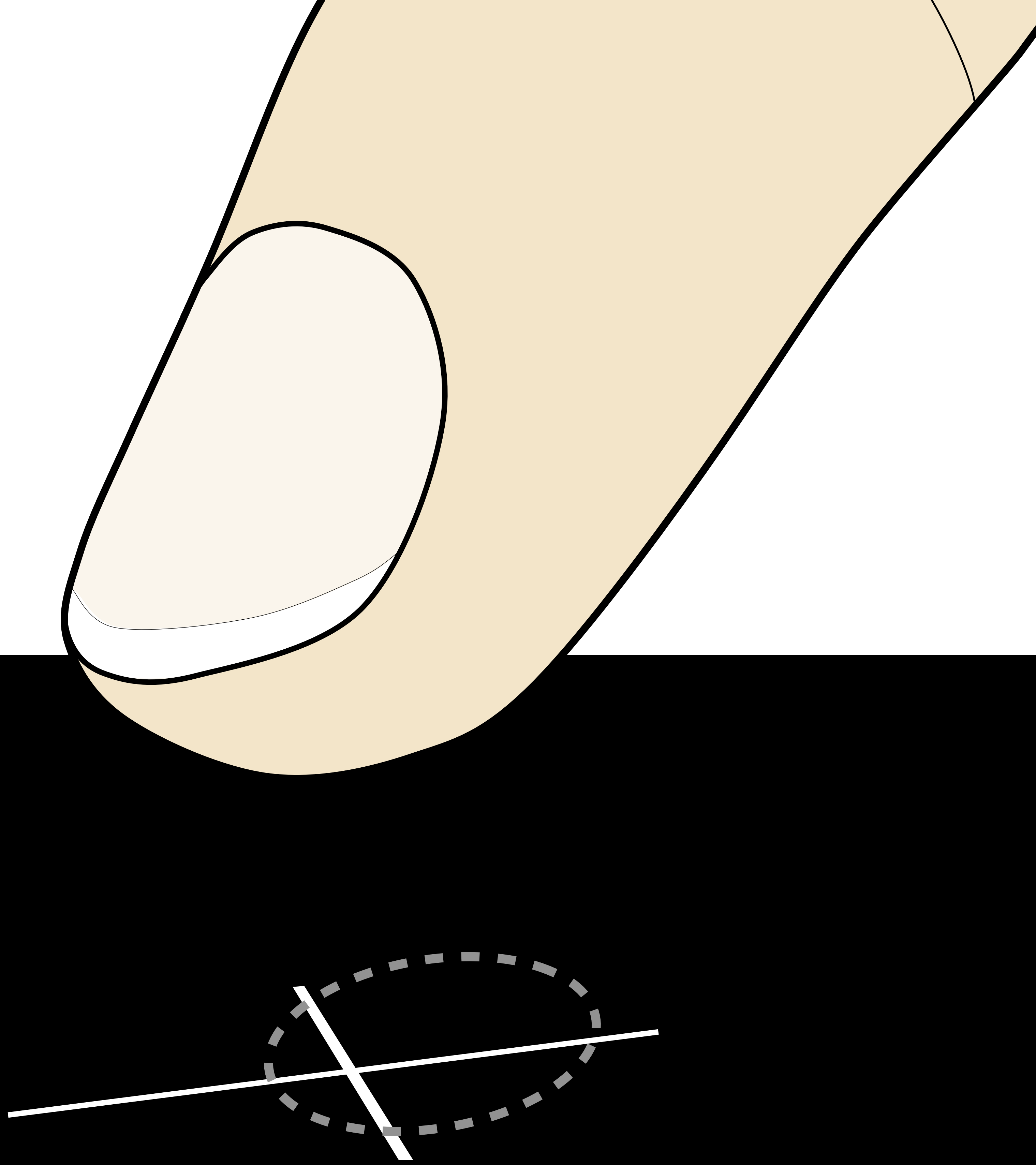
Touch Input



CSE 510

Christian Holz
Microsoft Research
http://www.christianholz.net

February 11, 2016

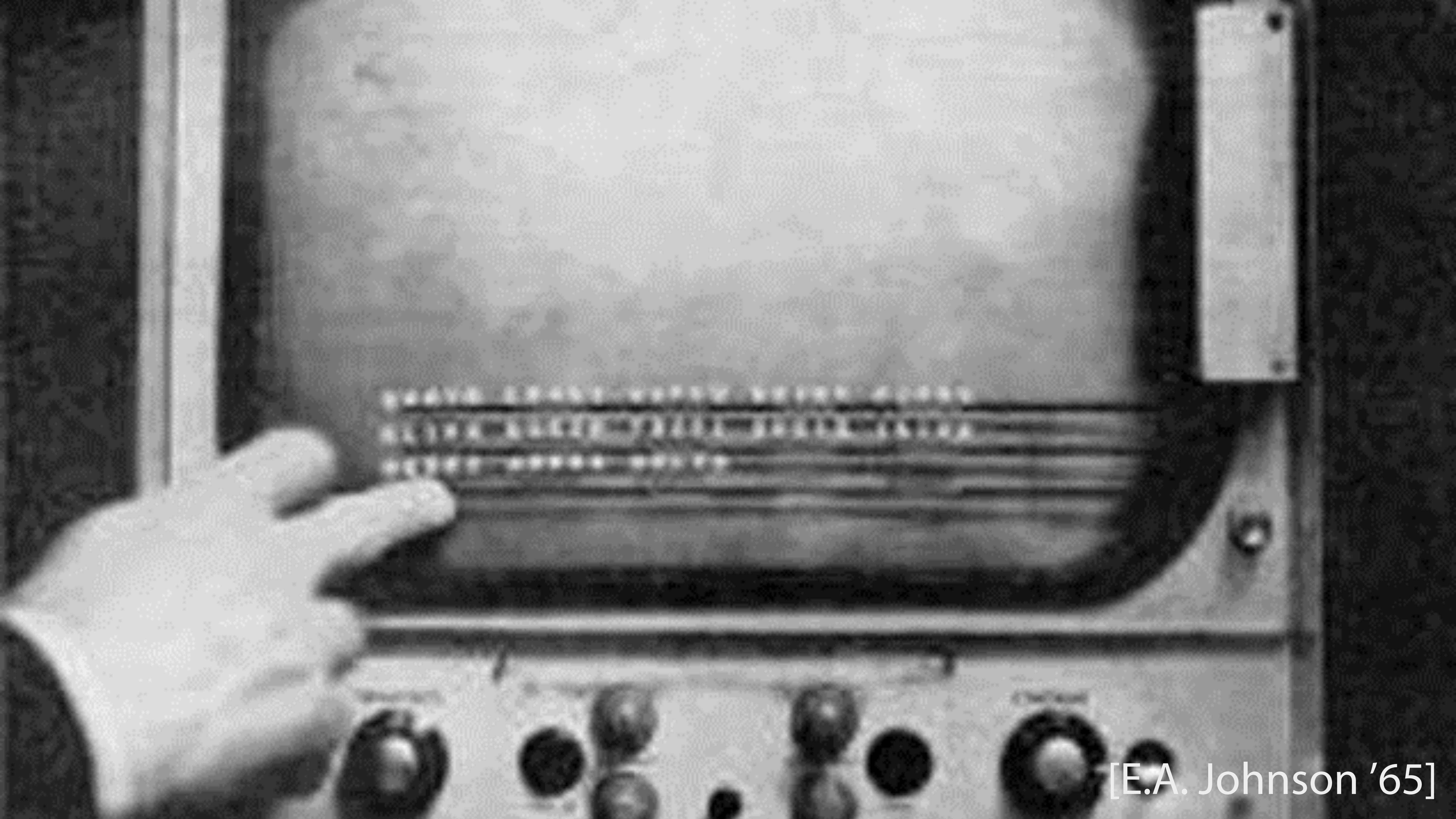
Nokia 5800, 2008

hall of fame/hall of shame?

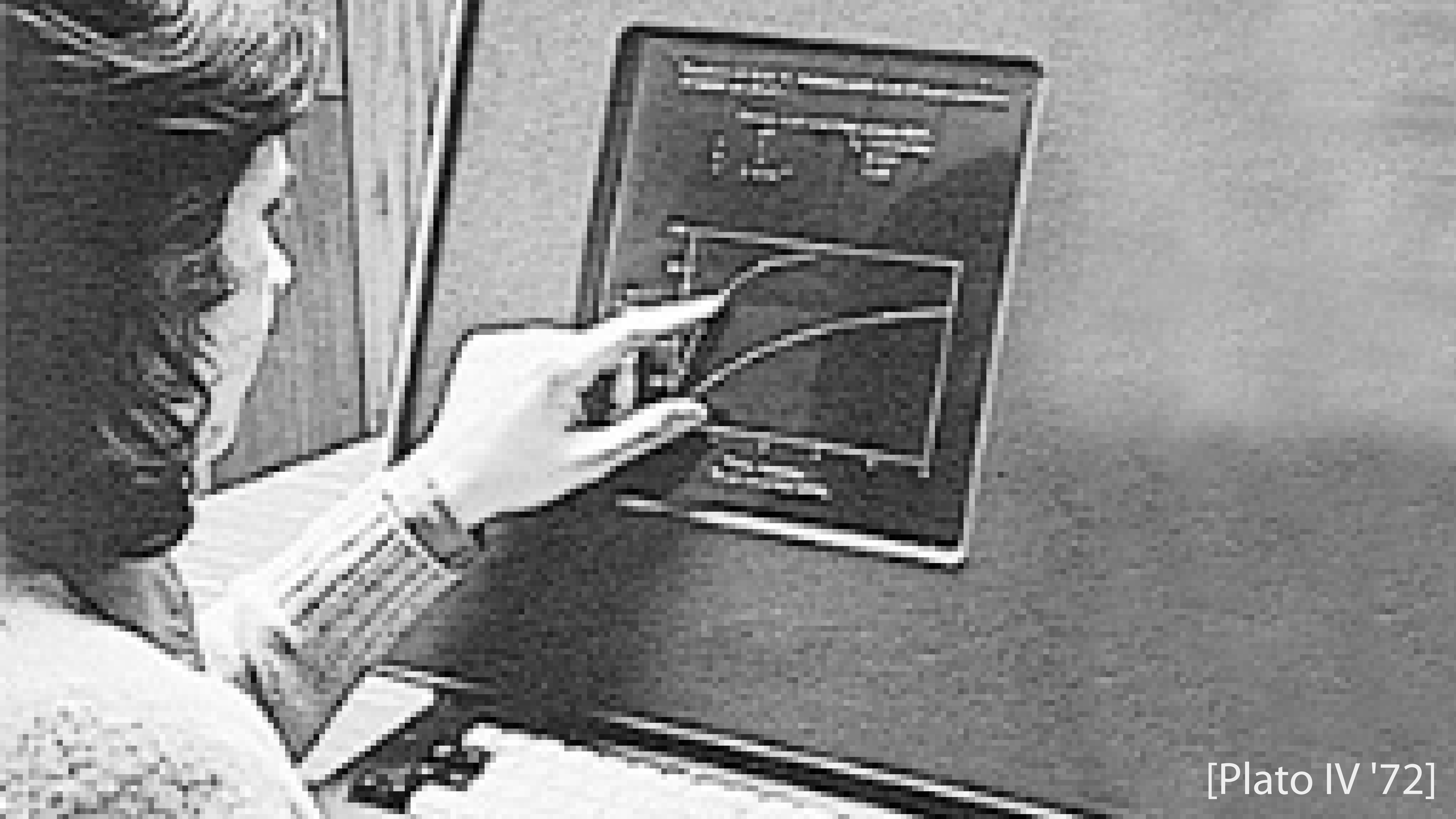
hall of fame/hall of shame?

“we’ve invented…”

[Lightpen ’62]



[E.A. Johnson '65]



[Plato IV '72]

➪ http://www.billbuxton.com/multitouchOverview.html


Works like magic


IBM Simon, 1992

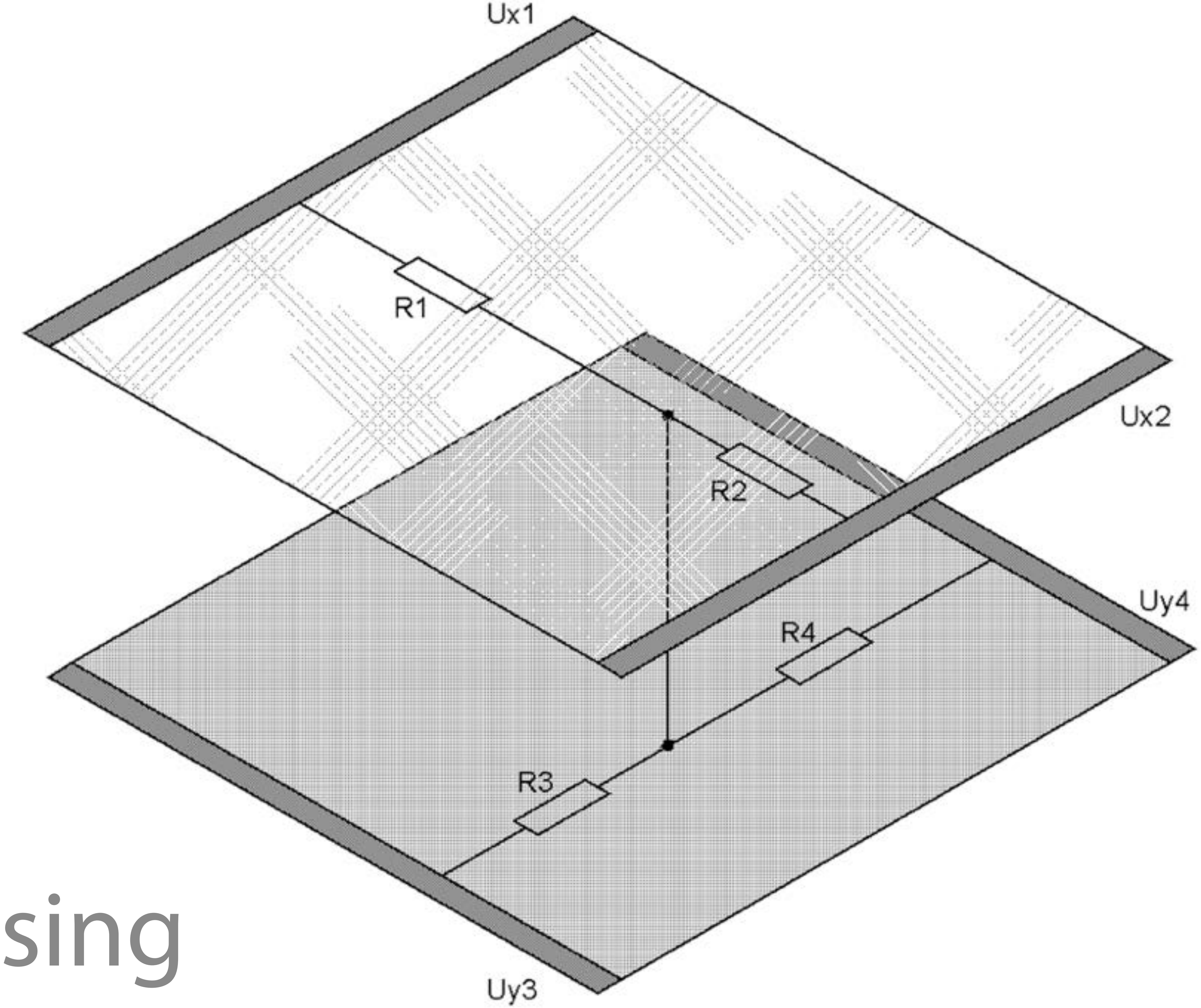
what was the real novelty here?

30 second brainstorming

1 Touch technologies

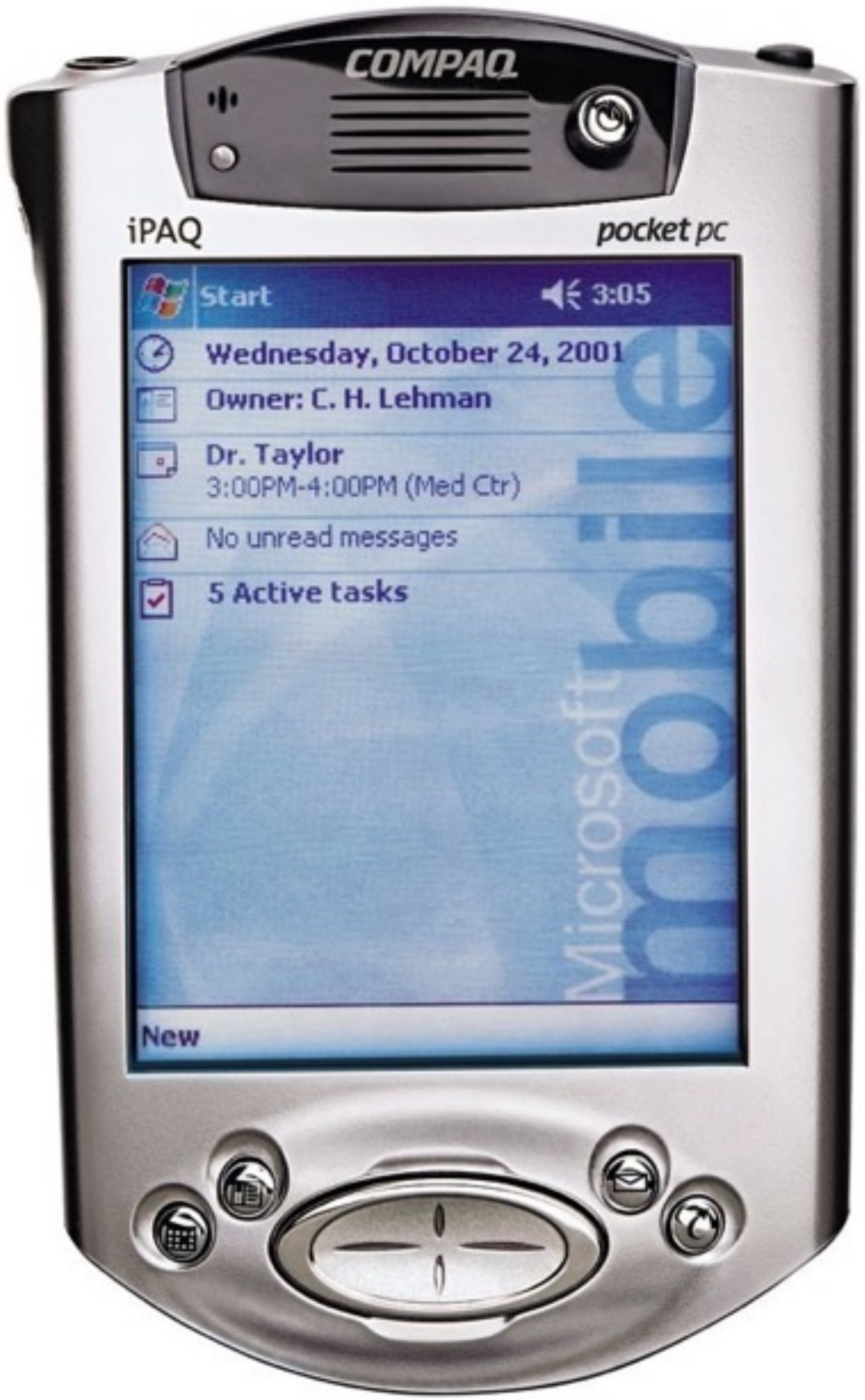
2 Touch accuracy

1 Touch technologies a cursory overview



resistive sensing

Inspiron 7000,1998



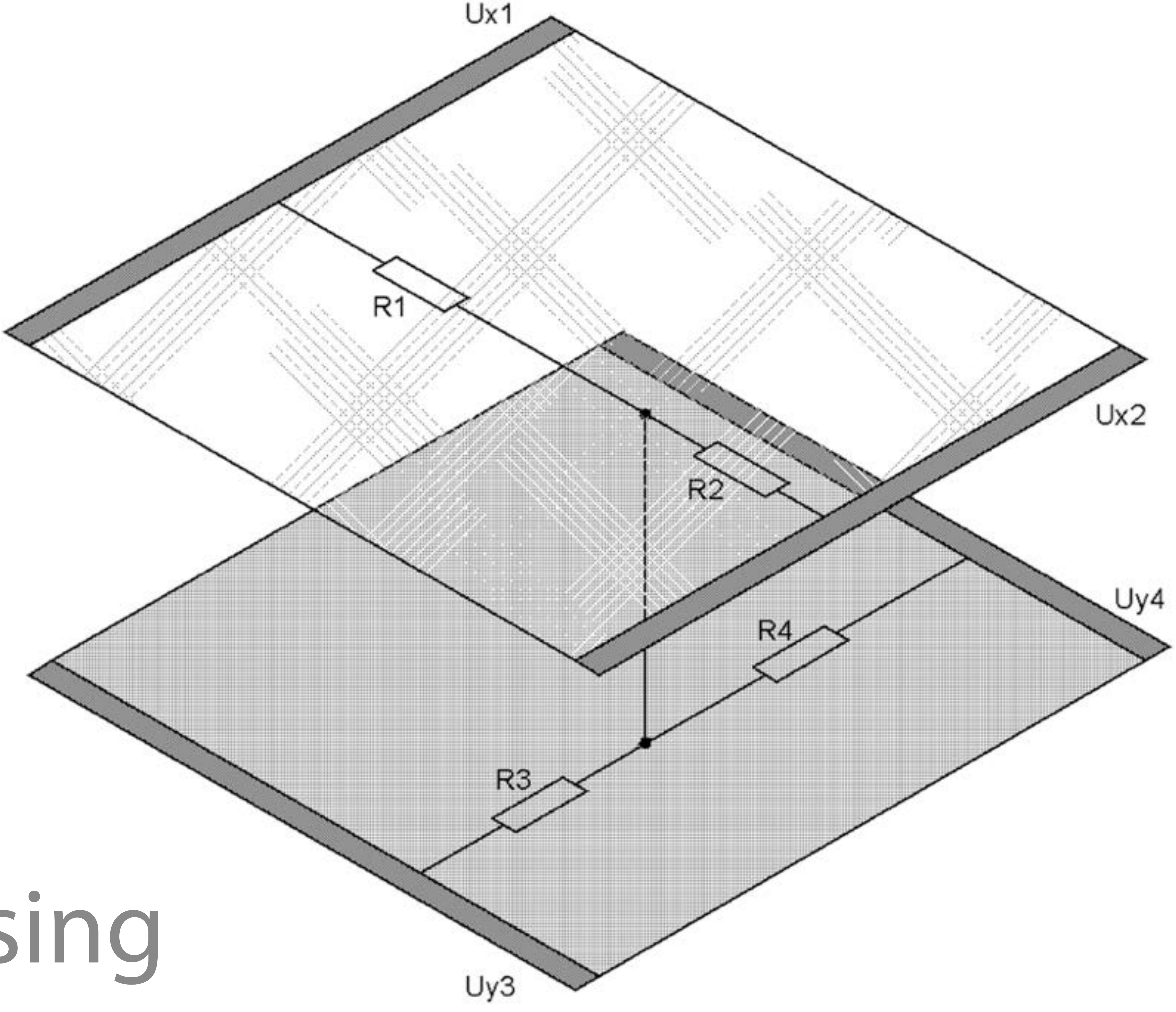
Compaq PDA, 2000

[Matsushita et al., UIST ’00]

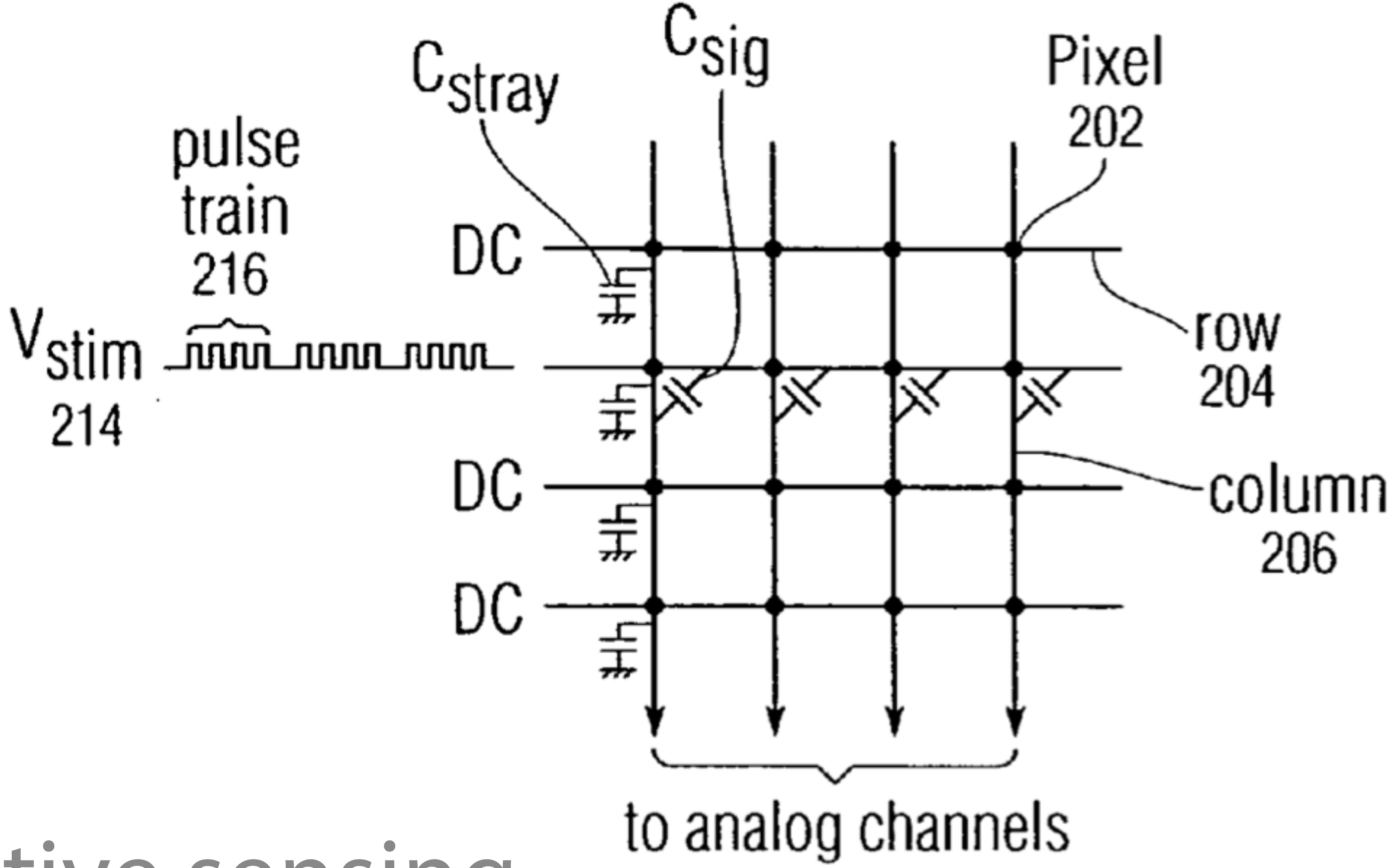
how did they enable dual-touch in a single touch sensor?

30 second brainstorming

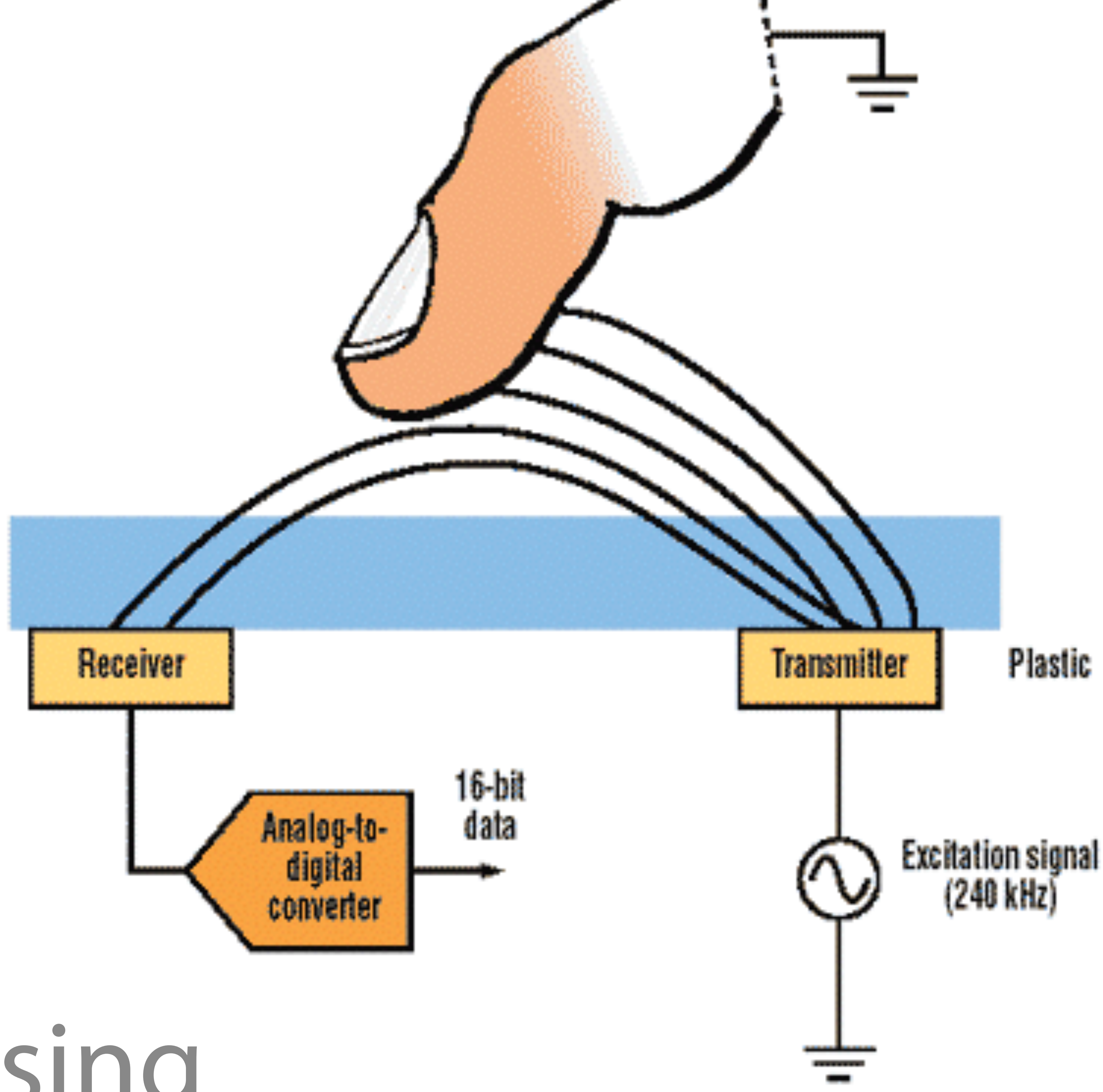
[Matsushita et al., UIST ’00]



resistive sensing

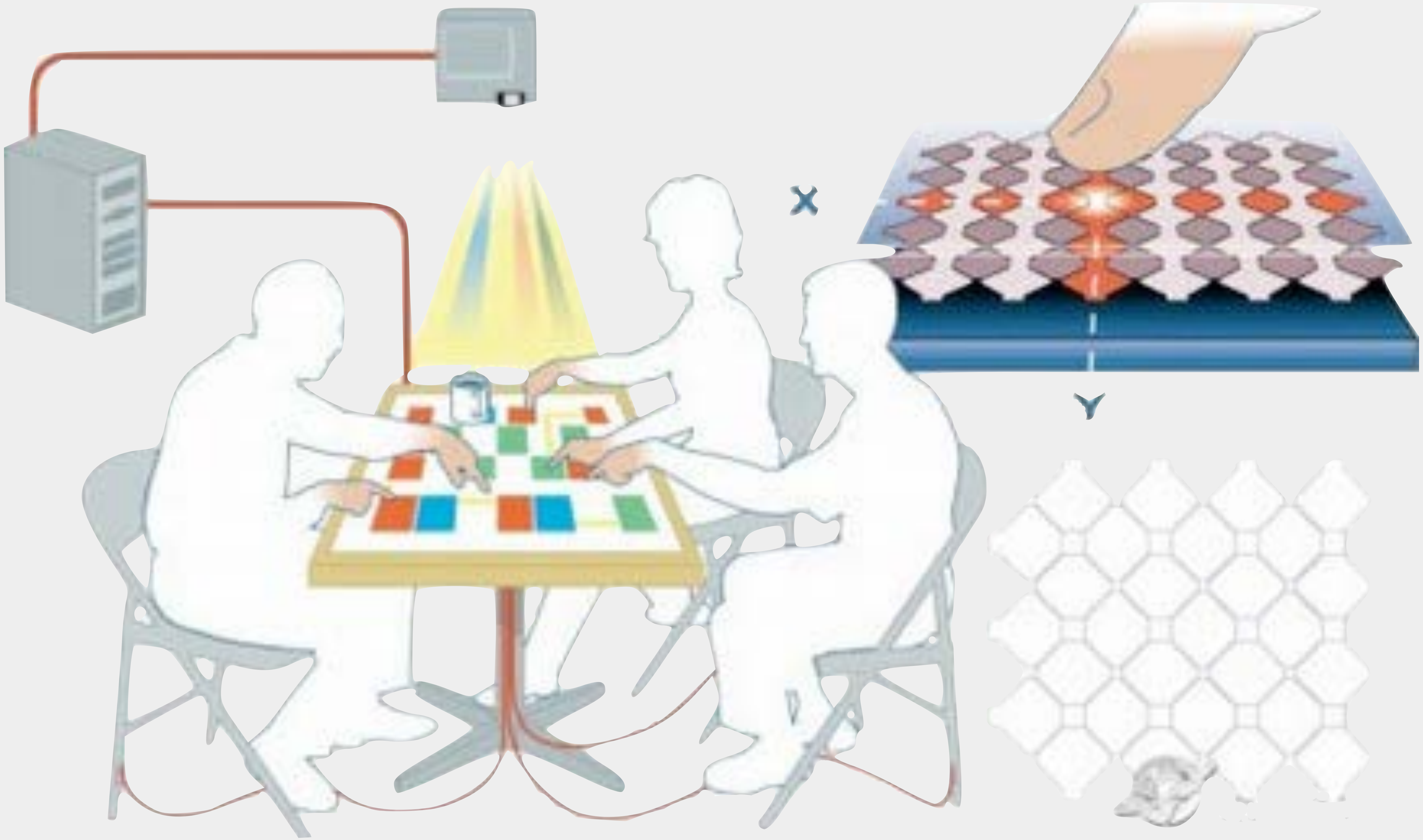


capacitive sensing



capacitive sensing

DiamondTouch [Dietz & Leigh '01]



DiamondTouch [Dietz & Leigh '01]

SmartSkin [Rekimoto '02]

SmartSkin [Rekimoto '02]

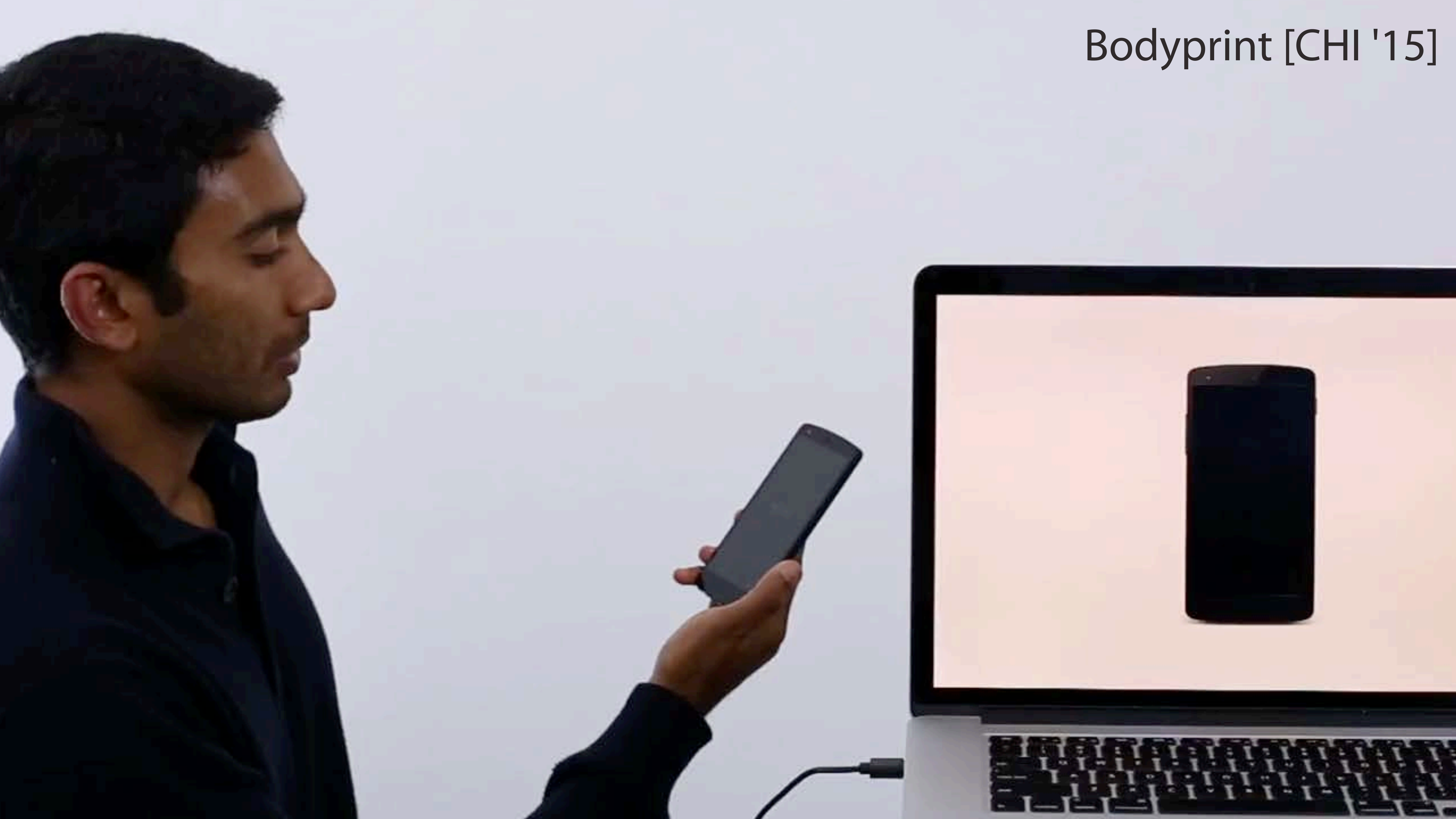
Fingerworks, 2005

iPhone 1, 2007

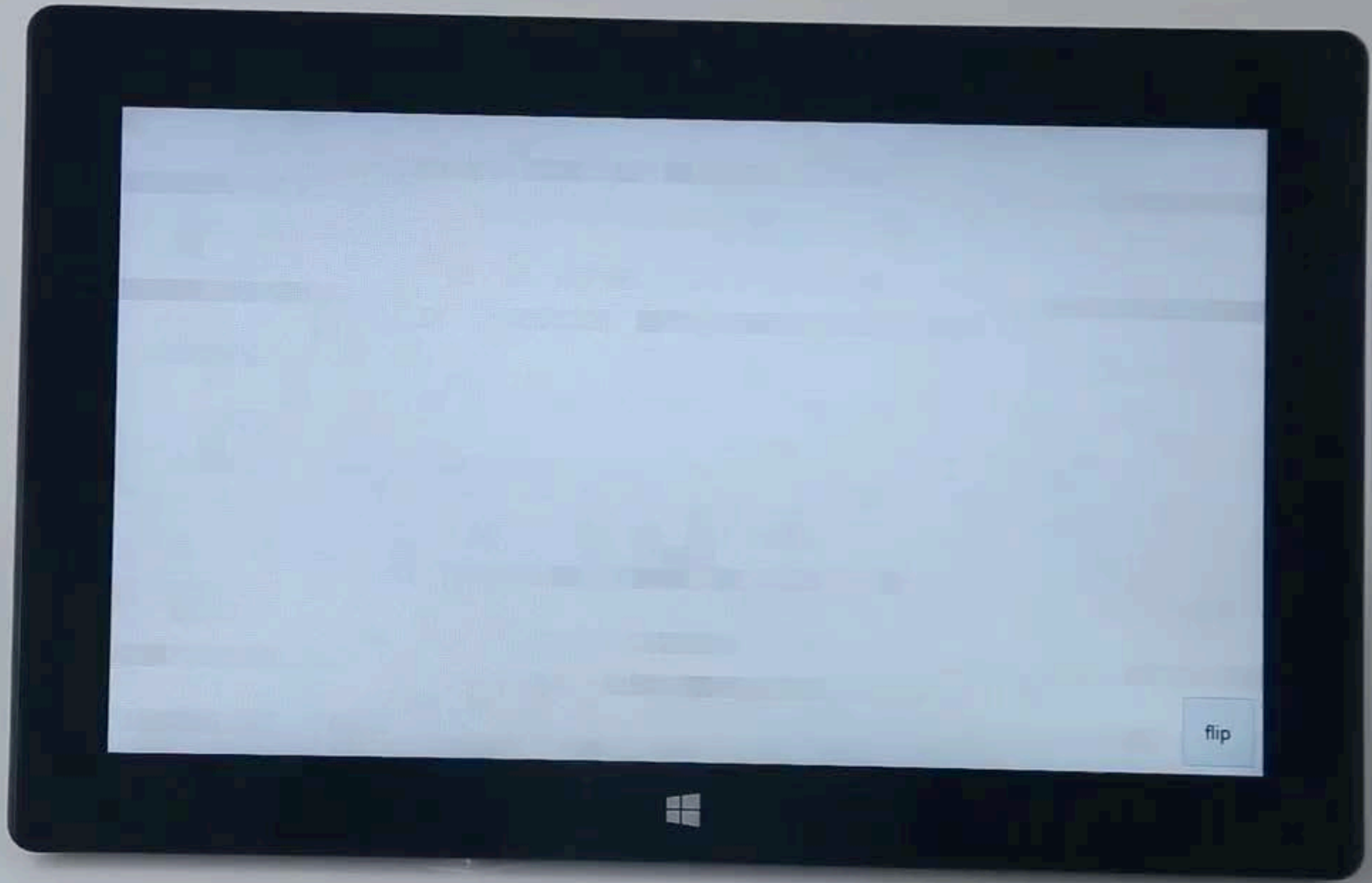
…and it prevailed

…and it prevailed

Bodyprint [CHI '15]

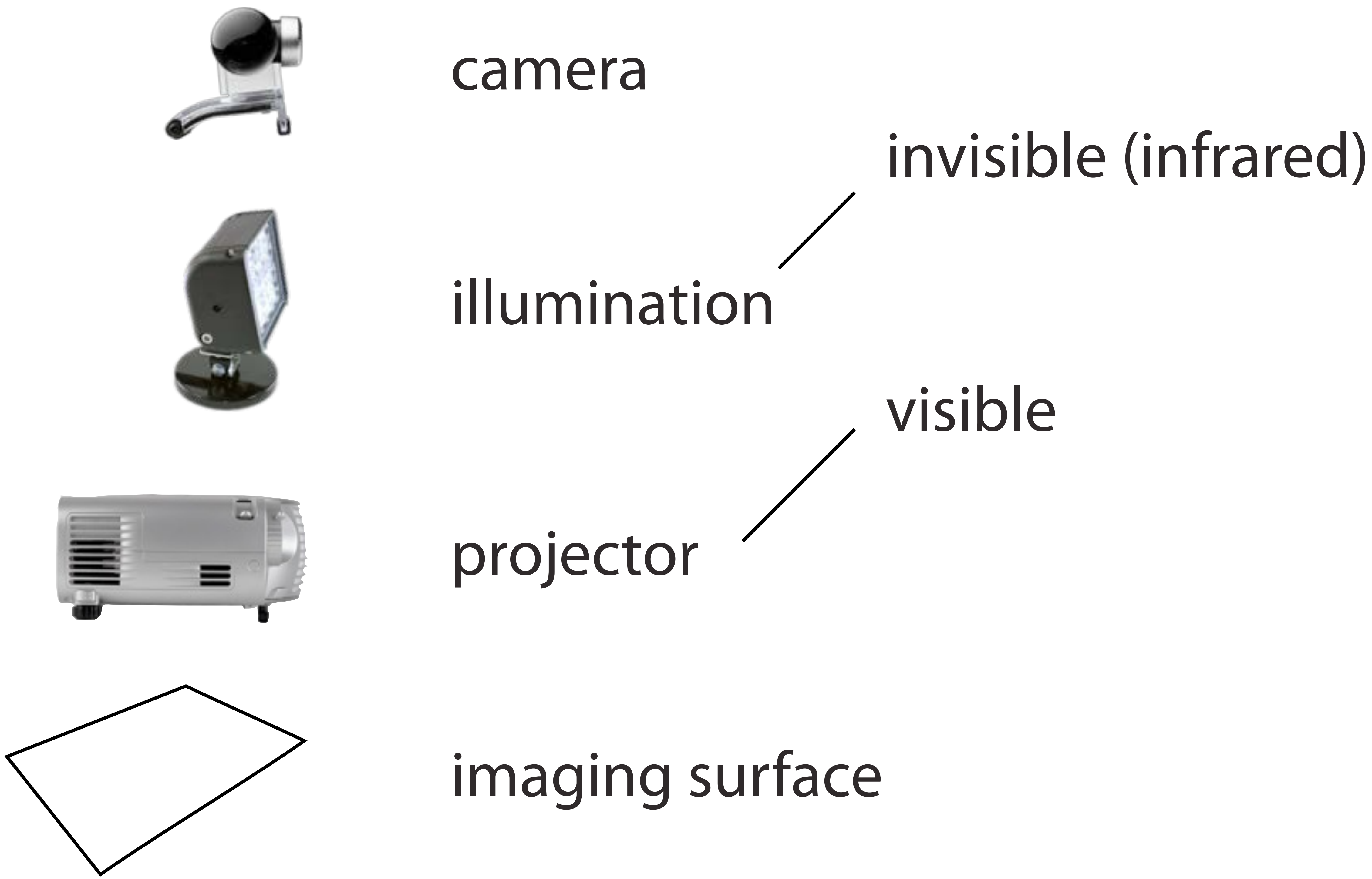


Biometric Touch Sensing [UIST '15]



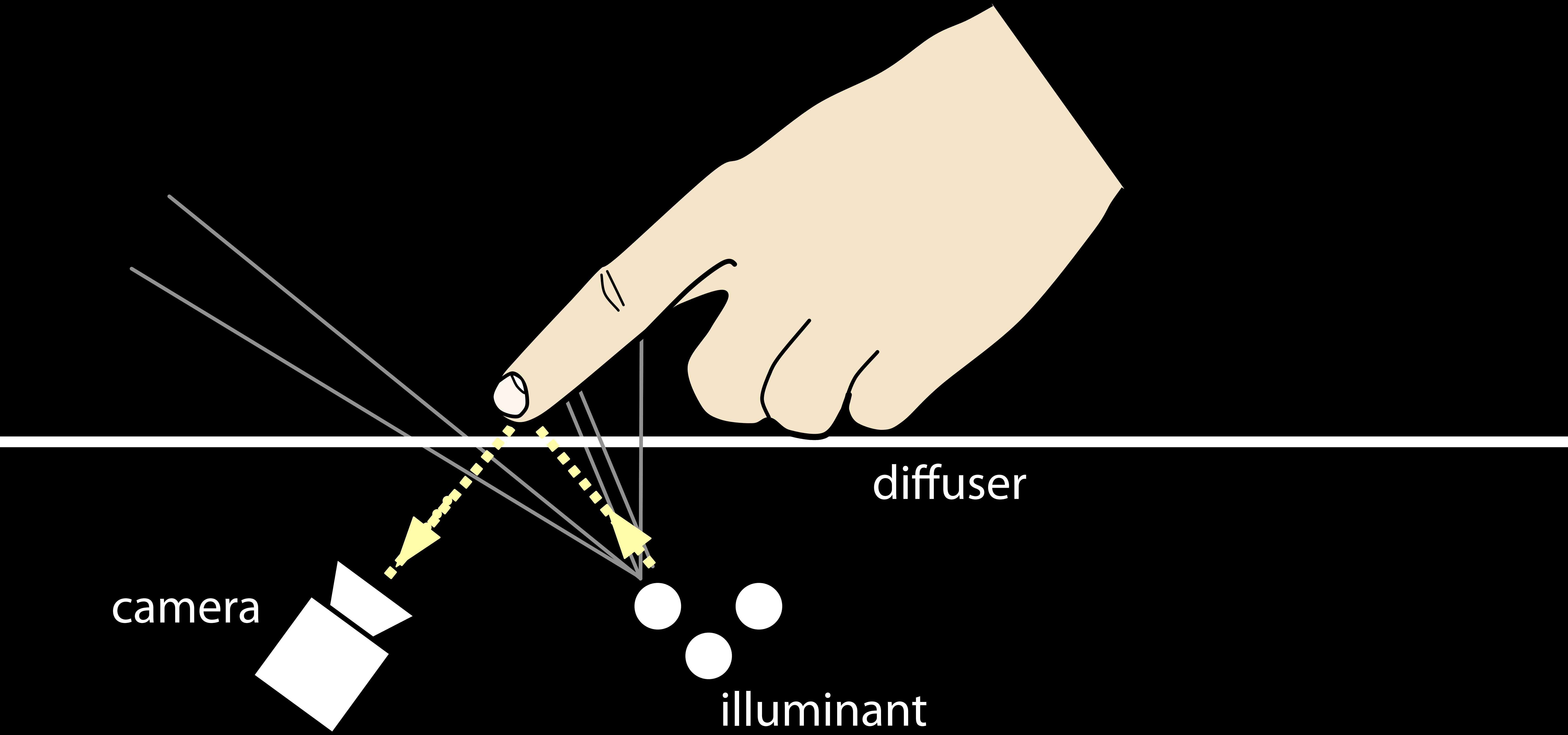
optical touch sensing

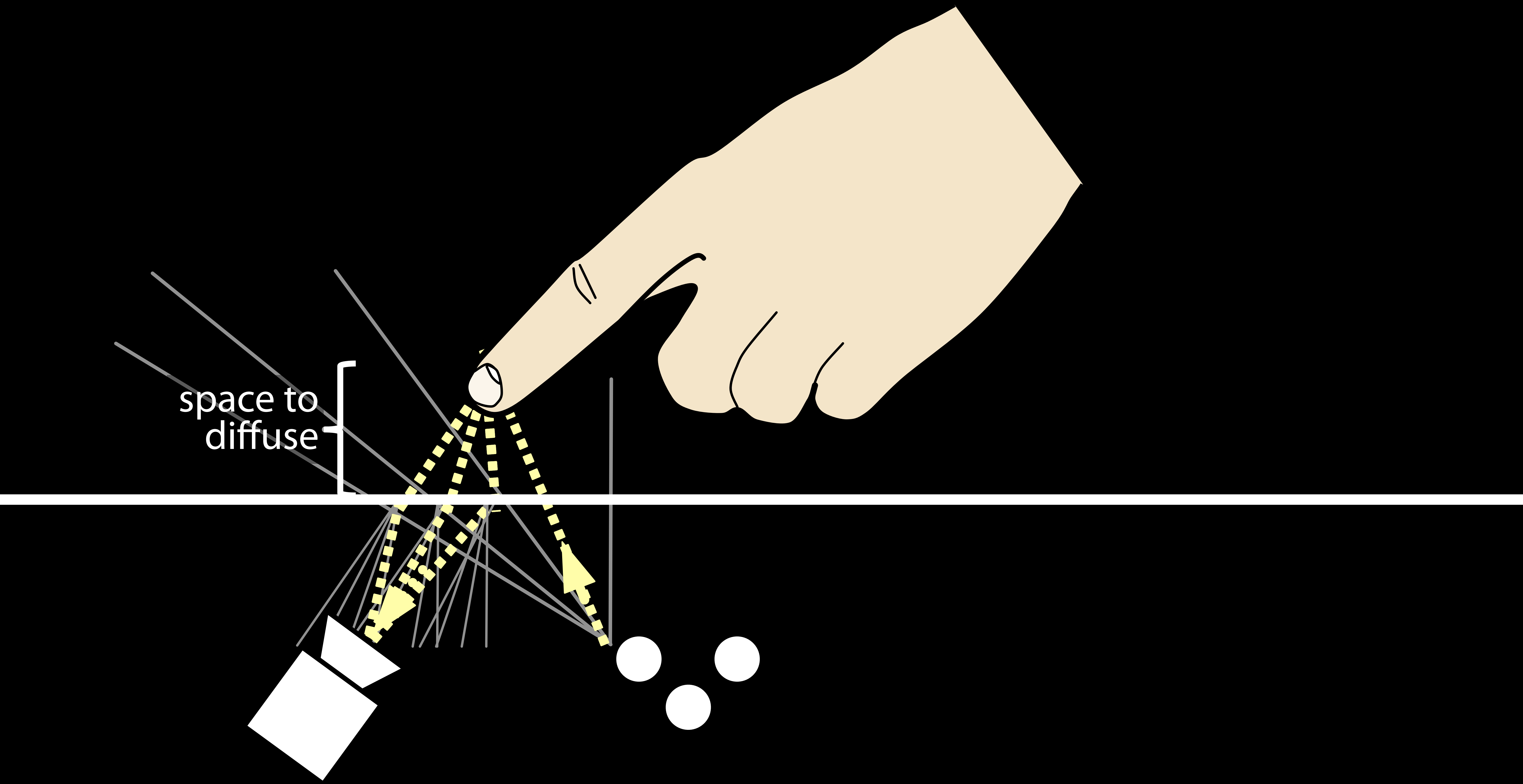
walls & tables

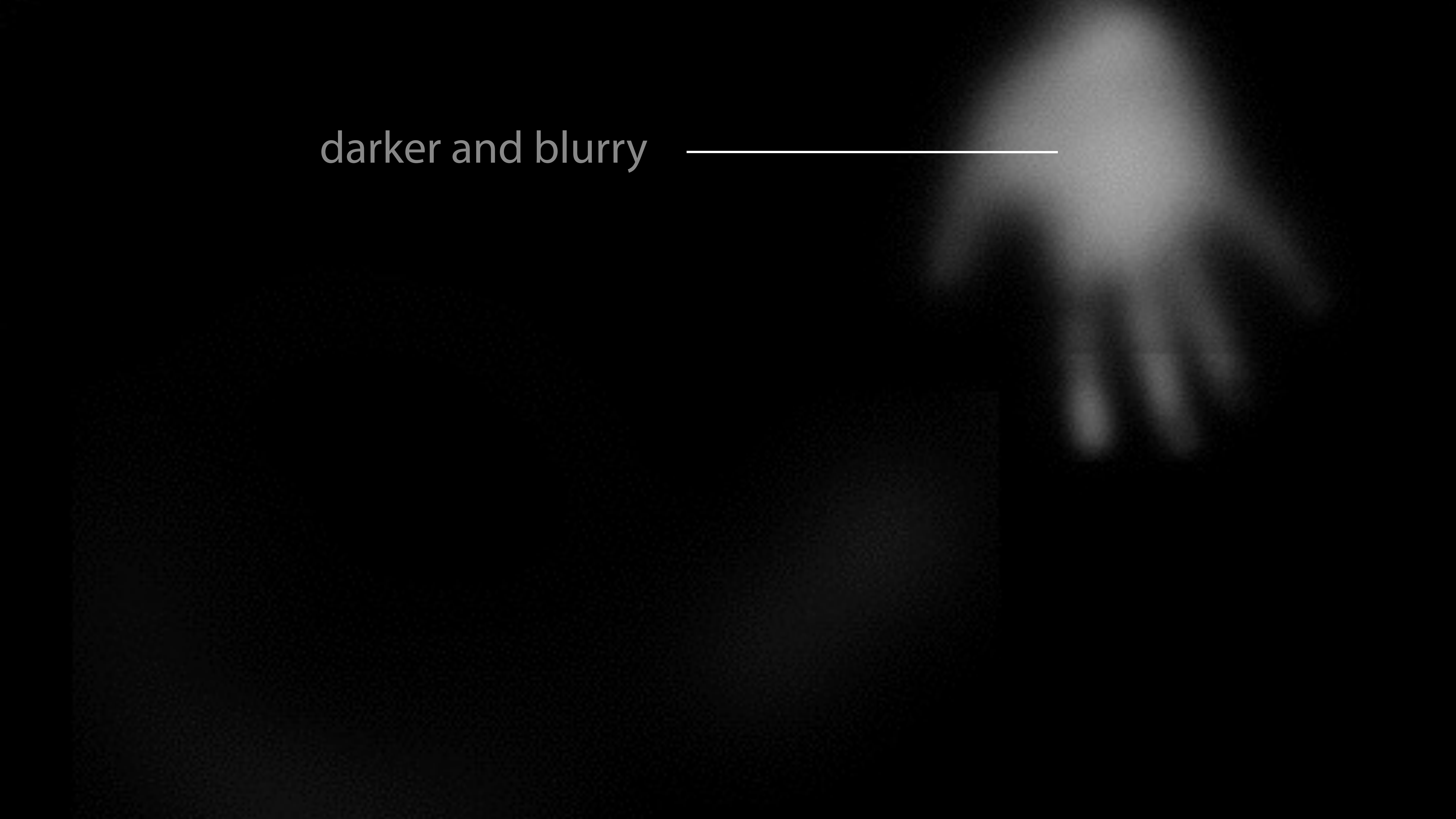


optical touch sensing

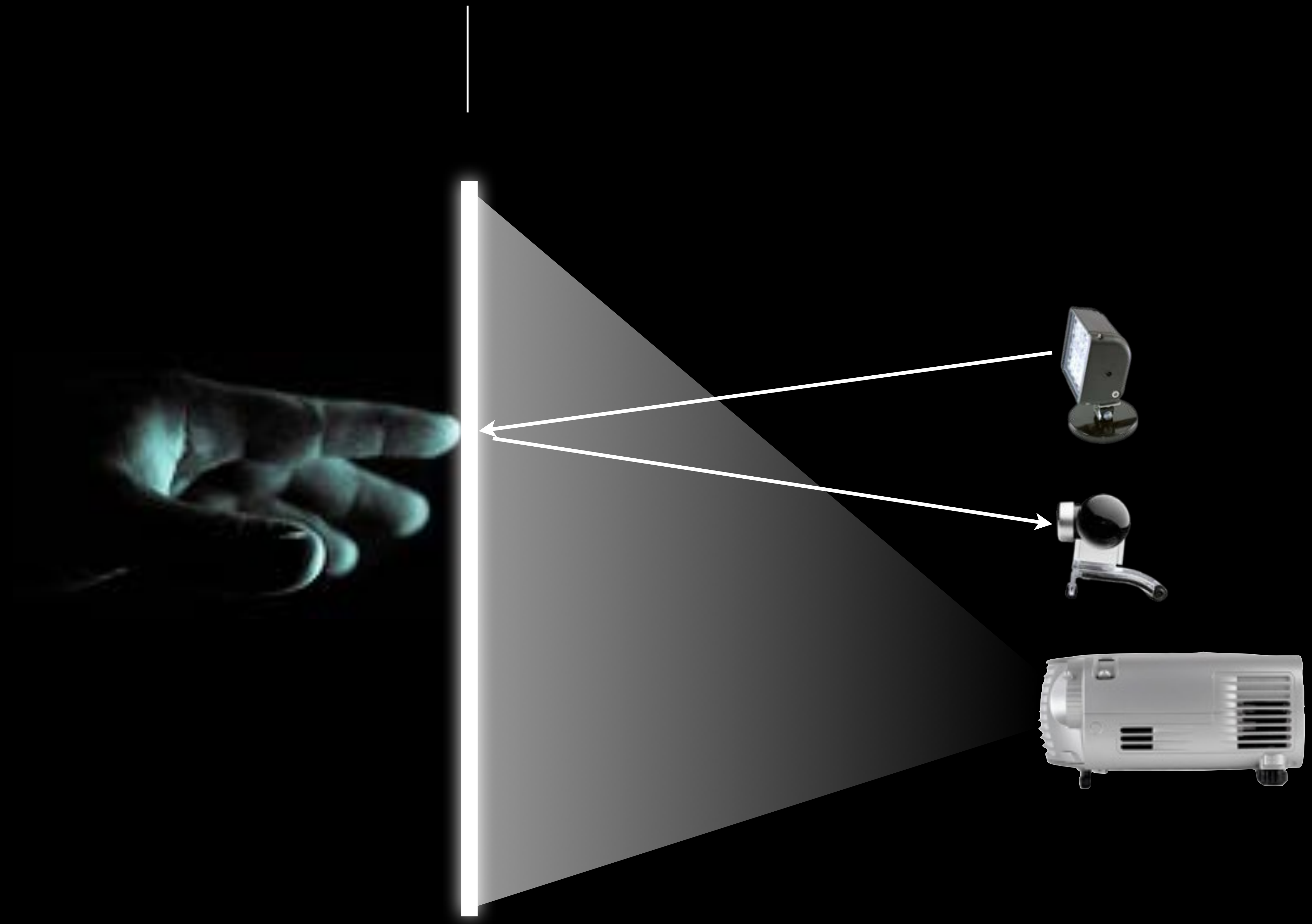
diffuse illumination

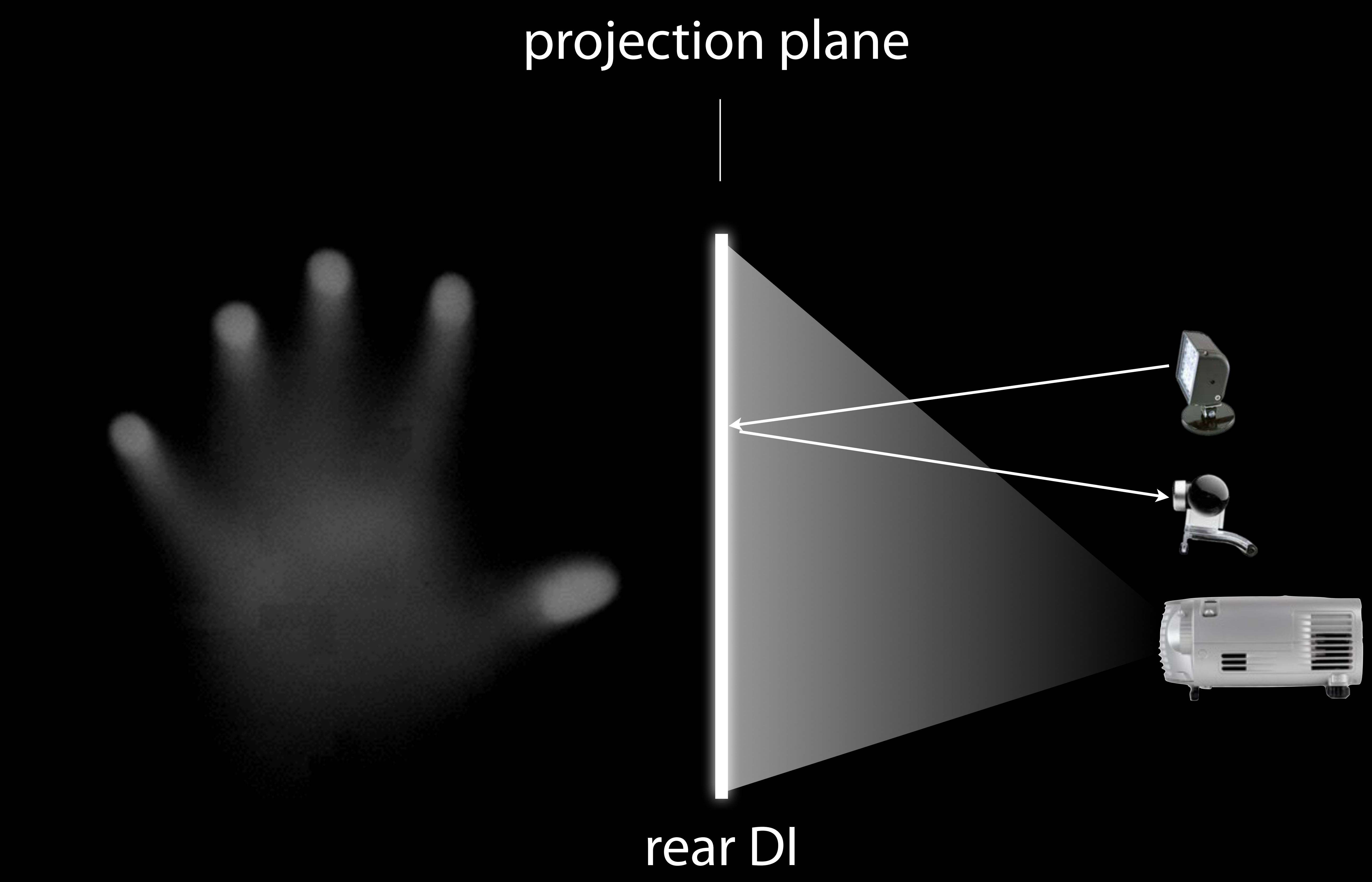

diffuser
camera
illuminant


space to
diffuse


darker and blurry

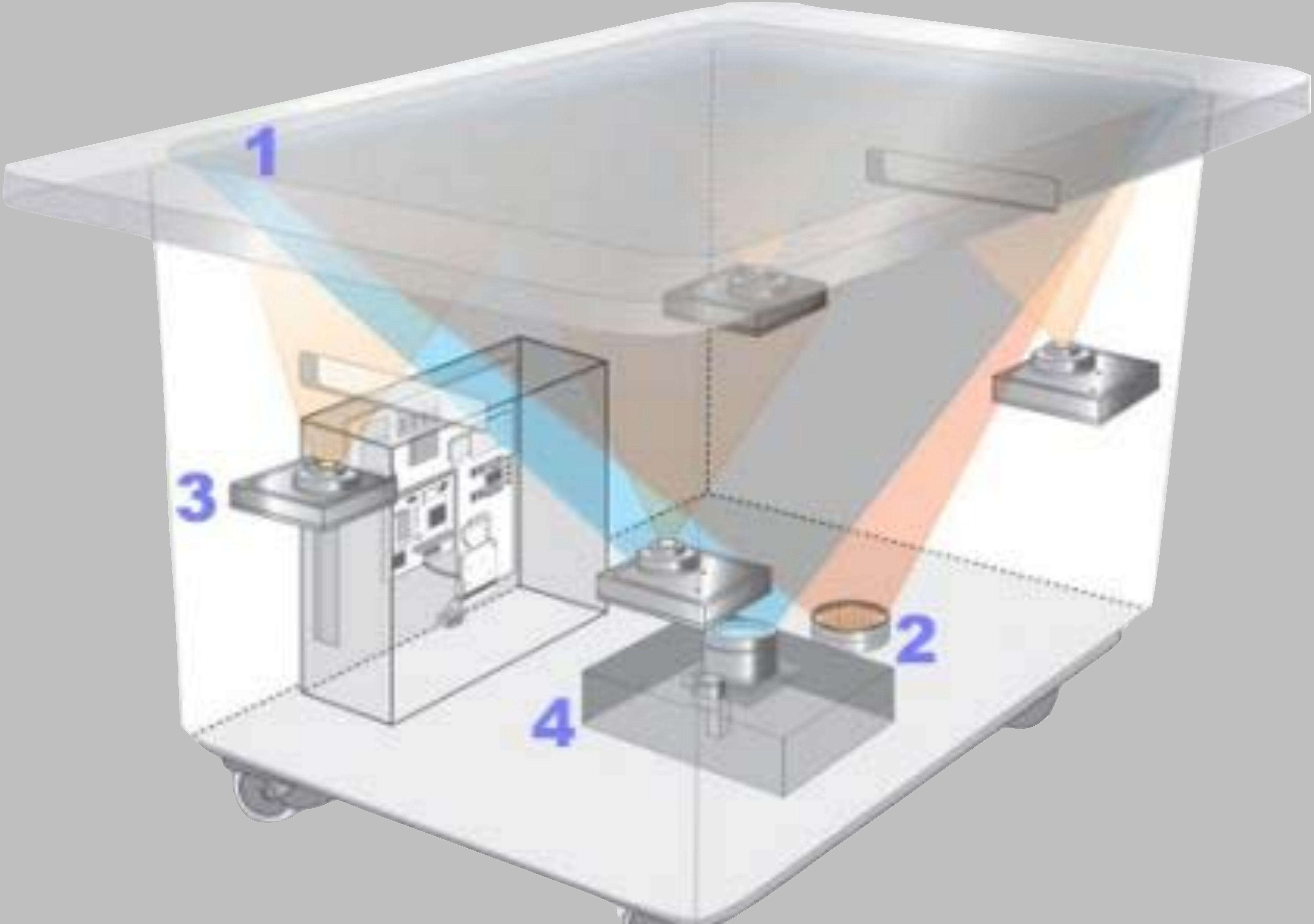
projection plane

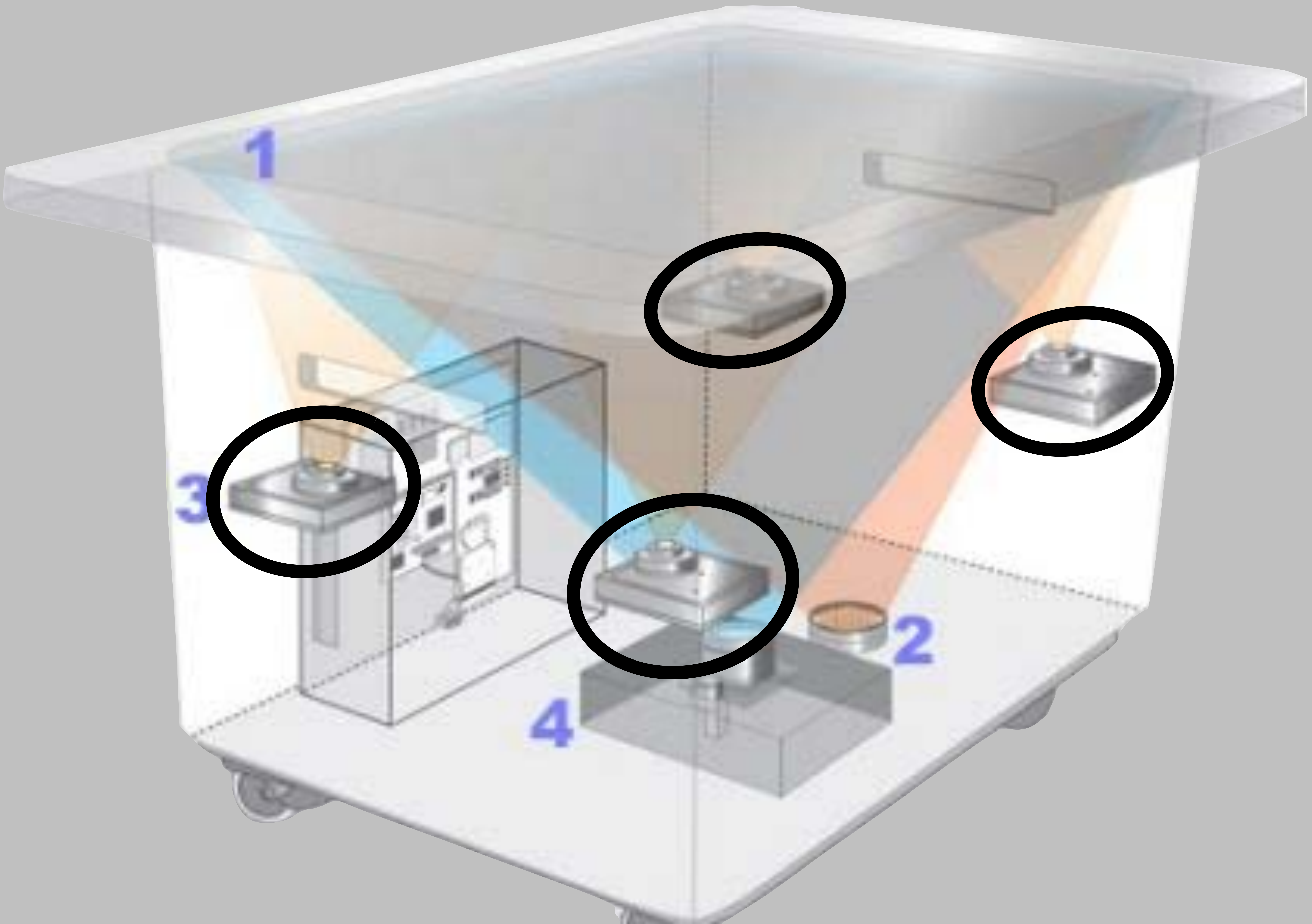



projection plane
rear DI

HoloWall [Rekimoto, UIST '97]

Microsoft Surface, 2008

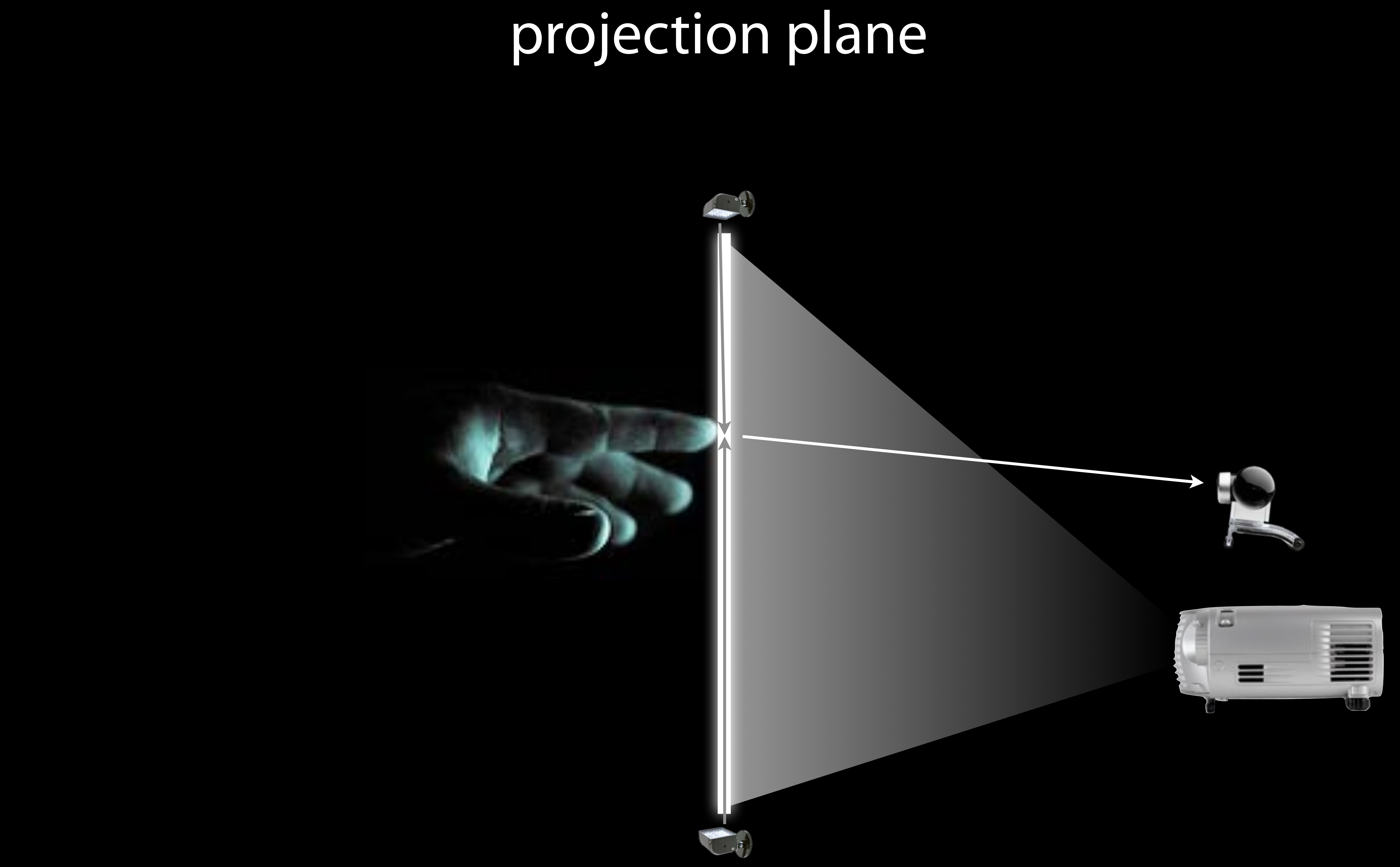

1
2
3
4


1
2
3
4

frustrated total internal reflection

the other camp

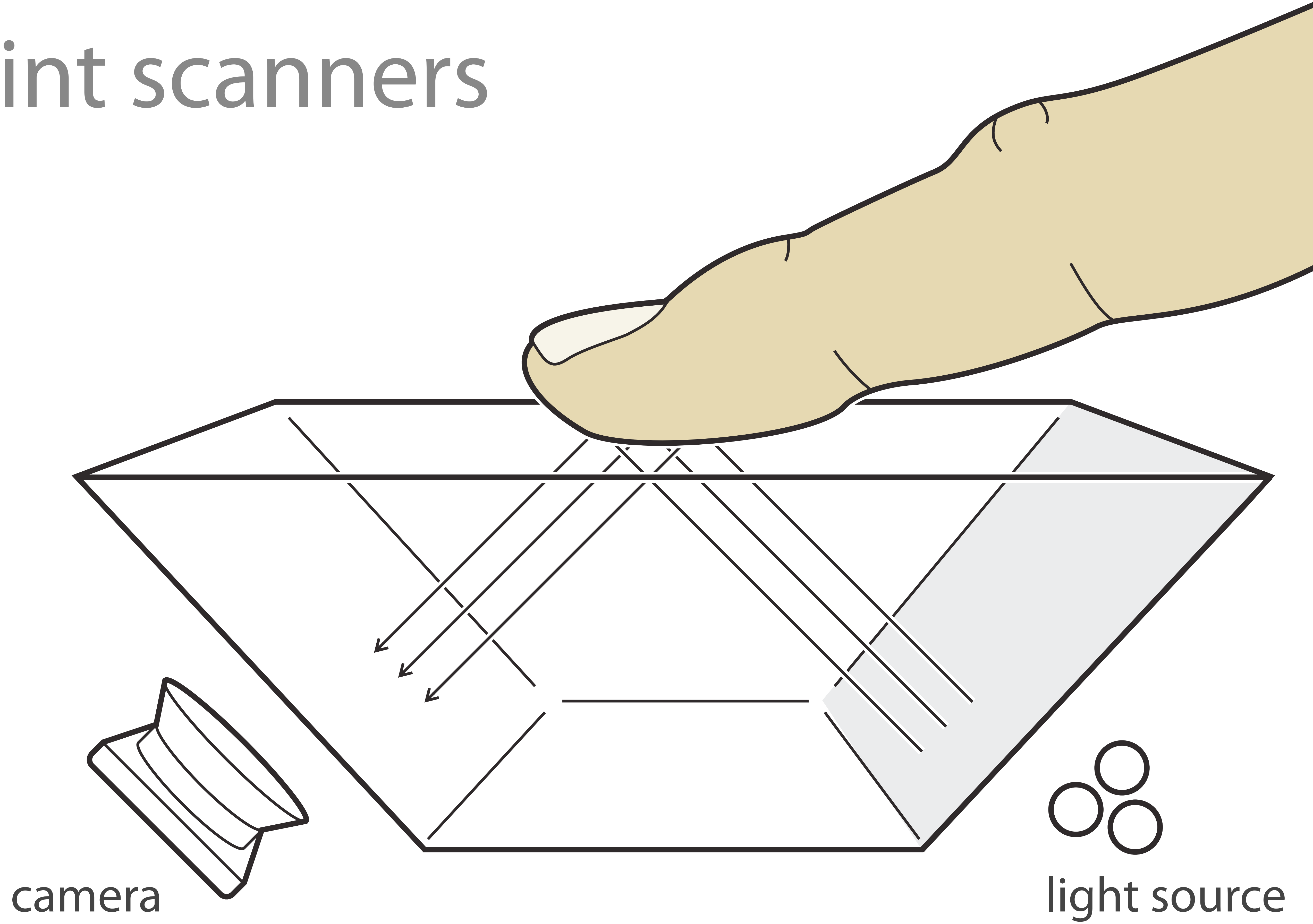

MULTI-TOUCH SENSING THROUGH
FRUSTRATED TOTAL INTERNAL REFLECTANCE

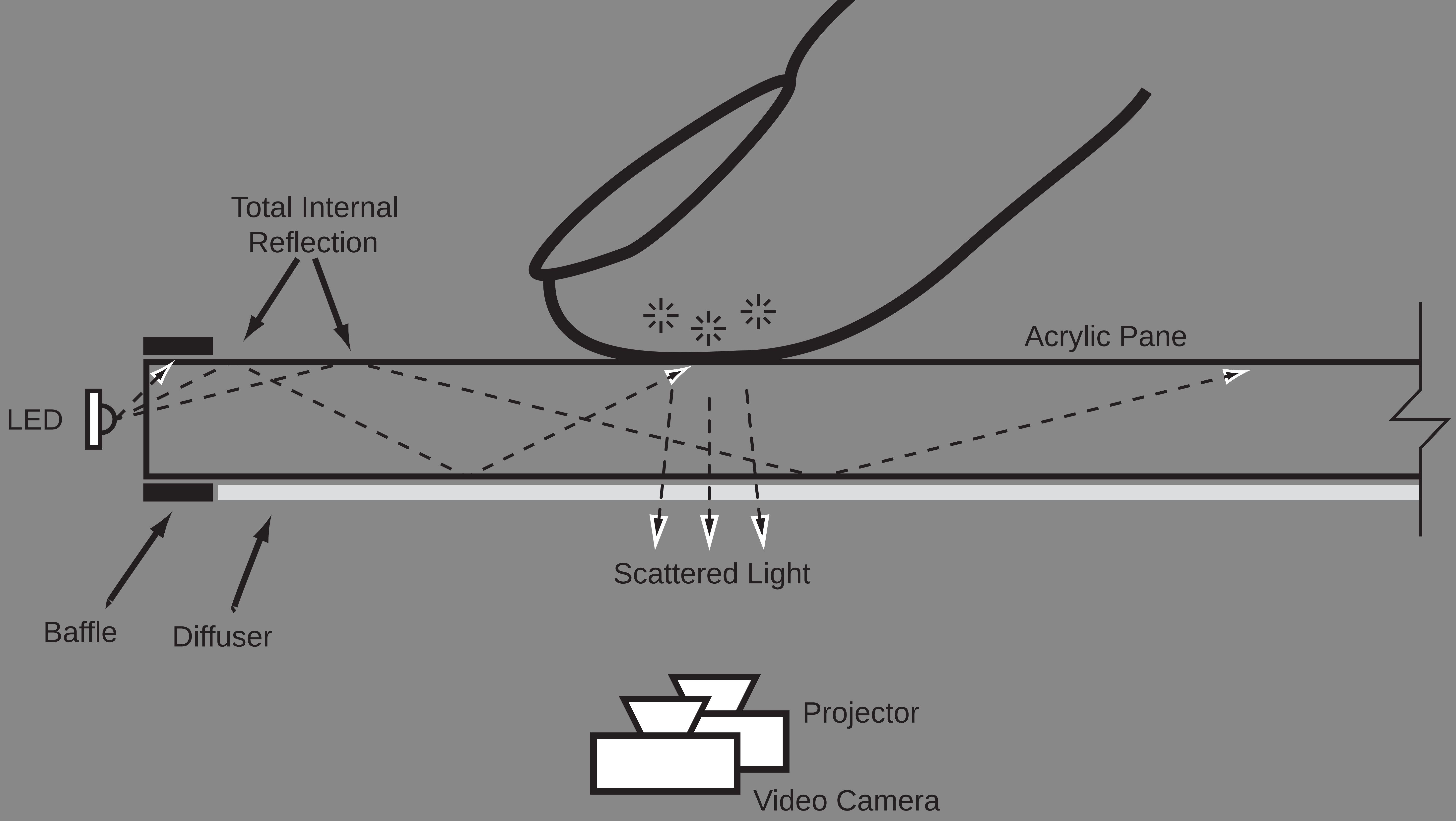


FTIR

[Han, UIST ’05]

fingerprint scanners





FTIR

[Han, UIST '05]

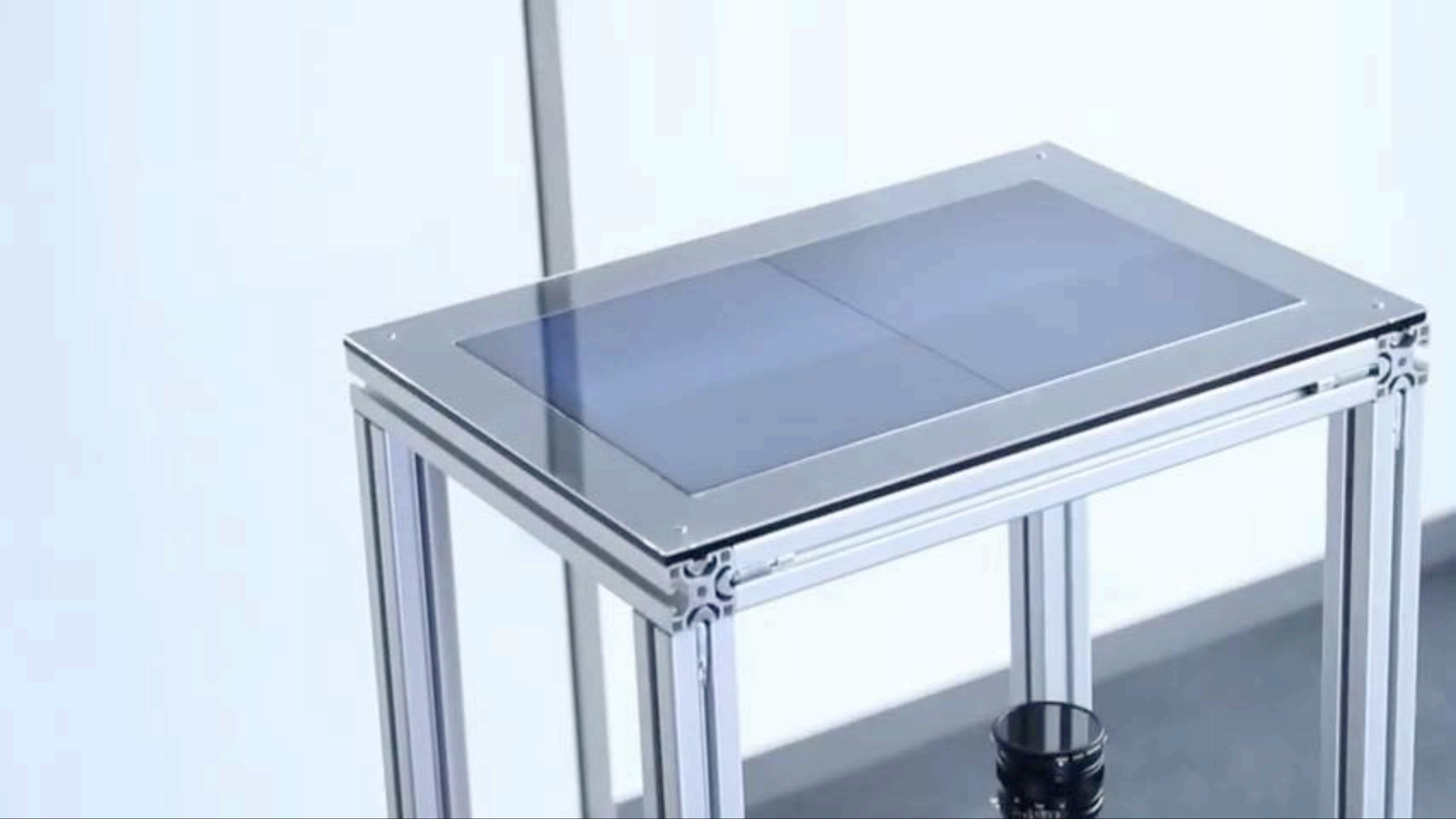
[Han, UIST ’05]

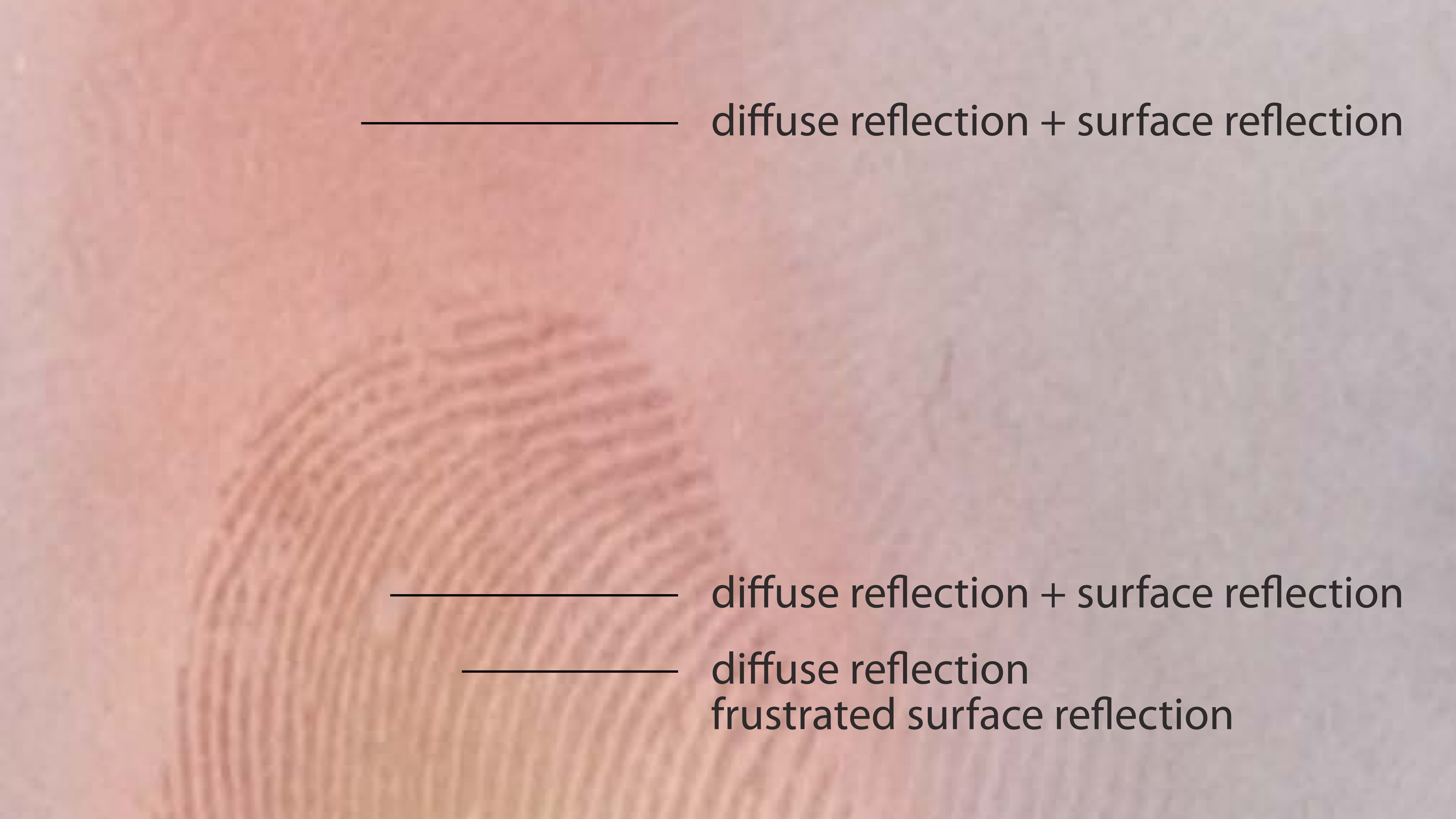
(

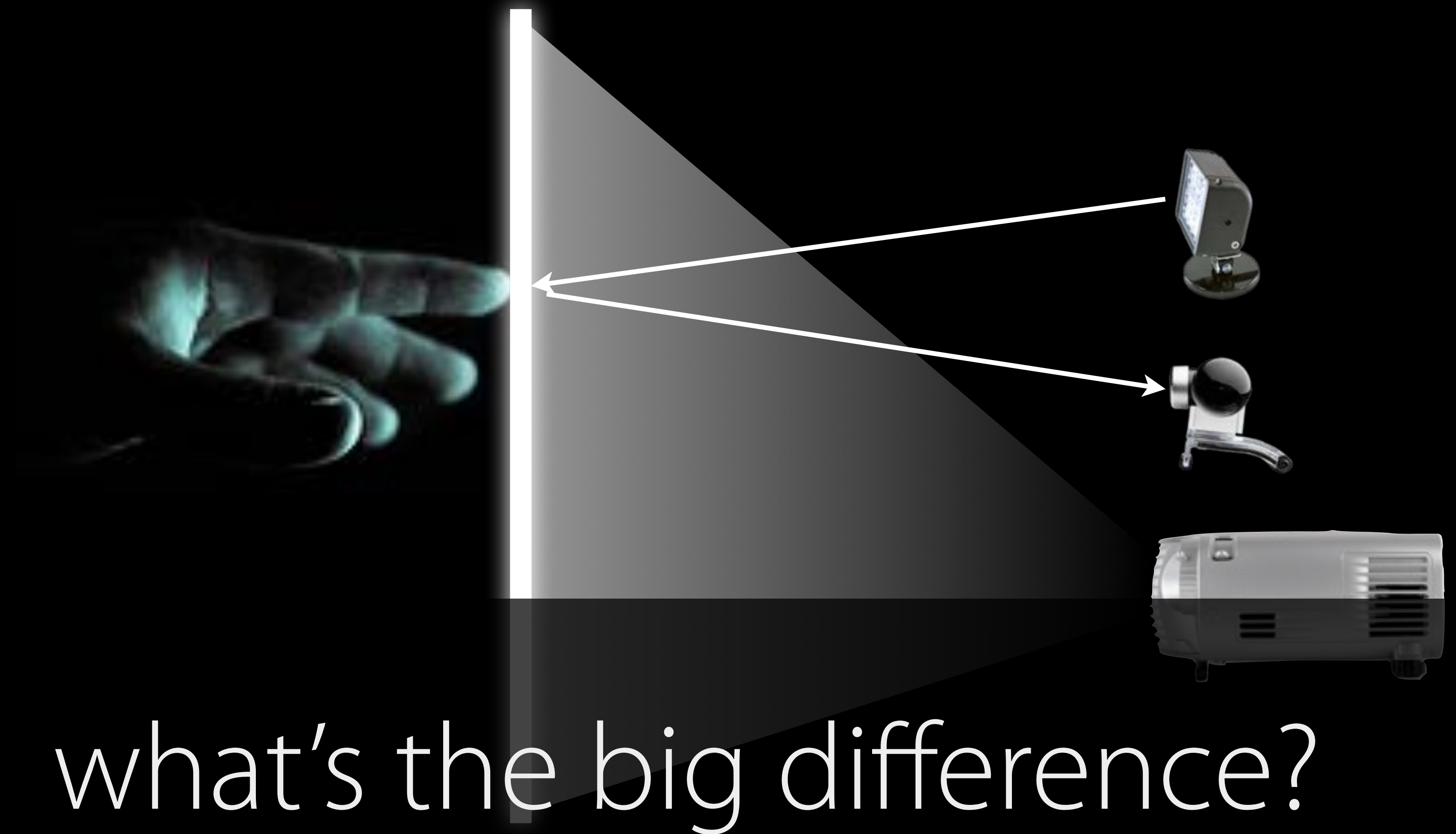
weird mixes

diffuse illumination + frustrated Fresnel reflection

[Fiberio, UIST '15]



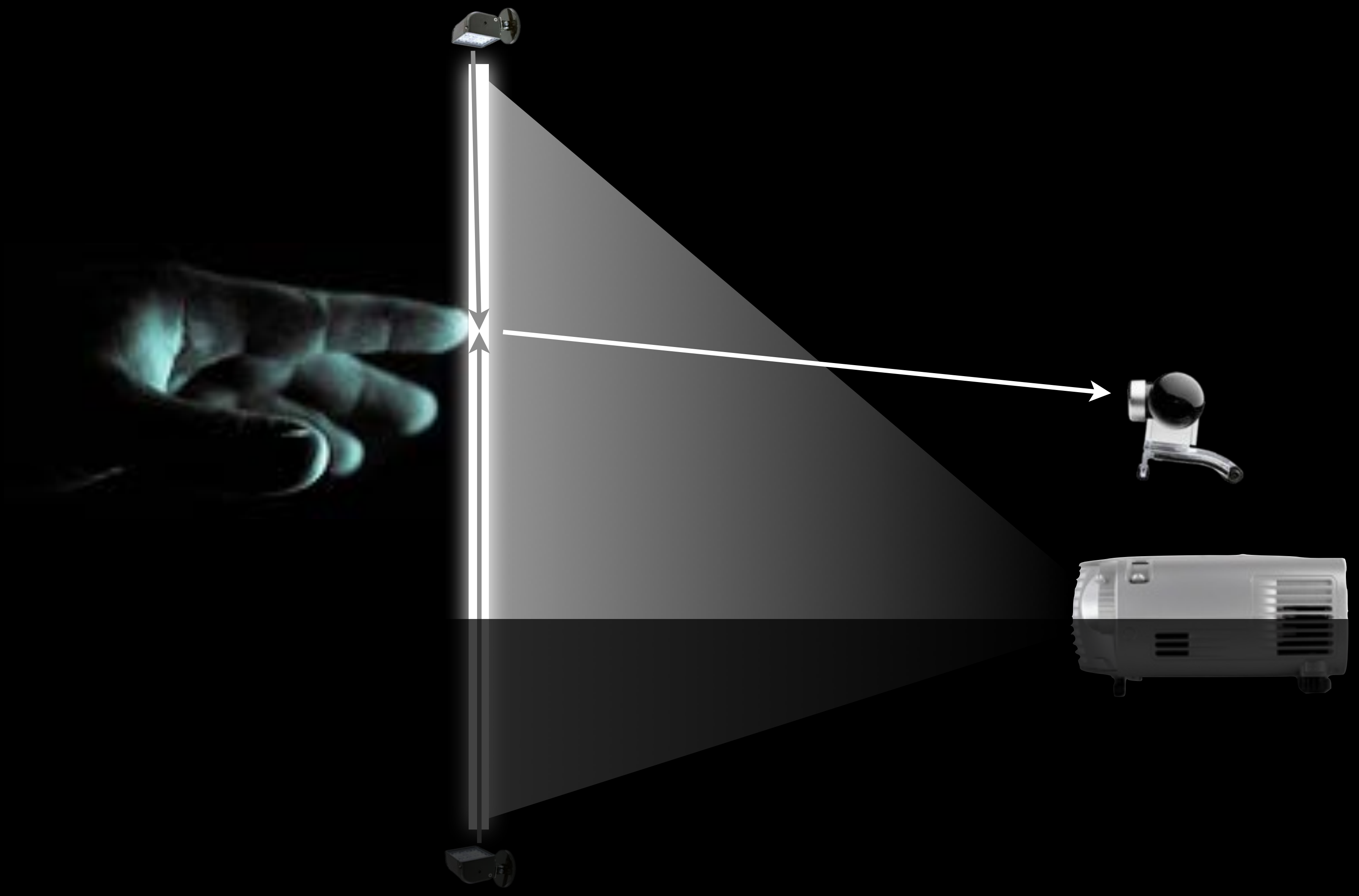

diffuse reflection + surface reflection
diffuse reflection + surface reflection
diffuse reflection
frustrated surface reflection



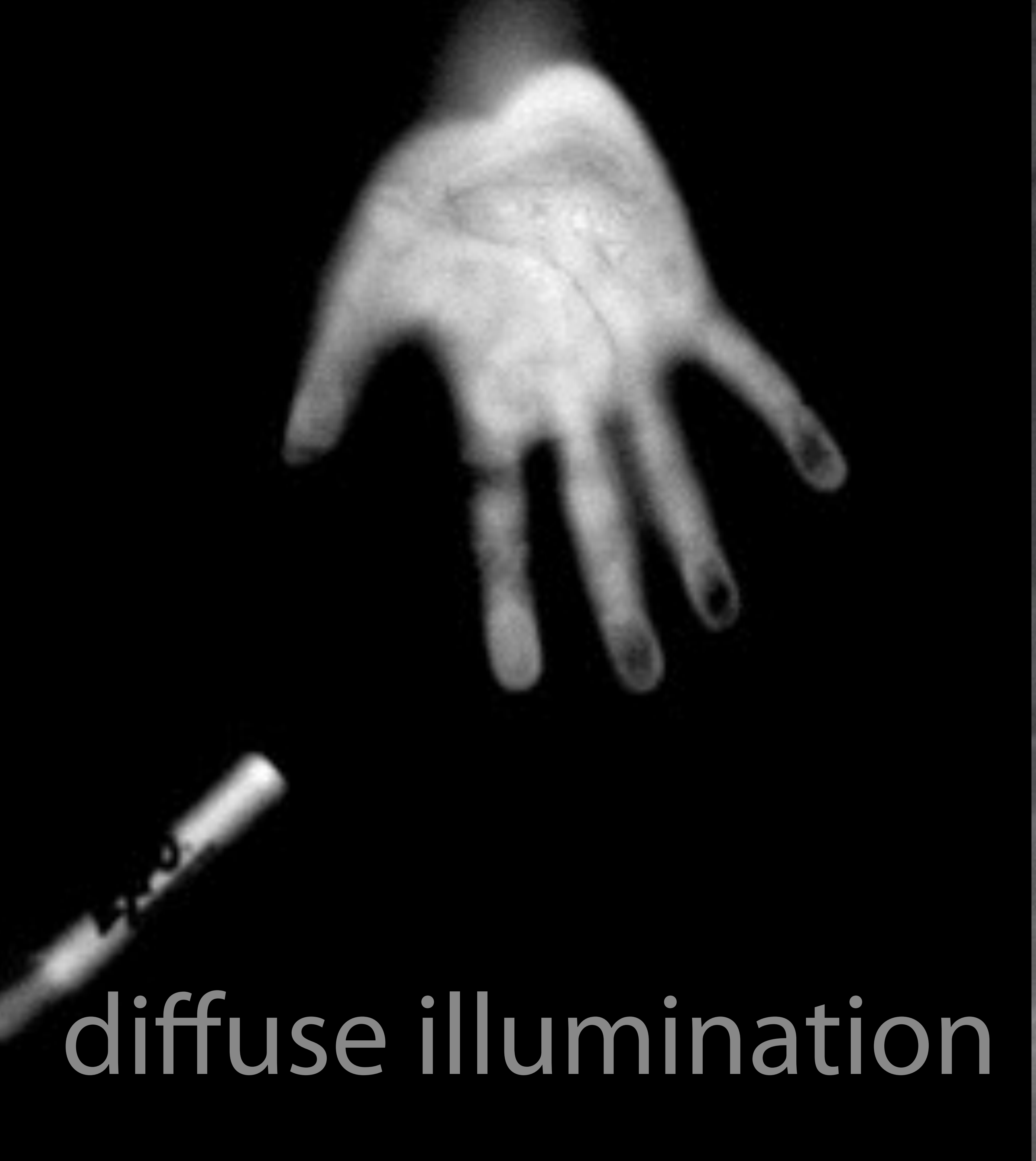
what’s the big difference?

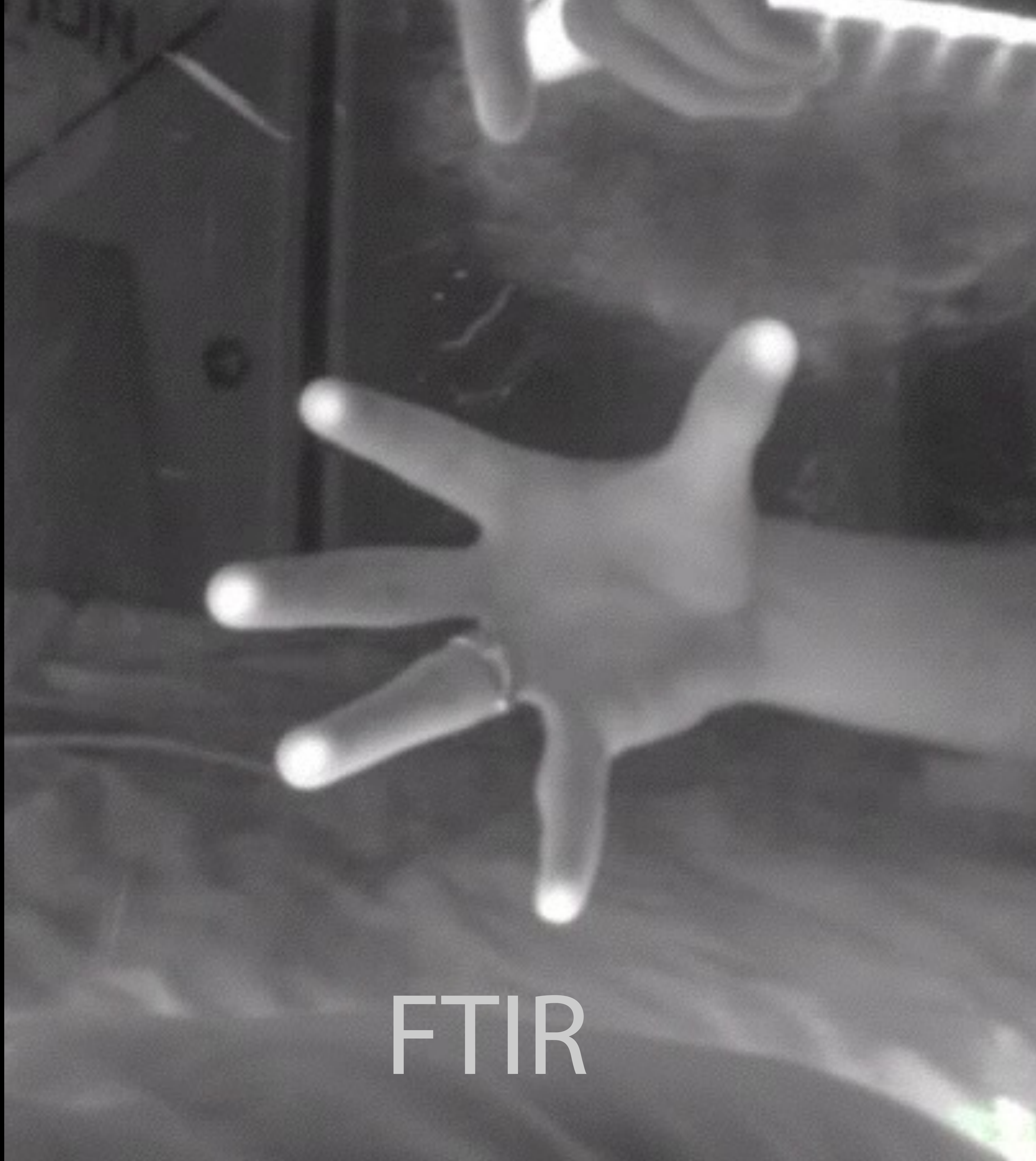
30 second brainstorming

diffuse illumination



FTIR

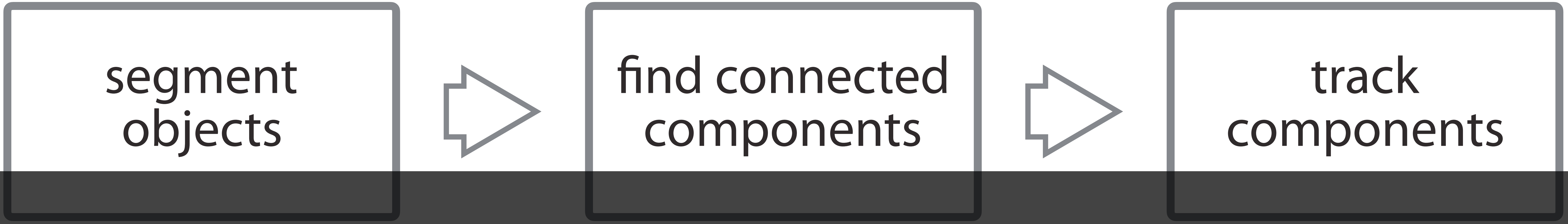

diffuse illumination


FTIR

1.5 Touch processing

typical processing pipeline

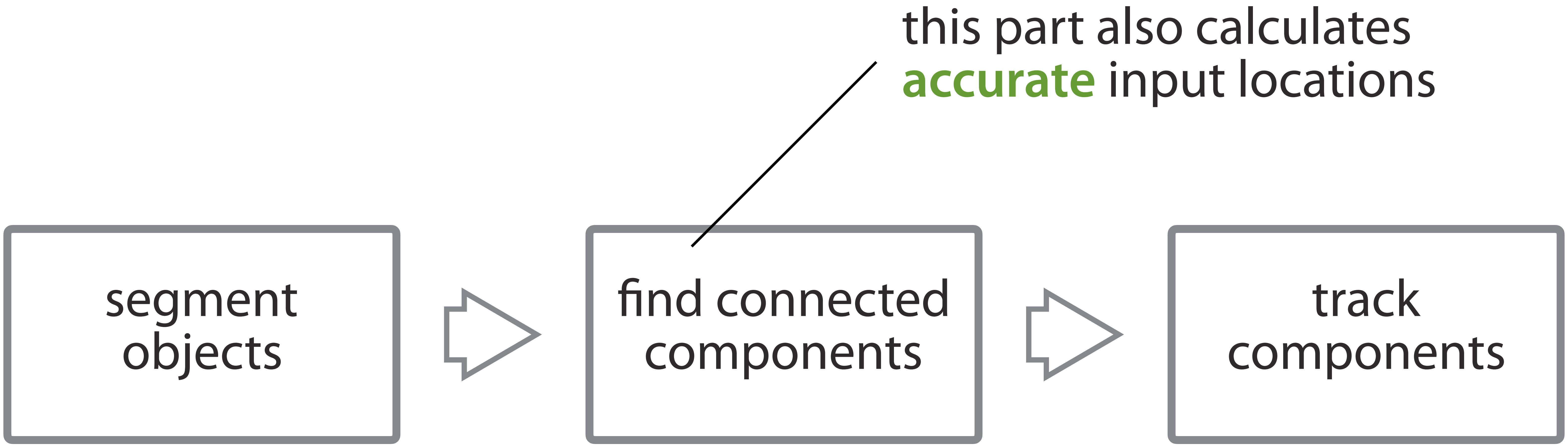
typical processing pipeline



who sees the link to Buxton's Touch, Gesture & Marking?

30 second brainstorming

typical processing pipeline



typical processing pipeline

2 Touch accuracy

Biometric Touch Sensing [UIST '15]

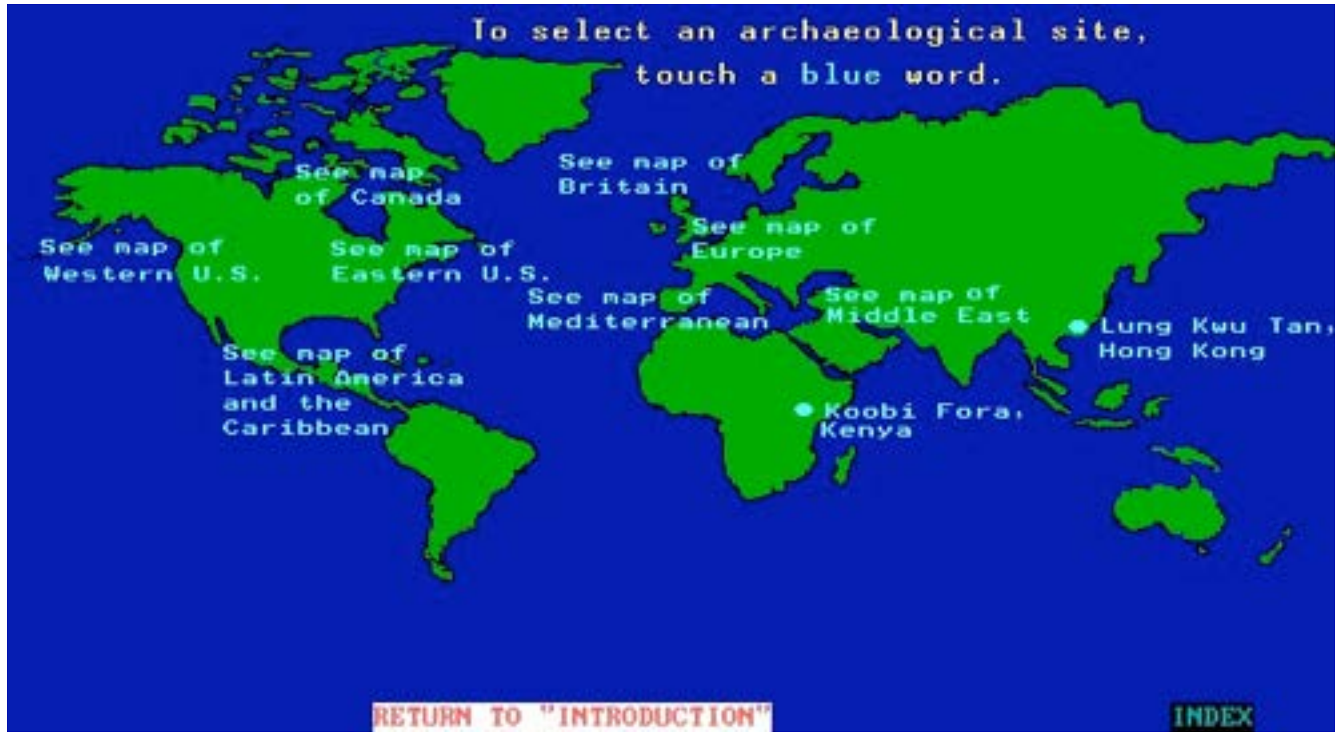
input resolution: 42 x 33 across a 10″ display

map to an accurate input location

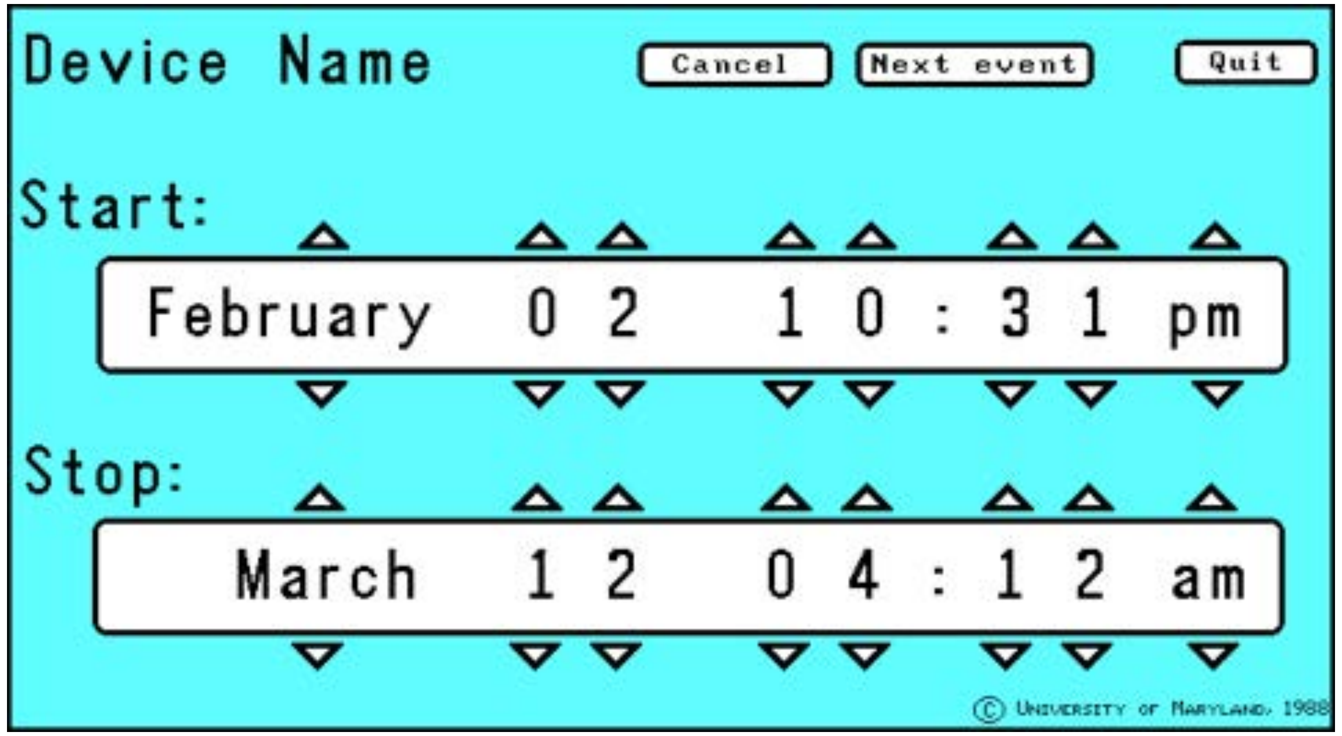
screen resolution: 2,160 x 1,440

center of gravity

if only it were that easy :-)

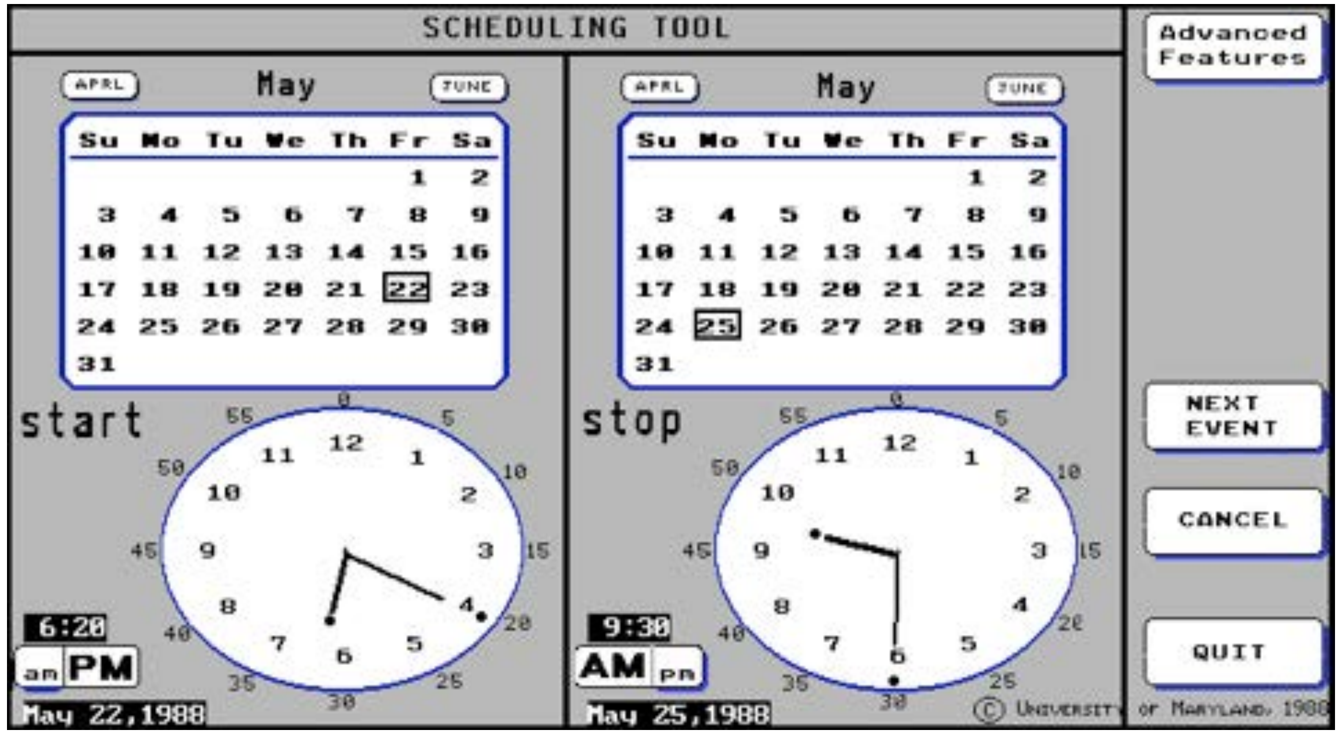


Information Kiosks [Plaisant et al. '88]

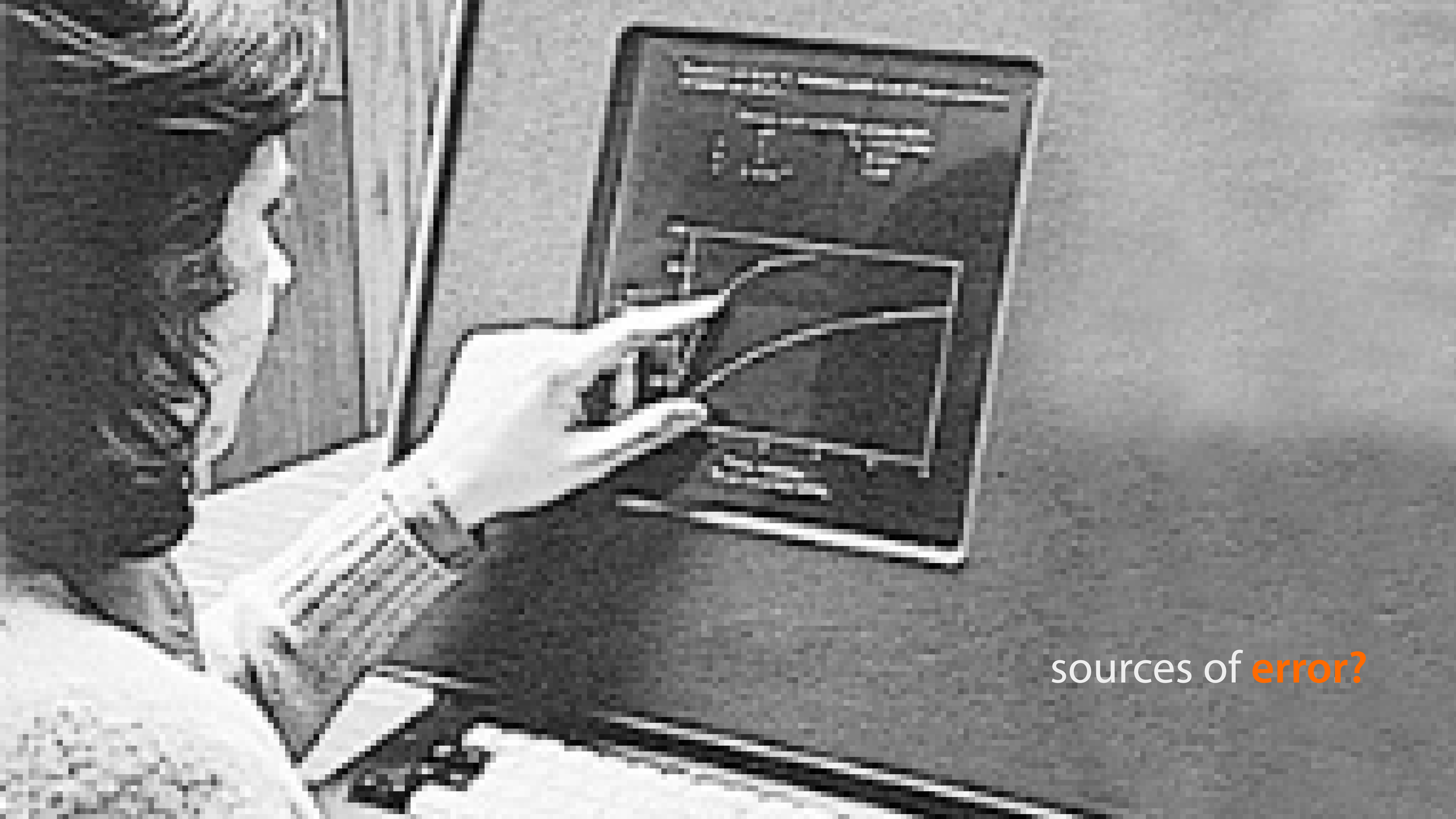


Home Automation [Plaisant et al. '90 and on]

Touch painting [Sears et al. '91]



Home Automation [Plaisant et al. '90 and on]


sources of error?

“parallax between the touch screen surface and the display surface”

“high error shown in many studies”

“fatigue in arm motion”

[Potter et al. CHI '88]

“parallax between the touch screen surface and the display surface”

“high error shown in many studies”

“fatigue in arm motion”

solution: “finger mouse”, a cursor the user drags on the screen

[Potter et al. CHI '88]

AK	HI	ME	NJ	SD
AL	IA	MI	NM	TN
AR	ID	MN	NV	TX
AZ	IL	MO	NY	UT
CA	IN	MS	OH	VA
CO	KS	MT	OK	VT
CT	KY	NC	OR	WA
DE	LA	ND	PA	WI
FL	MA	NE	RI	WV
GA	MD	NH	SC	WY

[Potter et al. CHI '88]

“parallax between the touch screen surface and the display surface”

“high error shown in many studies”

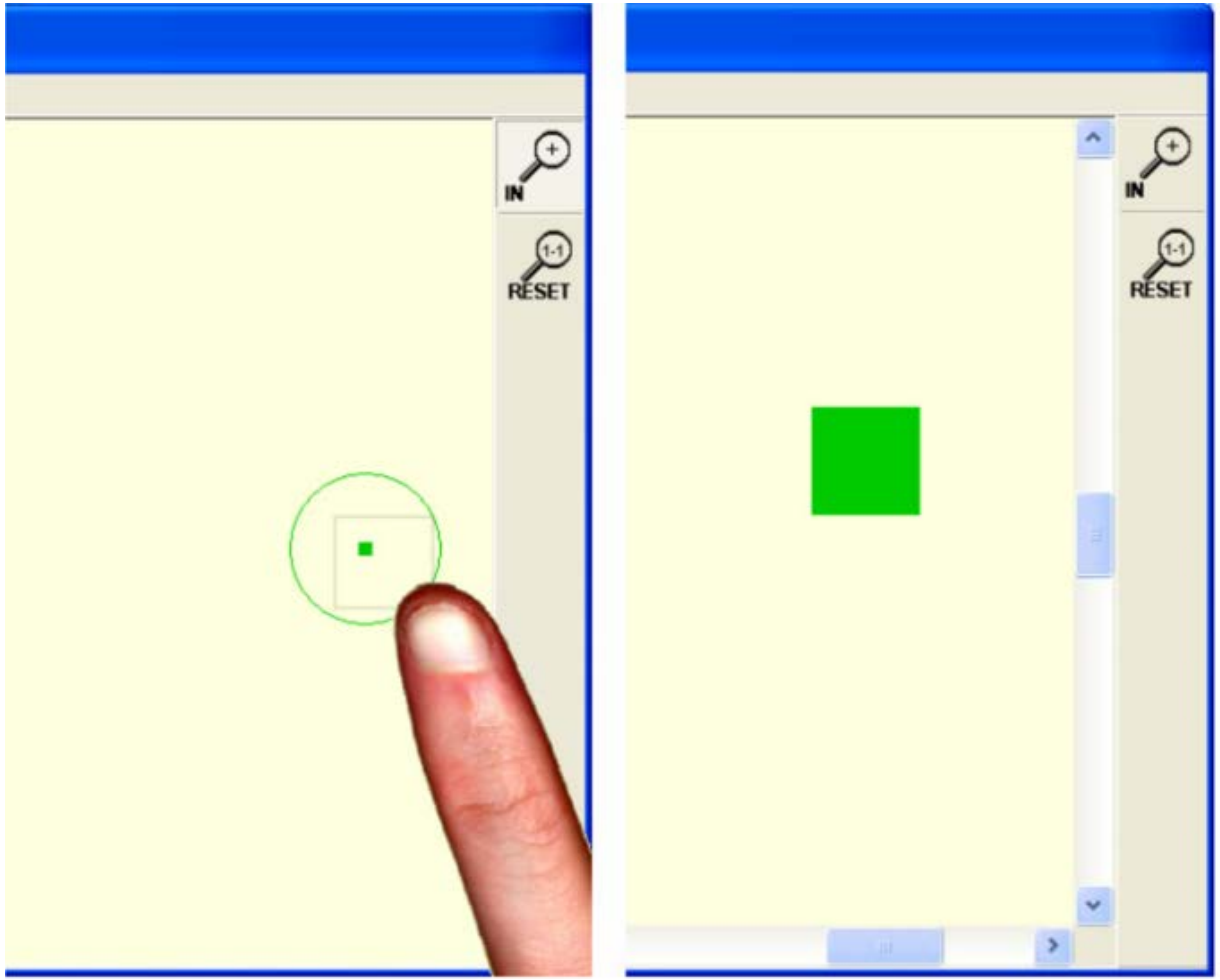
“fatigue in arm motion”

solution: “finger mouse”, a cursor the user drags on the screen

strategies: touch-down, first-contact, lift-off + **offset cursor**

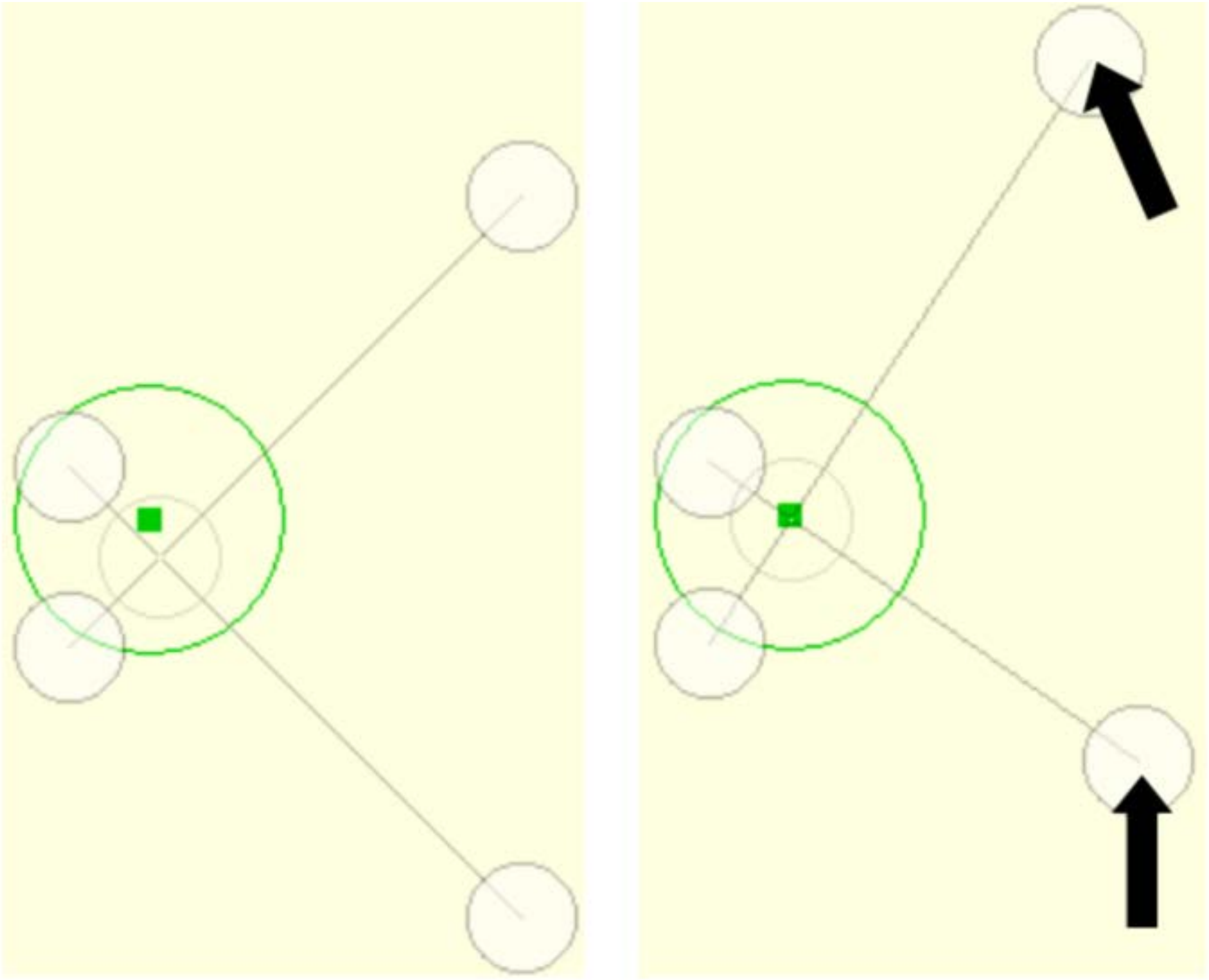
[Potter et al. CHI '88]

okay, let’s use cursors then…



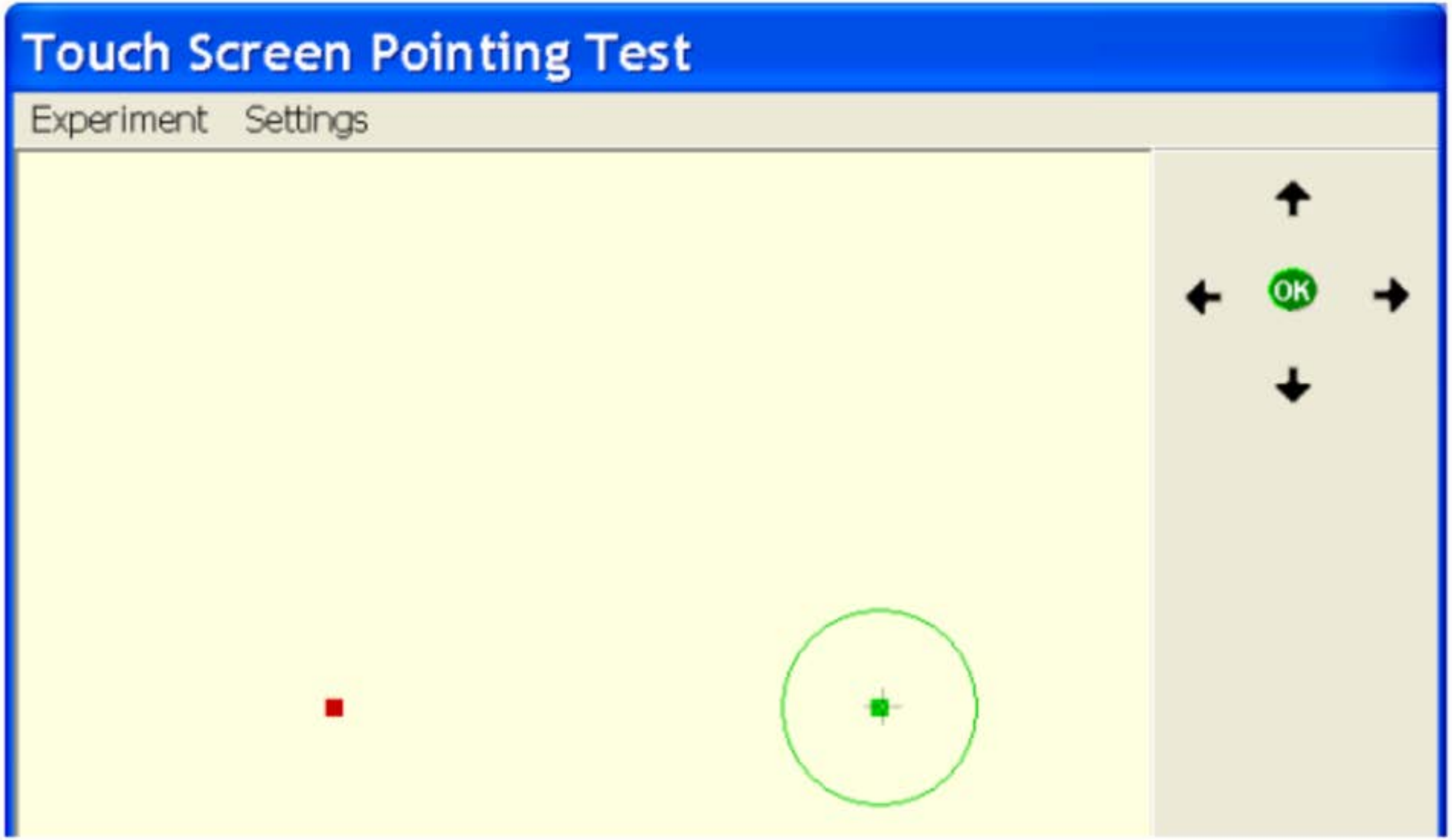
High precision touch screen interaction

[Albinsson and Zhai, CHI '03]



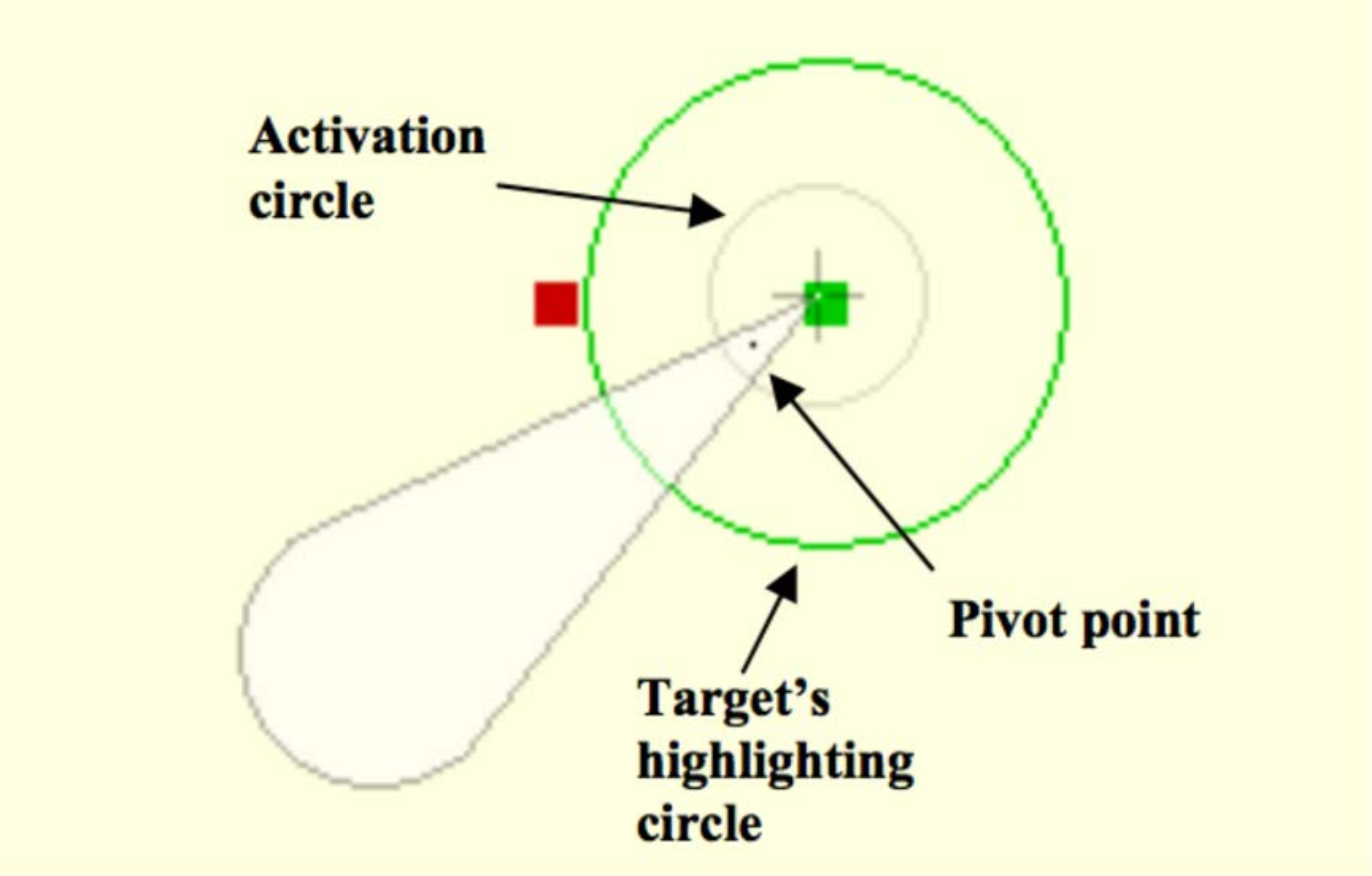
High precision touch screen interaction

[Albinsson and Zhai, CHI '03]



High precision touch screen interaction

[Albinsson and Zhai, CHI '03]



High precision touch screen interaction

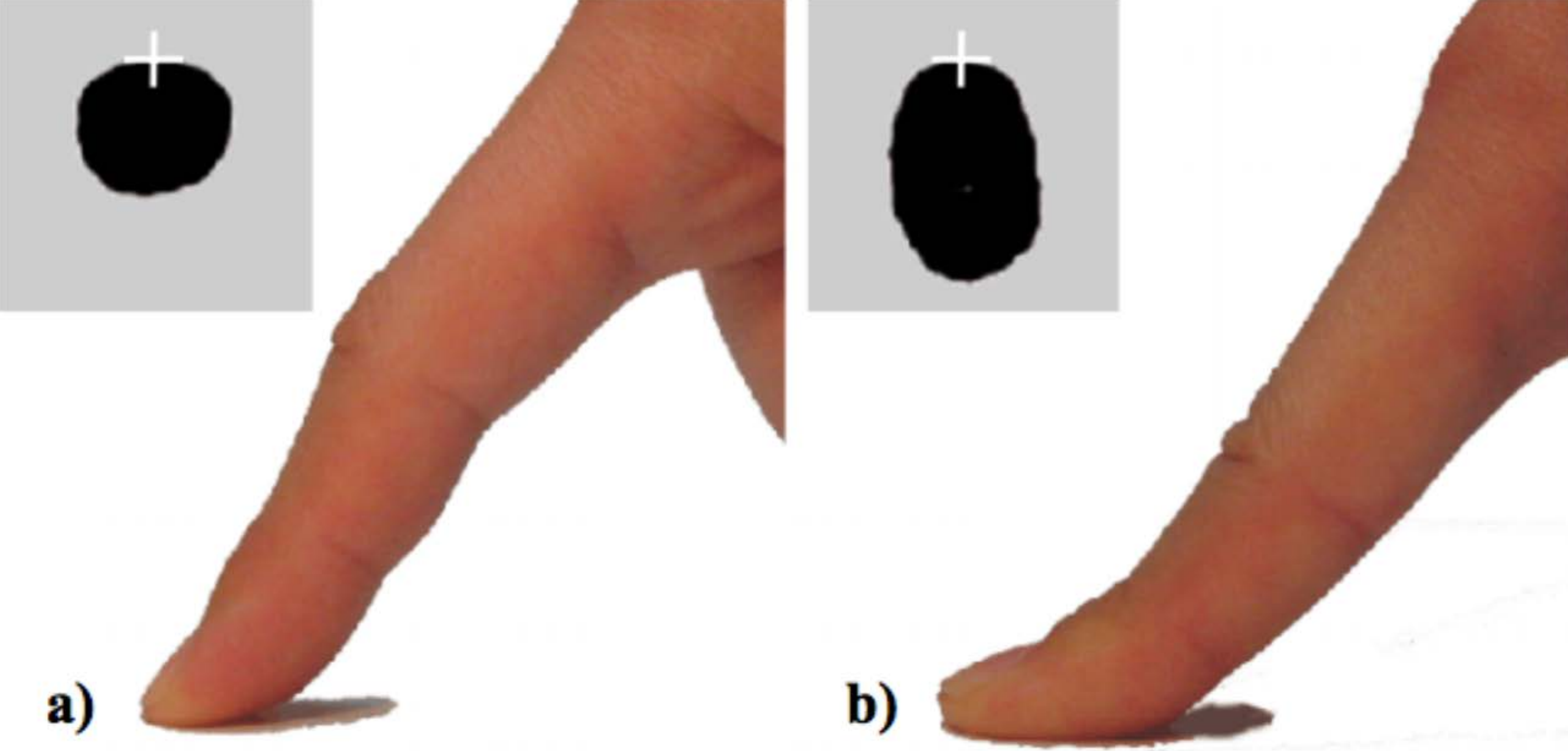
[Albinsson and Zhai, CHI '03]

Precise Selection Techniques

[Benko et al., CHI '06]

Precise Selection Techniques

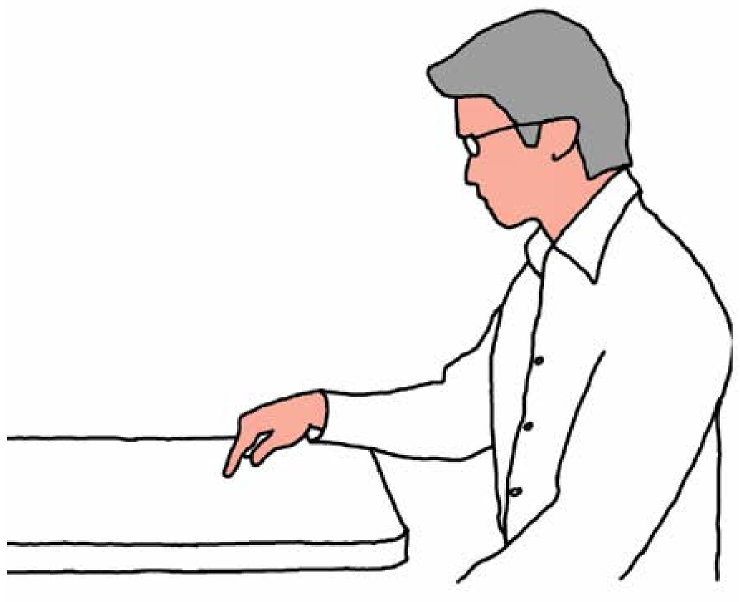
[Benko et al., CHI '06]

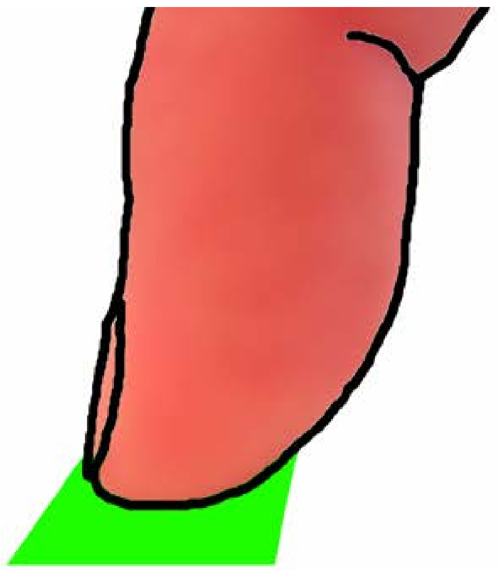


Precise Selection Techniques

[Benko et al., CHI '06]

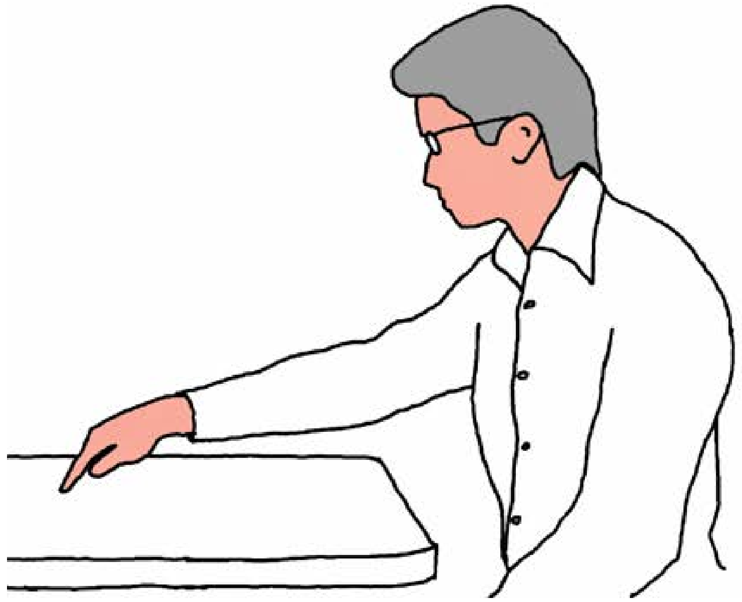
vertical finger pitch

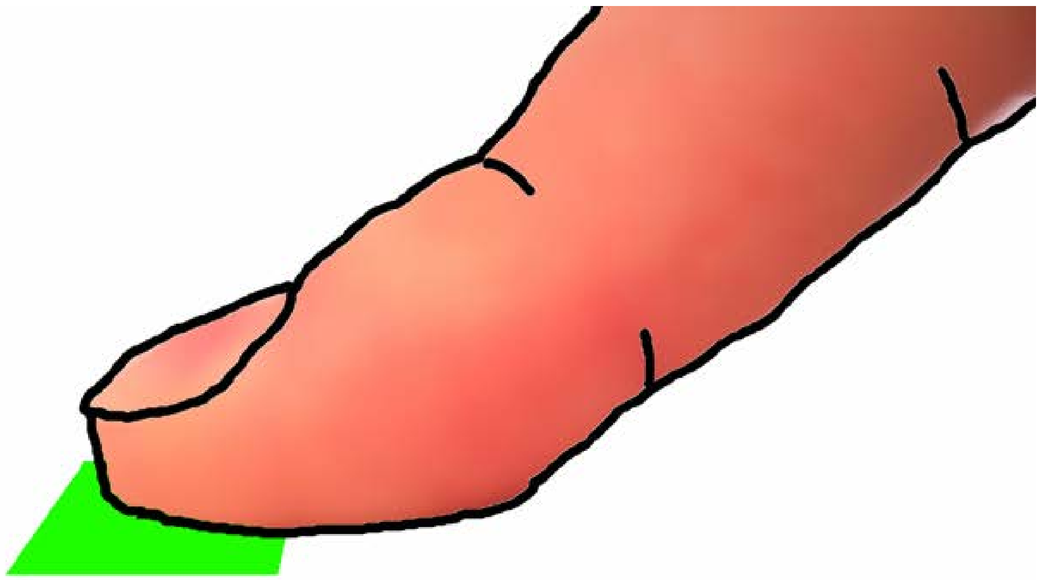




contact area

flat finger pitch





Direct-touch vs. mouse input

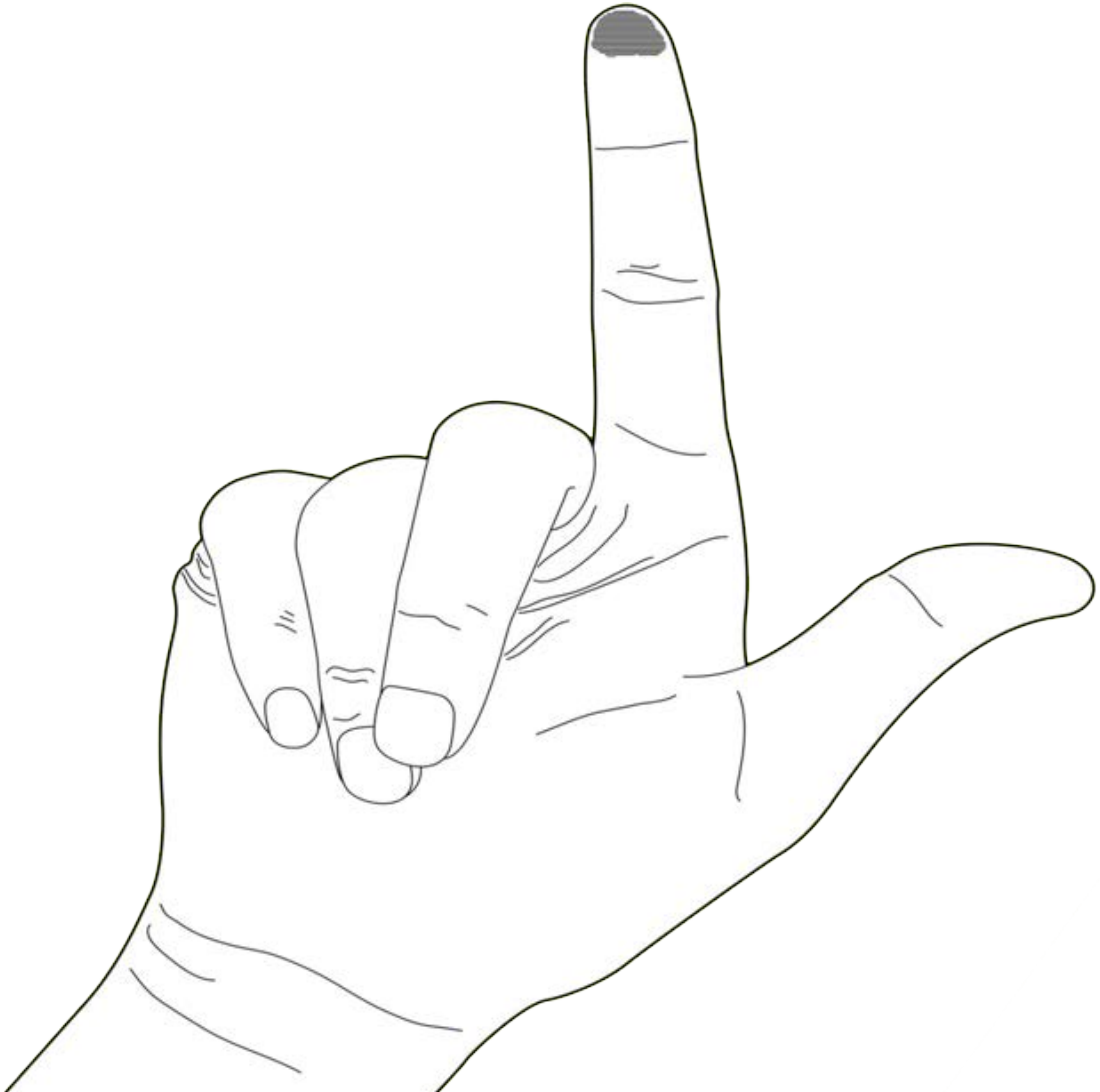
[Forlines et al., CHI '07]

the culprit:

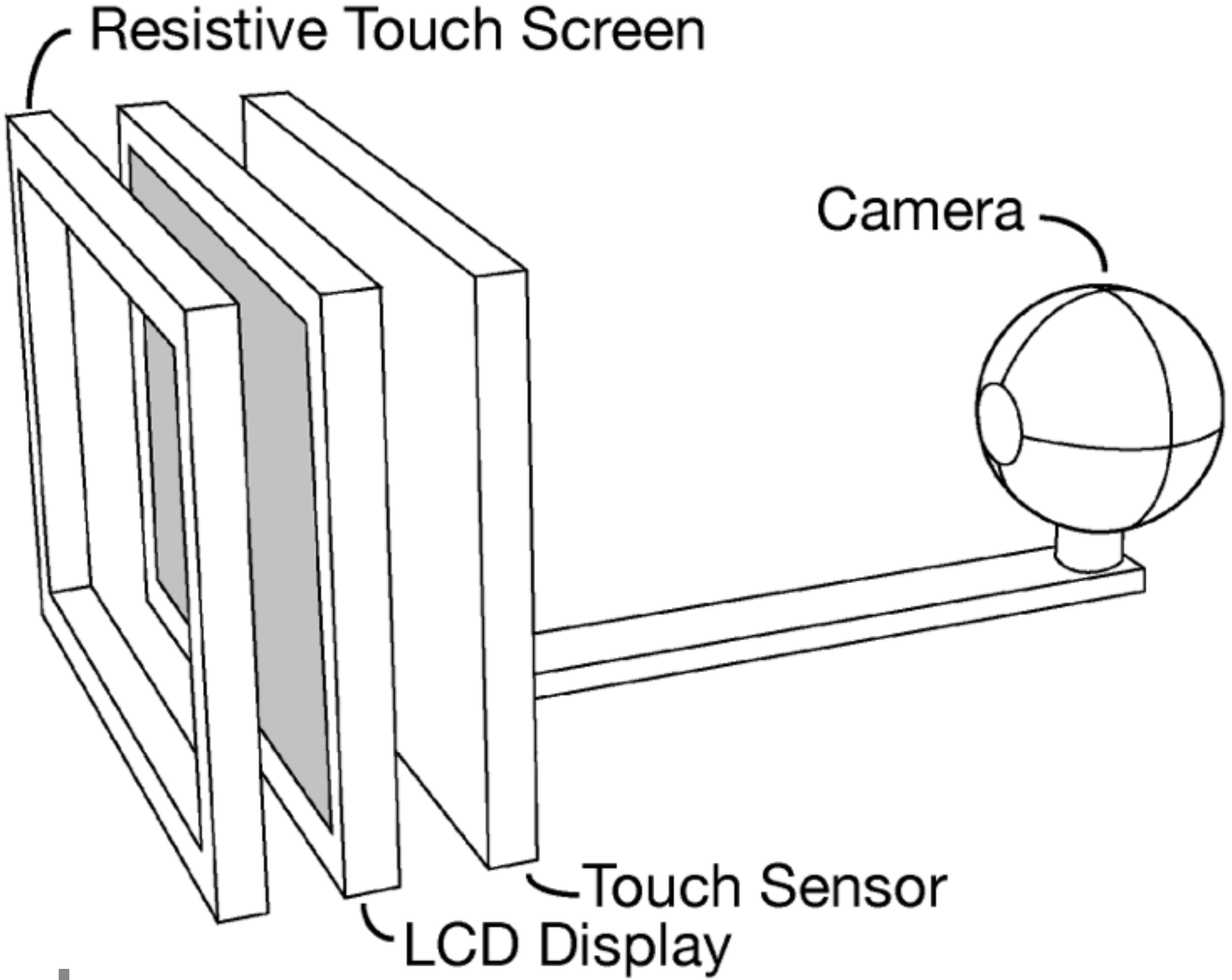
the **fat-finger** problem


11:00
12:00
1:00
2:00
3:00
4:00
5:00
6:00
Dentist Andrea
Yoga
New
Details
Go To

fat finger



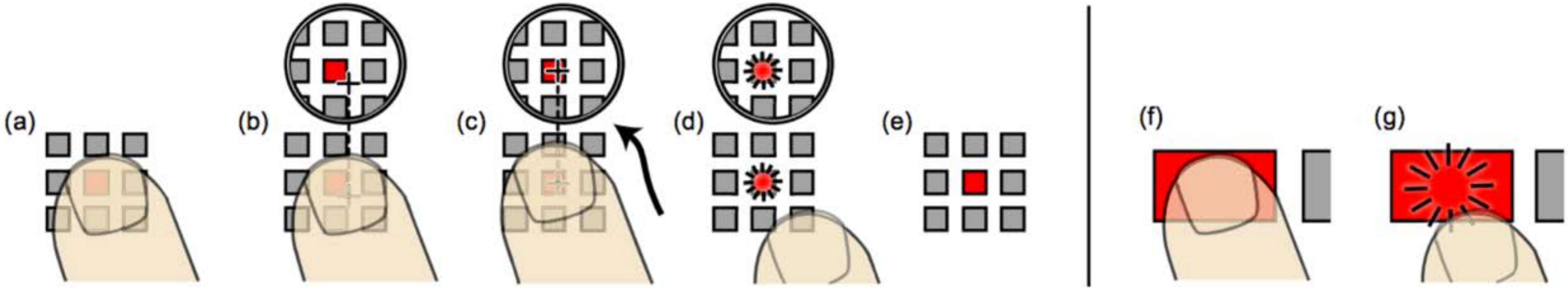
fat finger



LucidTouch

[Wigdor et al., CHI '07]

[Baudisch and Chu, CHI '09]



Shift

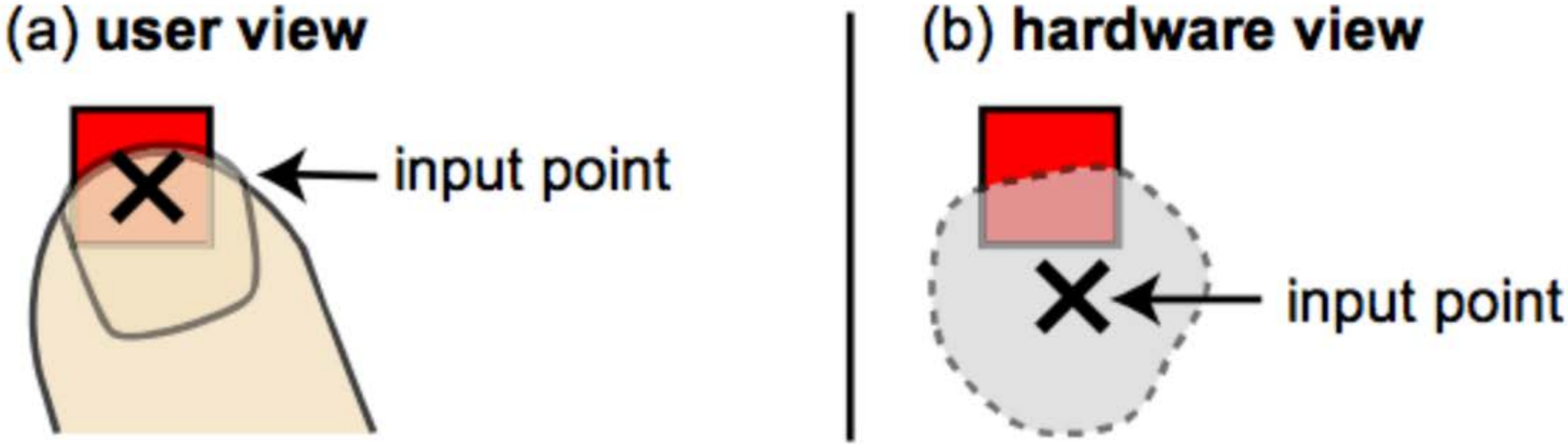
[Vogel and Baudisch, CHI '07]

why did you read this paper?

30 second brainstorming

Shift

[Vogel and Baudisch, CHI '07]



perceived input point problem

[Vogel and Baudisch, CHI '07]

showing cursors is **cheating!**

…and they almost convinced us!

what’s the real problem here?

the problem is **underspecified!**

which link
am I selecting?

could it be

that it is **not the fingers**
but our **touch devices** that are **wrong**?

let’s assume for a second that there is

no fat finger

problem

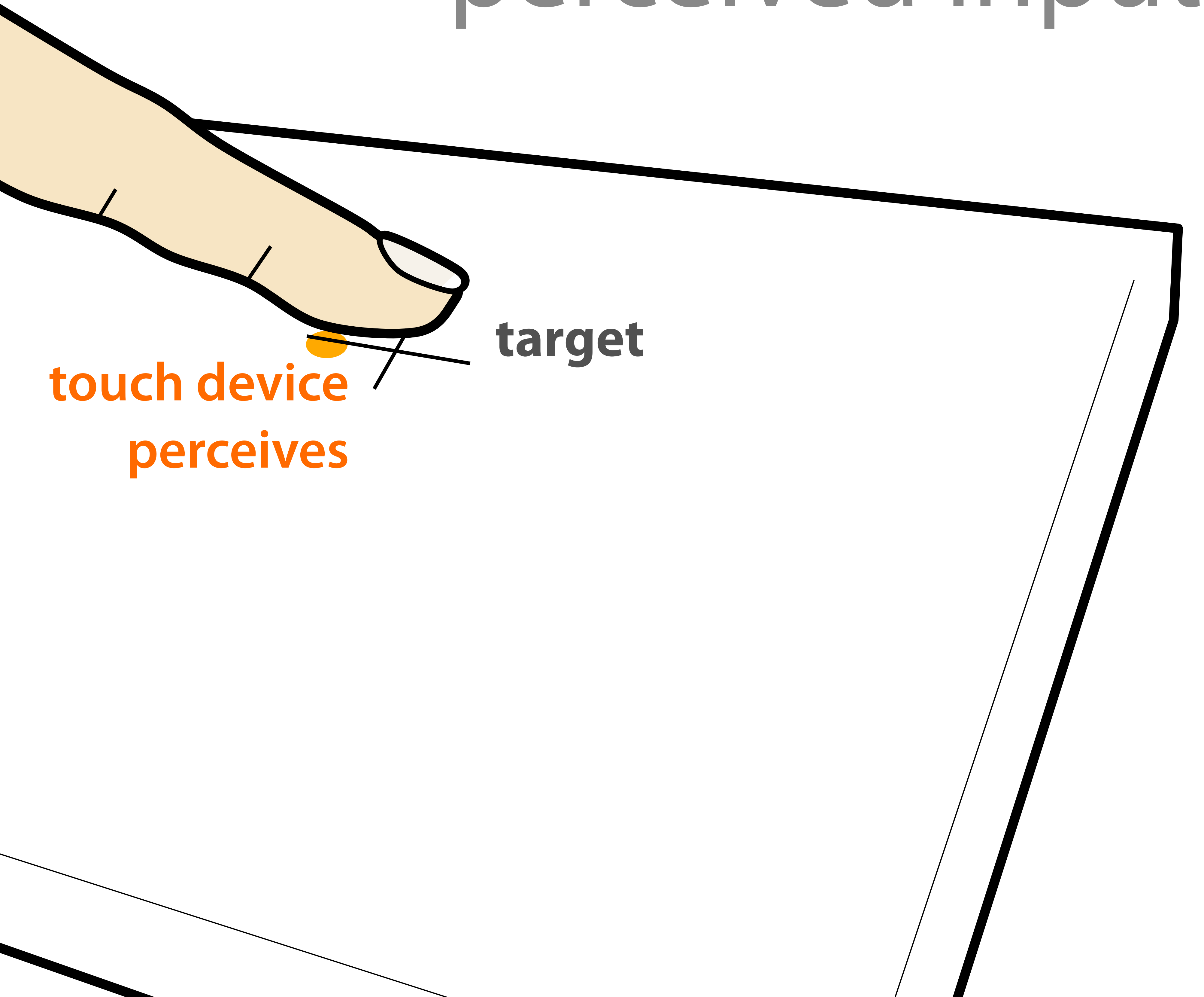
instead, almost all observed targeting error comes from

perceived

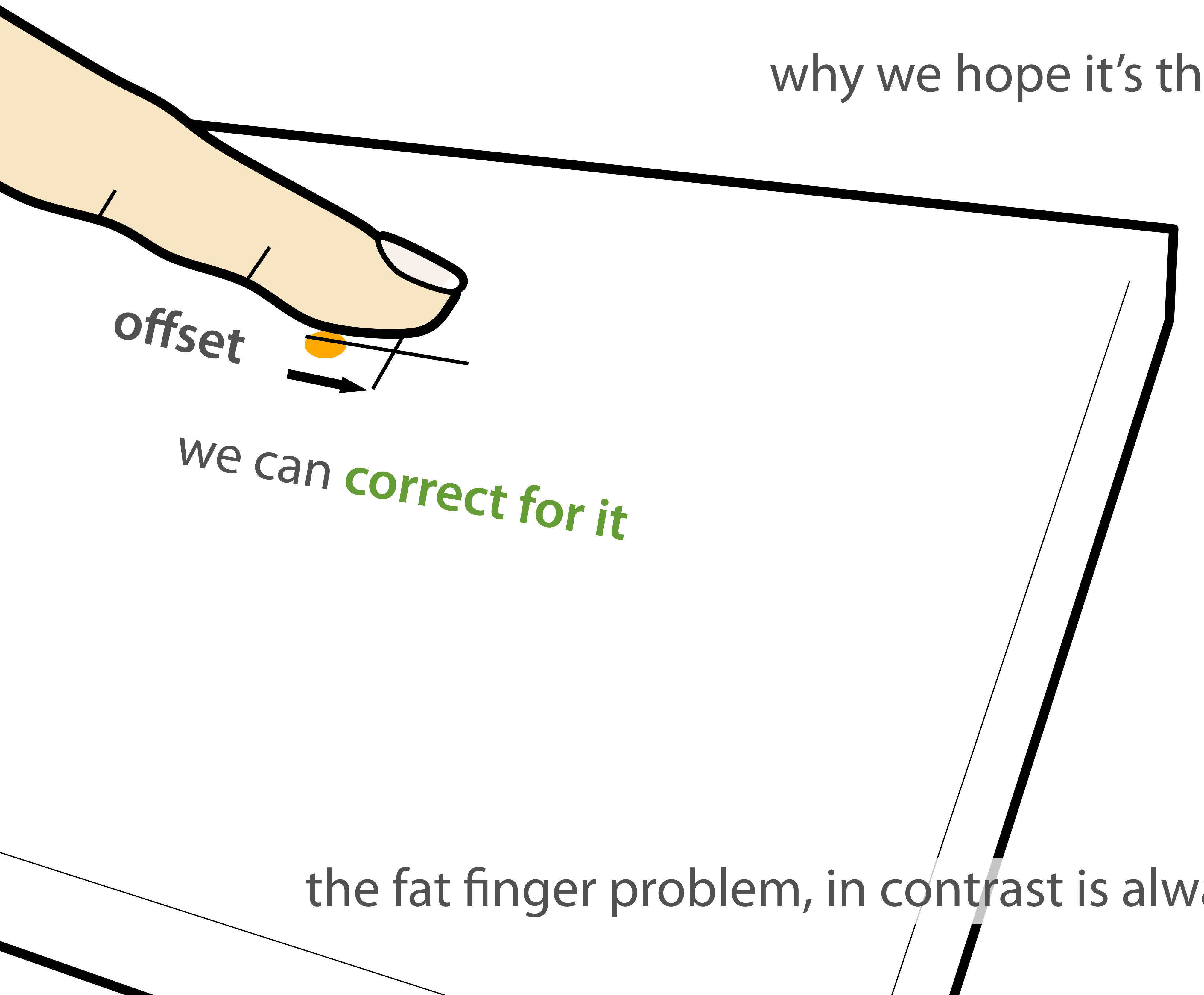
input point

problem

perceived input point problem



why we hope it’s the perceived input point problem?

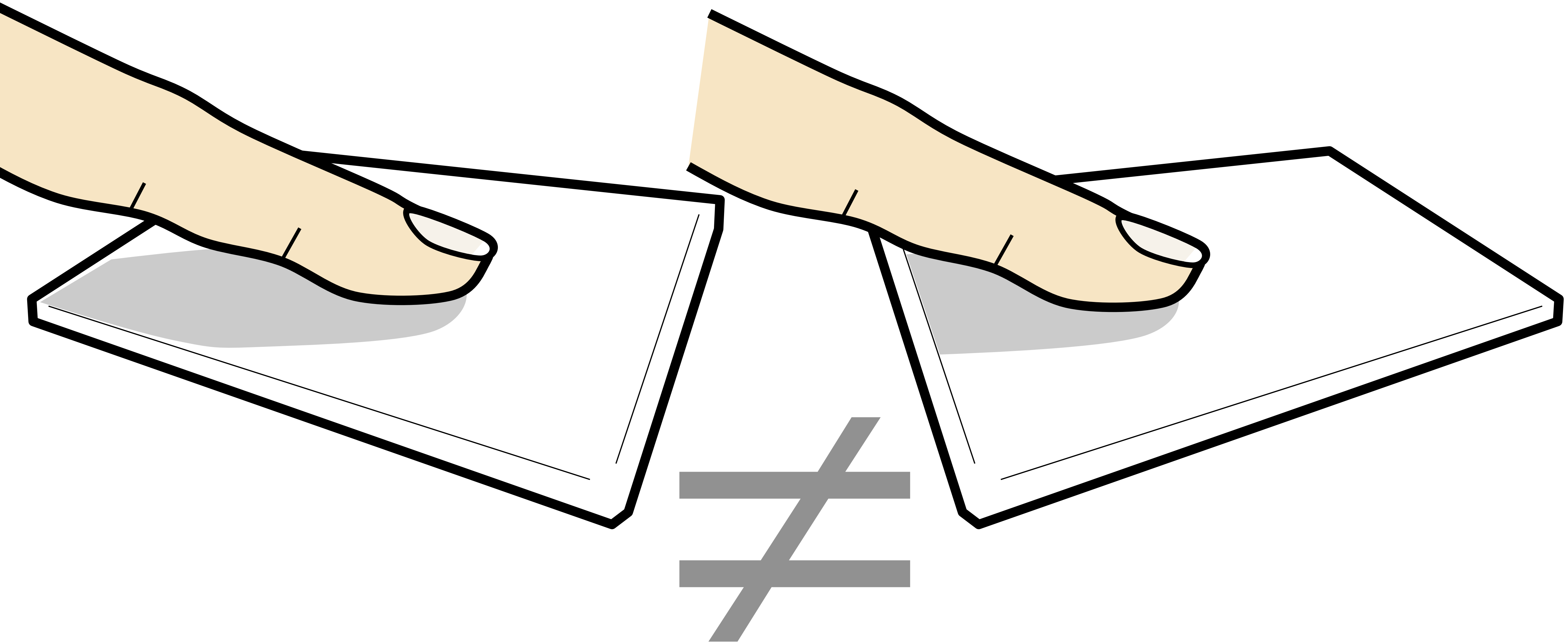


the fat finger problem, in contrast is always noise = error

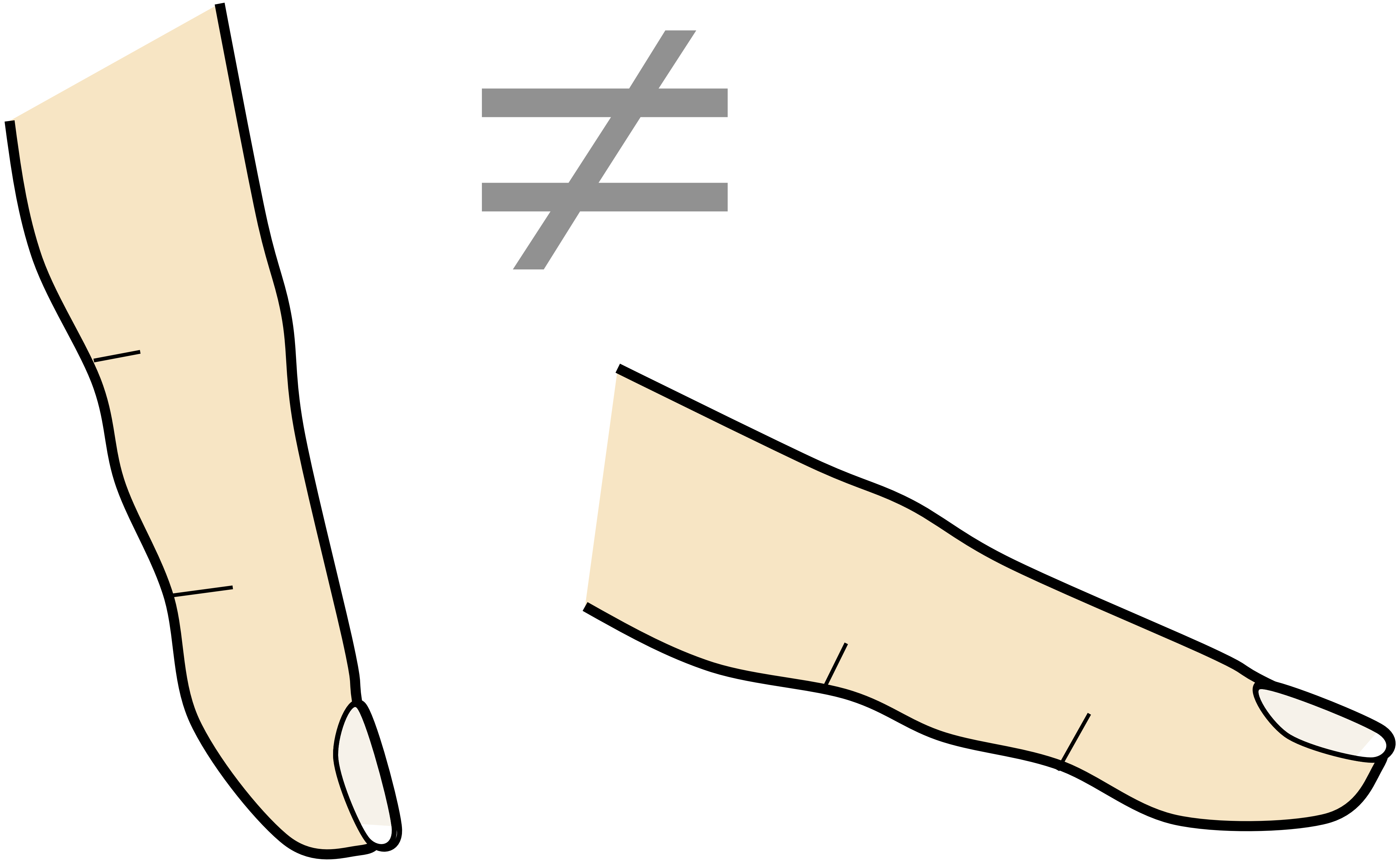
our main hypothesis

while there is always an offset, we hypothesize that the offset **depends on the pointing situation**

1 yaw

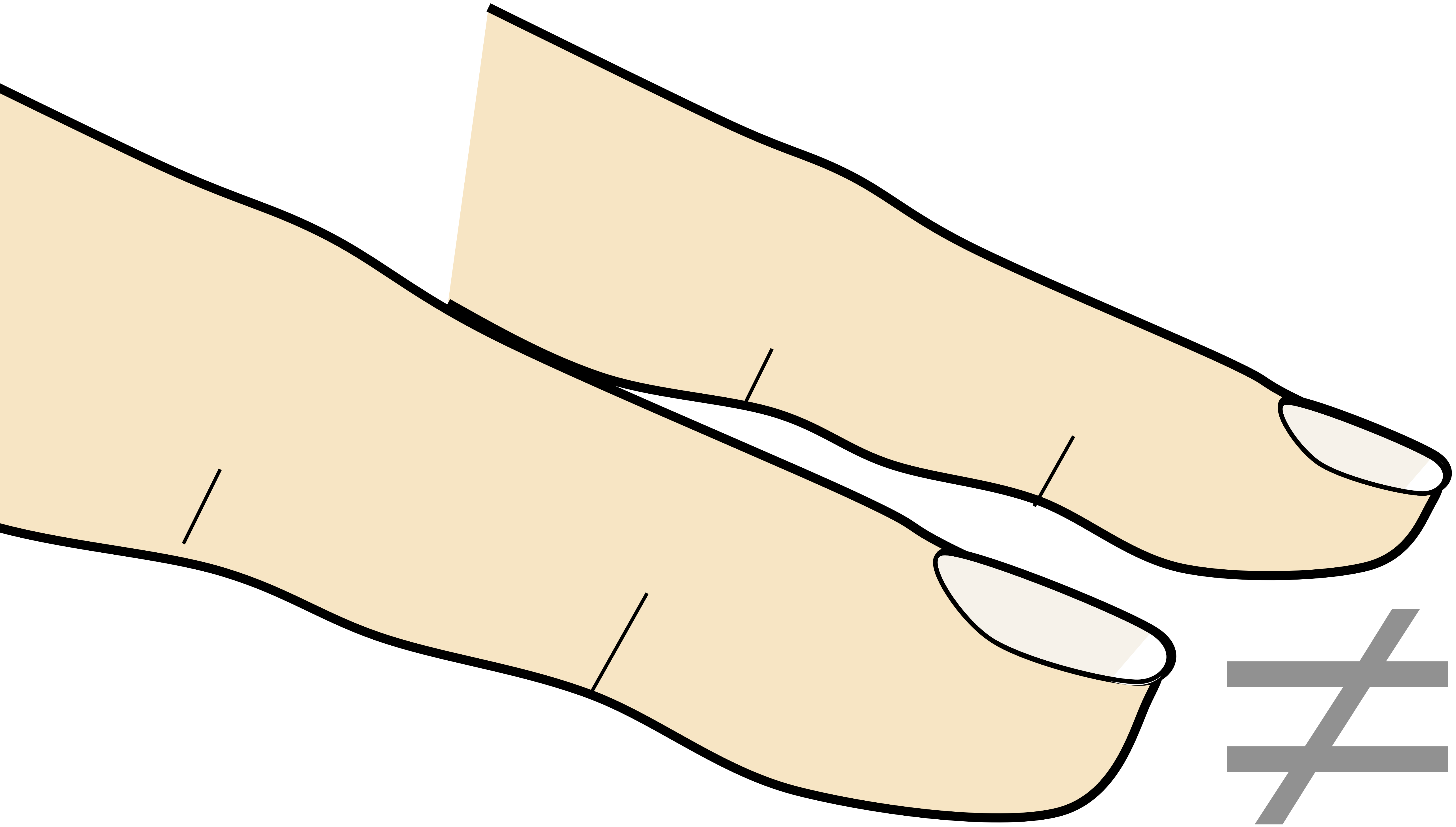


2 pitch

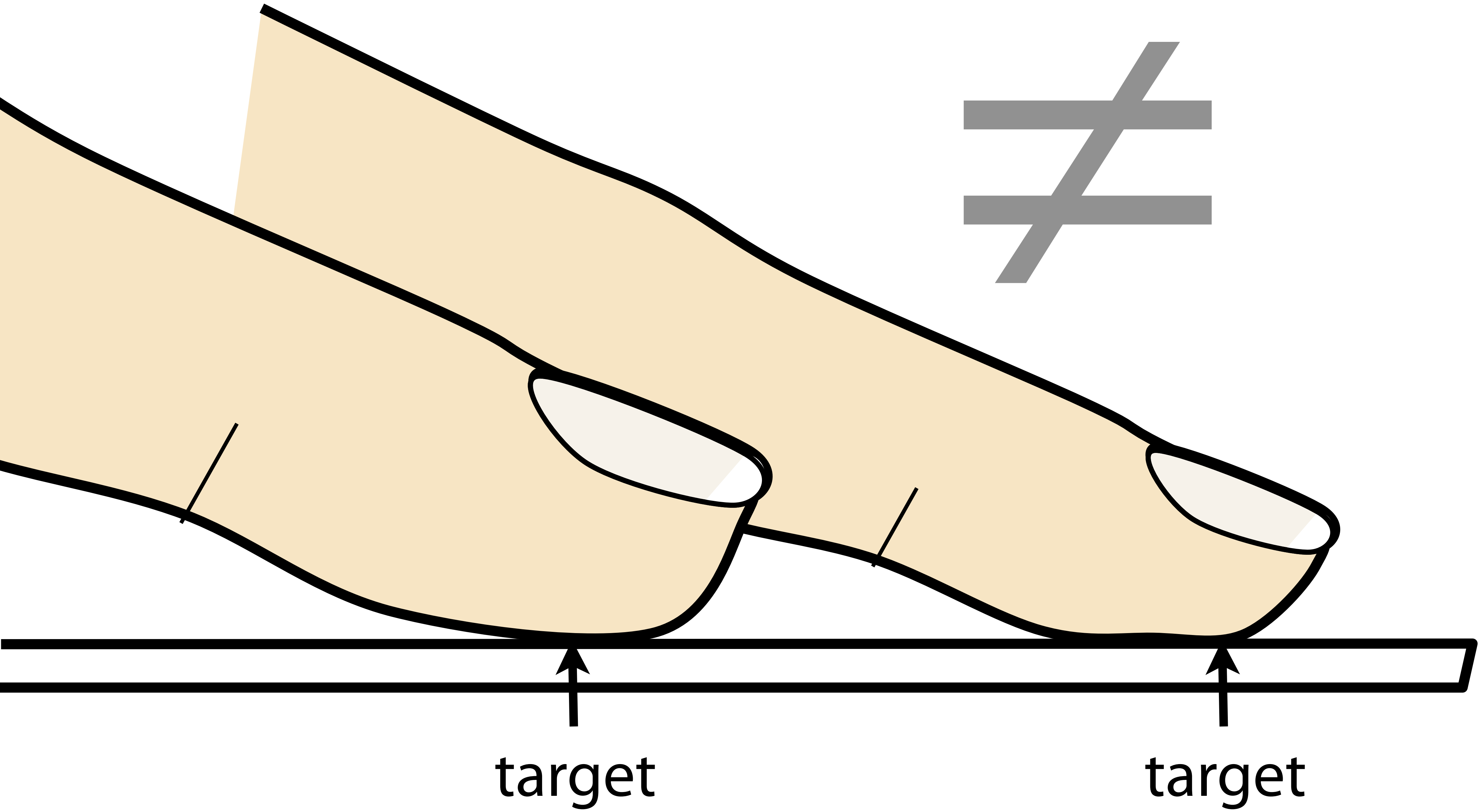


3 roll

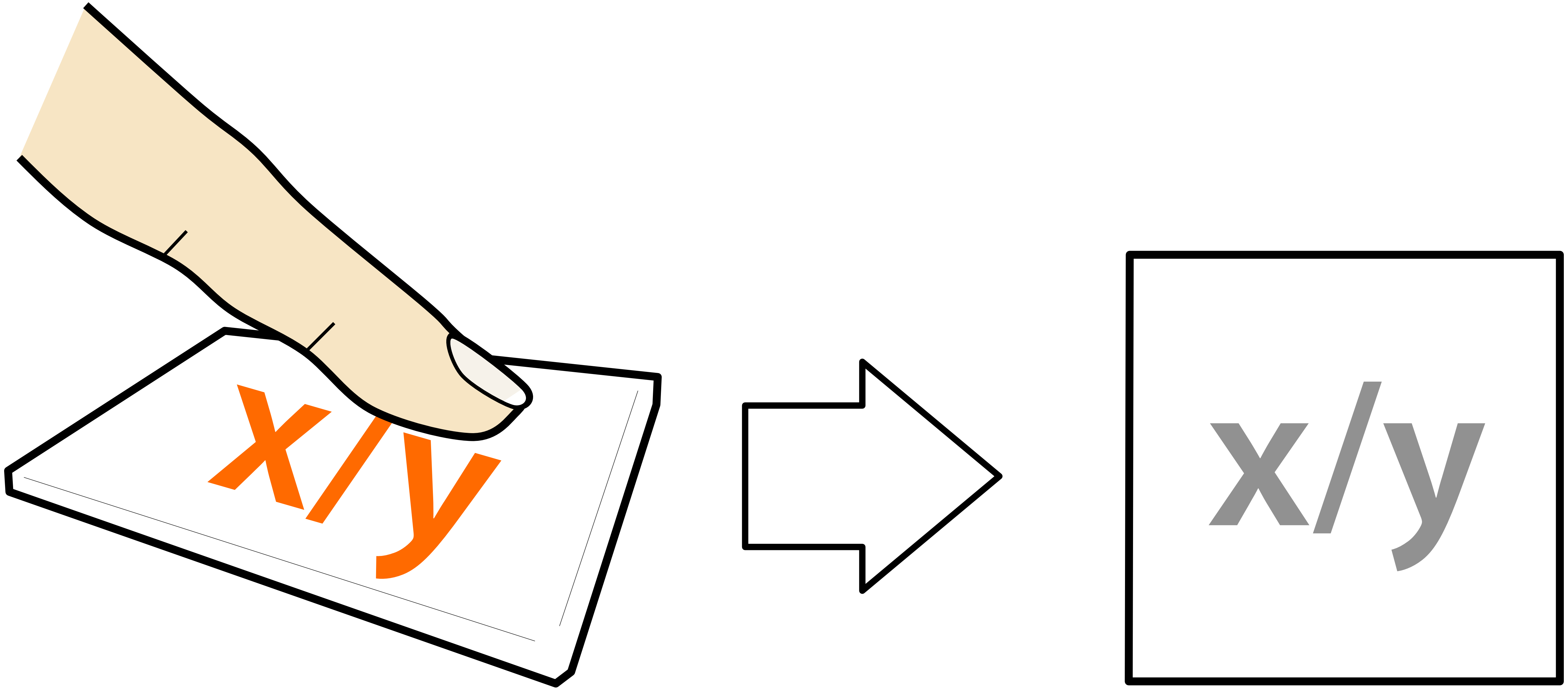
4 users: finger shape



4 users: mental model



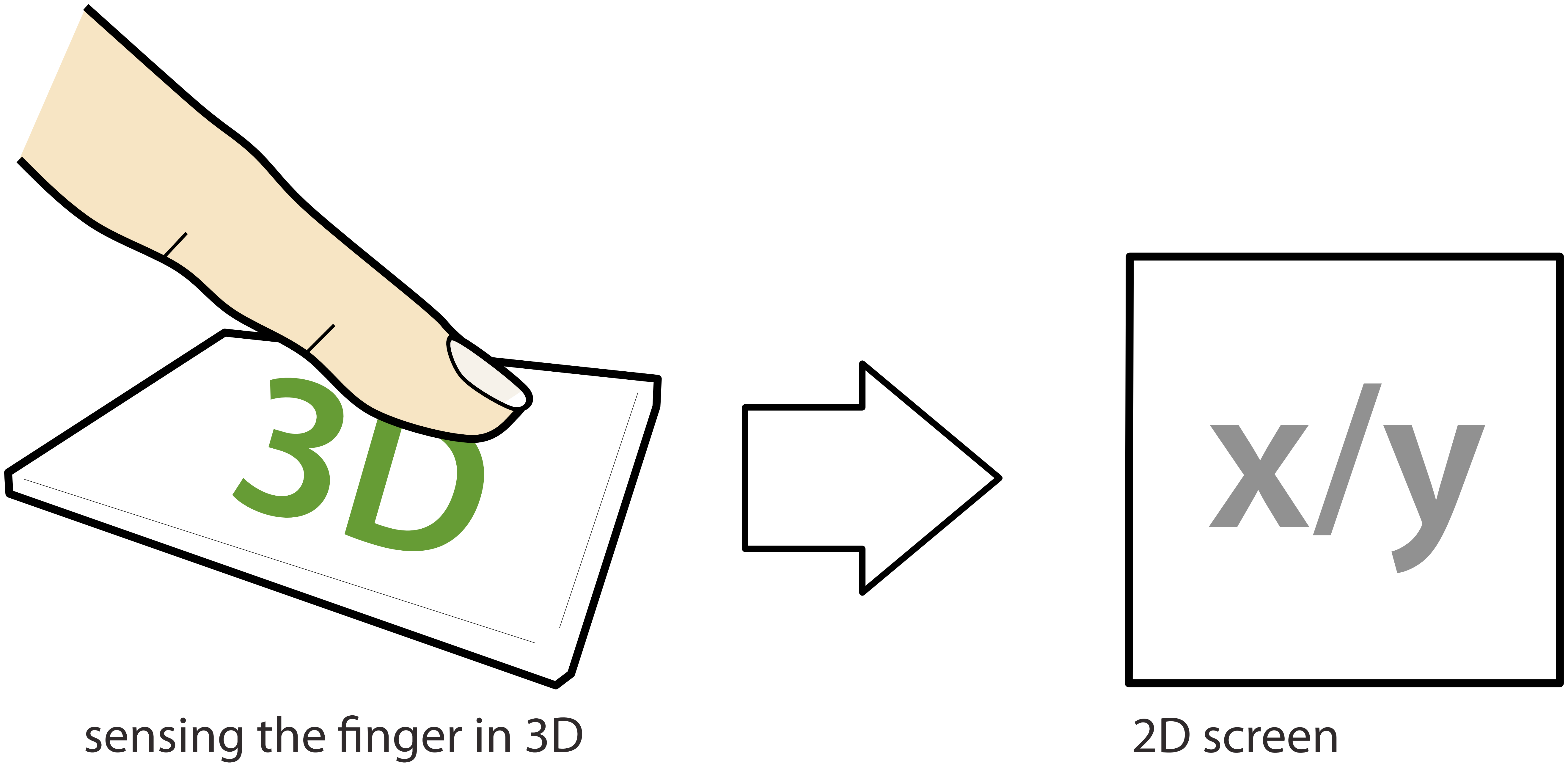
current model



center of contact area

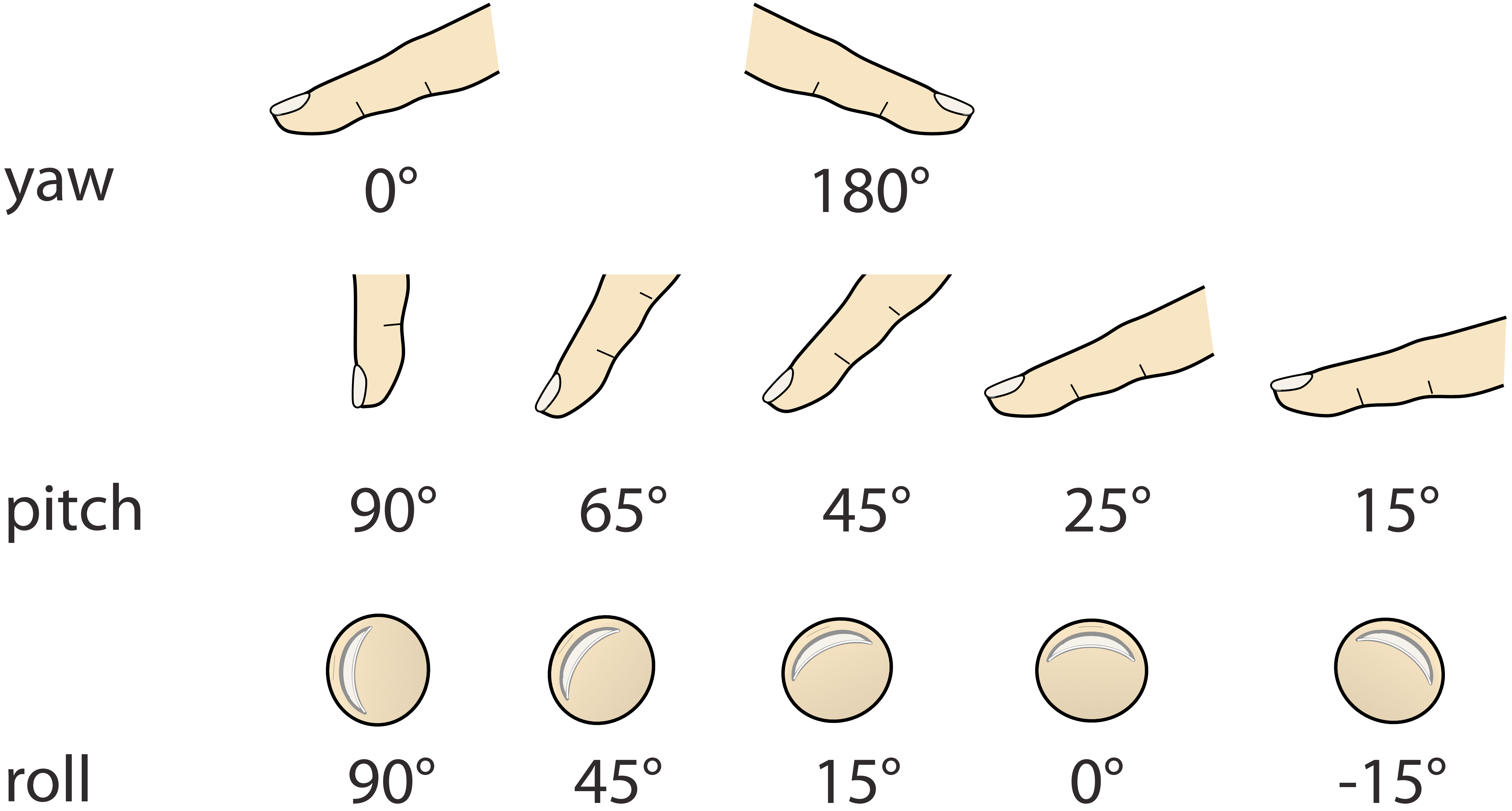
2D screen

we propose

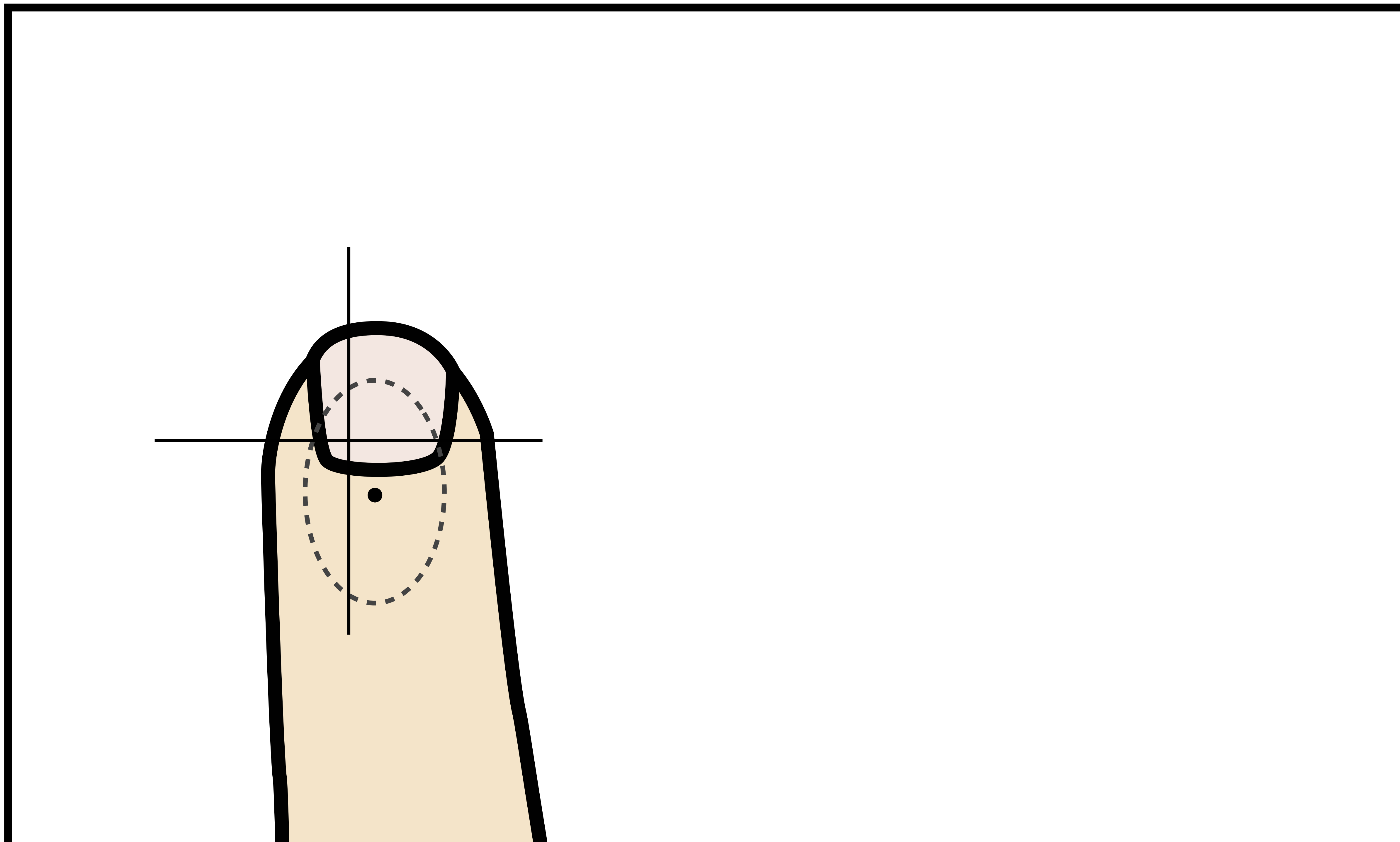



user study

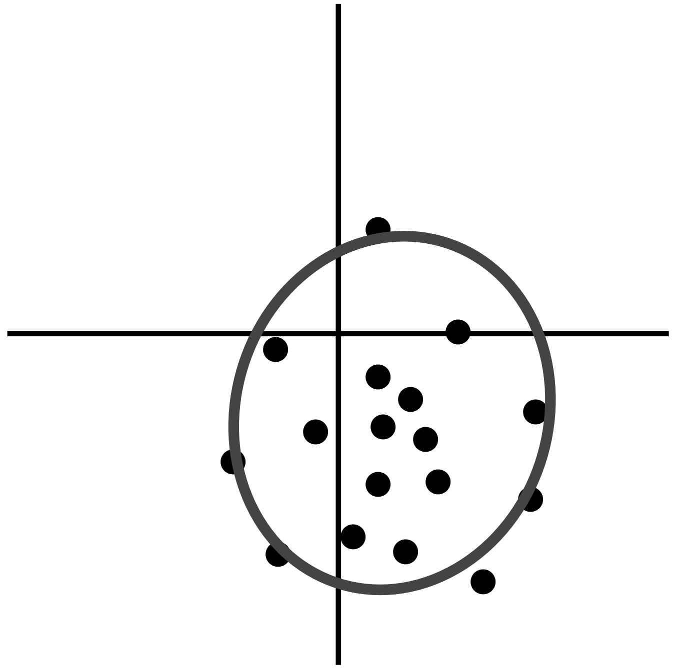
independent variables



error metric

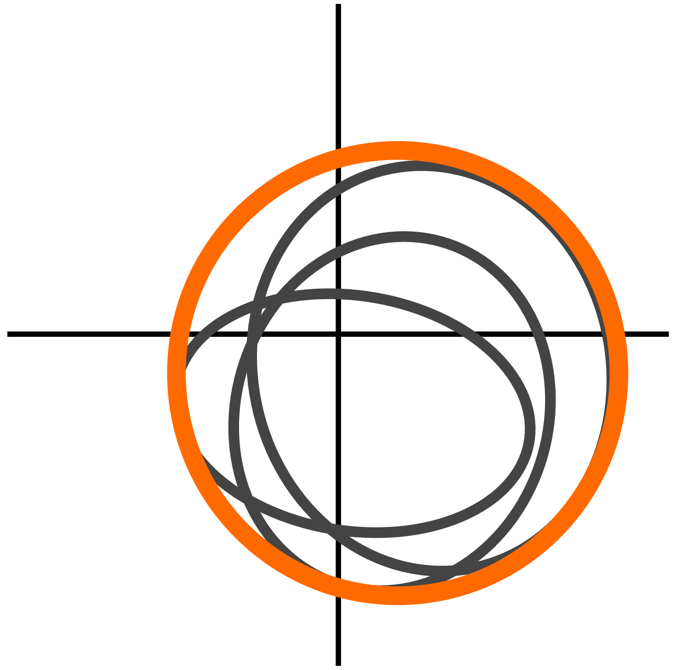


error metric



spread
:= variation **within** a condition

error metric



spread
:= variation **within** a condition

minimum button size
:= 95% of samples
across conditions

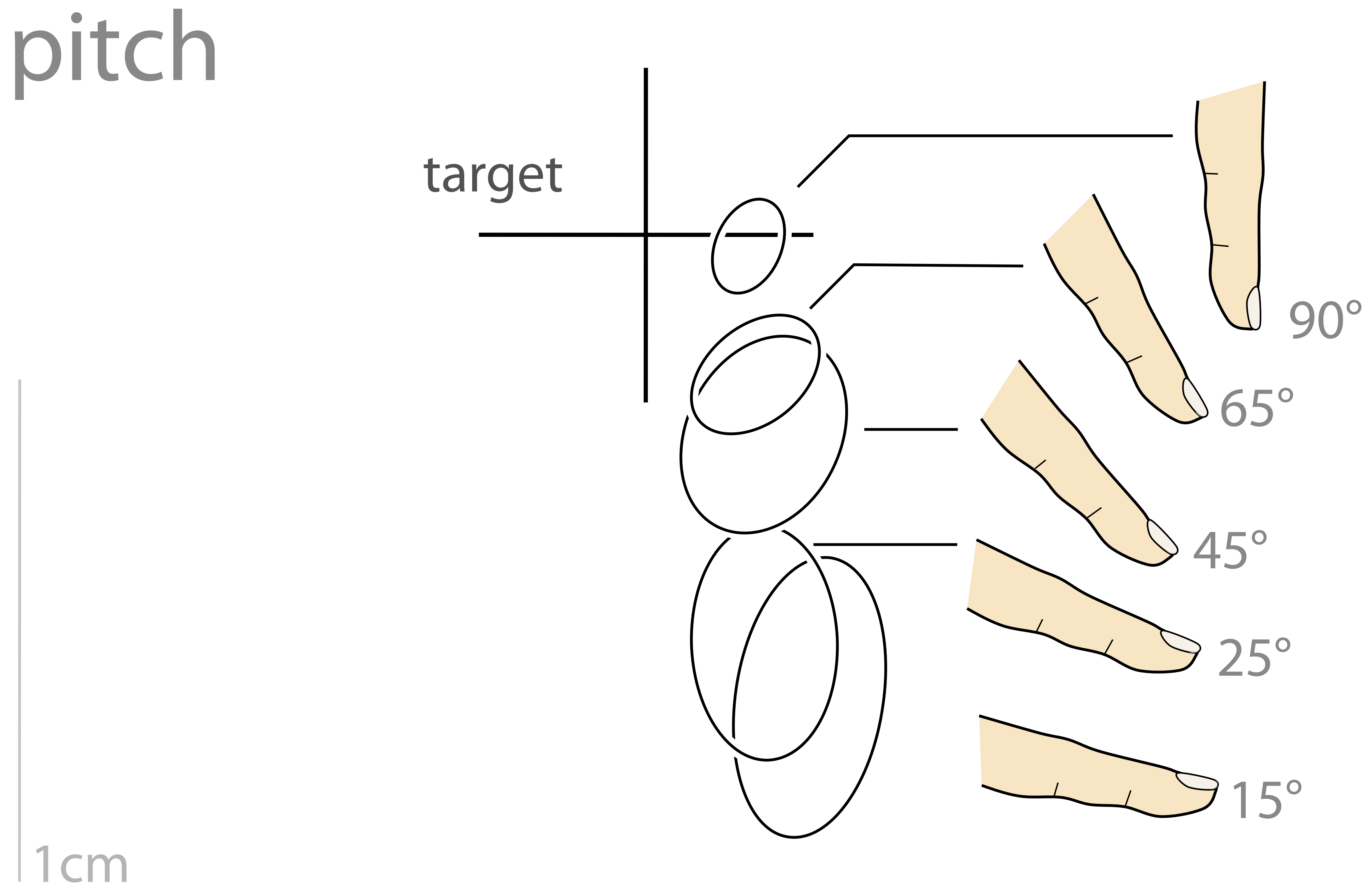
study design

2 yaw
× 2 sessions (pitch, roll)
× 5 angles
× 6 repetitions per angle
× 5 blocks

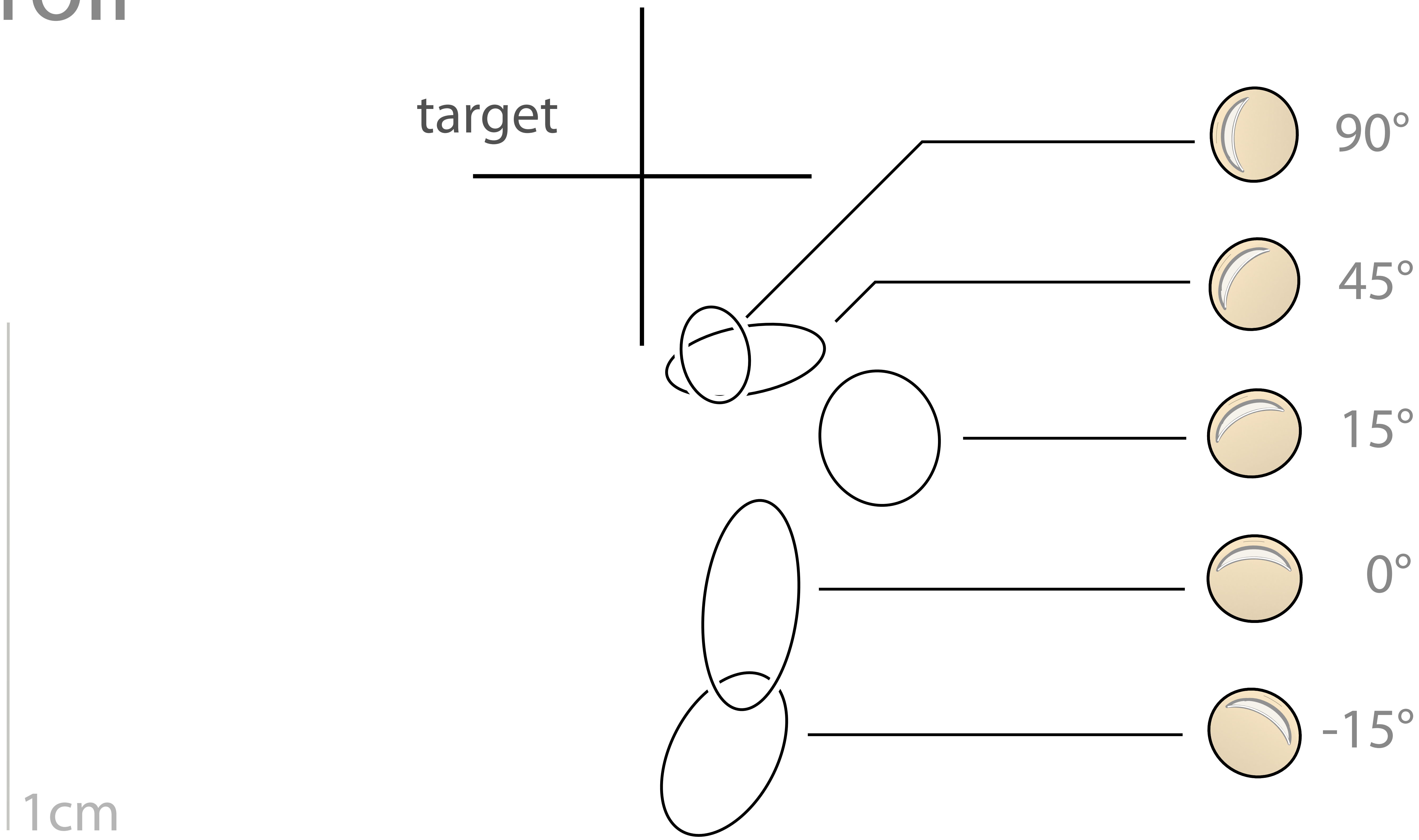
= 600 trials / participant

12 participants

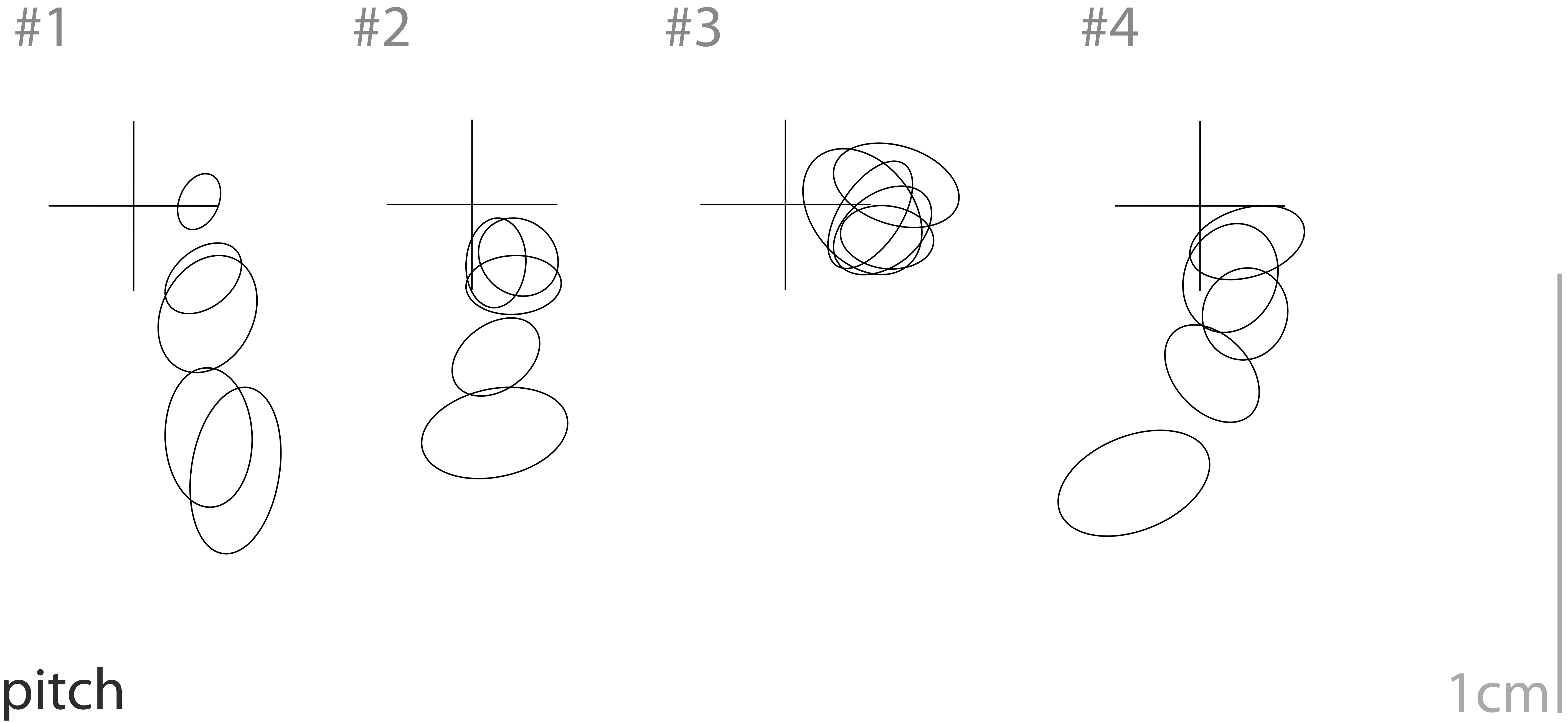
results


pitch
target
90°
65°
45°
25°
15°
1cm

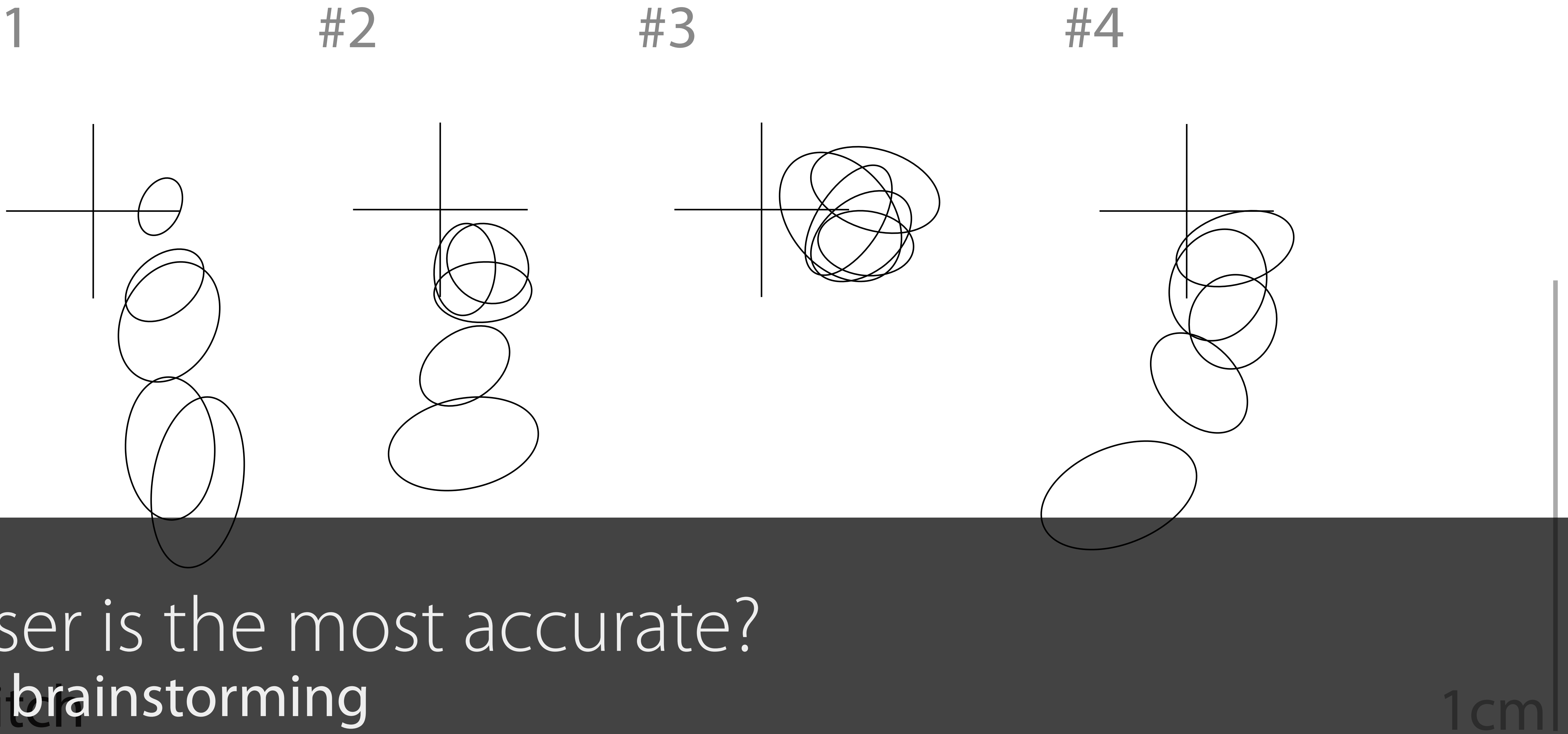
roll



user



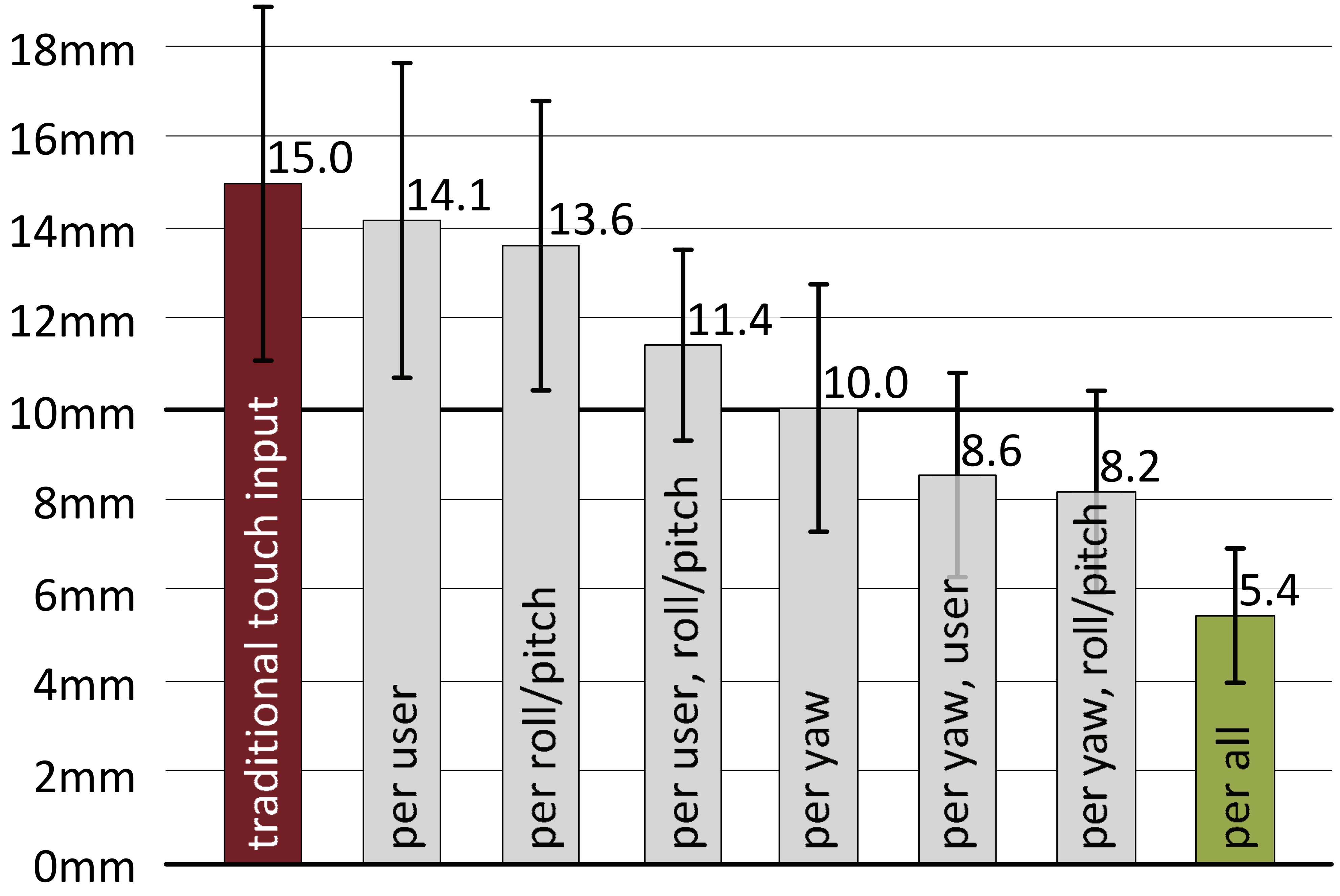
user



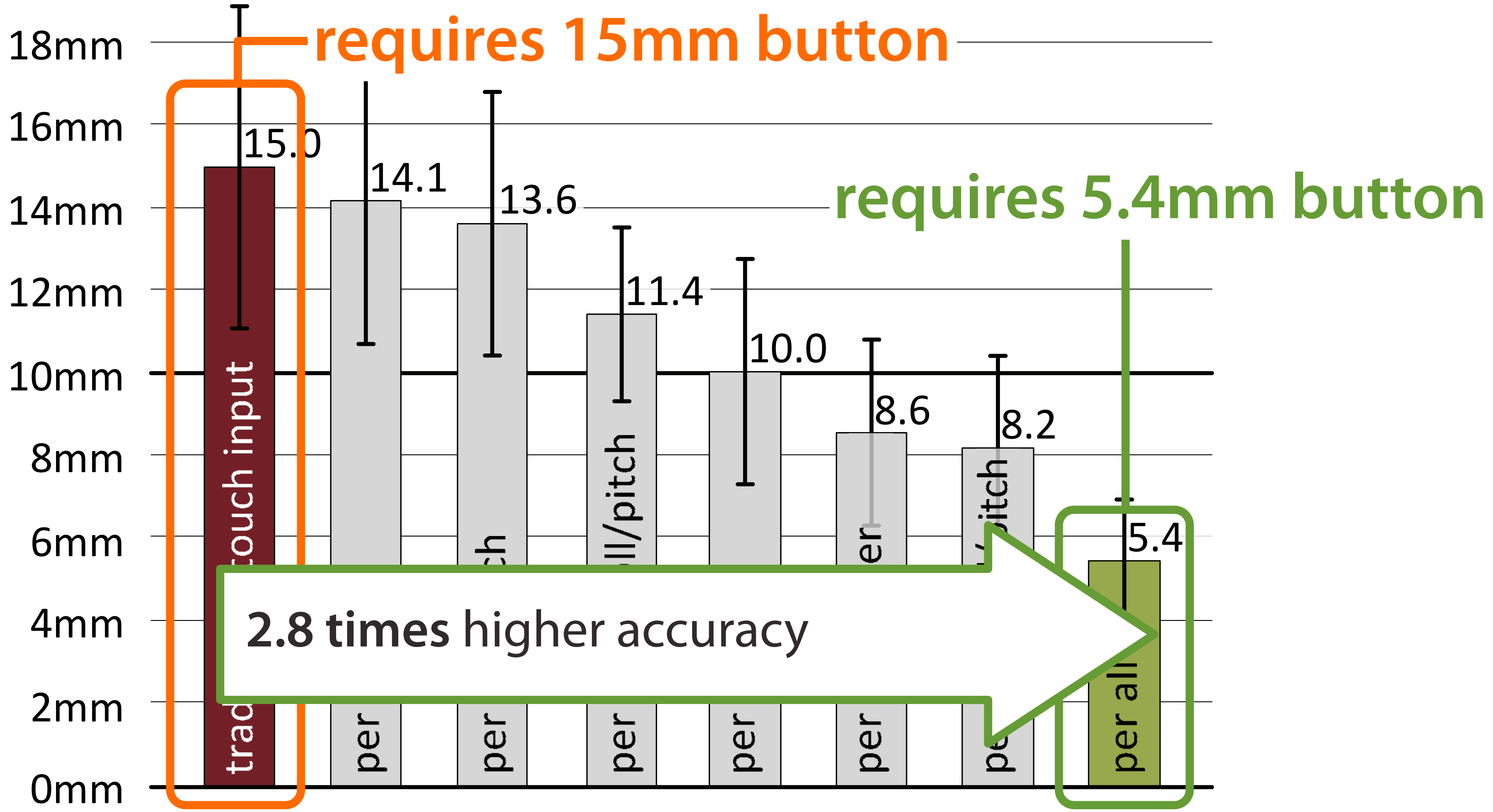
which user is the most accurate?

30 second brainstorming

minimum button size



minimum button size



can we make this real?

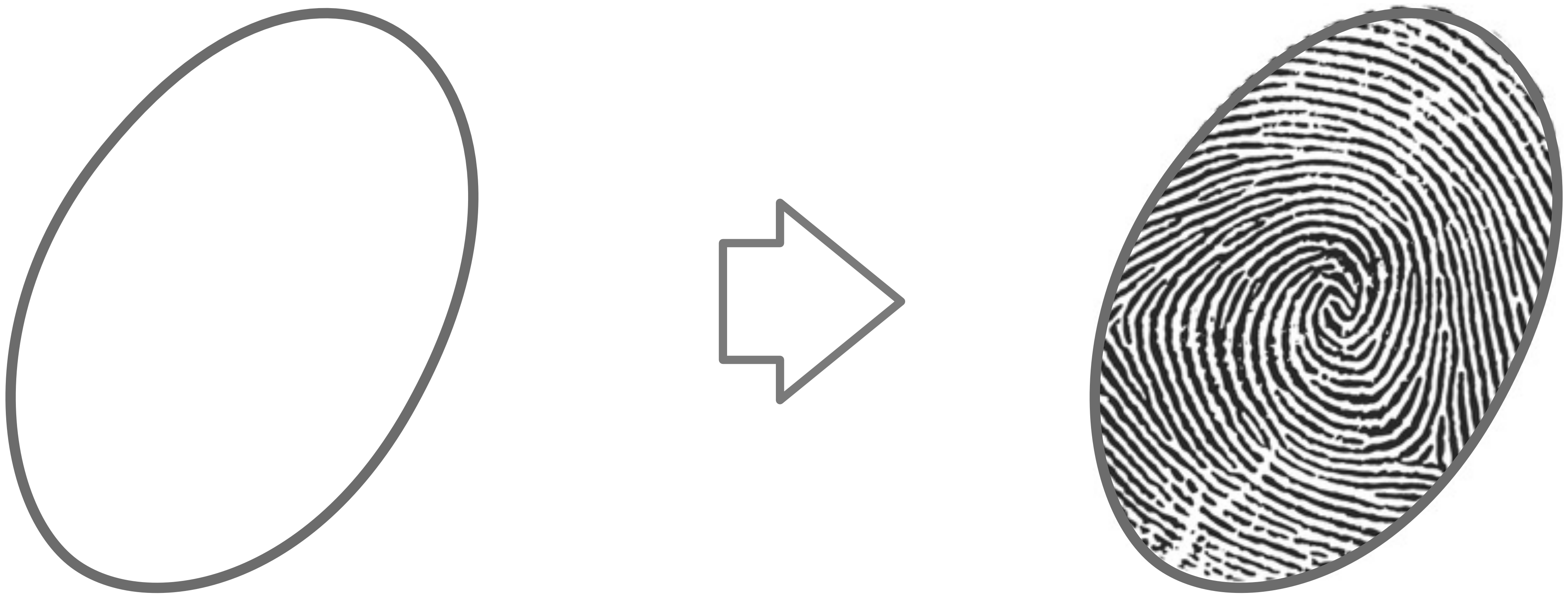
Ridgepad

optical fingerprint scanner

500 dpi

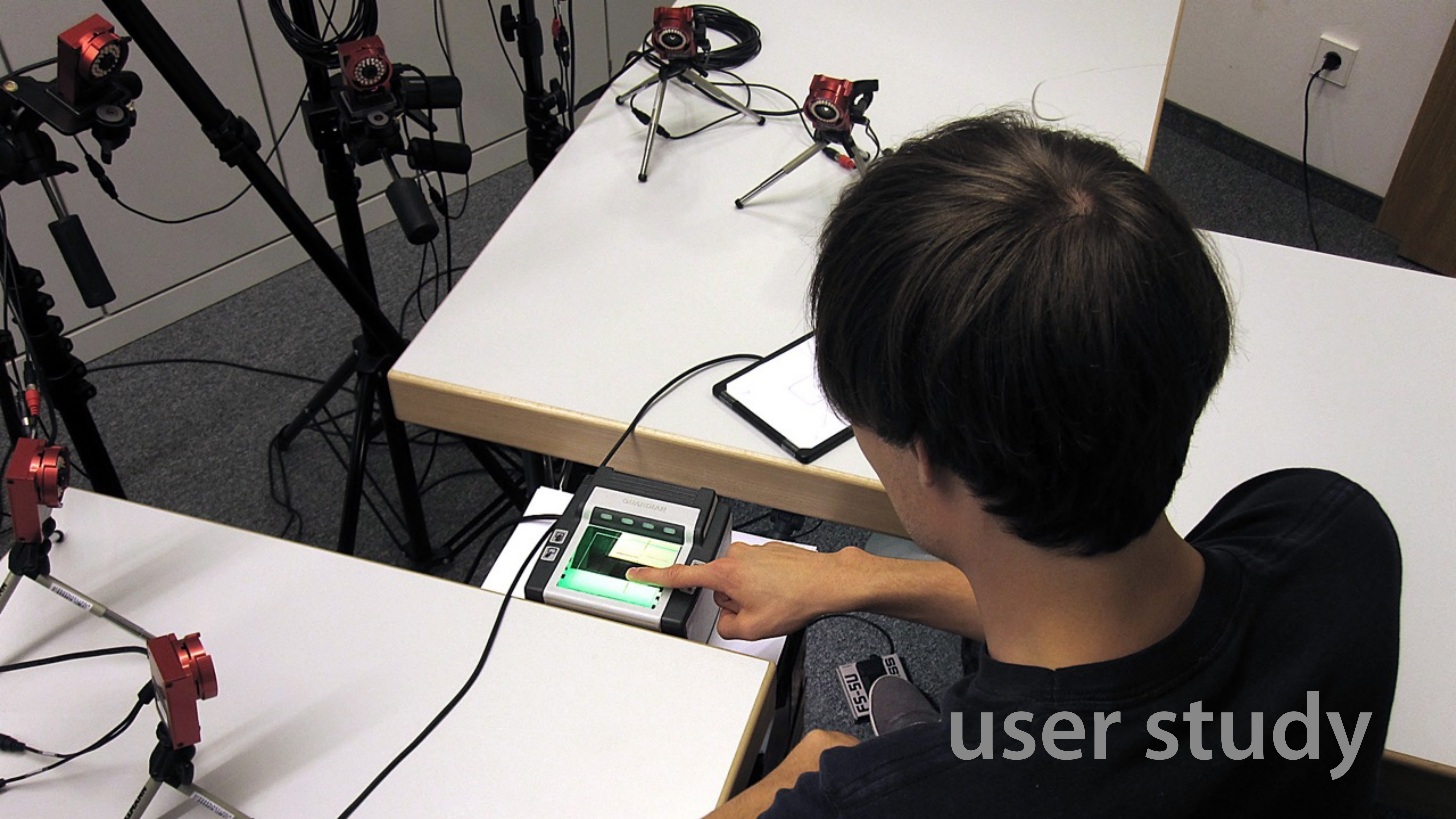
1600 × 1500 pixels

touchpad vs. fingerprint scanner

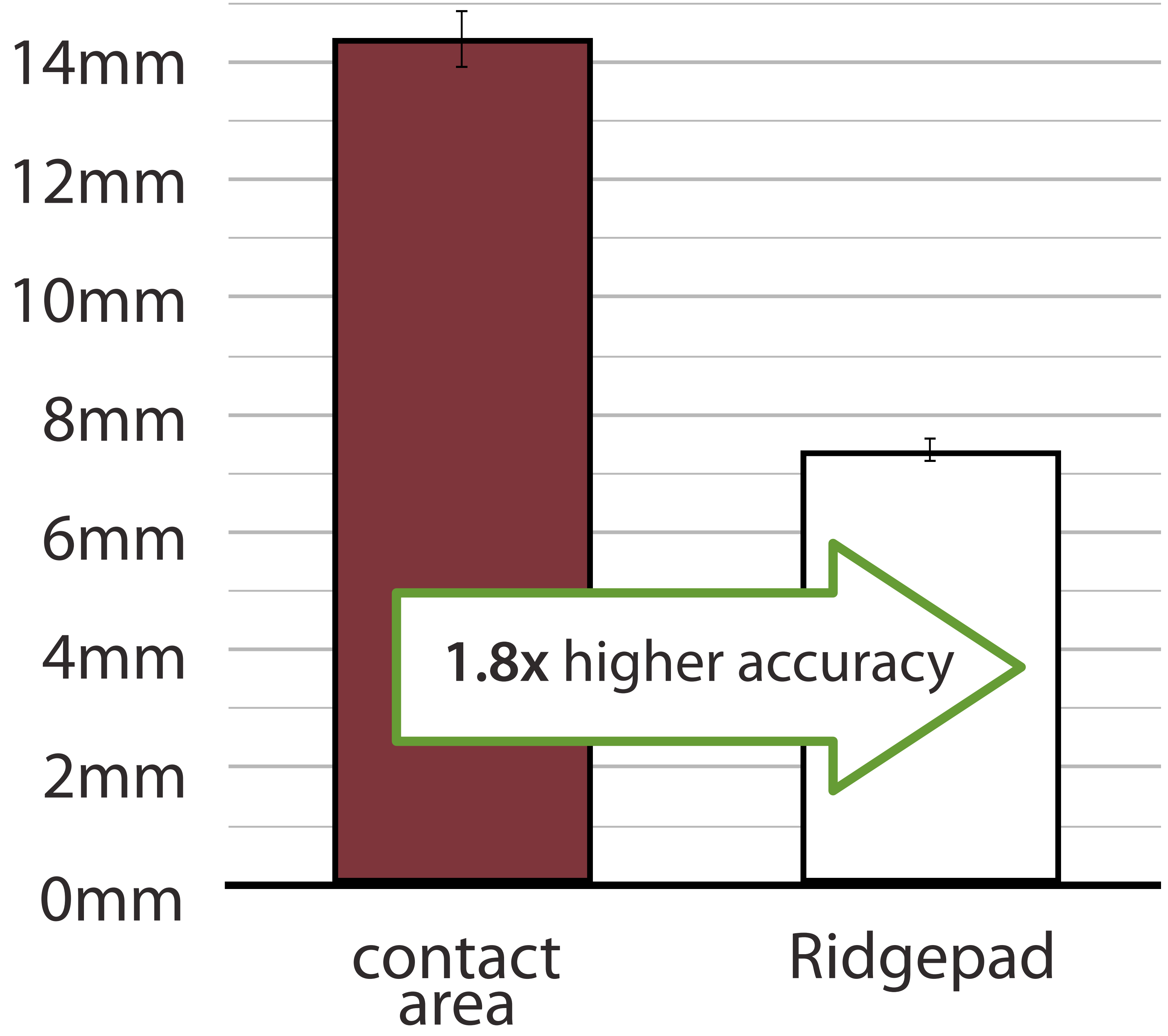


2D contact area

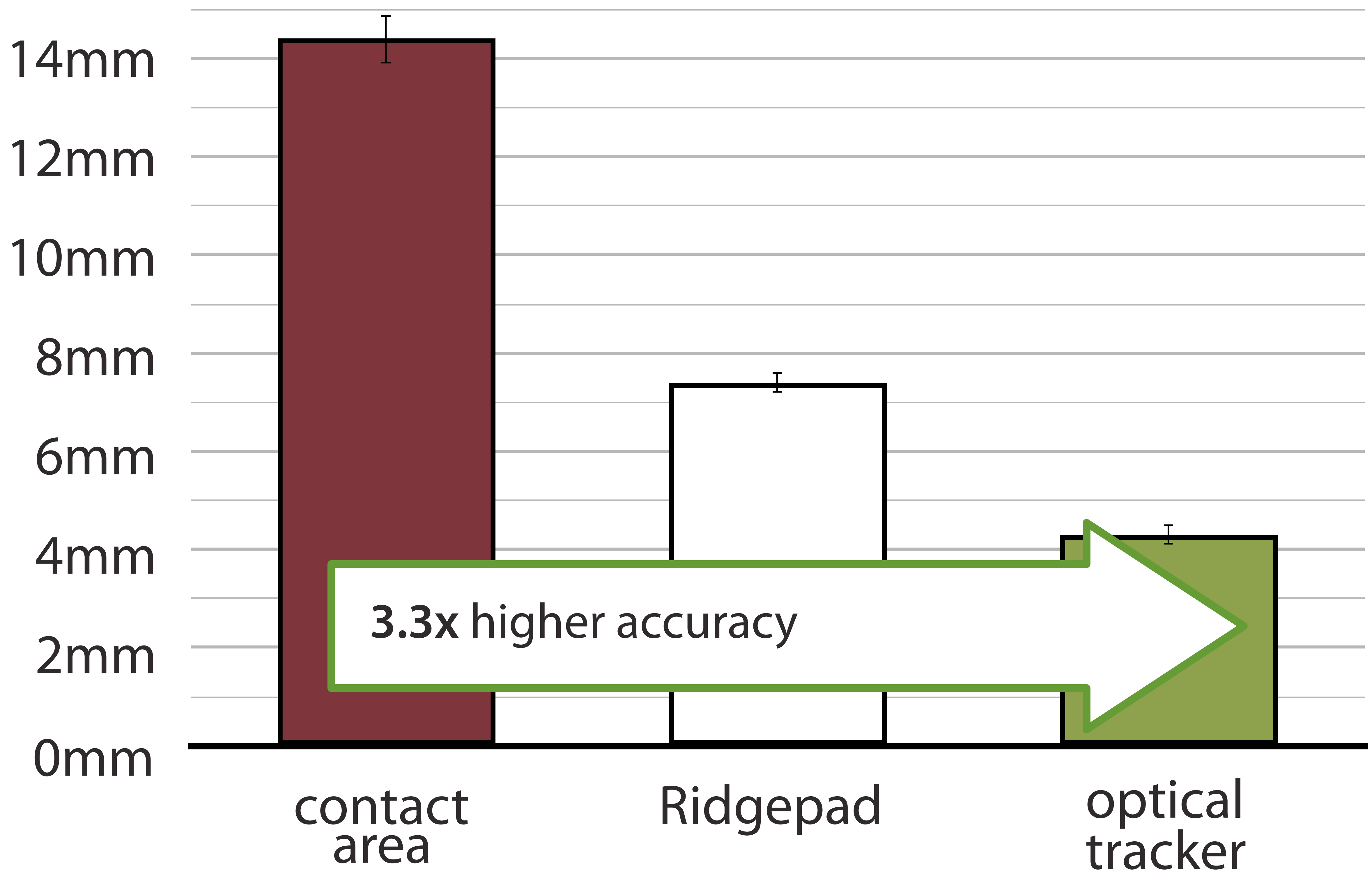
2D contact area
+ yaw, pitch, roll
+ participant ID


FS-5U
user study

minimum button size



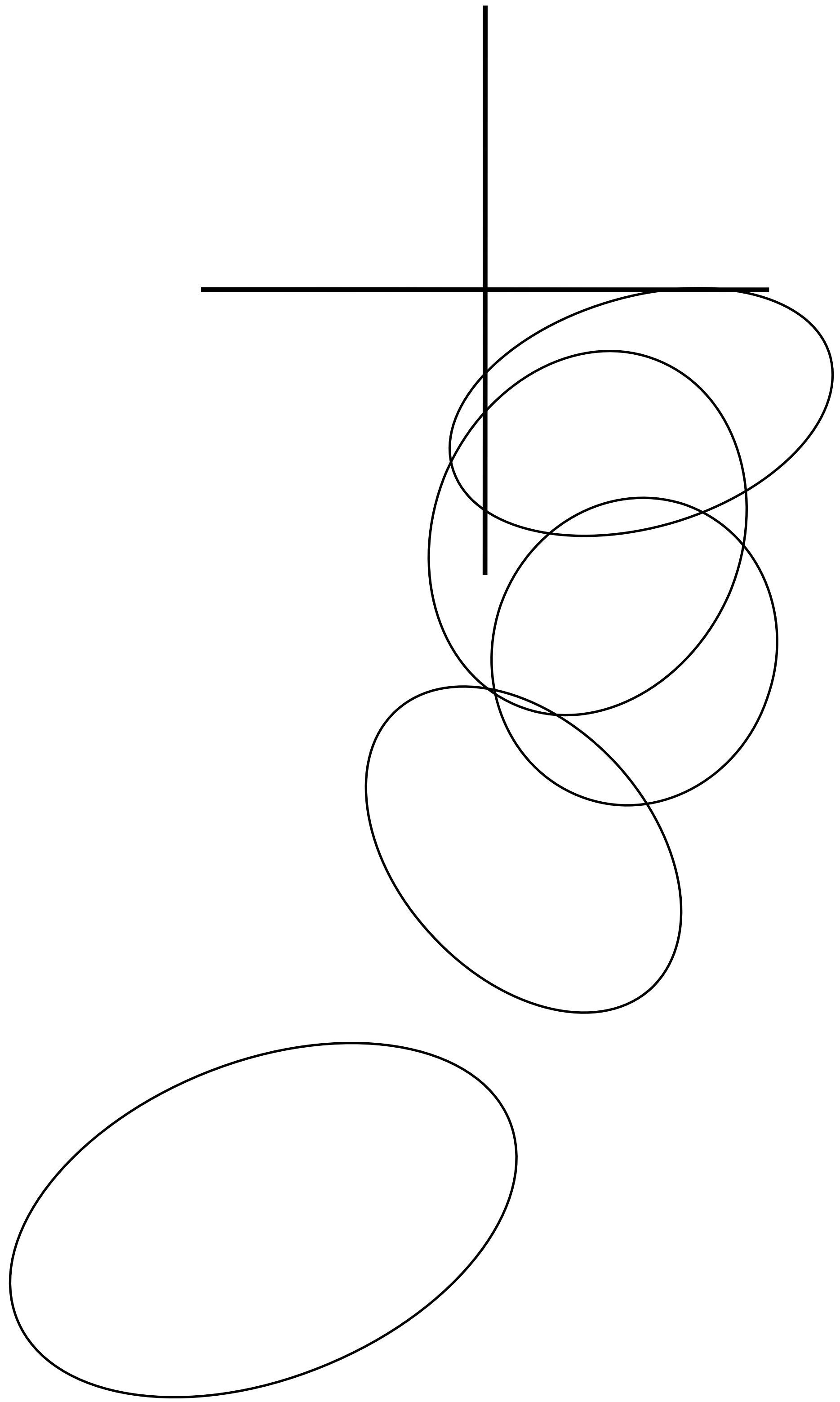
minimum button size



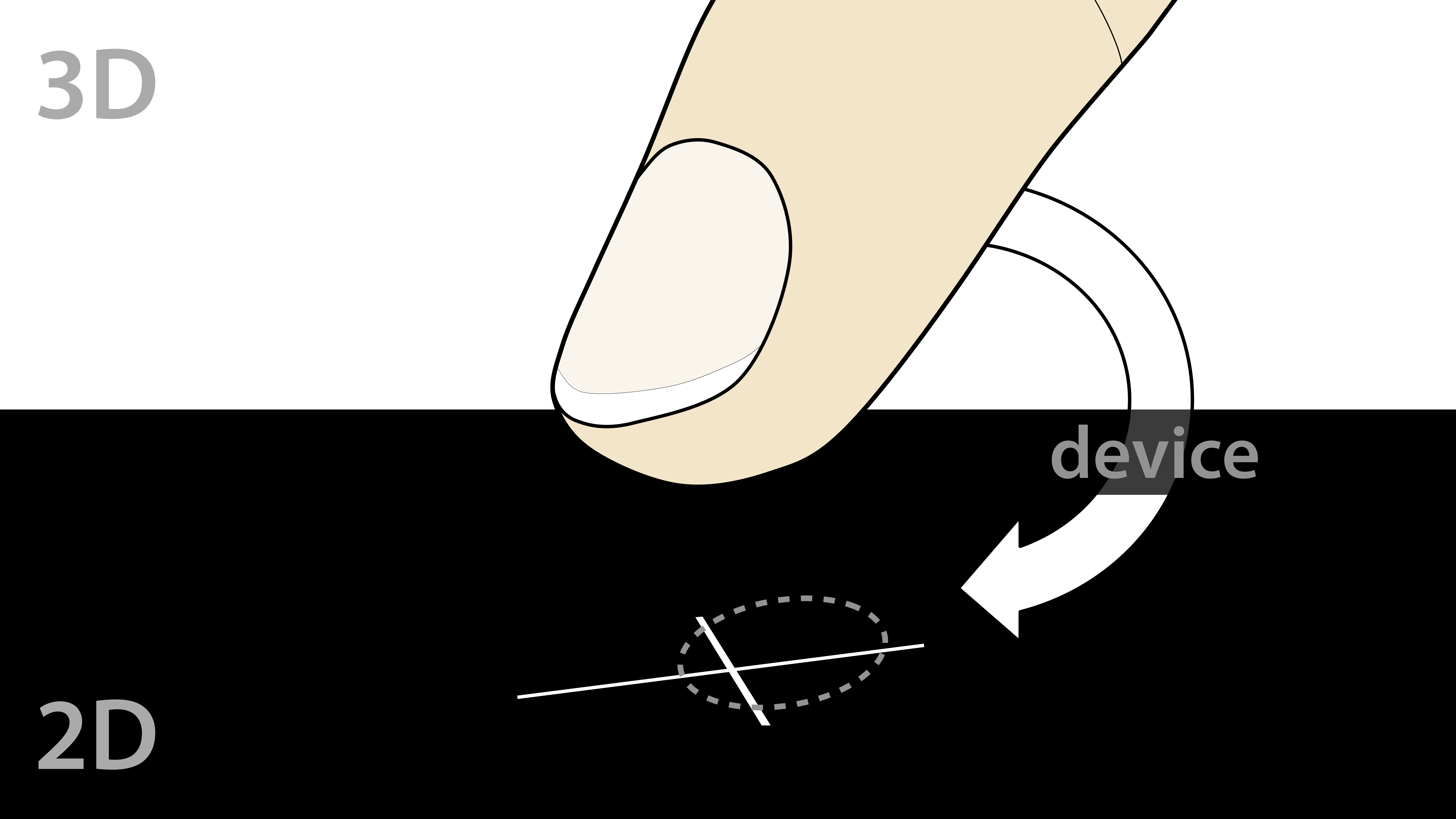
now we’re done and touch is accurate.

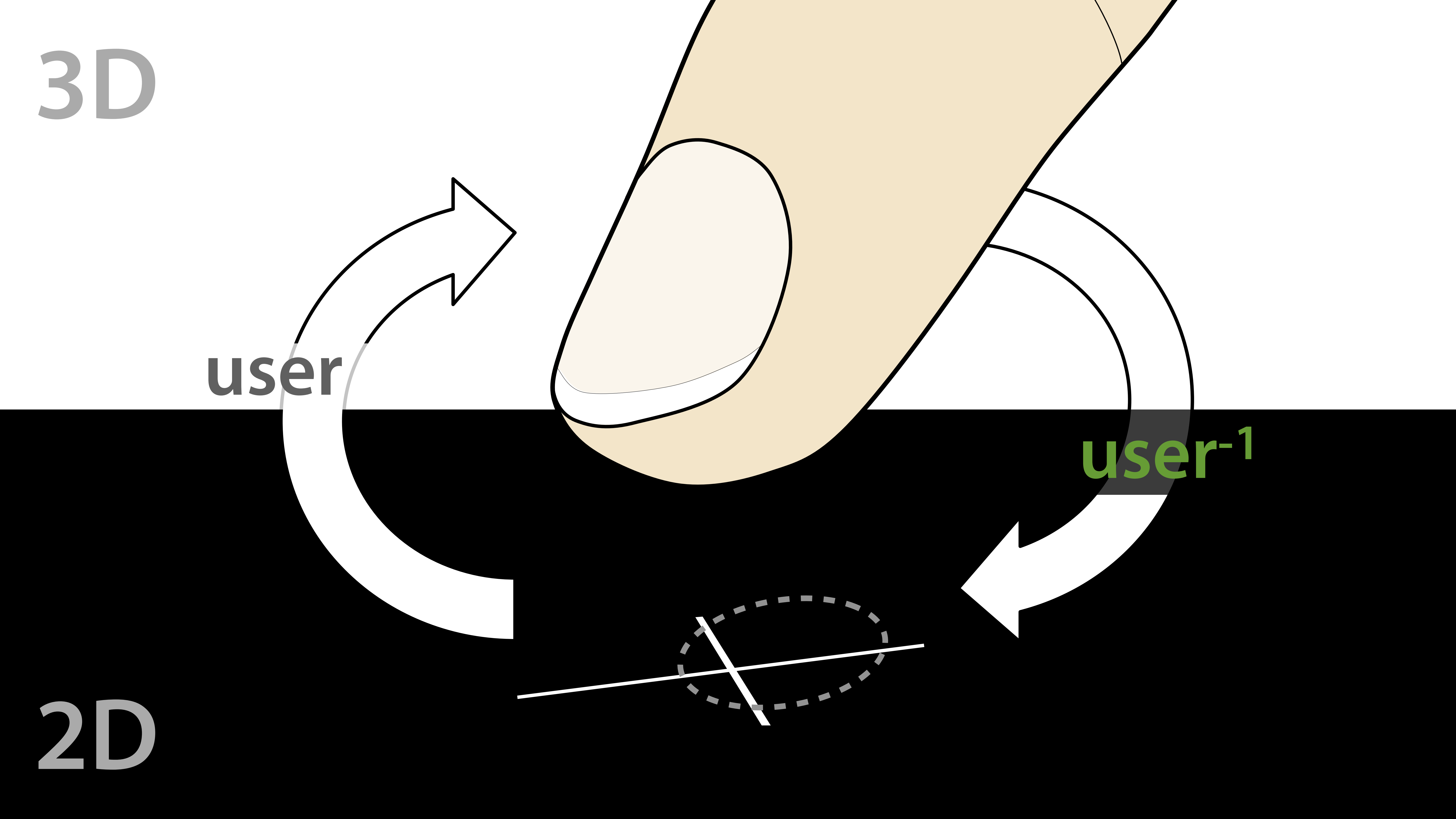
no! there's a bug here!

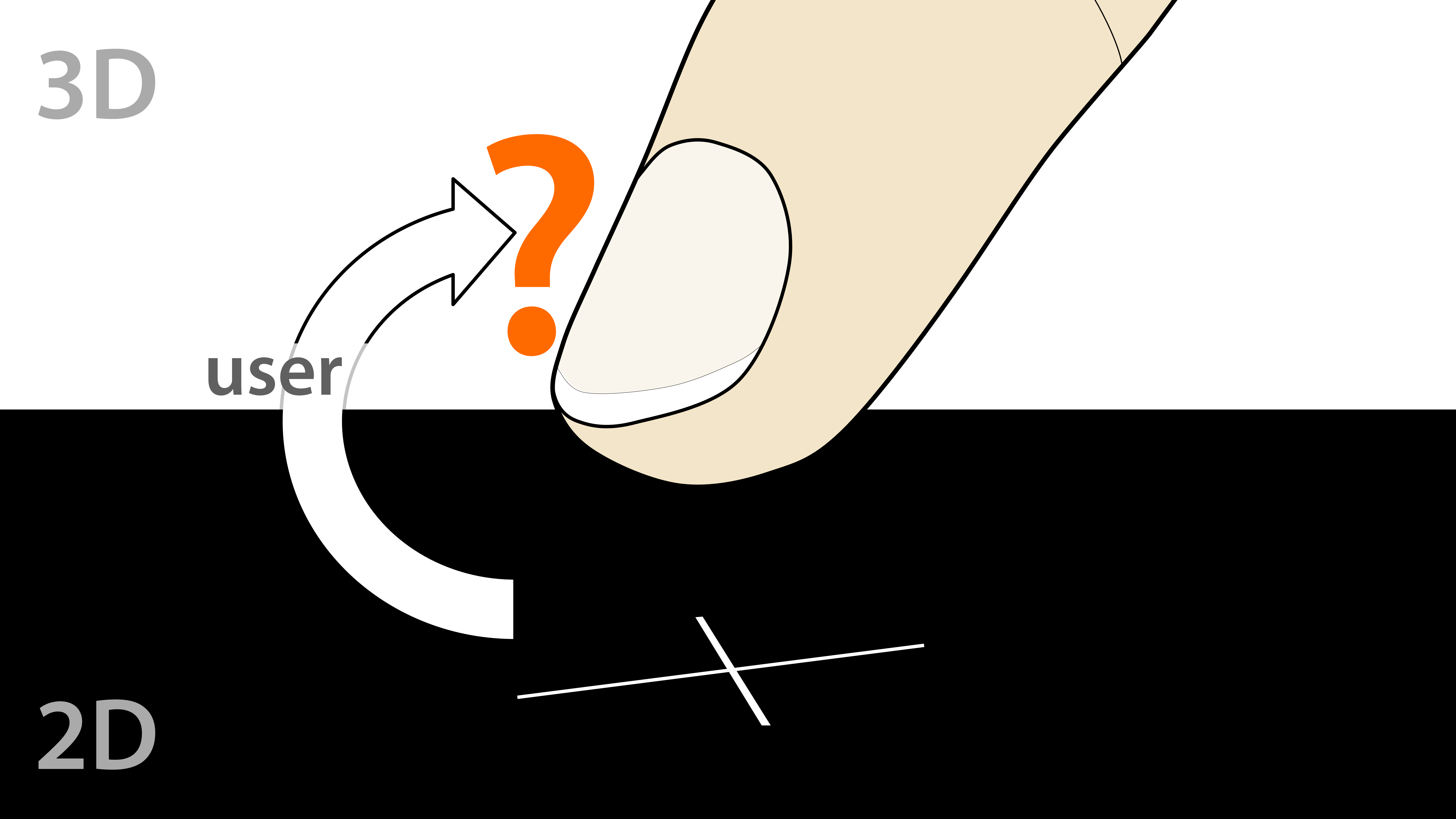
we're still compensating…



systematic effect


3D
device
2D


3D
user
user^{-1}
2D


3D
?
user
2D


goal:
trying to understand

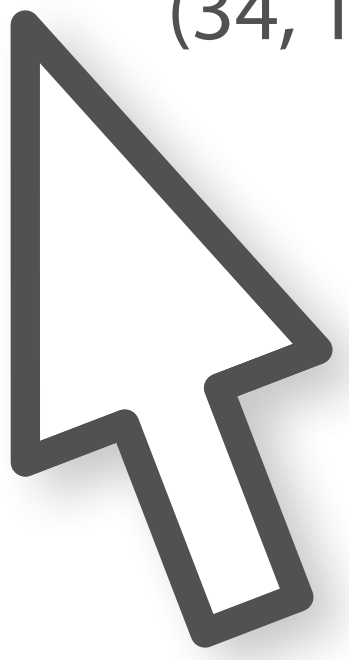
challenge

challenge

we need a **model**

in HCI, models are typically obtained using an **unambiguous** device (e.g., mouse)

1. measure data points
2. **fit a curve**



but **what** shall we measure?

there are **infinite ways**
how users might map
these crosshairs to 3D

so we had to revert to
basic experimental process...

guess a model

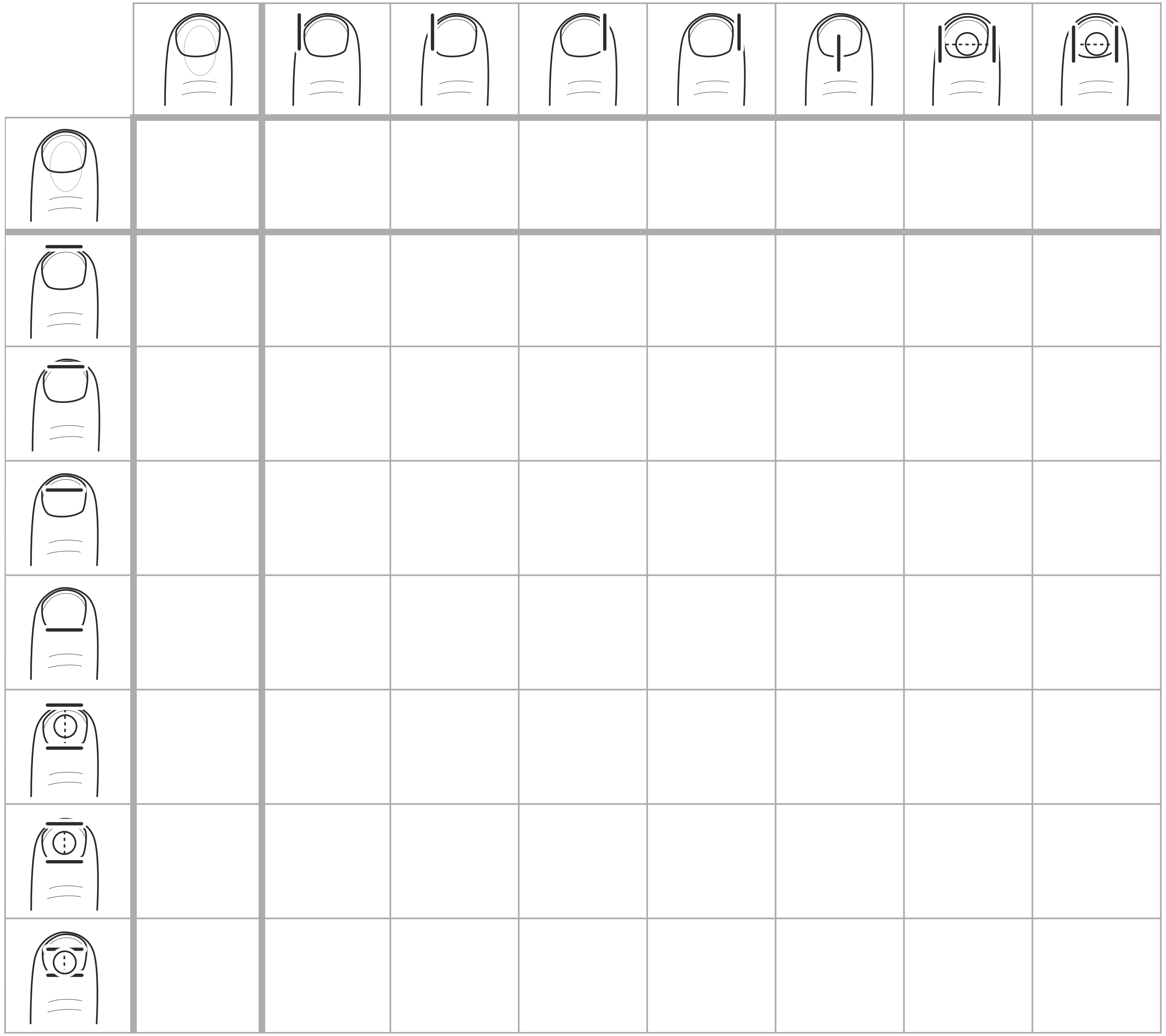
try it out in an experiment

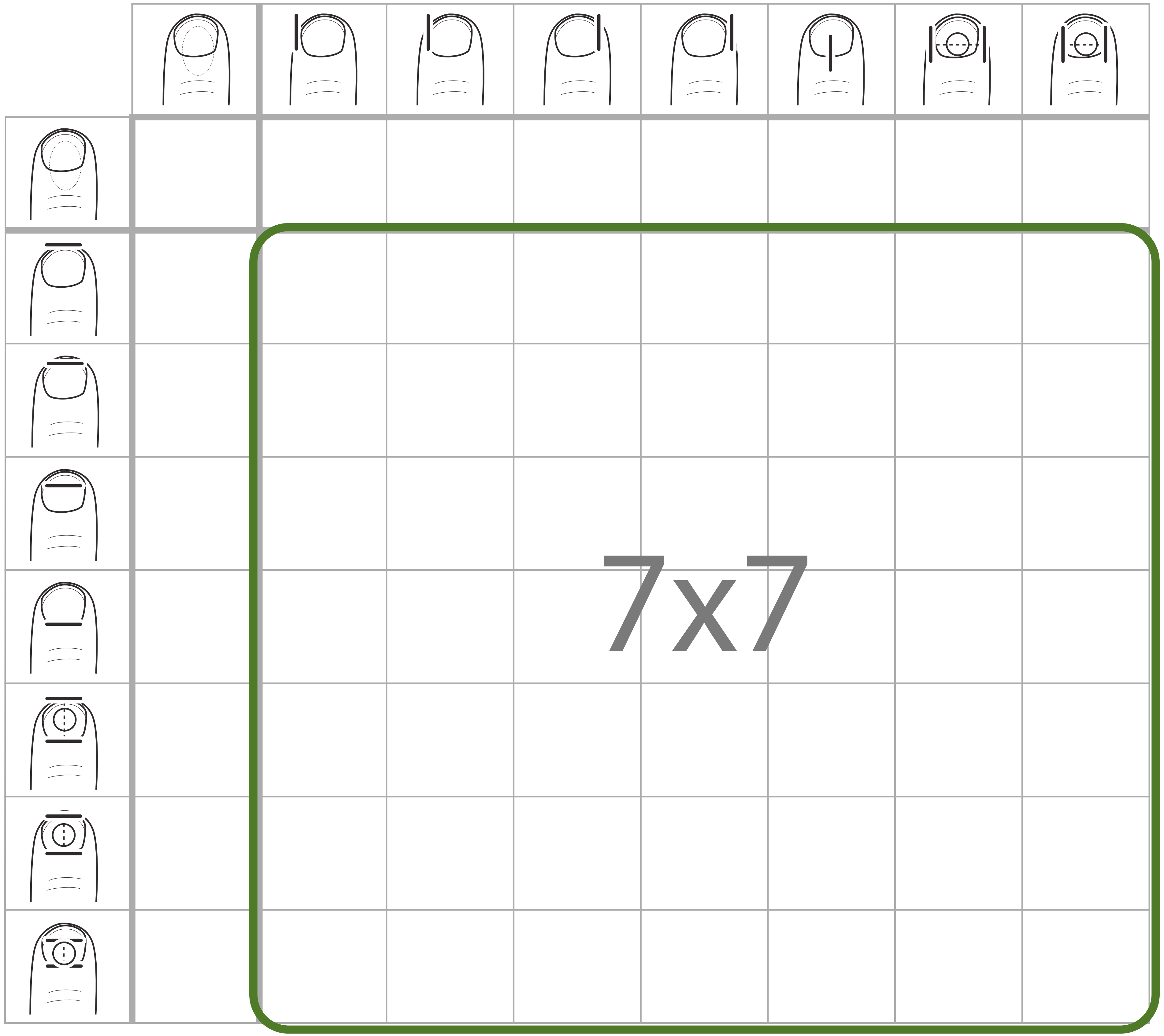
if outcome is bad, **repeat**

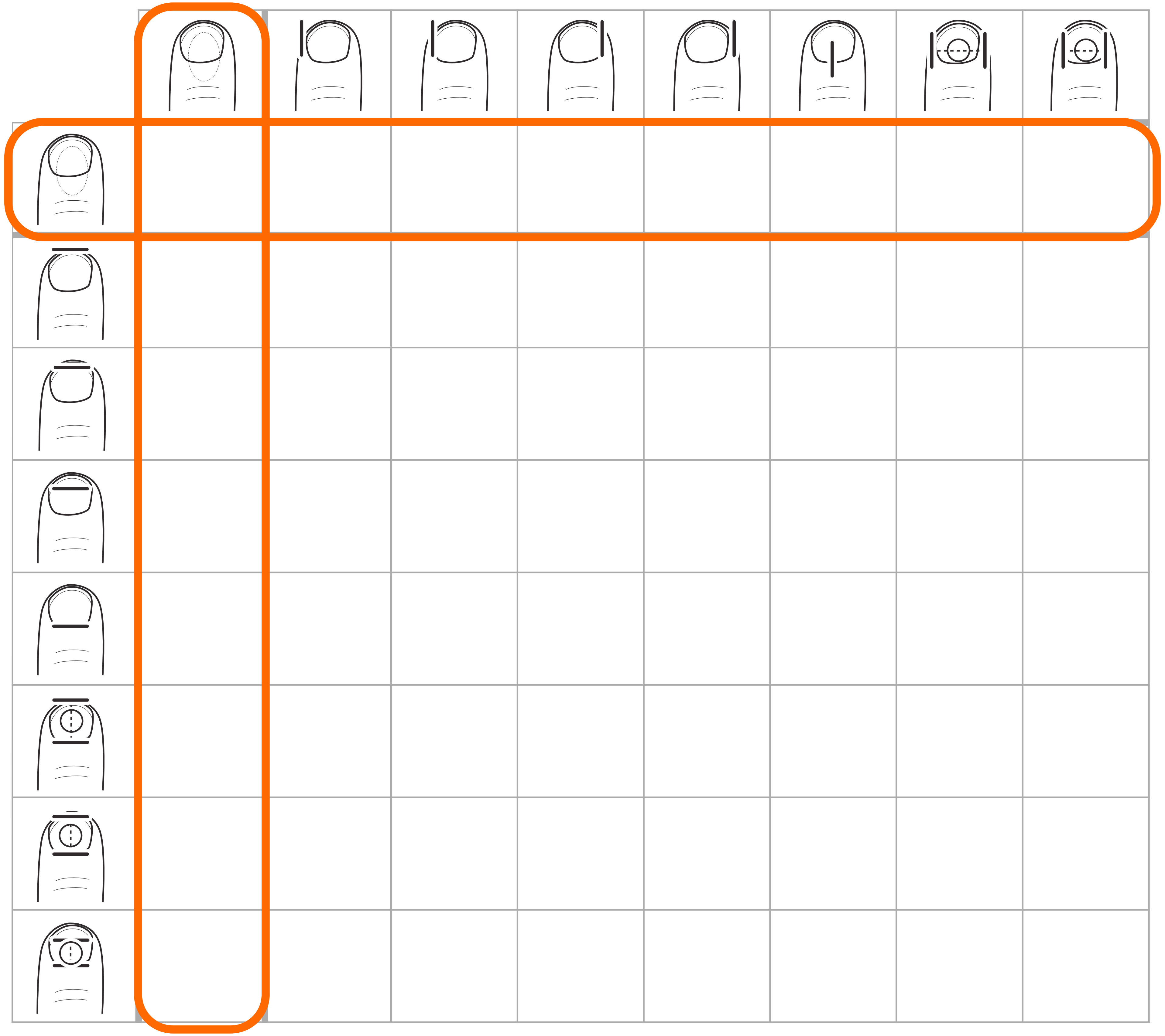
which model?

if it is not
the contact area...

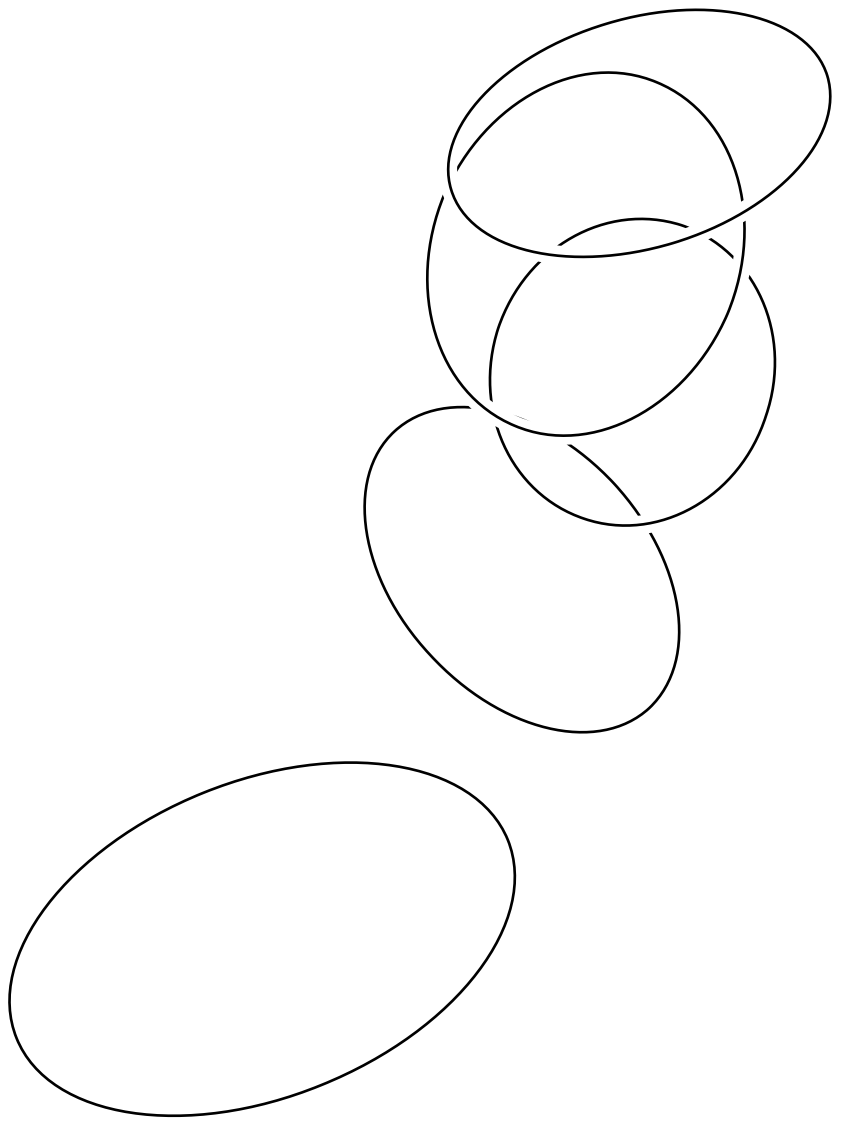
creating models using visual features



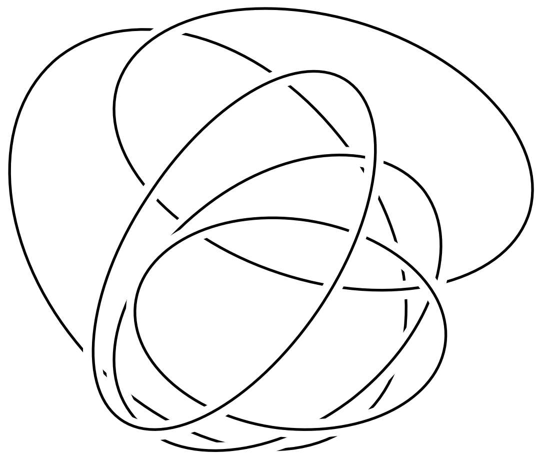

7x7



evaluating the models



bad model
large error offsets

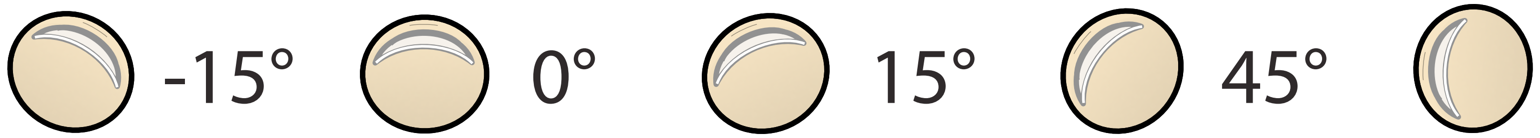


good model
small error offsets

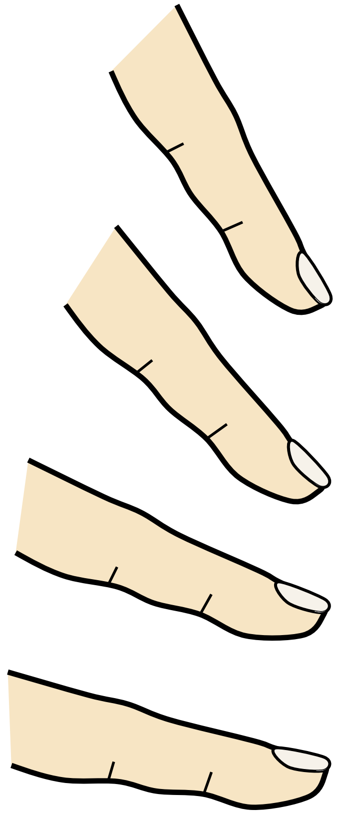
3 user studies

independent variables

roll

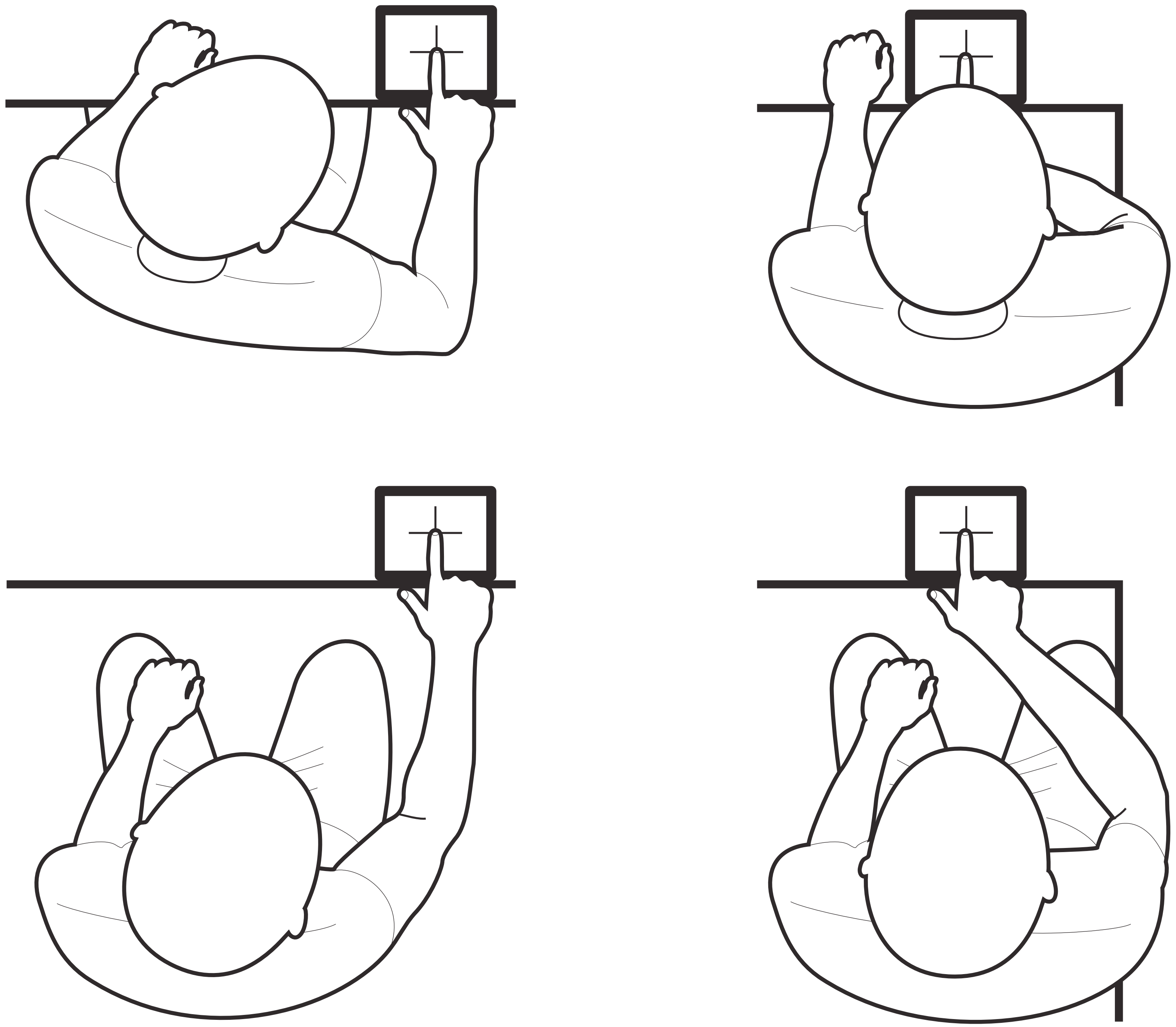


pitch



pitch \ roll	-15°	0°	15°	45°	90°
65°		x			
45°	x	x	x	x	x
25°		x			
15°	x	x	x	x	x

...and head position



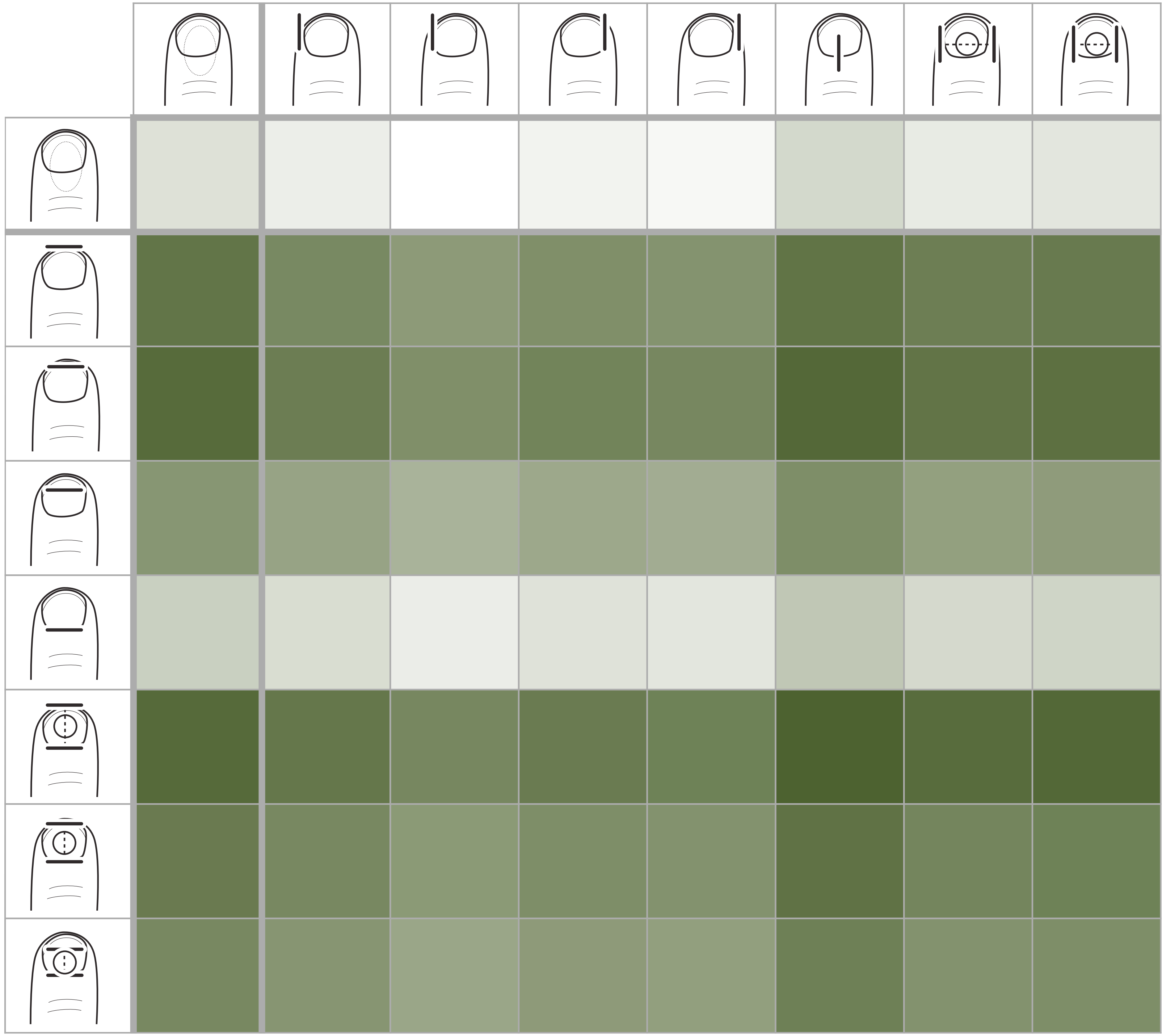
study design

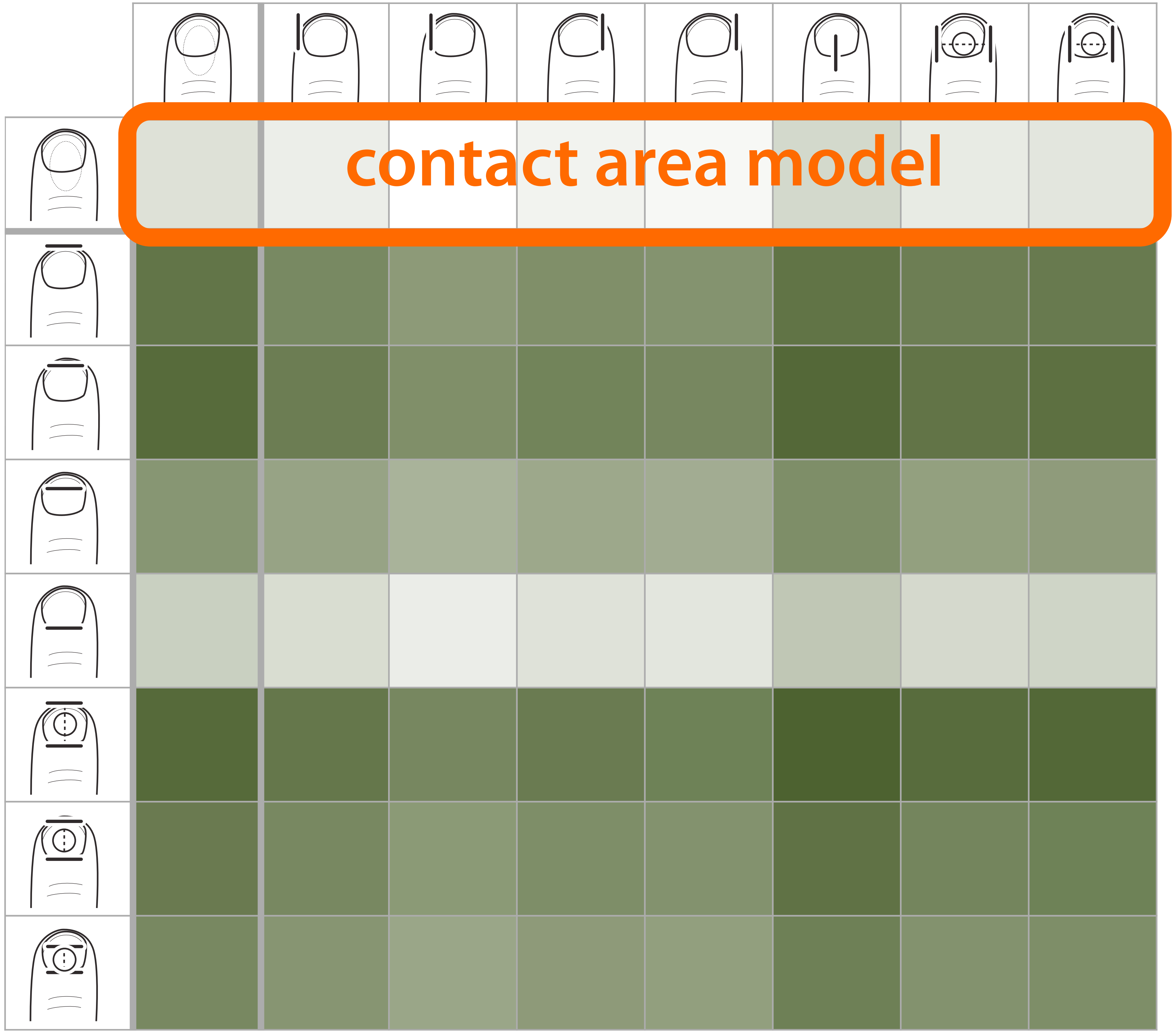
6 combinations of finger angles (pitch, roll)
×4 head positions
×2 blocks
×4 repetitions

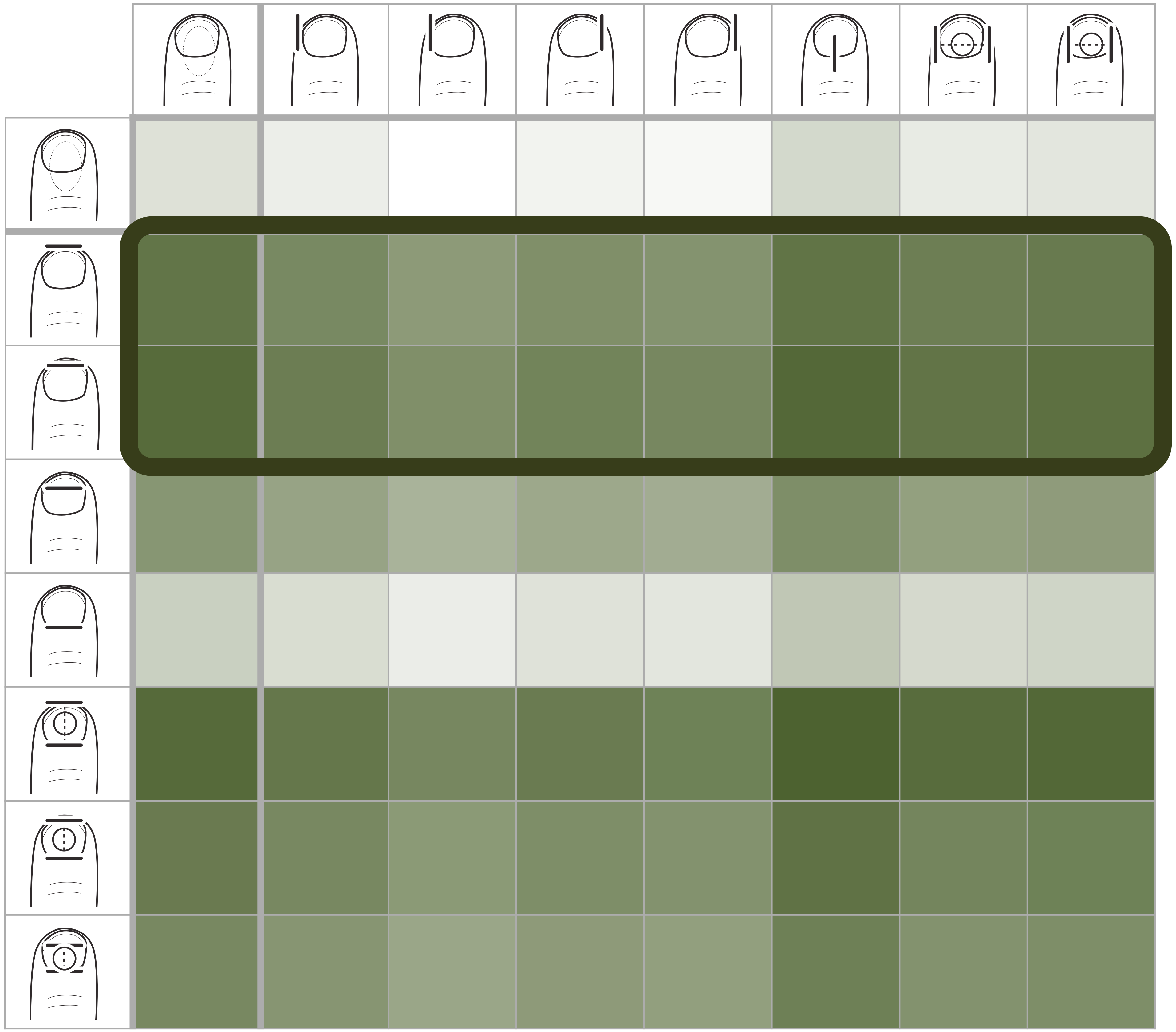
=192 trials / participant

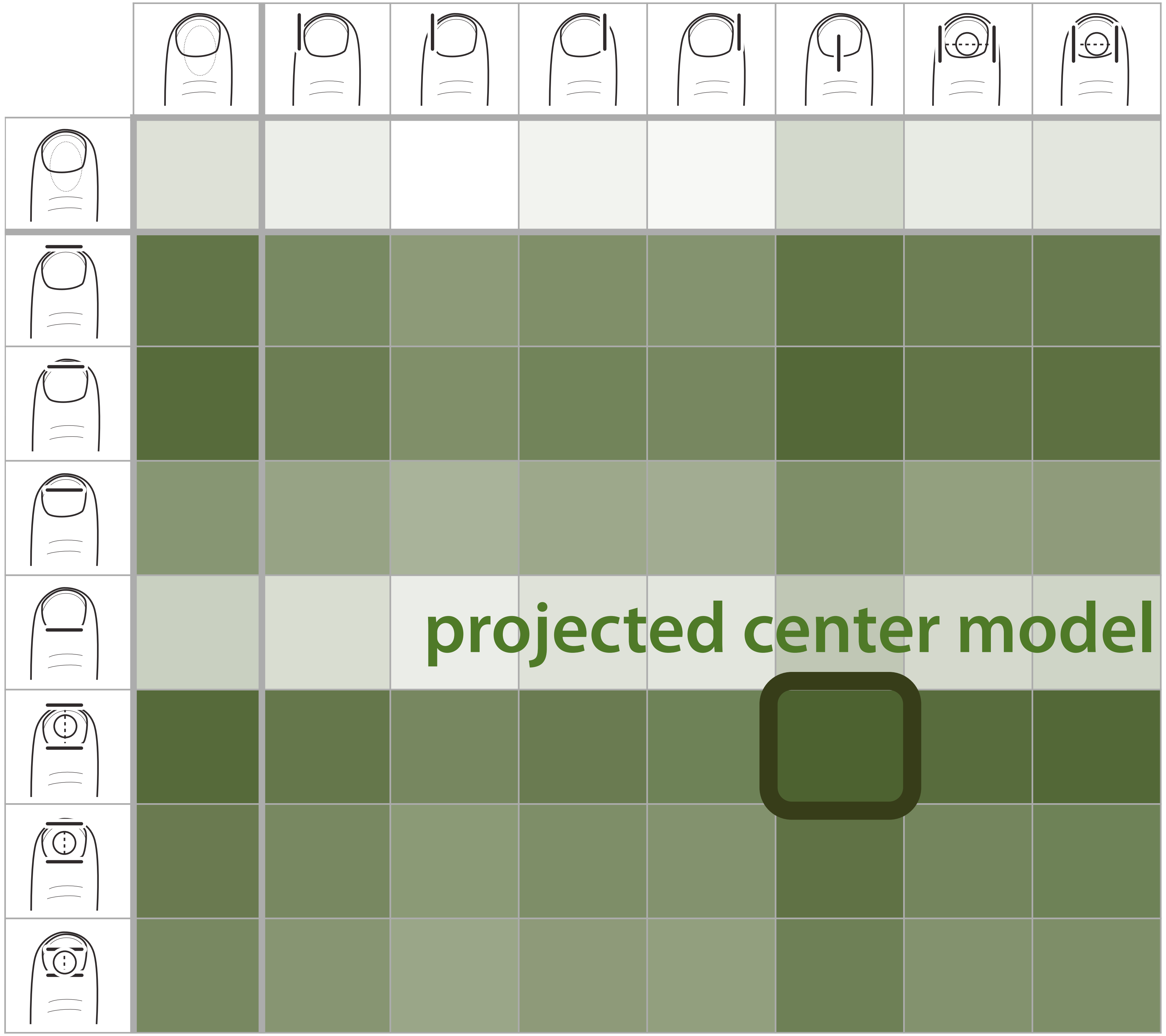
30 + 12 + 12 participants

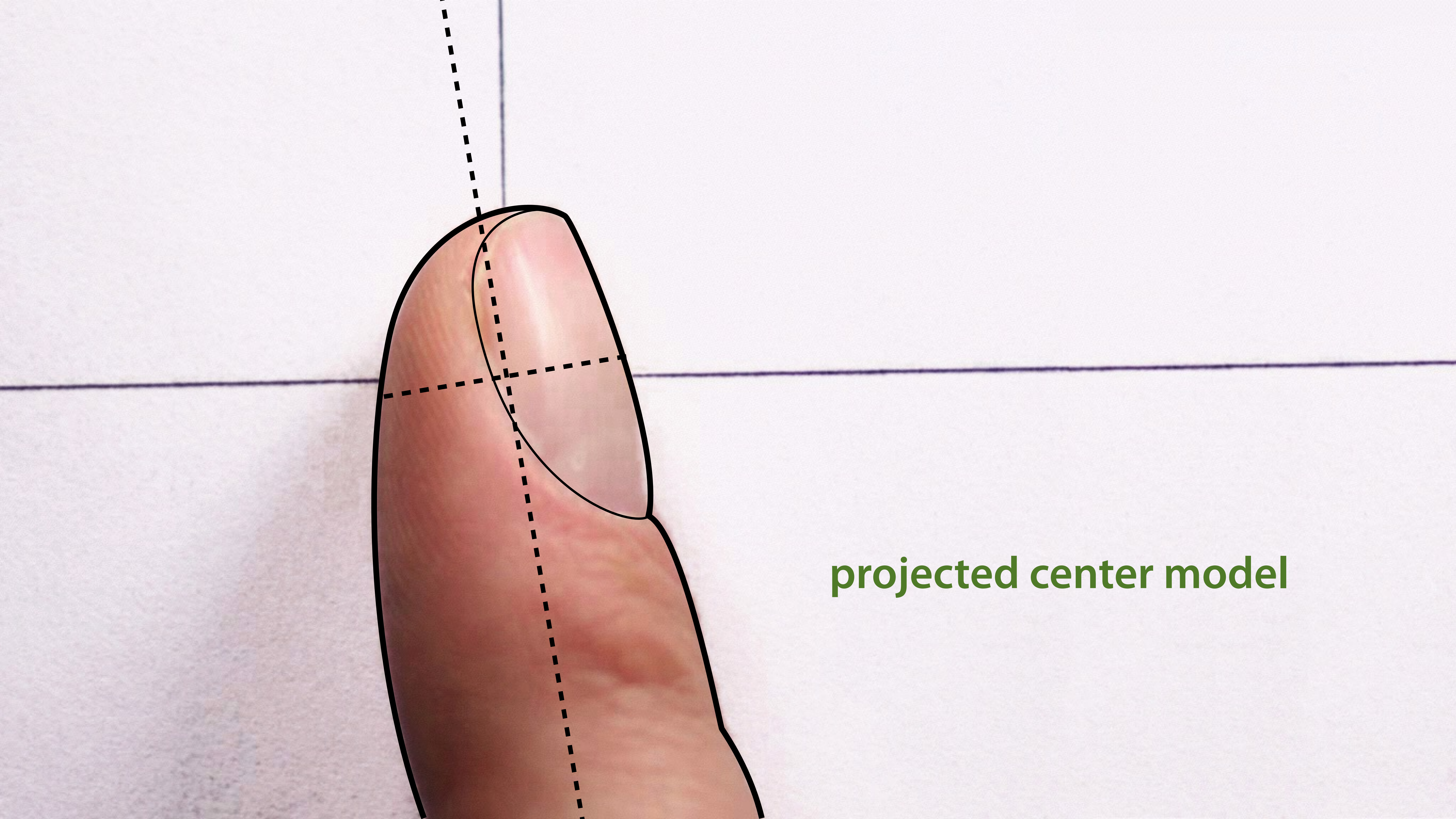

results



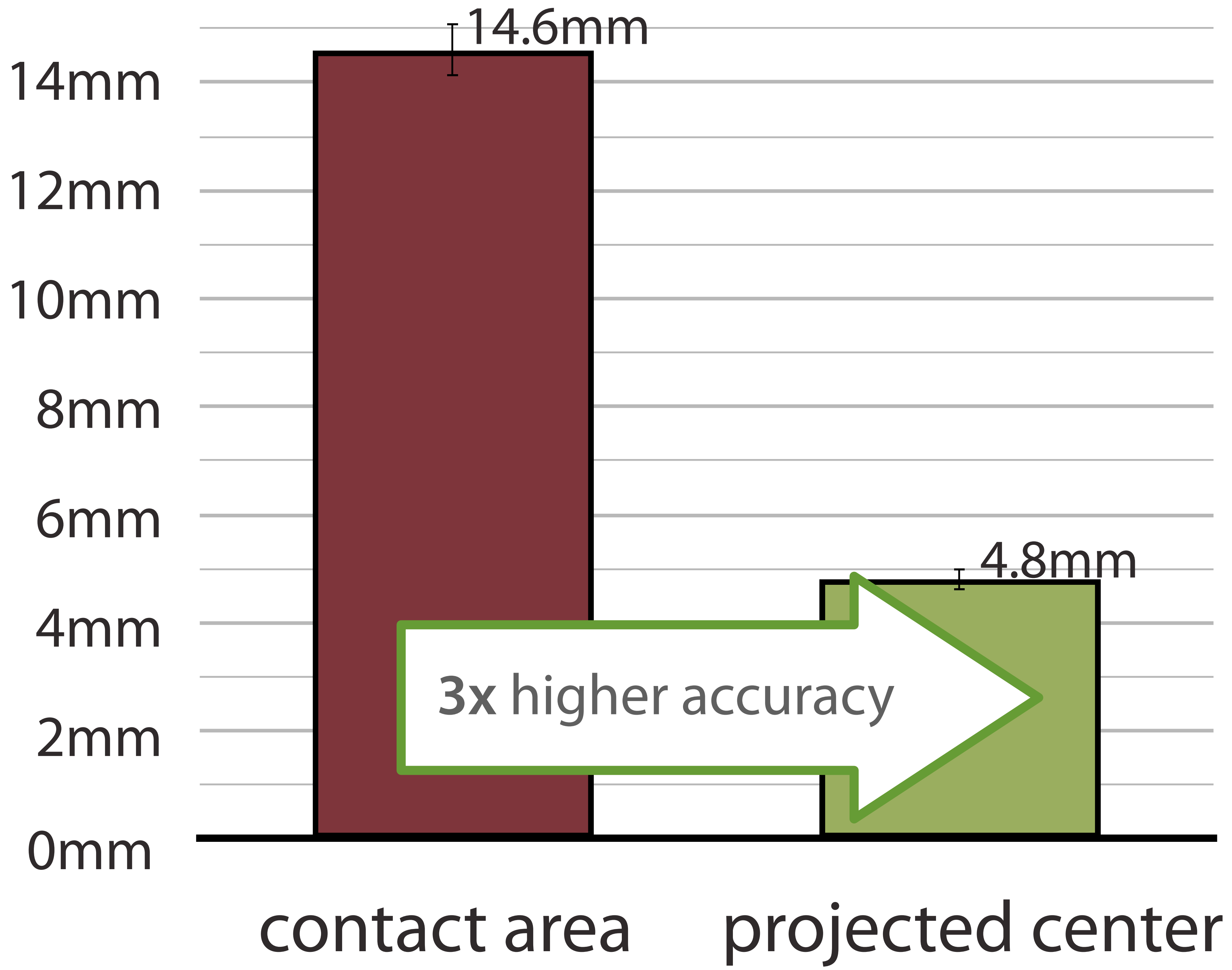

contact area model



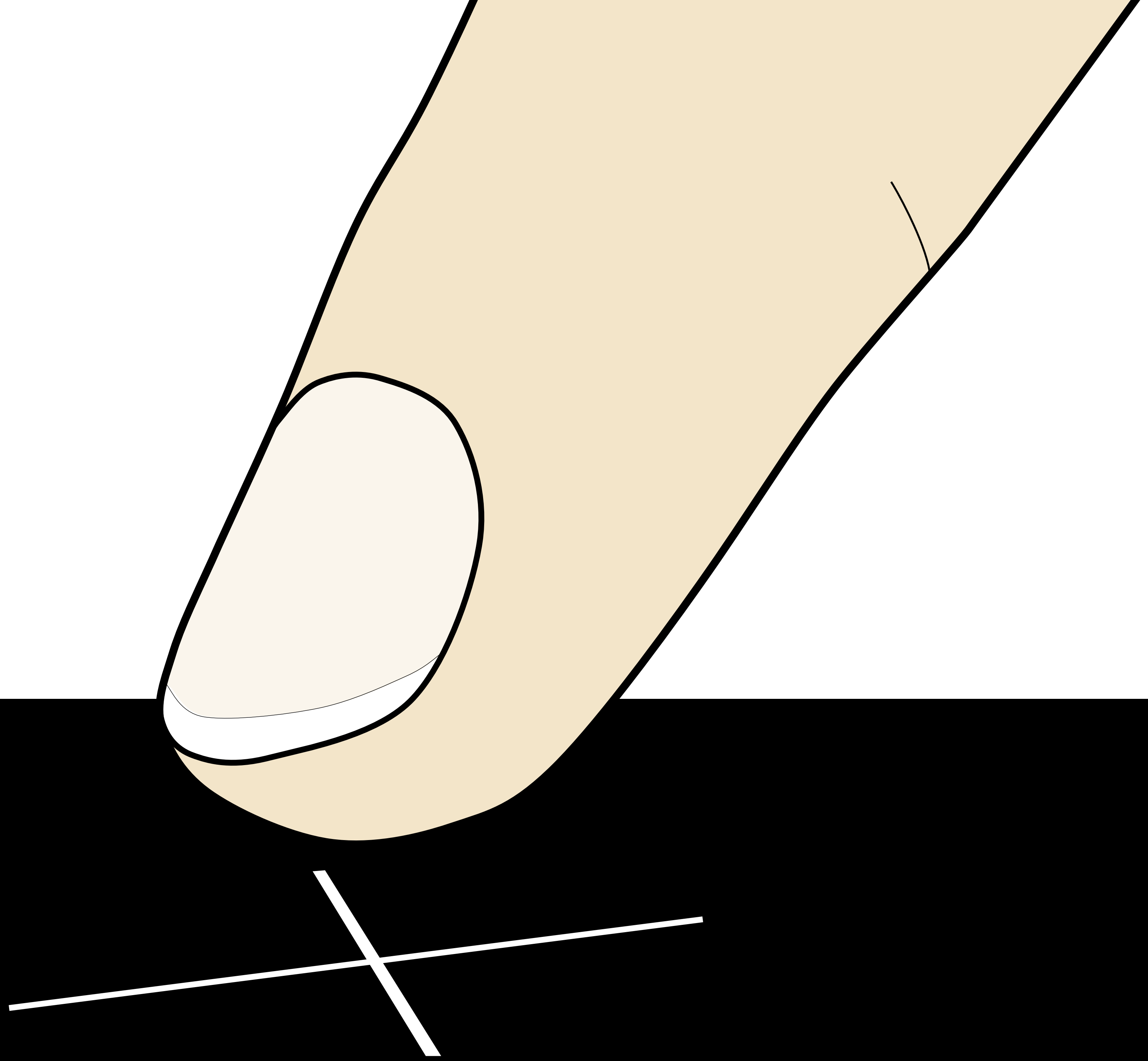

projected center model


projected center model

minimum button size



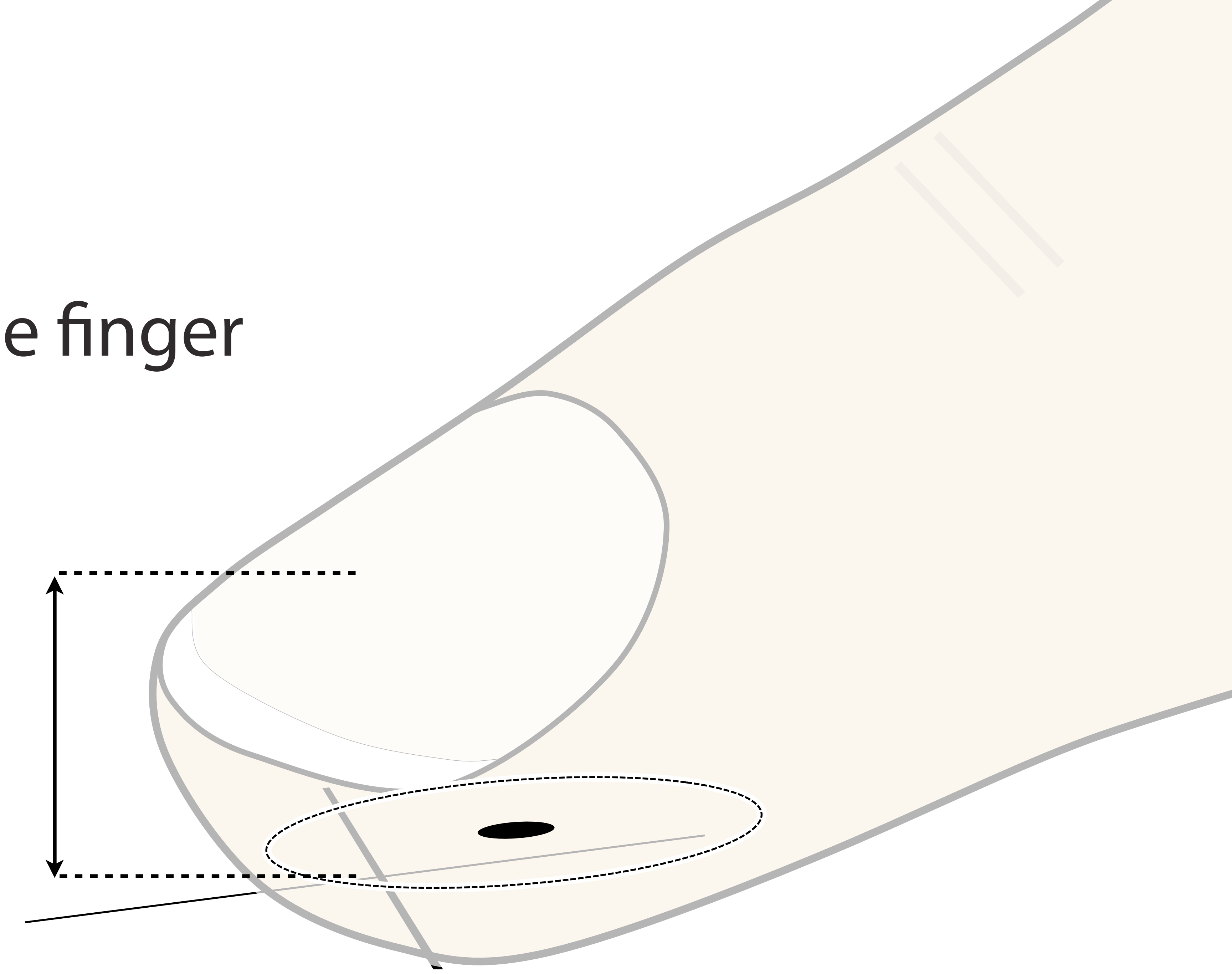
main insight



touch input is a **3D operation**

users target using
features **on top** of the finger

parallax



current devices sense
features **at the bottom** of finger

now we have **two options…**

1) We implement users' **mental models**

Imaginary Phone [UIST '11]

2) We **compensate** for errors

Ridgepad

reconstructs the finger in 3D

input-only

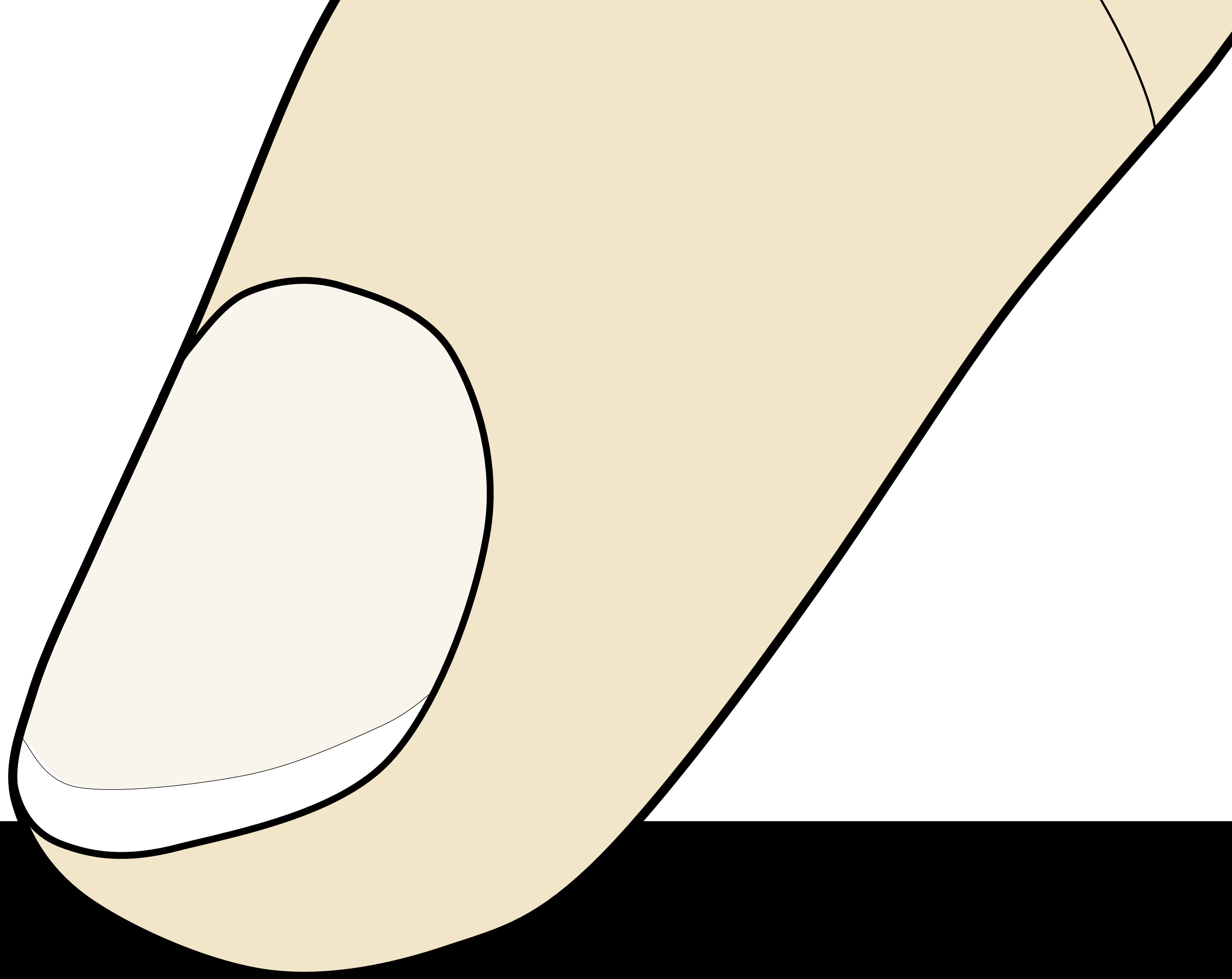
not real-time

[Fiberio, UIST '15]

1 Touch technologies

2 Touch accuracy

Touch Input



CSE 510

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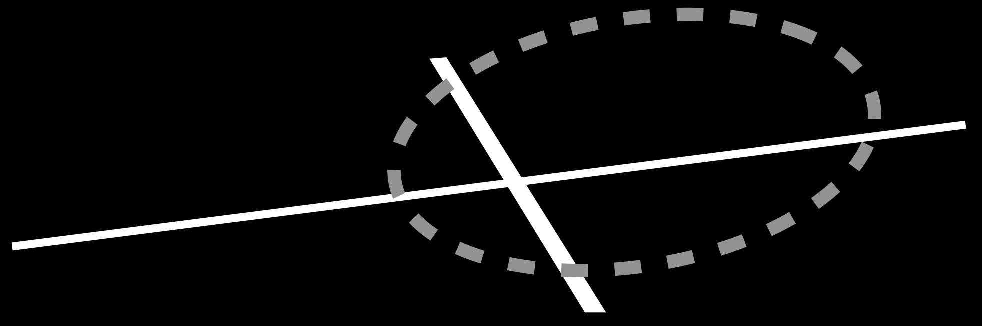

February 11, 2016