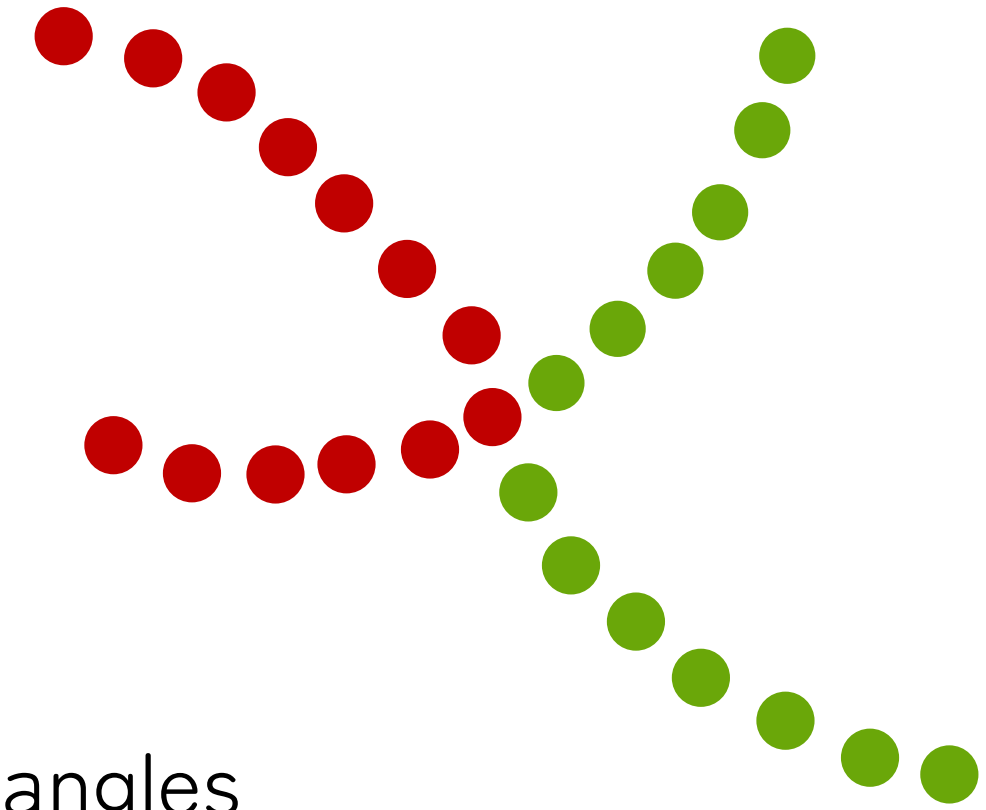
[slide from Pedro Lopes, University of Chicago]



most likely two like this...

... because these are the **smoother shapes**

[slide from Pedro Lopes, University of Chicago]



unlikely, too harsh angles

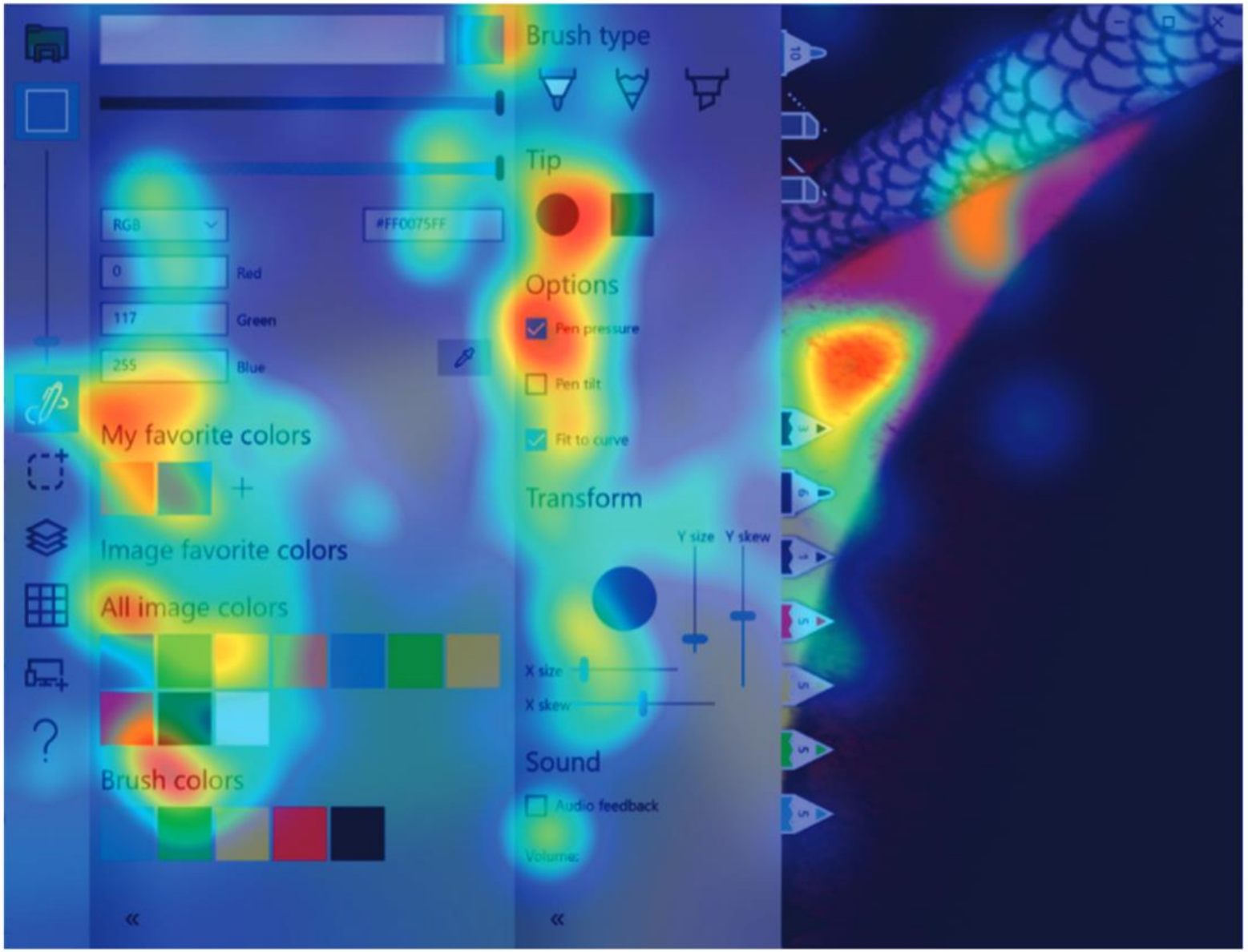
[slide from Pedro Lopes, University of Chicago]

leveraging these insights for
more **usable** interface

leveraging these insights for more **usable** interface

… find gestalt laws

user eye tracking to understand perception



user eye tracking to understand perception

from **perception** to **action**...

user eye tracking to understand perception

from **perception** to **action**...

affordance

affordance refers to the perceived and actual properties of the thing, primarily those **fundamental properties that determine just how the thing could possibly be used.**

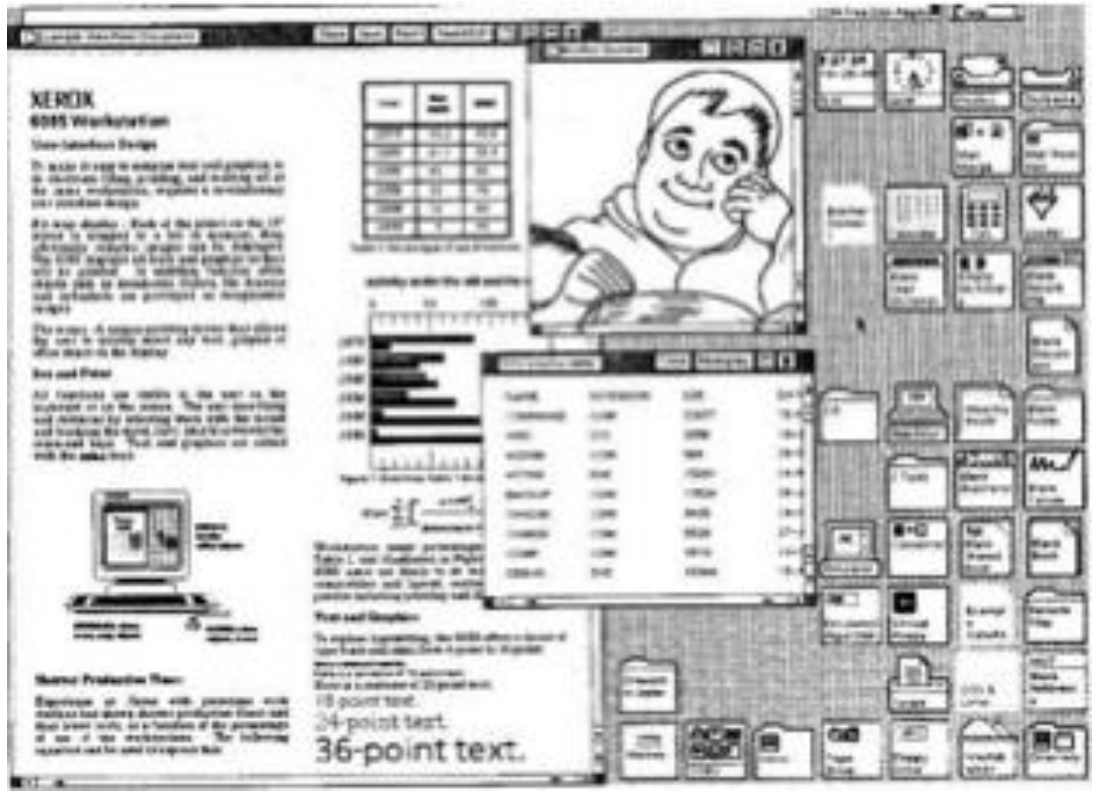
Don Norman [1999]
(building up on Gibson's definition)

[slide from Pedro Lopes, University of Chicago]

how to open this door?

mismatch of affordance & perceived affordance

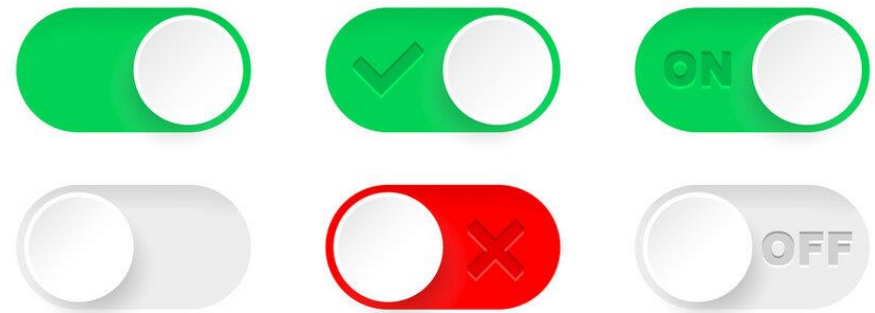
graphical user interface provides perceived affordance, some learned from physical world



Xerox Alto, 1970

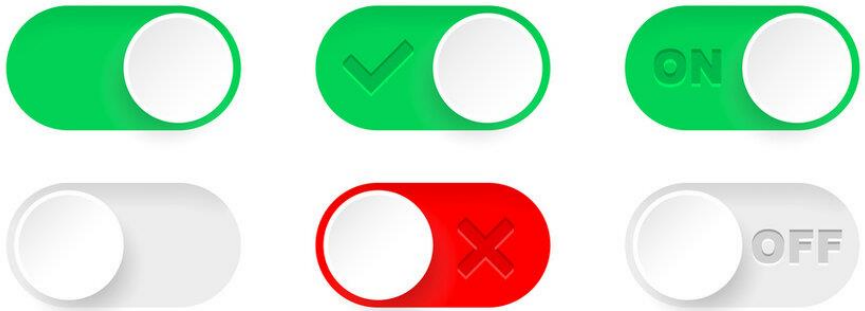

WORD NUMBER
BITS
COMBINATIONAL TRIGGER
ARM
TRIG
MODE
CLOCK SELECT
PRE-TRIG
DELAYED
134.5
300
600
950
TRIGGER


WORD NUMBER
BITS
COMBINATIONAL TRIGGER
CLOCK SELECT
TRIG
MODE
ARM
PRE-TRIG
DELAYED
134.5
300
600
950
TRIGGER


ON
OFF

physical affordance

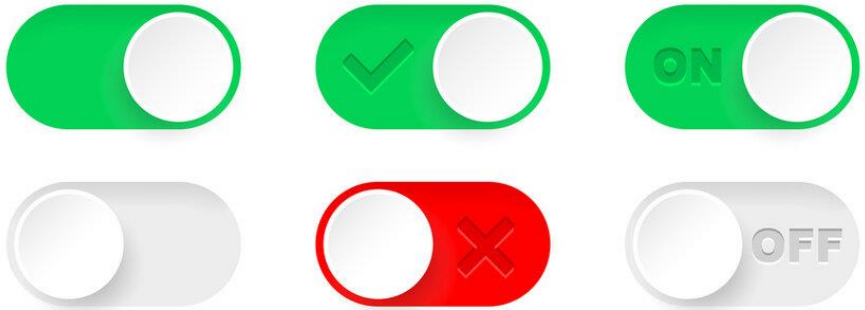
perceived affordance



physical affordance

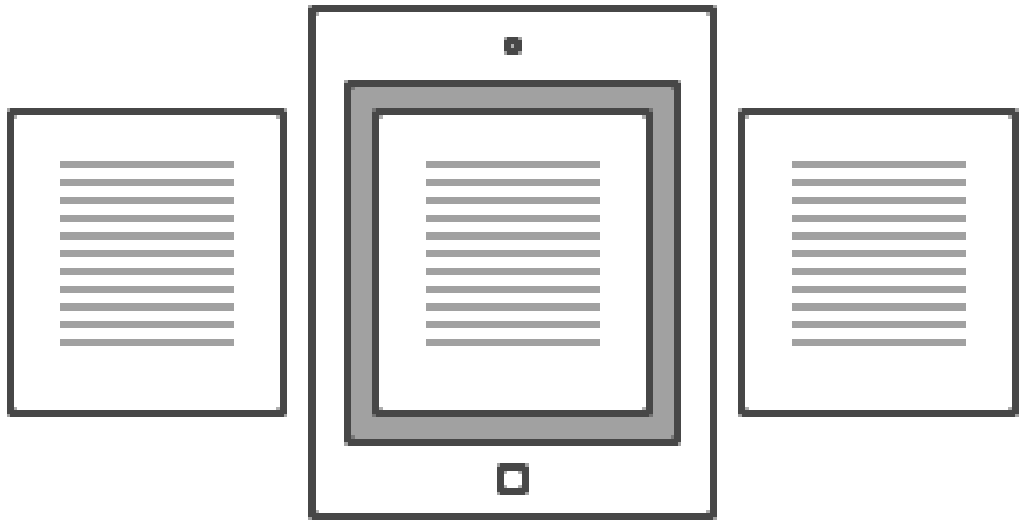
force resists movement

perceived affordance



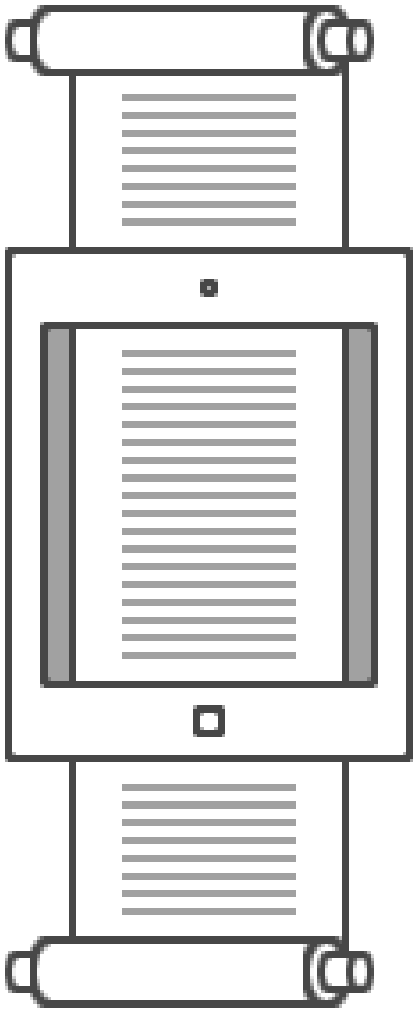

5:04
Thursday, January 6
slide to unlock

perceived affordance (mental model)



the page

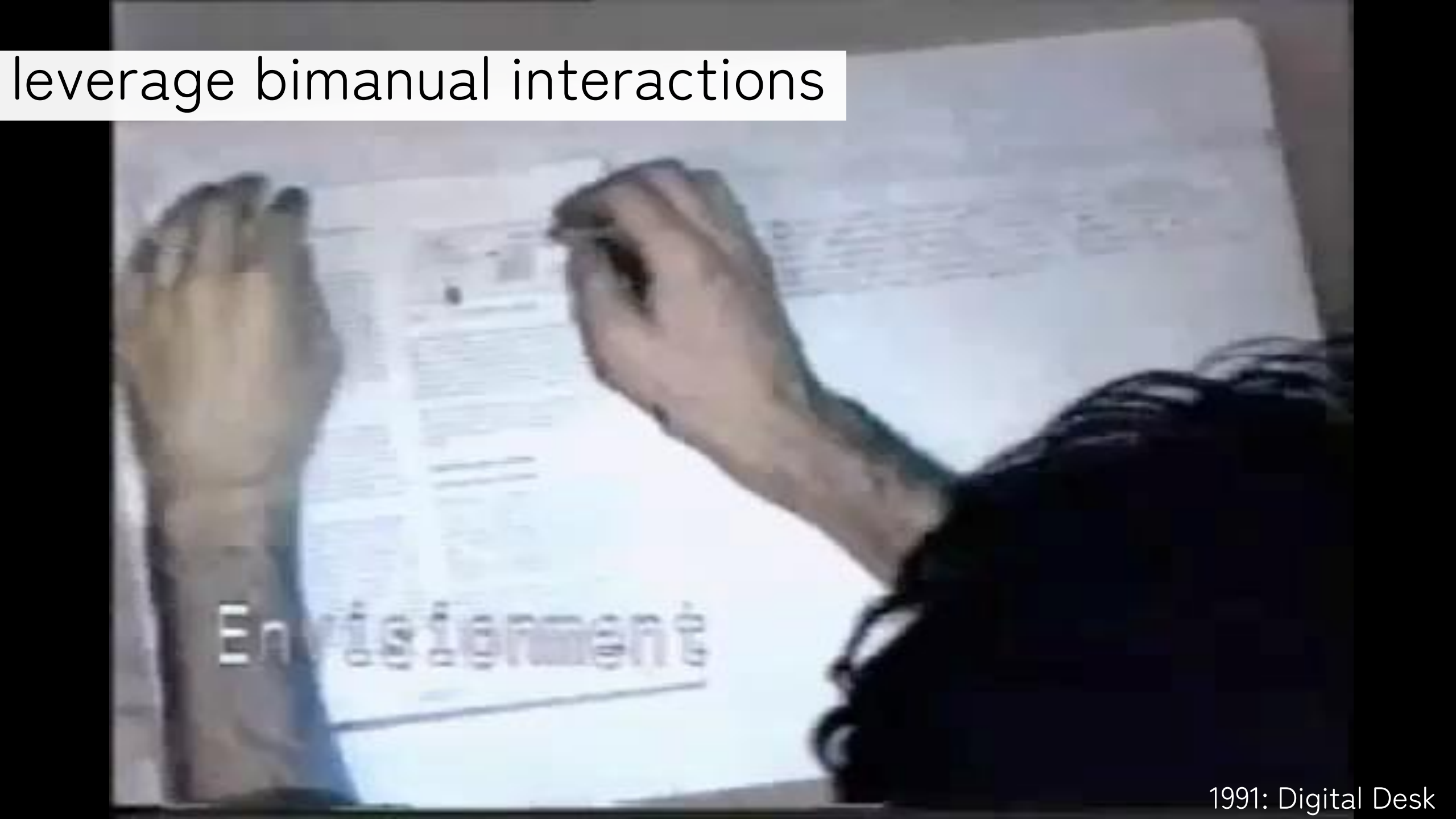
the scroll



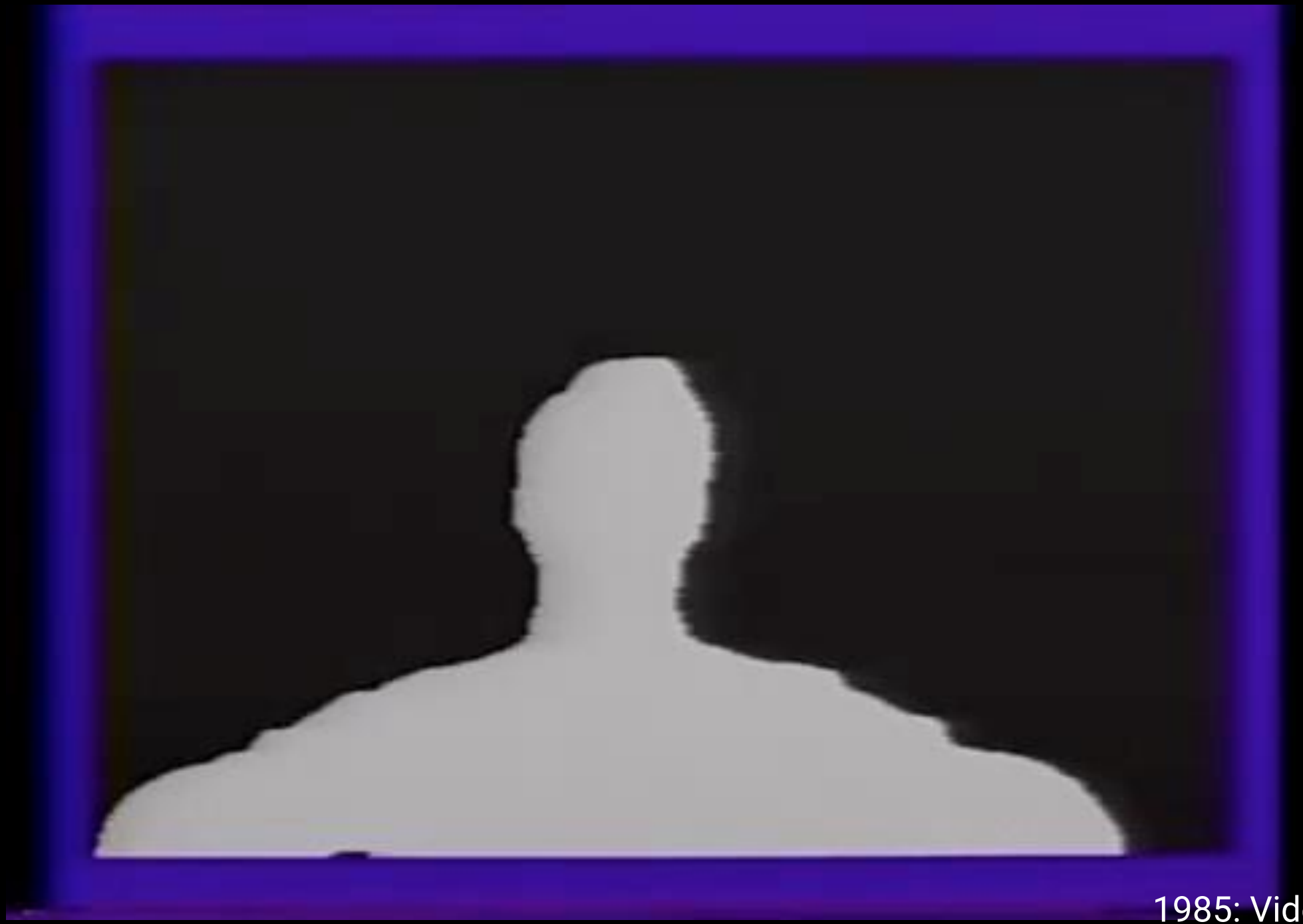
Natural User Interface (NUI)

natural user interface

leverage bimanual interactions



1991: Digital Desk



1985: Videoscape

integrate more modalities

Put That There
Rick Bolt, 1980

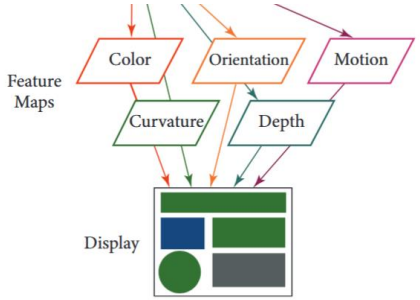

Santorini


TO TELL YOU WHERE TO GO.

benefits of multimodal HCI:

1. efficiency
   make computers more efficient

2. usability
   make computers easier to use



3. fidelity
   make computers feel more realistic

benefits of multimodal HCI:

1. efficiency
   make computers more efficient

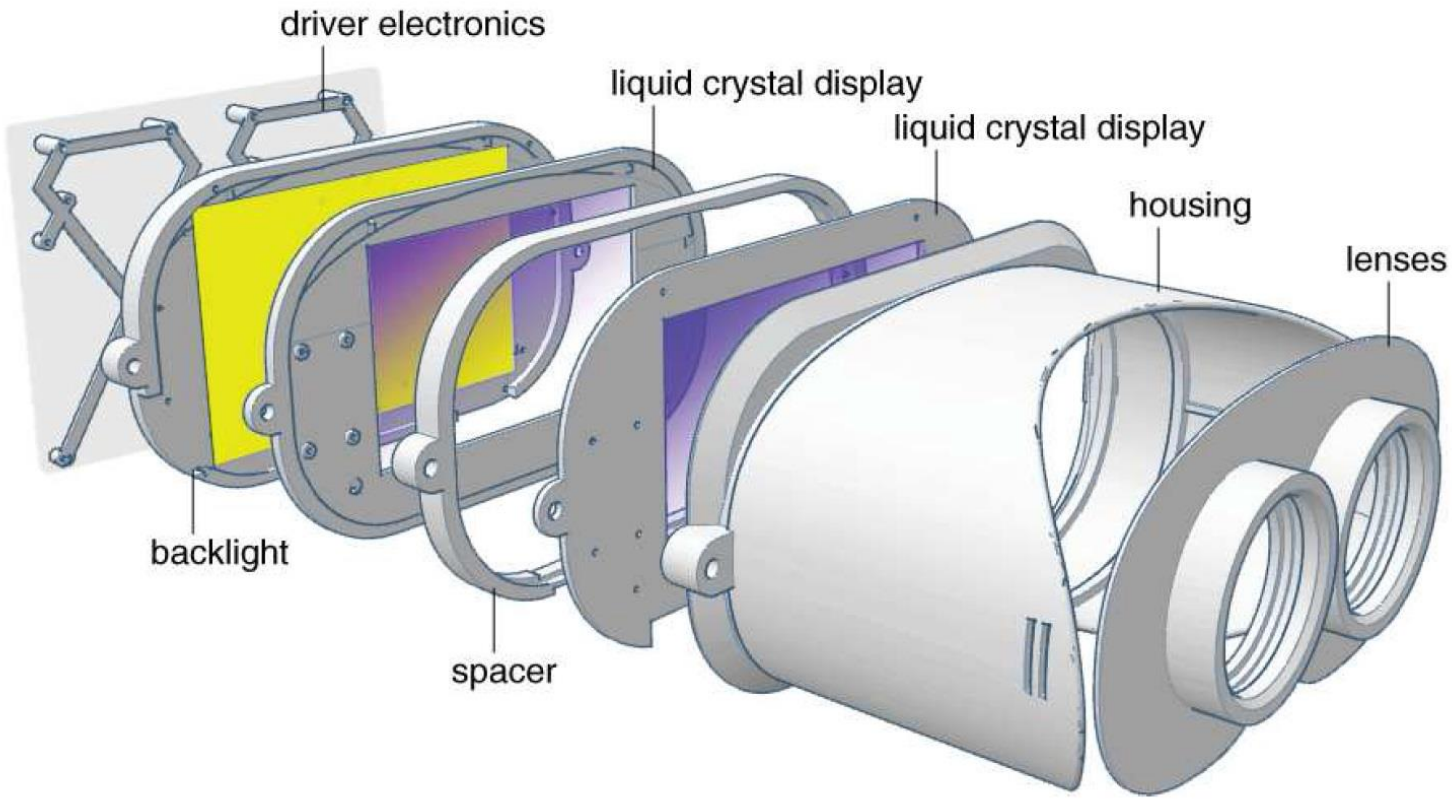
2. usability
   make computers easier to use

3. fidelity
   make computers feel more realistic

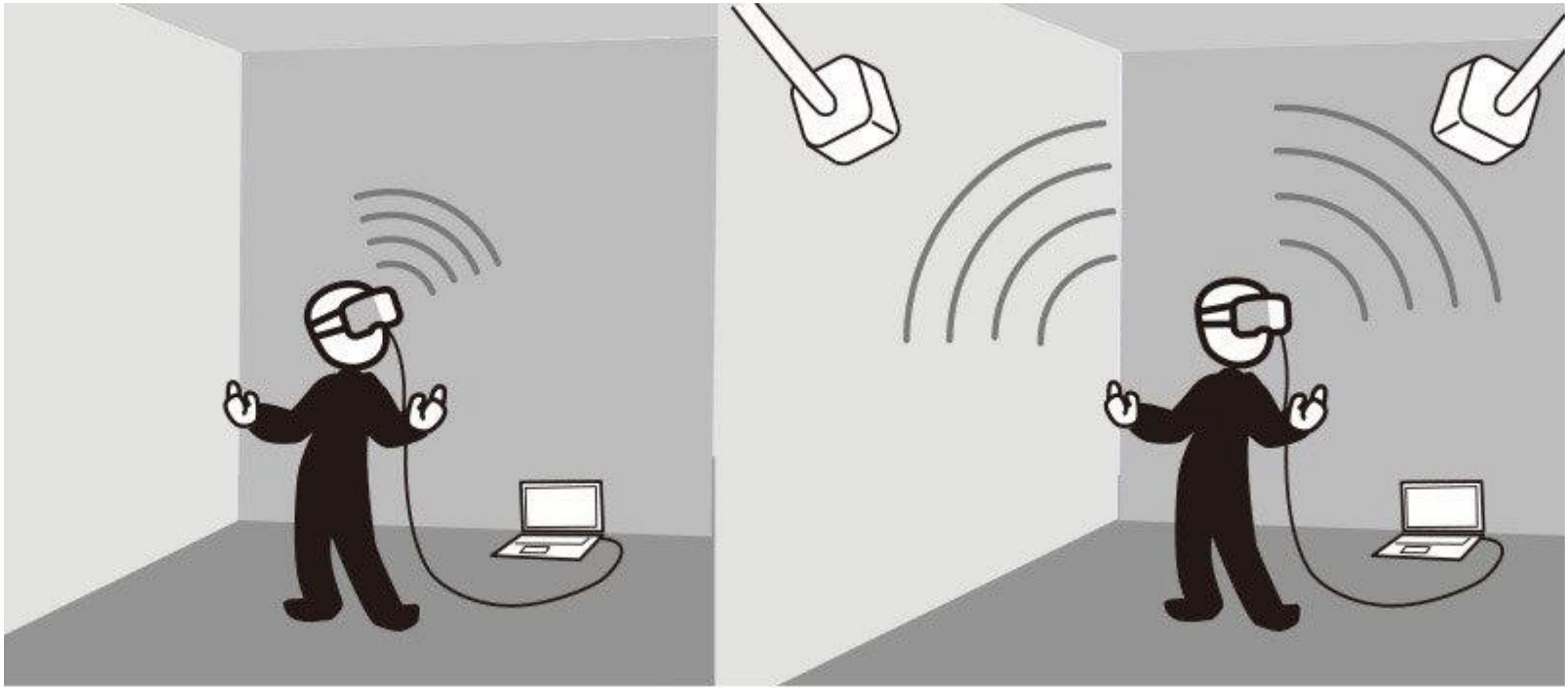
1968: head-mounted display by Ivan E. Sutherland

Virtual Reality (VR)


[Meta]



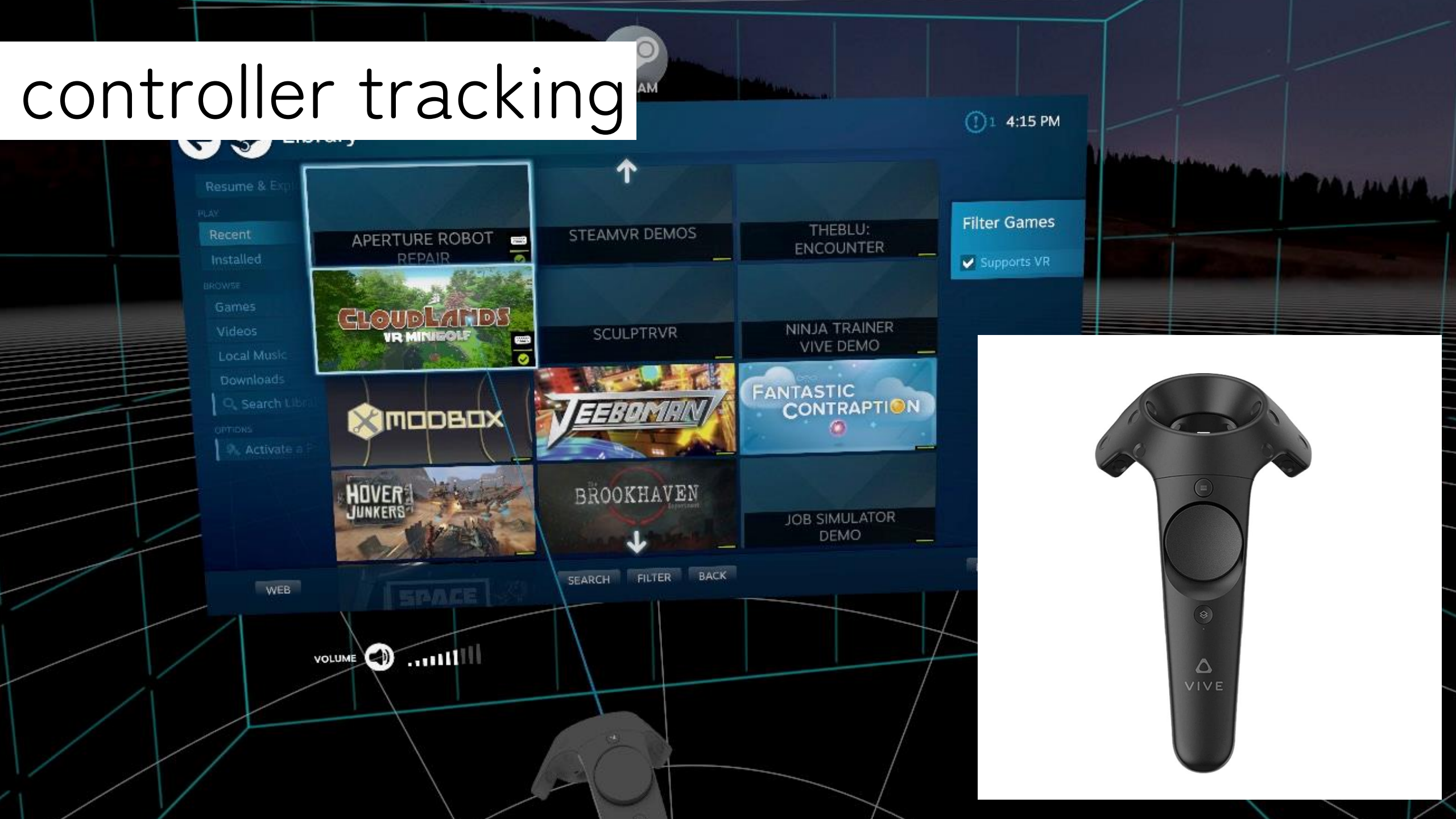
spatial tracking



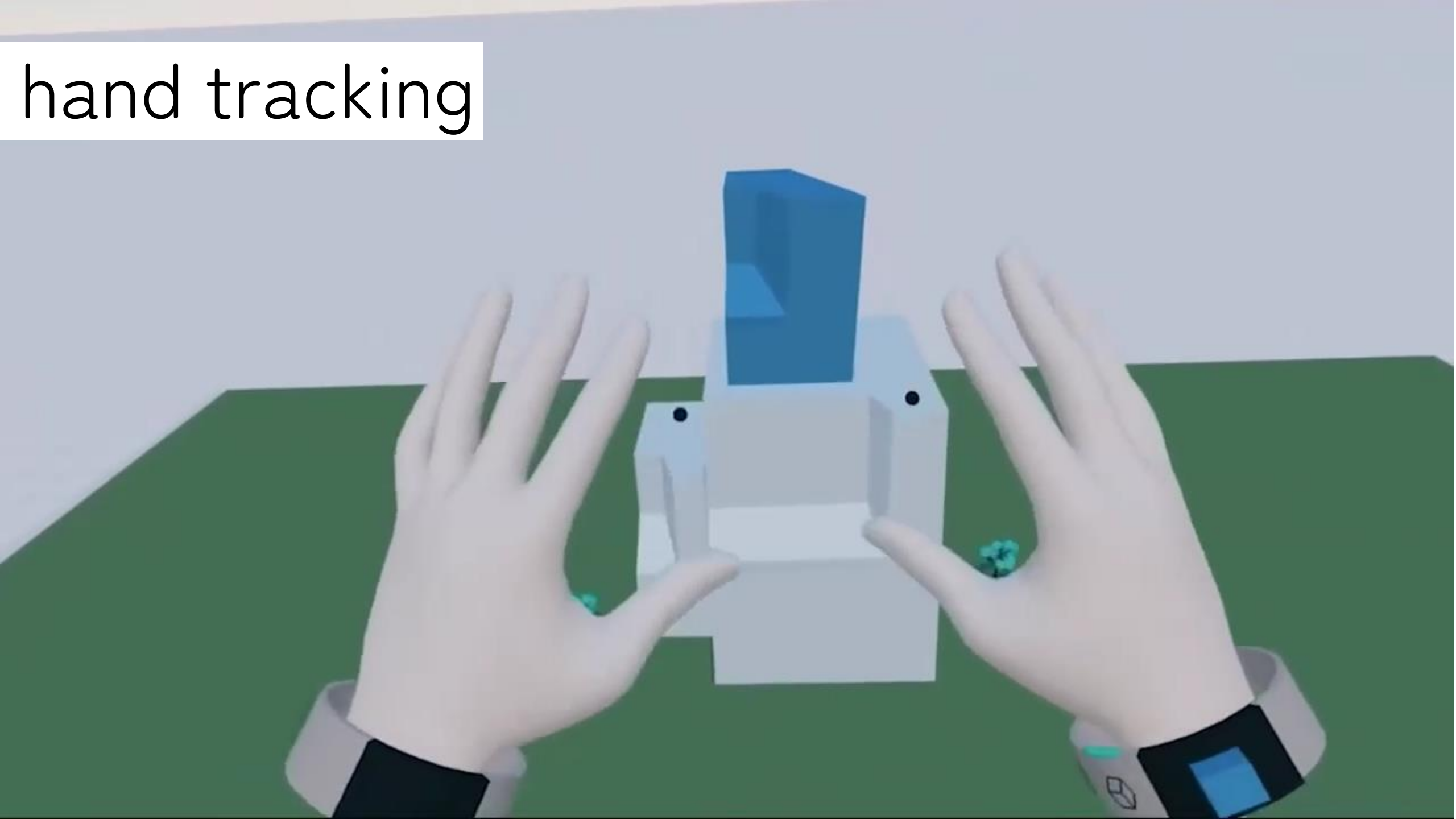
Inside-Out Tracking

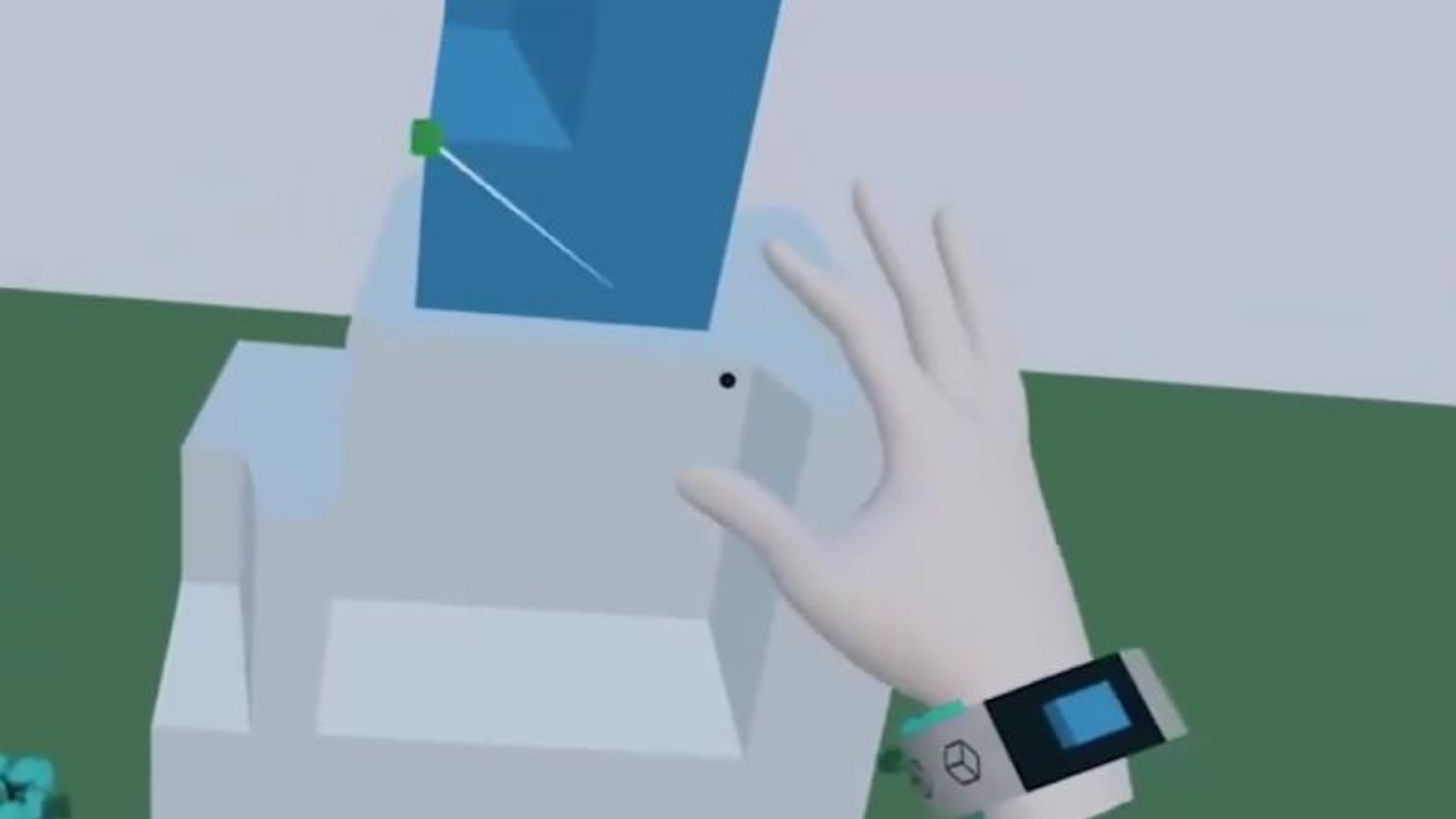
Outside-In Tracking

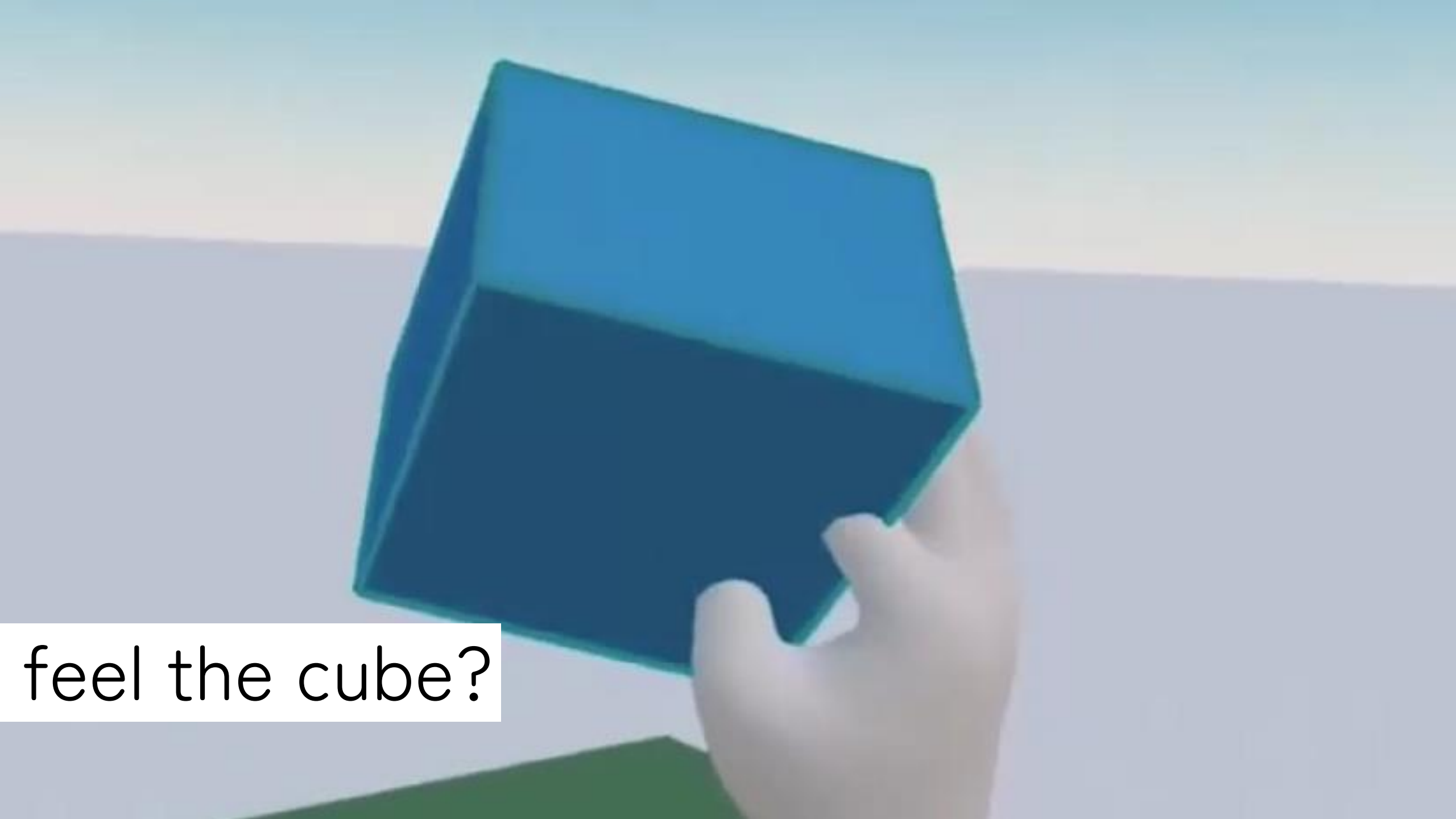
controller tracking



hand tracking






feel the cube?

1965

“the ultimate display”

Ivan E. Sutherland

“If the task of the display is to serve as **a looking-glass into the mathematical wonderland constructed in computer memory**, **it should serve as many senses as possible.** […]

1965: concept of “the ultimate display” by Ivan E. Sutherland

“If the task of the display is to serve as **a looking-glass into the mathematical wonderland constructed in computer memory**, **it should serve as many senses as possible.** […]
I want to describe for you a **kinesthetic display**.”

1965: concept of “the ultimate display” by Ivan E. Sutherland

“If the task of the display is to serve as **a looking-glass into the mathematical wonderland constructed in computer memory**, **it should serve as many senses as possible.** […] I want to describe for you a **kinesthetic display**.”

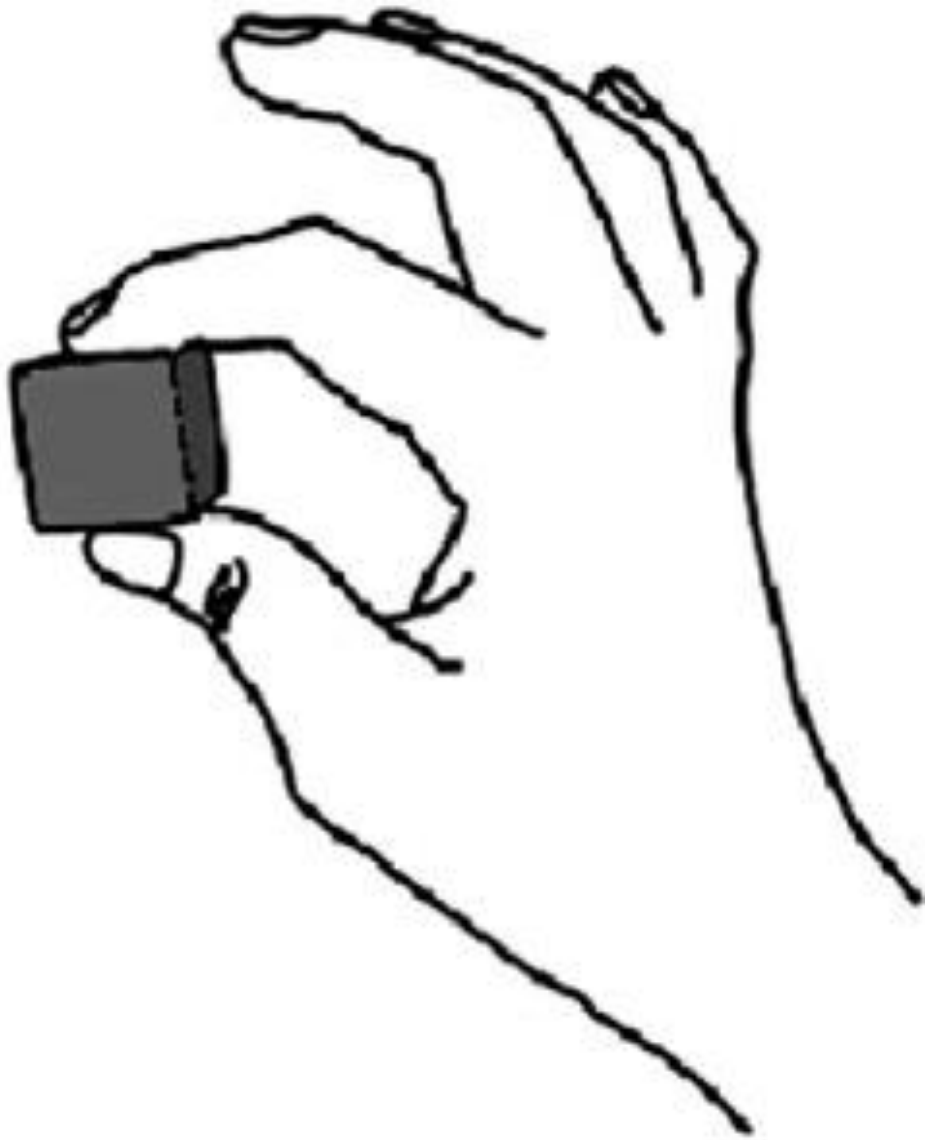
“With such a display, **a computer model of particles in an electric field** could combine manual control of the position, of a moving charge, replete with the **sensation of forces** on the charge, […]”

1965: concept of “the ultimate display” by Ivan E. Sutherland

haptics

[from the Greek *Hapteshai*, ‘touch’ or ‘contact’]

Generally used to describe the **sense of touch**.

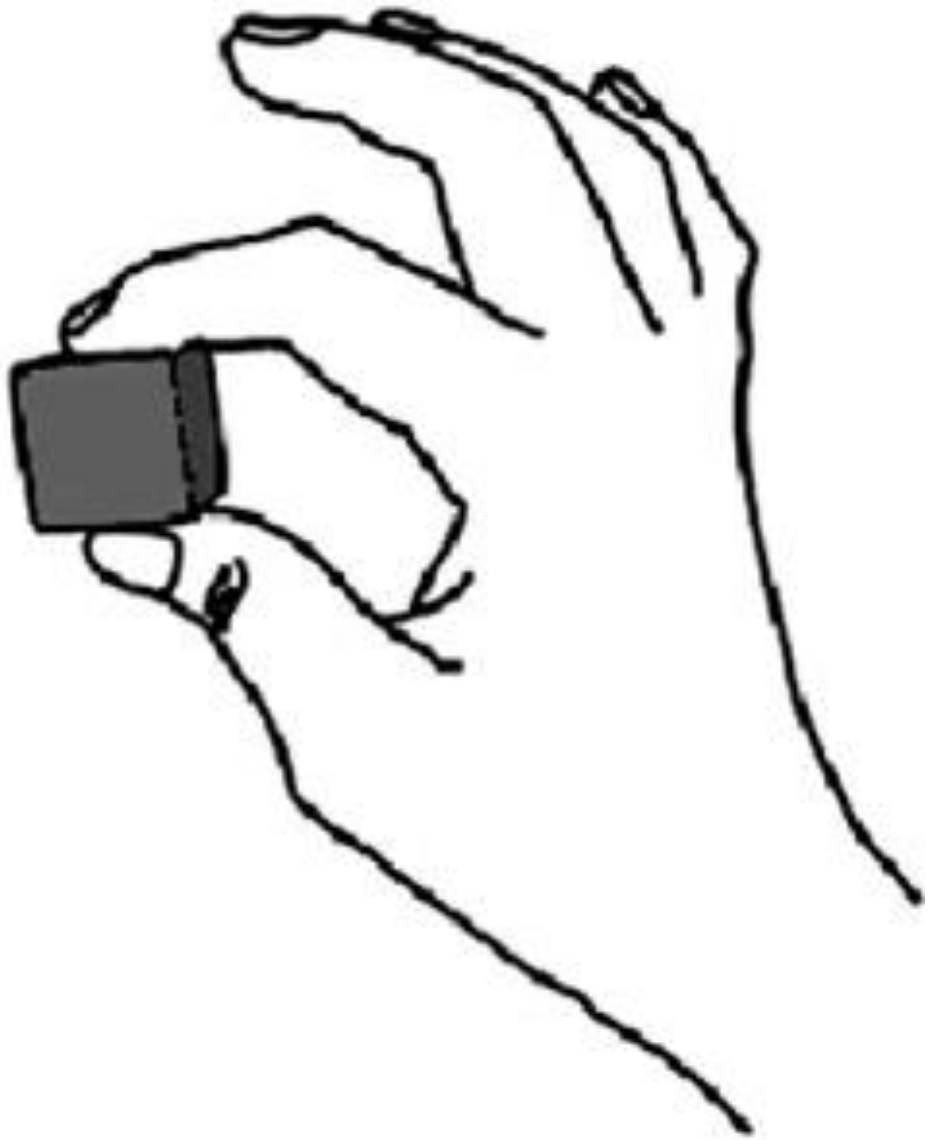


haptics

[from the Greek *Hapteshai*, ‘touch’ or ‘contact’]

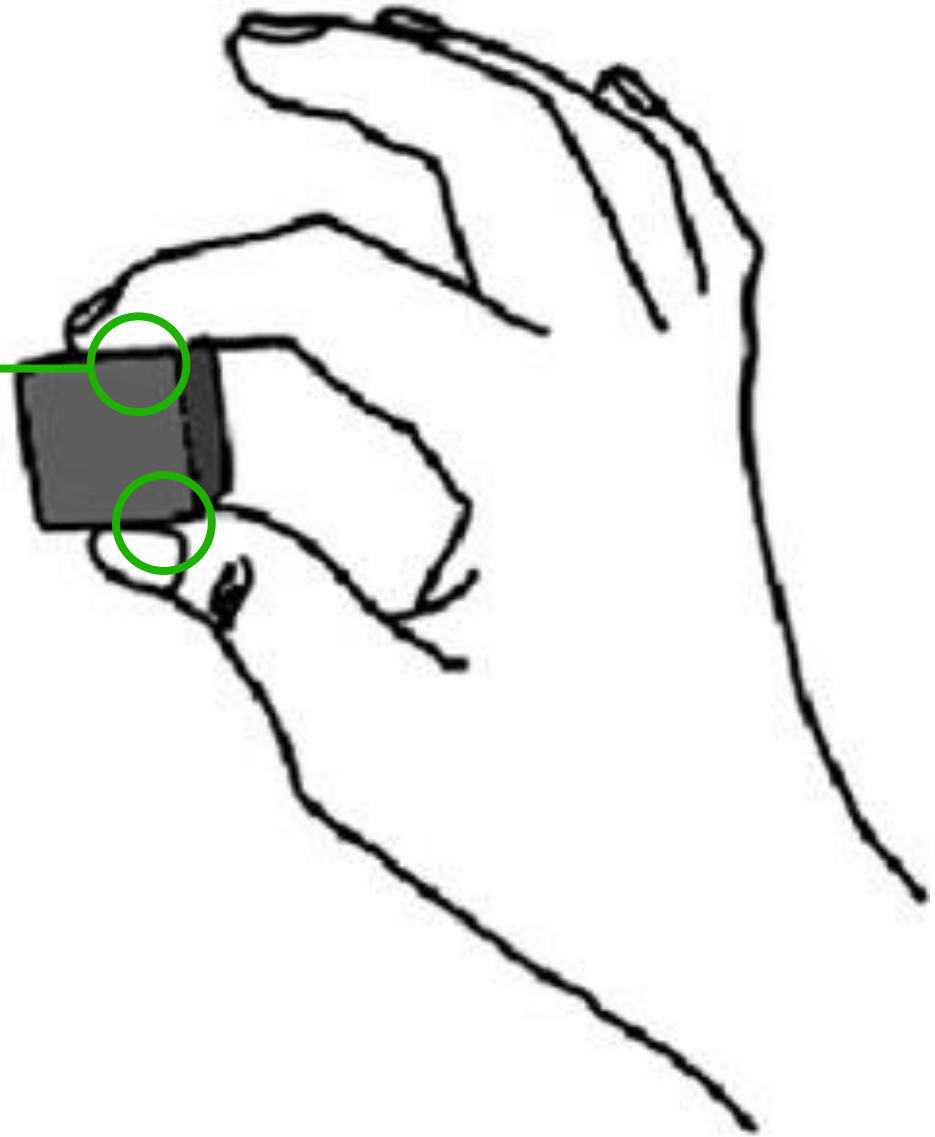
Generally used to describe the sense of touch.

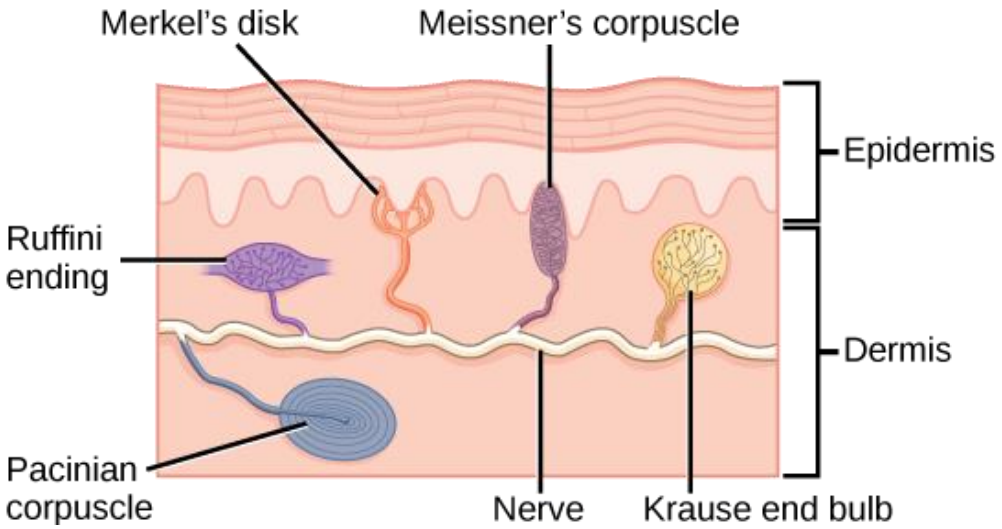
→ any senses other than **optics** & **acoustics**



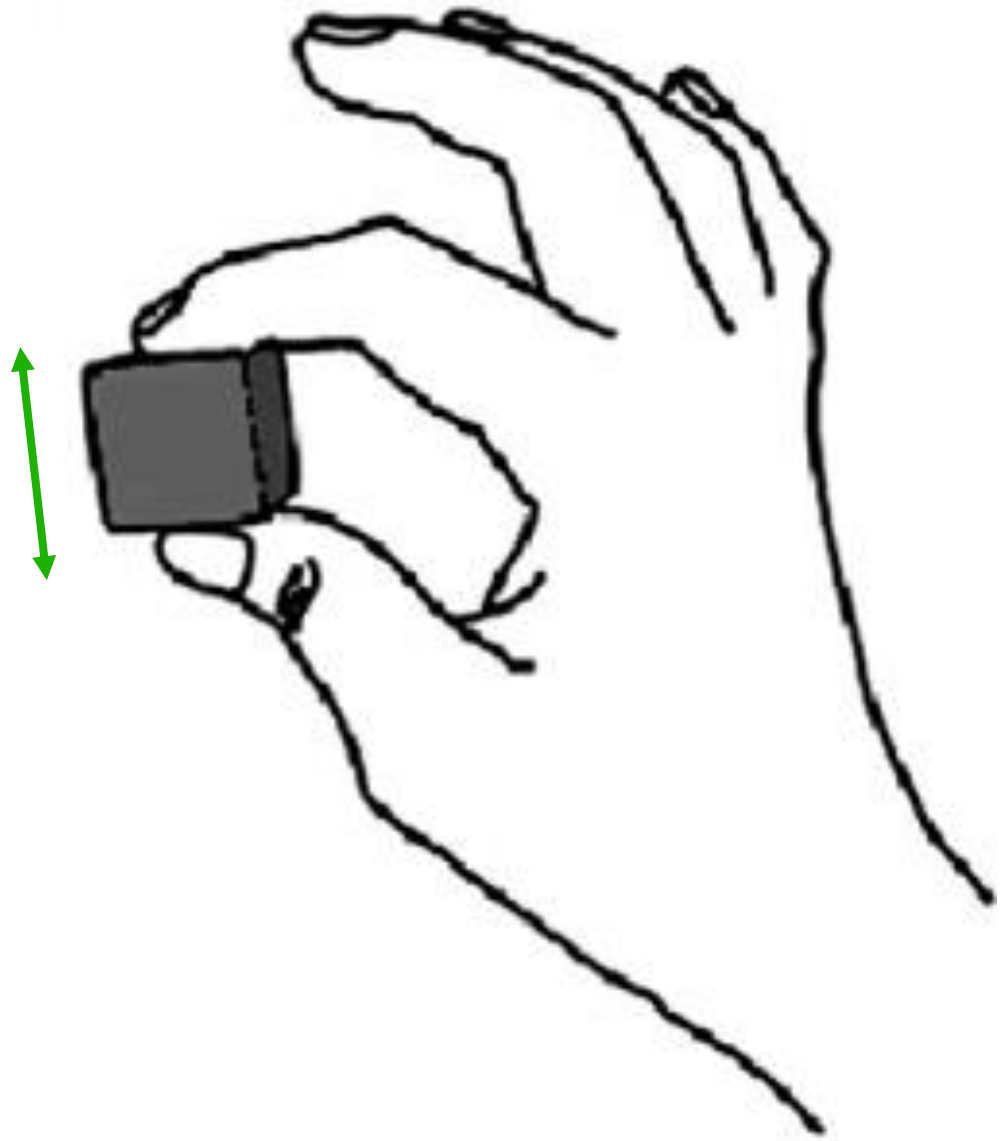
haptics

cutaneous (tactile) sensation

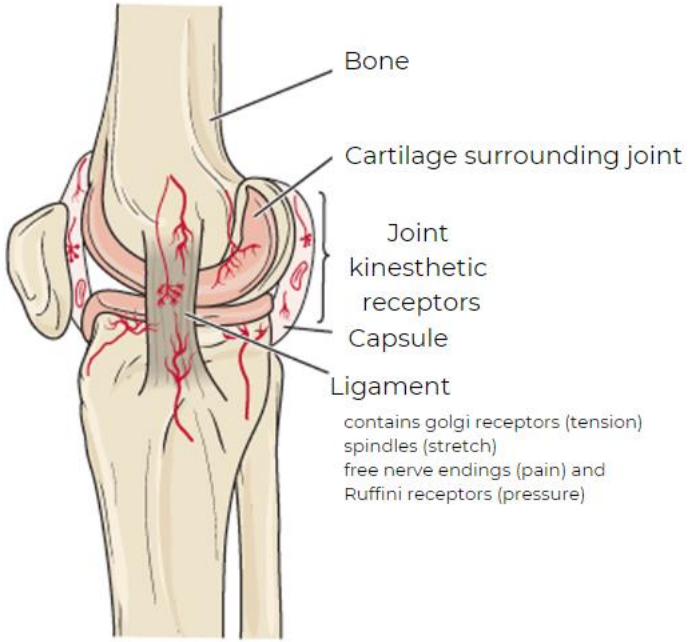


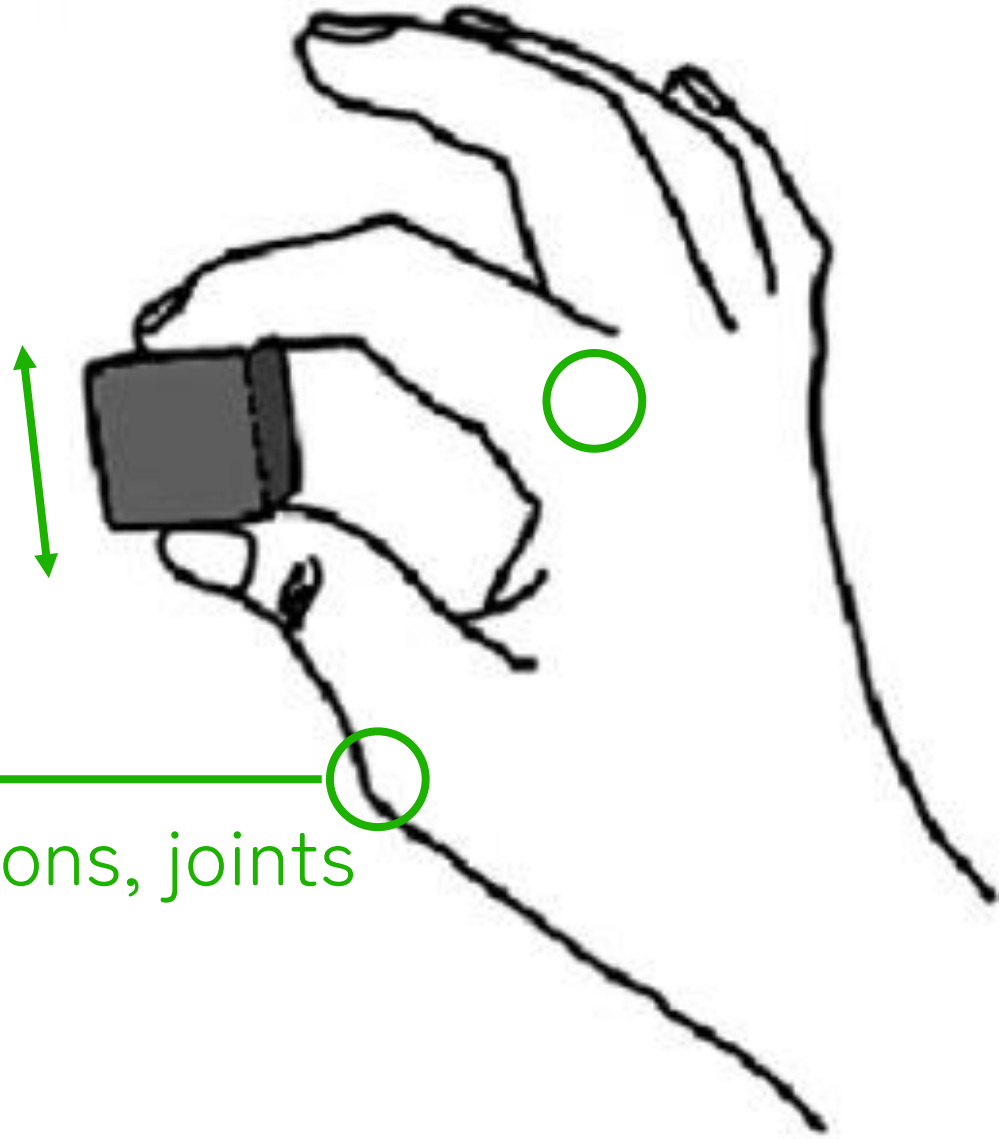


haptics



haptics





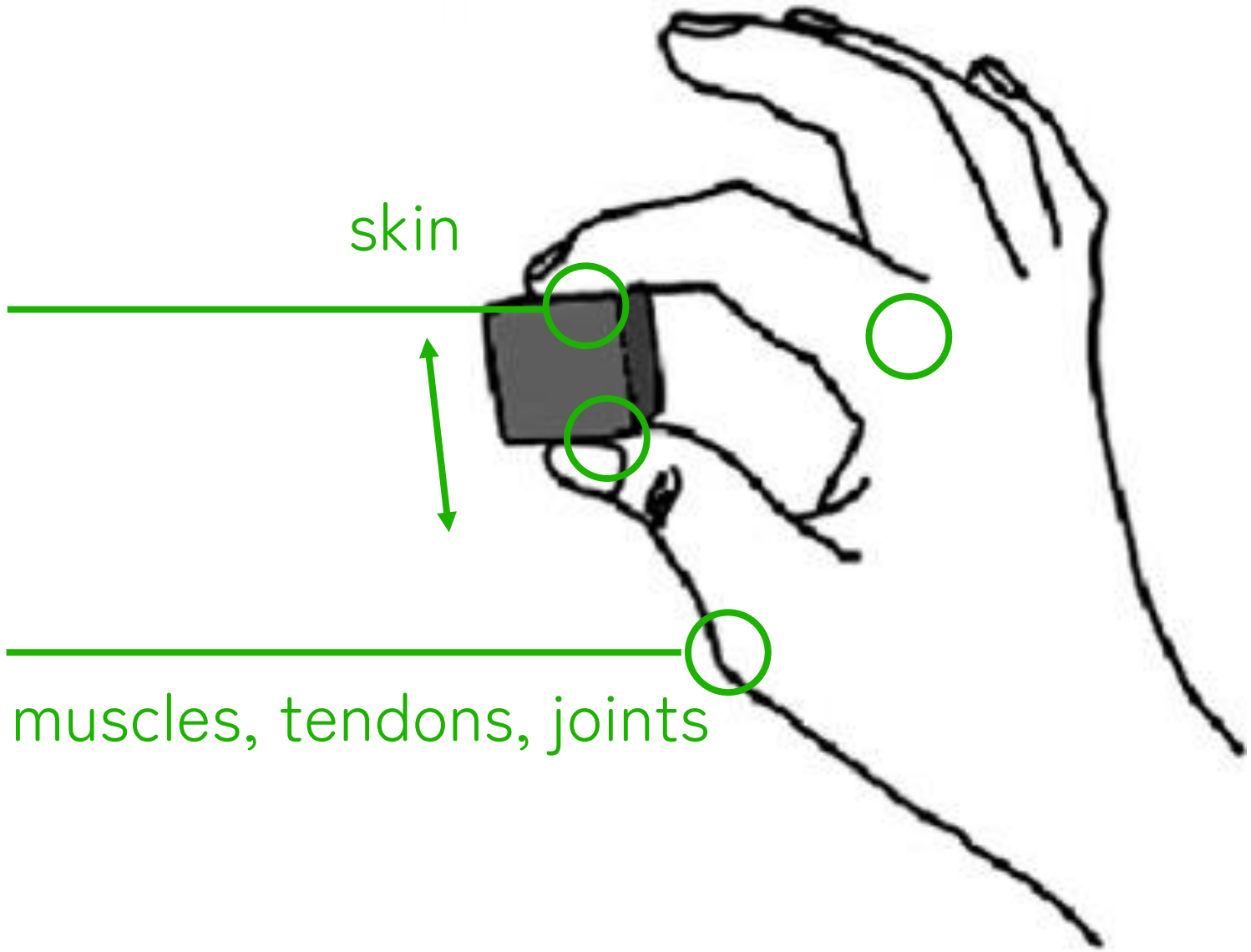
kinesthetic (force) sensation

muscles, tendons, joints

haptics

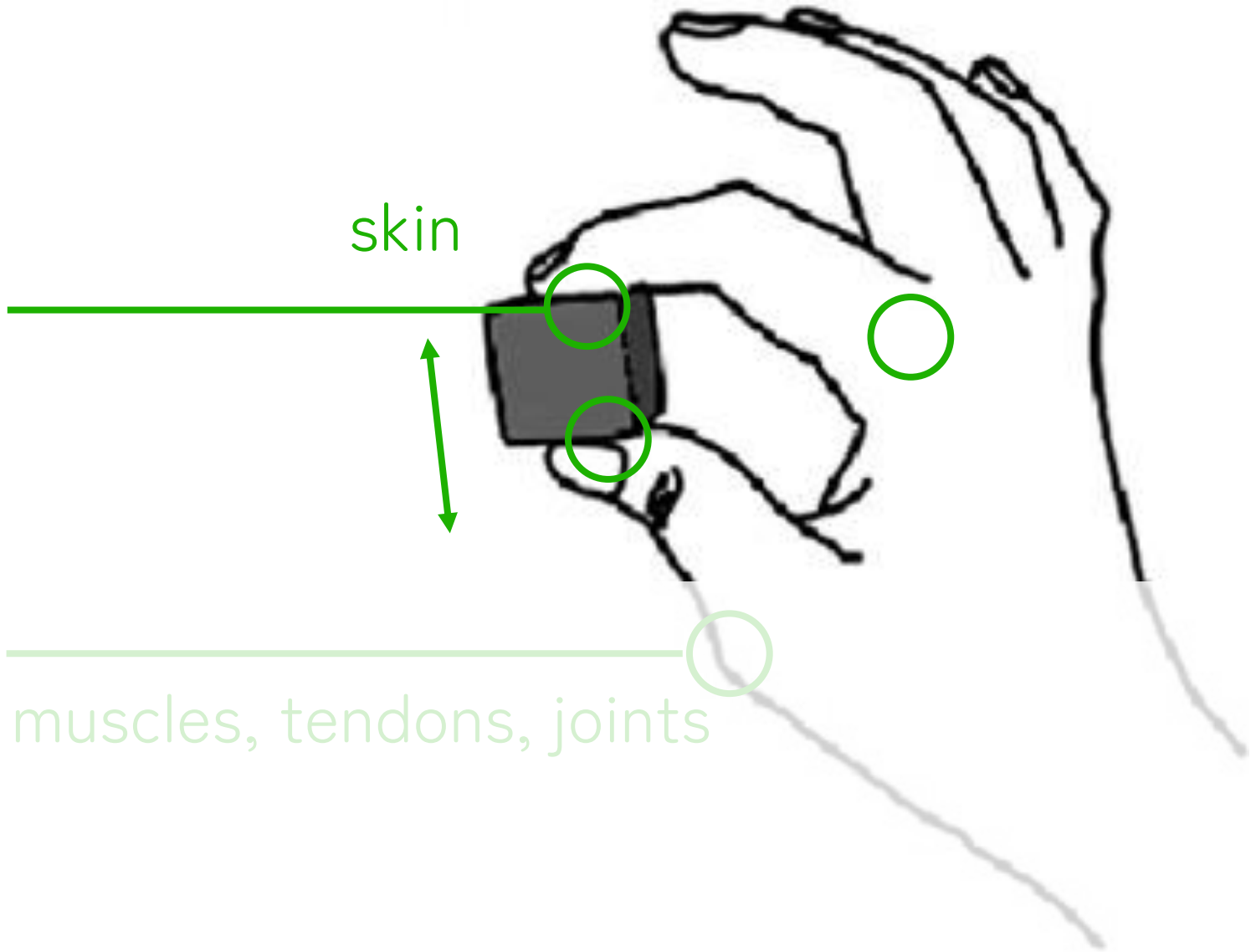
cutaneous (tactile) sensation

kinesthetic (force) sensation



haptics

cutaneous (tactile) sensation



kinesthetic (force) sensation

cutaneous feedback: vibration

Meta quest

Forte Data Gloves
[BeBop Sensors, ’20]

cutaneous feedback: vibration

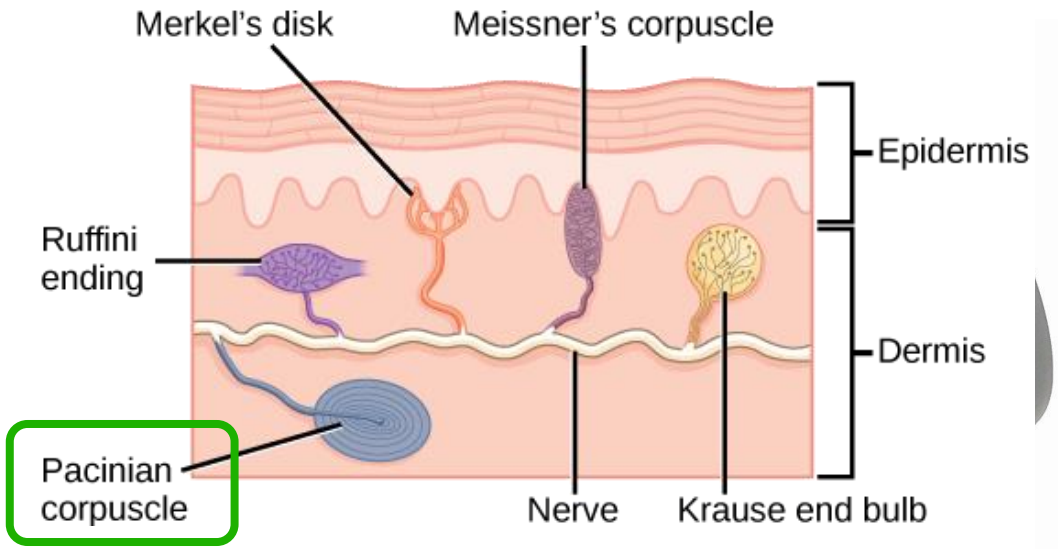
Meta quest

vibration motors

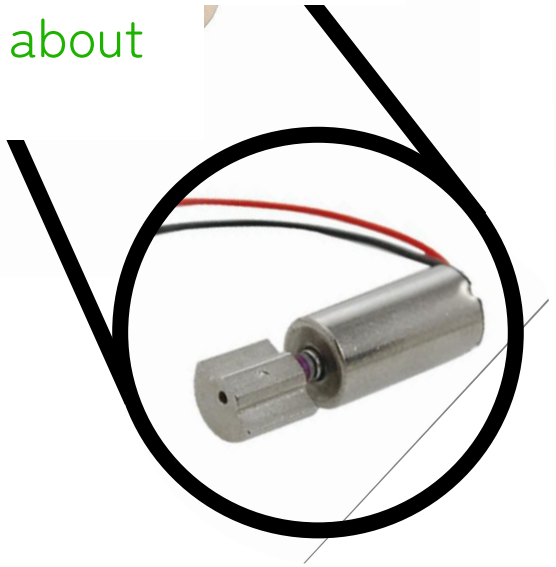
(one kind of haptic actuators)

Forte Data Gloves
[BeBop Sensors, ’20]

cutaneous feedback: vibration



detect rapid vibrations (of about 200–300 Hz)



vibration motors

(one kind of haptic actuators)

cutaneous feedback: vibration

detect rapid vibrations (of about 200–300 Hz)

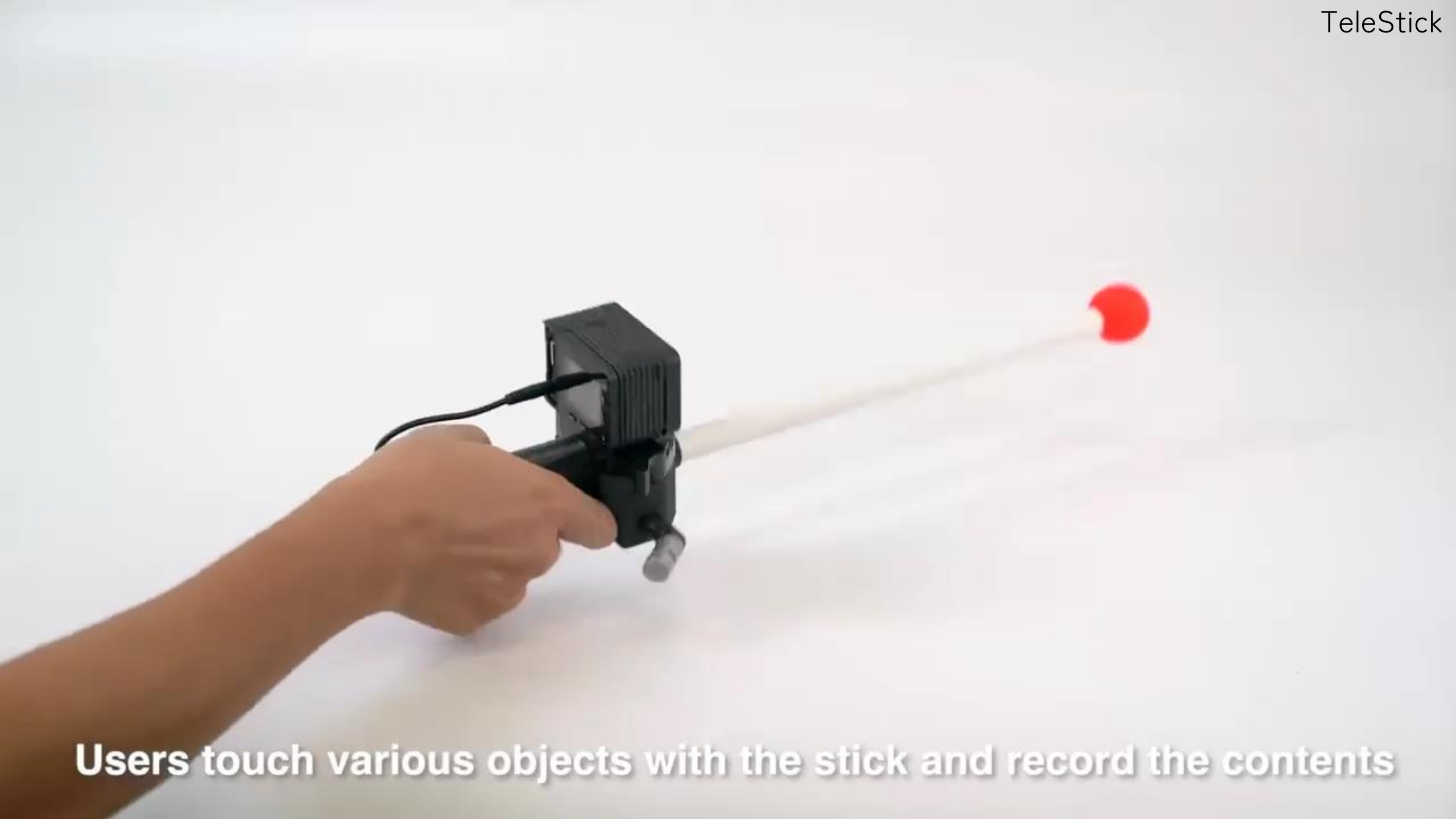
vibration motors

what types of feelings can you simulate with vibrations?

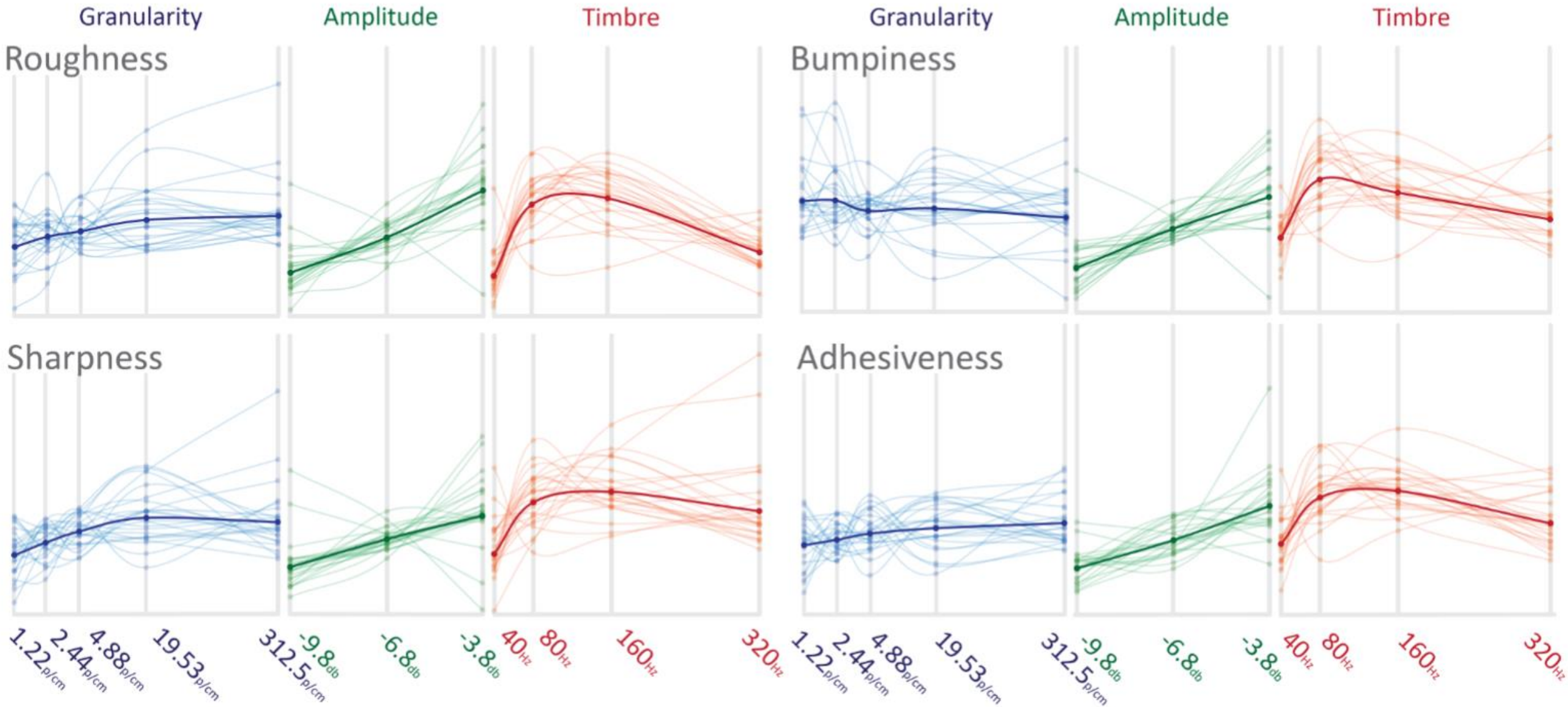
Nintendo Power: Star Fox 64 & Rumble Pak, 1997

[PS4 controller, Numb Nerves]

Generating Haptic Textures with a Vibrotactile Actuator [Strohmeier & Hornbæk, CHI ’17]


Users touch various objects with the stick and record the contents

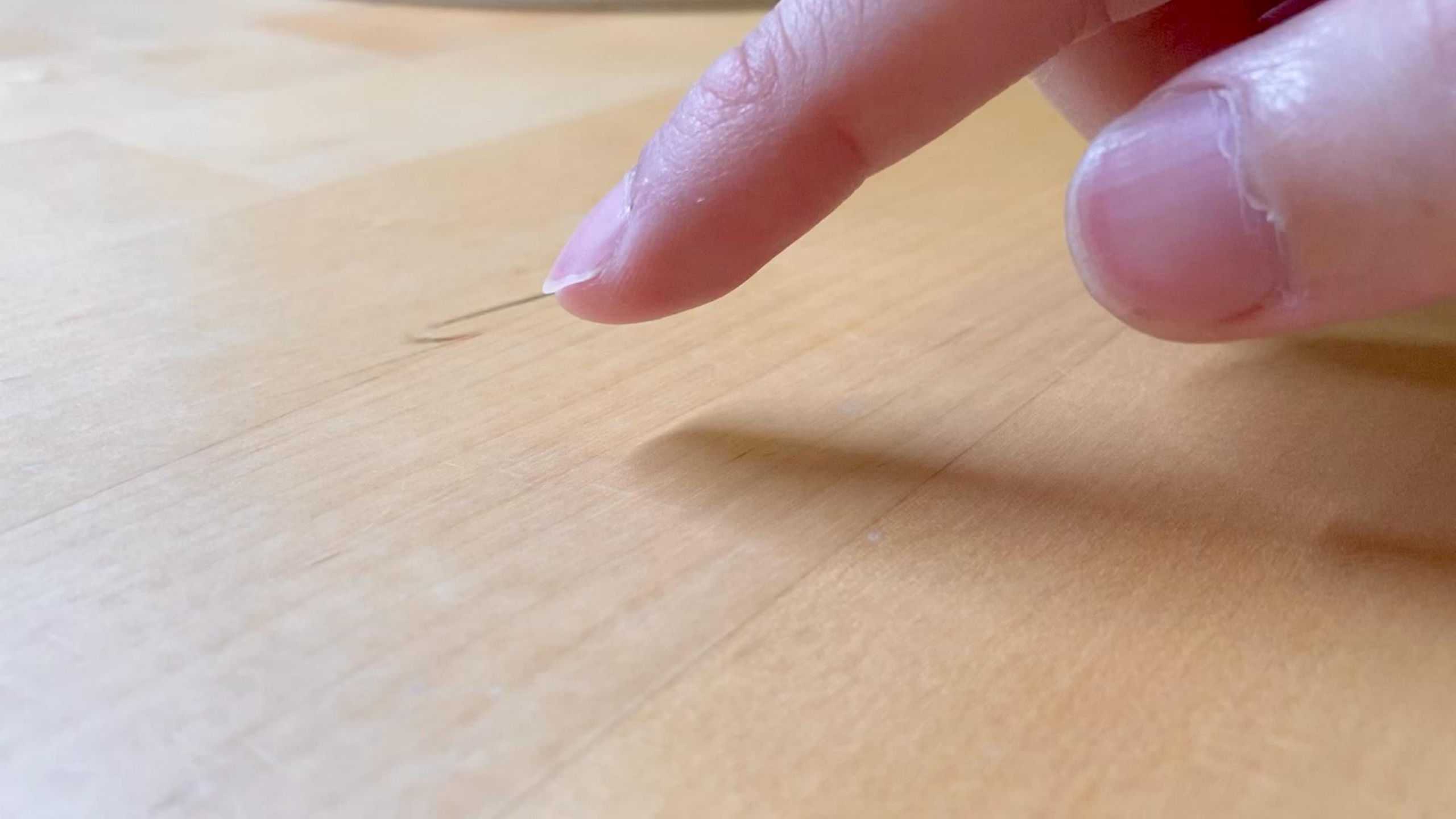
Generating Haptic Textures with a Vibrotactile Actuator [Strohmeier & Hornbæk, CHI ’17]

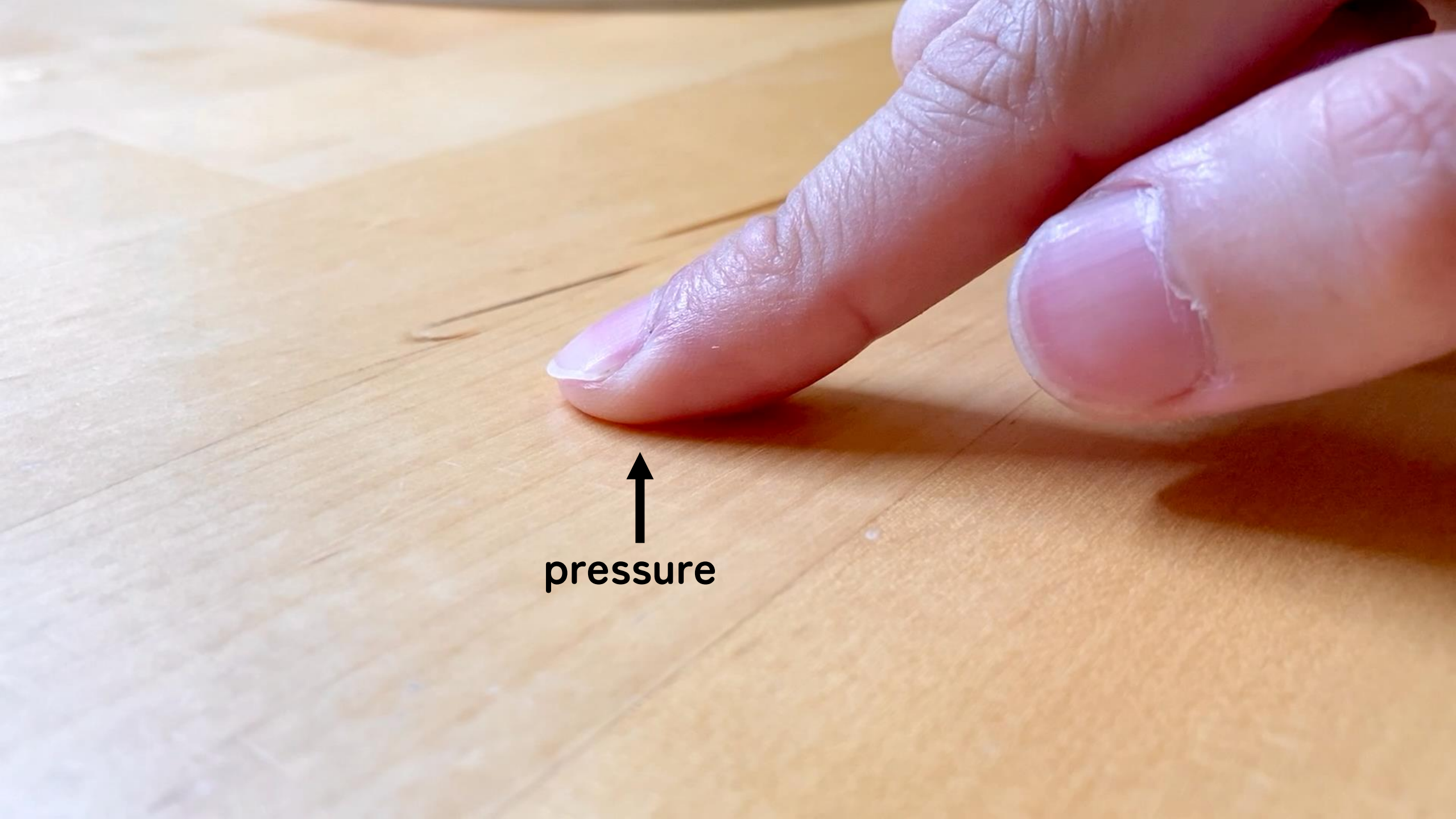

Granularity
Amplitude
Timbre
Roughness
Granularity
Amplitude
Timbre
Bumpiness
Sharpness
Adhesiveness
1.22p/cm
2.44p/cm
4.88p/cm
19.53p/cm
312.5p/cm
-9.8db
-6.8db
-3.8db
40Hz
80Hz
160Hz
320Hz
1.22p/cm
2.44p/cm
4.88p/cm
19.53p/cm
312.5p/cm
-9.8db
-6.8db
-3.8db
40Hz
80Hz
160Hz
320Hz

linear resonant actuator (LRA)

[Taptic Digital]

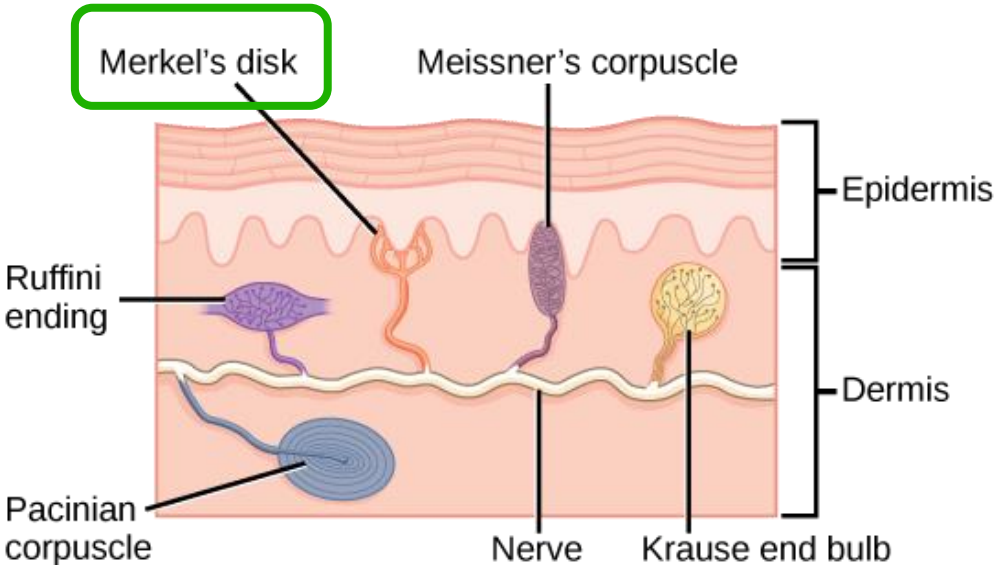

[Nathie]




pressure

cutaneous feedback: pressure

detect skin displacement (even 1 μm)
& sense also vibrations (5-15 Hz)



cutaneous feedback: pressure

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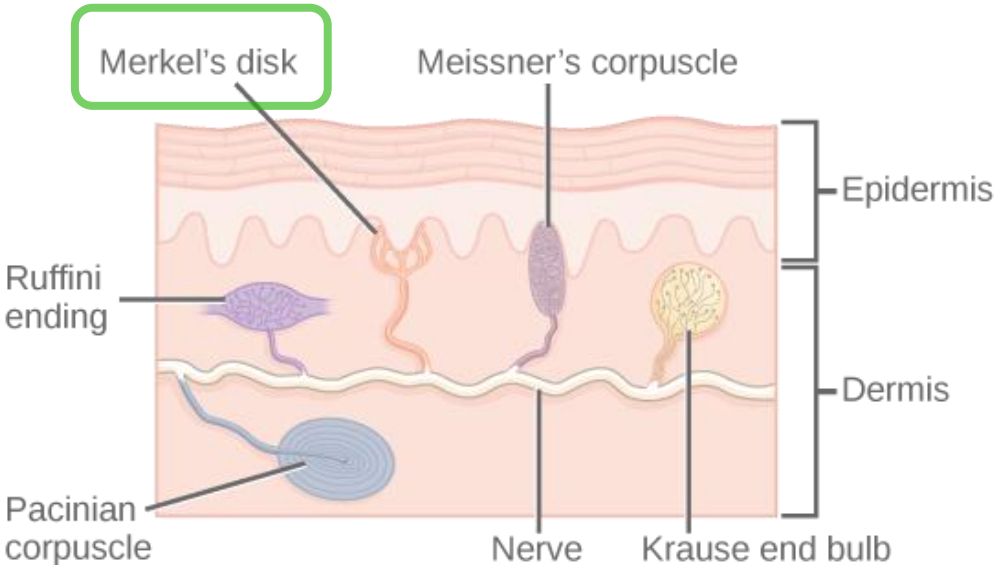
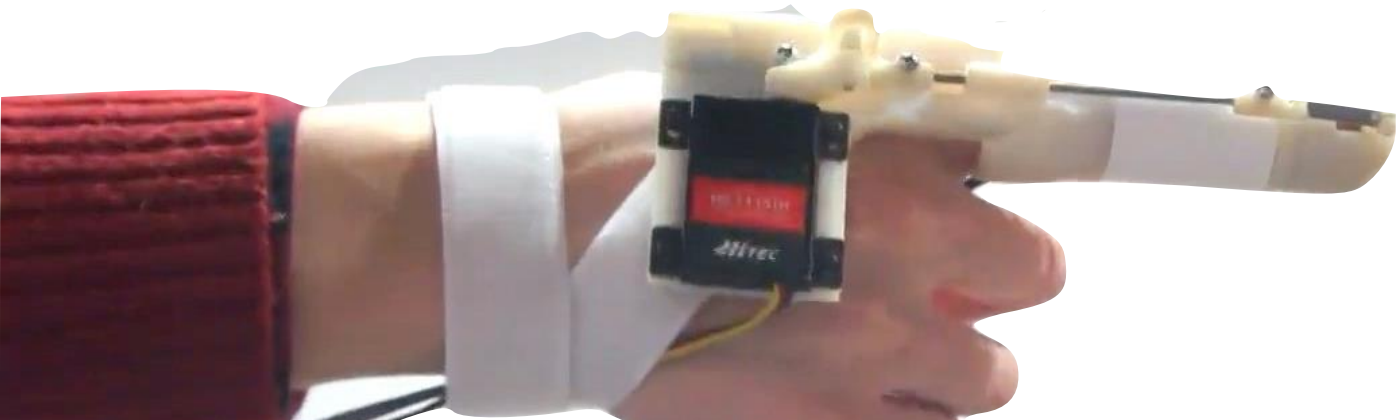
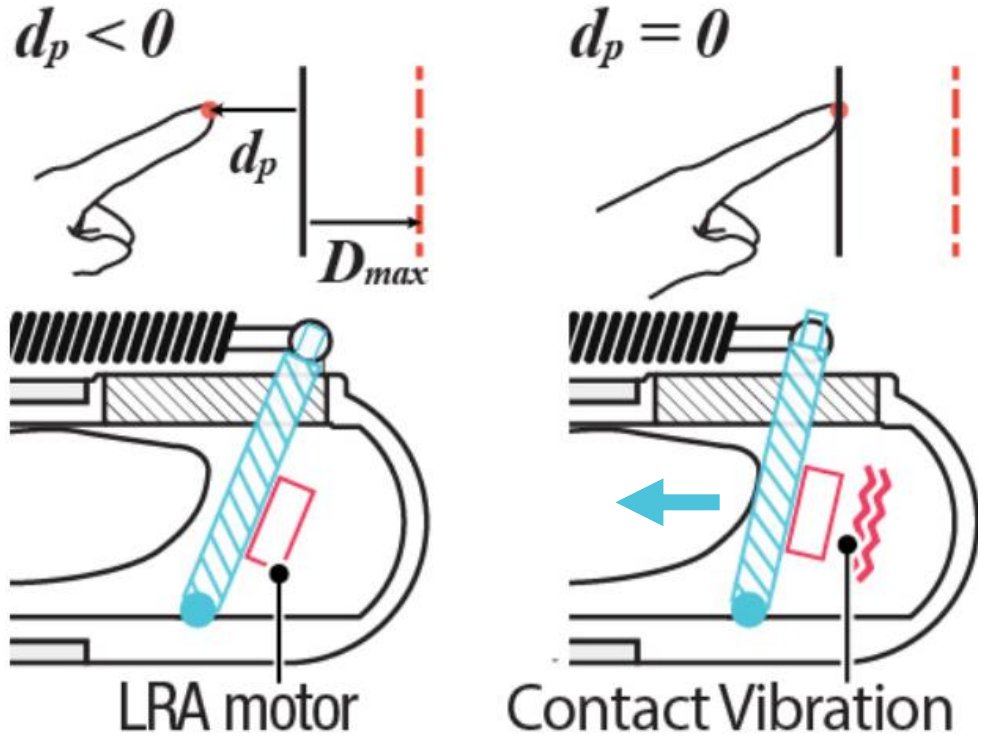
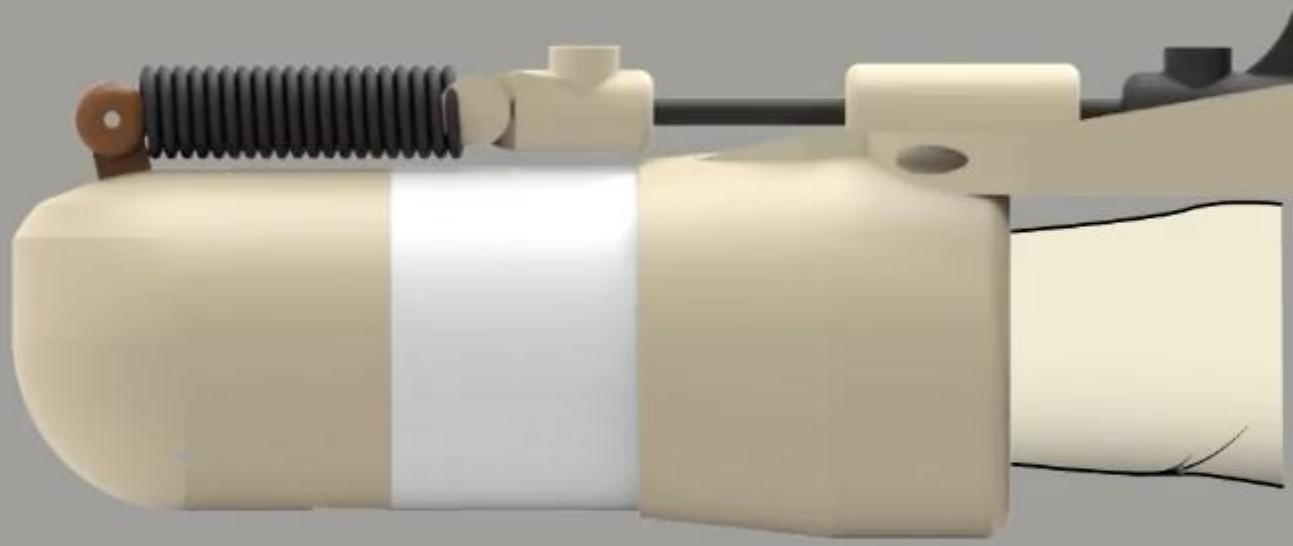






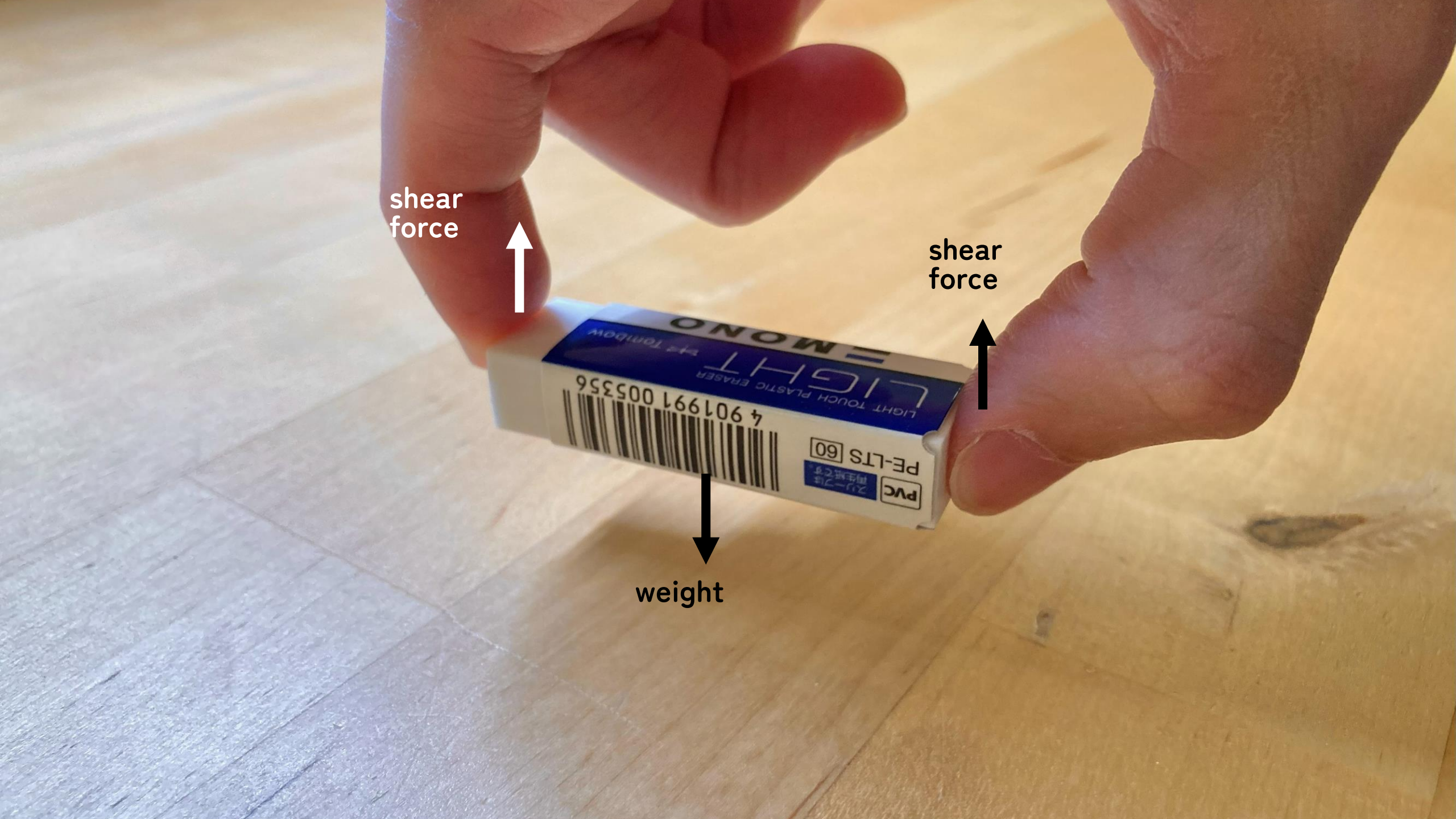
HapThimble: A Wearable Haptic Device towards Usable Virtual Touch Scree [Kim et al., CHI '16]

Structure of
HapThimble

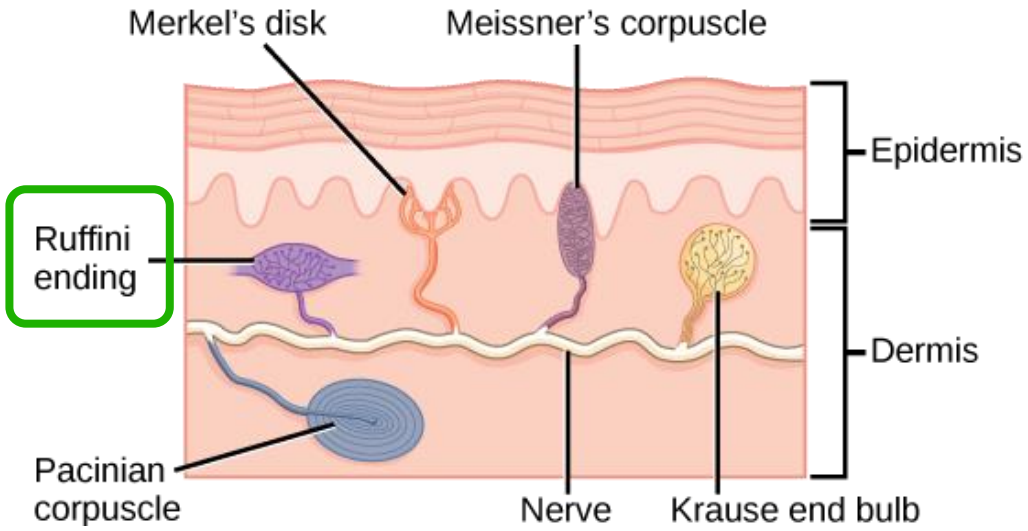


HapThimble: A Wearable Haptic Device towards Usable Virtual Touch Scree [Kim et al., CHI ’16]


PVC
スリーブは再生紙です。
PE-LTS 60
4 901991 005356
LIGHT TOUCH PLASTIC ERASER
LIGHT
Tombow
MONO

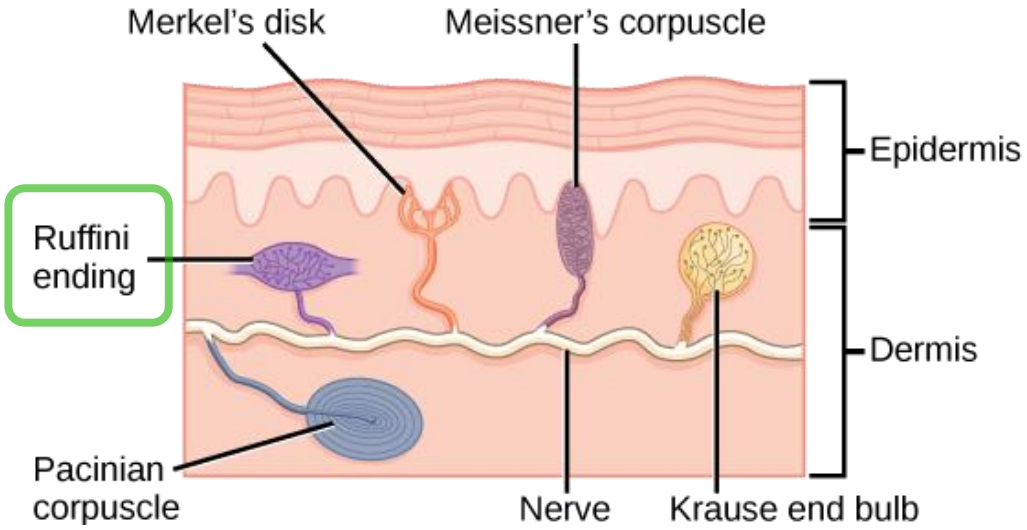

shear
force
shear
force
weight

cutaneous feedback: shear forces



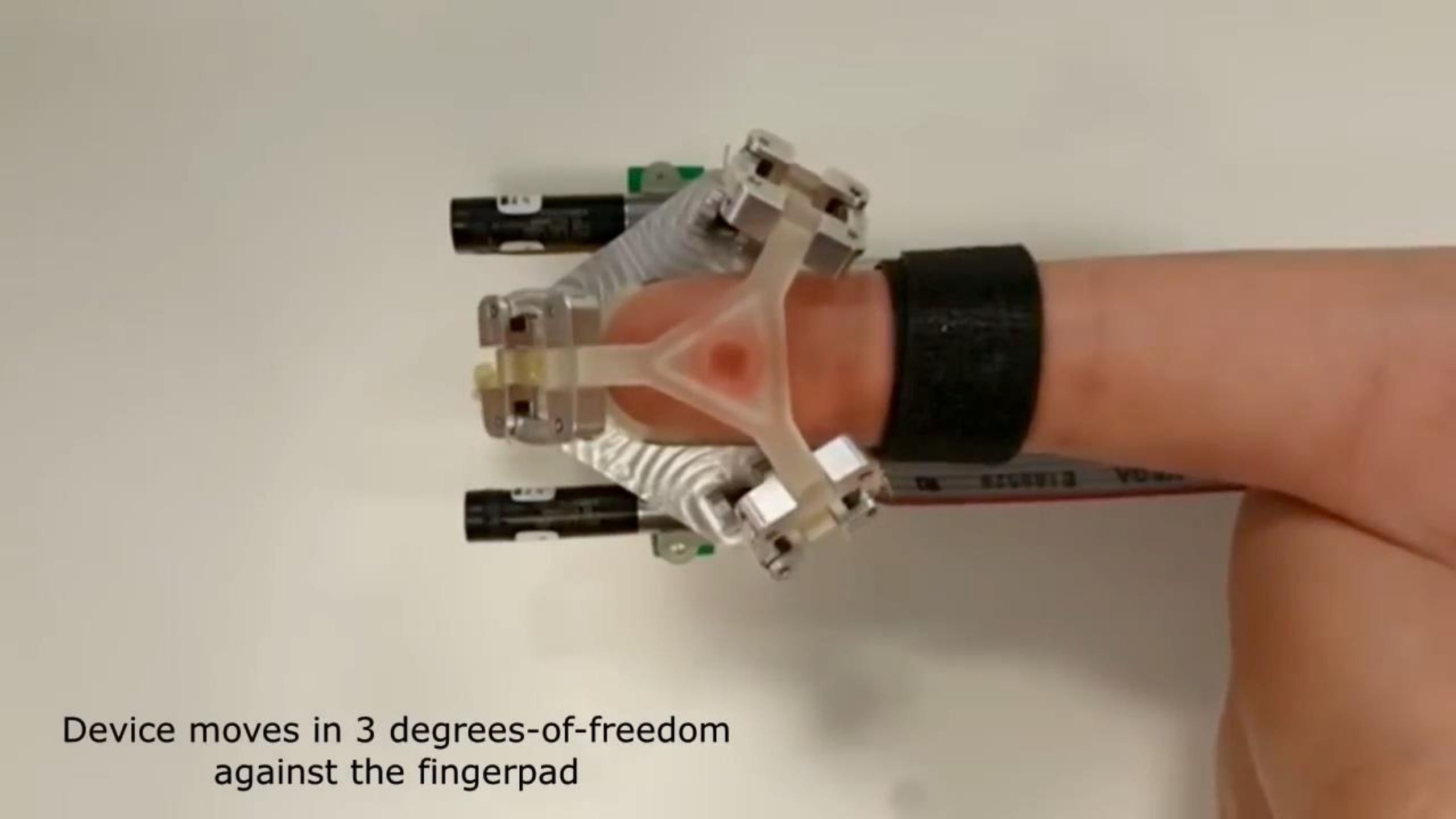
detect skin slipping (grip)

cutaneous feedback: shear forces

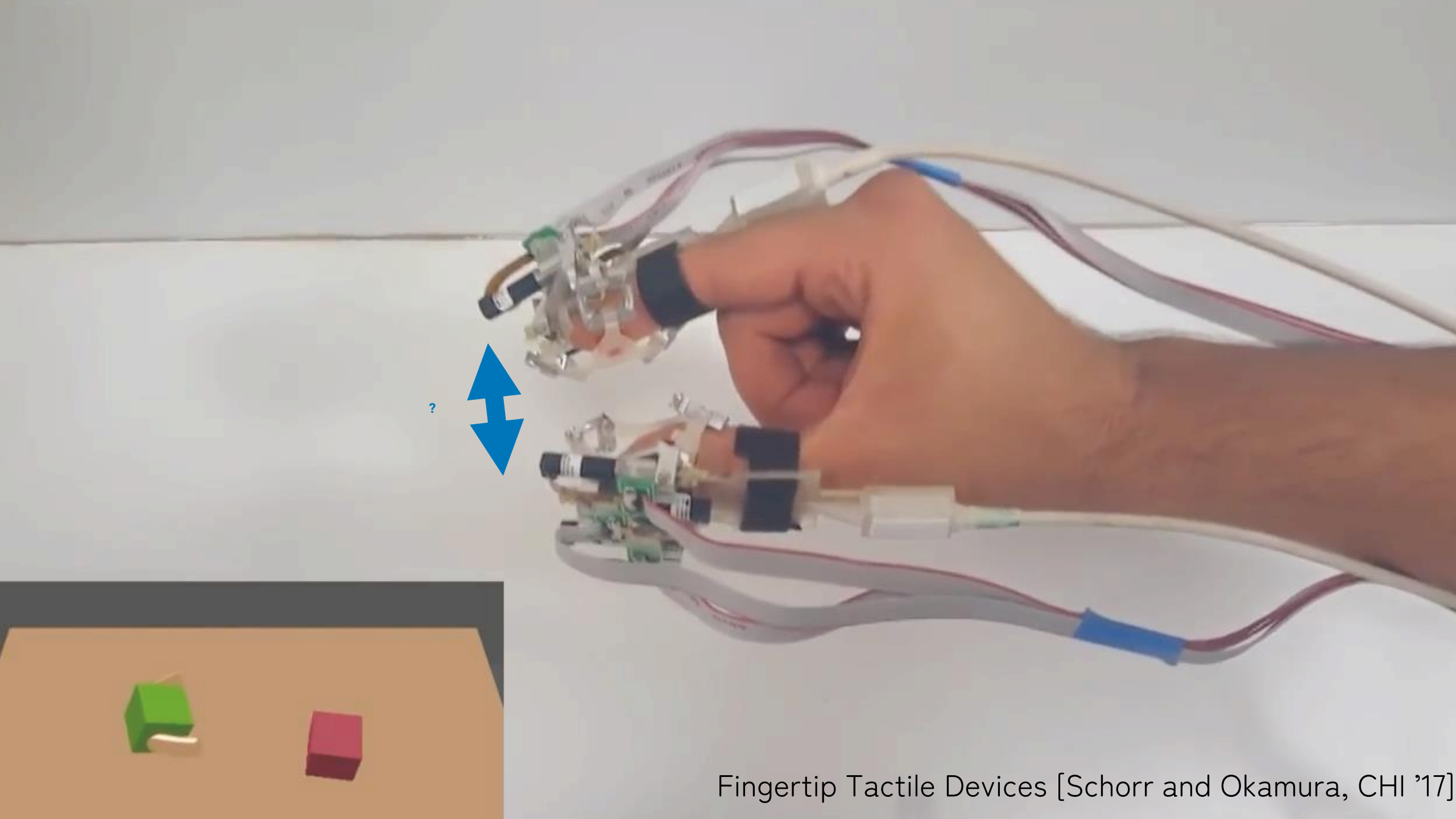


detect skin slipping (grip)

Fingertip Tactile Devices
[Schorr and Okamura, CHI '17]



Device moves in 3 degrees-of-freedom
against the fingerpad

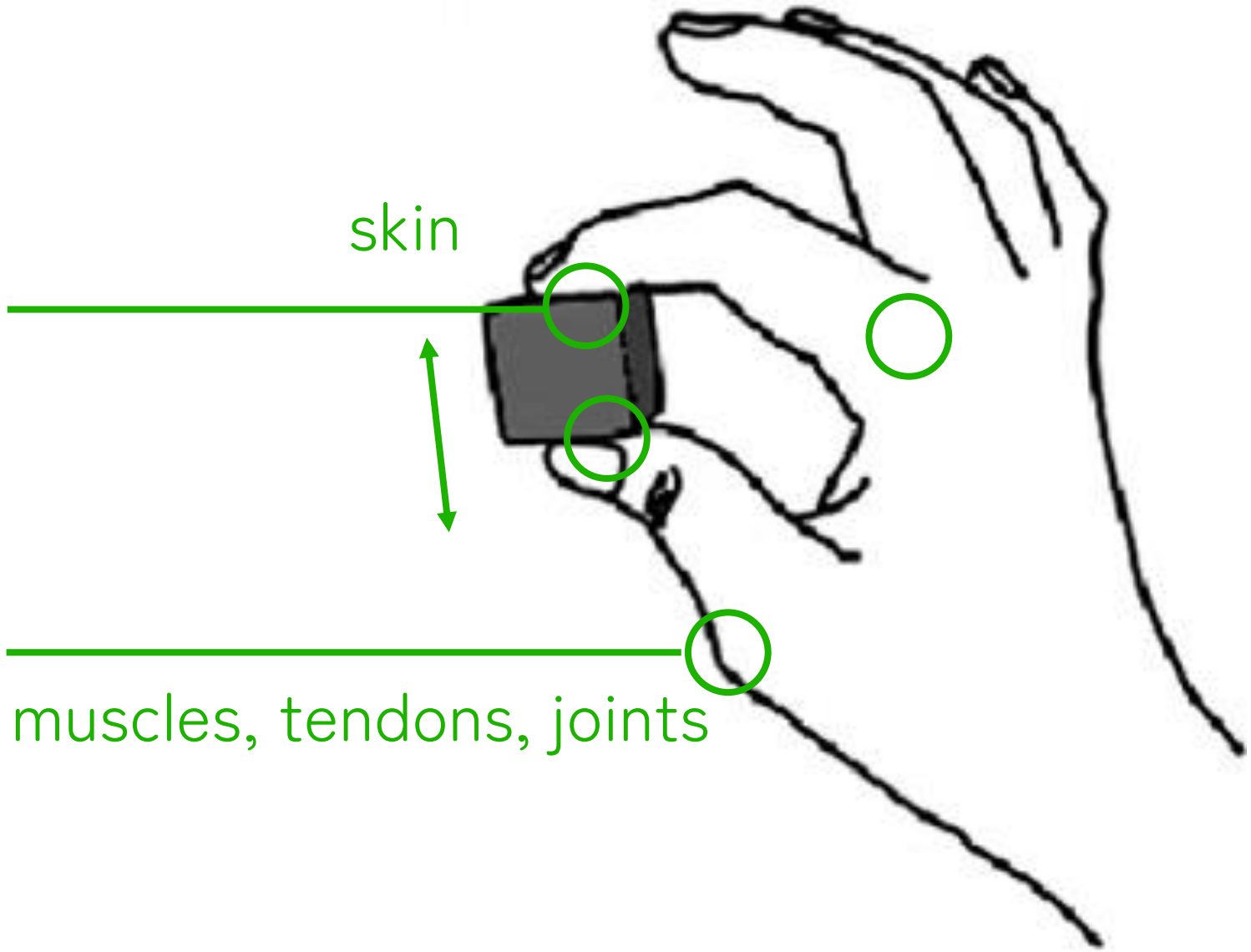


Fingertip Tactile Devices [Schorr and Okamura, CHI ’17]

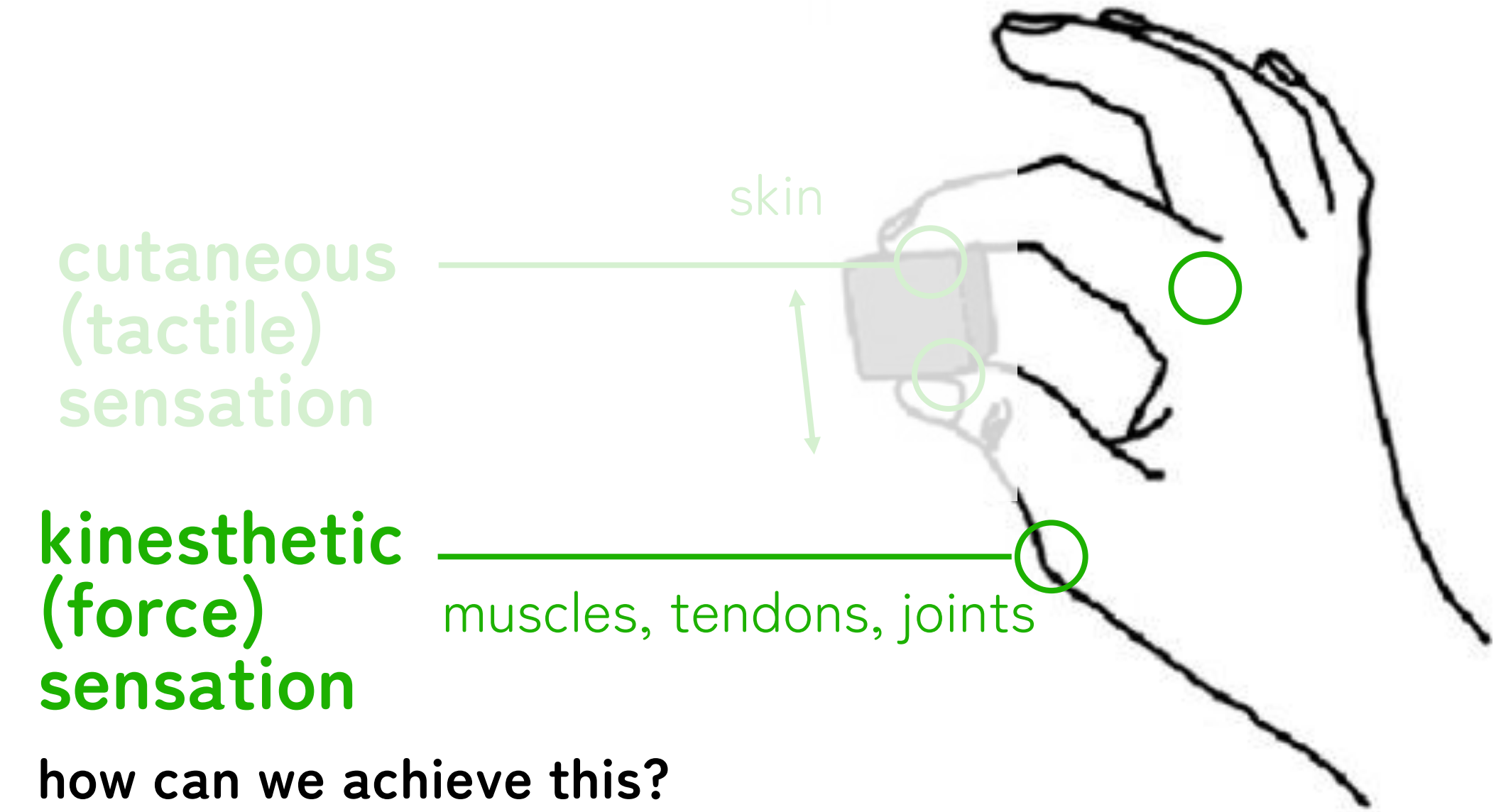
haptics

cutaneous (tactile) sensation

kinesthetic (force) sensation

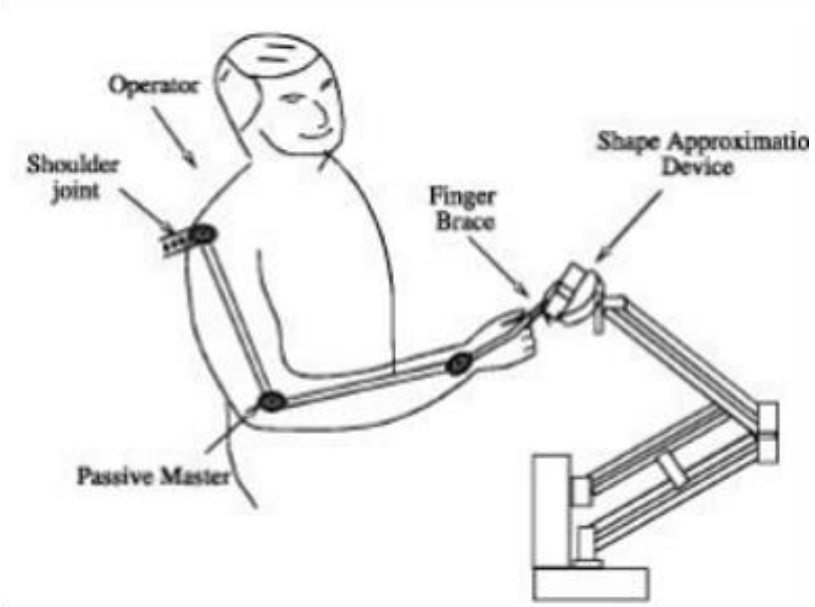


haptics

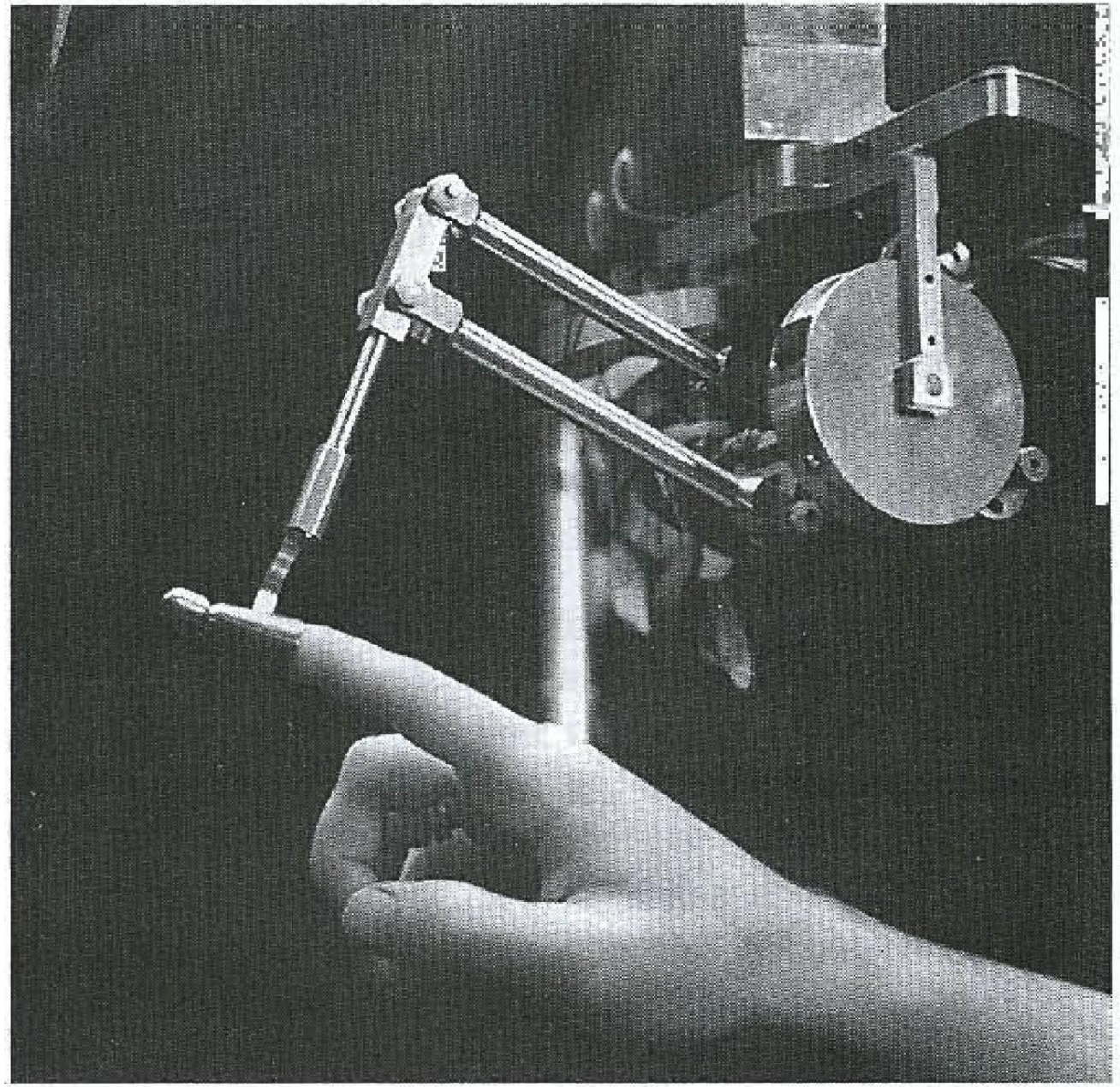


how can we achieve this?

kinesthetic feedback:
shape, stiffness

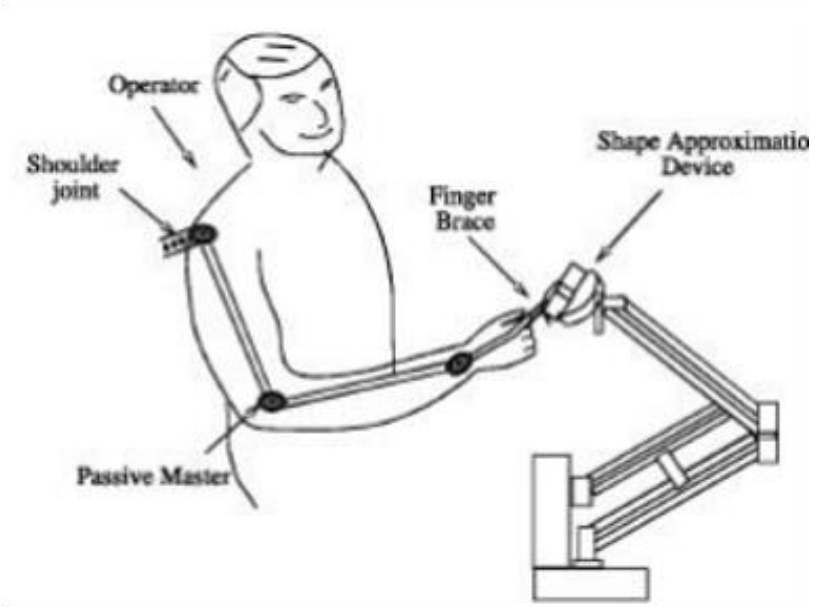


Robot Graphics [McNeely, '93]

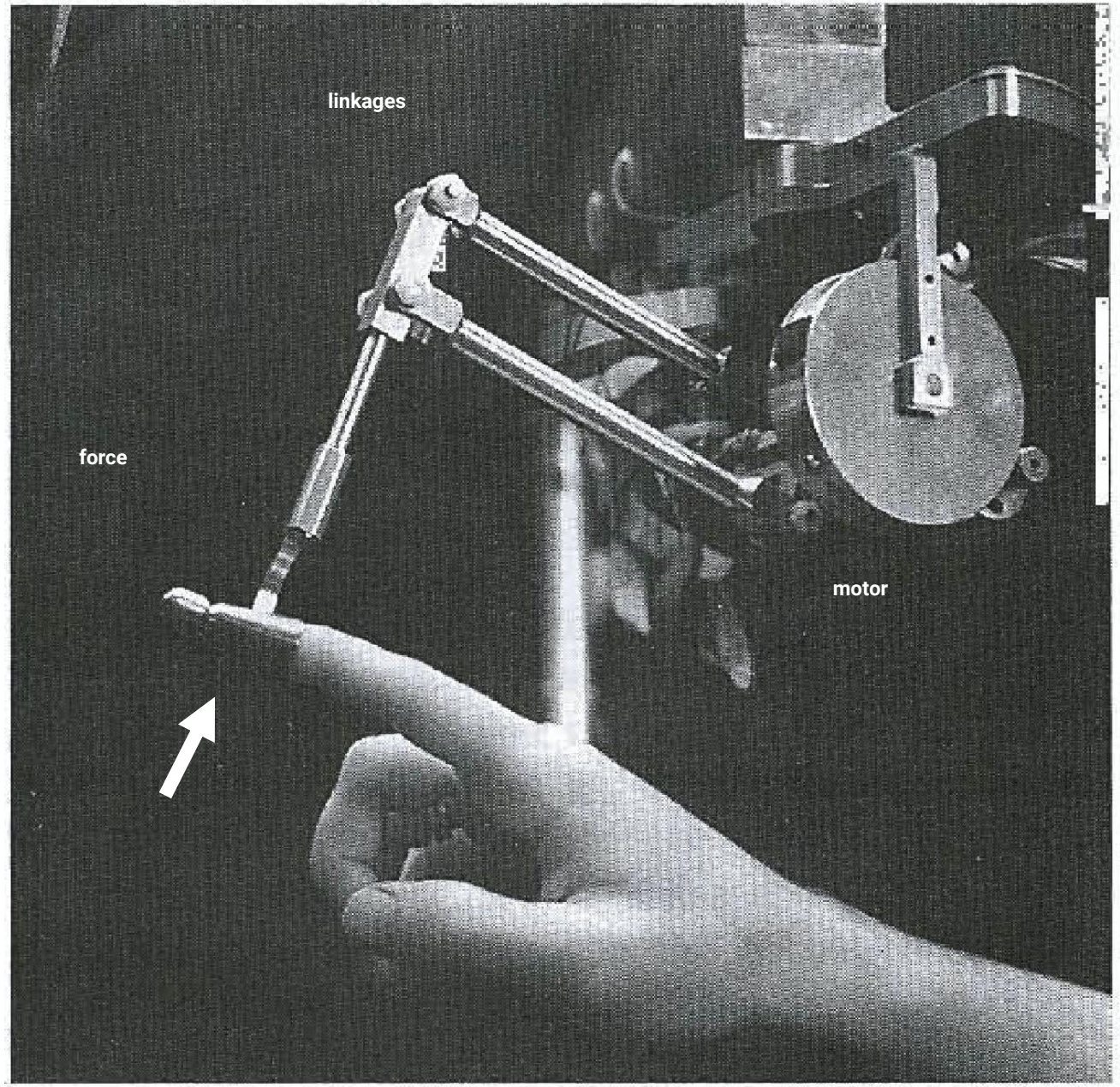


1995: PHANToM

kinesthetic feedback:
shape, stiffness

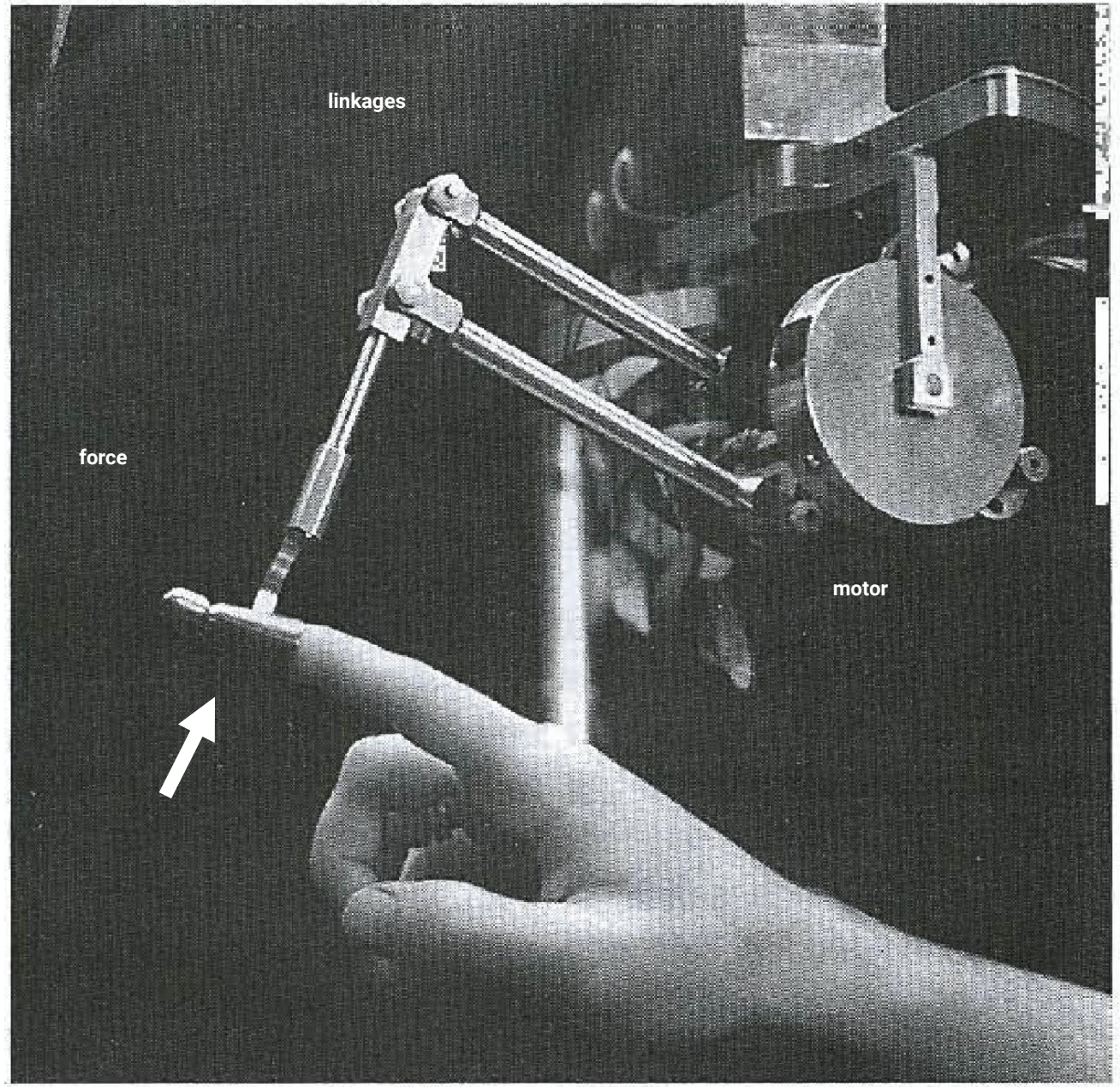


Robot Graphics [McNeely, ’93]



1995: PHANToM

kinesthetic feedback:
shape, stiffness



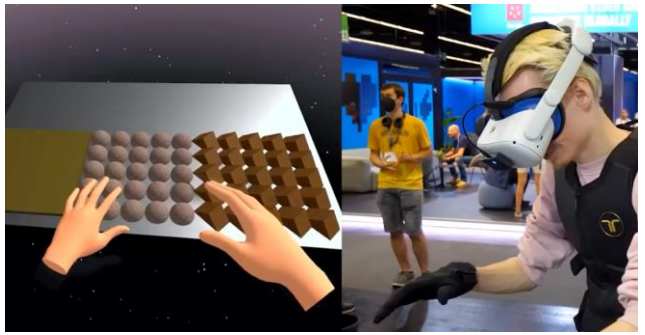
1995: PHANToM

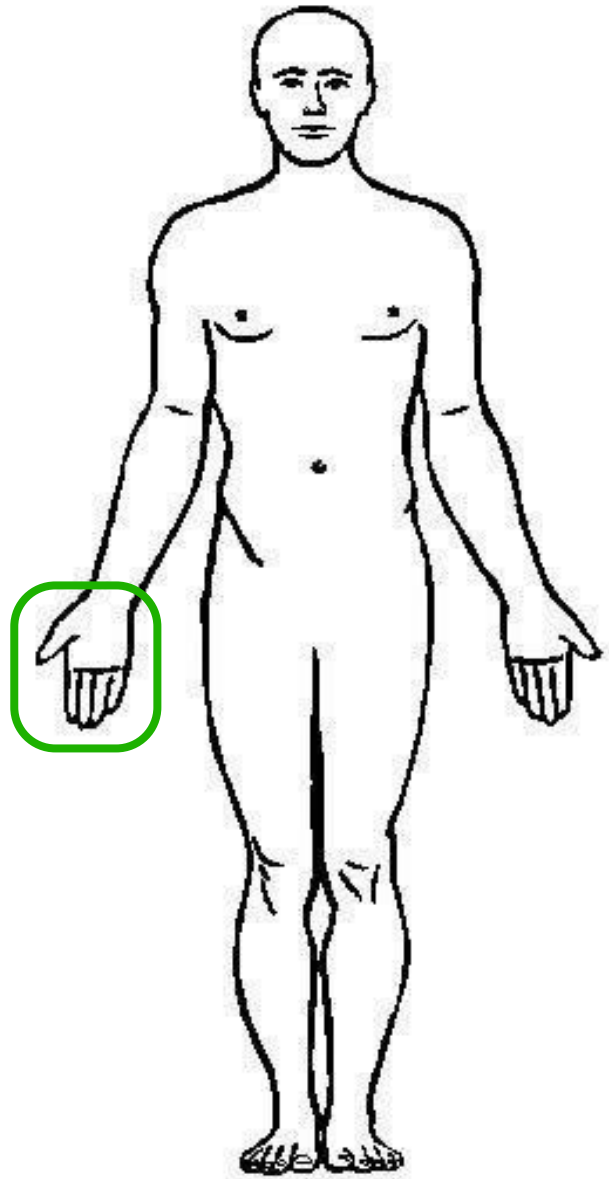
benefits of multimodal HCI:

1. efficiency
   make computers more efficient

2. usability
   make computers easier to use

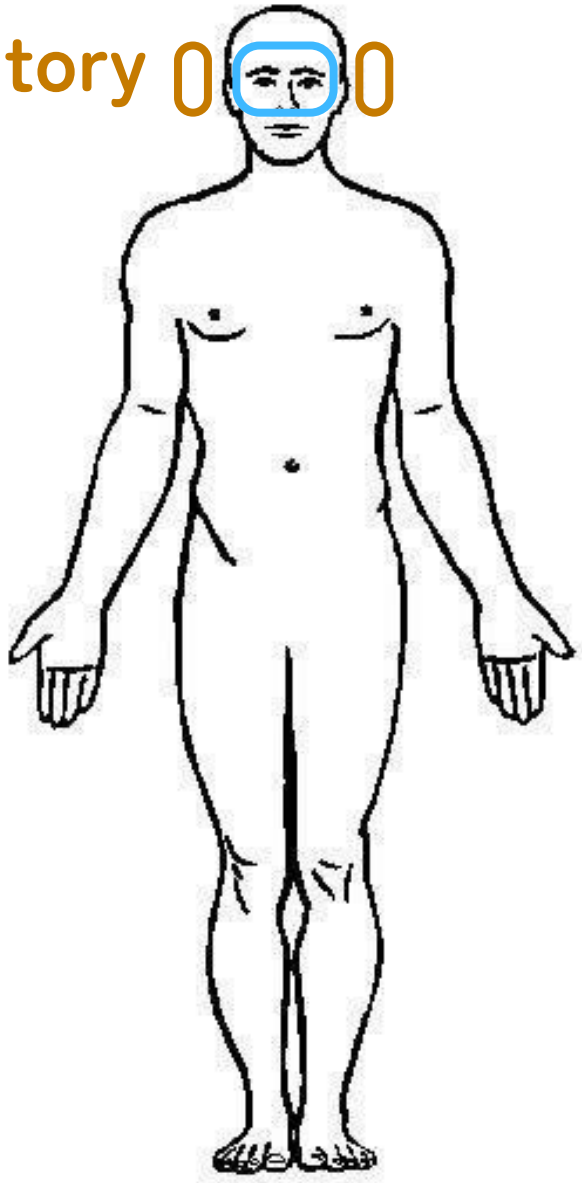
3. fidelity
   make computers feel more realistic





visual

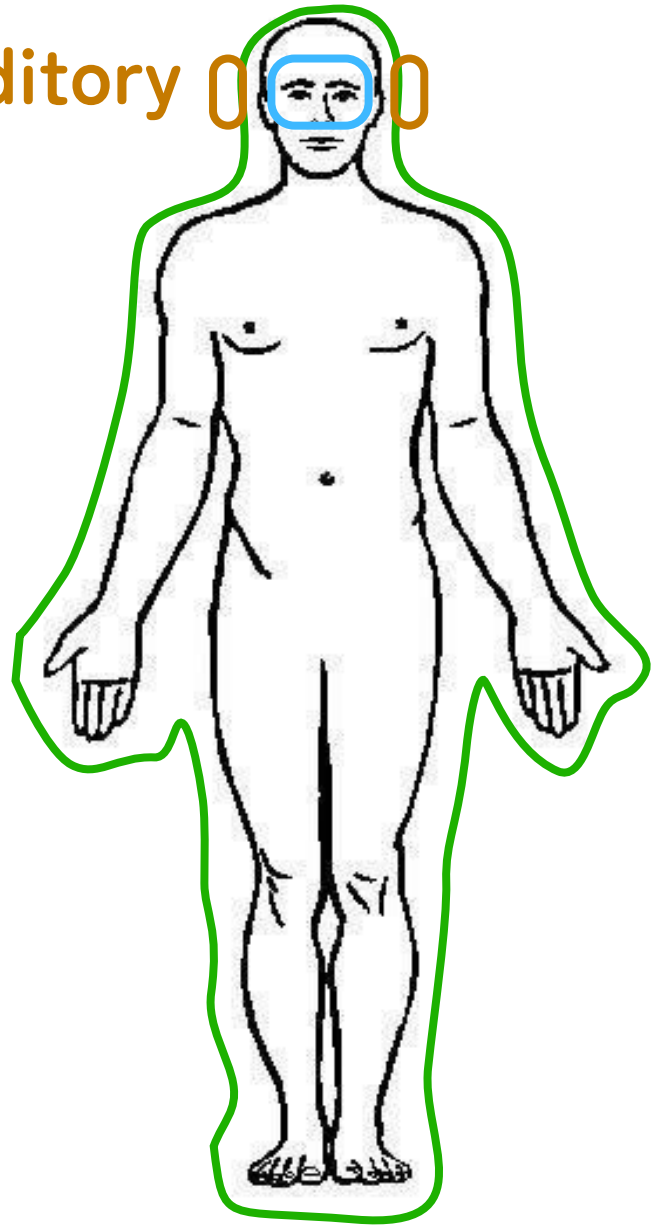
auditory



visual

auditory

haptics



assignment

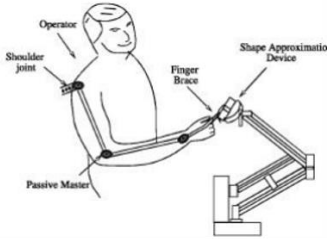
find haptics in your daily life!

STEP 1. Find an interesting haptic experience in your daily life (**take a 30-sec video to record**)





STEP 2. Analyze the sensations and search for potential technologies that can realize so (**a slide & two citations**)



Submission: NTU COOL link to Google Form
Deadline: 11/26 (Wed), 23:59
email tengshanyuan@csie.ntu.edu.tw for questions