SKETCHING HAPTICS

Camille Moussette, 27-02-2012, TU/E

UMEÅ UNIVERSITET


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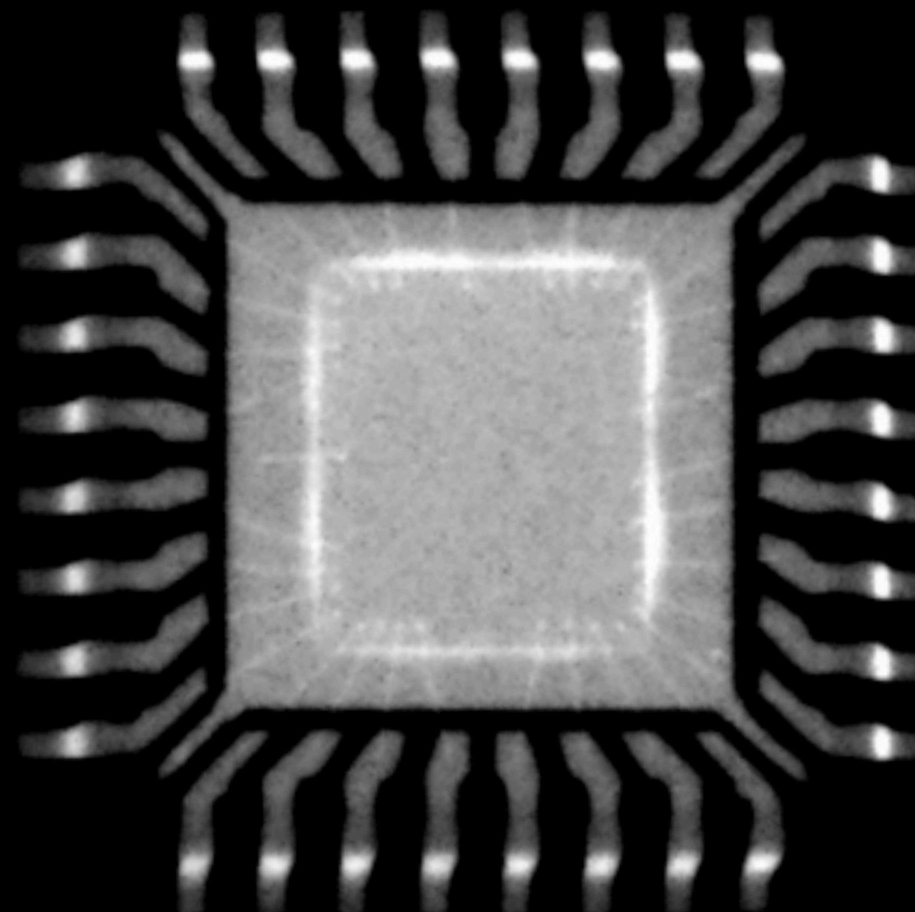
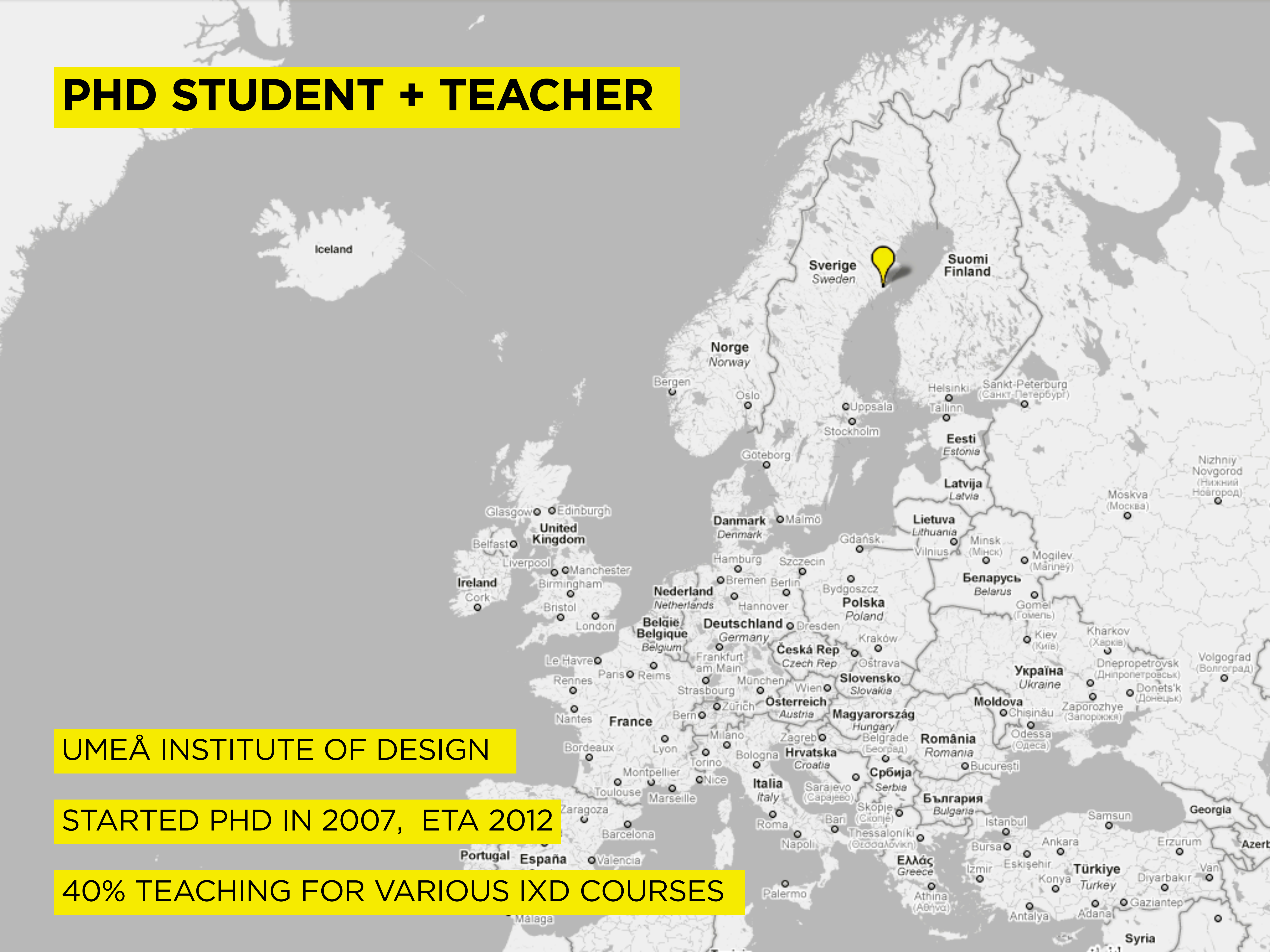
PHYSICS, IBM, **INDUSTRIAL DESIGN**, FREELANCE, SWEDEN, **INTERACTION DESIGN**, PHD, TEACHING



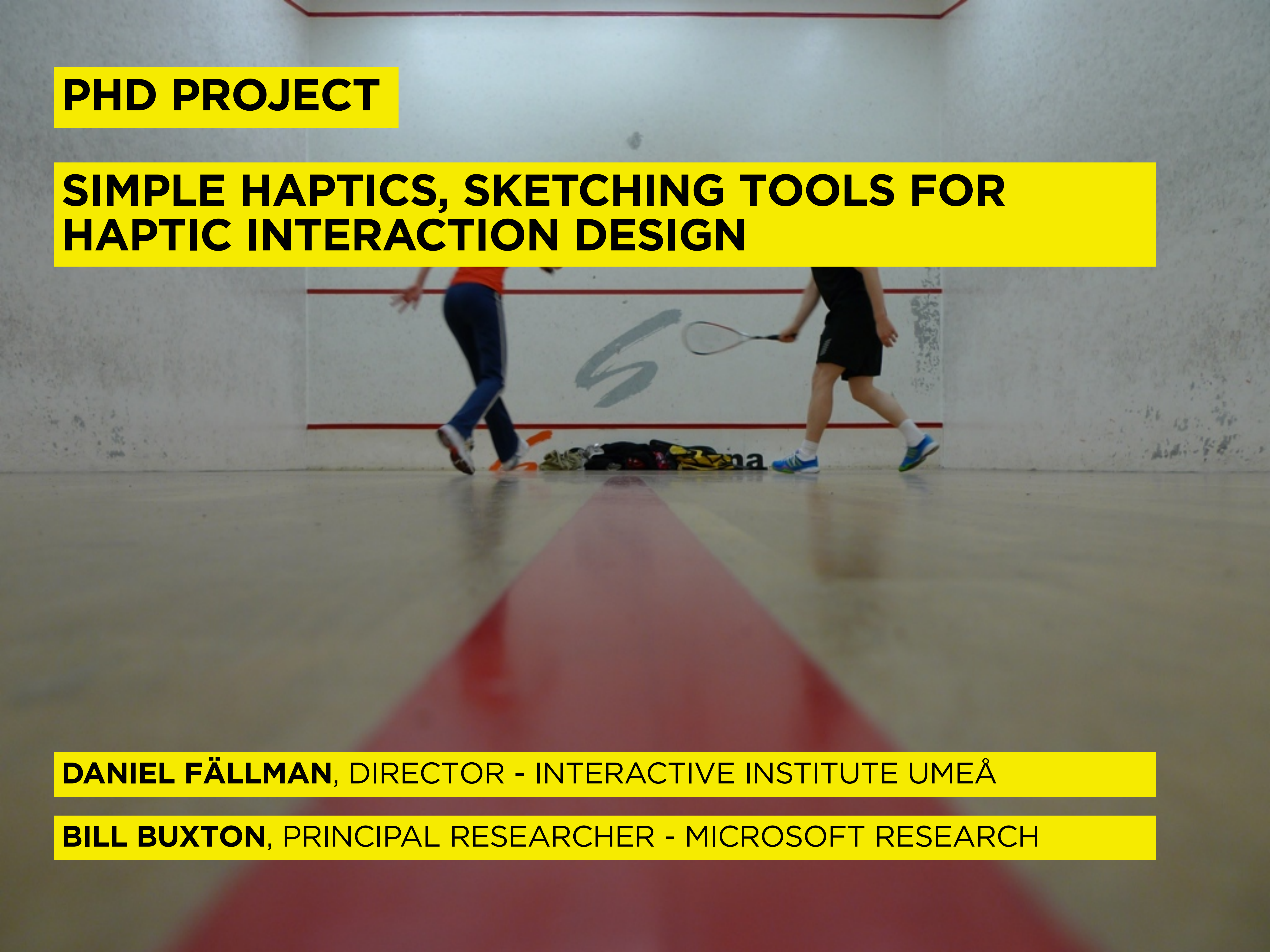
PHD STUDENT + TEACHER



UMEÅ INSTITUTE OF DESIGN

STARTED PHD IN 2007, ETA 2012

40% TEACHING FOR VARIOUS IXD COURSES



PHD PROJECT

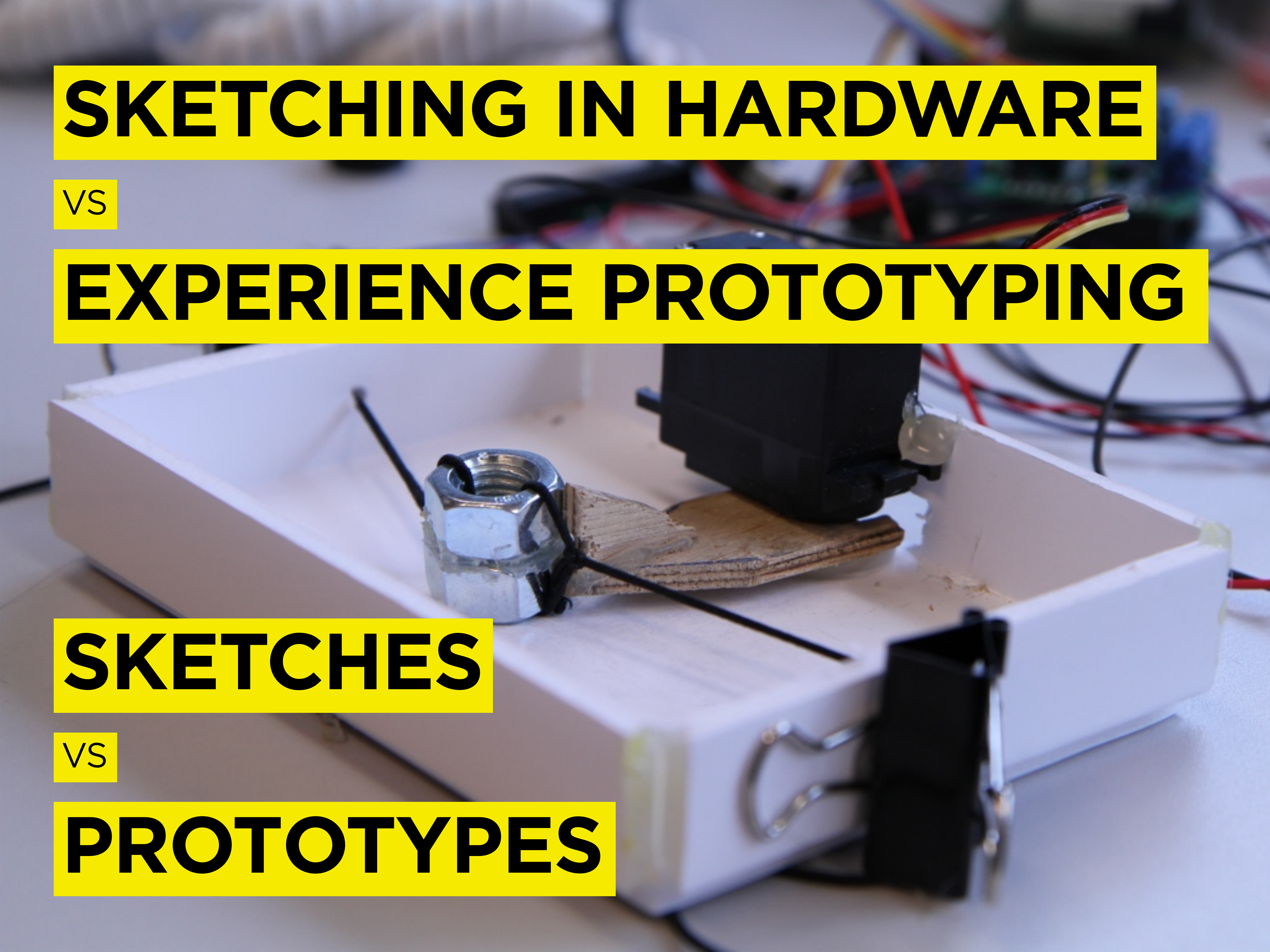
SIMPLE HAPTICS, SKETCHING TOOLS FOR HAPTIC INTERACTION DESIGN

DANIEL FÄLLMAN, DIRECTOR - INTERACTIVE INSTITUTE UMEÅ

BILL BUXTON, PRINCIPAL RESEARCHER - MICROSOFT RESEARCH

SKETCHING HAPTICS

Adobe


SKETCHING IN HARDWARE
VS
EXPERIENCE PROTOTYPING
SKETCHES
VS
PROTOTYPES

SKETCHING IN HARDWARE
OR PROTOTYPING?

Controller

A. Status LCD
Two lines show current state of the input being manipulated

B. Beat Visualization
OFF and 5 levels

C. Visualization Booster
Range from -3 to +3, controlling the diameter of audio generated dots

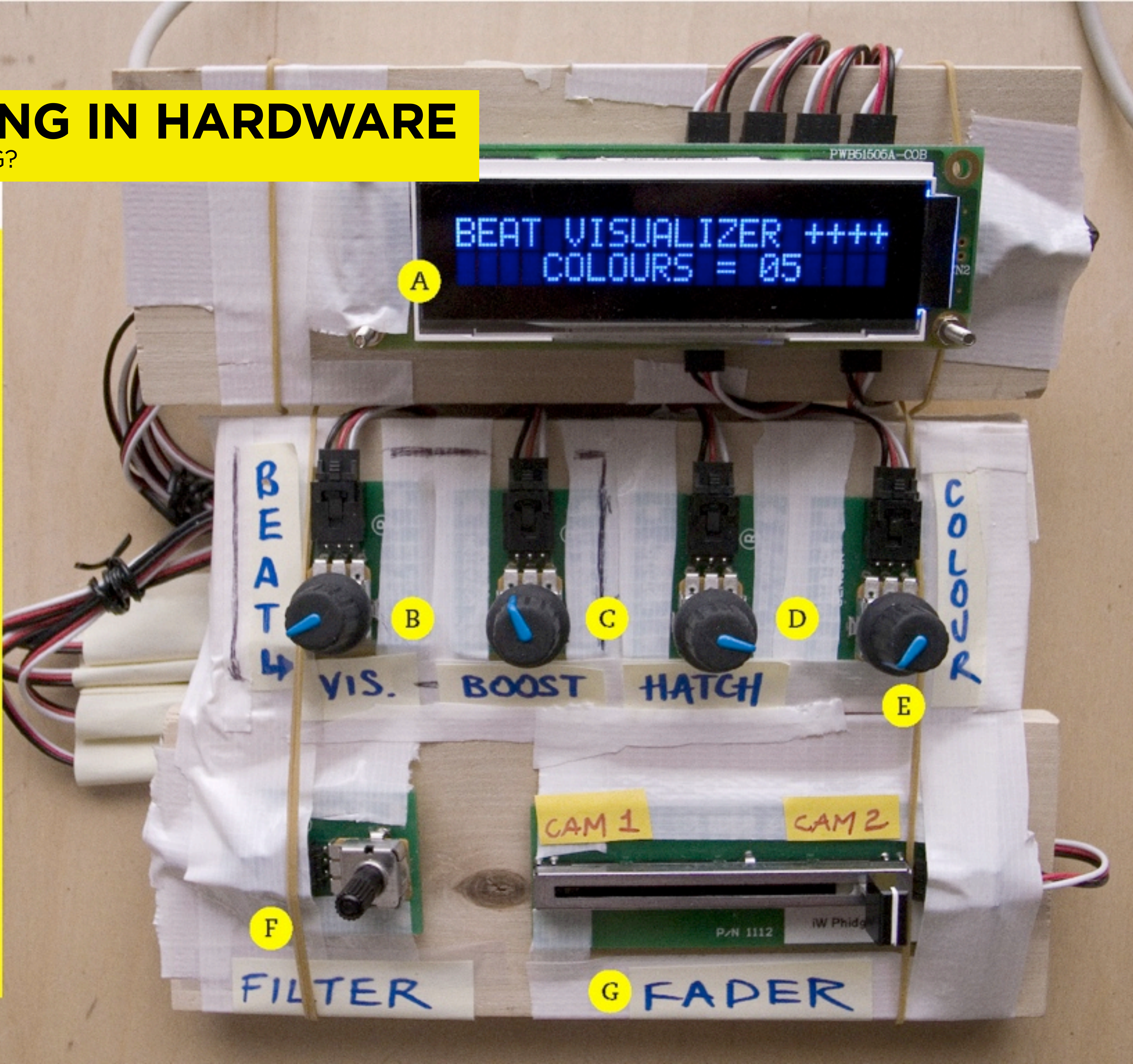
D. Hatch
A pattern of diagonal lines with settings from 0 (OFF) to 10 (maximum stroke)

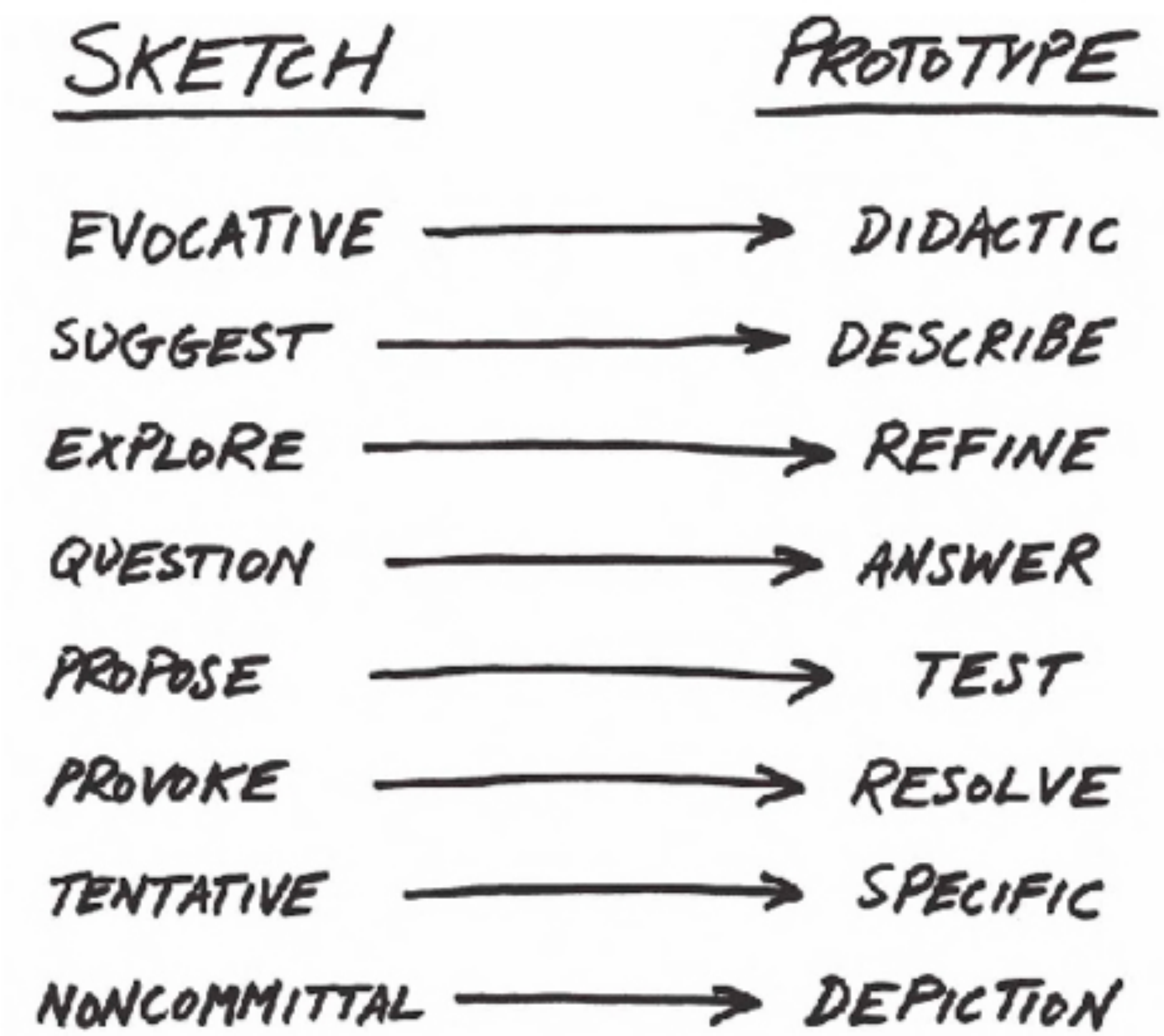
E. Colour
Suppresses colour from 16 to 2 (actual colors will vary depending on other effects

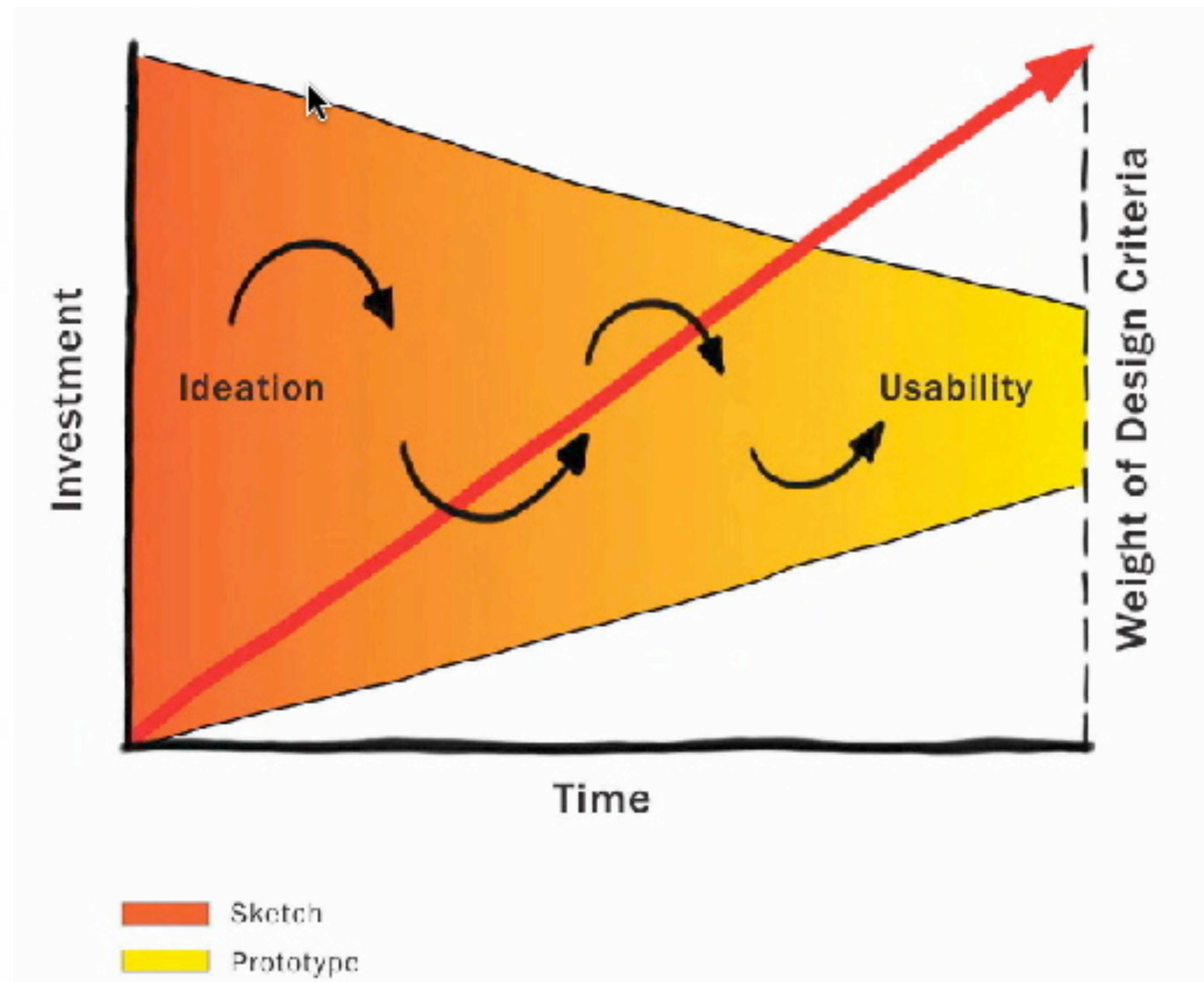
F. Filter
Sets the current filter from a bank of 10

G. Fader
Sets the video Channel

Keyboard Controls
Try keys 1-5, r, g, b




SKETCH
PROTOTYPE
EVOCATIVE → DIDACTIC
SUGGEST → DESCRIBE
EXPLORE → REFINE
QUESTION → ANSWER
PROPOSE → TEST
PROVOKE → RESOLVE
TENTATIVE → SPECIFIC
NONCOMMITTAL → DEPICTION


Investment
Ideation
Usability
Weight of Design Criteria
Time
Sketch
Prototype

Buxton, 2007

MANIFESTING IDEAS

FROM THE SKY DOWN TO EARTH , OR VICE-VERSA

DESIGNING IN THE UNKNOWN

PROBLEM-SOLVING WITH DETOURS

Characterizing a sketch/prototype?

audience

activity

←- →

goal

tool

time

Characterizing a sketch/prototype?

Fidelity scale (low/hi)

Characterizing a sketch/prototype?

Fidelity scale (low/hi)

Platform for engagement

Characterizing a sketch/prototype?

Fidelity scale (low/hi)

Platform for engagement

“Show & Tell”

Characterizing a sketch/prototype?

Fidelity scale (low/hi)

Platform for engagement

“Show & Tell”

“Show & Ask”

Characterizing a sketch/prototype?

Fidelity scale (low/hi)

Platform for engagement

“Show & Tell”

“Show & Ask”

Prototype as a Hypothesis
(scientific method)

Characterizing a sketch/prototype?

Fidelity scale (low/hi)

Platform for engagement

“Show & Tell”

“Show & Ask”

Prototype as a Hypothesis
(scientific method)

Prototype as a Marketplace
(exchange values, platform for productive collaboration, generation of knowledge/value)

Characterizing a sketch/prototype?

Fidelity scale (low/hi)

Platform for engagement

“Show & Tell”

“Show & Ask”

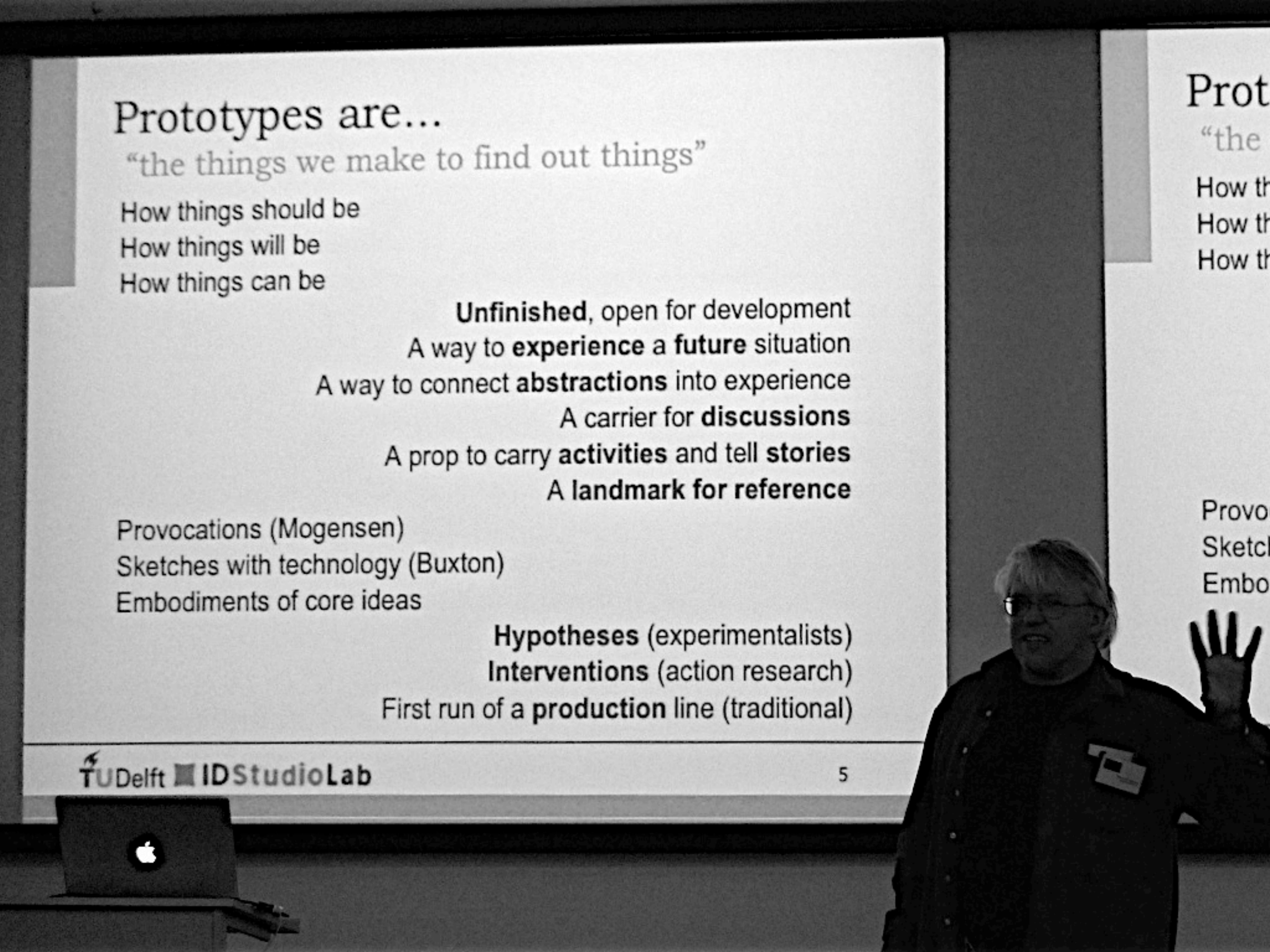
Prototype as a Hypothesis
(scientific method)

Prototype as a Marketplace
(exchange values, platform for productive collaboration, generation of knowledge/value)

Prototype as a Playground
(serious play, relaxation of rules, play vs serious vs real)

SERIOUS PLAY

Umeå Institute of Design + IDEO


Prototypes are…
"the things we make to find out things"
How things should be
How things will be
How things can be
Unfinished, open for development
A way to experience a future situation
A way to connect abstractions into experience
A carrier for discussions
A prop to carry activities and tell stories
A landmark for reference
Provocations (Mogensen)
Sketches with technology (Buxton)
Embodiments of core ideas
Hypotheses (experimentalists)
Interventions (action research)
First run of a production line (traditional)
TUDelft IDStudioLab
5

The Anatomy of Prototypes

Lim, Y.-K., Stolterman, E., and Tenenberg, J. 2008

Prototypes are **filters** that traverse a design space and are **manifestations** of design ideas that concretize and externalize conceptual ideas.

The Anatomy of Prototypes

Lim, Y.-K., Stolterman, E., and Tenenberg, J. 2008

Prototypes are **filters** that traverse a design space and are **manifestations** of design ideas that concretize and externalize conceptual ideas.

A "good" prototype is very dependent on what you are trying to explore, evaluate, or understand.

The Anatomy of Prototypes

Lim, Y.-K., Stolterman, E., and Tenenberg, J. 2008

The Principles of Prototyping

Fundamental prototyping principle

Prototyping is an activity with the purpose of creating a **manifestation** that, in its simplest form, **filters** the qualities in which designers are interested, without distorting the understanding of the whole.

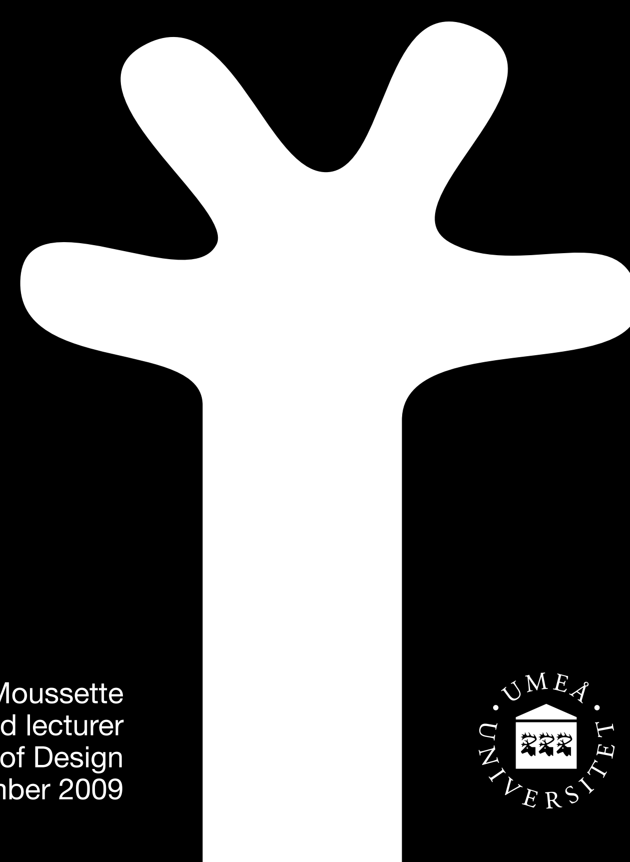
Economic principle of prototyping

The best prototype is one that, in the **simplest** and the **most efficient way**, makes the possibilities and limitations of a design idea visible and measurable.


TECHNO CENTRIC ↔ HUMAN CENTRIC

Sketching and Prototyping Levels

First presented at Physicality Workshop - HCI 2009 | Cambridge



Camille Moussette
PhD Student and lecturer
Umeå Institute of Design
September 2009

Sketching and prototyping levels

Minutes and hours | Hours, one day | Multiple days | Week

Minutes and hours

Rough

Crude

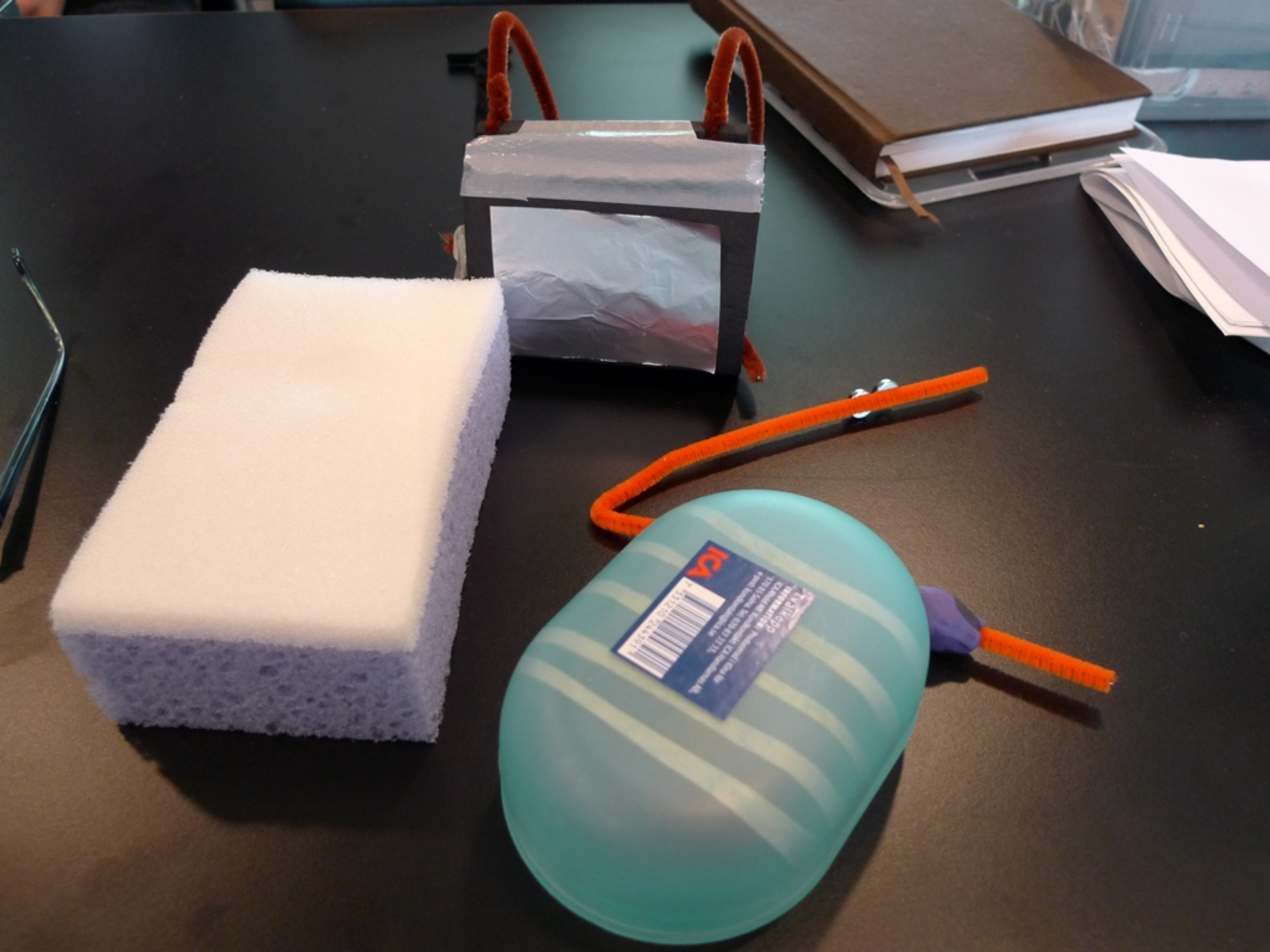
Human actuated, Wizard of Oz

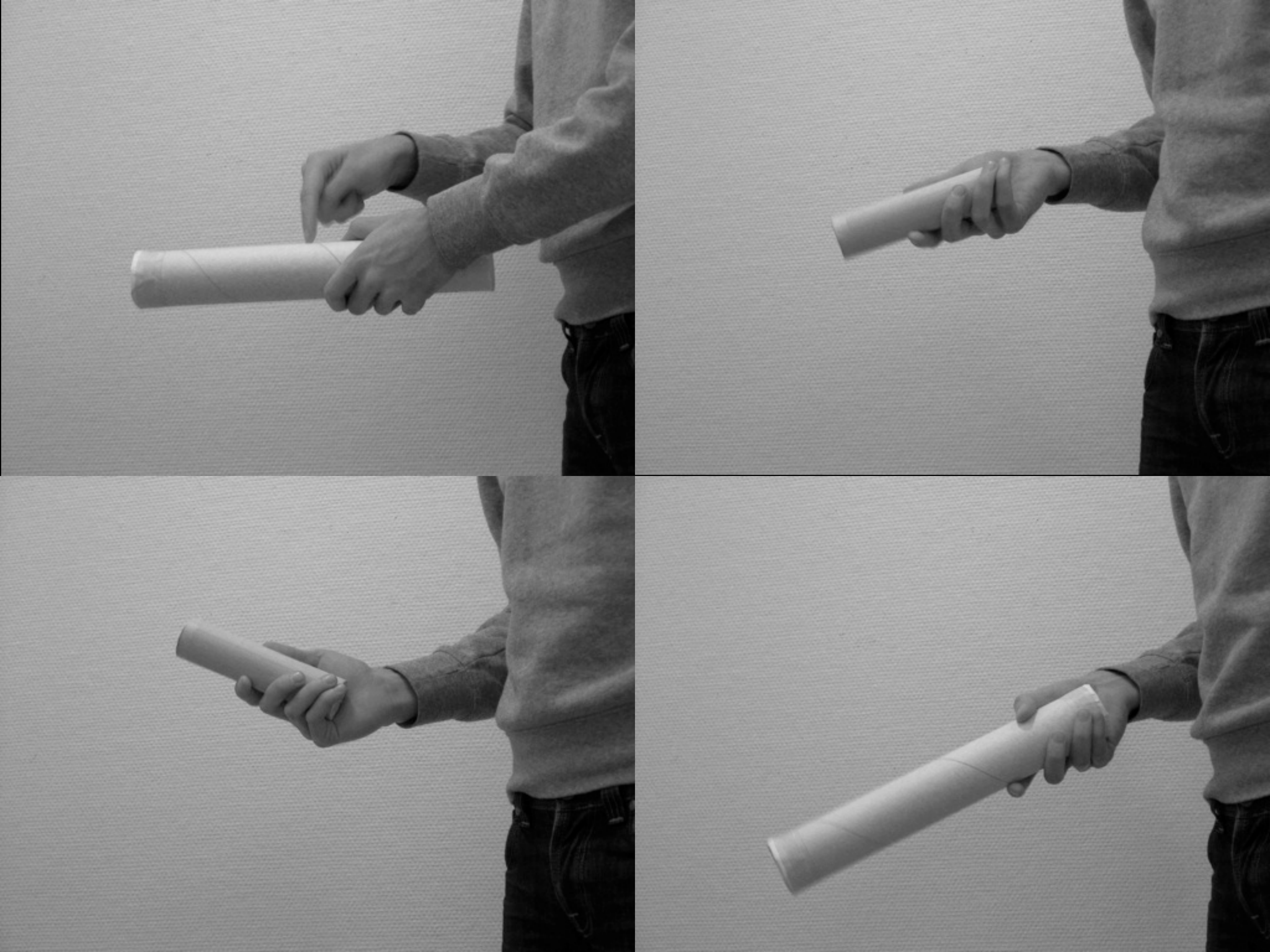
Quick and dirty “how does this feel”

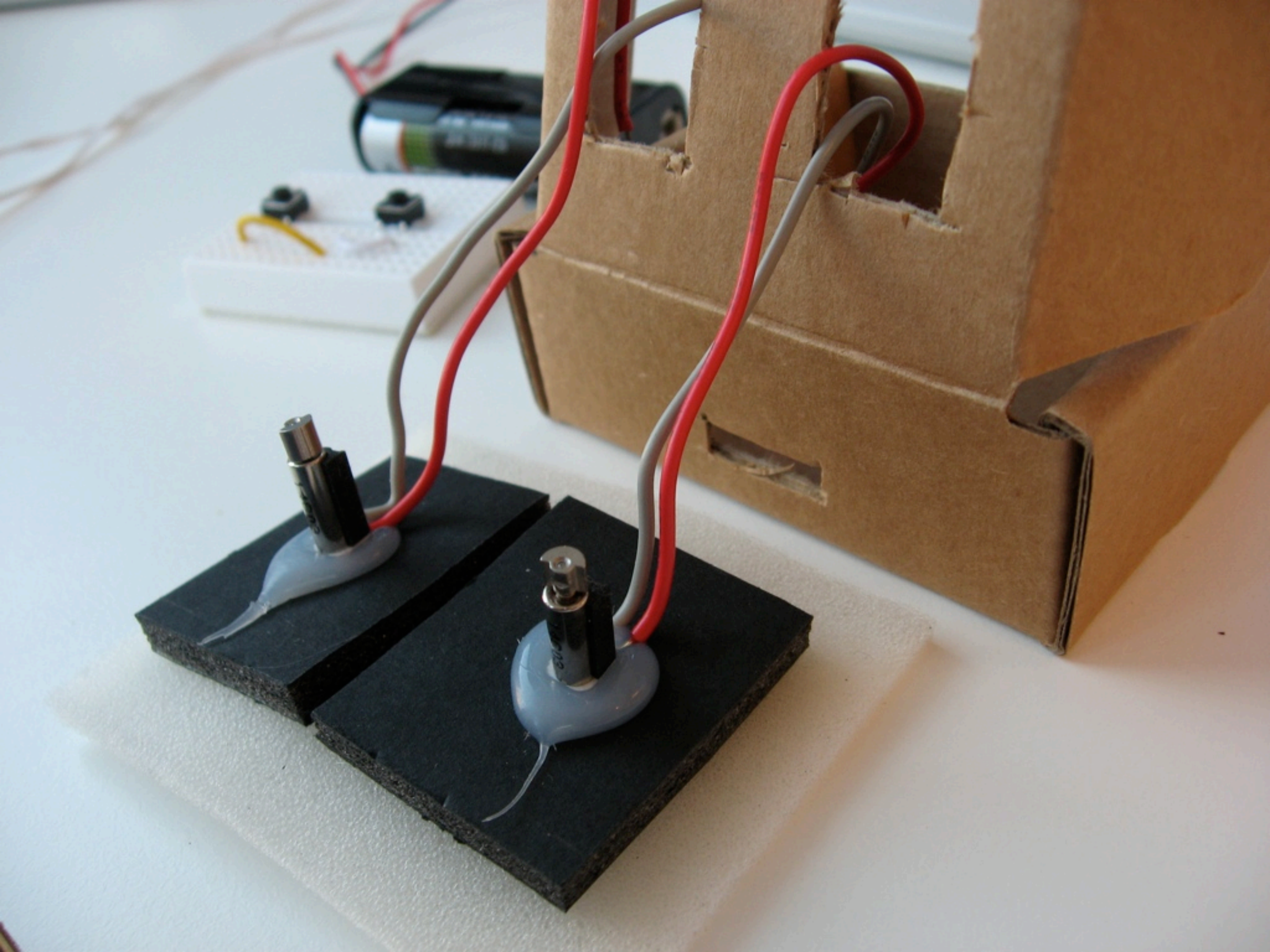
PD like (brainstorm, ideation workshop)

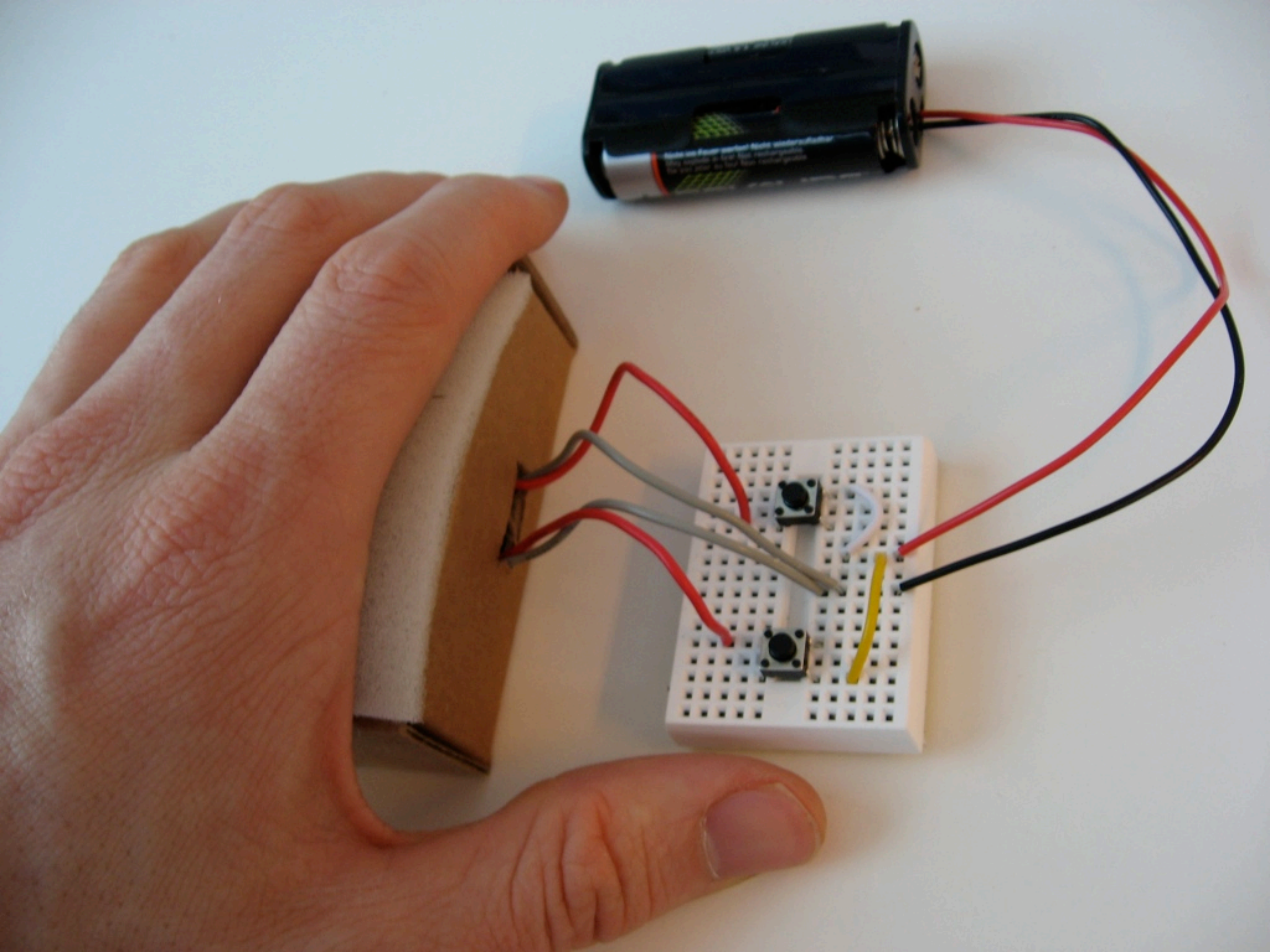
What you can do on your desk/table

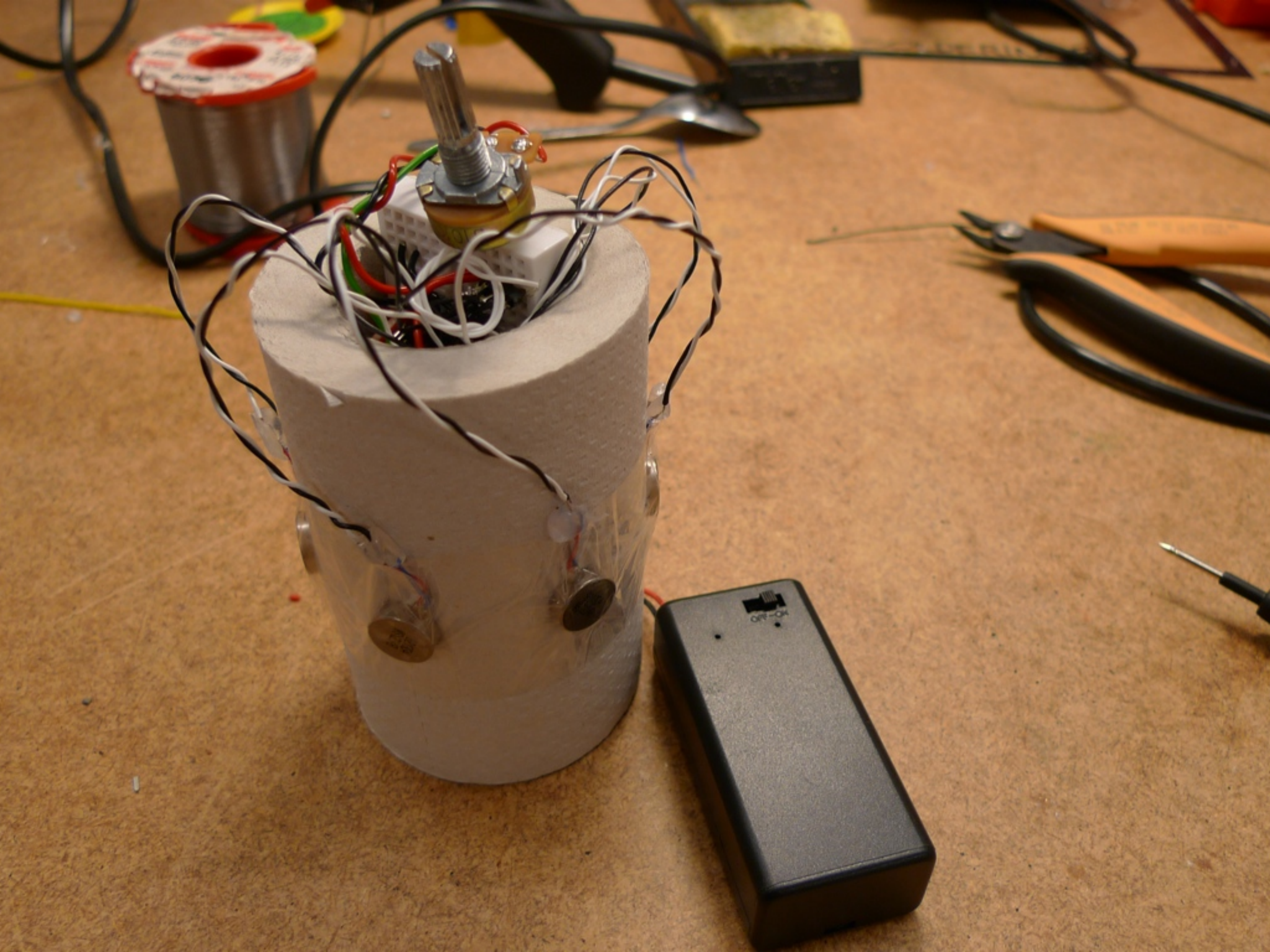
Low-tech (usually), low-fi (not necessarily)











Hours, one day

Explore variations

Not as clunky

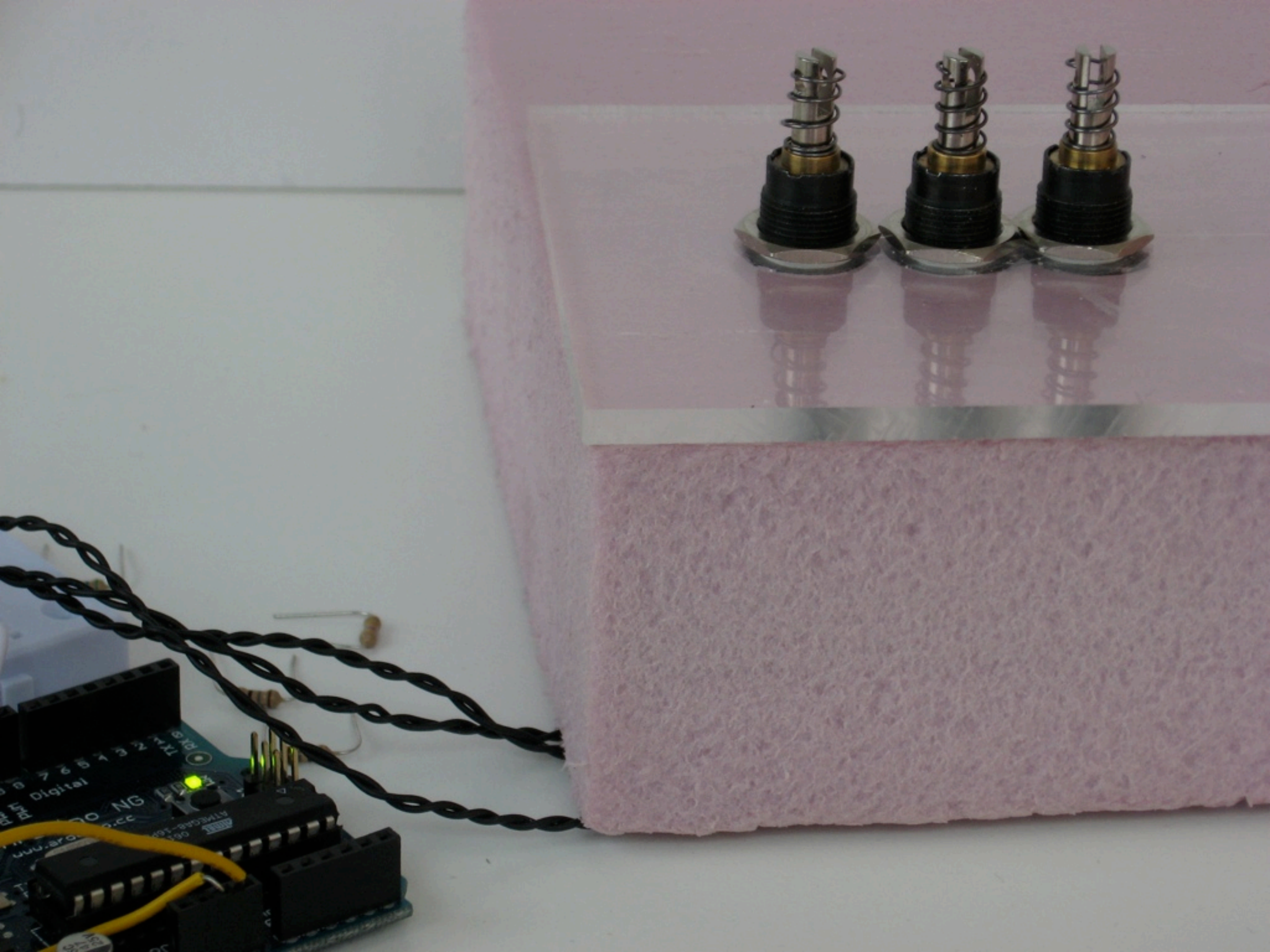
Human actuated, Wizard of Oz

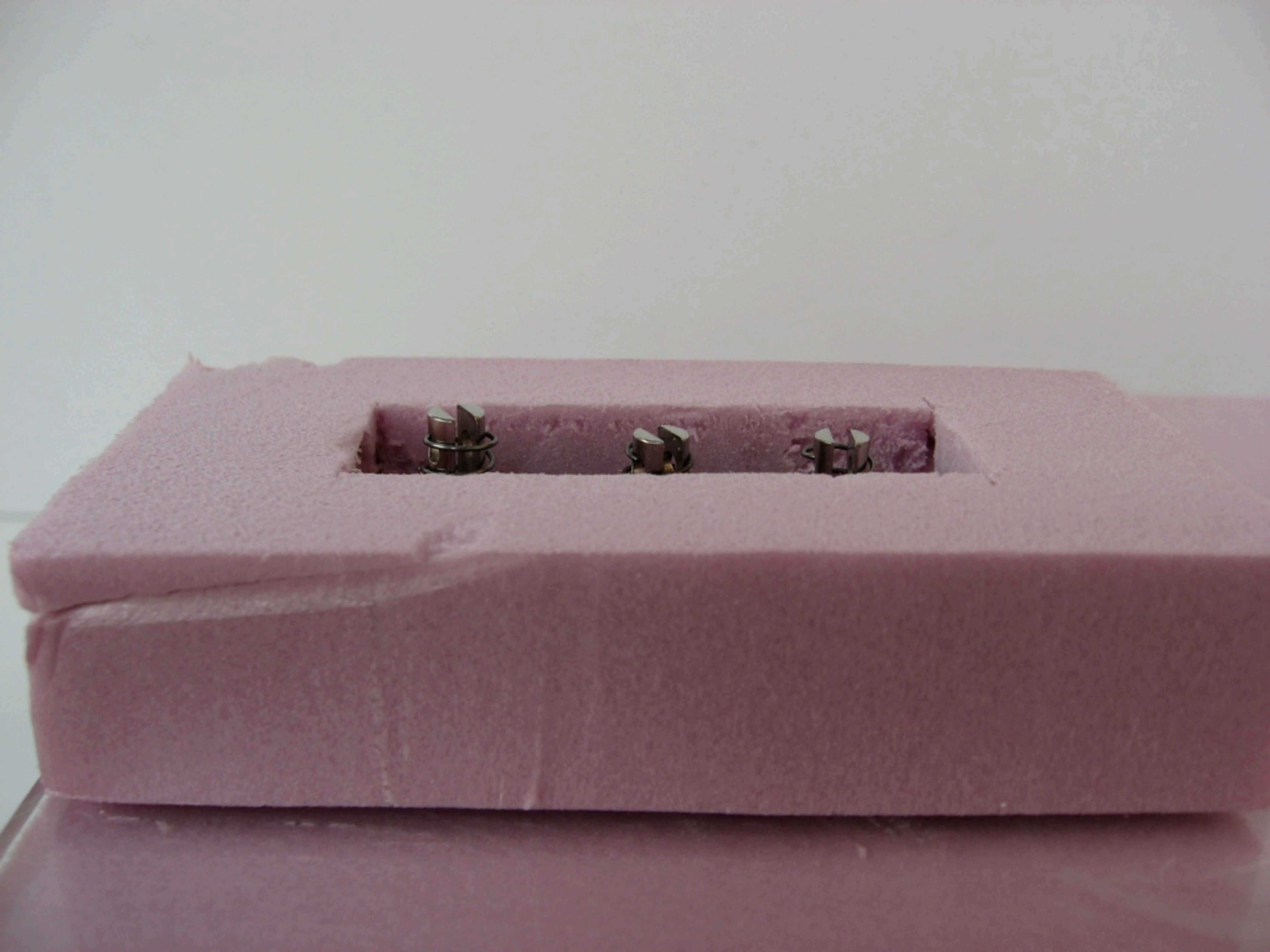
Basic assembly and construction elements

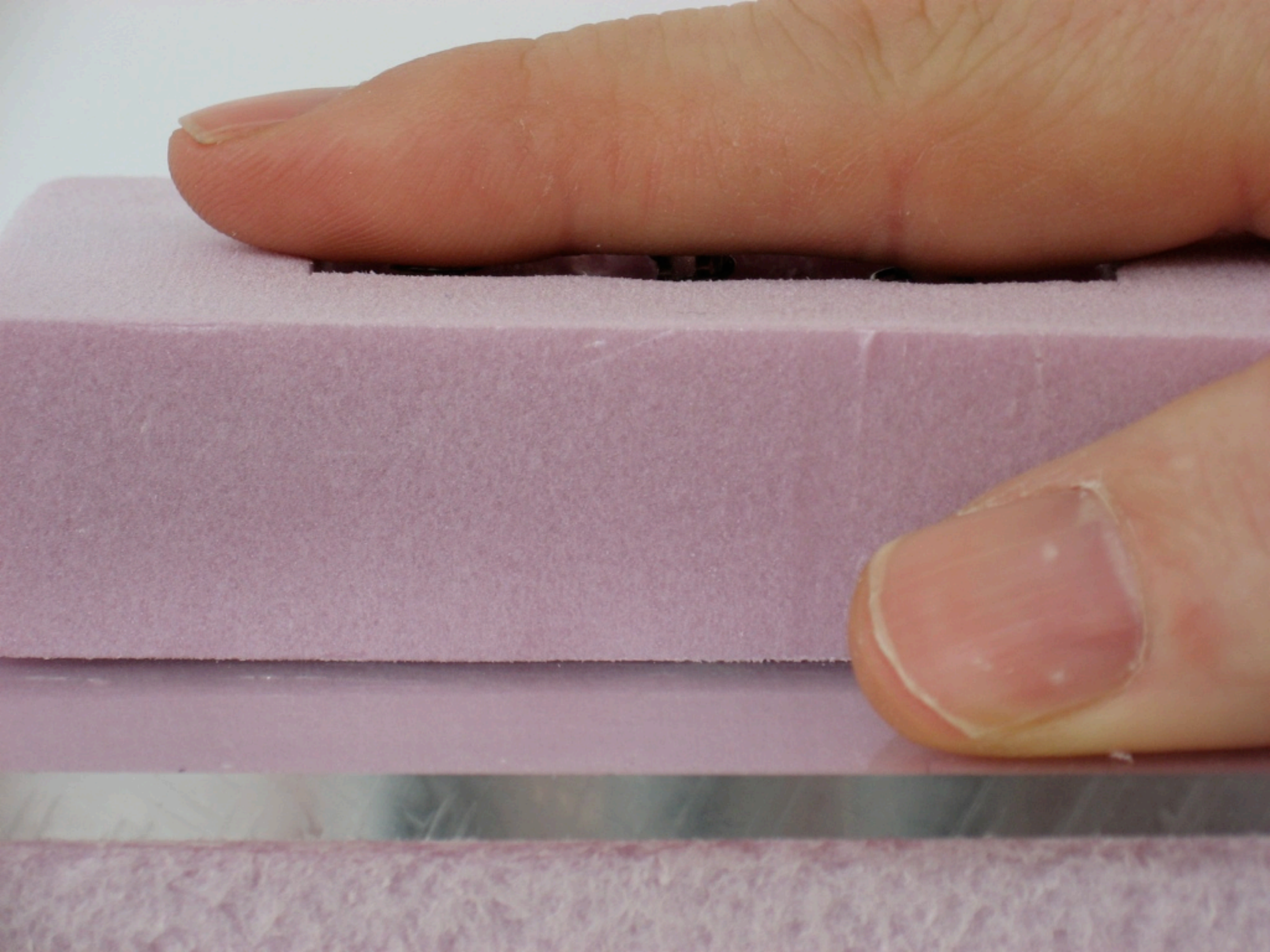
Simple trigger or control mechanism

What you can do in your “garage”

Low-fi (not necessarily)


Digital





Multiple days

Adjustability and more control

Repeatability

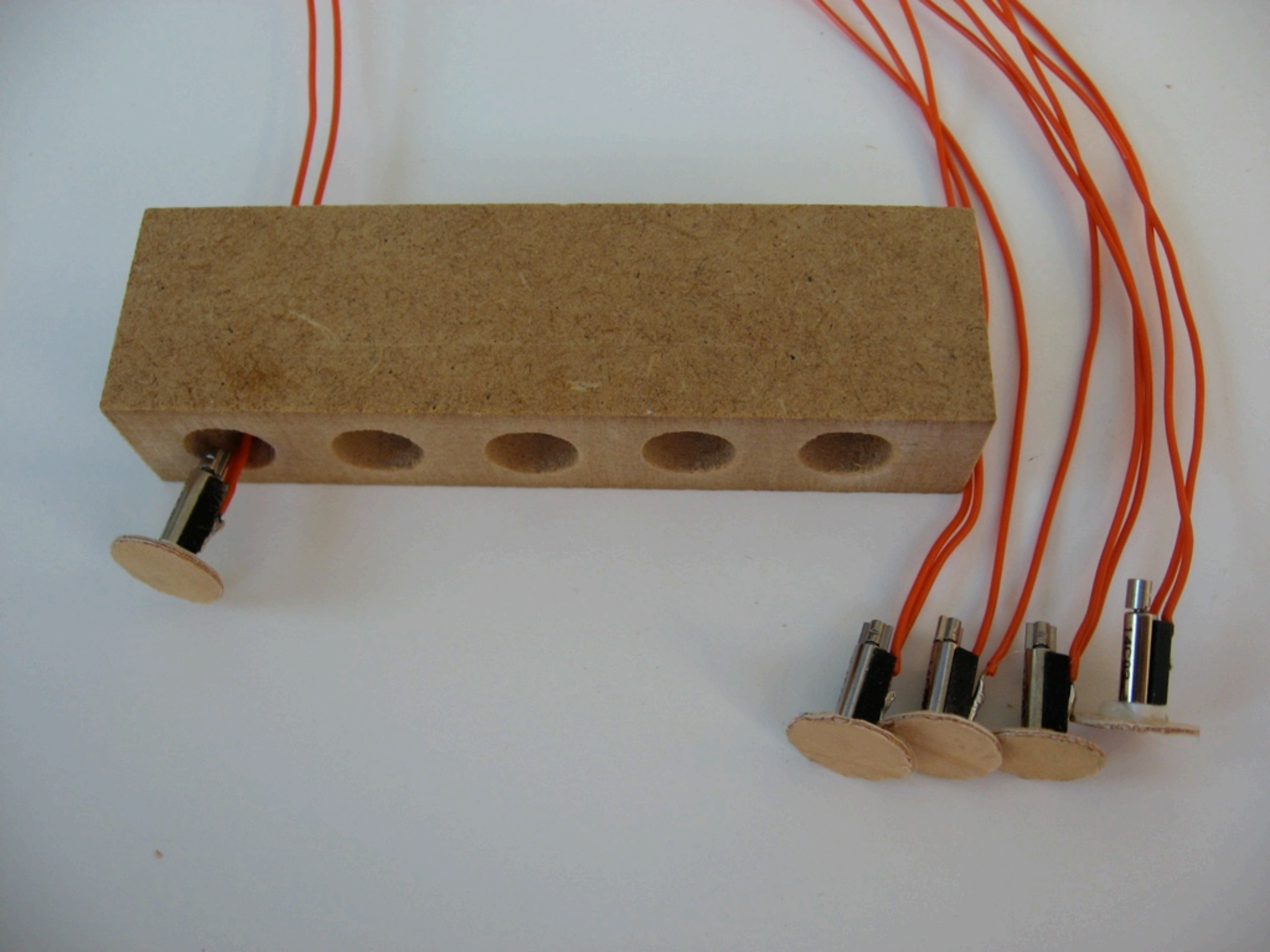
Some machine control

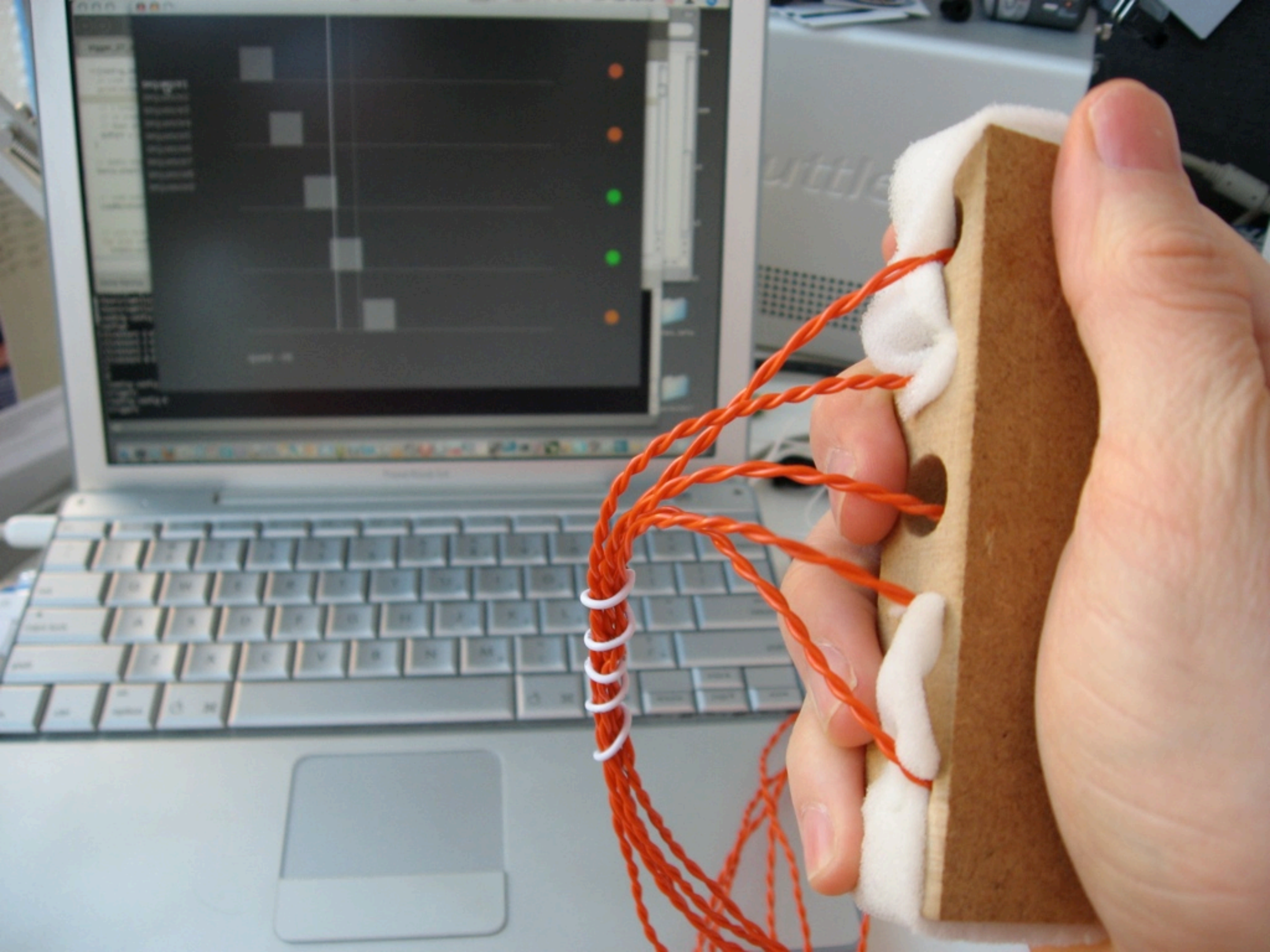
Fancier mechanisms or actuation systems

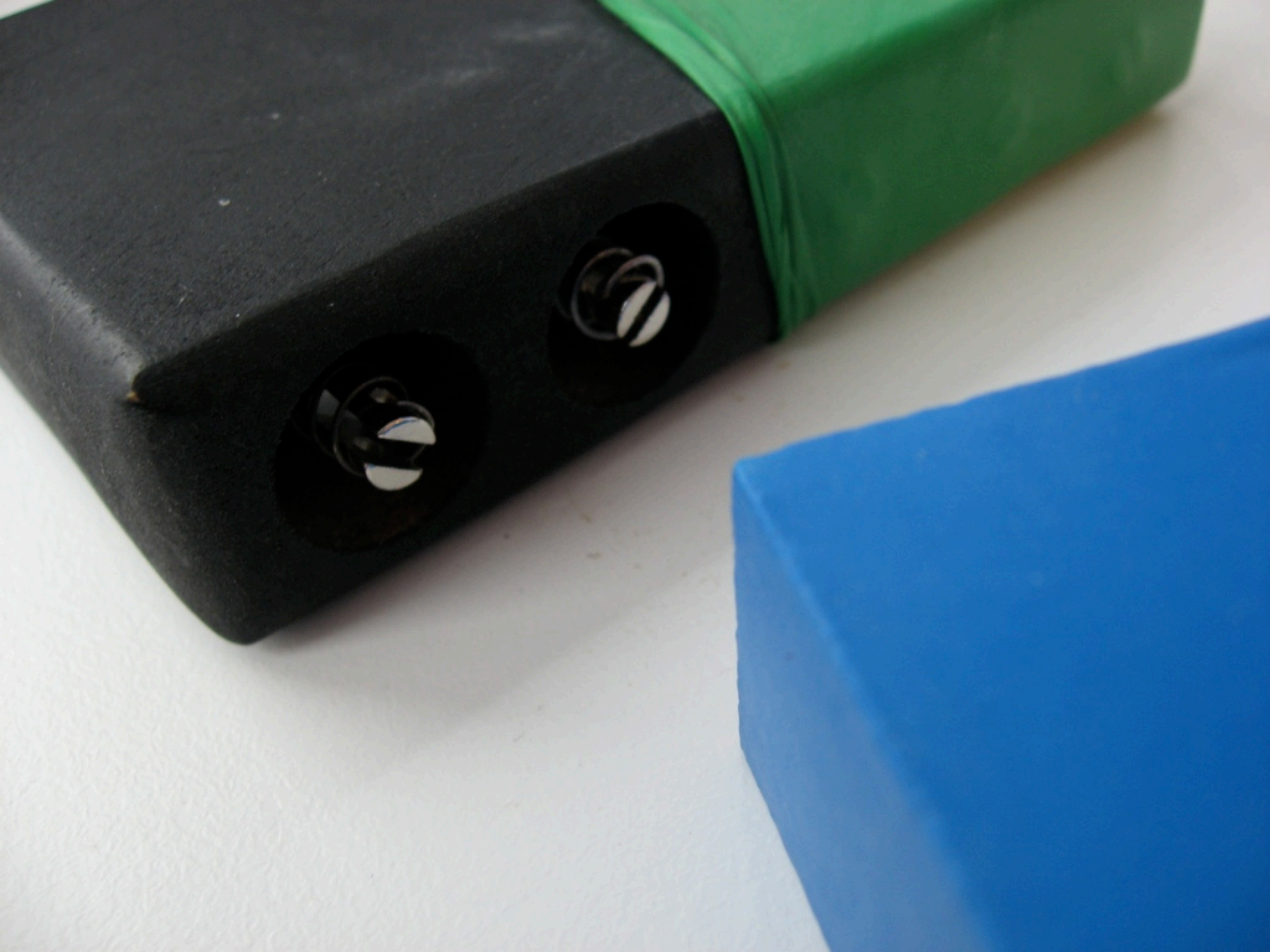
Electronics (maybe) and measuring capabilities

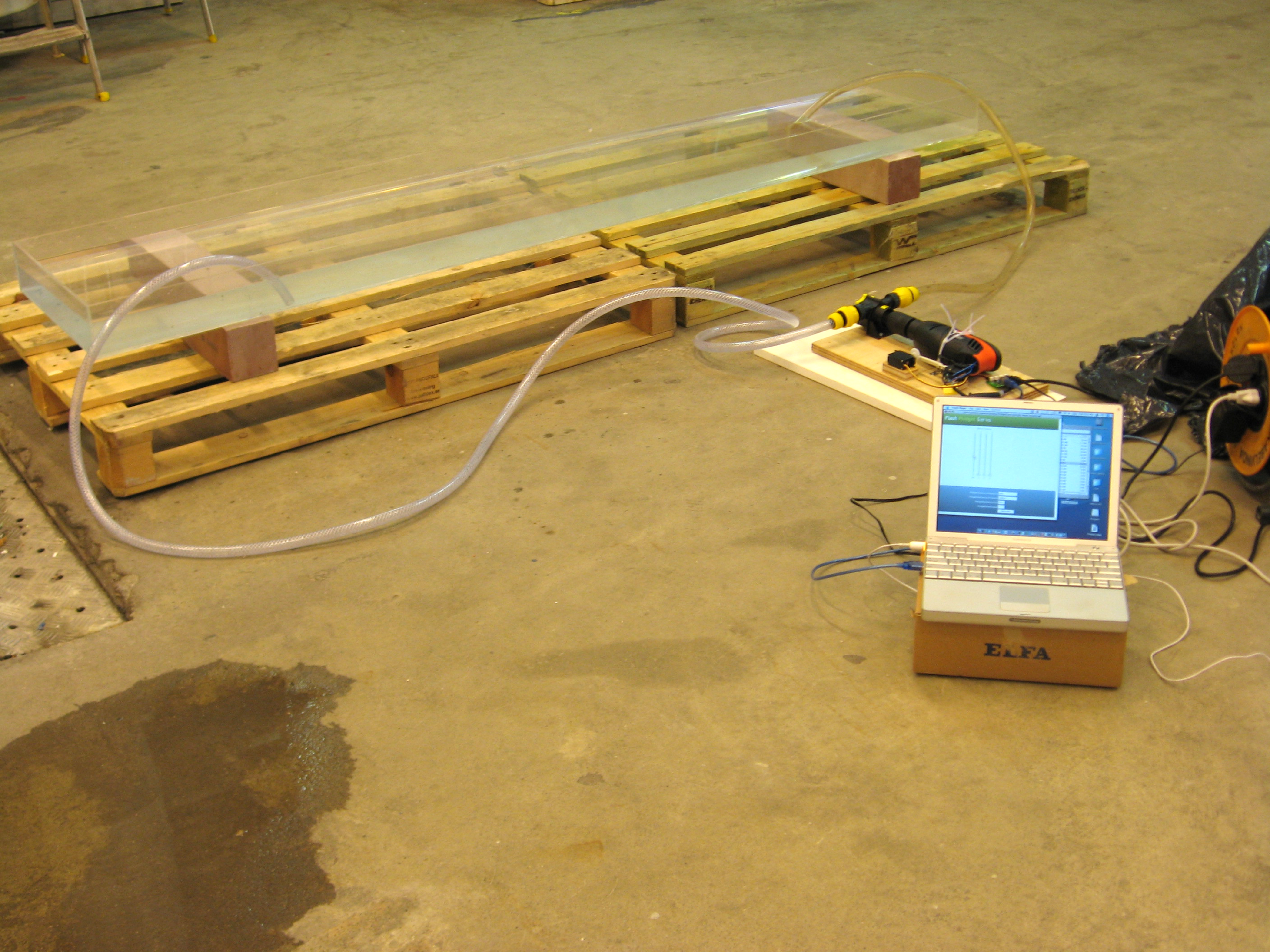
What you can do in a workshop

Full range of fidelity








ELFA

Week

Finer control

Costly but necessary

Machine autonomy

Optimized but fixed configurations

A mix of hardware, software and humanware

Dedicated haptic modules and equipment

Almost the *real* thing

6

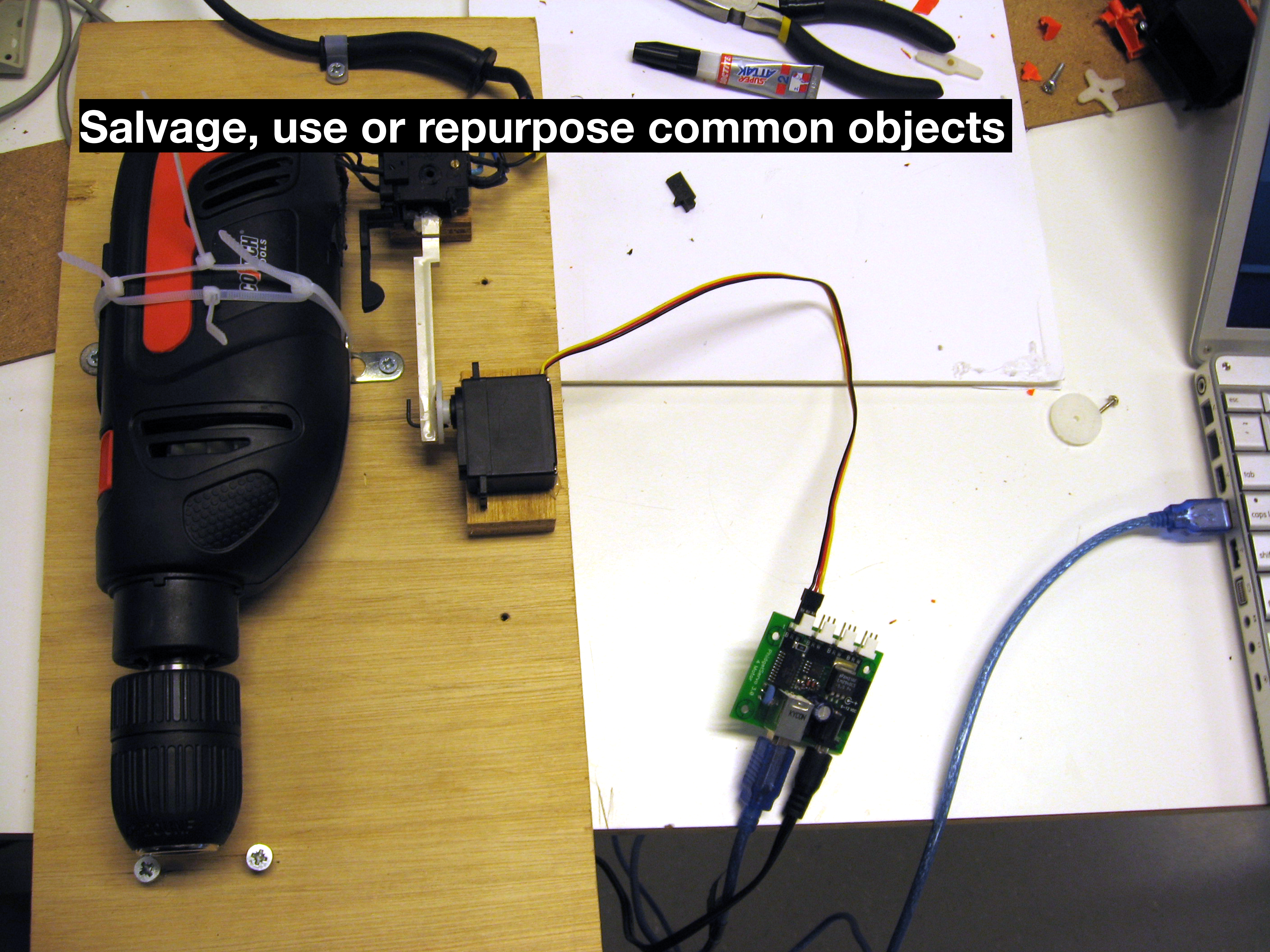
suggestions and guidelines for sketching

Ignore technology constraints

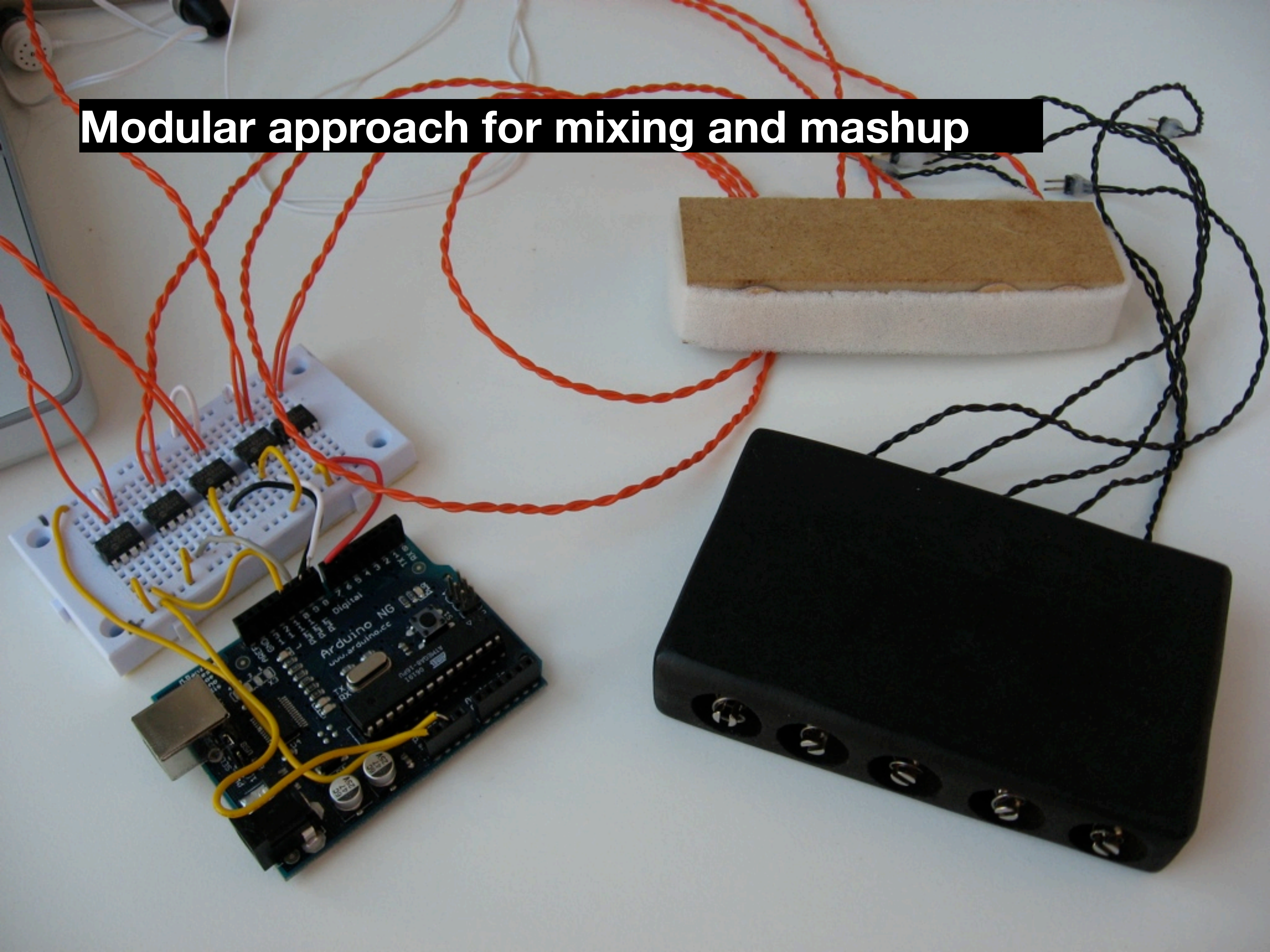
Fake as much as possible

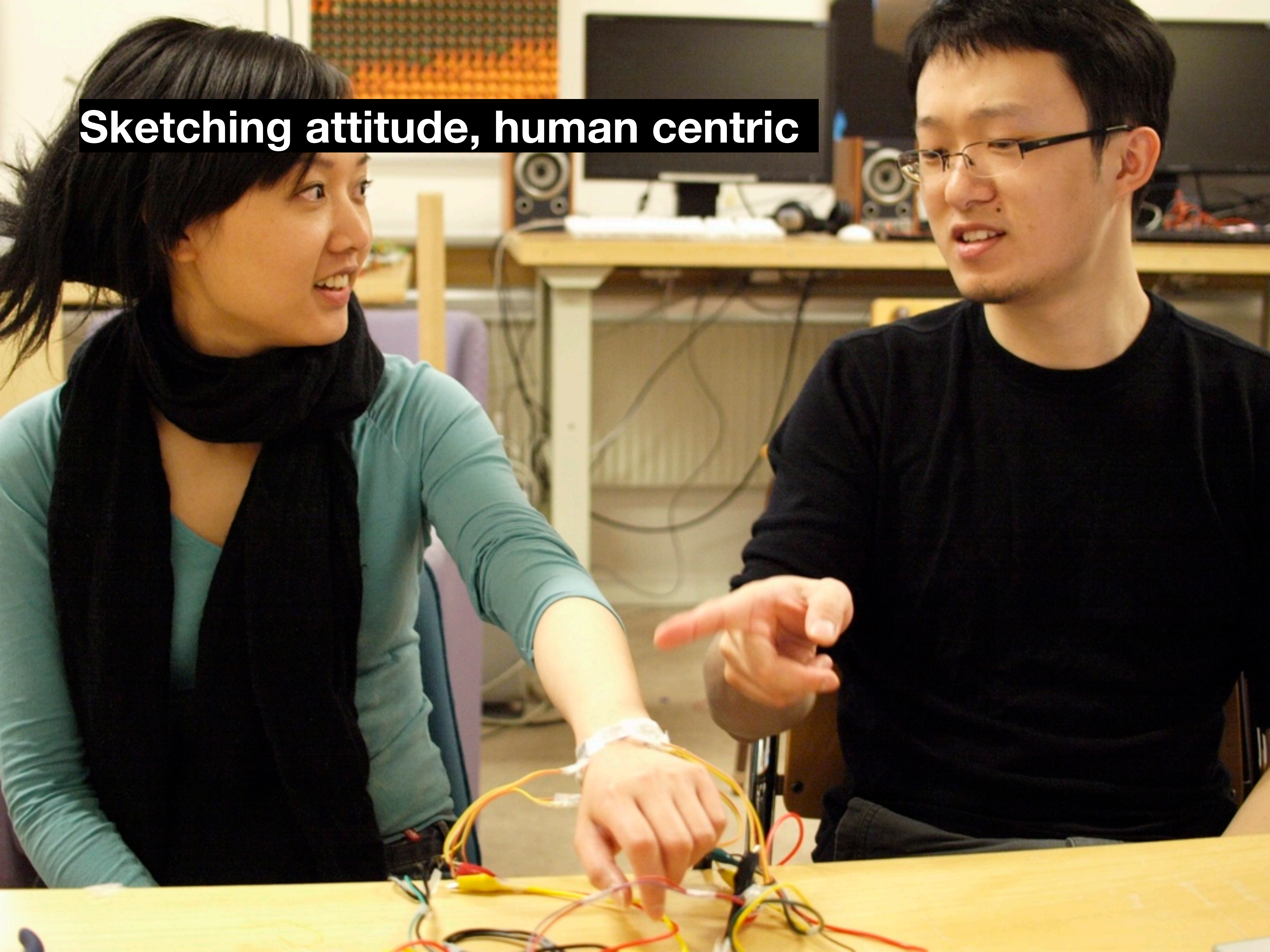

Use the world to control the world
Digital
Arduino NG
www.arduino.cc

Salvage, use or repurpose common objects



Modular approach for mixing and mashup




Sketching attitude, human centric

scaling challenges

number

power

size

price

time

unscientific complexity gamut

n	2n	n^x
large	compact	micro
ephemeral/transient		robust/permanent
wall powered		battery powered
3-5V	12V	110-220V
wired		wireless
binary output		PWM
binary input	ADC	SPI/I^2C
self-contained	one-way comm.	duplex comm.

SKETCHING **HAPTICS**

Haptic interface

Haptic interface presents synthetic stimulation to proprioception and skin sensation.

Haptic perception

Combination of somatosensory perception on the skin and proprioception, no limited to one organ

First sense to develop in humans and may be the last to fade.

20x faster than vision, we can notice two stimuli just 5 ms apart.

Can sense displacements on our palm as low as 0.2 microns in length.

Highly sensitive to vibration up to 1000 Hz, with the peak sensitivity around 250 Hz

Adaptive: easily fatigued and tired by continuous work/stimulation

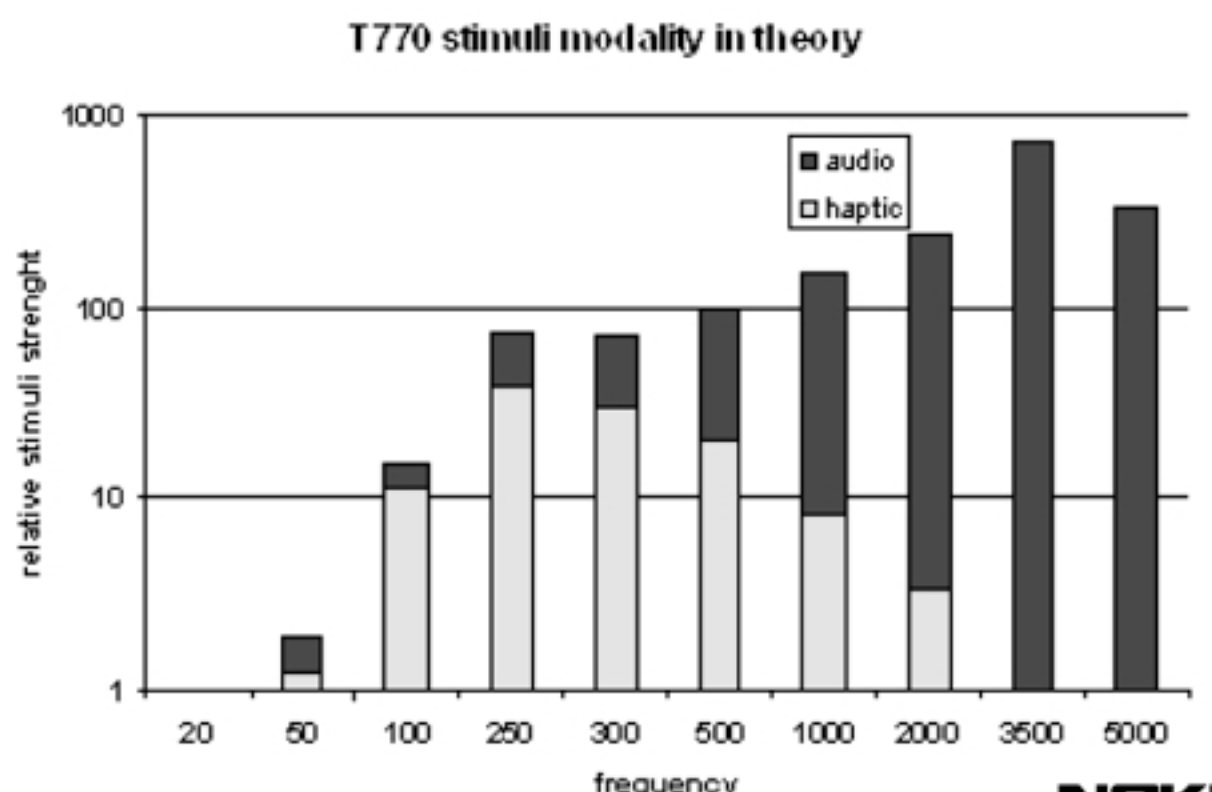
Haptic perception

Active vs passive touch

Haptic interaction is very often **multimodal**

Visual or audio cues can augment haptic perception

No clear boundary between sound and vibration, natural overlap



NOKIA

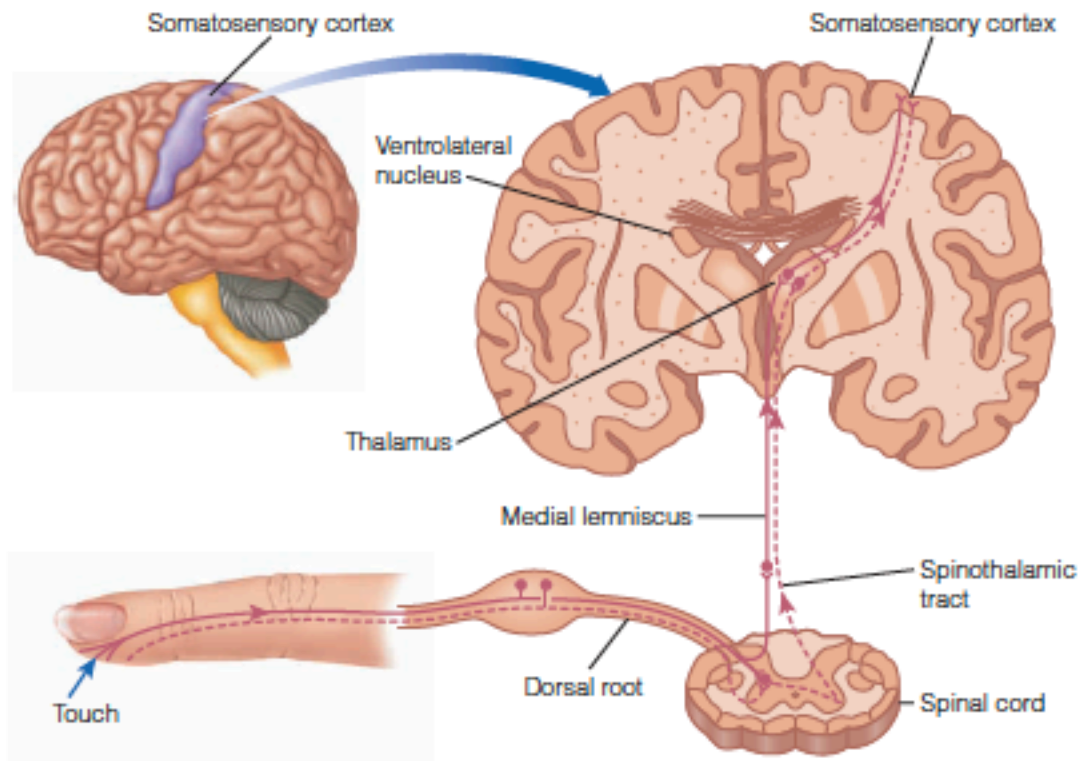


Figure 14.3 ▮ The pathway from receptors in the skin to the somatosensory receiving area of the cortex. The fiber carrying signals from a receptor in the finger enters the spinal cord through the dorsal root and then travels up the spinal cord along two pathways: the medial lemniscus and the spinothalamic tract. These pathways synapse in the ventrolateral nucleus of the thalamus and then send fibers to the somatosensory cortex in the parietal lobe.

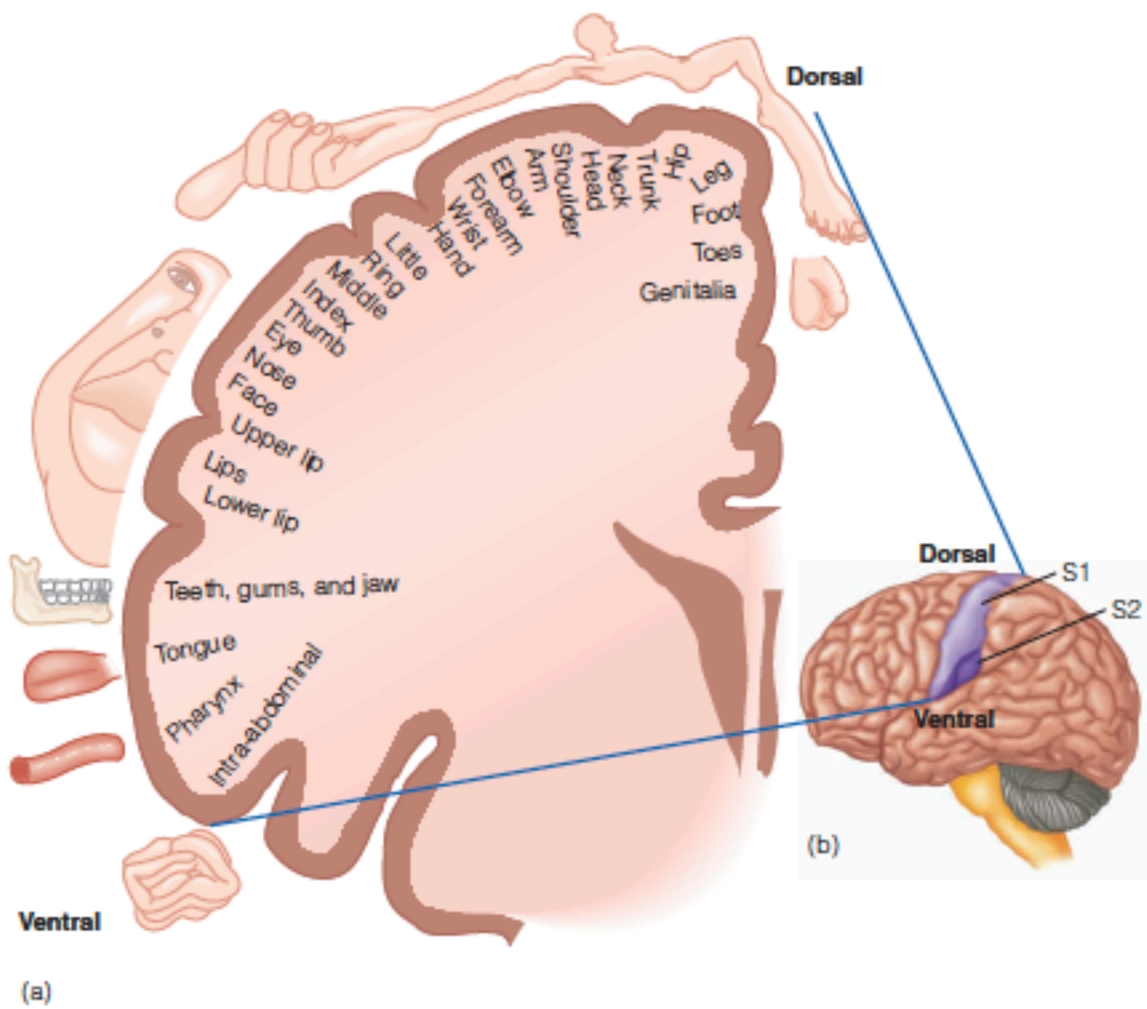


Figure 14.4 ▮ (a) The sensory homunculus on the somatosensory cortex. Parts of the body with the highest tactile acuity are represented by larger areas on the cortex. (b) The somatosensory cortex in the parietal lobe. The primary somatosensory area, S1 (light shading), receives inputs from the ventrolateral nucleus of the thalamus. The secondary somatosensory area, S2 (dark shading), is partially hidden behind the temporal lobe. *(Adapted from Penfield & Rasmussen, 1950.)*

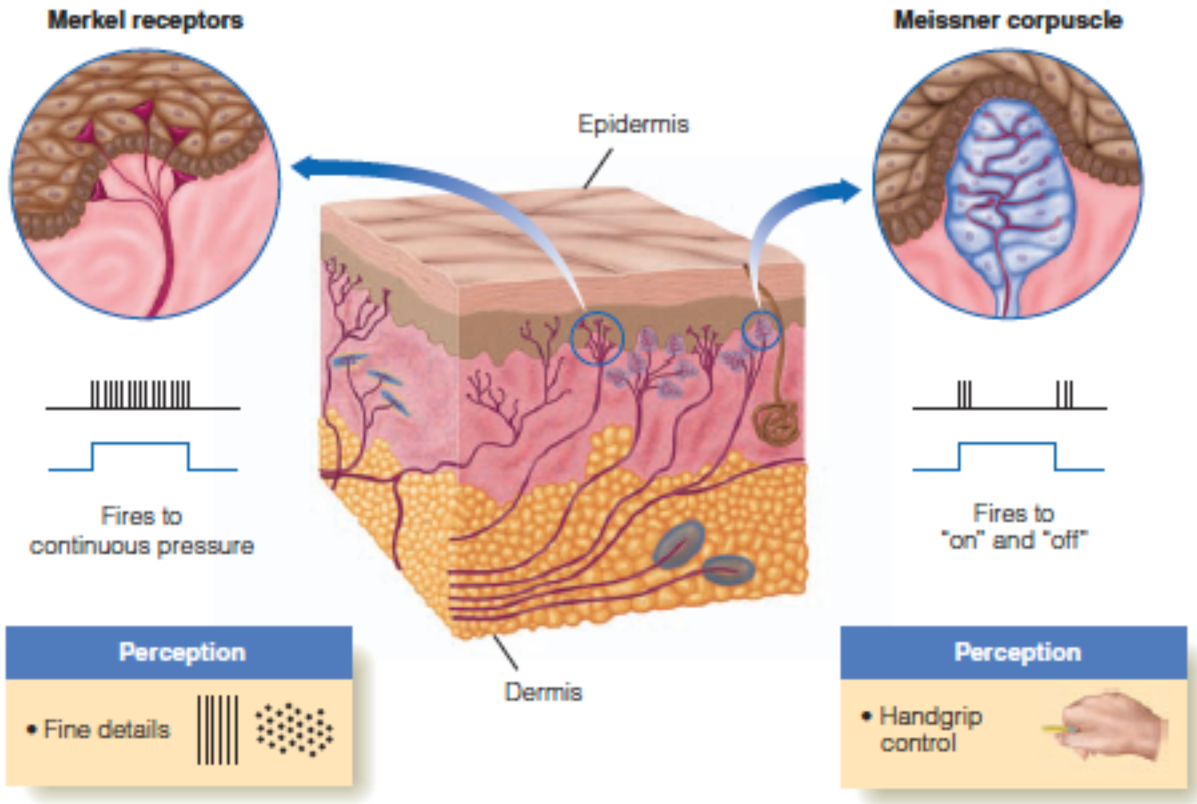


Figure 14.1 ▮ A cross section of glabrous (without hairs or projections) skin, showing the layers of the skin and the structure, firing properties, and perceptions associated with the Merkel receptor and Meissner corpuscle—two mechanoreceptors that are near the surface of the skin.

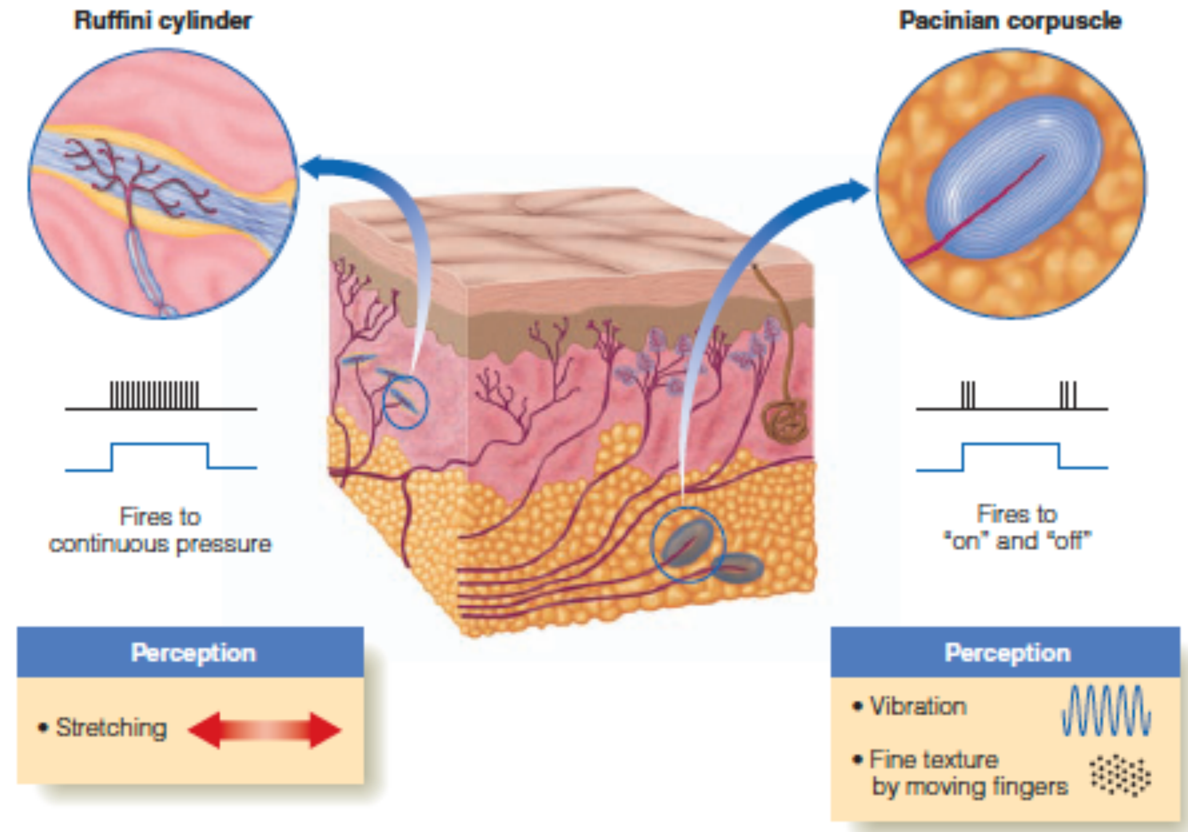


Figure 14.2 ▮ A cross section of glabrous skin, showing the structure, firing properties, and perceptions associated with the Ruffini cylinder and the Pacinian cropuscle—two mechanoreceptors that are deeper in the skin.

from Sensation and Perception, E. Bruce Goldstein

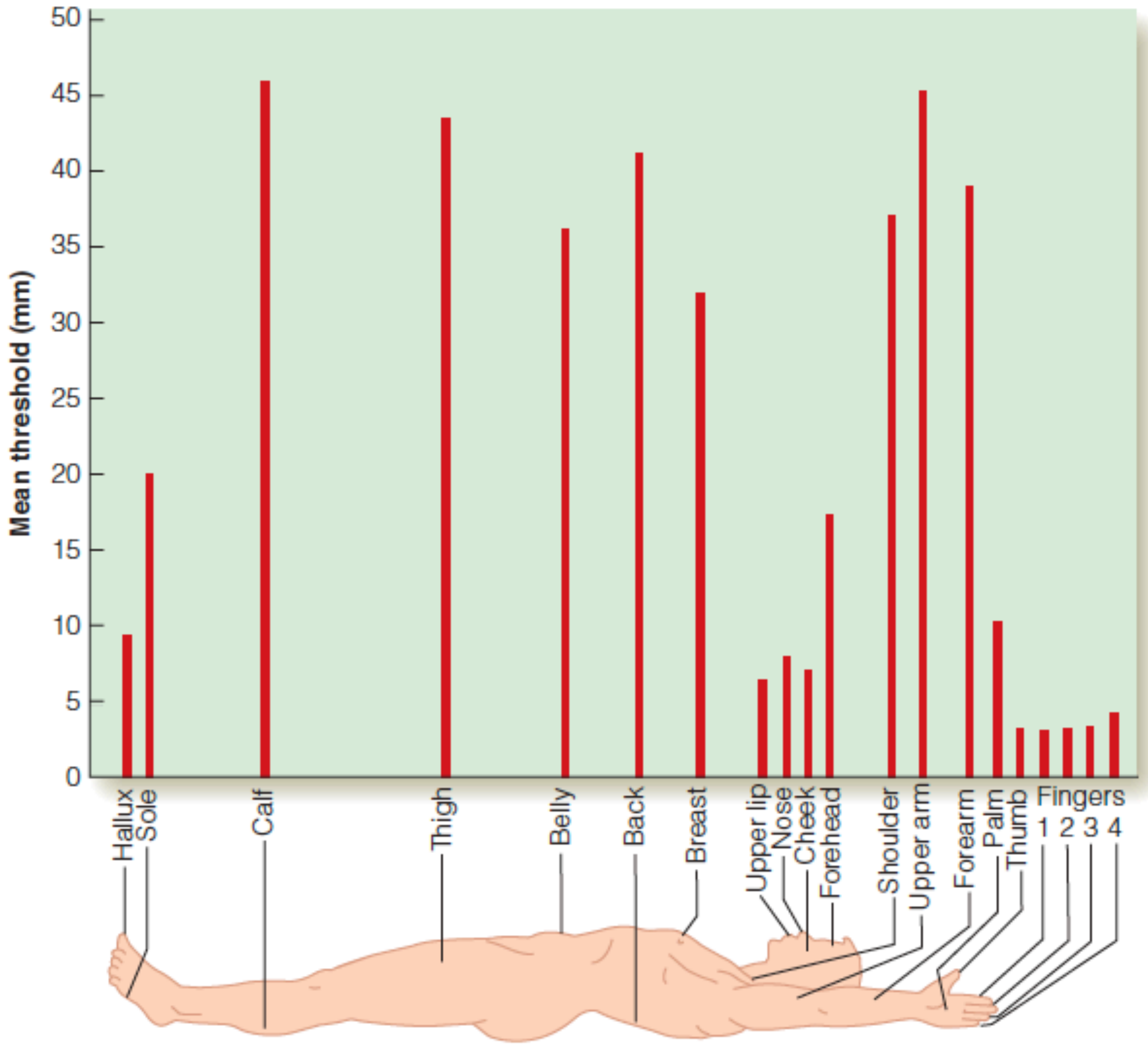


Figure 14.10 Two-point thresholds for males. Two-point thresholds for females follow the same pattern. *(From Weinstein, S., Intensive and extensive aspects of tactile sensitivity as a function of body part, sex, and laterality. In D. R. Kenshalo (Ed.),* The skin senses, *pp. 206, 207. Copyright © 1968 by Charles C. Thomas. Courtesy of Charles C. Thomas, Publishers, Springfield, IL.)*

from Sensation and Perception, E. Bruce Goldstein

Fechner's proposal of three psychophysical methods for measuring the threshold and his statement of Weber's law for the difference threshold were extremely important events in the history of scientific psychology because they demonstrated that mental activity could be measured quantitatively, which many people in the 1800s thought was impossible. But perhaps the most significant thing about these methods is that even though they were proposed in the 1800s, they are still used today. In addition to being used to determine thresholds in research laboratories, simplified versions of the classical psychophysical methods have been used to measure people's detail vision when determining prescriptions for glasses and measuring people's hearing when testing for possible hearing loss.

The classical psychophysical methods were developed to measure absolute and difference thresholds. But what about perceptions that occur above threshold? Most of our everyday experience consists of perceptions that are far above threshold, when we can easily see and hear what is happening around us. Measuring these above-threshold perceptions involves a technique called *magnitude estimation*.

Magnitude Estimation

If we double the intensity of a tone, does it sound twice as loud? If we double the intensity of a light, does it look twice as bright? Although a number of researchers, including Fechner, proposed equations that related perceived magnitude and stimulus intensity, it wasn't until 1957 that S. S. Stevens developed a technique called scaling, or **magnitude estimation**, that accurately measured this relationship (S. S. Stevens, 1957, 1961, 1962).

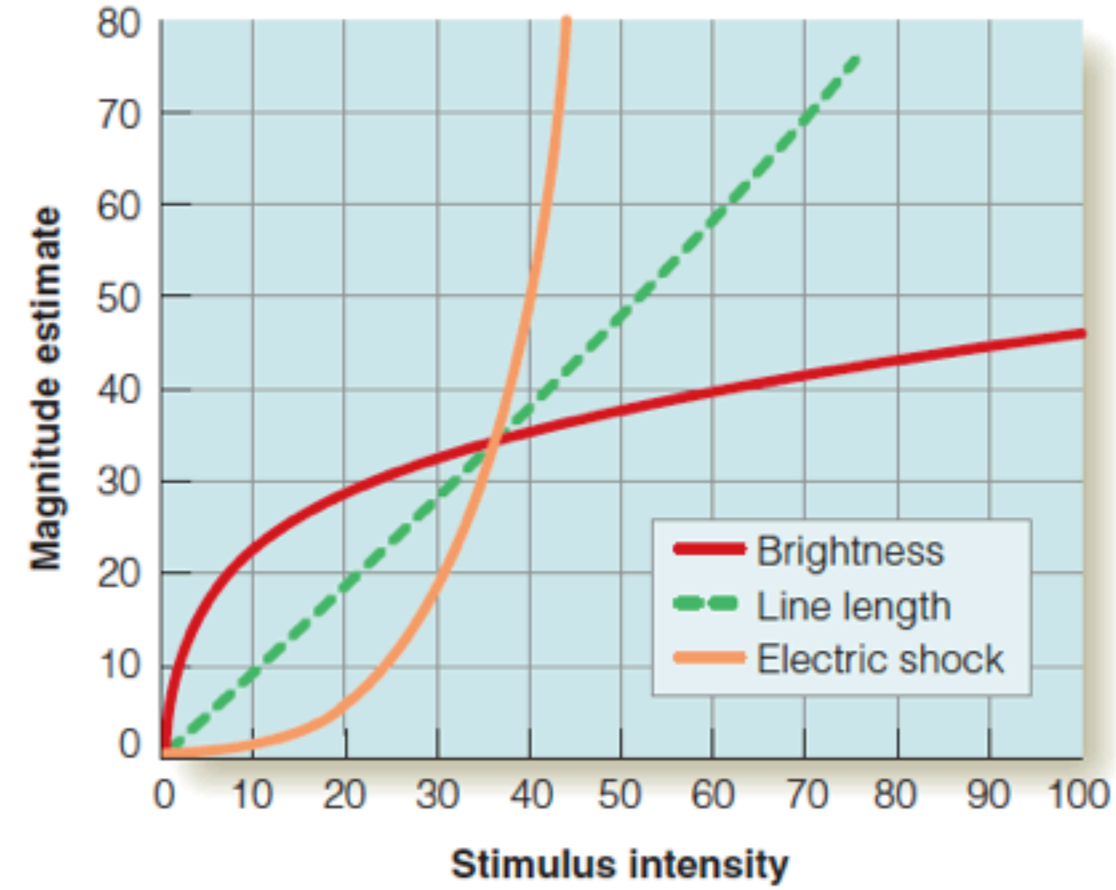


Figure 1.15 The relationship between perceived magnitude and stimulus intensity for electric shock, line length, and brightness. (Adapted from Stevens, 1962.)

a number of observers of the brightness of a light. This curve indicates that doubling the intensity does not necessarily double the perceived brightness. For example, when intensity is 20, perceived brightness is 28. If we double the intensity to 40, perceived brightness does not double, to 56, but instead increases only to 36. This result is called **response compression**. As intensity is increased, the magnitude increases, but not as rapidly as the intensity. To double the brightness, it is necessary to multiply the intensity by about 9.

Figure 1.15 also shows the results of magnitude estimation experiments for the sensation caused by an electric shock presented to the finger and for the perception of length of a line. The electric shock curve bends up, indicat-

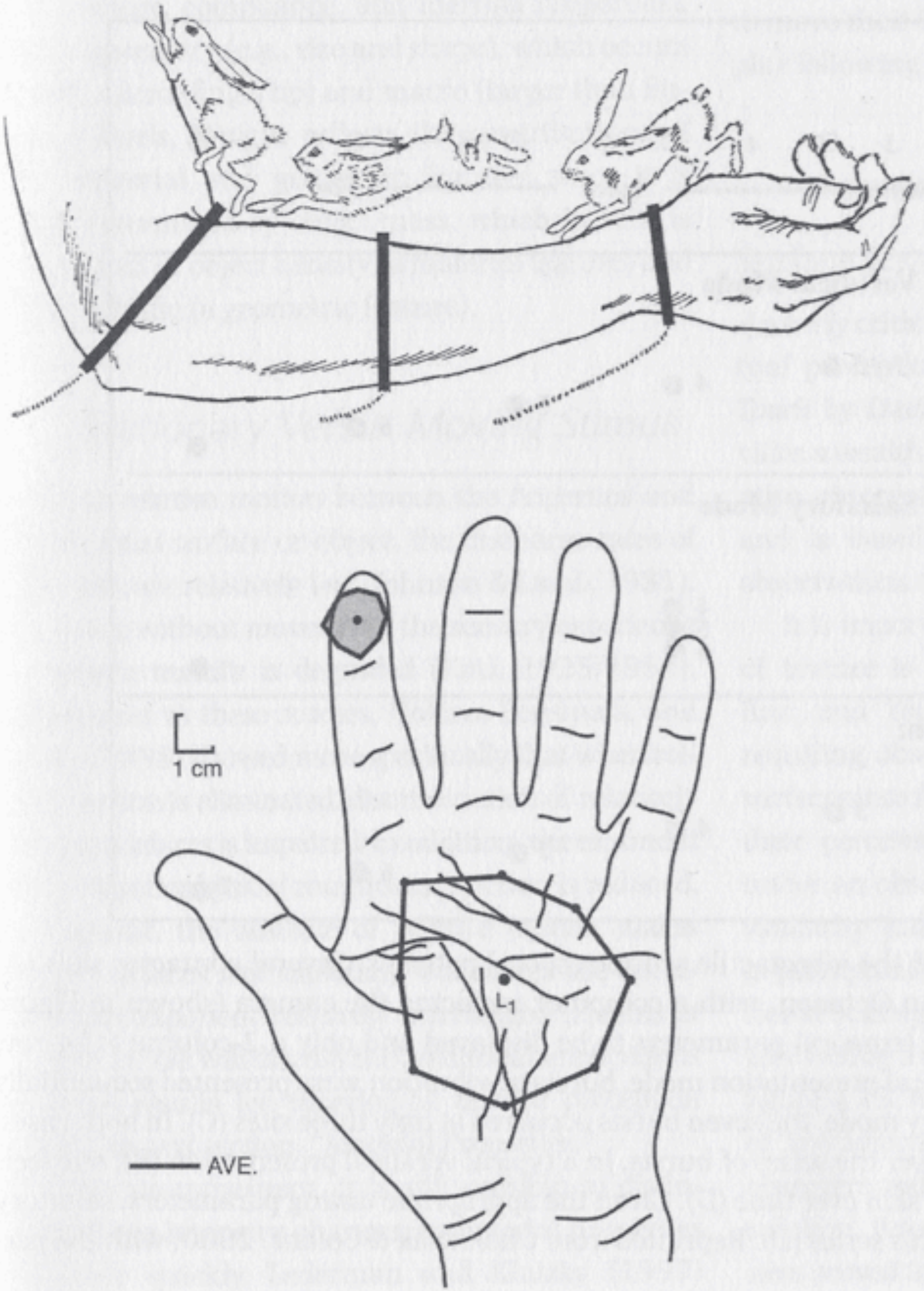


Figure 4.11. (Top panel) One conception of the "rabbit," supplied by a Norwegian newspaper cartoonist. Reprinted from Geldard, 1975, with the permission of Lawrence Erlbaum Associates. (Bottom panel) Area within which saltation occurs on the volar side of the hand (palm versus index finger). Reprinted from Geldard & Sherrick, 1972, with the permission of the Psychonomic Society.

(Westling & Johansson, 1984).

The scientific study of human hand function has always been significantly impeded by the technological demands inherent in systematically producing and displaying objects with multiple attributes and in precisely recording behavioral and neural responses. However, some of these difficulties have been surmounted recently by a third research thrust, which focuses on hand function from the perspective of hardware (e.g., robotics, haptic displays, recording somatosensory neural responses) and software design (e.g., virtual environment technology). The goal of this research is to design and build haptic and multisensory interfaces for remotely exploring and manipulating virtual and real worlds. We note that it is of critical ergonomic

manual functions.

Tactile sensing serves to effect contact between the person's stationary hand and a surface or object which may or may not be moving. In contrast to the active haptic mode, in tactile sensing, the hand is always passive. This type of mode produces a variety of internal, subjective sensations. Although not typically used to learn about the properties of external objects and surfaces, tactile sensing does provide some information about certain properties (e.g., surface texture, thermal conductivity), especially when the object or surface is moved across the skin.

Active haptic sensing serves to effect contact between the person's hand as it moves voluntarily over a surface or object. The term haptic will be considered in detail later in the book, but in brief, it

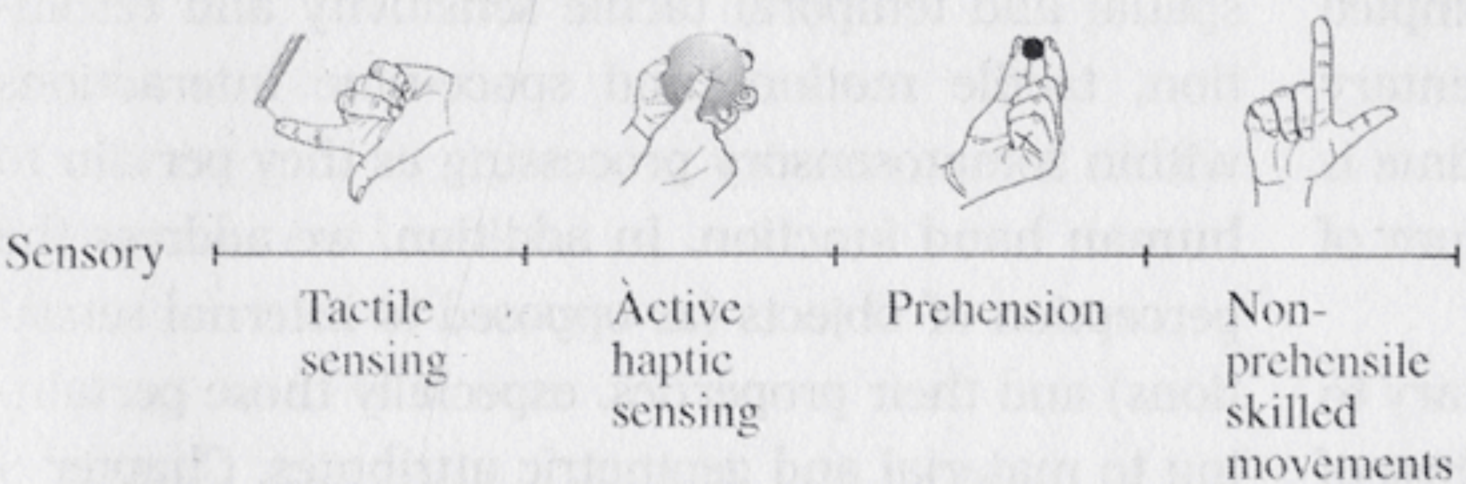
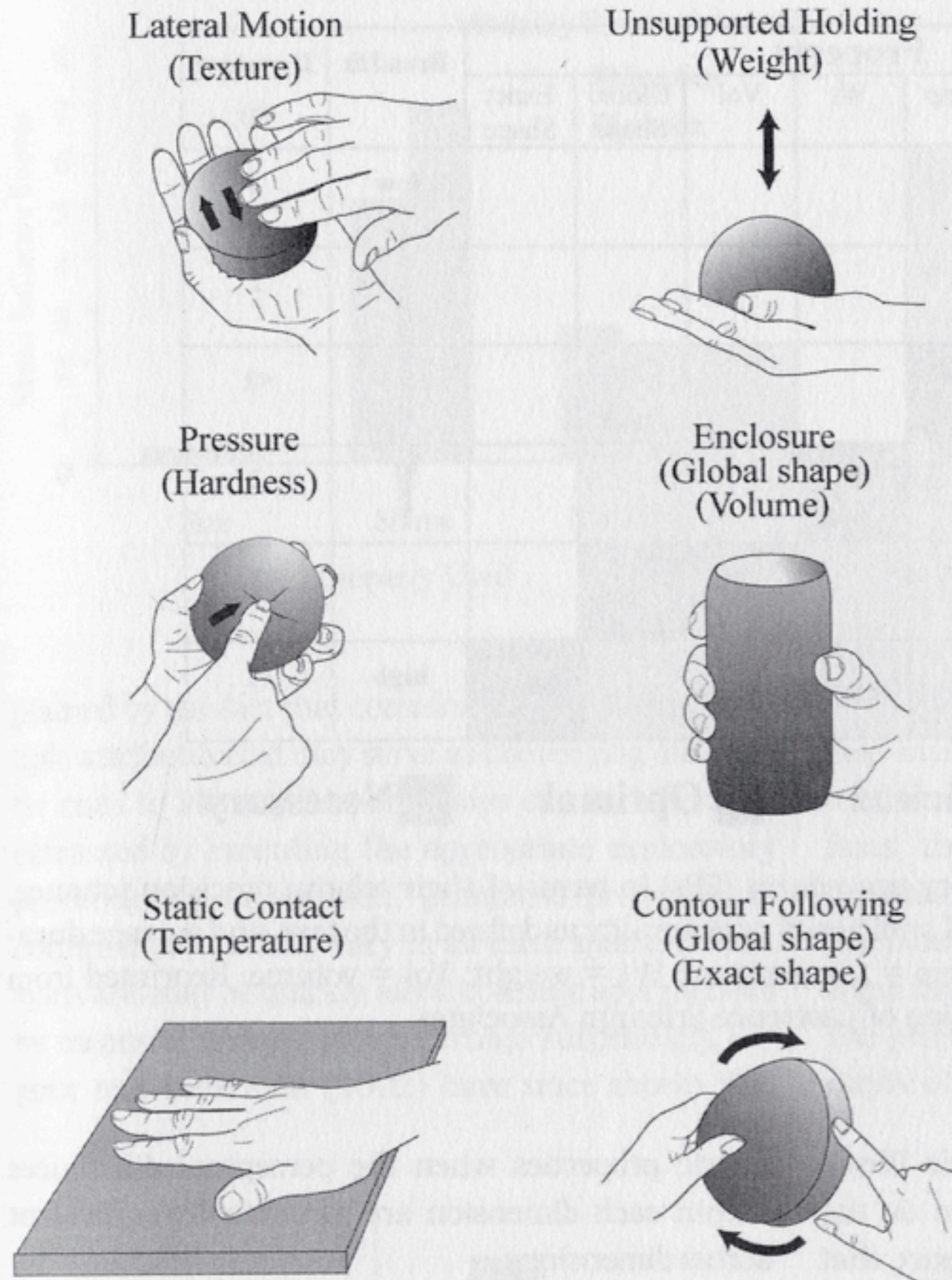


Figure 1.1. A sensorimotor continuum of human hand function.

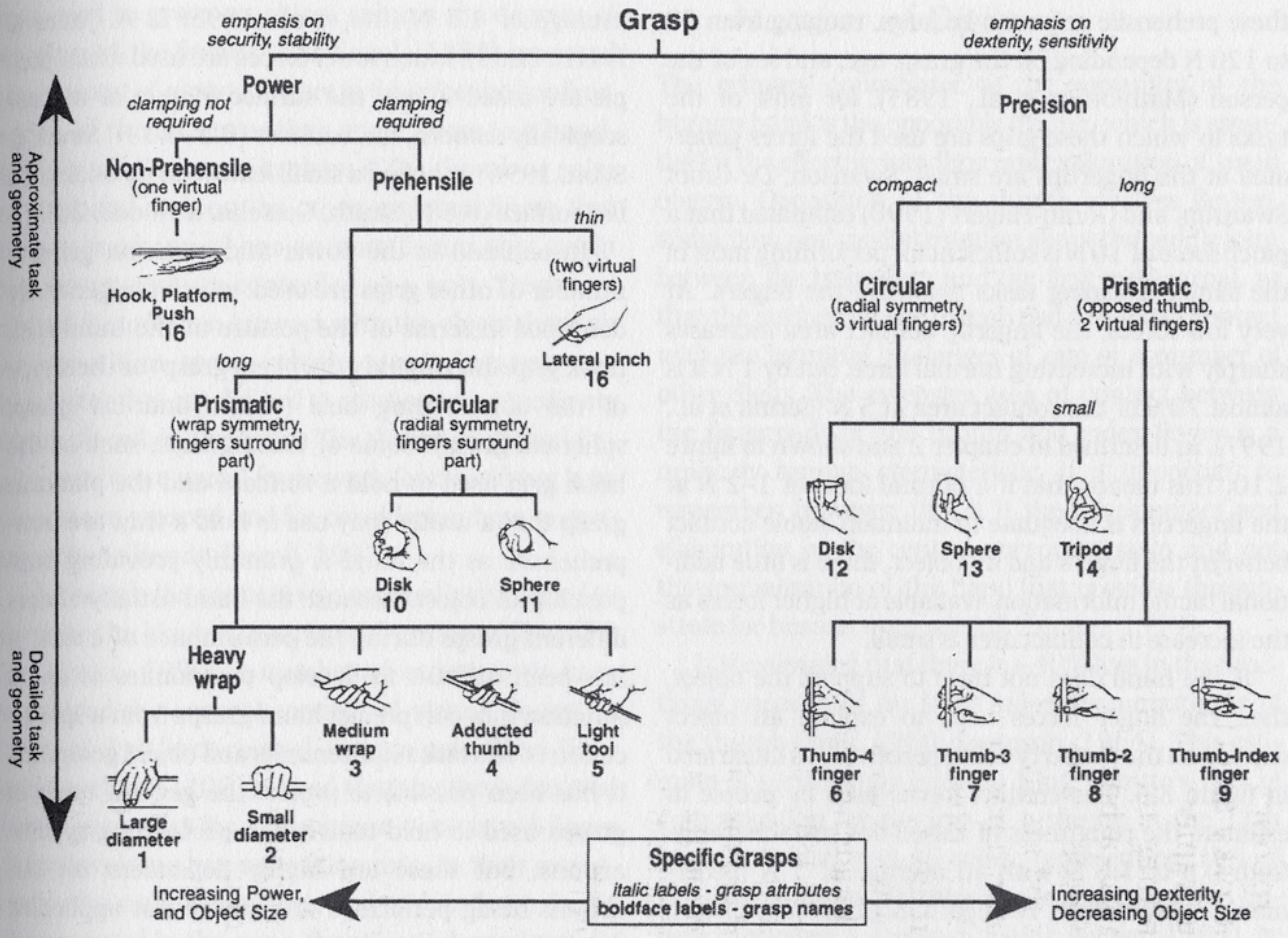
Active haptic sensing



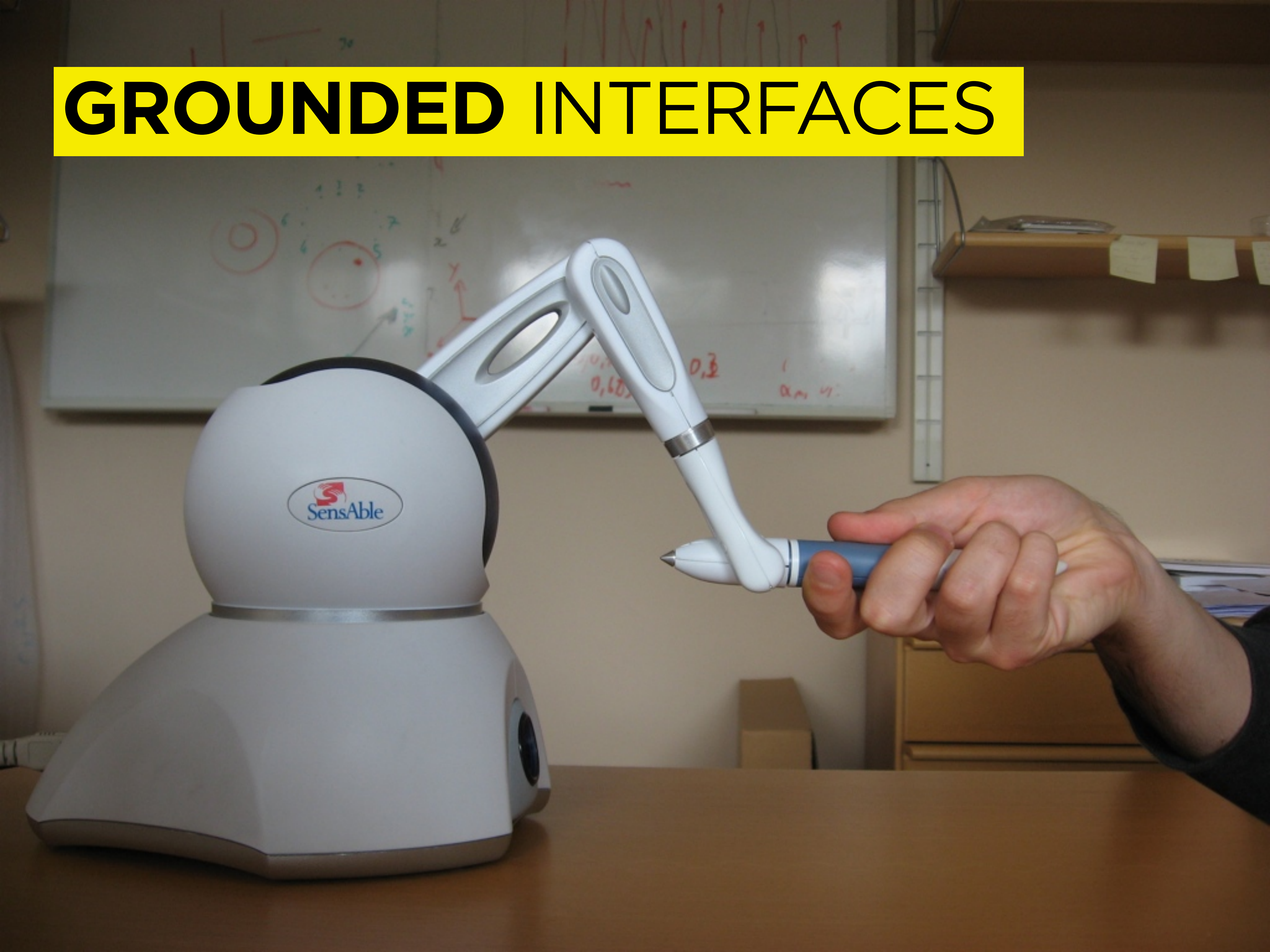
Active haptic sensing

EP	Property: Text	Hard	Temp	Wt	Vol	Global Shape	Exact Shape	Breadth	Duration (s)
Lateral Motion	Optimal	Sufficient	Sufficient	Chance	Chance	Chance	Chance	low	3
Pressure	Sufficient	Optimal	Sufficient	Chance	Chance	Chance	Chance	↓	2
Static Contact	Sufficient	Chance	Optimal	Chance	Sufficient	Sufficient	Chance	↓	<1
Unsupp. Holding	Chance	Sufficient	Sufficient	Optimal	Sufficient	Sufficient	Chance	↓	2
Enclosure	Sufficient	Sufficient	Sufficient	Sufficient	Optimal	Optimal	Chance	↓	2
Contour Follow	Sufficient	Sufficient	Sufficient	Sufficient	Sufficient	Sufficient	Necessary	high	11

Chance Sufficient Optimal Necessary


Grasp
emphasis on security, stability
emphasis on dexterity, sensitivity
Power
clamping not required
clamping required
Non-Prehensile
(one virtual finger)
Hook, Platform, Push
16
Prehensile
thin
(two virtual fingers)
Lateral pinch
16
long
compact
Prismatic
(wrap symmetry, fingers surround part)
Circular
(radial symmetry, fingers surround part)
Disk
10
Sphere
11
Heavy wrap
Large diameter
1
Small diameter
2
Medium wrap
3
Adducted thumb
4
Light tool
5
Precision
compact
long
Circular
(radial symmetry, 3 virtual fingers)
Prismatic
(opposed thumb, 2 virtual fingers)
small
Disk
12
Sphere
13
Tripod
14
Thumb-4 finger
6
Thumb-3 finger
7
Thumb-2 finger
8
Thumb-Index finger
9
Approximate task and geometry
Detailed task and geometry
Specific Grasps
italic labels - grasp attributes
boldface labels - grasp names
Increasing Power, and Object Size
Increasing Dexterity, Decreasing Object Size

GROUNDED INTERFACES



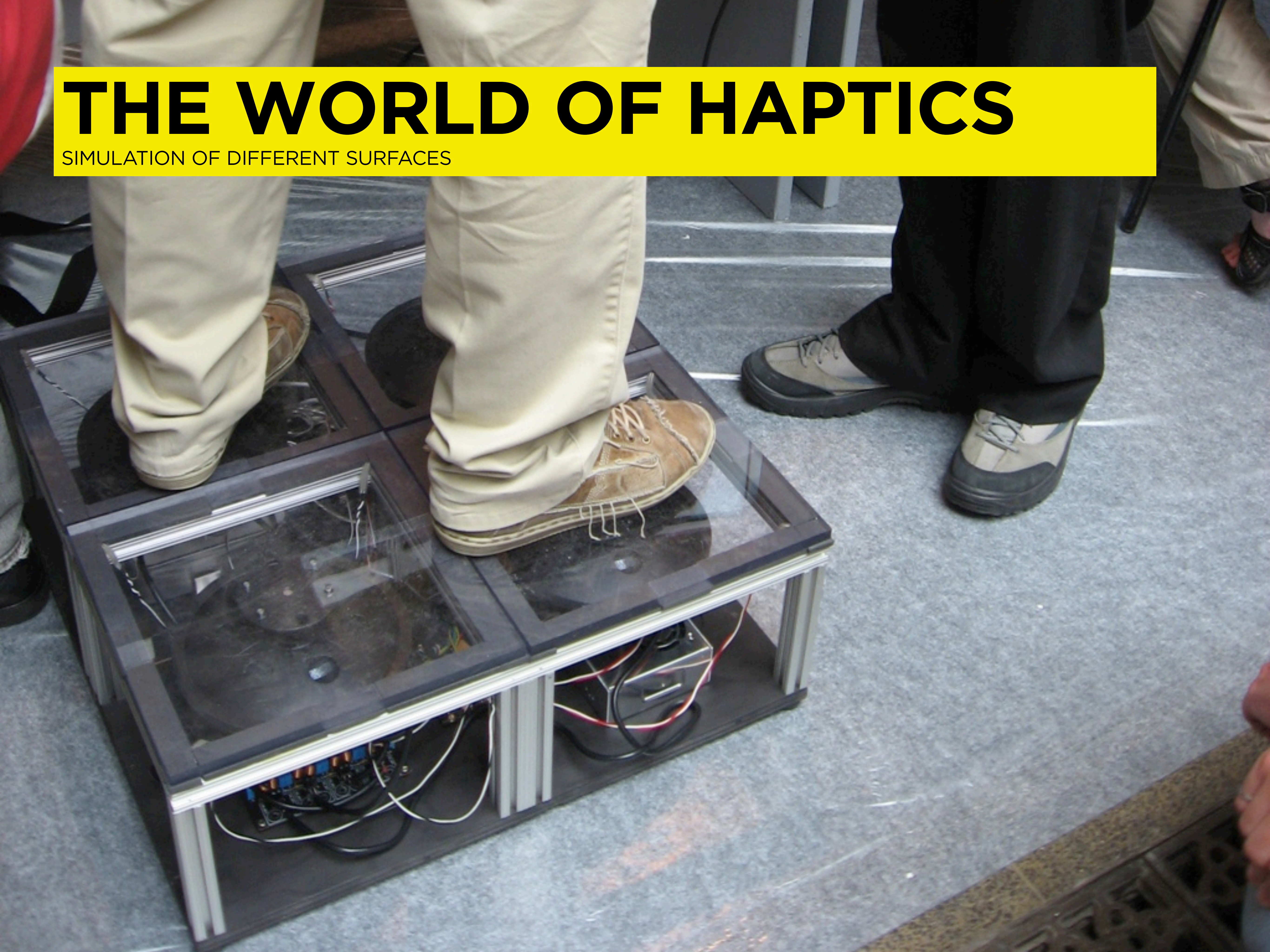
UNGROUNDED INTERFACES

THE WORLD OF HAPTICS

TYPICAL INTERFACES

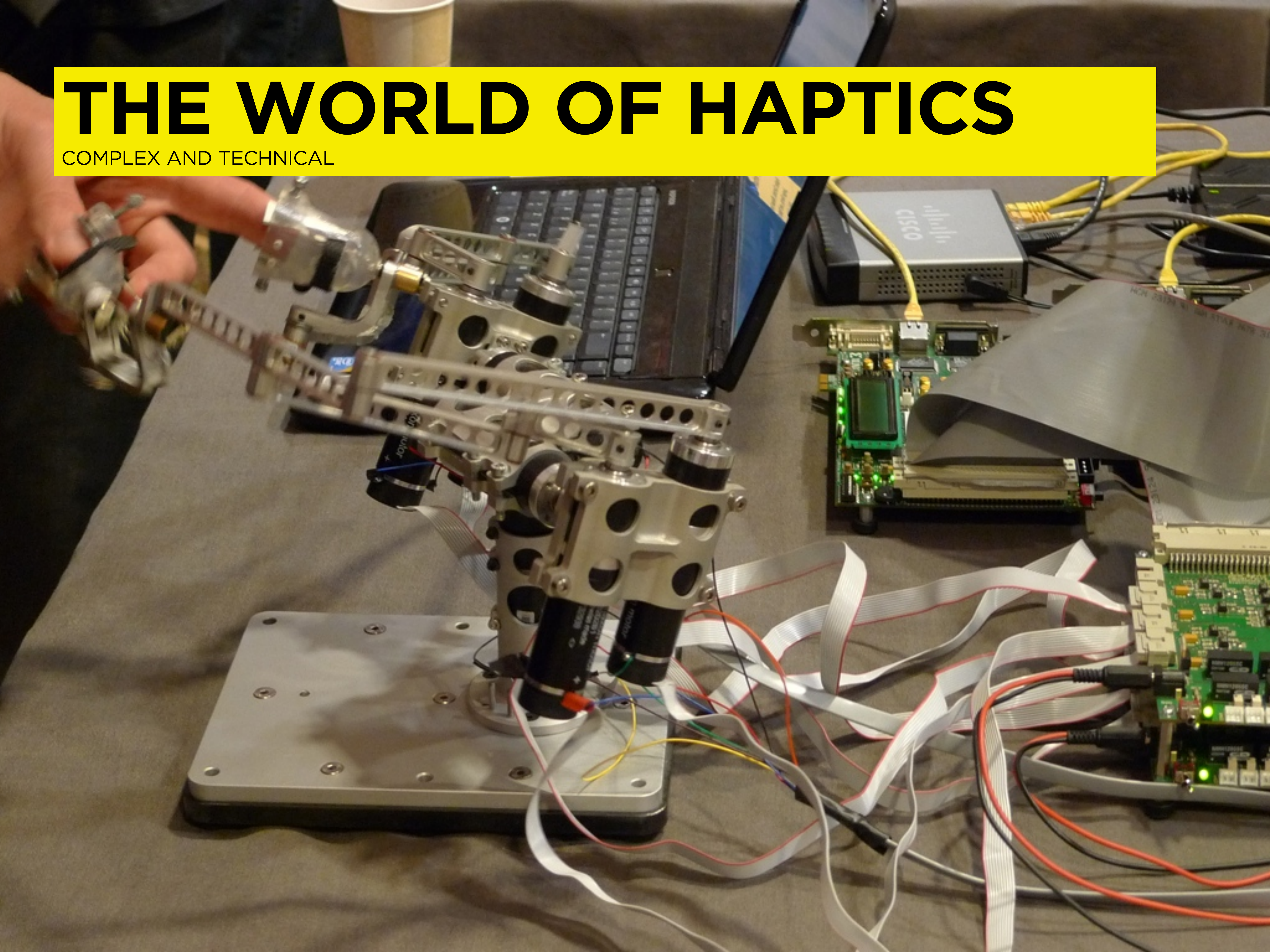
THE WORLD OF HAPTICS

SIMULATION OF DIFFERENT SURFACES



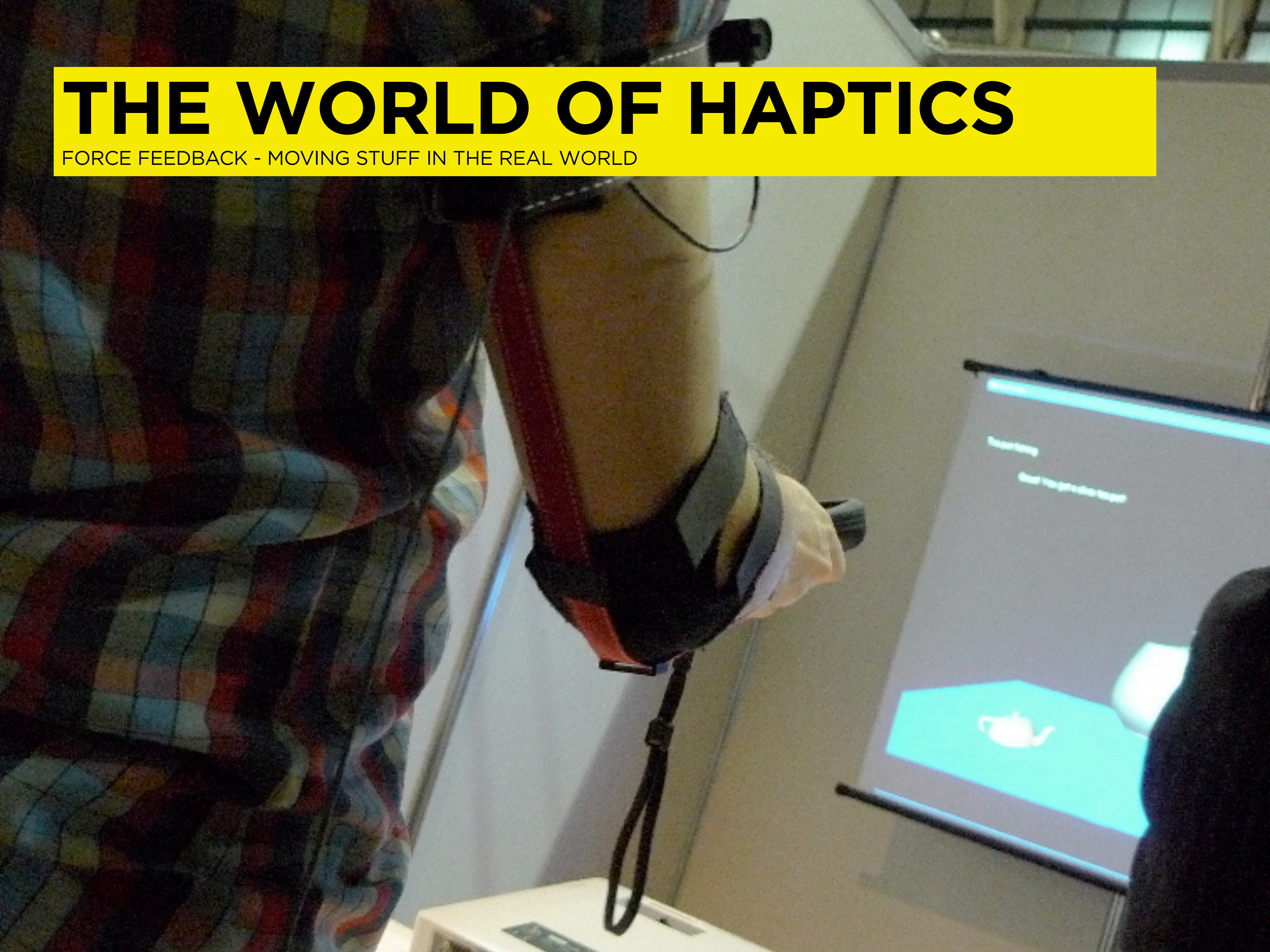
THE WORLD OF HAPTICS

COMPLEX AND TECHNICAL



THE WORLD OF HAPTICS

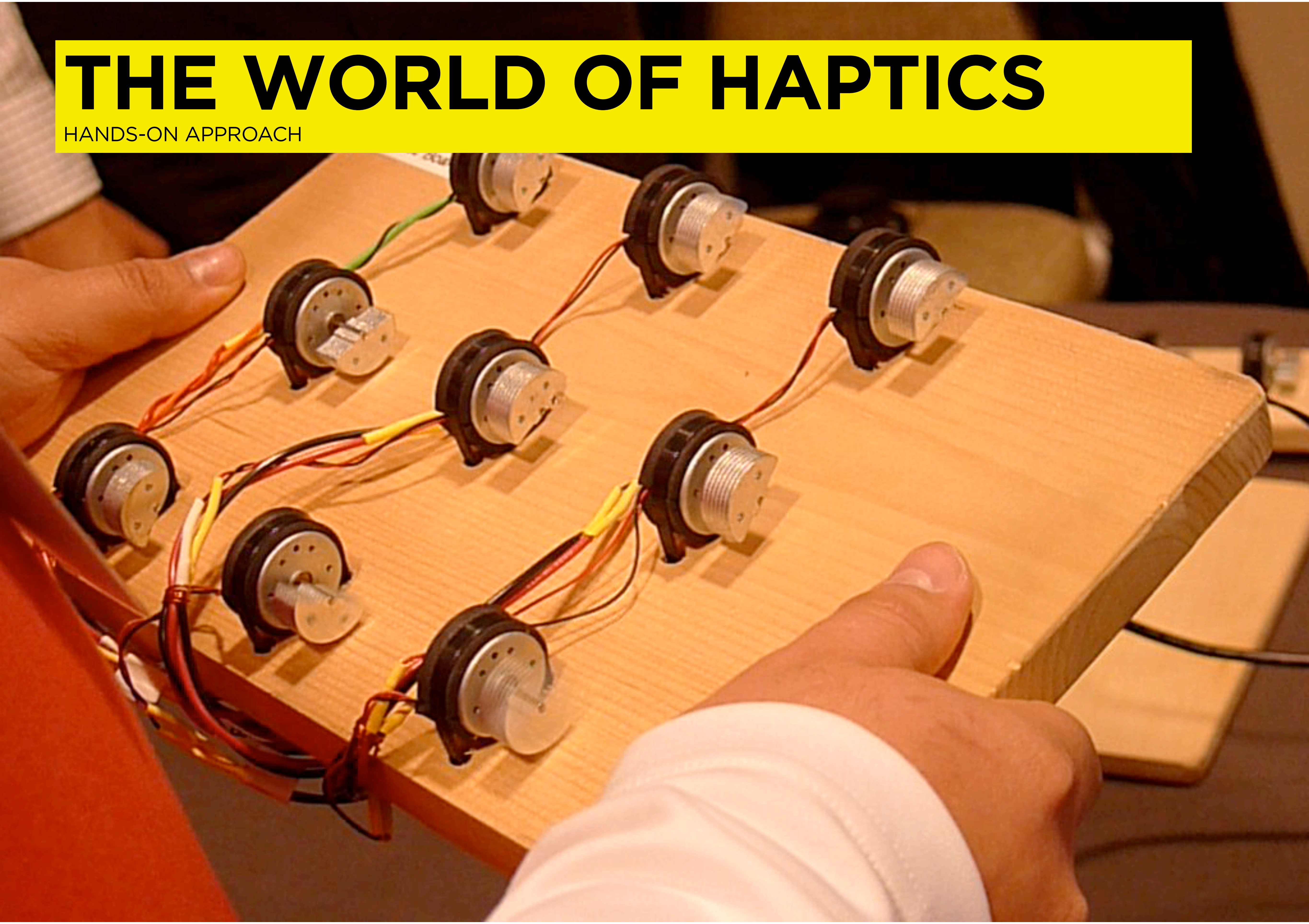
FORCE FEEDBACK - MOVING STUFF IN THE REAL WORLD



THE WORLD OF HAPTICS

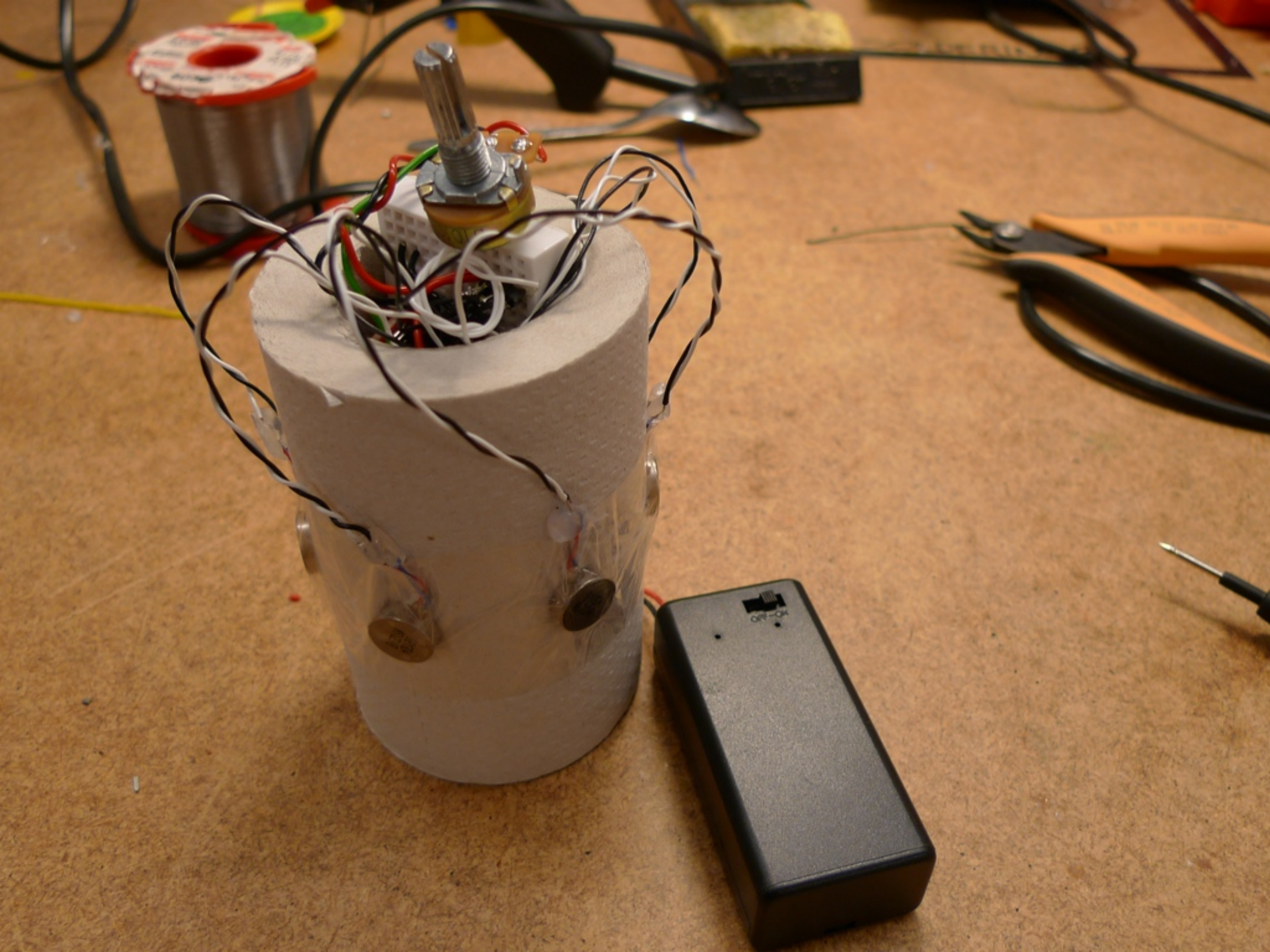
SYNTHESIZING AND FAKING

THE WORLD OF HAPTICS
HANDS-ON APPROACH



THE WORLD OF HAPTICS

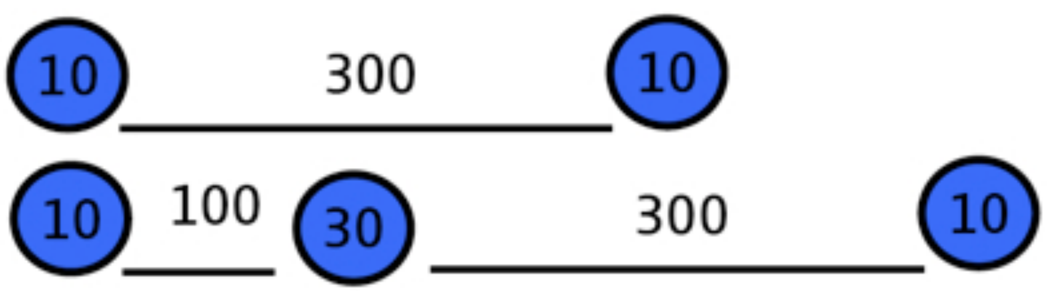
RECREATING THE NATURAL INTERACTIONS



How do you describe and design haptic I/O?

Lexicon & vocabulary?

Notation system for I/O? Music, sequencer, etc.



Measurement unit for haptic? Audio => dB

Hardware based or perception based?

Does it work across devices, humans, contexts, brands?

Related Works: Do It Yourself Haptics

The Art of Nonrealistic Usefulness and Realism Through Shortcuts

Hayward & MacLean, 2007

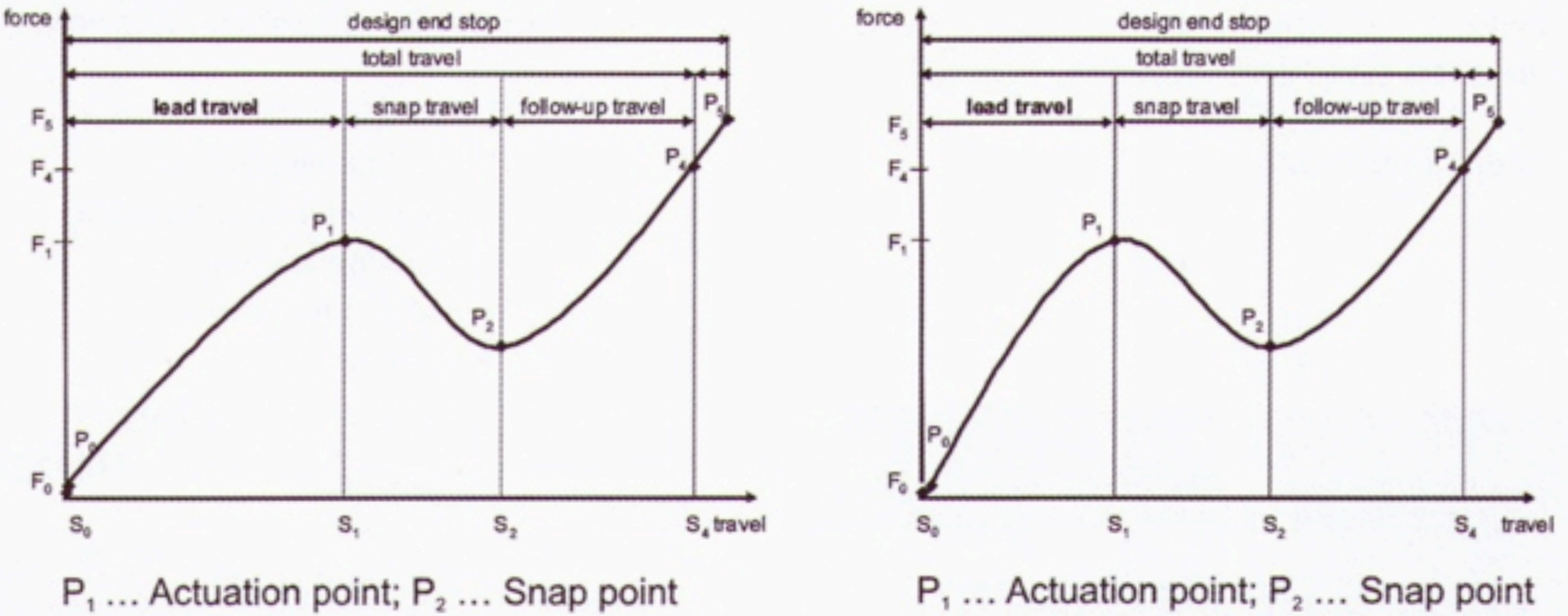


FIGURE 4. FORCE-TRAVEL CHARACTERISTIC: MODIFICATION OF LEAD TRAVEL TWICE

definition of variants the aim is to achieve maximum constancy of influencing factors which are not
swit
forc
contrast, is varied as systematically as possible in order to clearly attribute differences in subjective assessment (dependent variable) to physical

ed (e.g., three conditions for lead travel x three conditions for snap travel). Figure 4 depicts sys-
variants being
te pair comparison, as used in psychophysics, is employed; that is, each variant is compared to each other variant with regard to various features. Paired

Haptics research at Daimler AG
Enigk, Foehl & Wagner, 2008

A Brief Taxonomy of Tactile Illusions and Demonstrations That Can Be Done In a Hardware Store

Vincent Hayward, 2008

Sec.	Name	Demonstrability	Stability	Analogs
2.1	Diplesthesia	Household	Not robust	Debatable
2.2	Funneling	Setup	Robust	Debatable
2.2	Cutaneous rabbit	Setup	Robust	Debatable
2.3	Size constancy failure	Household	Robust	Visual
2.4	Blackboard and parchment-skin	Household & setup	Robust	Cross modal
2.5	Weight-size and weigth-X	Household	Robust	Cross modal
2.6	Numerosity of taps from beeps	Setup	Robust	Cross modal
2.6	Numerosity of flashes from taps	Setup	Robust	Cross modal
2.7	Change numbness	Setup	Robust	Auditory and visual
2.8	Temporal ordering	Setup	Robust	Auditory and visual
2.9	Pseudo-haptic effects	Any computer	Moderate	Cross modal
2.10	Comb	Household & hardware	Robust	Tactile specific
2.10	Tactile lens	Specialized device	Robust	Tactile specific
2.10	Fishbone	Household & hardware	Robust	Tactile specific
2.10	Curved plate	Household & hardware	Robust	Tactile specific
2.10	Tactile barber pole	Hardware	Robust	Visual analog
2.11	Müller-Lyer *et alia*	Household & hardware	Moderate	Visual analogs
2.12	Kinaesthetic effects	Household	Robust	Visual analogs
2.12	Force by acceleration asymmetry	Setup	Robust	Tactile specific
2.13	Distal attribution	Household	Robust	Visual and auditory
2.13	Rolling ball	Setup	Robust	Auditory
2.14	Tactile Motion after-effect	Setup	Moderate	Visual and auditory
2.14	Weight after-effect	Household	Robust	Visual and auditory
2.14	Shape after-effect	Household	Robust	Visual
2.15	Texture force fields	Setup	Robust	Haptic specific
2.15	Corner smoothing	Setup	Robust	Haptic specific
2.15	Bump/holes	Hardware	Robust	Haptic specific

Mechanical non-programmable devices

Vincent Hayward, 2008

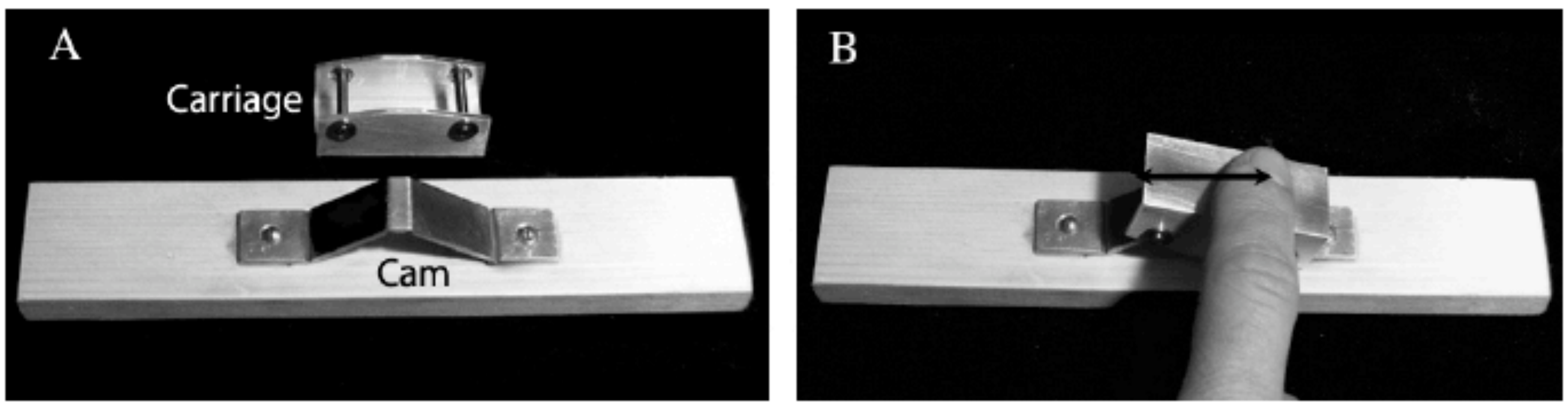
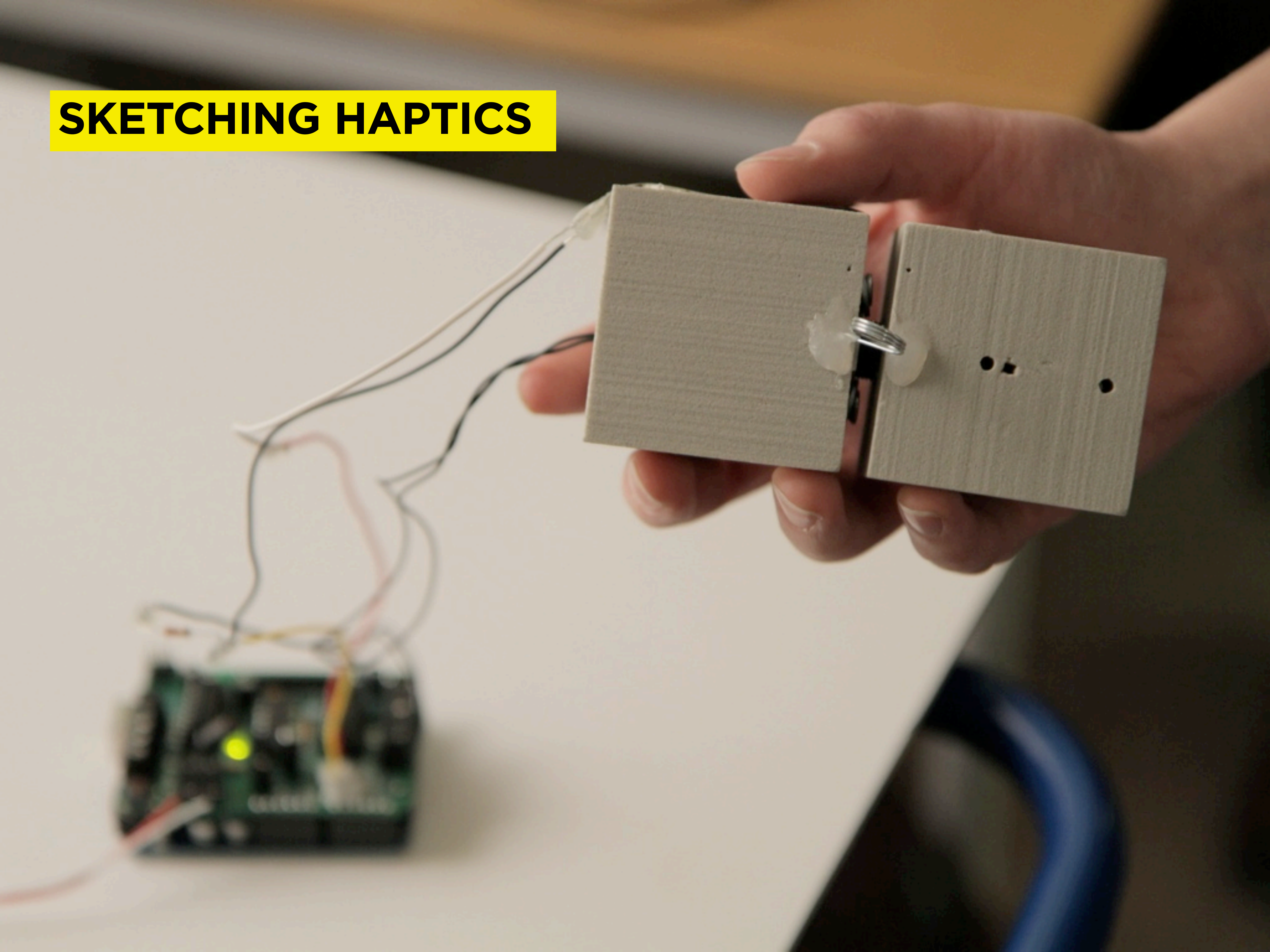


Figure 6: Mechanical delivery of the "curved plate illusion" [22]. (A) The device has a cam made of a bent metal strip which is secured to a wood base and a carriage having two rollers mounted on ball-bearings. Dimensioning is given in appendix. (B) Finger exploring the illusory curvature. For some subjects, the effect is more pronounced when the exploration is fore-aft rather than sideways. In any case it is important that the mechanism has little friction and produces little mechanical noise. These types of disturbances are prone to destroy or weaken the illusion. It is also important to press down lightly.

SKETCHING HAPTICS



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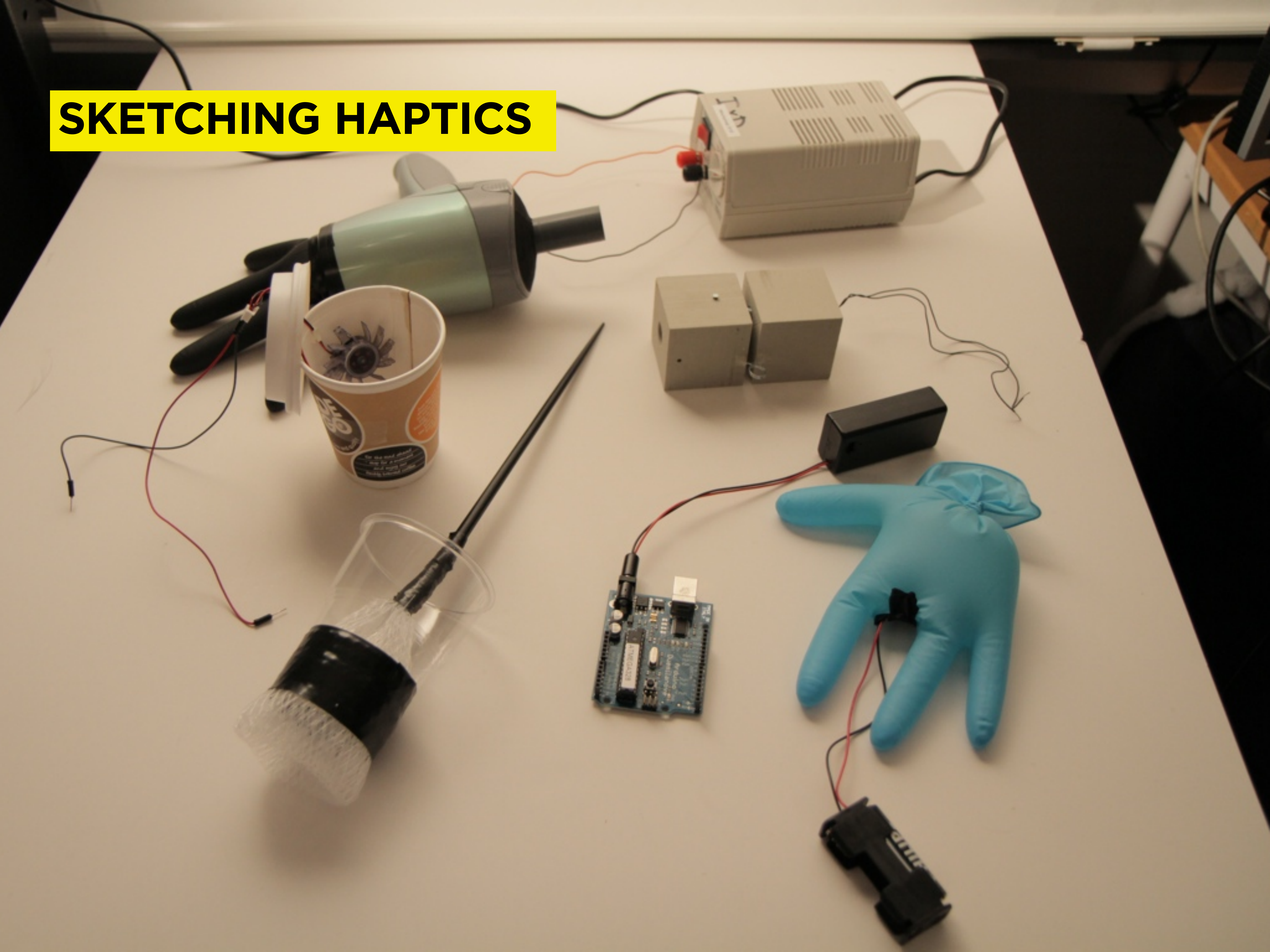
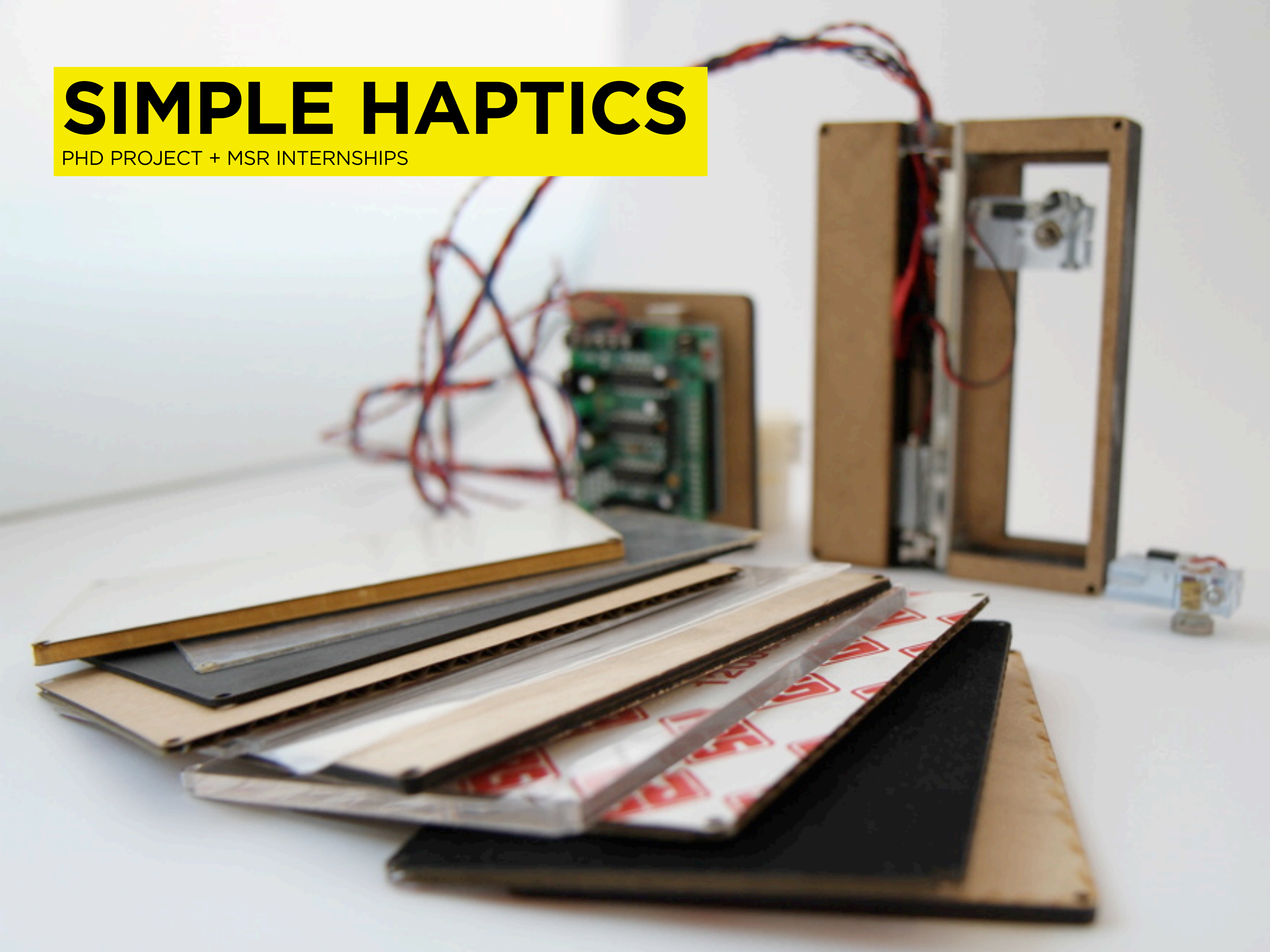


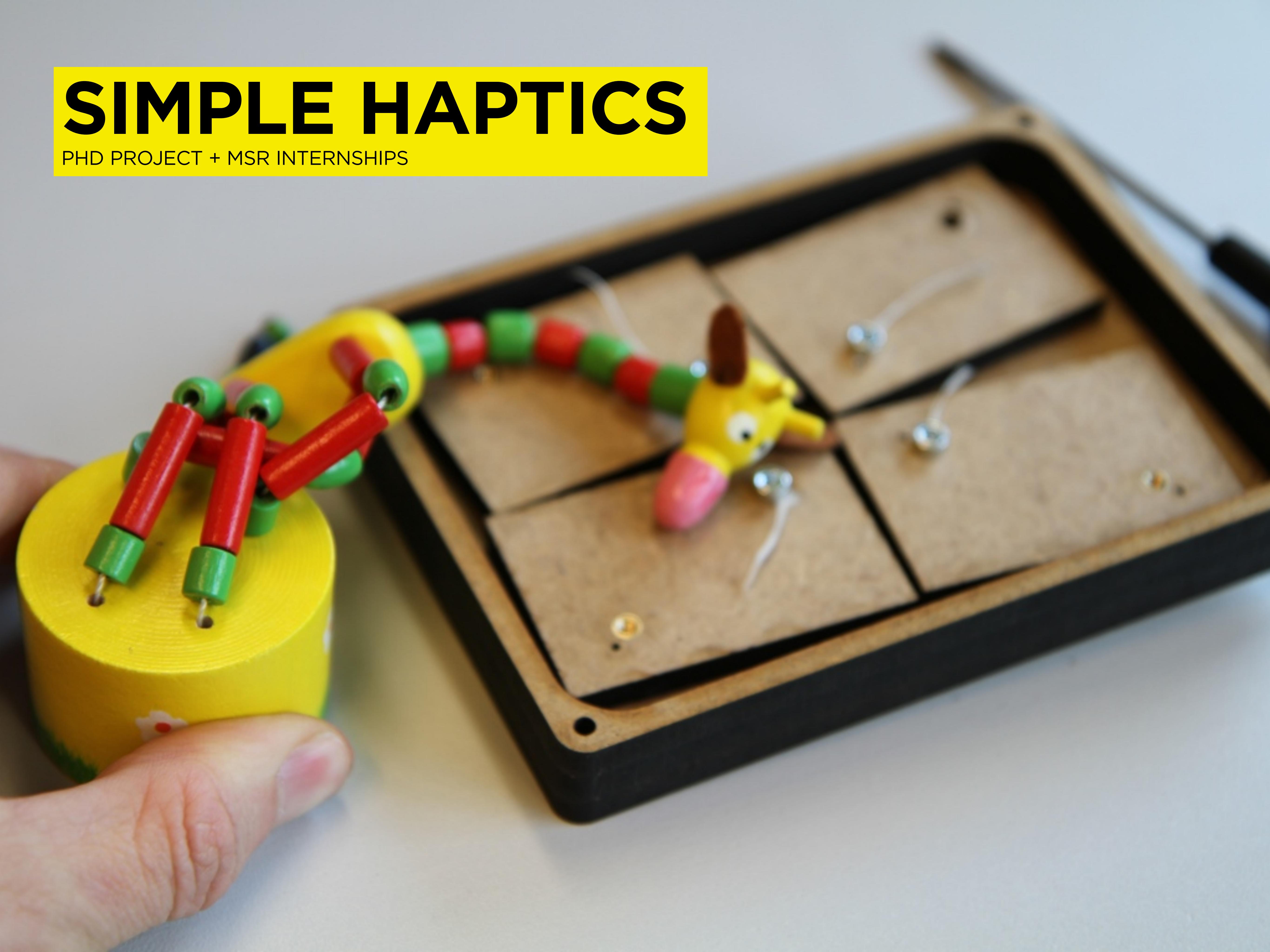
SIMPLE HAPTICS

PHD PROJECT + MSR INTERNSHIPS



SIMPLE HAPTICS

PHD PROJECT + MSR INTERNSHIPS



CHALLENGES AND DIFFICULTIES

Perception of touch: a collection of small and converging cues

Problems verbalizing and communicating sensations

Synthesizing movement and haptic feedback is not trivial, can be highly technical

Often technical problems/issues (i.e stiffness, latency) completely kill the interaction

Formal evaluation and comparison is impossible

Have to build stuff to inform/grasp/evaluate/discuss

QUALITIES AND AESTHETICS OF HAPTIC INTERFACES

Difficult balance between aesthetic and functional qualities

Haptic interfaces generally don't fit well in our tactile eco-system

Naturalistic interactions are a good fit, but not an absolute rule

Timing, quality/precision, consistency, robustness, others [MacLean]

Tight sensory coupling seems appreciated

THANKS!

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