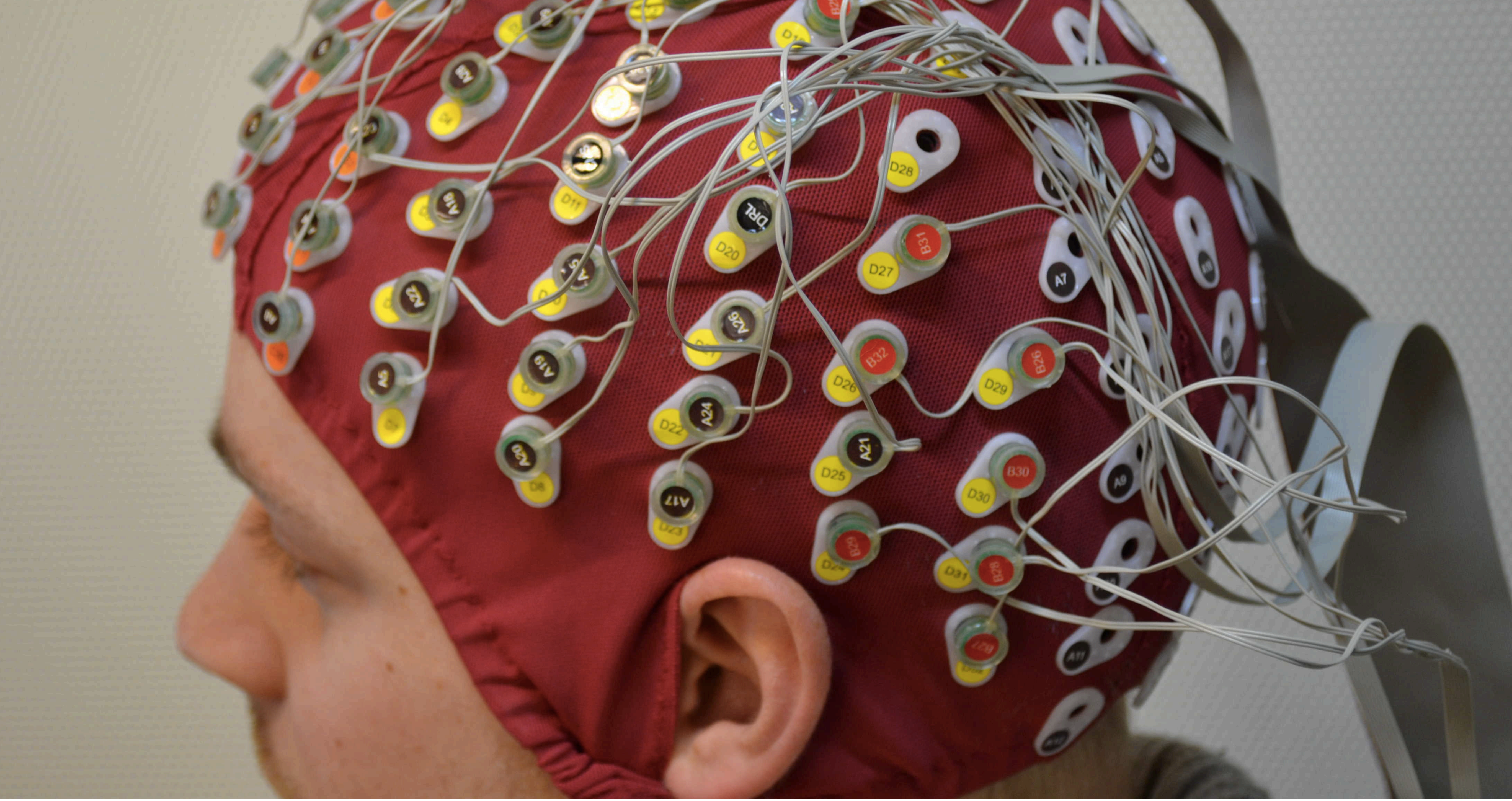


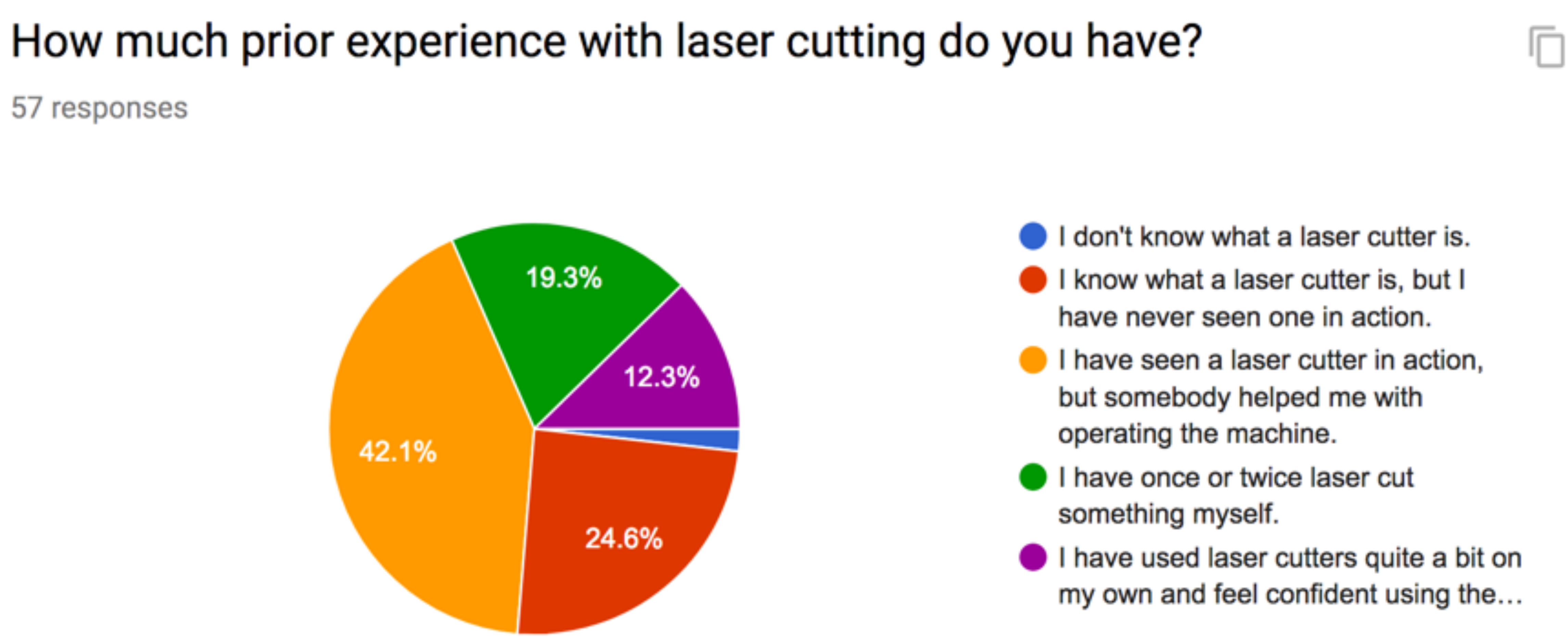
Brain Computer Interfaces

6.810 Engineering Interaction Technologies

Prof. Stefanie Mueller | HCI Engineering Group

done:

- IDC workshop training
- laser cutting (finish card until friday)
- read adaptive learning paper + form



feedback from last friday:

- merge all laser cutting pages into one
- end of class deadline caused some panic

- it was pretty packed in EDS
- (and internet was awful)

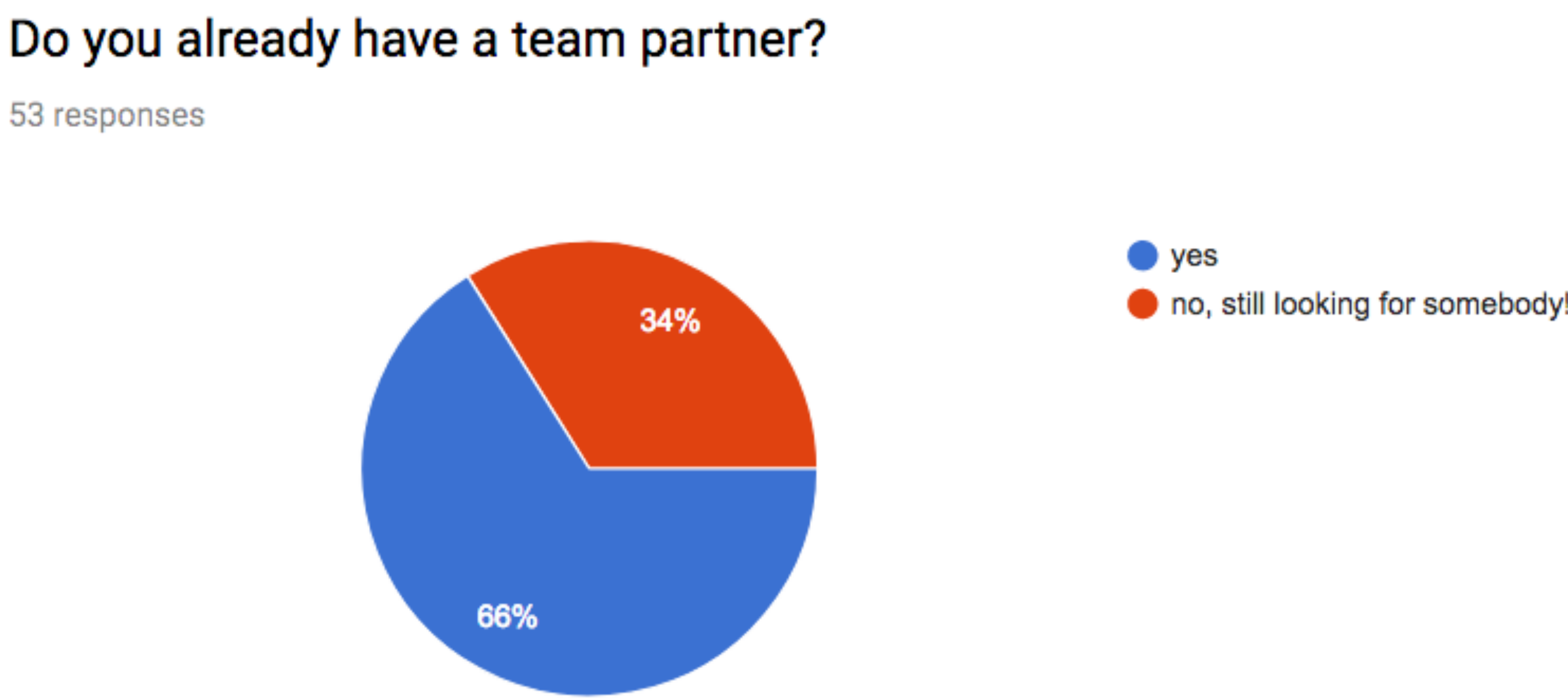
- laser cutting orientation vs. IDC orientation
- slides too low… can't see anything

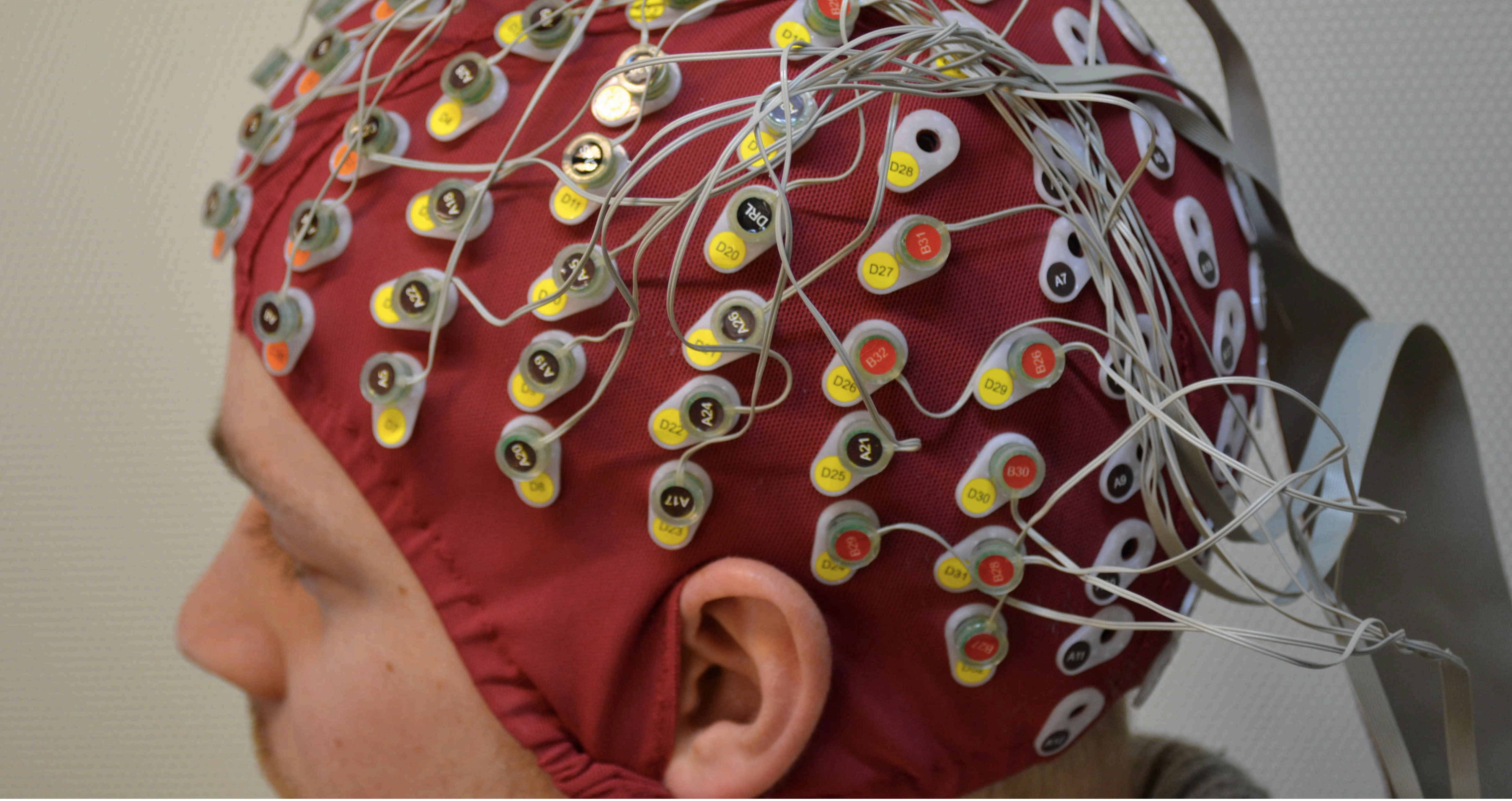

pick up project
materials you ordered
using the spreadsheet
materials for your
homework
& group project
Scissors
DO NOT TOUCH
DO NOT TOUCH
DO NOT TOUCH
DO NOT TOUCH

materials

today:

- lecture
- info for friday (3D printing) & next week
- 10 min to find a team partner





Brain Computer Interfaces

6.810 Engineering Interaction Technologies

Prof. Stefanie Mueller | HCI Engineering Group

the body as an interface::

1. **brain computer interfaces**
2. muscle computer interfaces
3. implanted interfaces

#1

brain computer interfaces

brain computer interface ::

interacting directly using **"thought"**

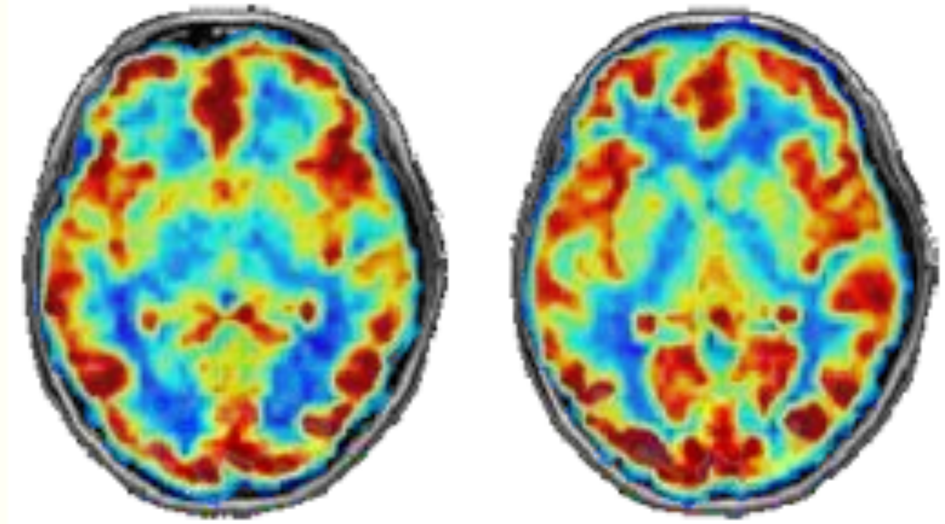
what does that even mean?

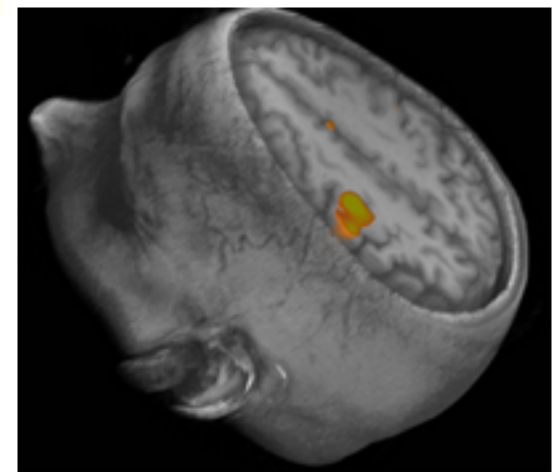
can we sense thoughts?
how would you do it?

<30s brainstorming>

sensing ‘thought’:

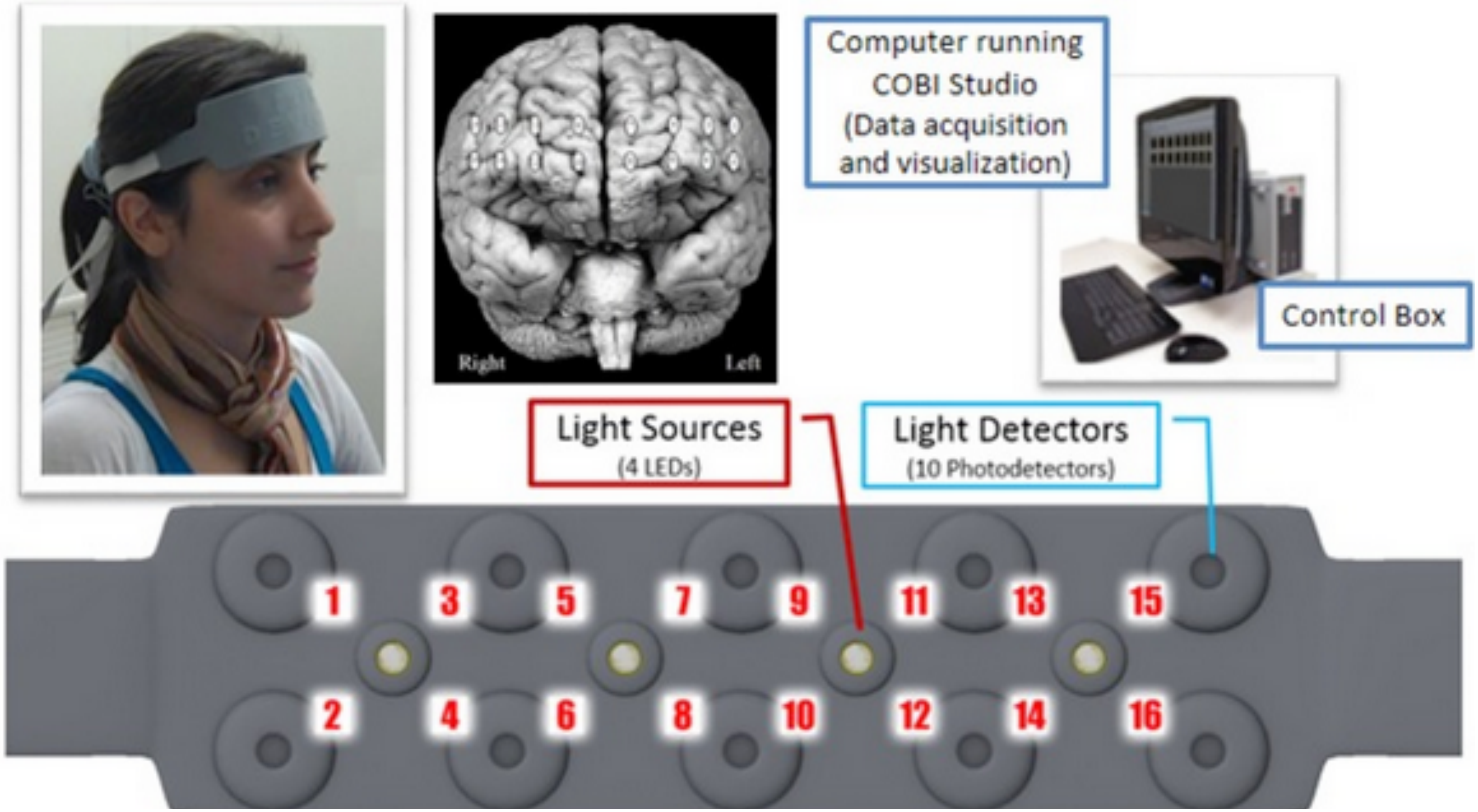
- **magnetic** resonance (fMRI)
- **near-infra-red** spectroscopy (fNIRS)
- **electro-**encephalography (EEG)

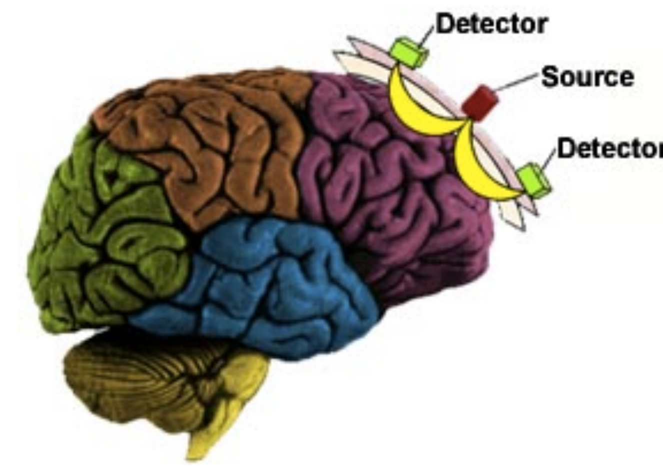




magnetic resonance (fMRI)

- blood flows in the brain
- **neural activity increases -> more oxygen is in the blood**
- oxygen rich vs. -poor causes different **magnetic properties**
- measure magnetic field changes in the brain
- pro/con: can measure deep inside brain, but large setup





near infrared-spectroscopy (fNIRS)

- **neural activity increases -> more oxygen is in the blood**
- oxygen-rich vs. -poor causes different **optical properties**
- i.e. more or less absorbed light in near-infra-red spectrum
- pro: small setup, cheap
- con: mean penetration depth: ca. 23mm
- con: depends on sensor position on head

electro-encephalography (EEG):

- electric activity: neurons communicate with electrical impulses
- measuring **neurons firing in the brain to exchange signals**
- electrodes on the head measure the electric field
- pro: high time resolution
- con: low spatial resolution

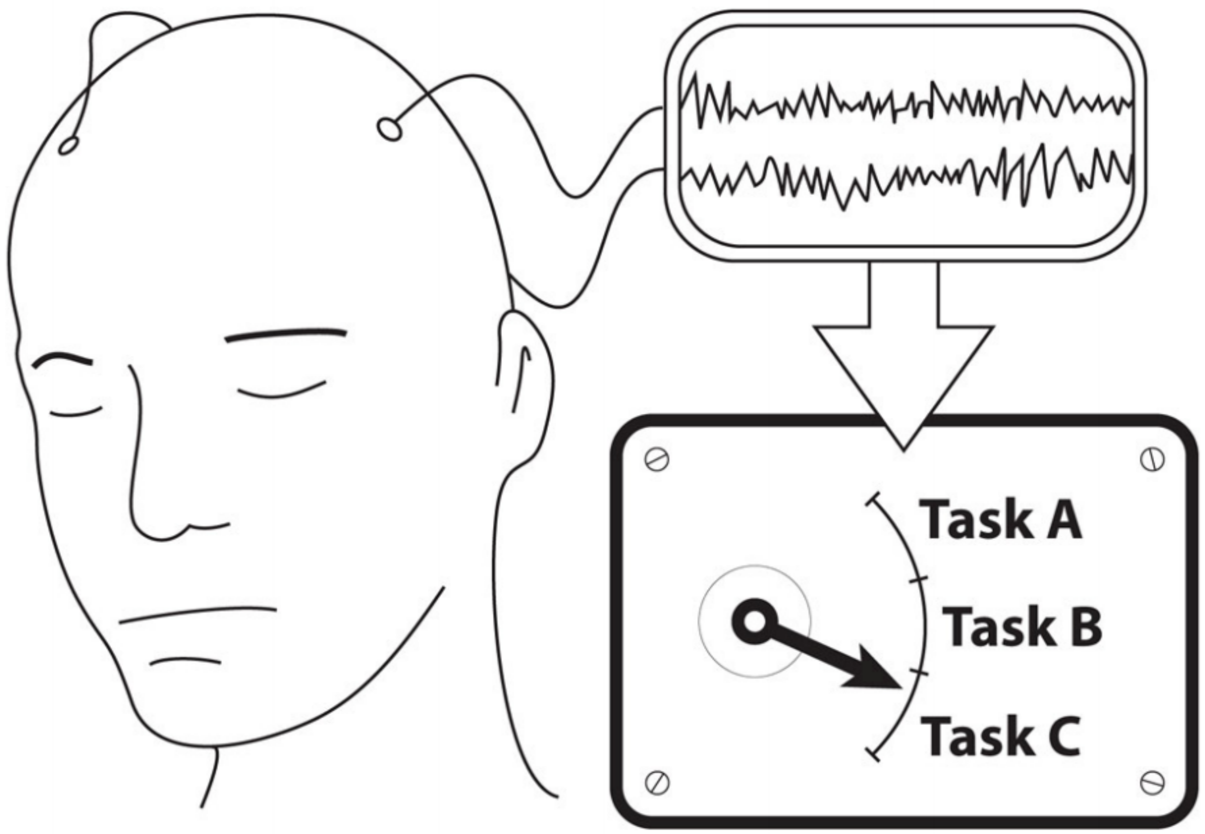
sensing 'thought':

- **magnetic** resonance (fMRI)
- **near-infra-red** spectroscopy (fNIRS)
- **electro-**encephalography (EEG)

so are we measuring **thoughts** or not?

<30s brainstorming>

no, we **measure signals**
and **extract features** from them.



and then **match the result** with
a certain task (or ‘thought’)
(based on known training data)

when did BCI research start?

1924: Hans Berger:
first human EEG (but no real time analysis)

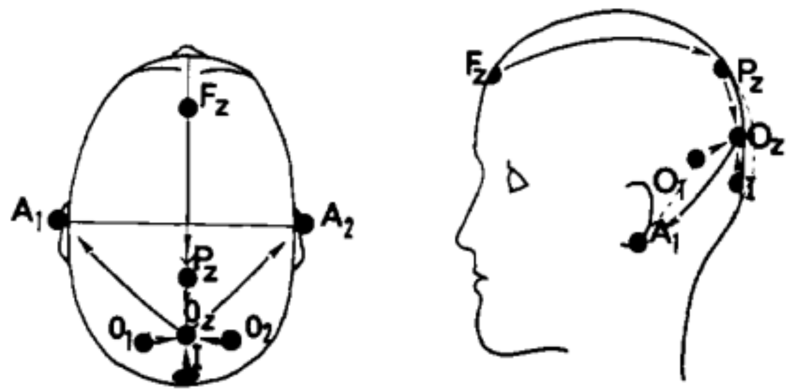


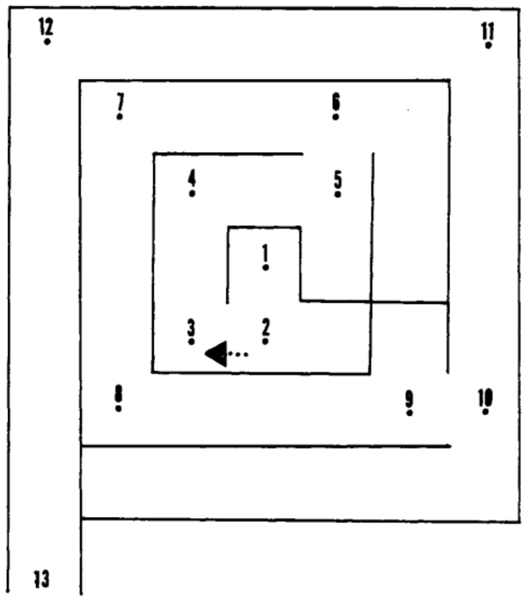
Fig. 3. Electroae locations in pattern experiments. Electrodes are applied at five scalp locations and to the connected ears. The ERP data is collected from the occipital and parietal areas with four bipolar channels: P_z-O_z, O1-O_z, O2-O_z, I-O_z and one monopolar channel (to the ear reference): O_z-A. The frontal electrode is used for artifact detection only (F_z-P_z).

The experiment campaign conducted in our laboratory with visual evoked responses involved single epoch classification in real-time, i.e., the identification for each epoch of the value or class of the input stimulus. Stimulus parameters included flash intensity and color, background intensity and color (retinal adaptation) and finally pattern shape. The real-time paradigm in every case lead to a nontrivial elaboration of the experiment design.

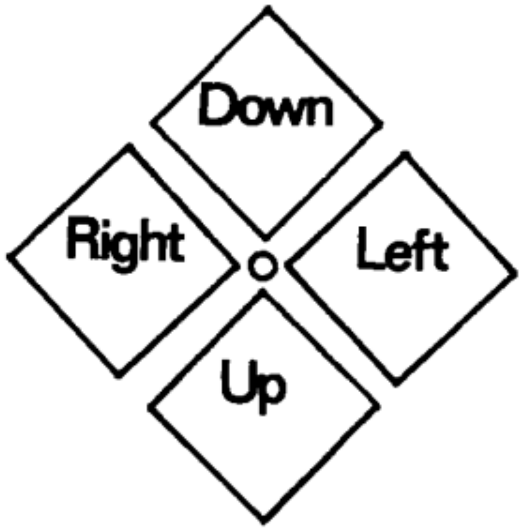
IV. Example of Experiment Design

One of these experiment series, dealing with parafoveal pattern stimuli, will be briefly described here to illustrate the general paradigm.

Subjects are seated in a shielded room, in front of a multiple



(a)

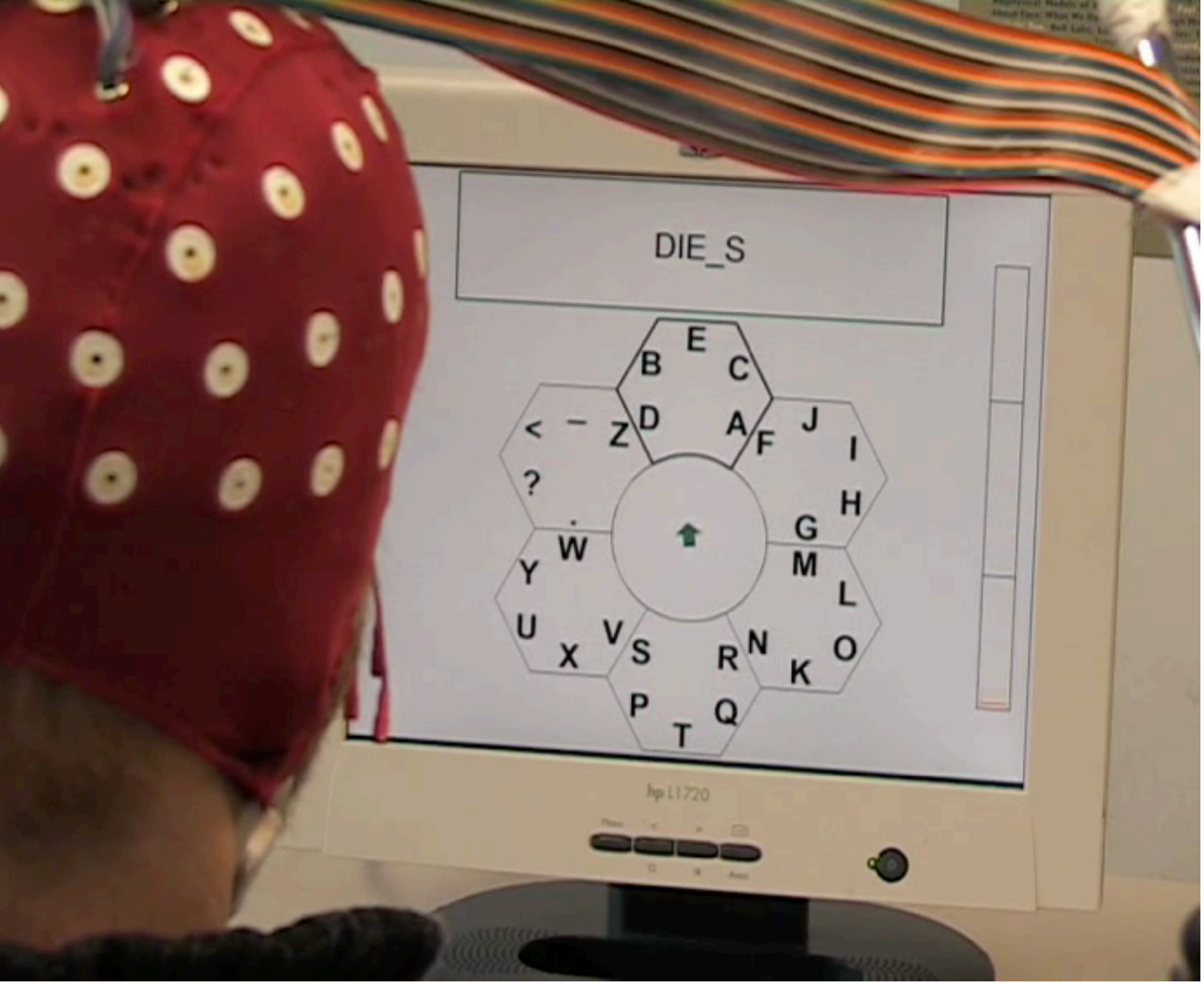


(b)

Fig. 4. Stimulus target in real-time visual ERP experiments. The target consists of a fixed diamond shaped red cherckerboard illuminated with a xenon flash to provide visual stimulation. (a) The four

1977: Jaques Vidal
'Real-time detection of brain events in EEG'

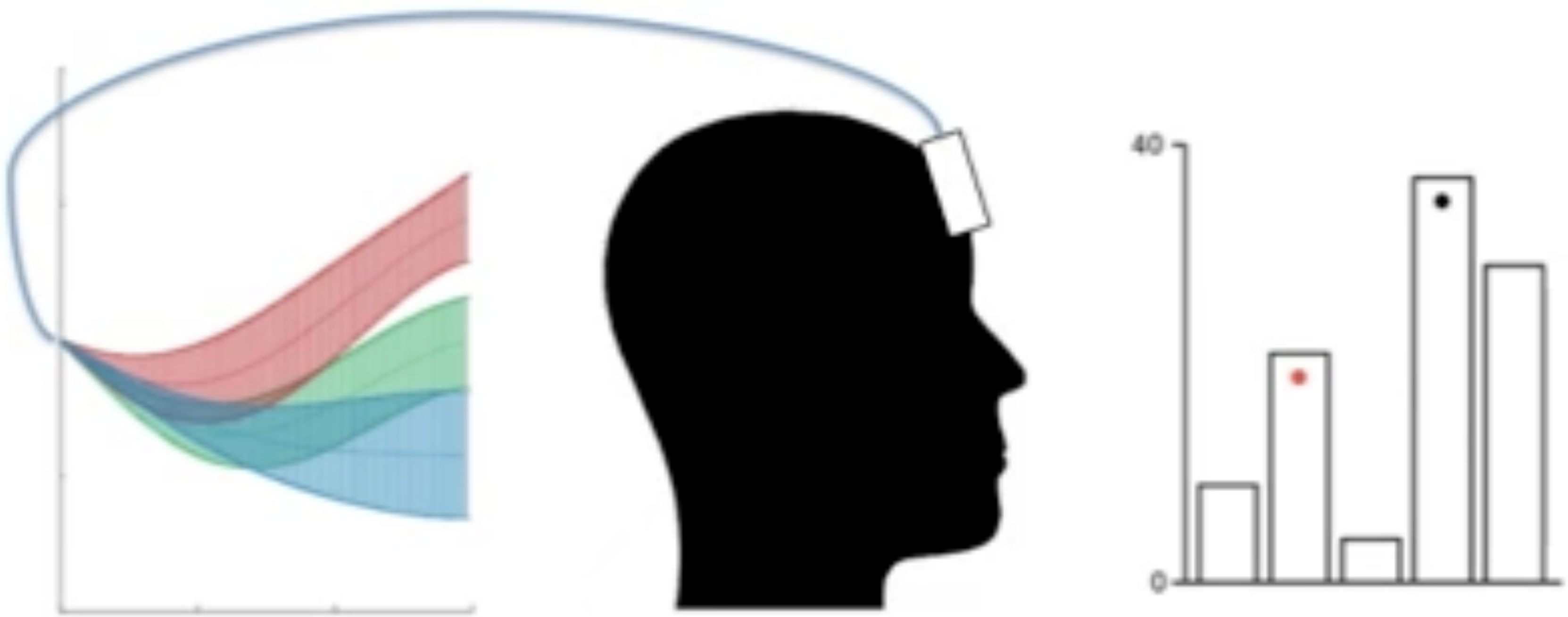
current applications
for brain sensing…



helping people with **disabilities**

Samek et al. Stationary Common Spatial Patterns for Brain-Computer Interfacing, Journal Neural Engineering '12.

Using fNIRS Brain Sensing to Evaluate Information Visualization Interfaces



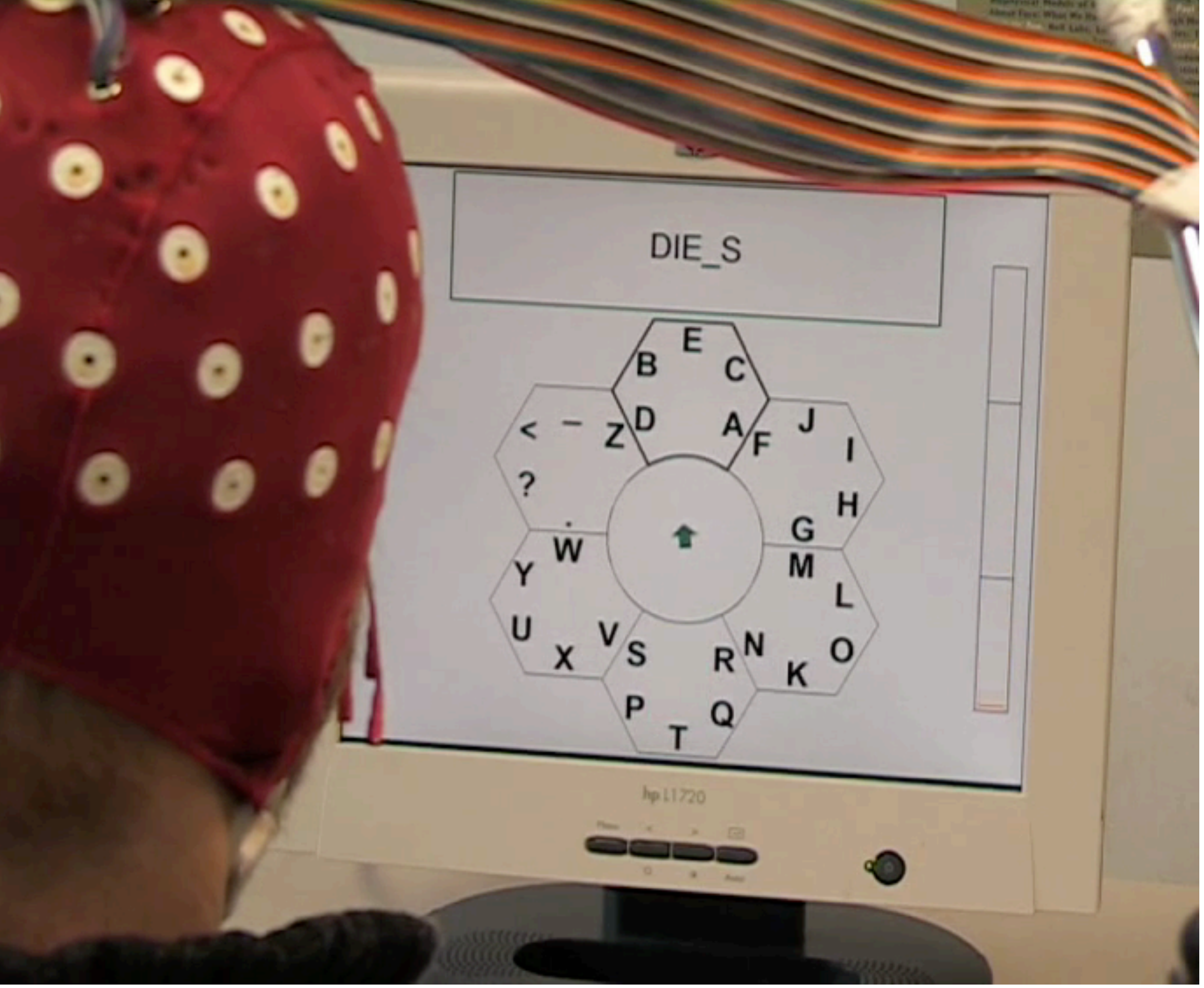
Evan M Peck . Beste F Yuksel . Alvitta Ottley
Robert JK Jacob . Remco Chang
Tufts UNIVERSITY

user interface evaluation:
more direct feedback than when interviewing users

Evan Peck. Using fNIRS Brain Sensing to Evaluate Information Visualization Interfaces, CHI'13

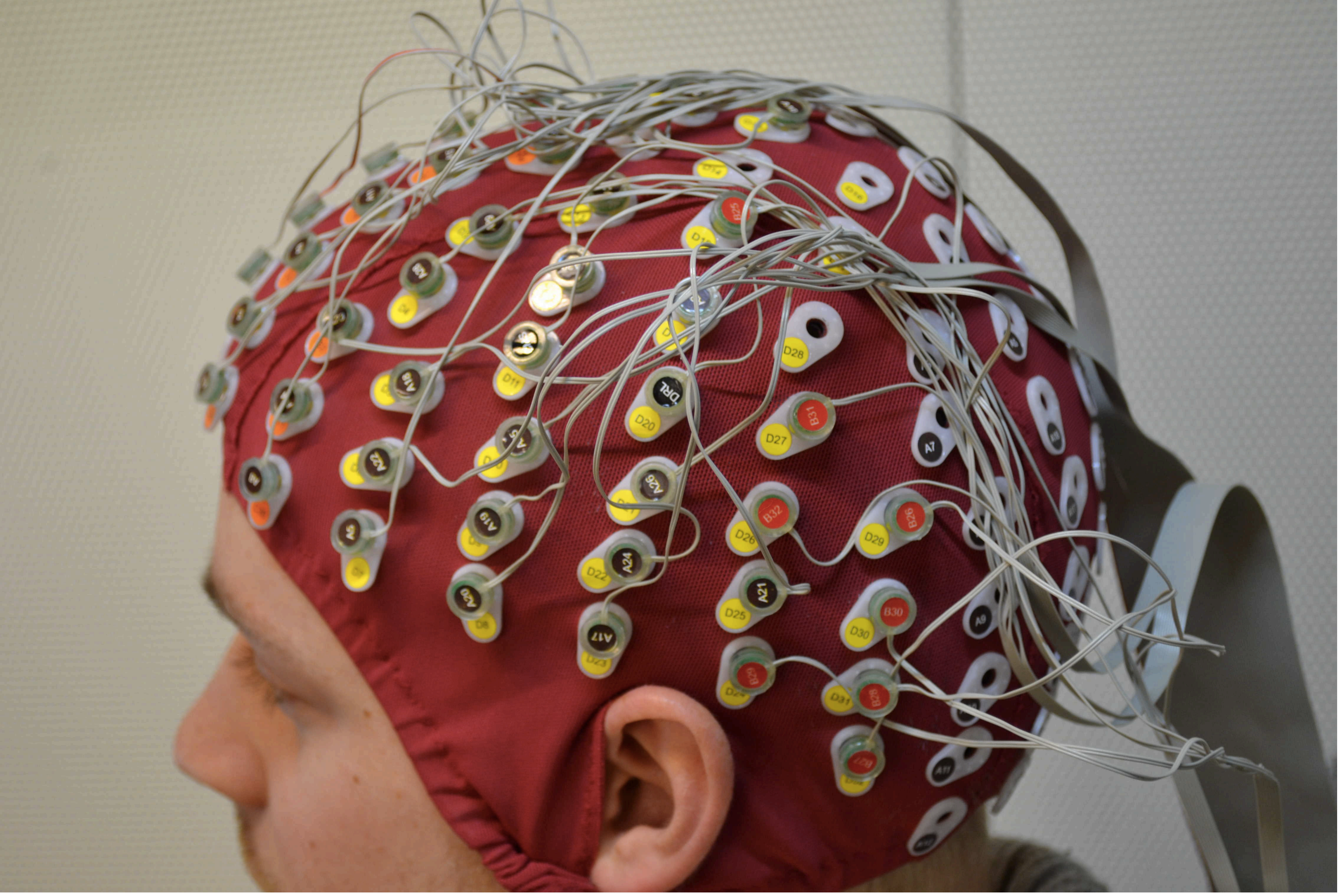
games and entertainment

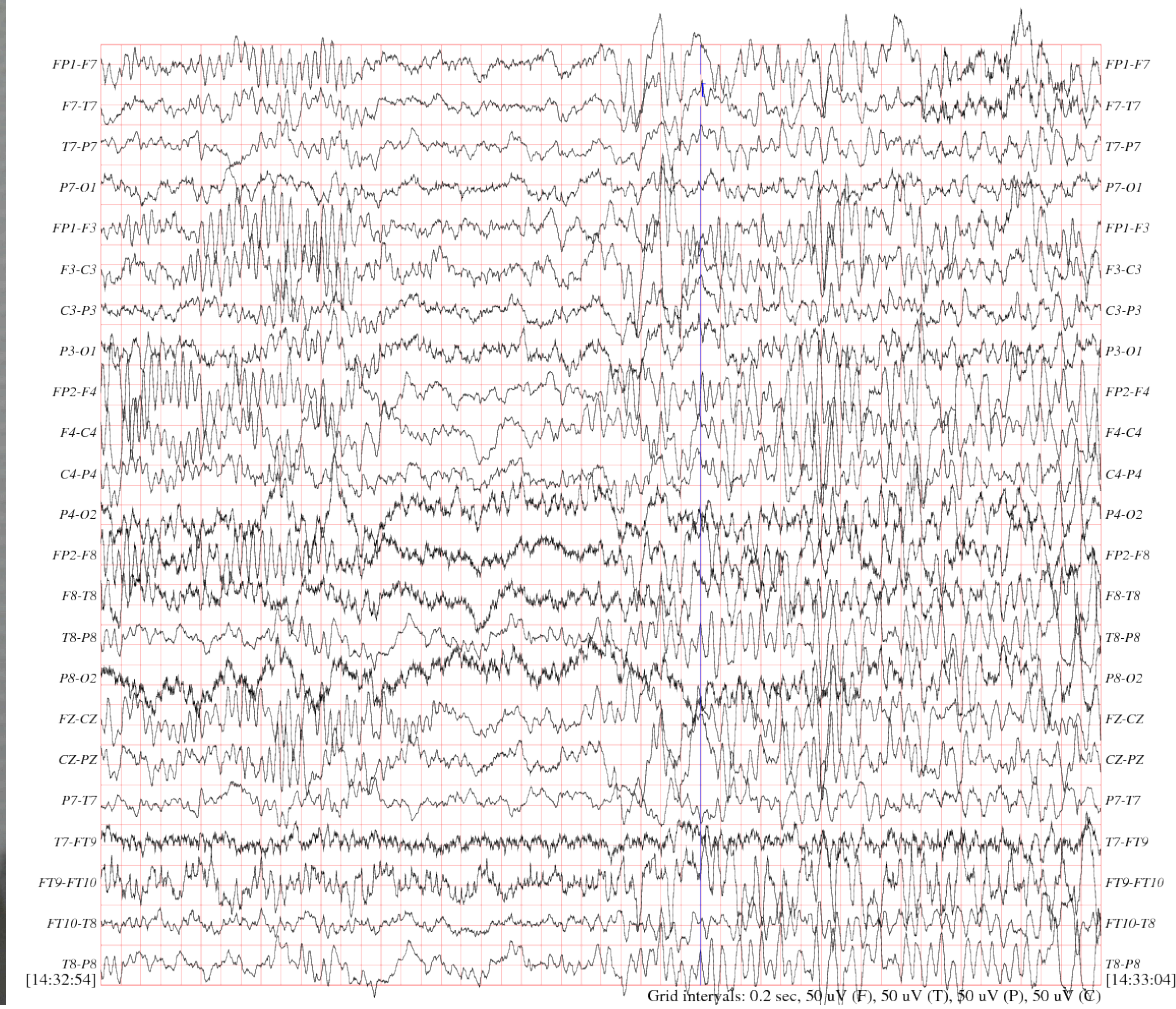
limitations
of brain-computer interfaces



so **slow?**

what is the problem here?





electrodes = camera of the brain
one electrode = one pixel

you **need a lot of data** to find a good signal
(‘collection over time’)

latest progress in imaging of the brain::

if BCI worked perfectly,

would we use BCI for all interaction?

<30s brainstorming>

motionless: nothing wrong with moving

affordance: gestures are (very) natural

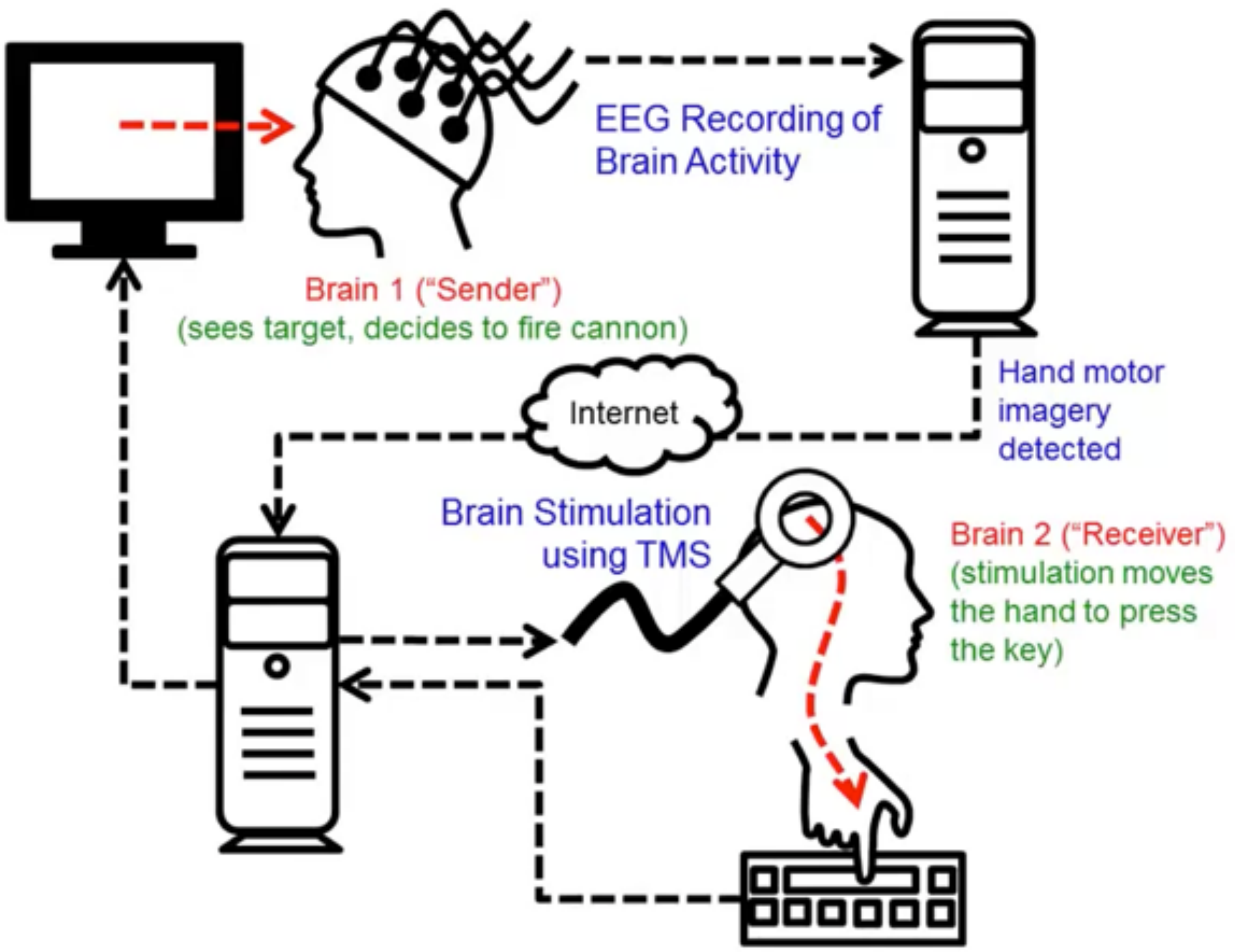
cannot stop thinking! midas touch problem

(king turns everything into gold,
even his daughter)

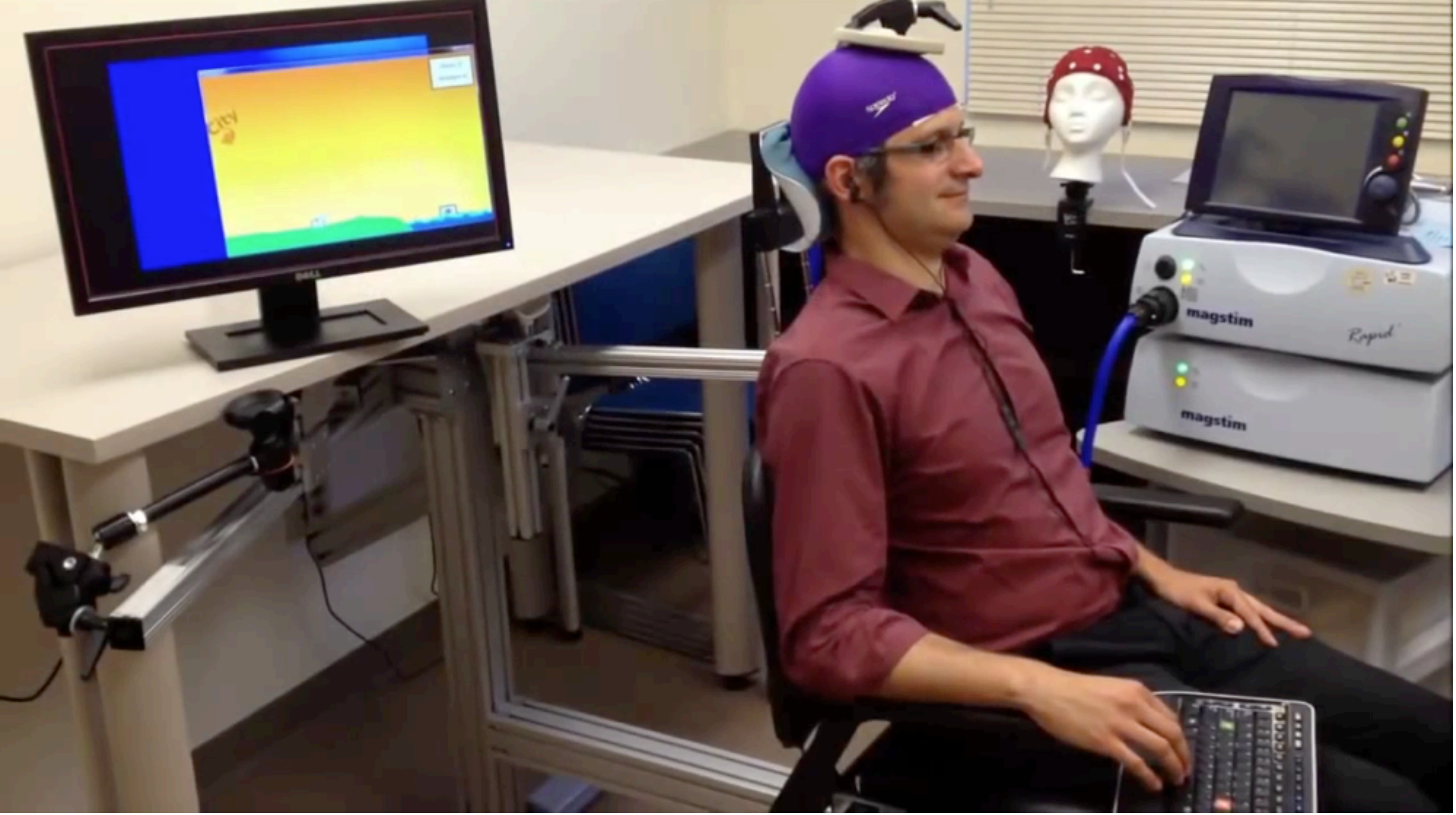
so we have brain **sensing…**

how about **actuation?**

brain-to-brain stimulation::



2013: Rajesh Rao sent a brain signal to Andrea Stocco



2013: Rajesh Rao sent a brain signal to Andrea Stocco

sensing ‘thought’:

- **magnetic** resonance (fMRI)
- **near-infra-red** spectroscopy (fNIRS)
- **electro-**encephalography (EEG)

actuating ‘thought’:

- transcranial **magnetic** stimulation (TMS)

uses a coil which induces small currents into the brain via electromagnetic induction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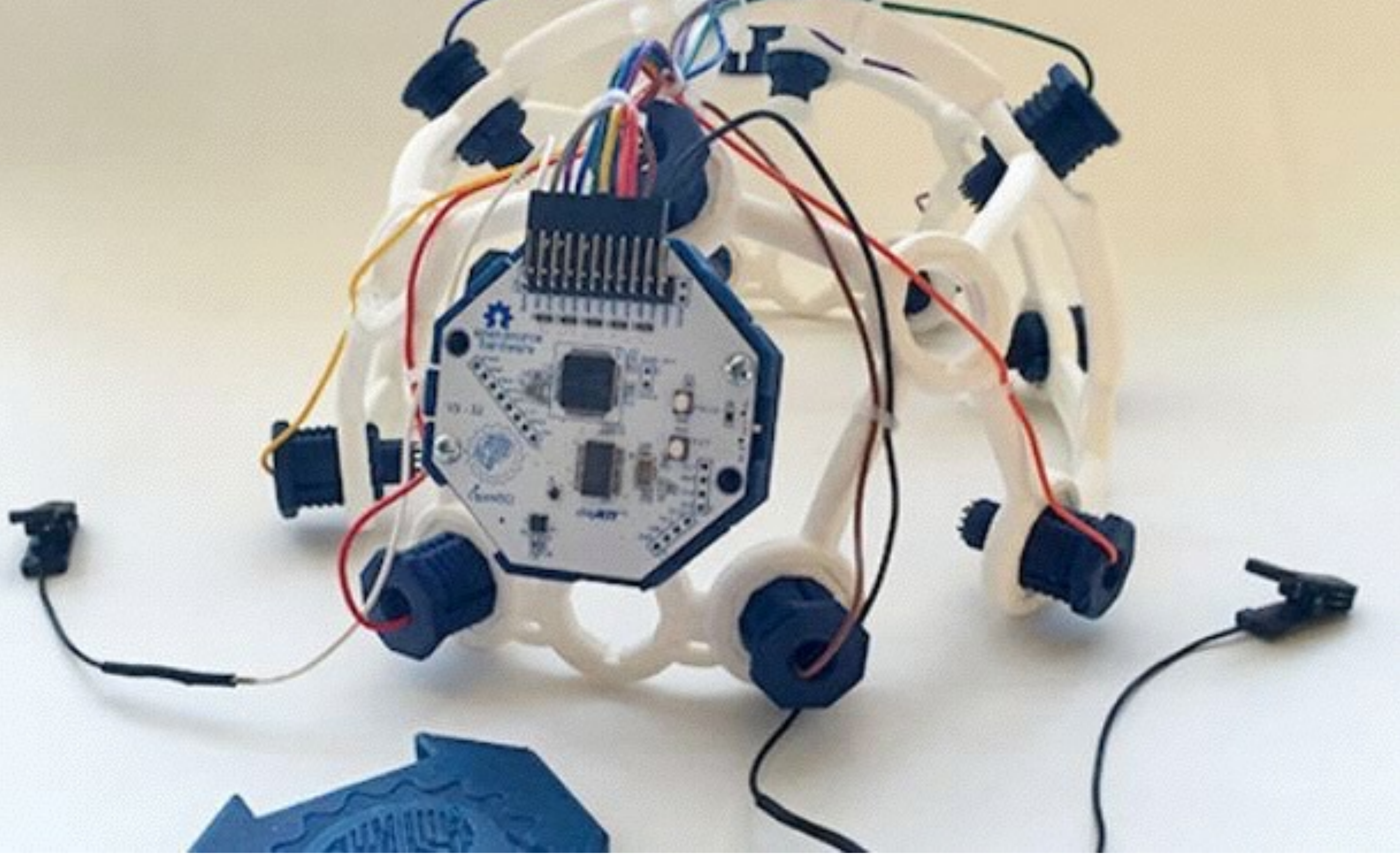


OpenBCI (EEG)

the body as an interface::

1. brain computer interfaces
2. **muscle computer interfaces**
3. implanted interfaces

#2

muscle computer interfaces


the creators project

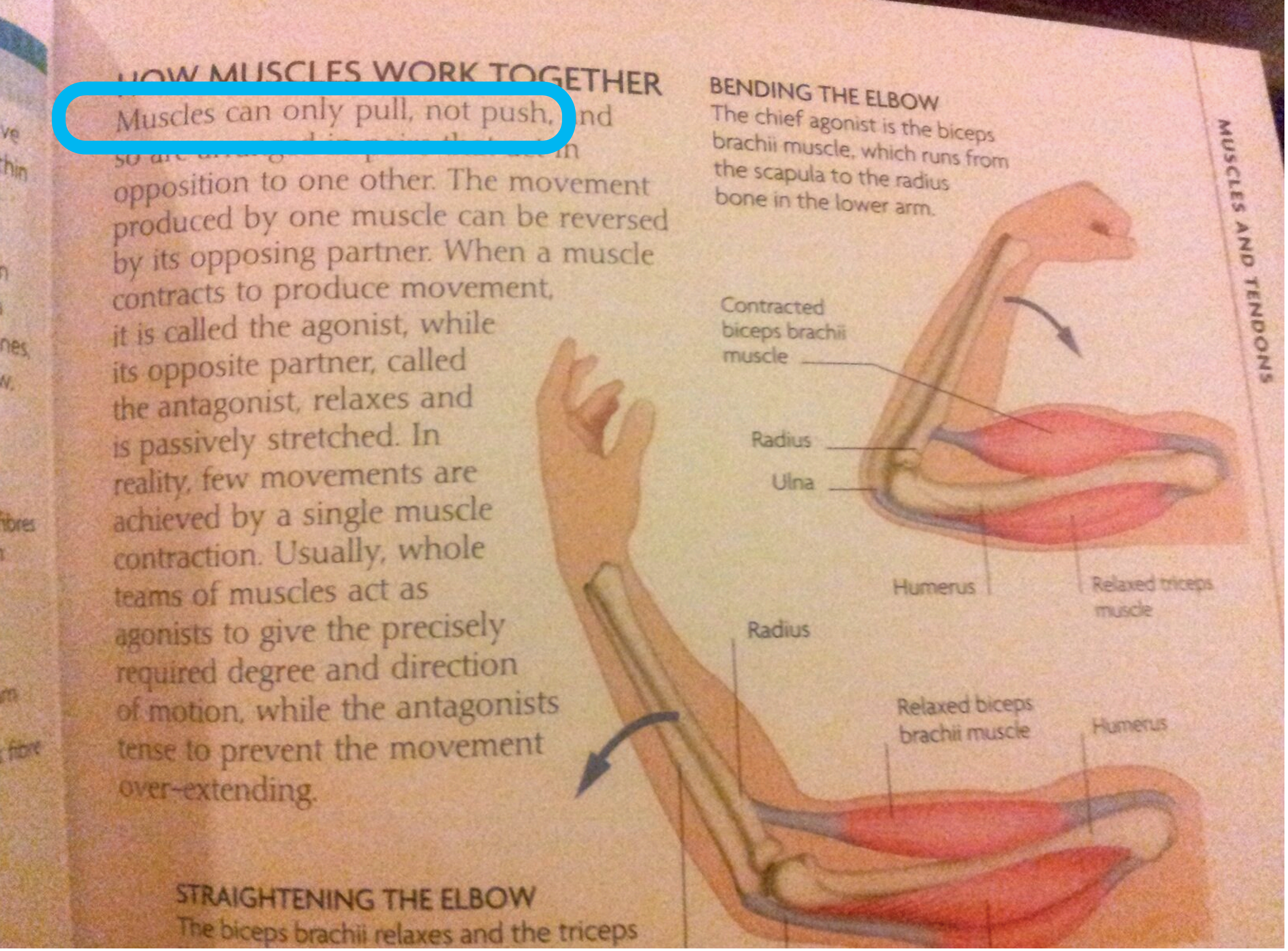
where could this lead?

what would you do with the ability to move sb else's muscles?

<30s brainstorming>

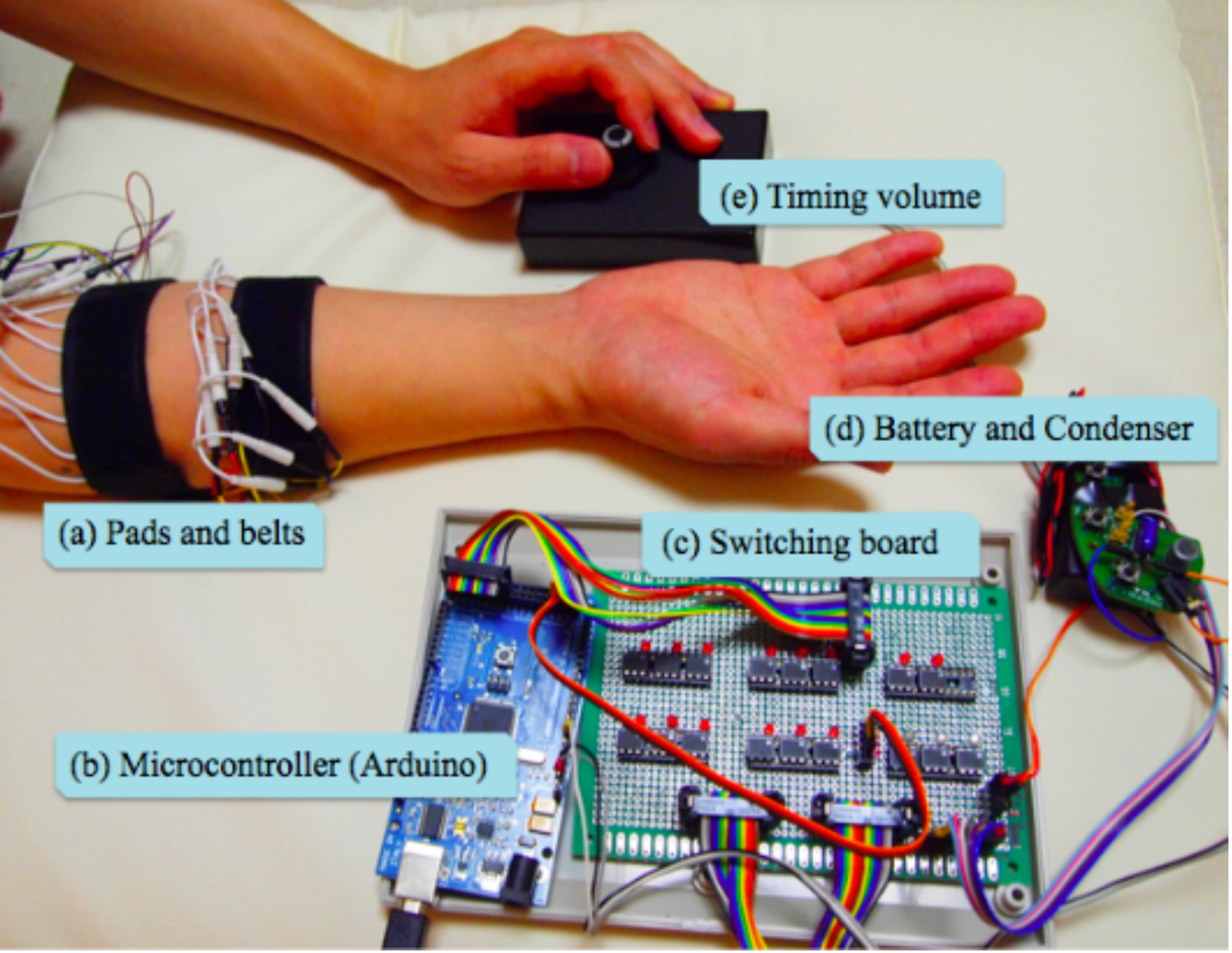
electro-muscle stimulation (EMS):

- current applied to muscle activates ‘muscle neurons’
- originated in rehabilitation medicine in the 60’s

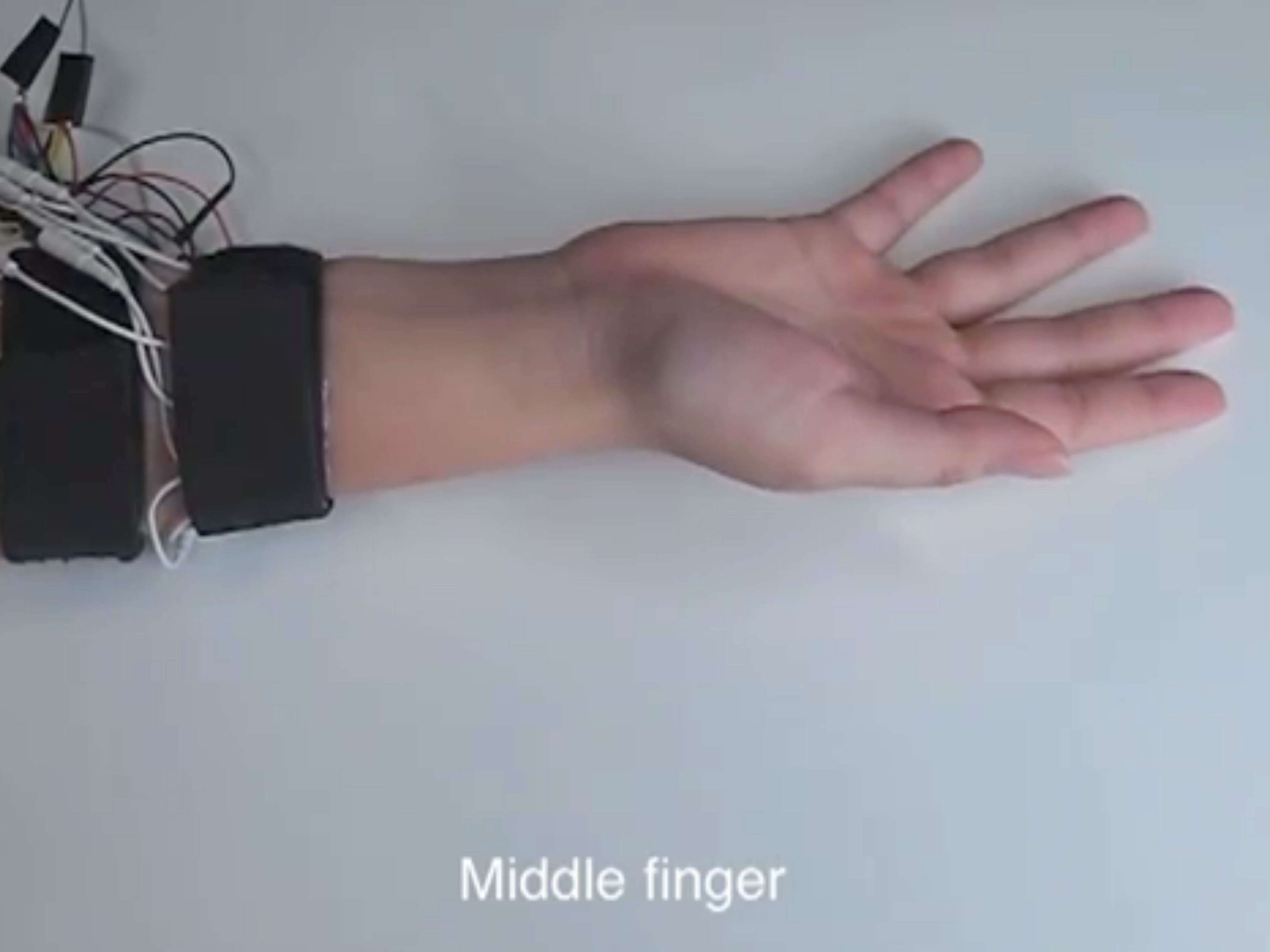


muscle contraction ::

muscles can **only contract,** i.e. pull not push



2011: Jun Rekimoto used EMS for HCI


Middle finger

PossessedHand: Techniques for Controlling Human Hands using Electrical Muscles Stimuli

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Sony Computer Science Laboratories, Inc.
rekimoto@acm.org

ABSTRACT
If a device can control human hands, the device can be useful for HCI and tangible application's output. To aid the controlling of finger movement, we present PossessedHand, a device with a forearm belt that can inform when and which fingers should be moved. PossessedHand controls the user's fingers by applying electrical stimulus to the muscles around the forearm. Each muscle is stimulated via 28 electrode pads. Muscles at different depths in the forearm can be selected for simulation by varying the stimulation level. PossessedHand can automatically calibrate the system for individuals. The automatic calibration system estimates relations between each electrode pad, stimulation level and muscle movement. Experiments show that PossessedHand can control the motion of 16 joints in the hand. Further, we also discuss an application based on this device to aid in playing a musical instrument.

Author Keywords
EMS, FES, Electric Stimulation, Hand Gesture, Musical Performance

ACM Classification Keywords
H.5 Information interfaces and presentation: [HCI]

General Terms

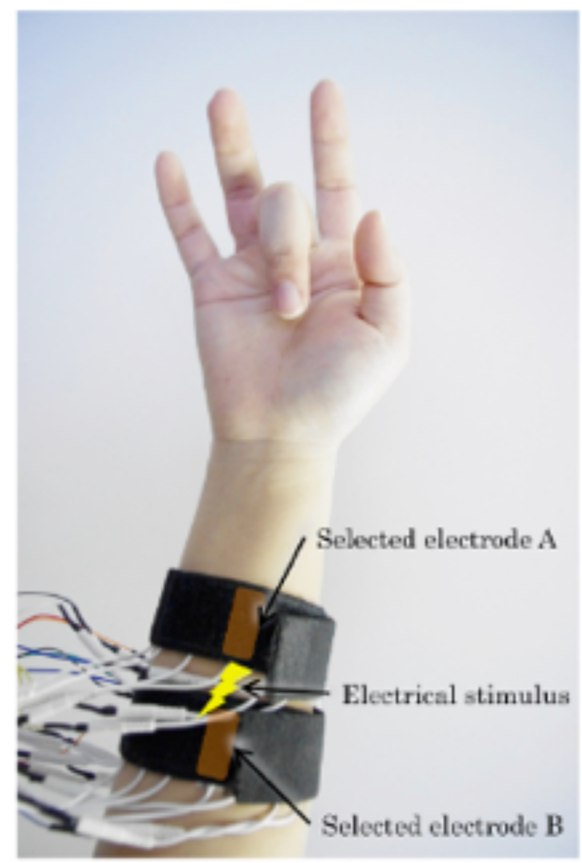
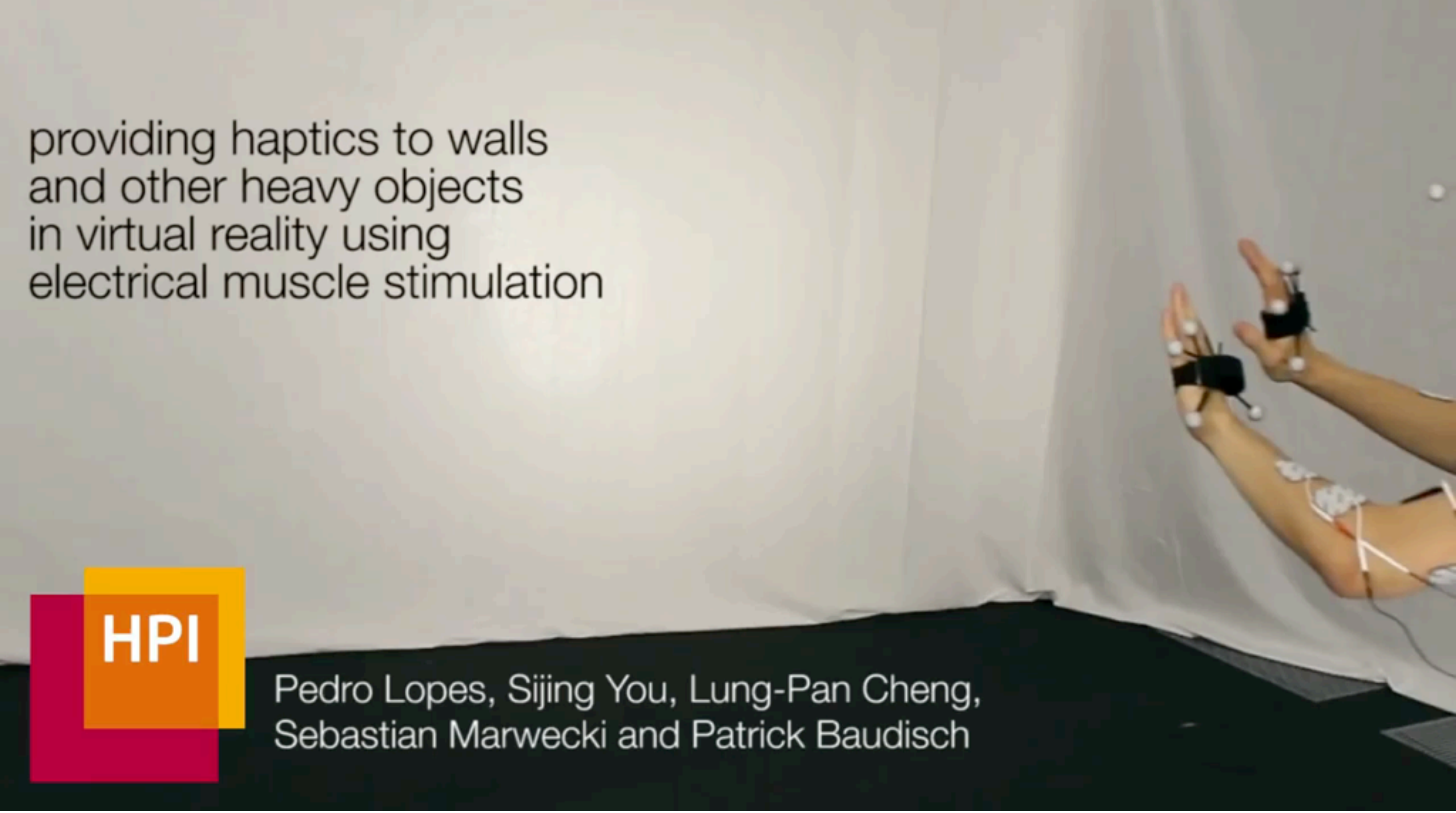


Figure 1. Our concept. PossessedHand controls user's finger.

a device can control human hands, the device would lead the next generation of HCI and tangle applications.

In this paper, we introduce PossessedHand, a device with a



2017: Pedro Lopes: EMS for **Force Feedback**

Providing Haptics to Walls & Heavy Objects in Virtual Reality by Means of Electrical Muscle Stimulation

Pedro Lopes, Sijing You, Lung-Pan Cheng, Sebastian Marwecki, and Patrick Baudisch
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Potsdam, Germany
{firstname.lastname}@hpi.de

ABSTRACT
We explore how to add haptics to walls and other heavy objects in virtual reality. When a user tries to push such an object, our system actuates the user's shoulder, arm, and wrist muscles by means of electrical muscle stimulation, creating a counter force that pulls the user's arm backwards. Our device accomplishes this in a wearable form factor.

In our first user study, participants wearing a head-mounted display interacted with objects provided with different types of EMS effects. The *repulsion* design (visualized as an electrical field) and the *soft* design (visualized as a magnetic field) received high scores on "prevented me from passing through" as well as "realistic."

In a second study, we demonstrate the effectiveness of our approach by letting participants explore a virtual world in which all objects provide haptic EMS effects, including walls, gates, sliders, boxes, and projectiles.

Author Keywords
Muscle interfaces; virtual reality; EMS; force feedback.

ACM Classification Keywords
H5.2 [Information interfaces and presentation]: User Interfaces. - Graphical user interfaces.

INTRODUCTION
Recent virtual reality systems allow users to walk freely in the virtual world (aka *real walking* [36]). As the next step towards realism and immersion, many researchers argue that these systems should also support the haptic sense in

Unfortunately, adding haptics to *heavy* objects, such as furniture or walls, has proven substantially more challenging. Even if one simulates the tactile aspects of such objects, the illusion fails as soon as users try to *push* through the object, as their proprioceptive system informs them about the lack of resistance [28].

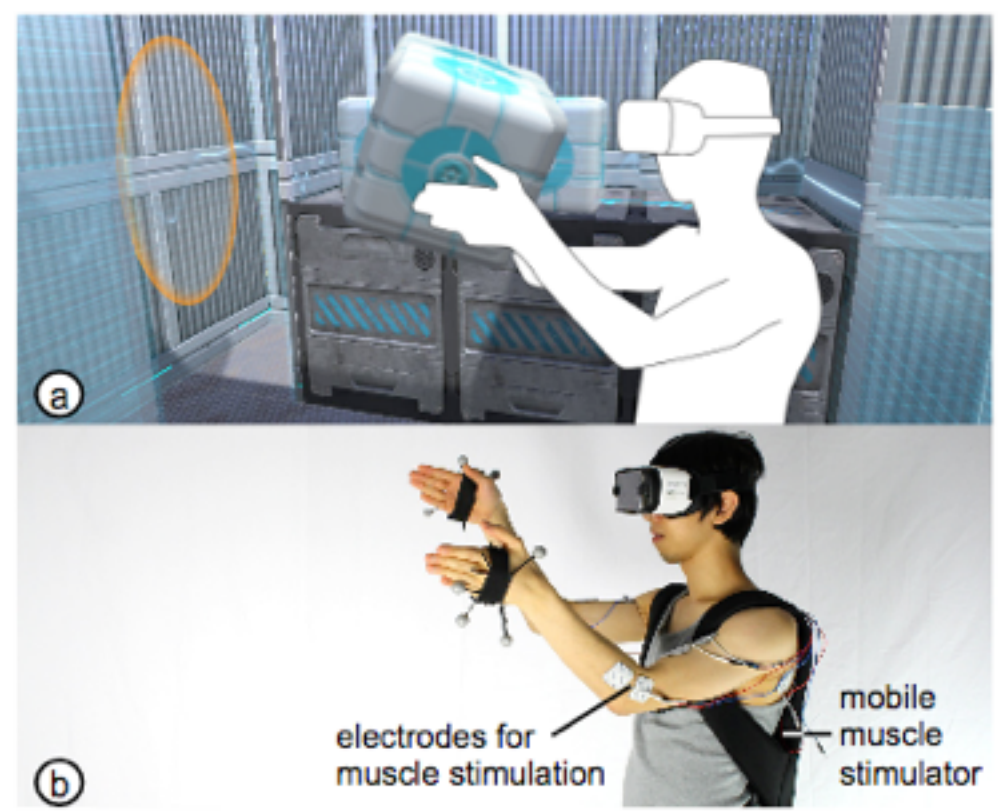


Figure 1: (a) As this user lifts a virtual cube, our system lets the user feel the weight and resistance of the cube. (b) Our system implements this by actuating the user's *opposing* muscles using electrical muscle stimulation.

2017: Pedro Lopes: EMS for **Force Feedback**

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

Pedro Lopes, Alexandra Ion, and Patrick Baudisch
Hasso Plattner Institute, Potsdam, Germany
{firstname.lastname}@hpi.de

ABSTRACT

We present impacto, a device designed to render the haptic sensation of hitting and being hit in virtual reality. The key idea that allows the small and light impacto device to simulate a strong hit is that it decomposes the stimulus: it renders the tactile aspect of being hit by tapping the skin using a solenoid; it adds impulse to the hit by thrusting the user's arm backwards using electrical muscle stimulation. The device is self-contained, wireless, and small enough for wearable use, and thus leaves the user unencumbered and able to walk around freely in a virtual environment. The device is of generic shape, allowing it to also be worn on legs so as to enhance the experience of kicking, or merged into props, such as a baseball bat. We demonstrate how to assemble multiple impacto units into a simple haptic suit. Participants of our study rated impacts simulated using impacto's combination of a solenoid hit and electrical muscle stimulation as more realistic than either technique in isolation.

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

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

General terms: Design, Human factors.

INTRODUCTION

The objective of virtual reality systems is to provide an immersive and realistic experience [28]. While research in virtual reality has traditionally focused on the visual and auditory senses, many researchers argue that the next step

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

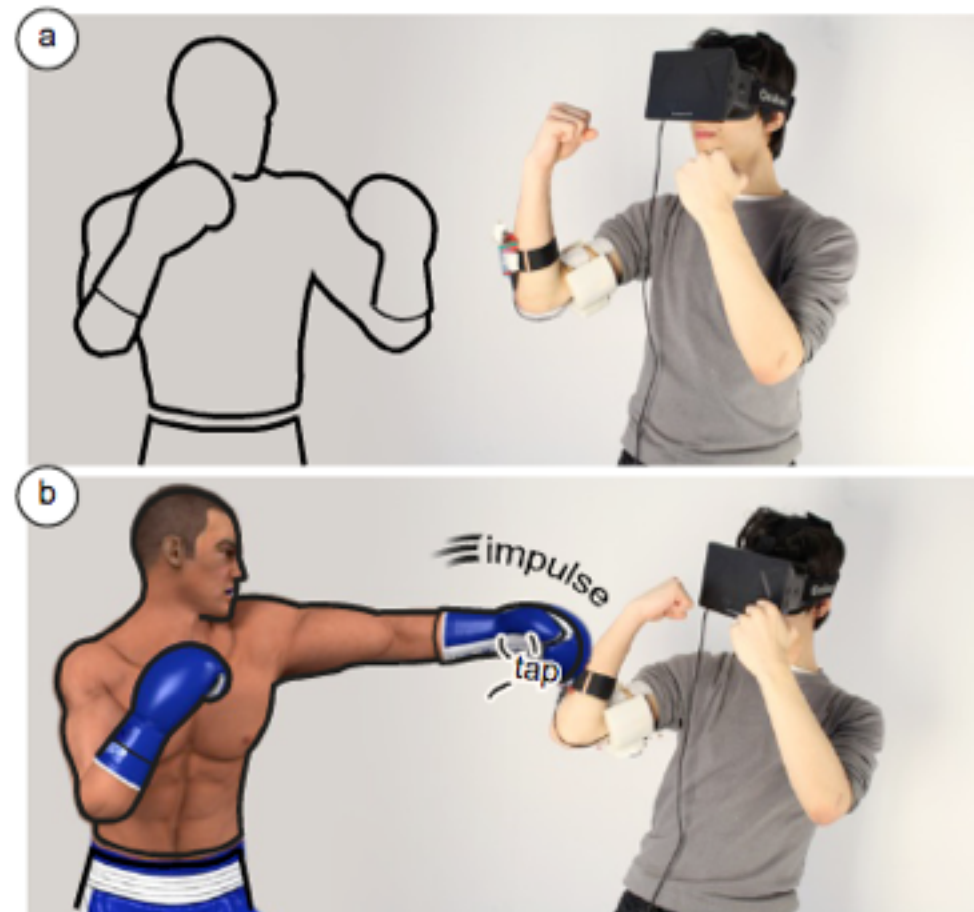
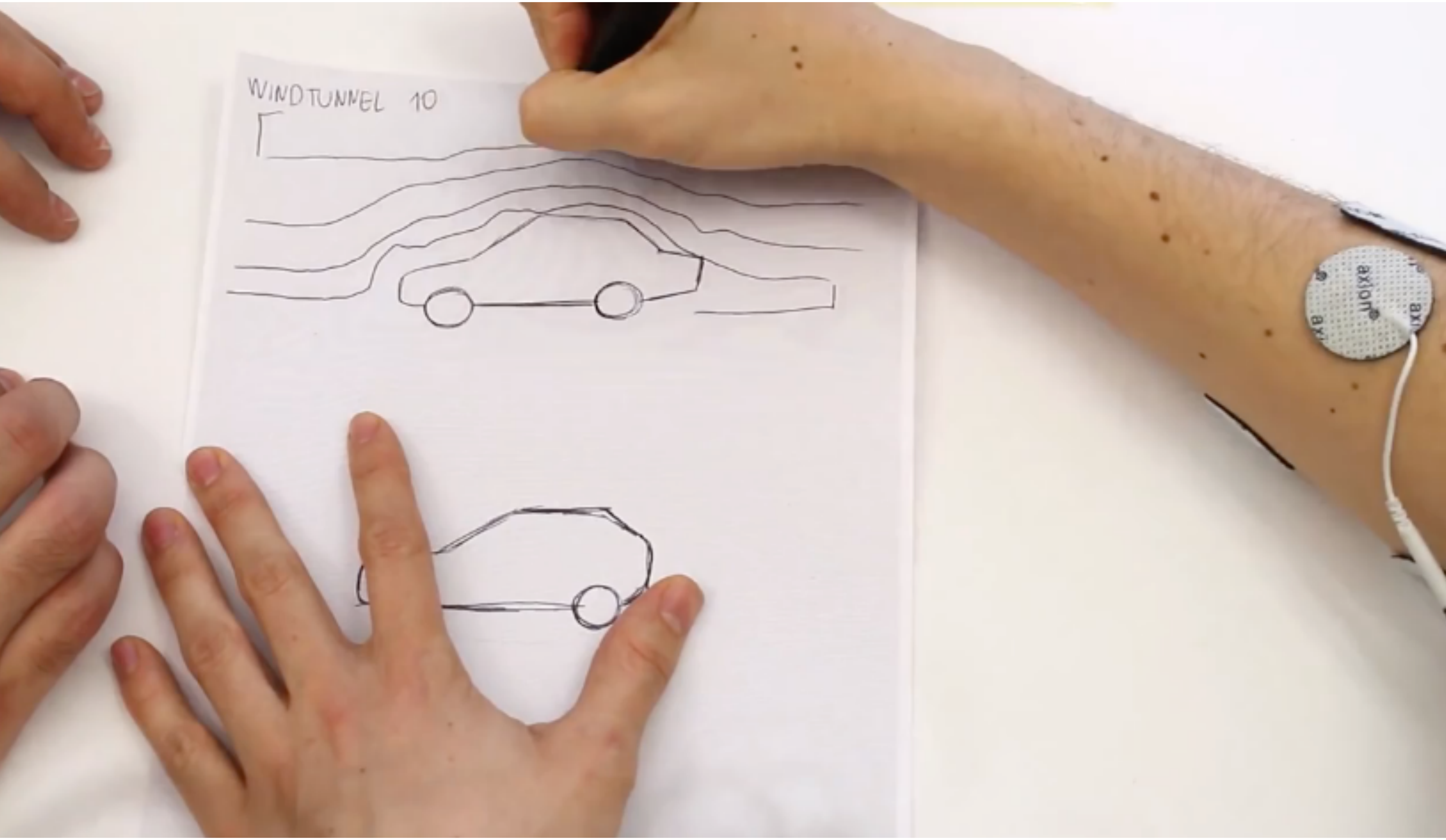


Figure 1: Impacto is designed to render the haptic sensation of hitting and being hit. The key idea that allows the small im-



2016: Pedro Lopes EMS as **output mechanism**

Muscle-plotter: an Interactive System based on Electrical Muscle Stimulation that Produces Spatial Output

Pedro Lopes[1], Doğa Yüksel[1], François Guimbretière[1,2], and Patrick Baudisch[1]

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Ithaca, NY 14850, USA
francois@cs.cornell.edu

ABSTRACT

We explore how to create interactive systems based on electrical muscle stimulation that offer expressive output. We present muscle-plotter, a system that provides users with input *and output* access to a computer system while on the go. Using pen-on-paper interaction, muscle-plotter allows users to engage in cognitively demanding activities, such as writing math. Users write formulas using a pen and the system responds by making the users' hand draw charts and widgets. While Anoto technology in the pen tracks users' input, muscle-plotter uses electrical muscle stimulation (EMS) to steer the user's wrist so as to plot charts, fit lines through data points, find data points of interest, or fill in forms. We demonstrate the system at the example of six simple applications, including a wind tunnel simulator.

The key idea behind muscle-plotter is to make the user's hand sweep an area on which muscle-plotter renders curves, i.e., series of values, and to *persist* this EMS output by means of the pen. This allows the system to build up a larger whole. Still, the use of EMS allows muscle-plotter to achieve a compact and mobile form factor. In our user study, muscle-plotter made participants draw random plots with an accuracy of ±4.07 mm and preserved the frequency of functions to be drawn up to 0.3 cycles per cm.

Keywords: electrical muscle stimulation; spatial; haptics;

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

INTRODUCTION

Interactive systems based on electrical muscle stimulation

The main strength of EMS is that the resulting systems miniaturize well, thus lend themselves well to mobile use (mobile gaming [16]) or wearable use (*pedestrian cruise control* [23]). A second key strength is their ability to implement input/output interactions that use the same modality (i.e., *symmetric* interaction [25]) by using the same gesture language for input and output [17].

Unfortunately, the price for these benefits is that the interactive EMS systems presented so far lack expressiveness. Existing interactive EMS systems output a single 1D output variable, such as screen tilt [16] *or* wrist tilt [17] *or* one of *n* behaviors [18]. Since subsequent output overwrites earlier output, users never see more than a single value.

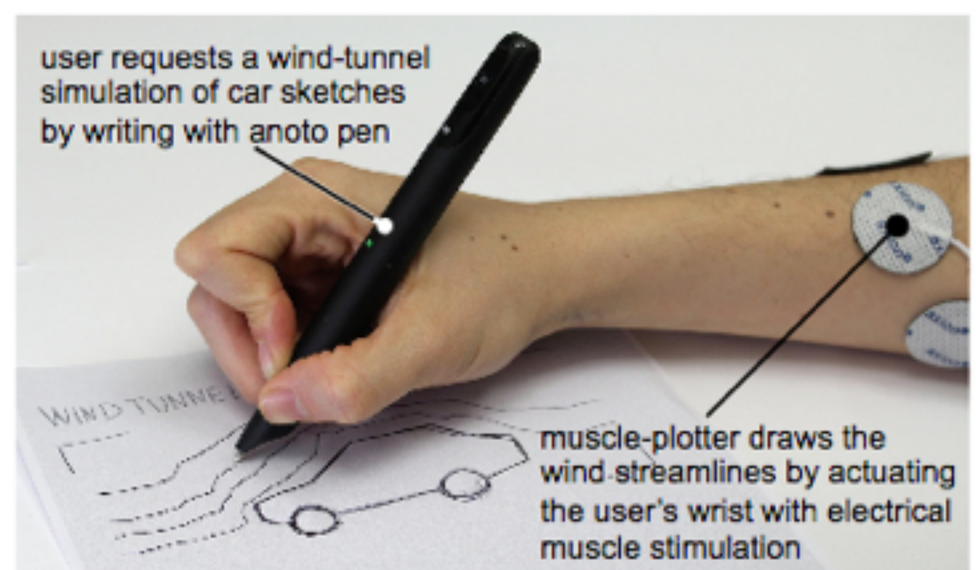
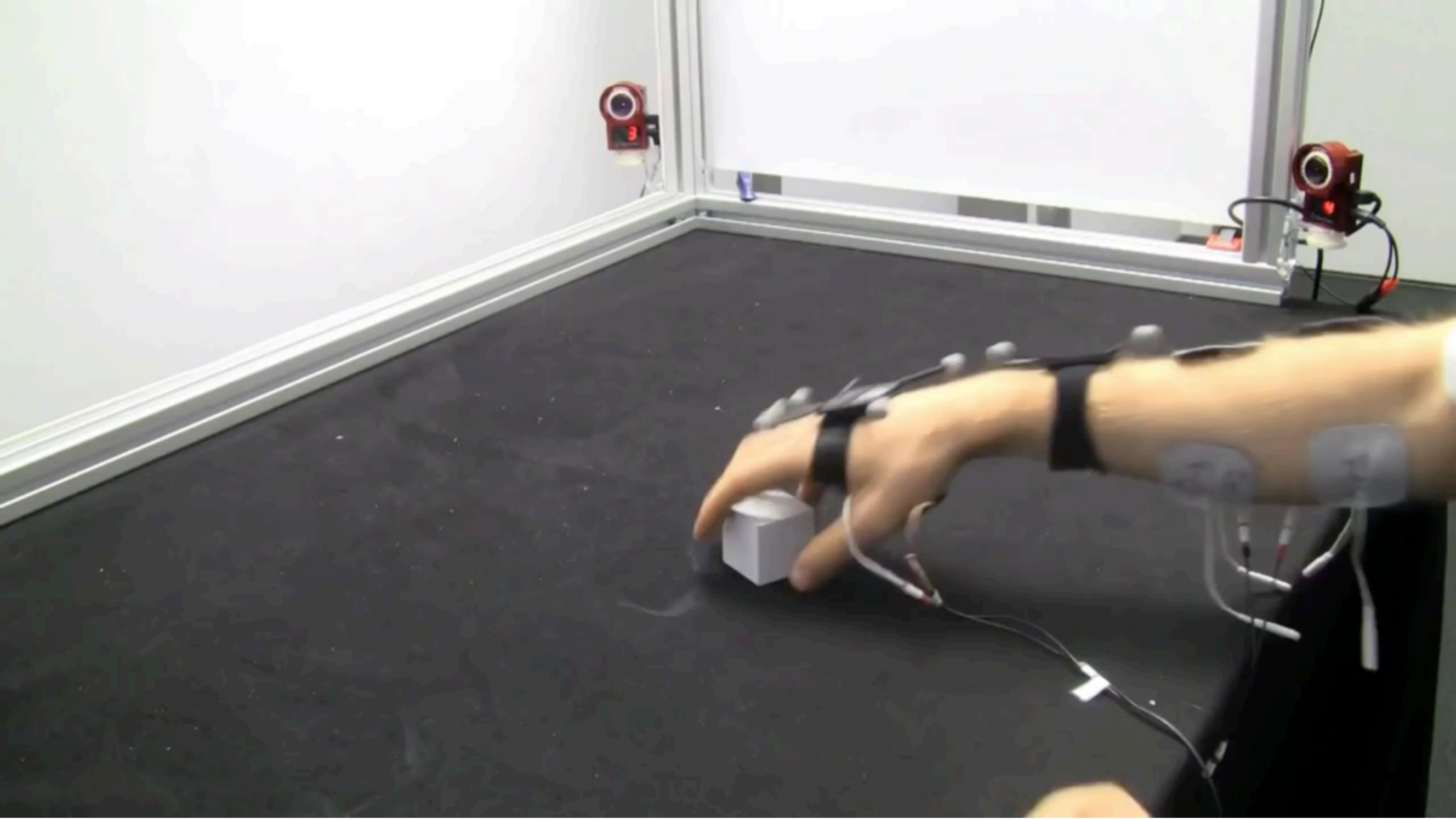


Figure 1: An interactive wind tunnel simulation with pen input and output—based on EMS. The user jotted down the word "windtunnel", set down the pen left of the car, and started to drag it towards the car sketch. In response, muscle-plotter computed this particular streamline in the context of



2015: Pedro Lopes:
EMS for **dynamic affordances**

Affordance++: allowing objects to communicate dynamic use

Pedro Lopes, Patrik Jonell, and Patrick Baudisch
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{firstname.lastname}@hpi.de

ABSTRACT
We propose extending the affordance of objects by allowing them to communicate *dynamic* use, such as (1) motion (e.g., spray can shakes when touched), (2) multi-step processes (e.g., spray can sprays only after shaking), and (3) behaviors that change over time (e.g., empty spray can does not allow spraying anymore). Rather than enhancing objects directly, however, we implement this concept by enhancing the user. We call this *affordance++*. By stimulating the user's arms using electrical muscle stimulation, our prototype allows objects not only to make the user actuate them, but also perform required movements while merely approaching the object, such as *not* to touch objects that do not "want" to be touched. In our user study, affordance++ helped participants to successfully operate devices of poor natural affordance, such as a multi-functional slicer tool or a magnetic nail sweeper, and to stay away from cups filled with hot liquids.

Keywords: electrical muscle stimulation; affordance;

ACM Classification: H5.2 [Information interfaces and presentation]: User Interfaces: Input Devices and Strategies, Interaction Styles.

INTRODUCTION
Affordance is a key concept in usability. When well-designed objects "suggest how to be used" [7], they avoid the necessity for training and enable walk-up use. Physical objects, for example, use their visual and tactile cues to suggest the possible range of usages to the user [7].

Unfortunately, physical objects are limited in that they cannot easily communicate use that involves (1) motion, (2) multi-step processes, and (3) behaviors that change over time. A spray can, for example, cannot communicate that it needs to be shaken before use, that it has to be held upright, or that it cannot be used for spraying anymore (and instead should now be thrown away).

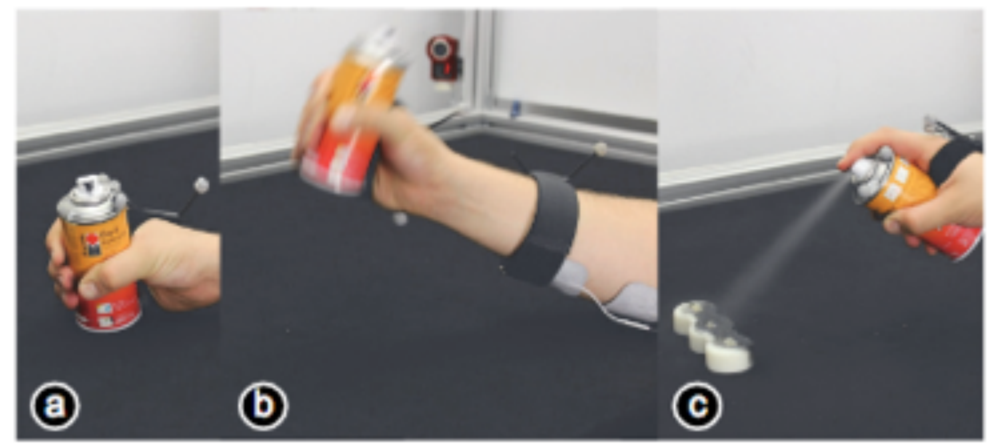


Figure 1: Affordance++ expands the affordance of an object beyond its visual attributes. (a) This spray can needs to be shaken before use. (b) Affordance++ allows the spray can to make the user shake it before use. Our prototype implements this by electrically stimulating the user's muscles. (c) Now the spray can is "willing" to be used.

As pointed out by Djajadiningrat et al., the underlying limitation of this type of physical object is that they cannot depict *time* [3]. The spray can is inanimate. Motion, multi-step processes, and behaviors that change over time, however, are phenomena in time.

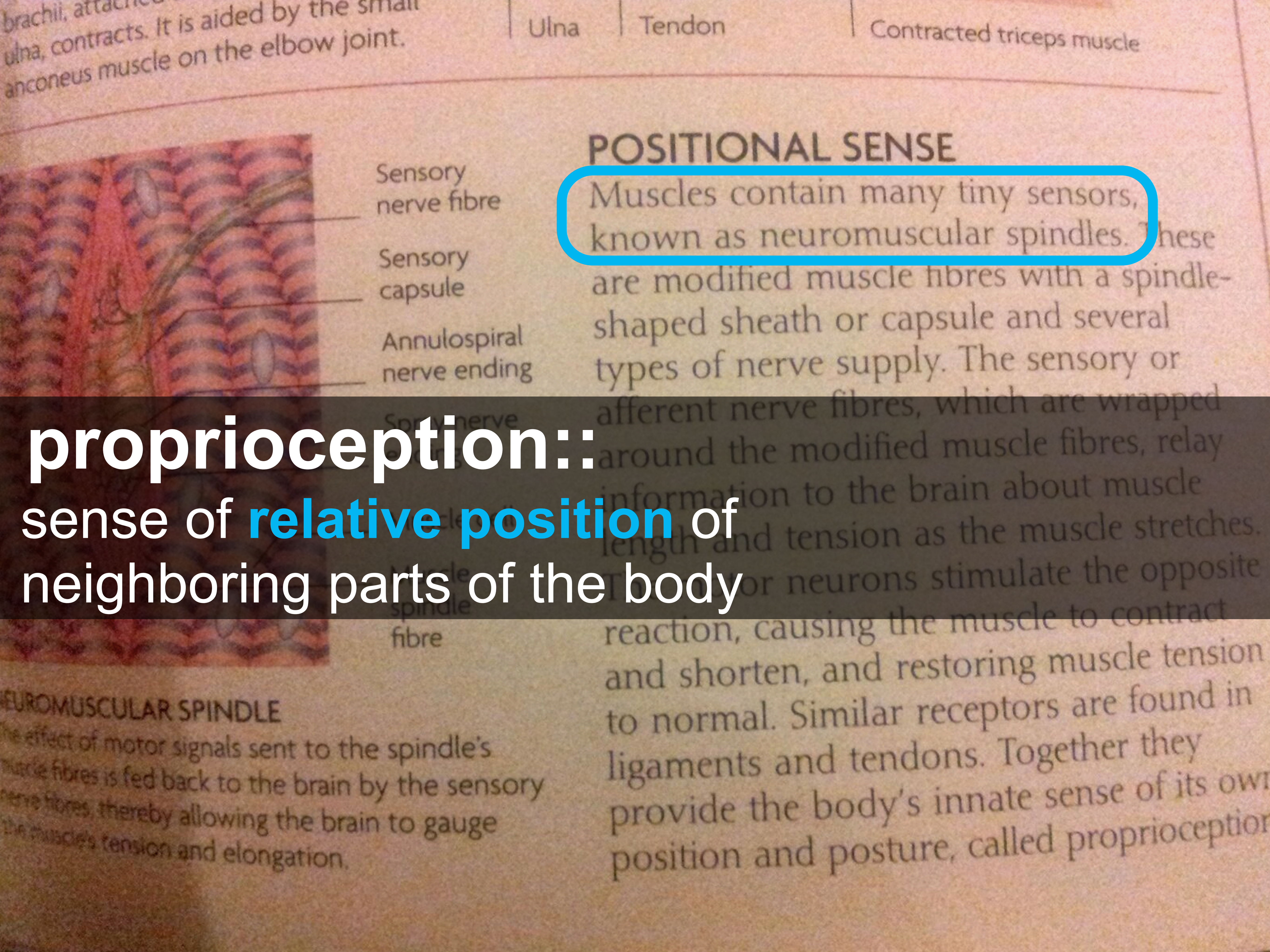
One way of addressing the issue is to provide objects with the ability to display instructions, e.g., using a spatial augmented reality display [20]. To offer a more "direct" way for objects to communicate their use, researchers have embedded sensors and actuators into objects, allowing them to be animated [21,25]. This approach works, unfortunately, at the expense of substantial per-object implementation effort.

this was **actuating** muscles…
but how about **sensing** a muscles current position?

can you make a pose with your hand while having your **eyes closed?**

how do you **know when to stop** pulling my muscles?

<30s brainstorming>


brachii, attac...
ulna, contracts. It is aided by the small
anconeus muscle on the elbow joint.
Ulna
Tendon
Contracted triceps muscle
POSITIONAL SENSE
Muscles contain many tiny sensors, known as neuromuscular spindles. These are modified muscle fibres with a spindle-shaped sheath or capsule and several types of nerve supply. The sensory or afferent nerve fibres, which are wrapped around the modified muscle fibres, relay information to the brain about muscle length and tension as the muscle stretches.
neurons stimulate the opposite reaction, causing the muscle to contract and shorten, and restoring muscle tension to normal. Similar receptors are found in ligaments and tendons. Together they provide the body's innate sense of its own position and posture, called proprioception
Sensory nerve fibre
Sensory capsule
Annulospiral nerve ending
fibre
NEUROMUSCULAR SPINDLE
The effect of motor signals sent to the spindle's muscle fibres is fed back to the brain by the sensory nerve fibres, thereby allowing the brain to gauge the muscle's tension and elongation.
proprioception::
sense of relative position of neighboring parts of the body

proprioception is
how a **humans** sense muscle activity!

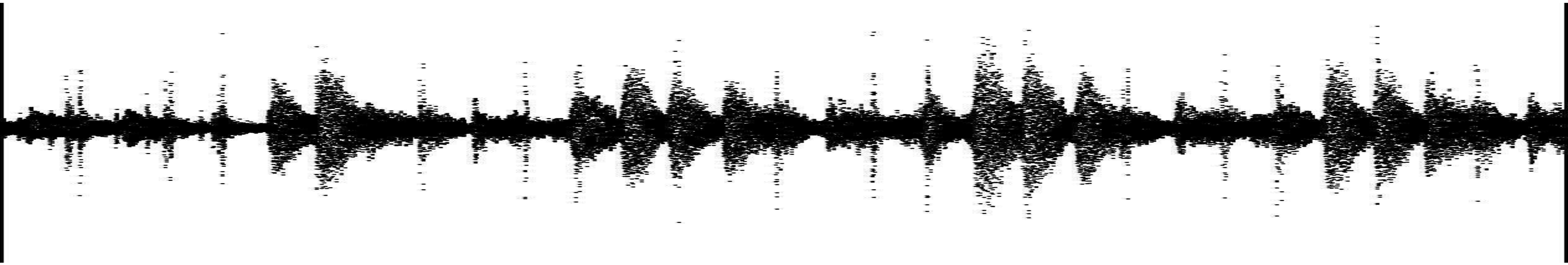
but how does a **computer** do it?

sensing muscles:

- **mechano-**myography (MMG)
- **electro-**myography (EMG)

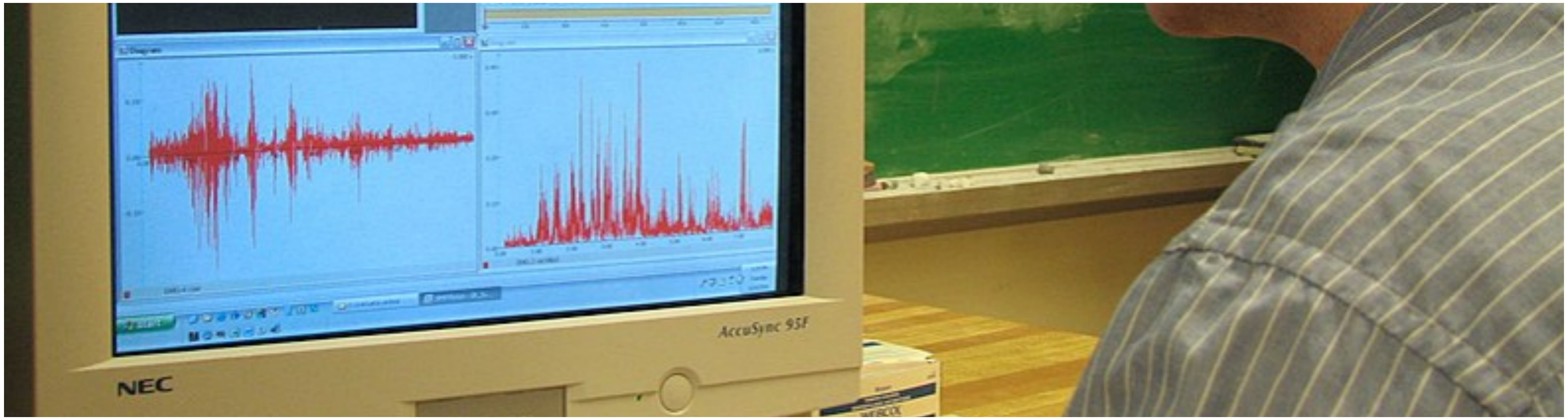
mechano-myogram (MMG):

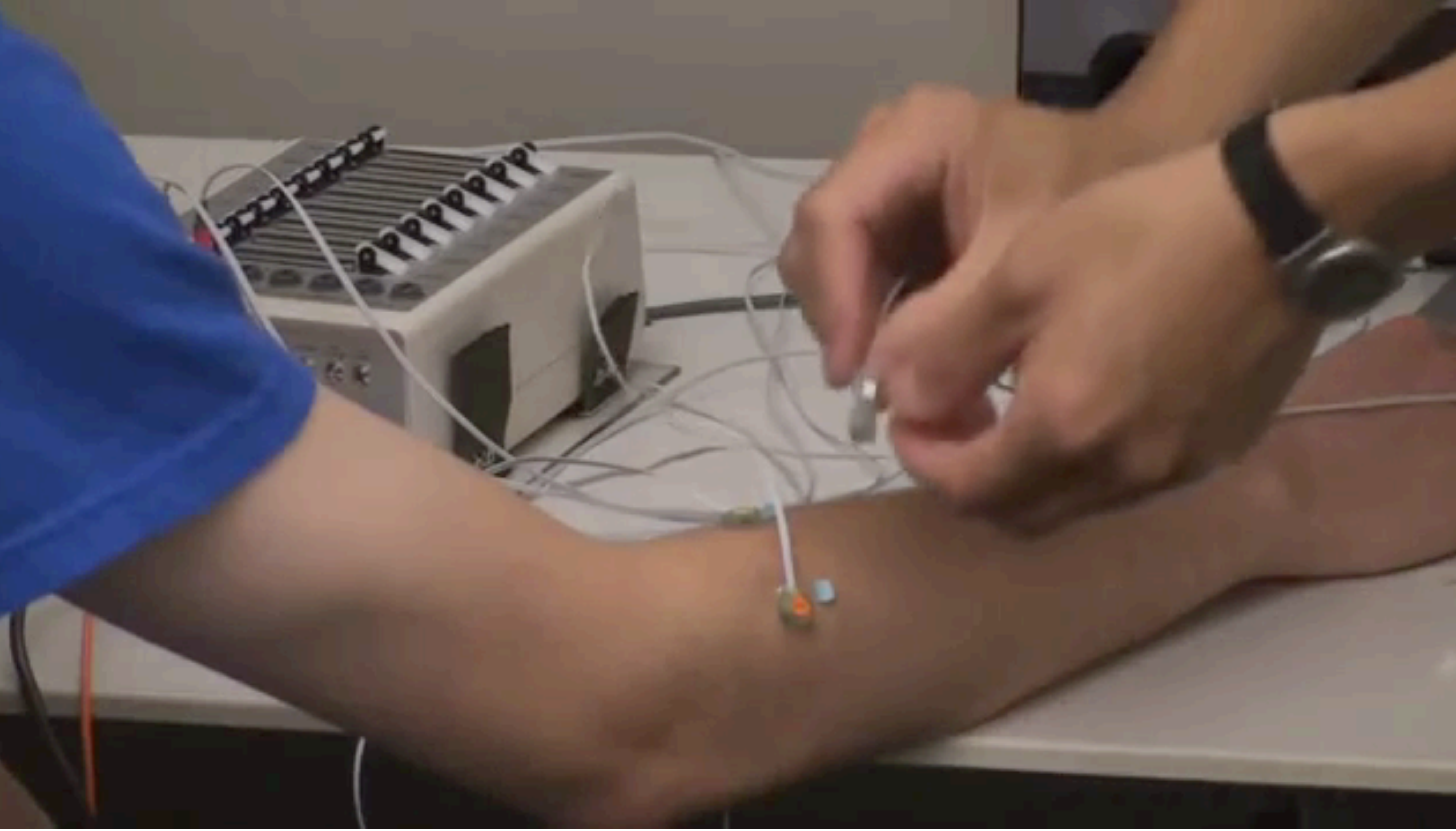
- a **vibration** that can be observed when a muscle contracts
- use a microphone or accelerometer placed on the skin



electro-myogram (EMG)::

- measure **electric potential** of muscle
- **at rest vs. used**
- nerves control muscles using electric signals
- electric signal makes muscle fibers contract





2009: Saponas: always available muscle input

2009: Saponas: always available muscle input

Enabling Always-Available Input with Muscle-Computer Interfaces

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ABSTRACT

Previous work has demonstrated the viability of applying offline analysis to interpret forearm electromyography (EMG) and classify finger gestures on a physical surface. We extend those results to bring us closer to using muscle-computer interfaces for always-available input in real-world applications. We leverage existing taxonomies of natural human grips to develop a gesture set covering interaction in free space even when hands are busy with other objects. We present a system that classifies these gestures in real-time and we introduce a bi-manual paradigm that enables use in interactive systems. We report experimental results demonstrating four-finger classification accuracies averaging 79% for pinching, 85% while holding a travel mug, and 88% when carrying a weighted bag. We further show generalizability across different arm postures and explore the tradeoffs of providing real-time visual feedback.

ACM Classification: H.1.2 [User/Machine Systems]; H.5.2 [User Interfaces]: Input devices and strategies; B.4.2 [Input/Output Devices]: Channels and controllers

General terms: Design, Human Factors

Keywords: Electromyography (EMG), Muscle-Computer Interface, input, interaction.

INTRODUCTION

Our hands and our ability to control them have evolved

Previous work has explored hands-free and implement-free input techniques based on a variety of sensing modalities. For example, computer vision enables machines to recognize faces, track movement and gestures, and reconstruct 3D scenes [24]. Similarly, speech recognition allows for hands-free interaction, enabling a variety of speech-based desktop and mobile applications [8, 11]. However, these technologies have several inherent limitations. First, they require observable interactions that can be inconvenient or socially awkward. Second, they are relatively sensitive to environmental factors such as light and noise. Third, in the case of computer vision, sensors that visually sense the environment are often susceptible to occlusion.

We assert that computer input systems can leverage the full bandwidth of finger and hand gestures without requiring the user to manipulate a physical transducer. In this paper, we show how forearm electromyography (EMG) can be used to detect and decode human muscular movement in real time, thus enabling interactive finger gesture interaction. We envision that such sensing can eventually be achieved with an unobtrusive wireless forearm EMG band (see Figure 1).

Previous work exploring muscle-sensing for input has primarily focused either on using a single large muscle (rather than the fingers) [2, 3, 4, 22, 25], which does not provide the breadth of input signals required for computer input, and/or on situations where the hand and arm are constrained

sensing muscles:

- **mechano-**myography (MMG)
- **electro-**myography (EMG)

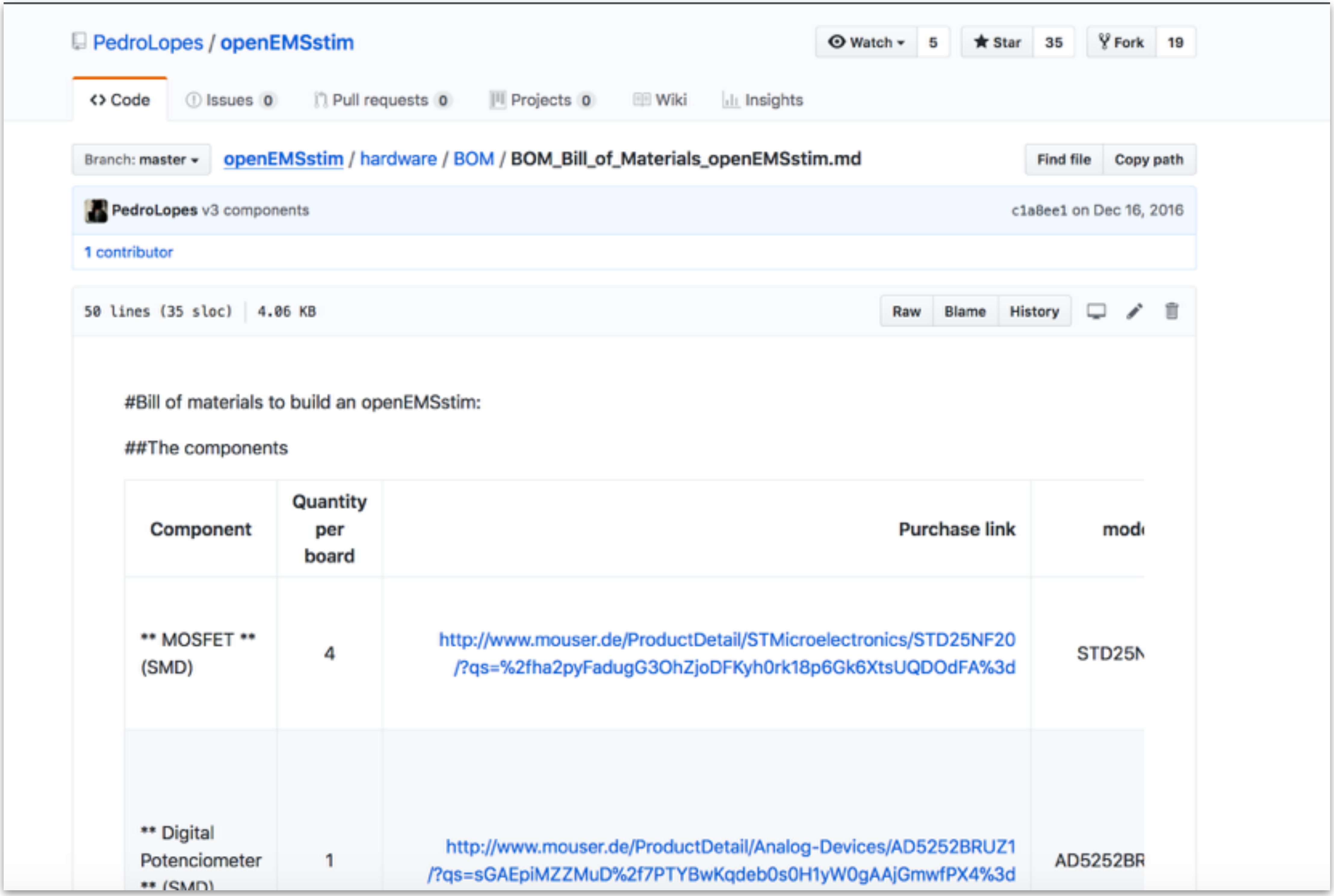
actuating muscles:

- **electro**-muscle stimulation (EMS)

openEMSstim #1: controlling electrical muscle stimulation via android [UIST 2016 SIC]

OpenEMS board

https://github.com/PedroLopes/openEMSstim/blob/master/hardware/BOM/BOM_Bill_of_Materials_openEMSstim.md



OpenEMS board

https://github.com/PedroLopes/openEMSstim/blob/master/hardware/BOM/BOM_Bill_of_Materials_openEMSstim.md

(other body-signals as interface)

any idea how this works?

<30s brainstorming>

galvanic vestibular stimulation (GVS):

- **liquid level in ear:** sense of balance
- **electrodes** stimulate liquid in ear

Maeda et al., Shaking the world: galvanic *vestibular stimulation as a novel sensation interface, SIGGRAPH’05*

Maeda et al., Shaking the world: galvanic *vestibular stimulation as a novel sensation interface, SIGGRAPH'05*

Shaking The World: Galvanic Vestibular Stimulation As A Novel Sensation Interface

Maeda T.*, Ando H., Amemiya T.,
NTT Communication Science Laboratories

Nagaya N., Sugimoto M., Inami M.
The University of Electro-Communications

Figure 1: Shaking The World: Galvanic Vestibular Stimulation As A Novel Sensation Interface

Abstract

We developed a novel sensation interface device using galvanic vestibular stimulation (GVS). GVS alters your balance. Our device can induce vection (virtual sense of acceleration) synchronized with optic flow or musical rhythms. The device can also induce lateral walking towards the anode while human walking.

Keywords: Communications Technology, Cognitive Psychology / Perception, Human-Computer Interfaces

1 Introduction

In galvanic vestibular stimulation (GVS), the vestibular system is stimulated by a weak current through an electrode placed on the mastoid behind ear. The vestibular system is sensitive to GVS intensity changes and responds by altering the magnitude of the response accordingly. GVS moves your balance toward the anode. This stimulation is has been used as the clinically functional test of vestibular. In this project, we apply GVS as a novel interface for virtual sense of acceleration. GVS can not only induce vection (virtual sense of acceleration) without an expensive mechanical motion platform. It can also make walkers deviate from the normal intended straight-line path. With our device, radio-controlled walking, automatic collision avoidance, and GPS walking navigation are possible. Moreover, the system is particularly useful for interpersonal kinematical sense sharing as an amusement by synchronizing the stimulation to the action. Movies will move you synchronized to the camera action. You and I can move each other with head action.

We developed a novel sensation interface device using GVS. It can be available to support human behavior directly. Direct walking navigation is a novel usage of GVS as a human interface. There is no feeling of enforced action. Because users are navigated very naturally and almost unconsciously, they are not distracted by the stimulation and would be aware that their behavior was an effect of the stimulation after they have done it. We designed this device also to provide a virtual sense of acceleration without an expensive mechanical platform synchronized to the flow of movies. In addition, we found the stimulation synchronized to rhythms of music provides a very fantastic experience as a novel sensation. It is useful also as a novel amusement media. Especially, by the high-frequency rhythmical stimulation of more than 1 2 Hz, you will feel as if your visual field and body shake tremblingly along with the rhythm. This experience is a novel sensation on human sensory display.

3 Conclusion

Until now, GVS has only been used as clinical functional test for the vestibular system. We developed a novel sensation interface using GVS. It can be available to support human behavior directly. Direct walking navigation is a novel usage of GVS as a human interface. We design this device also to work as a display for virtual sense of acceleration without expensive mechanical platform synchronized to the flow of movies. In addition, we found the stimulation synchronized to rhythms of music provides a very fantastic experience as a novel sensation. It is useful also as a novel amusement media.

(also works with muscle-stimulation)

pedestrian cruise control [pfeiffer et al. CHI’15]

Cruise Control for Pedestrians: Controlling Walking Direction using Electrical Muscle Stimulation

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ABSTRACT
Pedestrian navigation systems require users to perceive, interpret, and react to navigation information. This can tax cognition as navigation information competes with information from the real world. We propose *actuated navigation*, a new kind of pedestrian navigation in which the user does not need to attend to the navigation task at all. An actuation signal is directly sent to the human motor system to influence walking direction. To achieve this goal we stimulate the sartorius muscle using electrical muscle stimulation. The rotation occurs during the swing phase of the leg and can easily be counteracted. The user therefore stays in control. We discuss the properties of actuated navigation and present a lab study on identifying basic parameters of the technique as well as an outdoor study in a park. The results show that our approach changes a user's walking direction by about 16°/m on average and that the system can successfully steer users in a park with crowded areas, distractions, obstacles, and uneven ground.

Author Keywords
Pedestrian navigation; electrical muscle stimulation; haptic feedback; actuated navigation; wearable devices

ACM Classification Keywords
H.5.2 Information Interfaces and Presentation: User

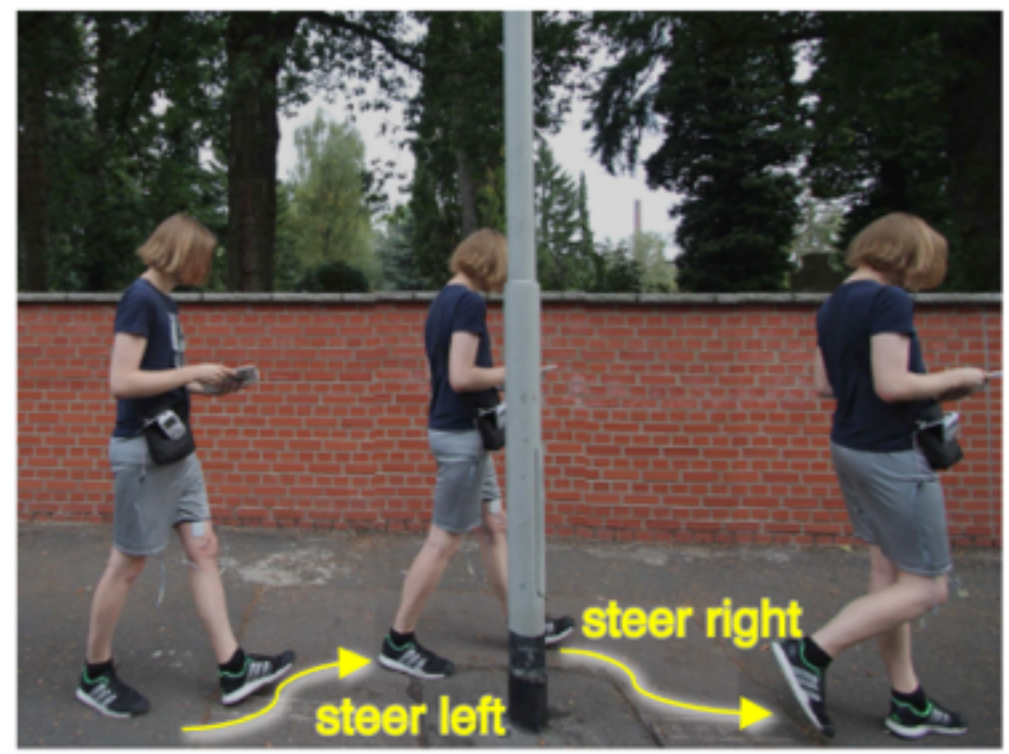


Figure 1. A user is absorbed in his reading, not noticing the lamppost. Actuated navigation automatically steers him around the obstacle.

An obvious drawback of such solutions is the need for users to pay attention to navigation feedback, process this information, and transform it into appropriate movements. Moreover, navigation information may be misinterpreted or overlooked.

the body as an interface::

1. brain computer interfaces
2. muscle computer interfaces
3. **implanted interfaces**

#3

implanted interfaces

all non-invasive

sensing ‘thought’:

- magnetic resonance (fMRI)
- near-infra-red spectroscopy (fNIRS)
- electro-encephalography (EEG)

actuating ‘thought’:

- transcranial magnetic stimulation (TMS)

uses a coil which induces small currents into the brain via electromagnetic induction

all non-invasive

sensing muscles:

- **mechano-**myography (MMG)
- **electro-**myography (EMG)

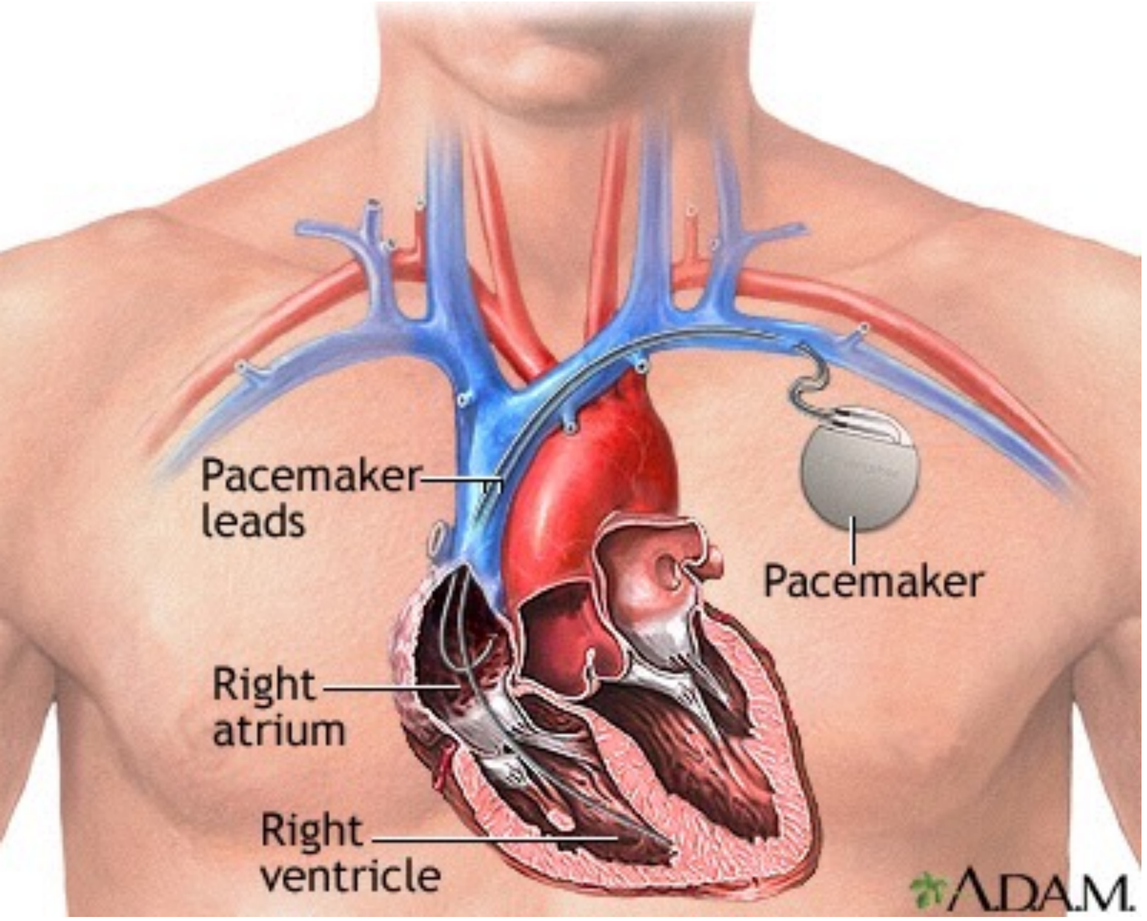
actuating muscles:

- **electro**-muscle stimulation (EMS)

is implanting interfaces really so far in the future?

what are
examples of implanted user interfaces
already in use today?

<30s brainstorming>



pacemakers…
drug delivery implants…

1998: Prof. Kevin Warwick: Project Cyborg zooming out…

the body as an interface::

1. brain computer interfaces
2. muscle computer interfaces
3. implanted interfaces

some organizational stuff:

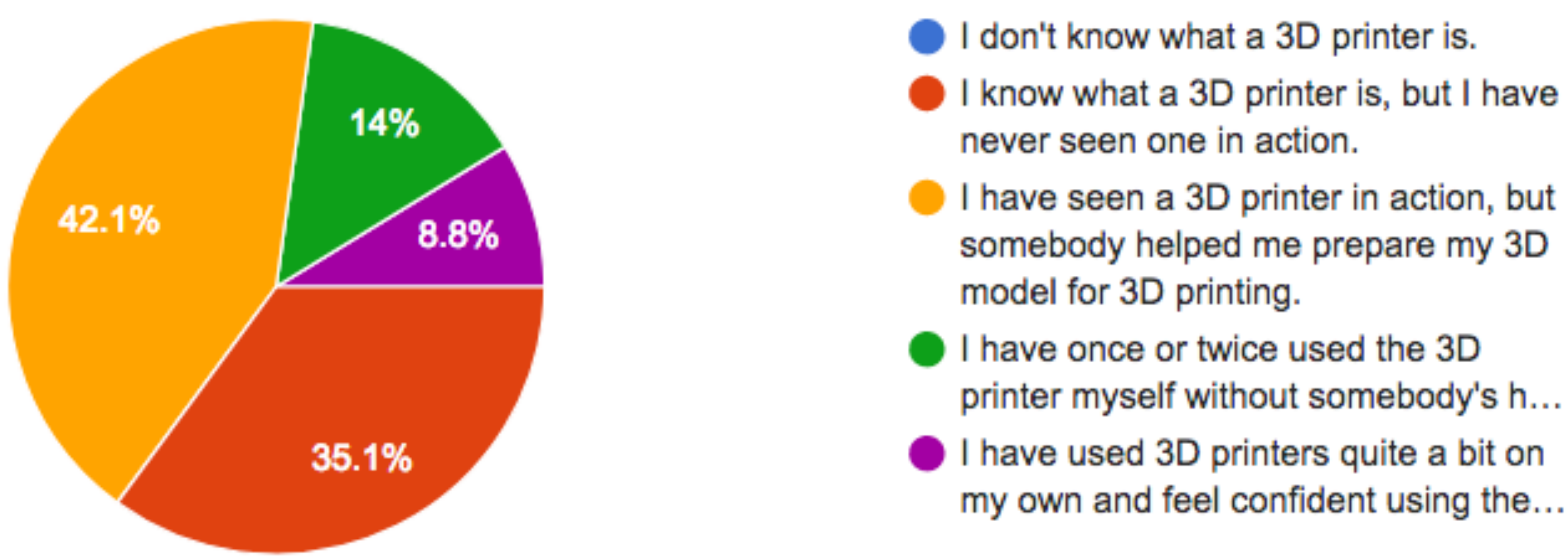
this friday

this friday: 3D printing (at IDC)

- + tell us your final team partner
- + **bring your business card to class!**

How much prior experience with 3D printing do you have?

57 responses



next wednesday

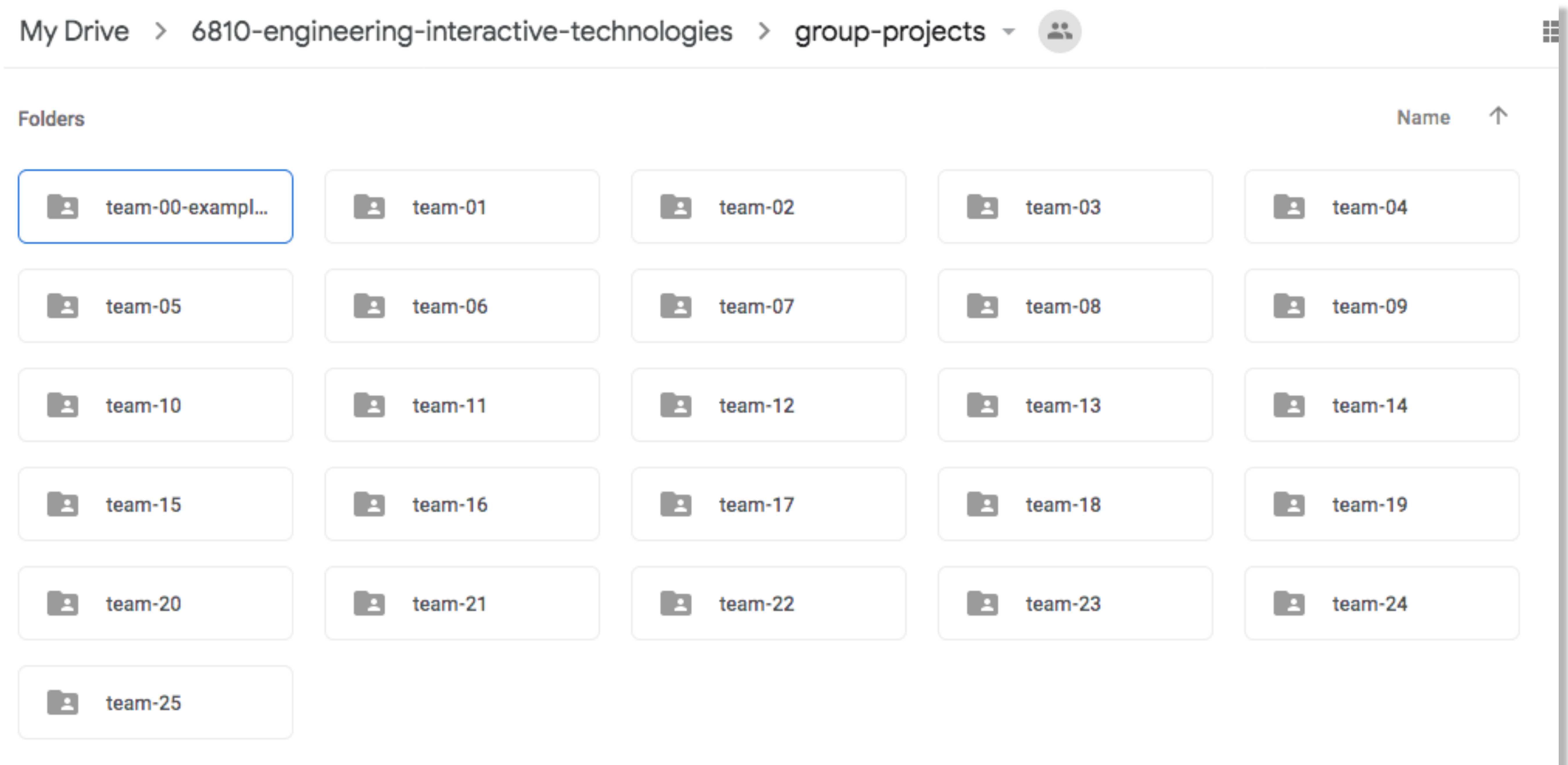
next wednesday:

- upload 10 ideas for your group project
- present the best 3 ideas in class
- use google slide example template

example for idea presentation

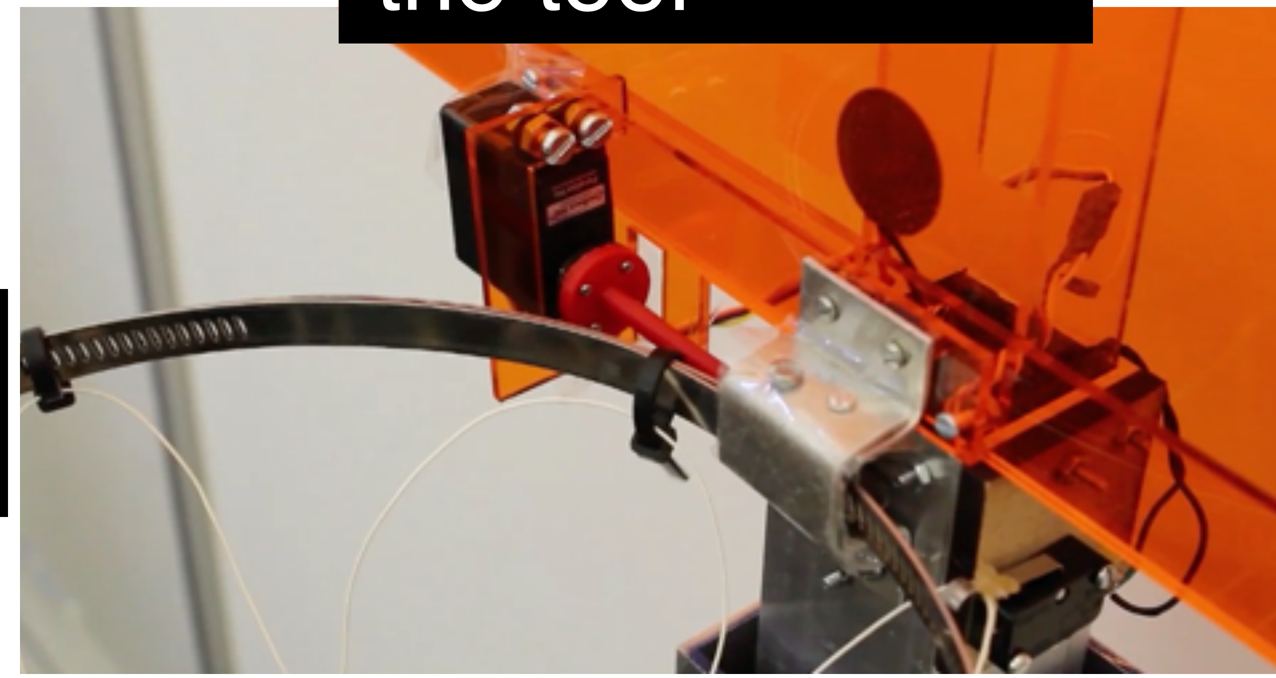
https://docs.google.com/presentation/d/1Ip0CrJLXs-azD5tsBrnJCEohTy72EPjqbW2lcDQWFFI/edit#slide=id.p

class google drive:



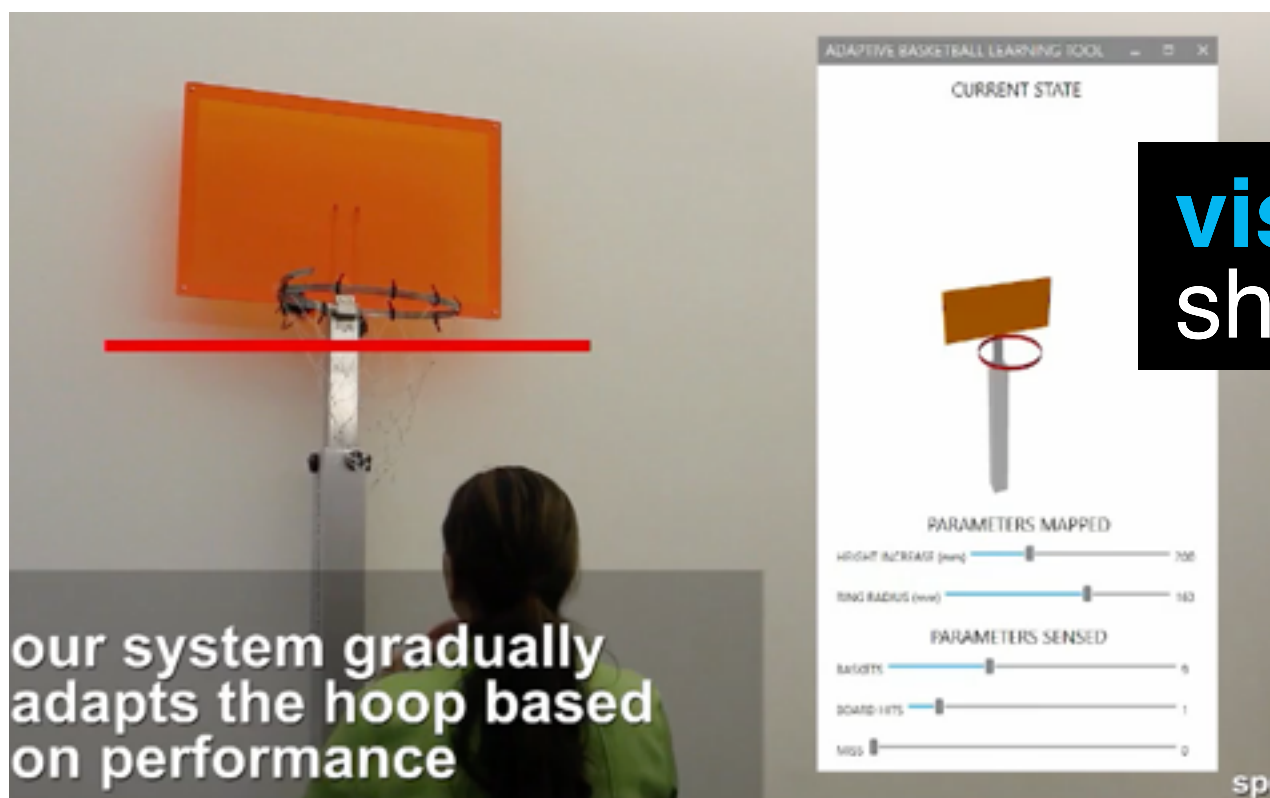
project components:

actuators adapt the tool



sensors detect user performance

what and how you build it is up to you

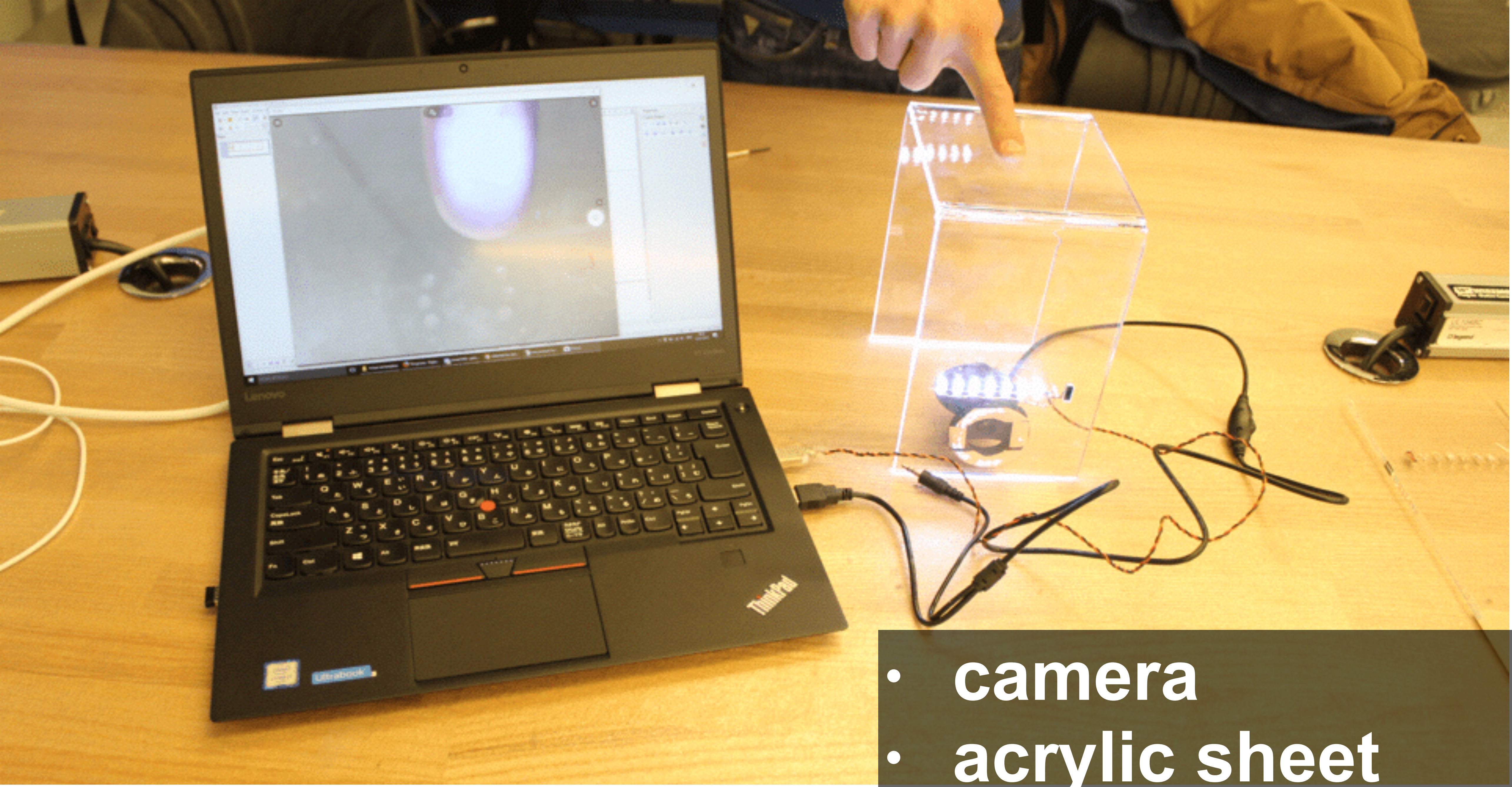


visualization shows progress

take a materials bag before you leave

Lotta hands them out at the back

- **alligator clips**
- **microcontroller**
- **breadboard**
- **prototyping cables**

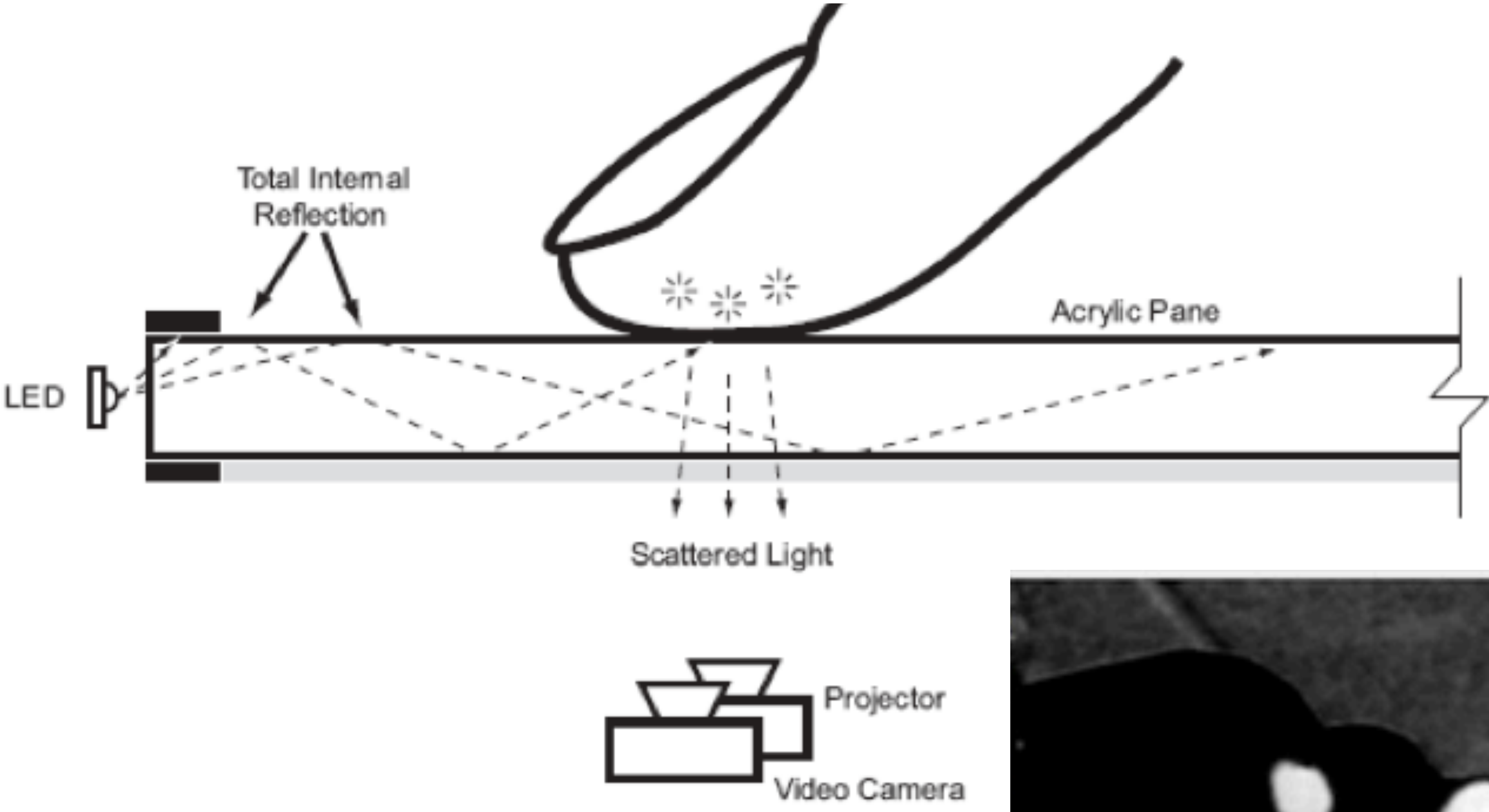


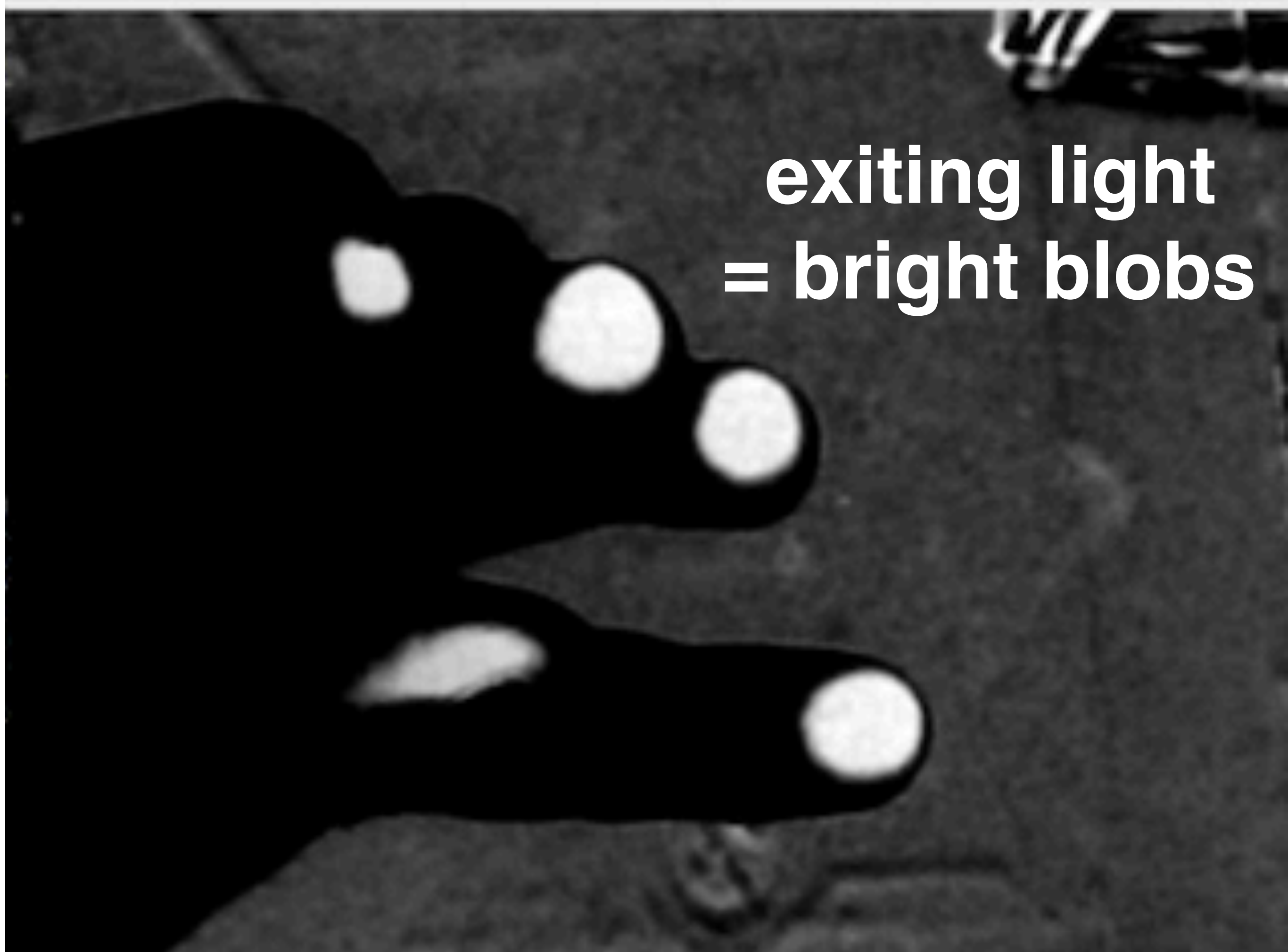
for pset Multitouch-Pad

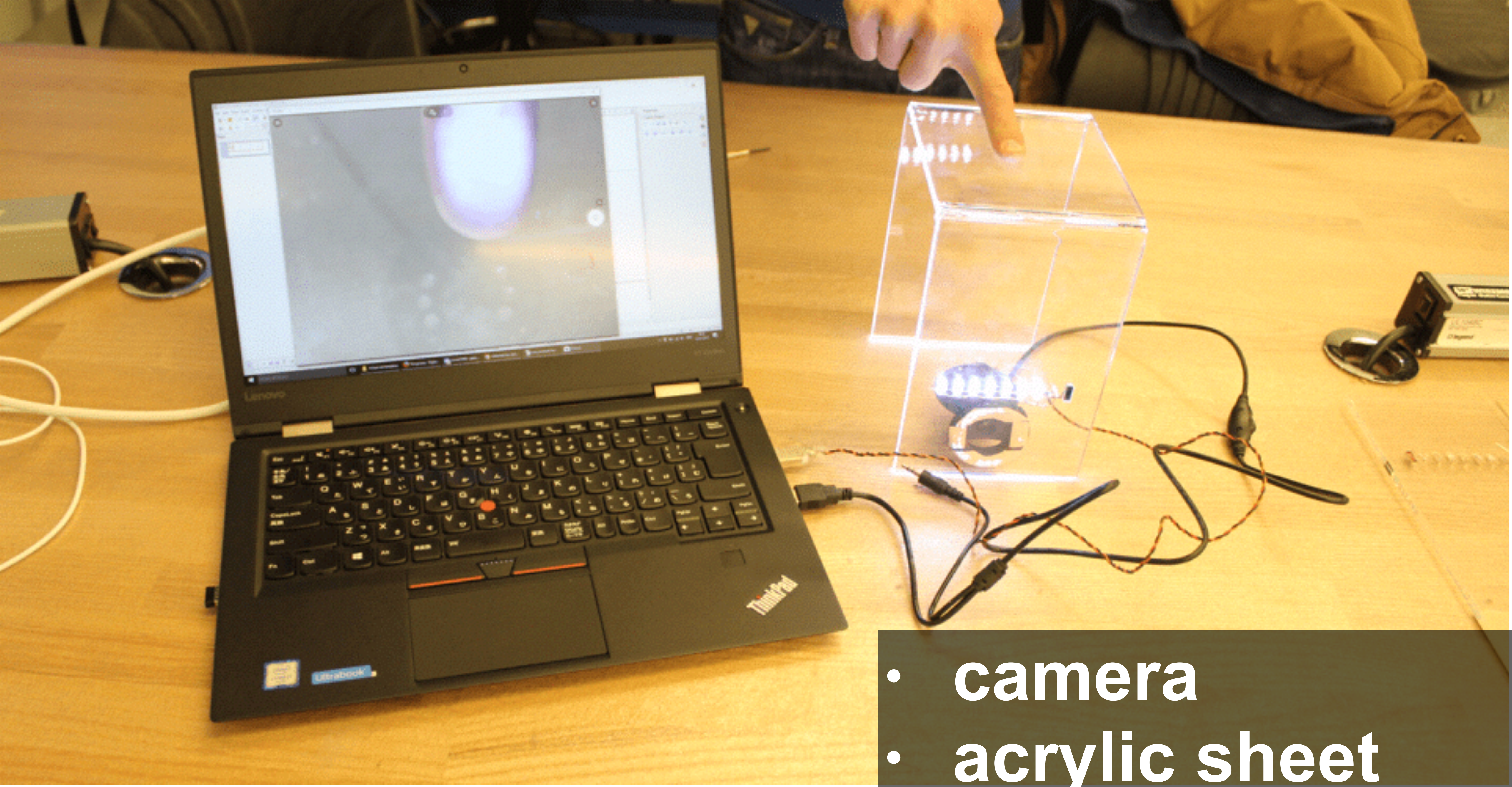
- camera
- acrylic sheet
- USB connector
- switch
- LEDs
- resistors

frustrated total internal reflection (FTIR)

frustrated total internal reflection (FTIR)





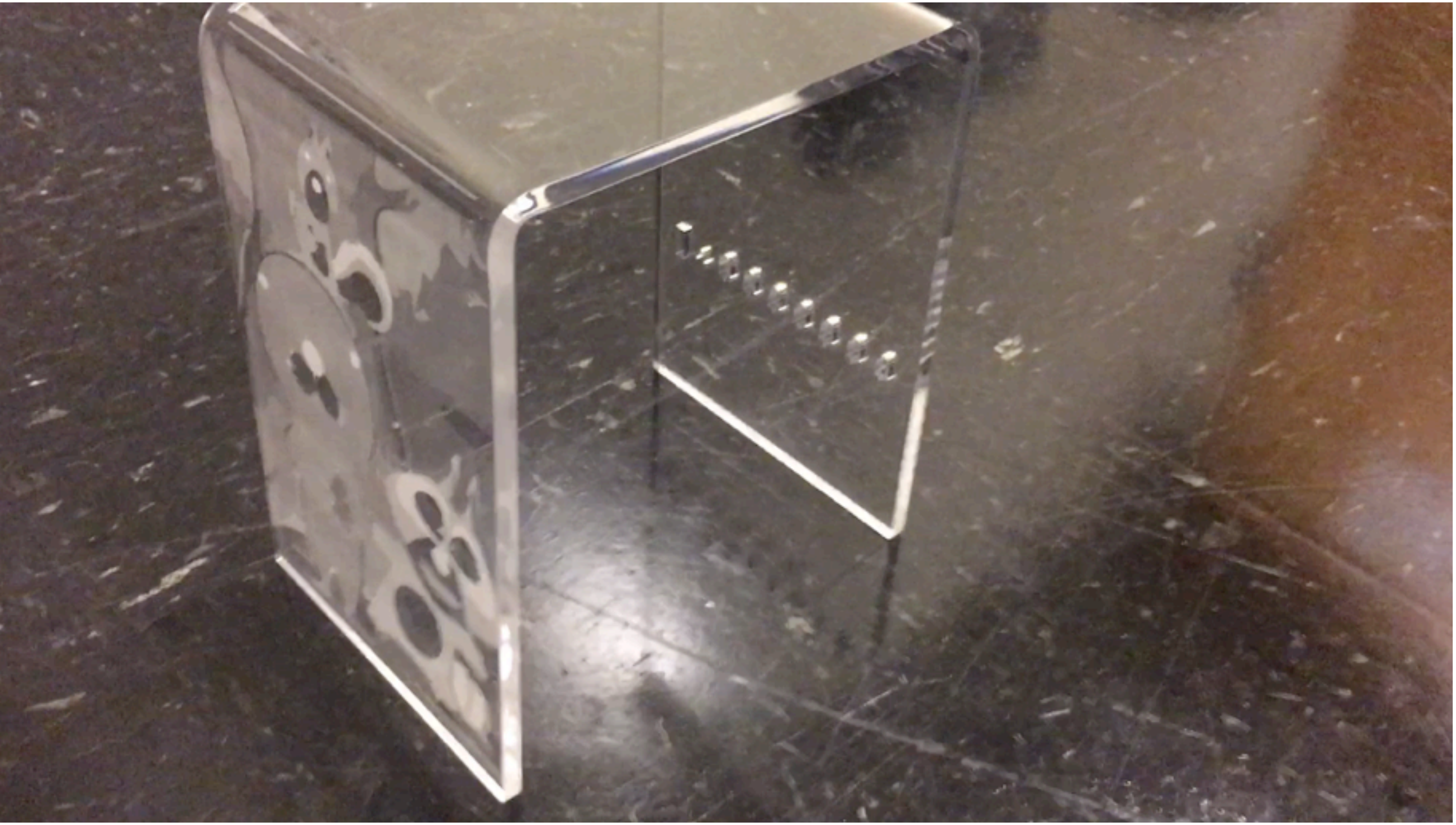


for pset Multitouch-Pad

- camera
- acrylic sheet
- USB connector
- switch
- LEDs
- resistors

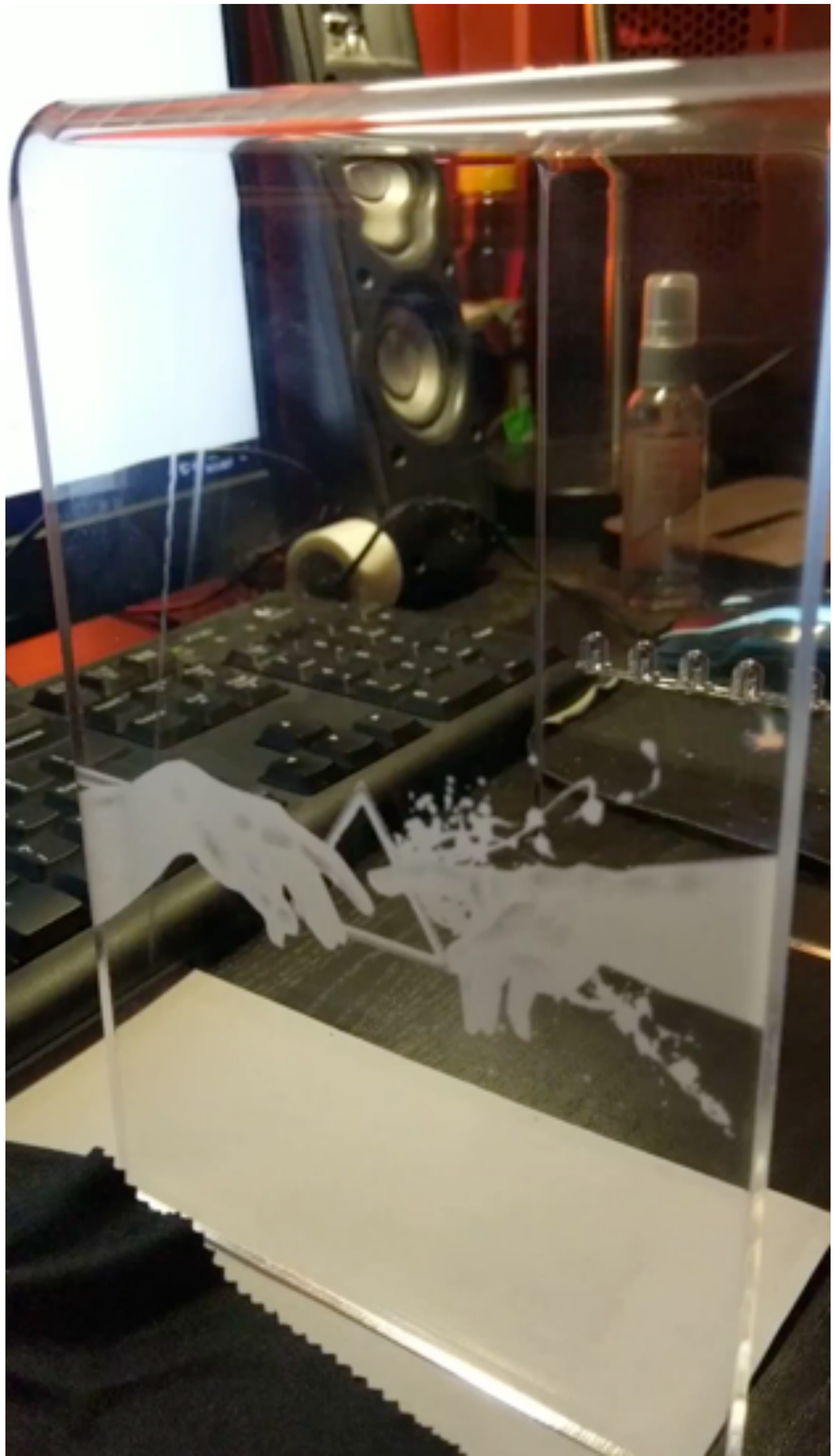
pset 1: only laser cutting + bending

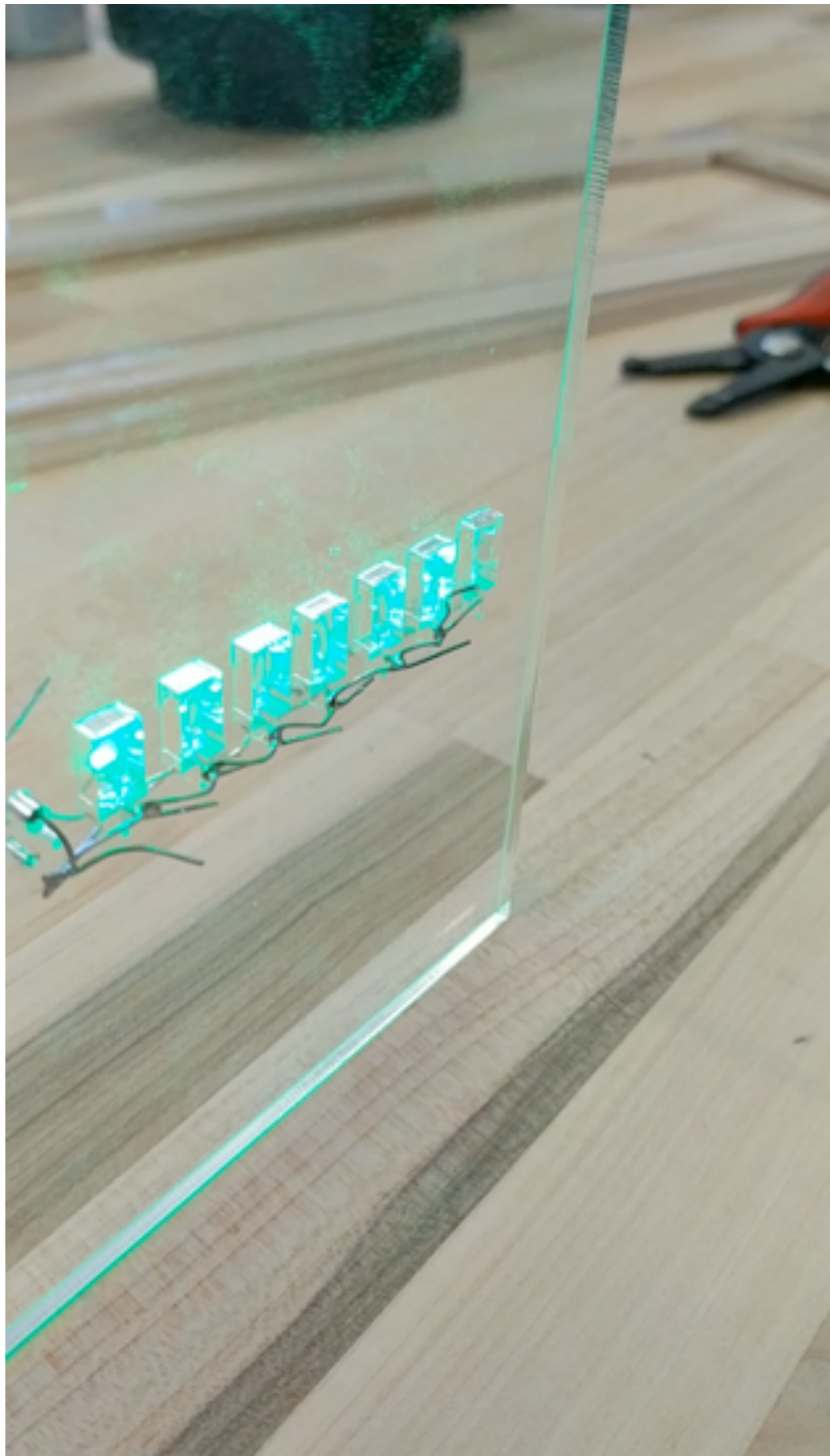
(due Sept. 21) —> you can start now



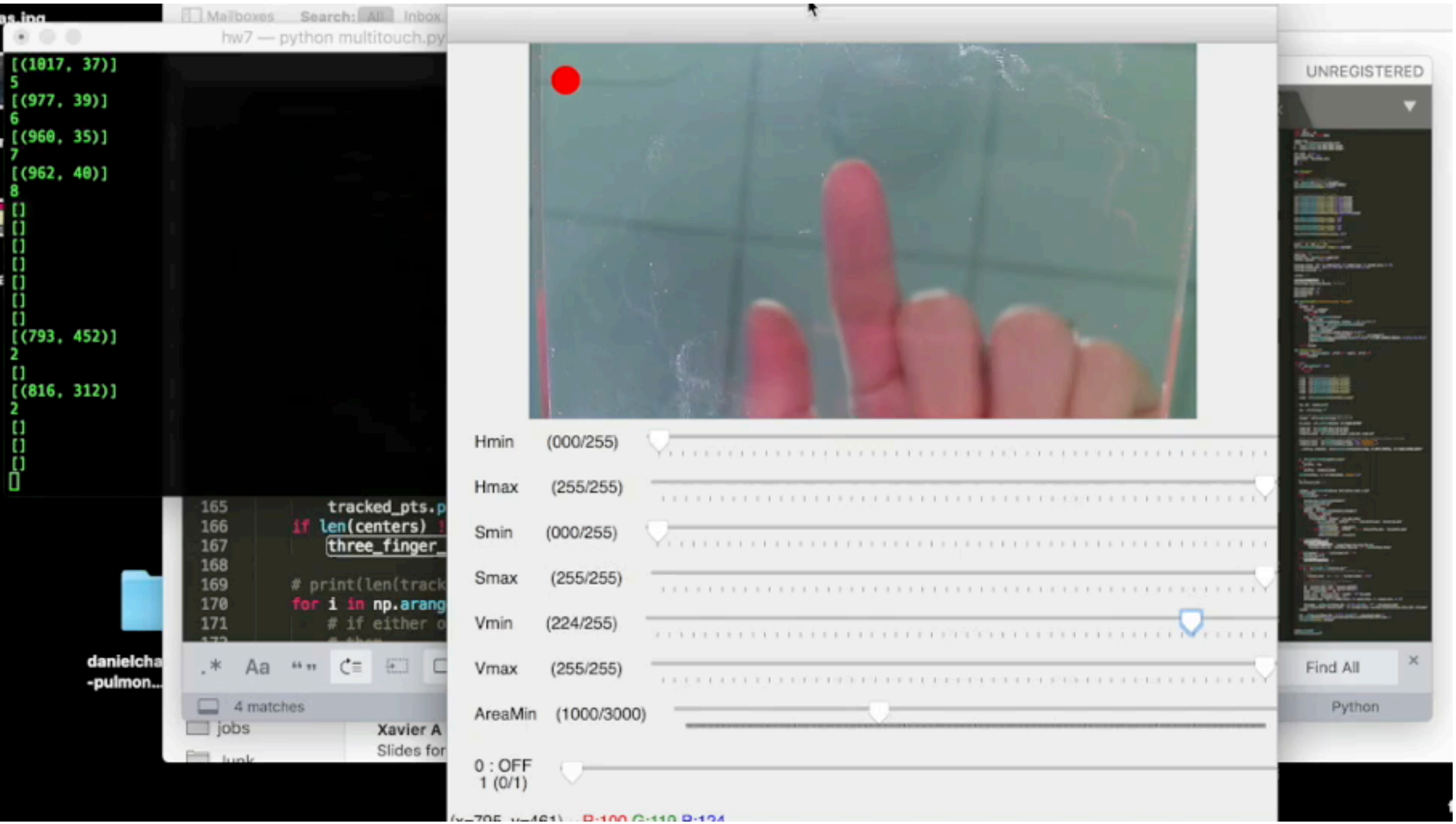
pset 2: LEDs, USB plug, switch, soldering

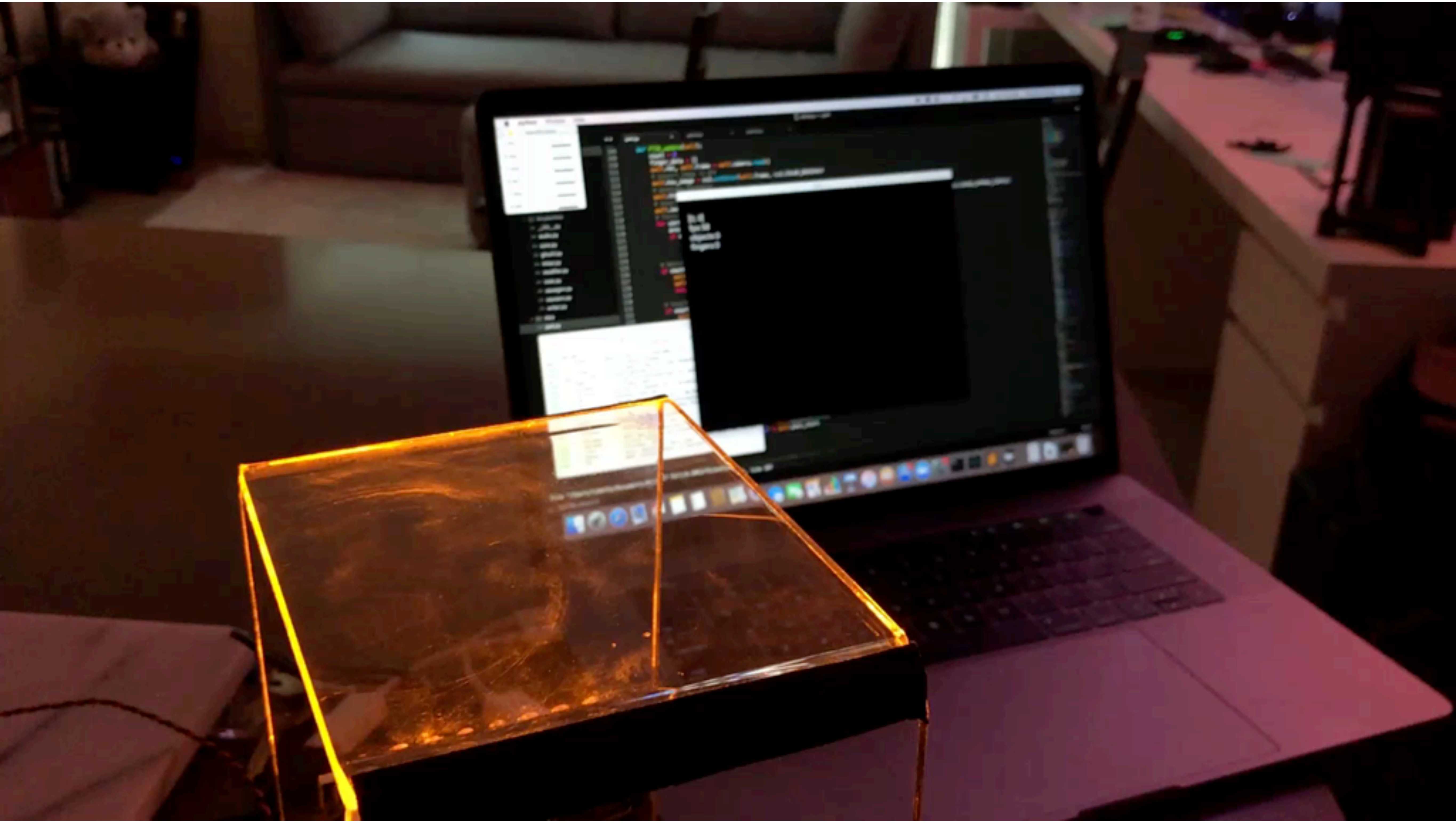
(due Oct. 5) —> please wait until tutorial



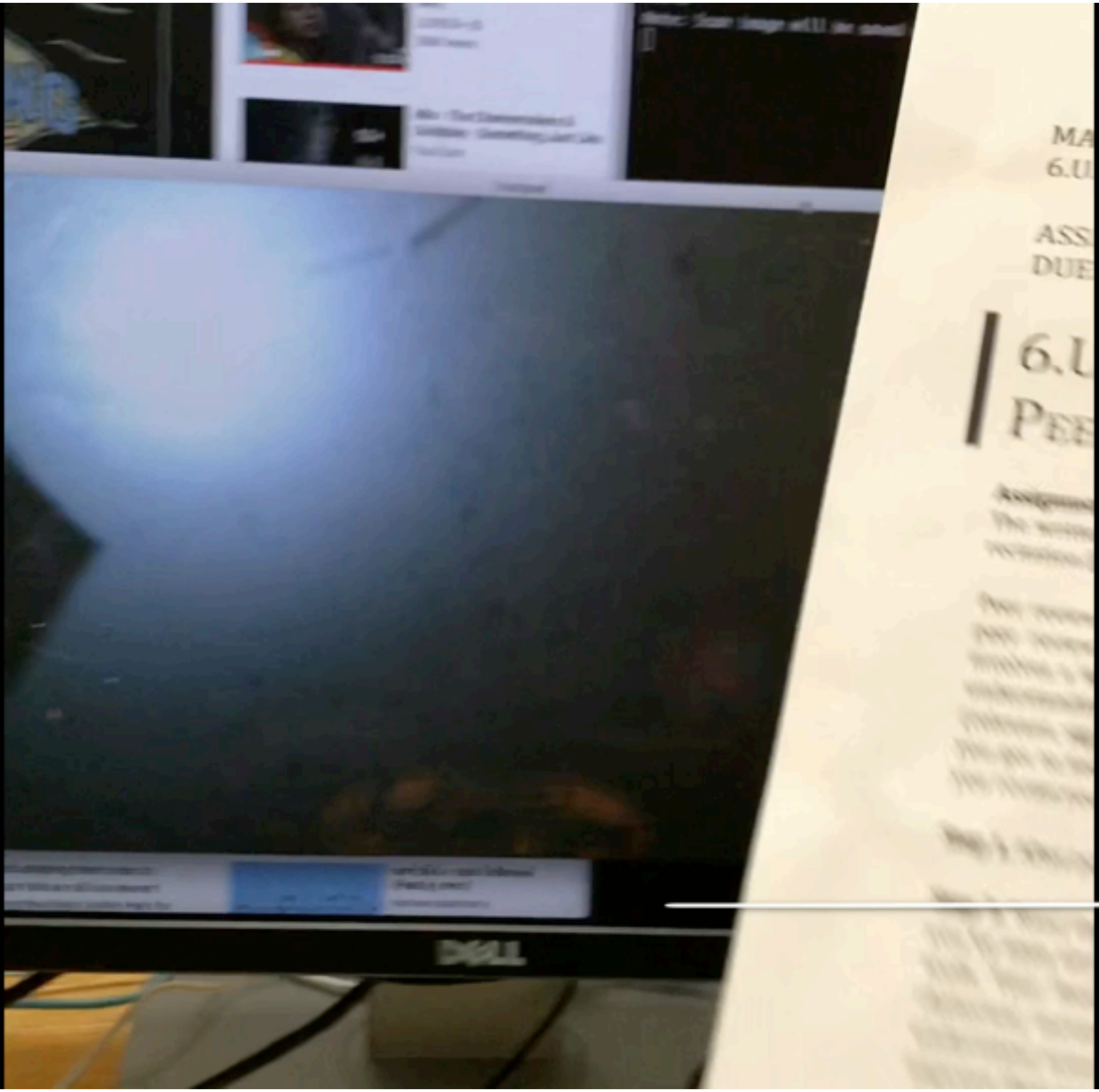


pset 3/4: finger tracking + applications
(due Oct. 19/26) -> please wait until tutorial

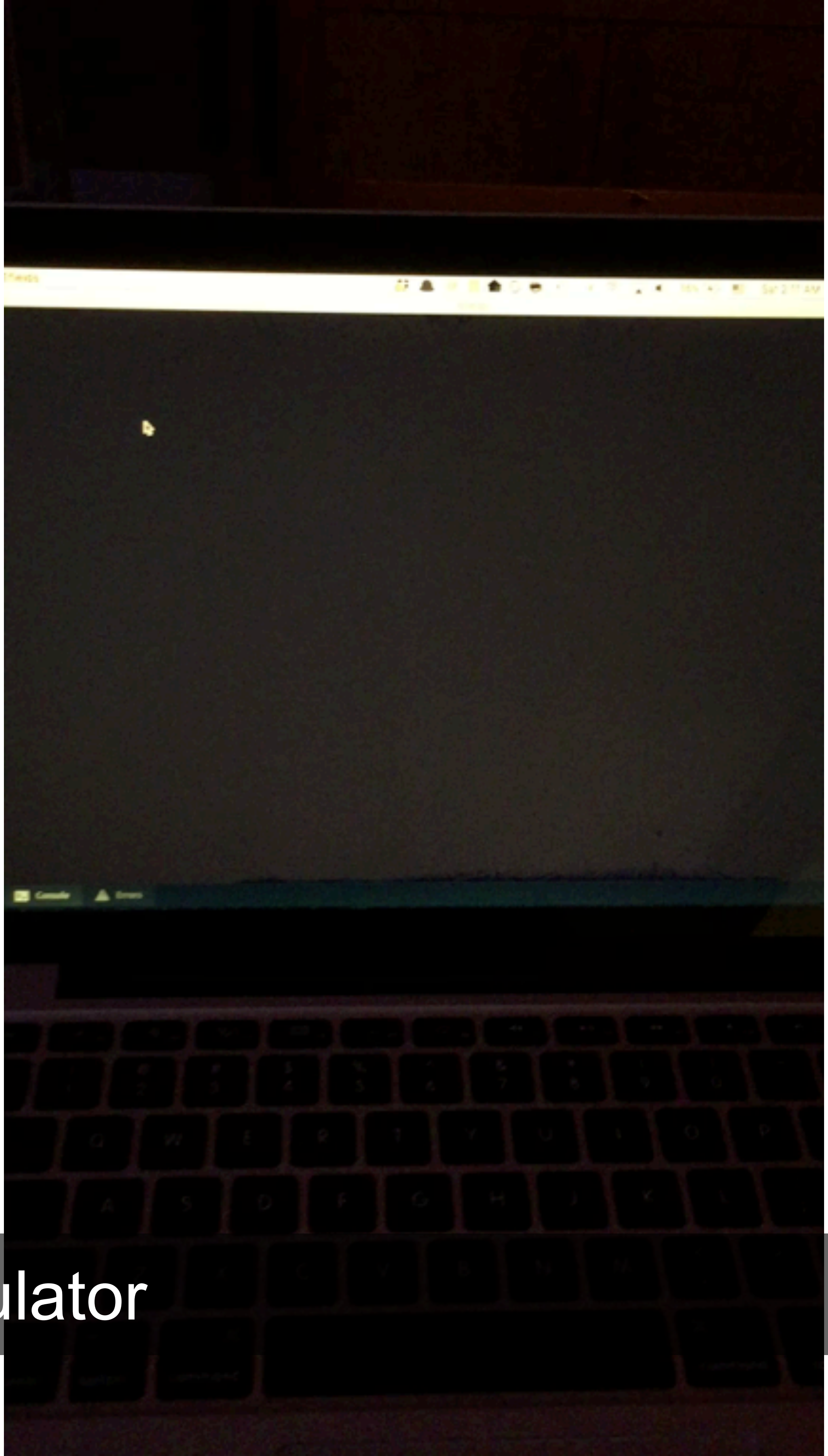




music generator



scanning documents, voice output, google search



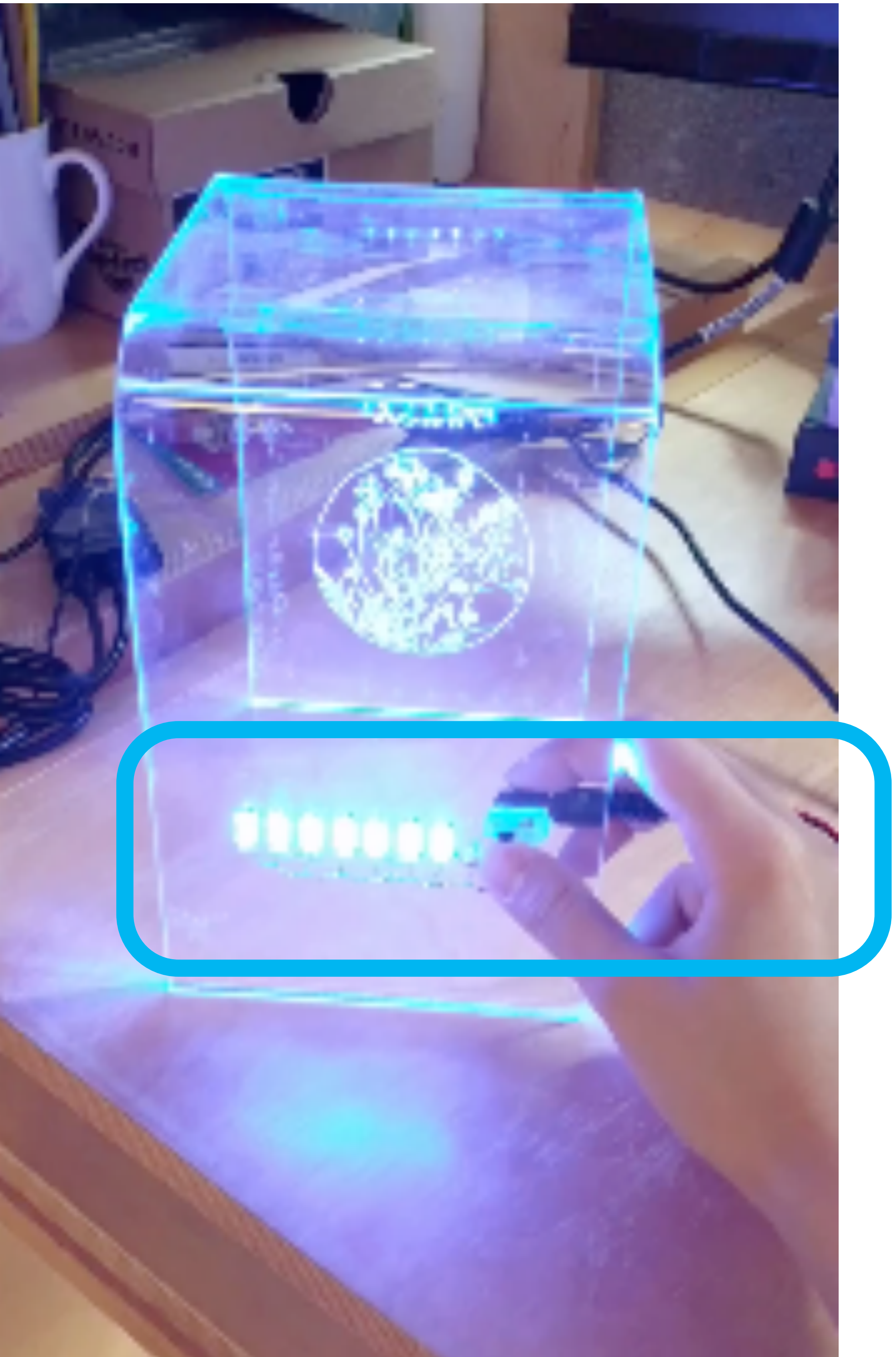
magnetic field simulator

drawing and geometry applications

help us with camera testing:

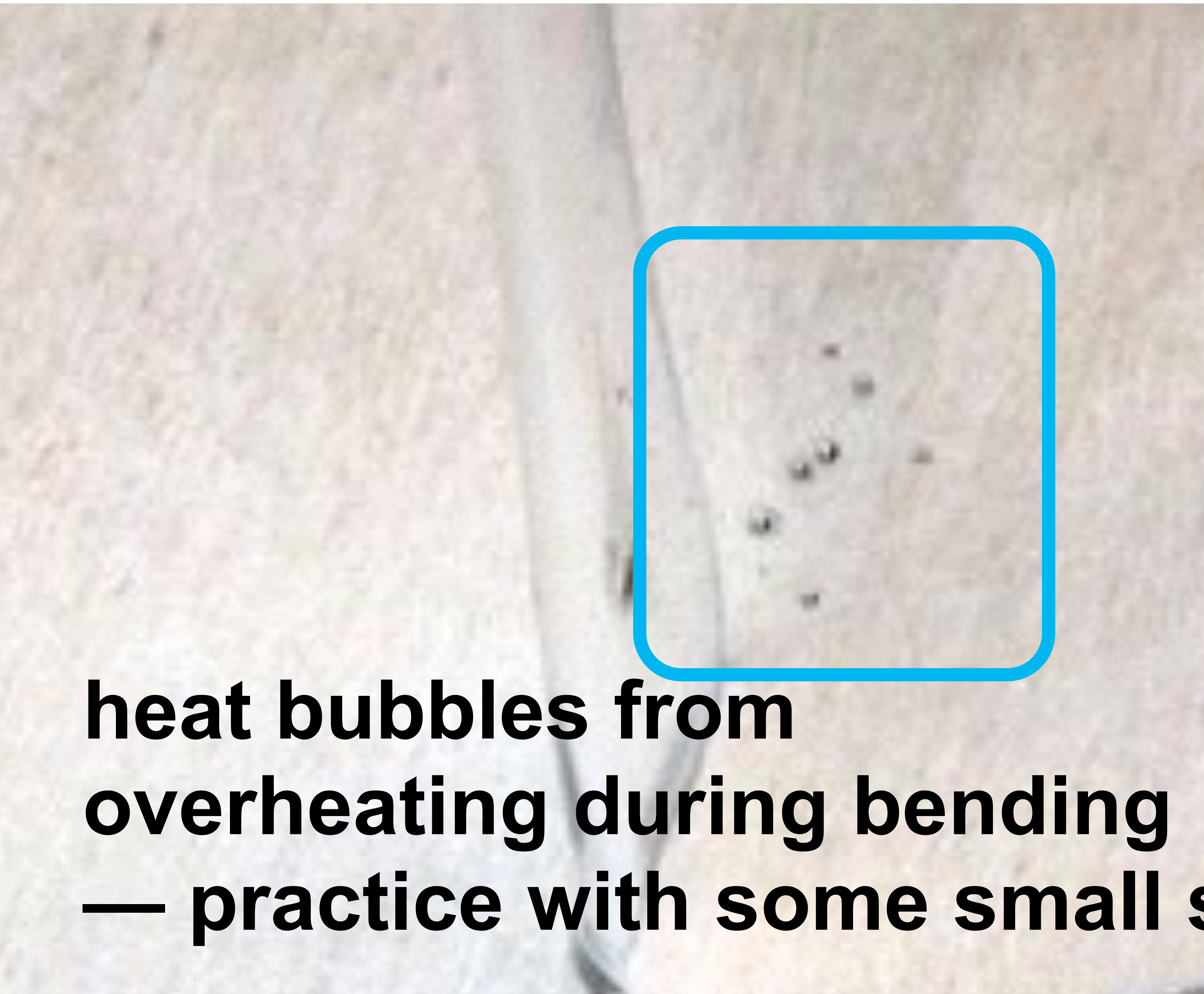
please do quick test until friday

always **test on a small part!!!**



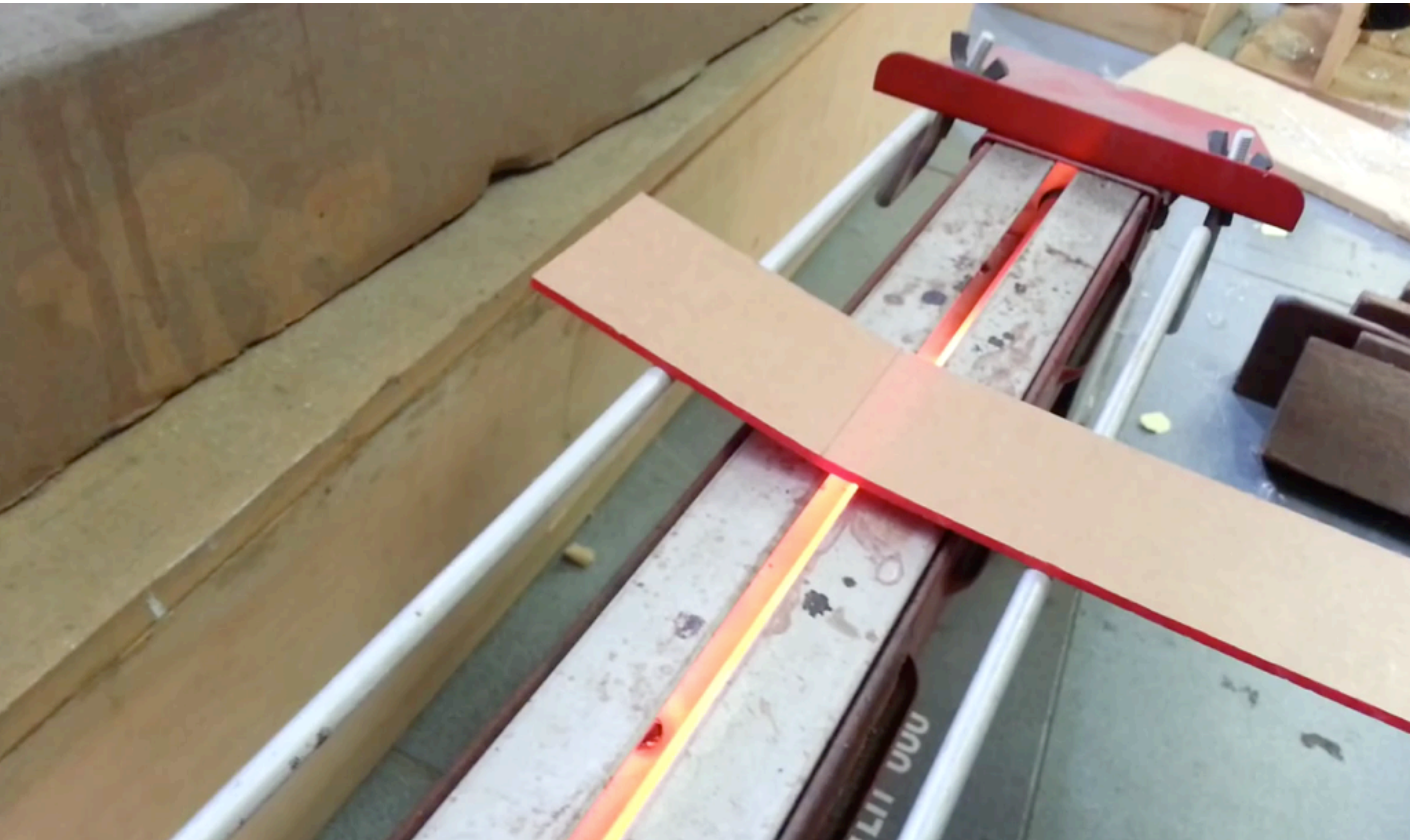
test **holes for LEDs**
on a separate piece
before using the big sheet

always **test on a small part!!!**



heat bubbles from overheating during bending — practice with some small strips first

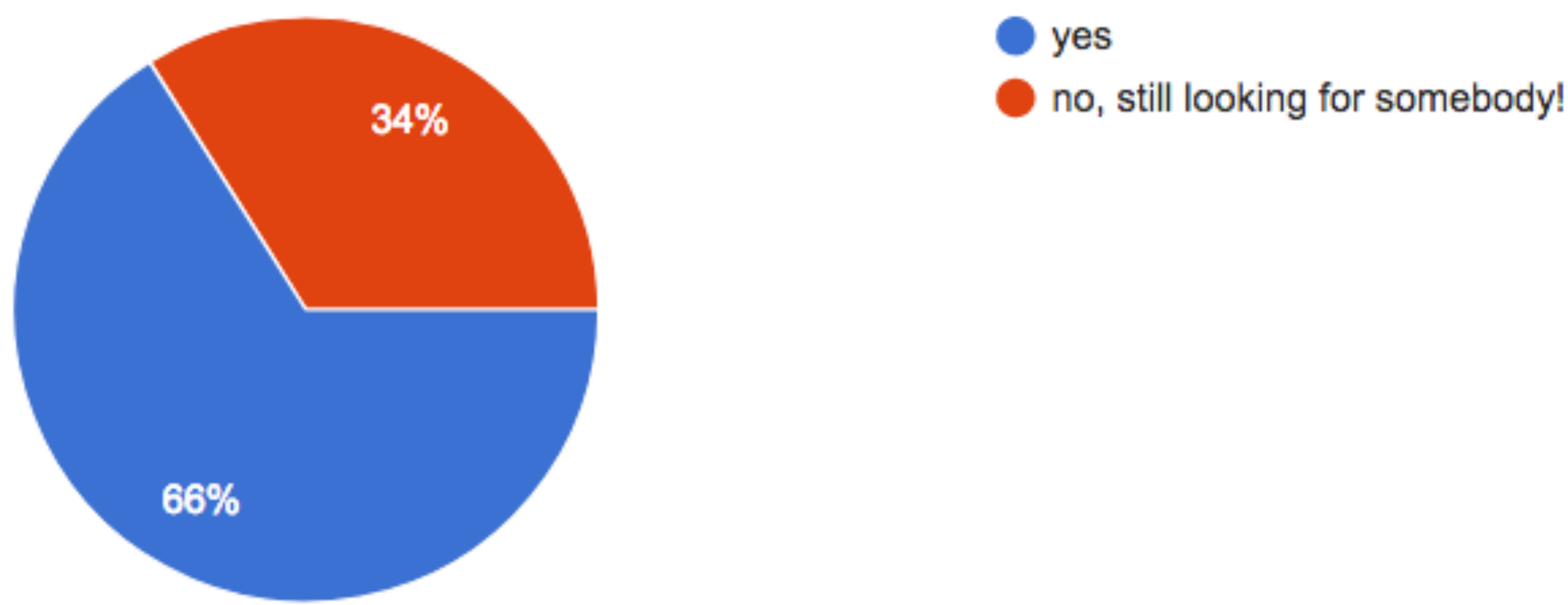
always **test on a small part!!!**



time to:
get your bag
+ find a team-partner

Do you already have a team partner?

53 responses



end.