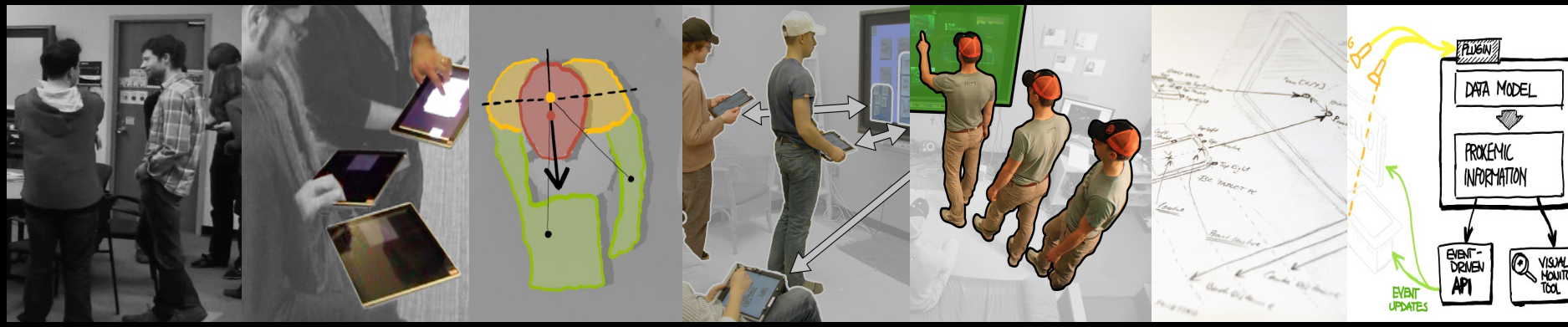
UCL
University College London
Interaction Centre



Towards Ad-hoc Collaboration Spaces with Cross-Device Interaction Techniques

Nicolai Marquardt
University College London
Invited talk at Middlesex University, October 2015

UCL

UCL Interaction Centre
Academic faculty

Yvonne Rogers

Paul Marshall

Ann Blandford

Anna Cox

Duncan Brumby

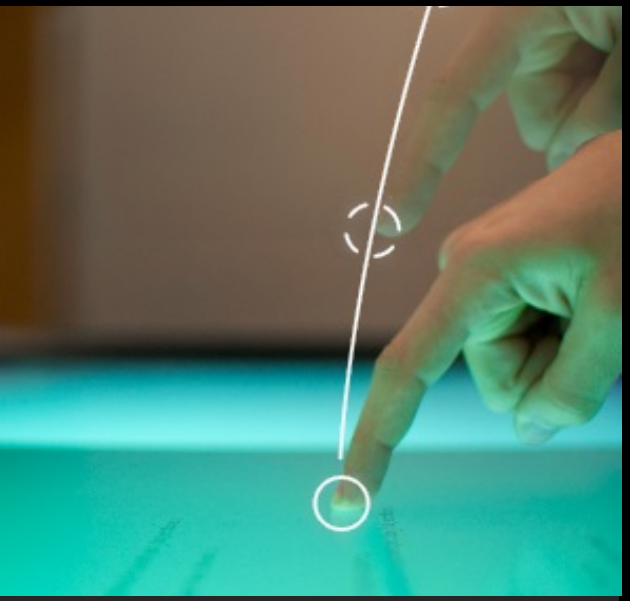
Nadia Berthouze

Rachel Benedyk

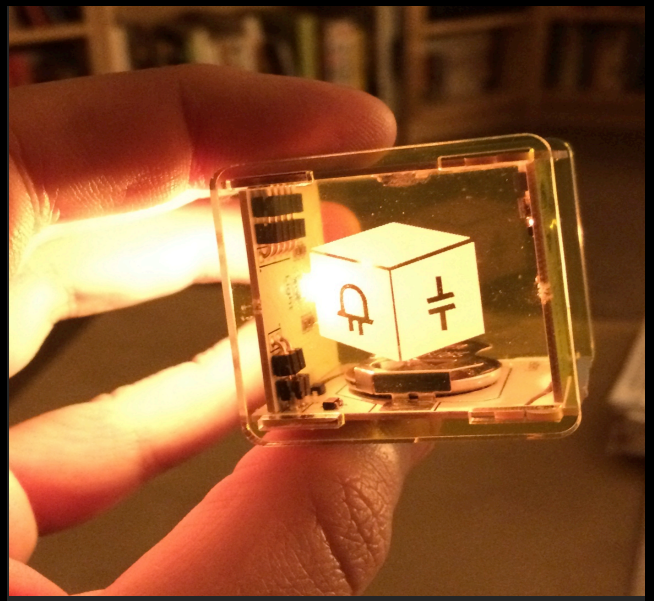
Nic Marquardt

Notting Hill Gate
390

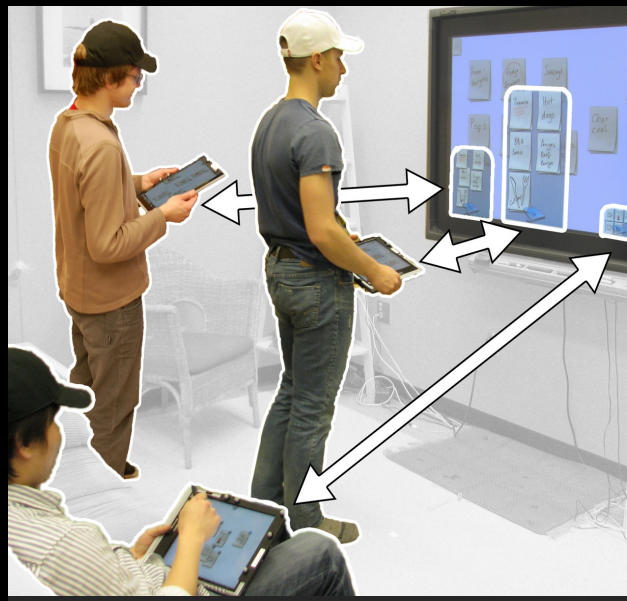
INTERACTION DESIGN



Interaction on and between digital surfaces



Physical Computing and Digital Fabrication

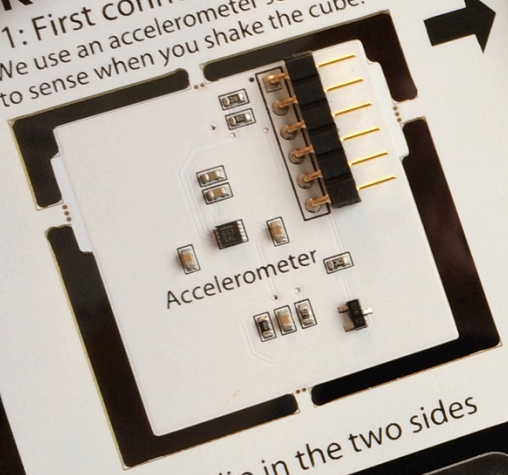


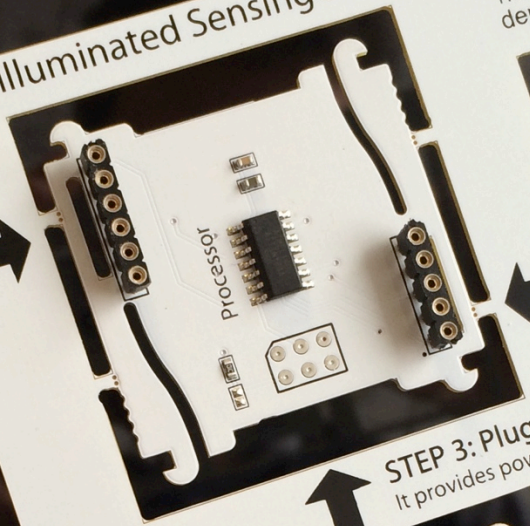
Proxemics in HCI and Proxemic-Aware Technology

Build your own illuminated SensingCube

STEP 1: First connect the Sensor

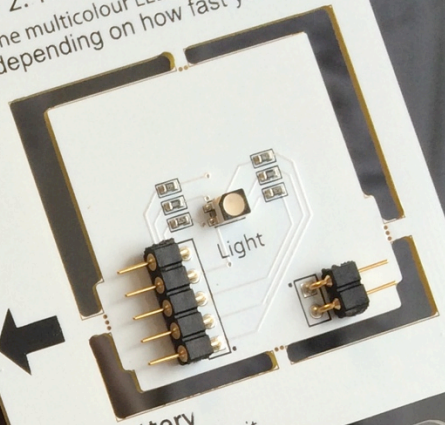
We use an accelerometer sensor to sense when you shake the cube.





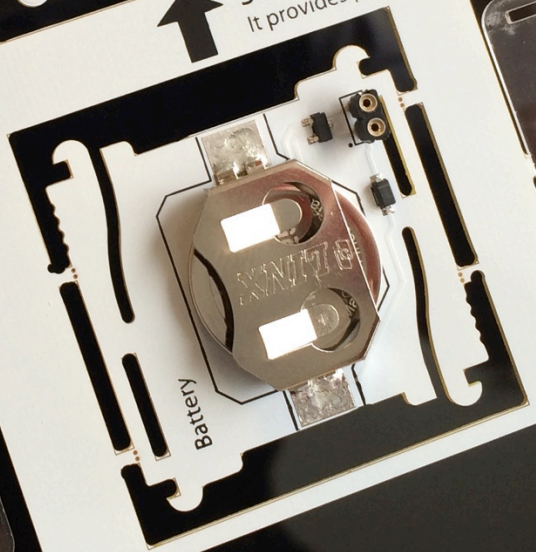
STEP 2: Then connect the Light

The multicolour LED changes its colour depending on how fast you shake.

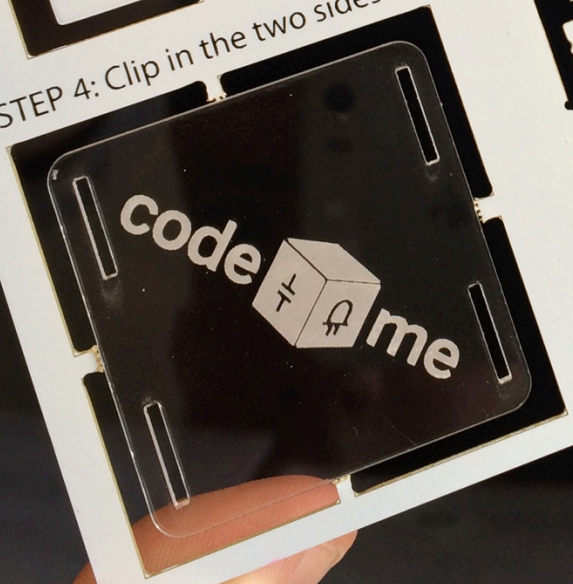


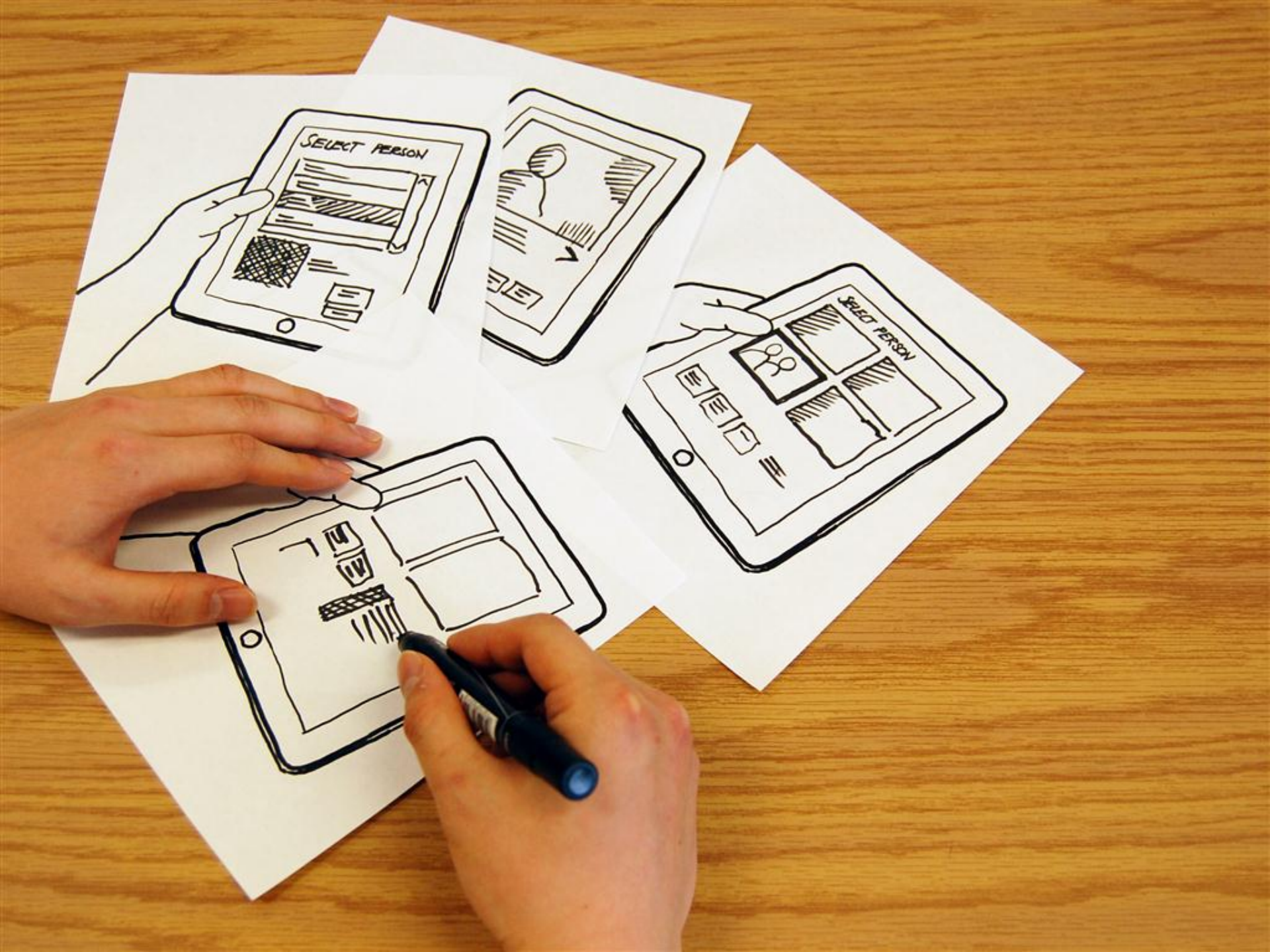
STEP 3: Plug in the battery

It provides power for your sensing circuit.

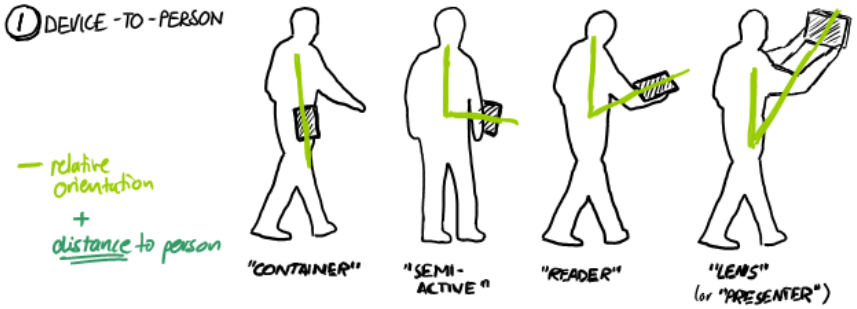


STEP 4: Clip in the two sides

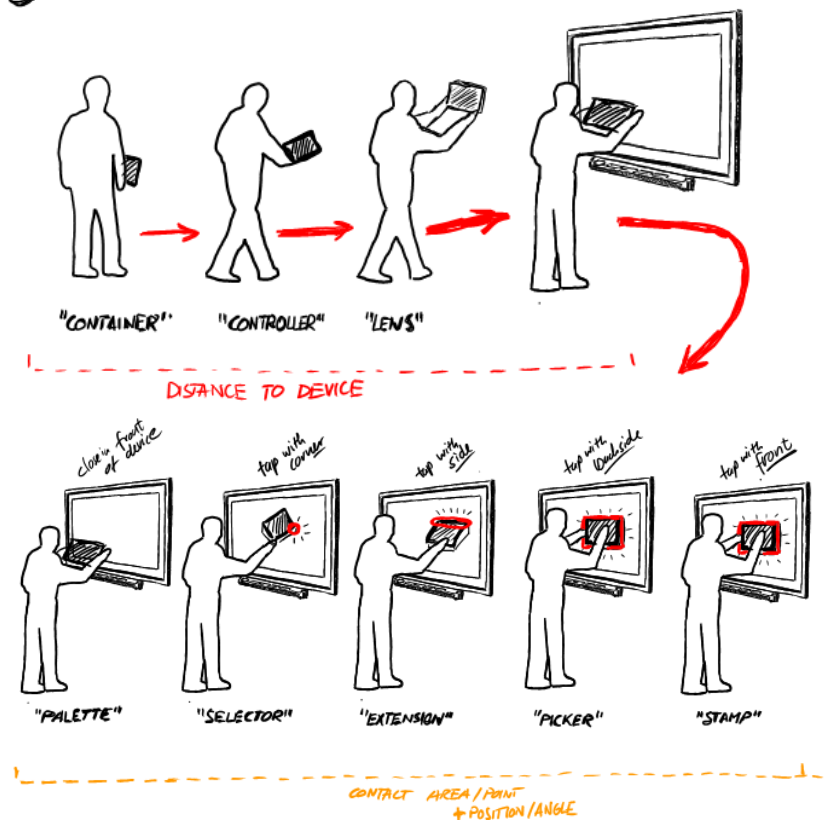



SELECT PERSON
SELECT PERSON

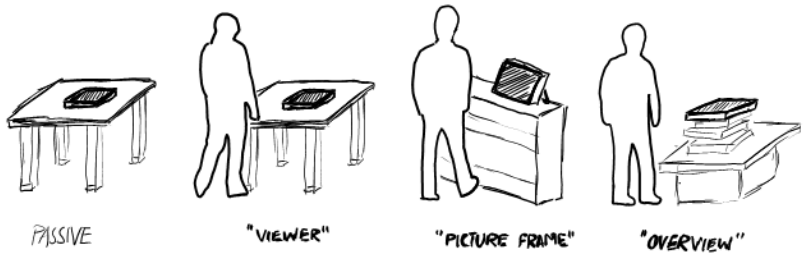
1 DEVICE-TO-PERSON



2 DEVICE-TO-DEVICE

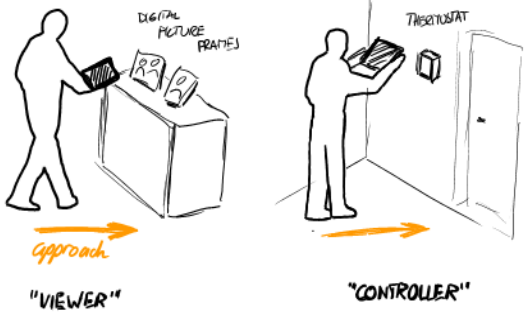


3 DEVICE-TO-NON DIGITAL OBJECTS / FIXED AND SEMIFIXED FEATURE SPACE

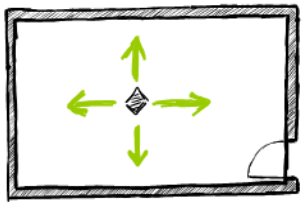


4 DEVICE-TO-INFORMATION APPLIANCES

(subset of device-to-device?)



5 DEVICE-TO-FIXED FEATURE/ ENVIRONMENT



- location & orientation relative to room
- identity of room?

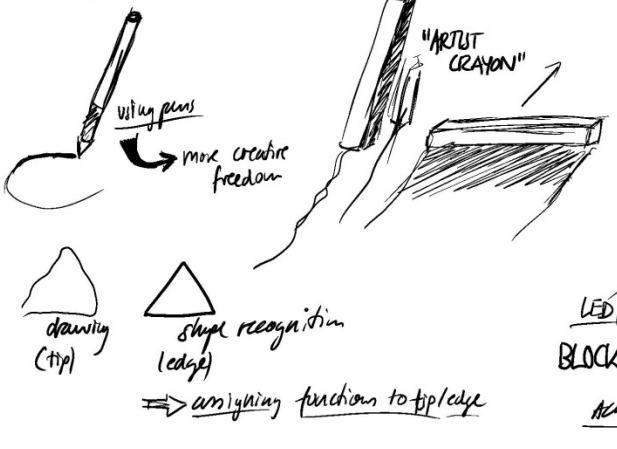
6 DEVICE PROPERTIES

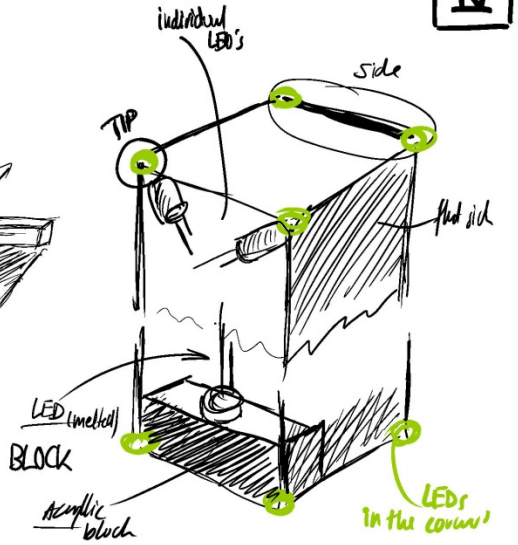
- visible
- activity
- owner
- people around
- global orientation (gyro + acc + compass)

UIST CONFERENCE 2011

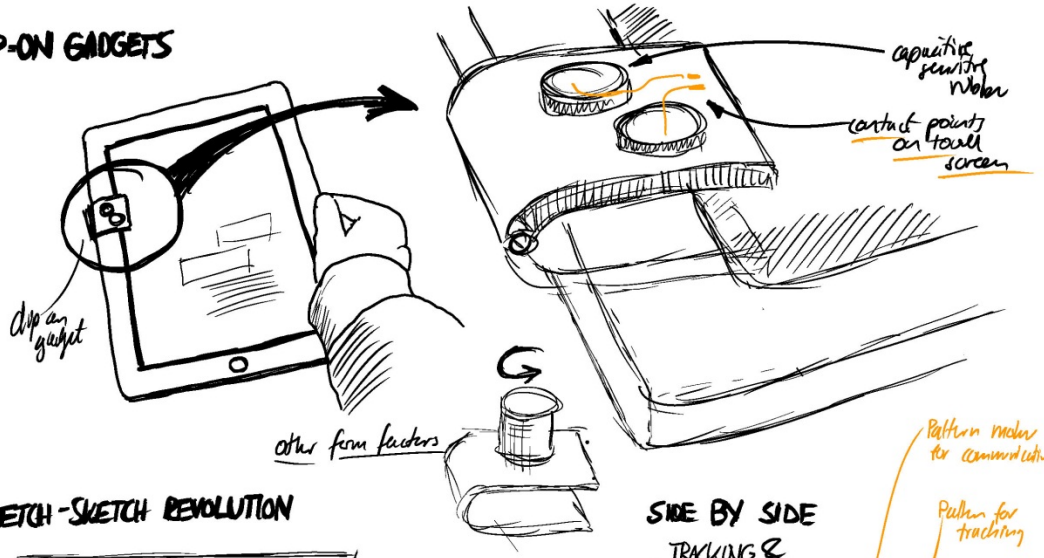
IV

CONTÉ (Daniel Vogel)

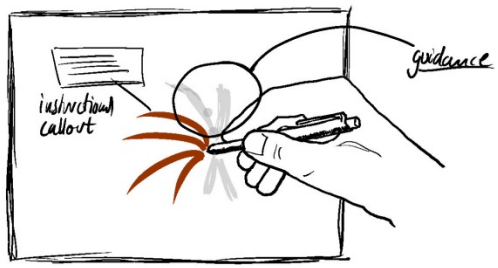




CLIP-ON GADGETS

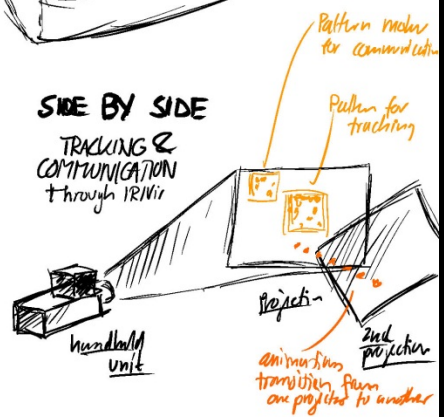


SKETCH-SKETCH REVOLUTION



SIDE BY SIDE

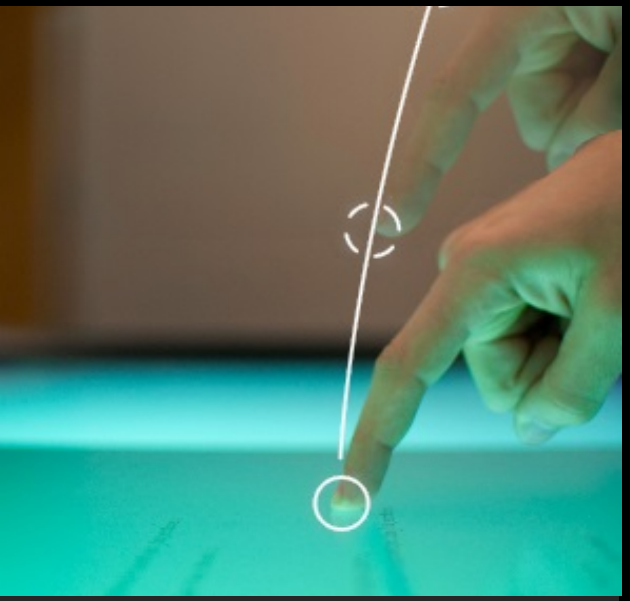
TRACKING & COMMUNICATION through IR/Vis



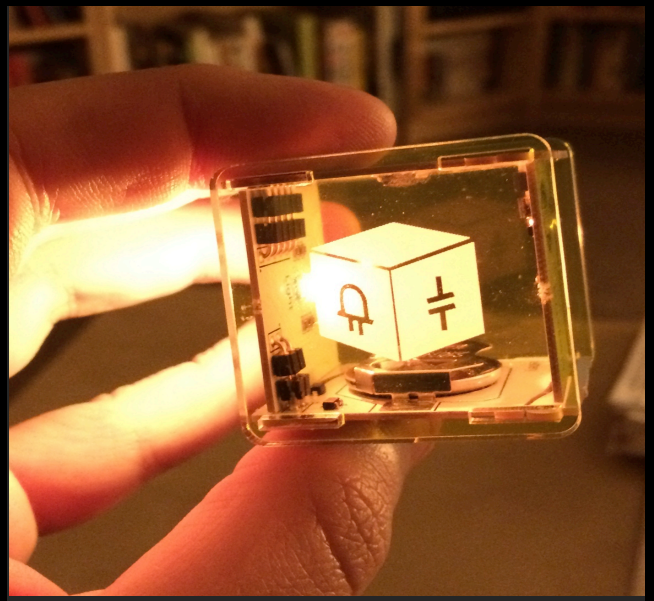
Sketching USER EXPERIENCES

Saul Greenberg
Sheelagh Carpendale
Nicolai Marquardt
Bill Buxton

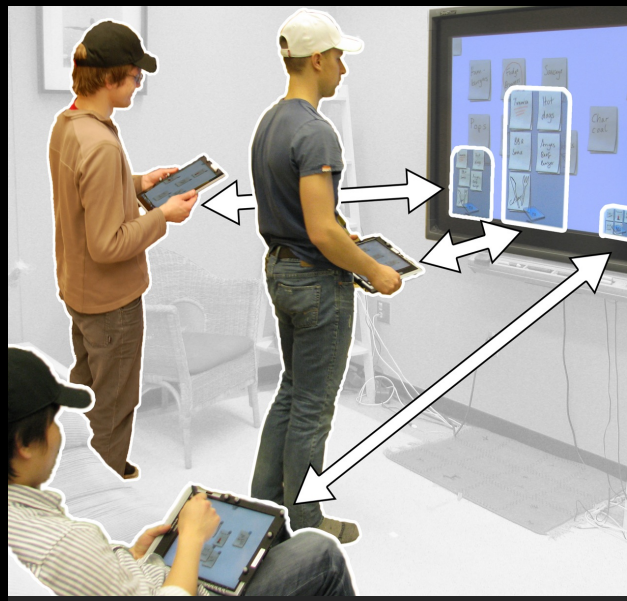
MK
MORGAN KAUFMANN



Interaction on and between digital surfaces



Physical Computing and Digital Fabrication



Proxemics in HCI and Proxemic-Aware Technology

Saul Greenberg
University of Calgary

Ken Hinckley
Microsoft Research Redmond

Till Ballendat
Avanade (Microsoft/Accenture)

Rob Diaz-Marino
SMART Technologies

Sebastian Boring
University of Copenhagen

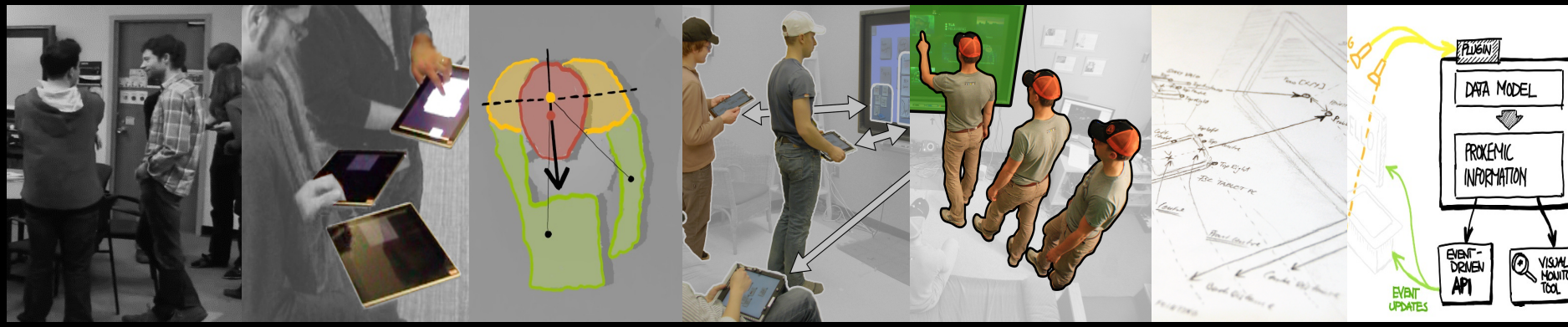
Yvonne Rogers
Director UCL Interaction Centre

Steven Houben
ICRI, University College London

Frederik Brudy
University College London

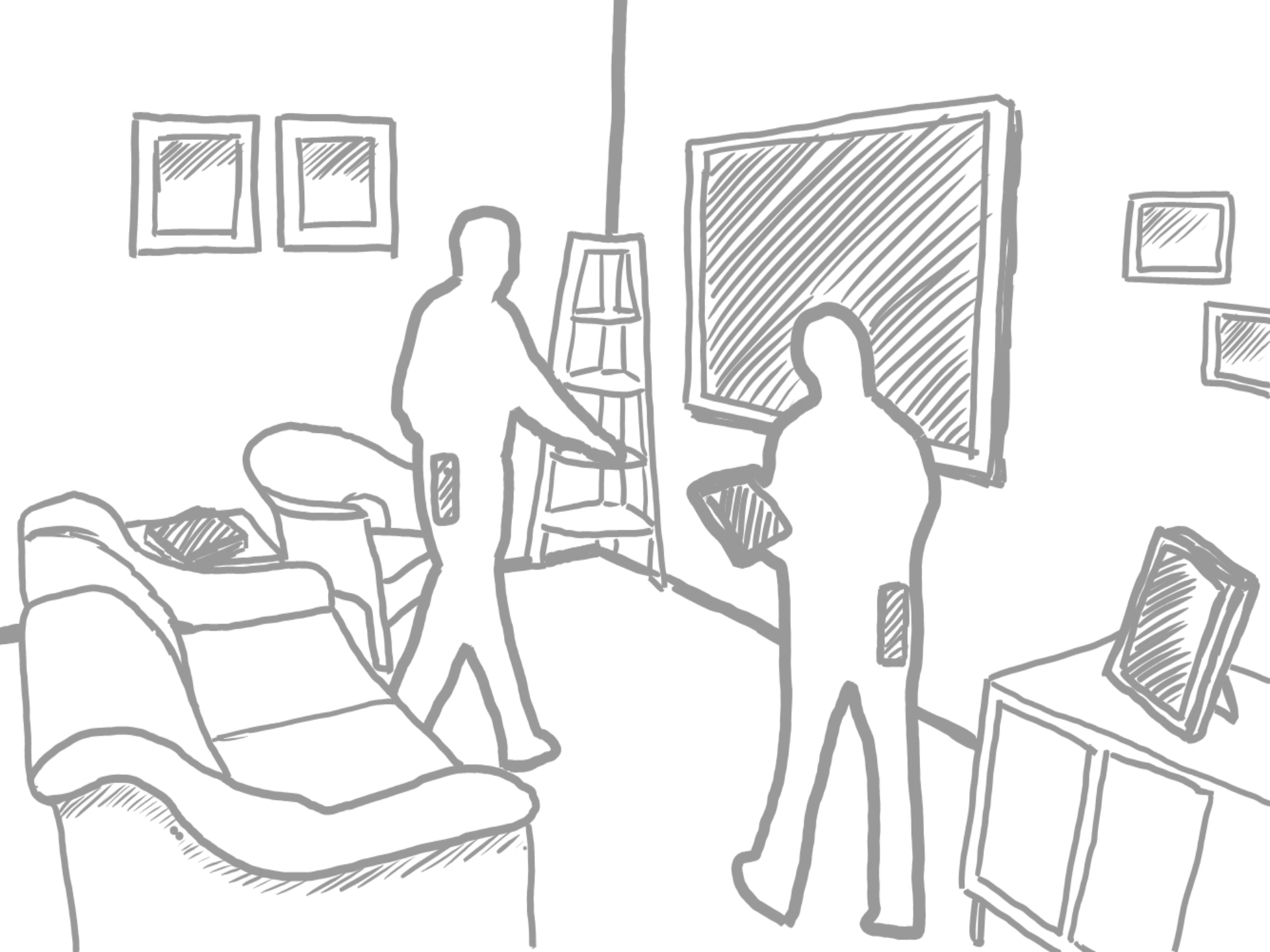
Roman Rädle
University Konstanz

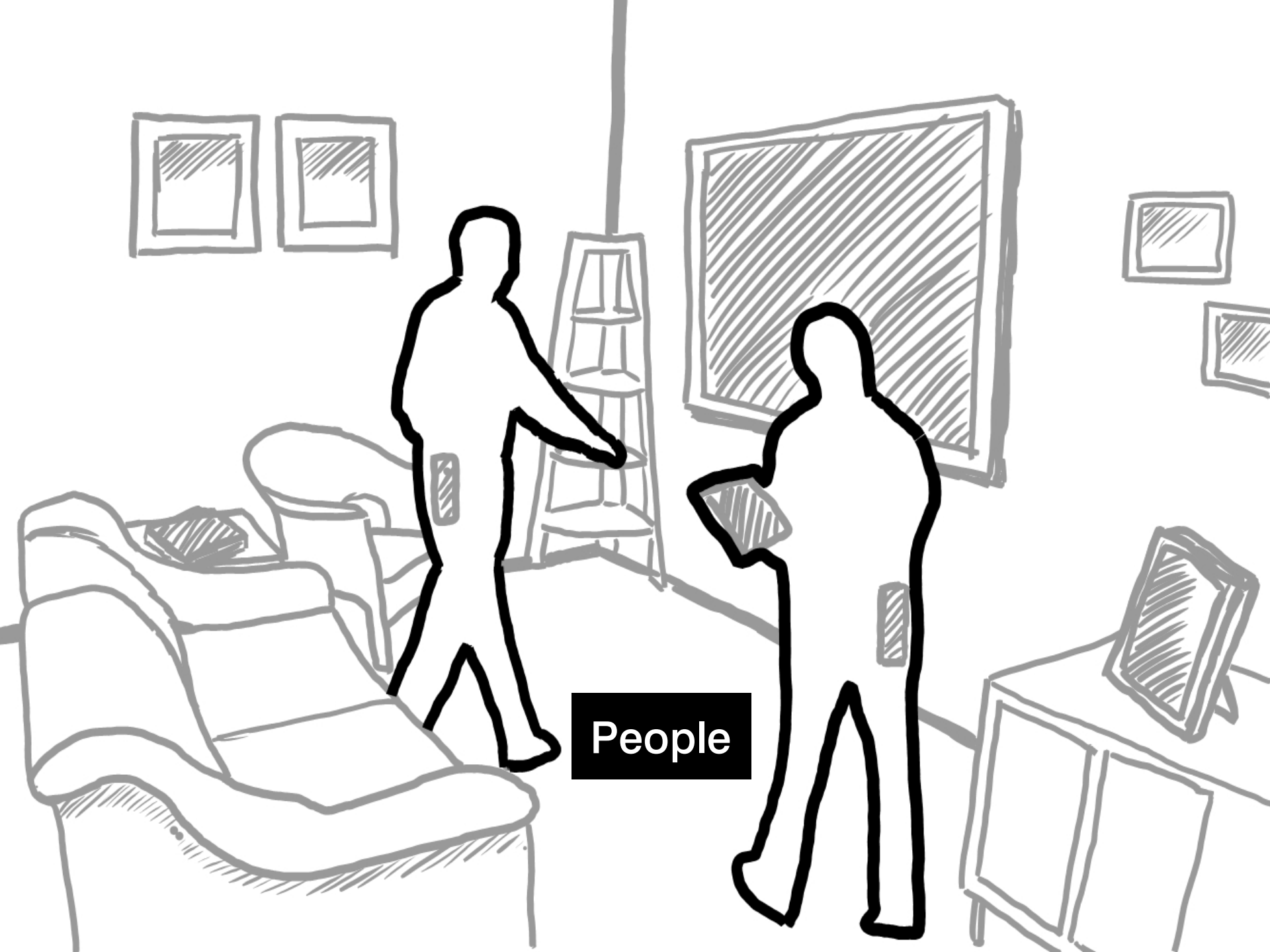
Christian Jetter
Postdoc INTEL ICRI

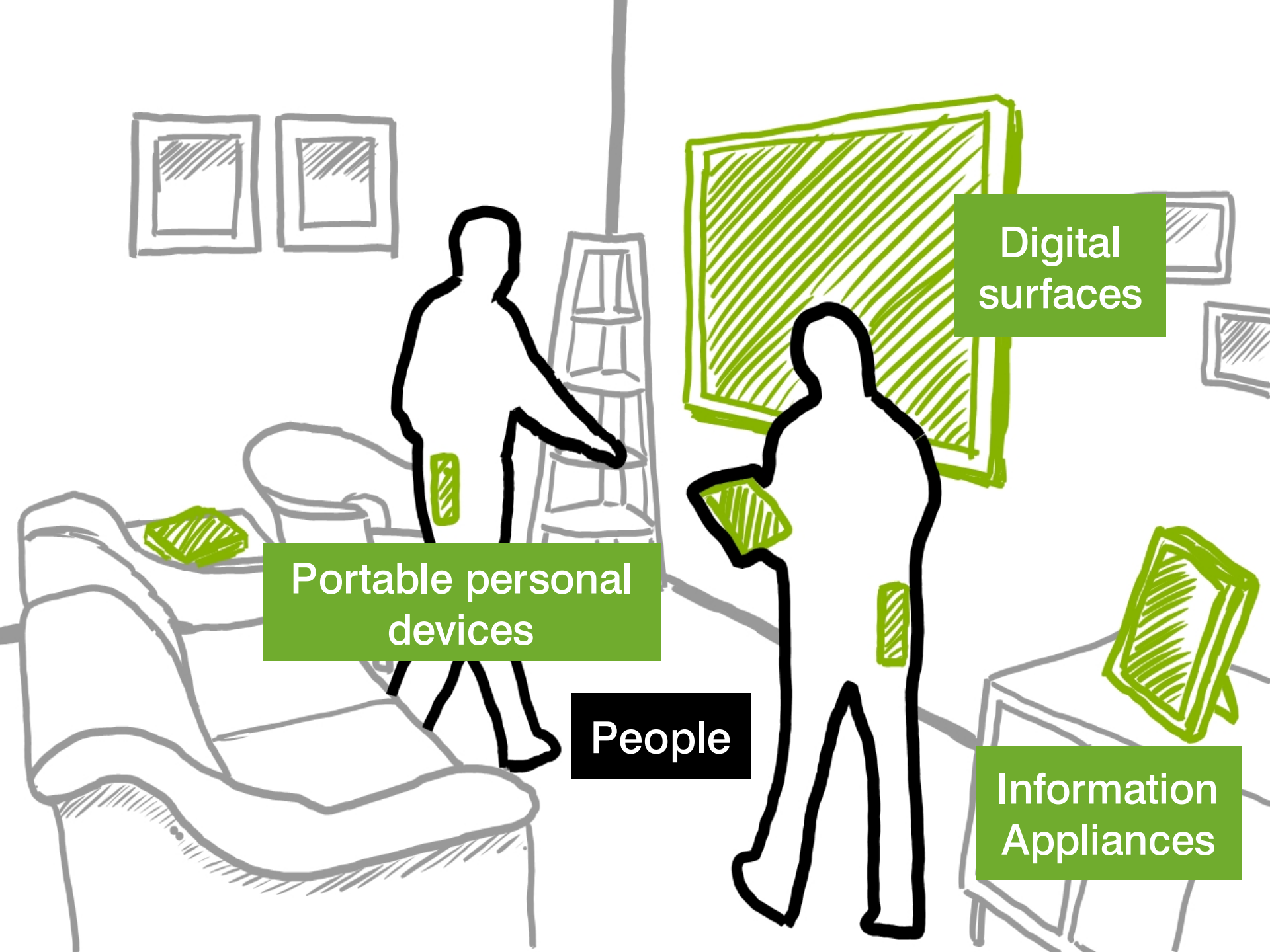


Towards Ad-hoc Collaboration Spaces with Cross-Device Interaction Techniques

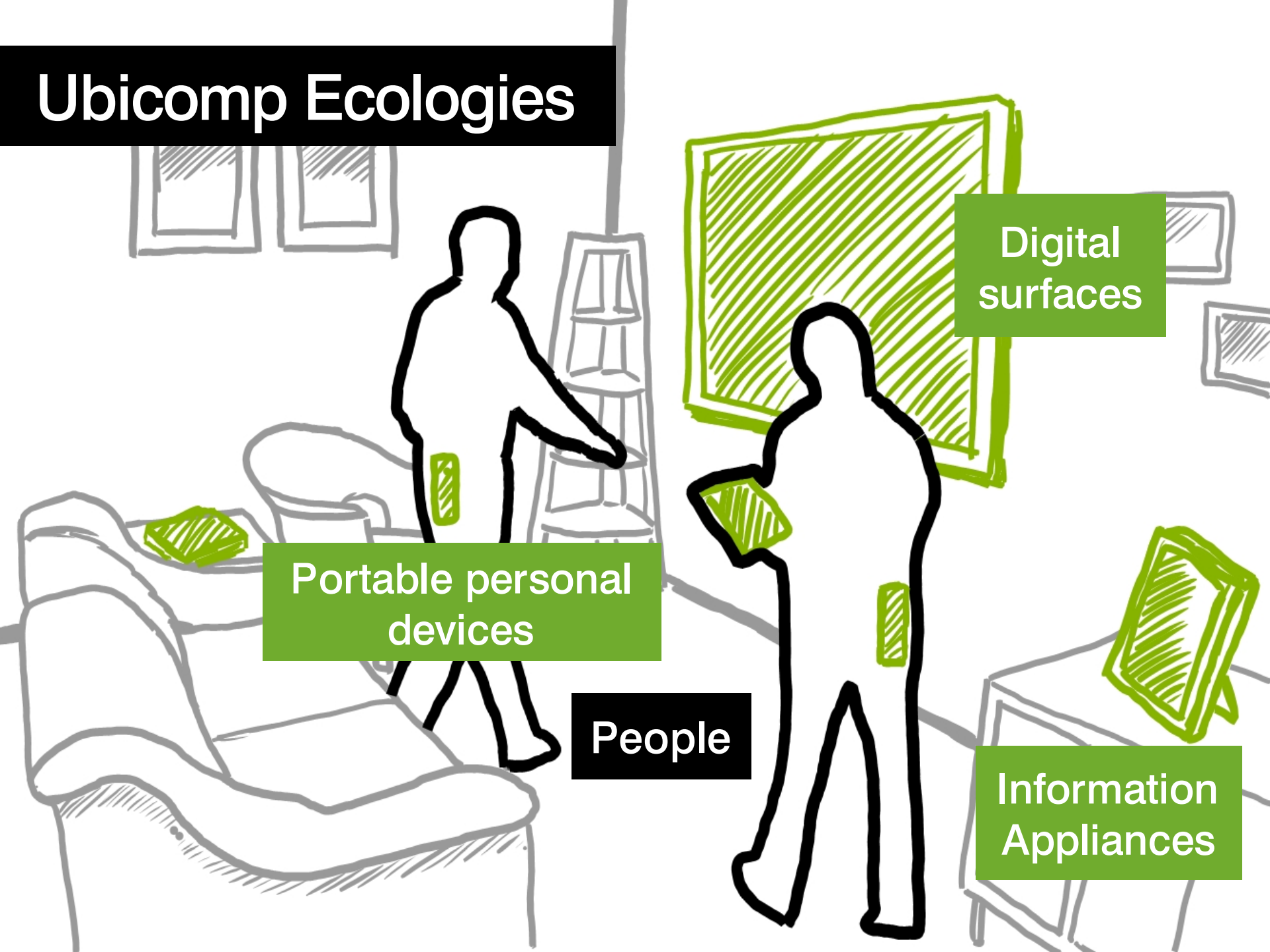
LGERIA
LIBYA
NIGER
CHAD
NIGERIA
CENTRAL AFRICAN REPUBLIC
ARABIA
YEMEN
SEYCHELLES
ANGOLA
NAMIBIA
BOTSWANA
SOUTH AFRICA
St. Helena

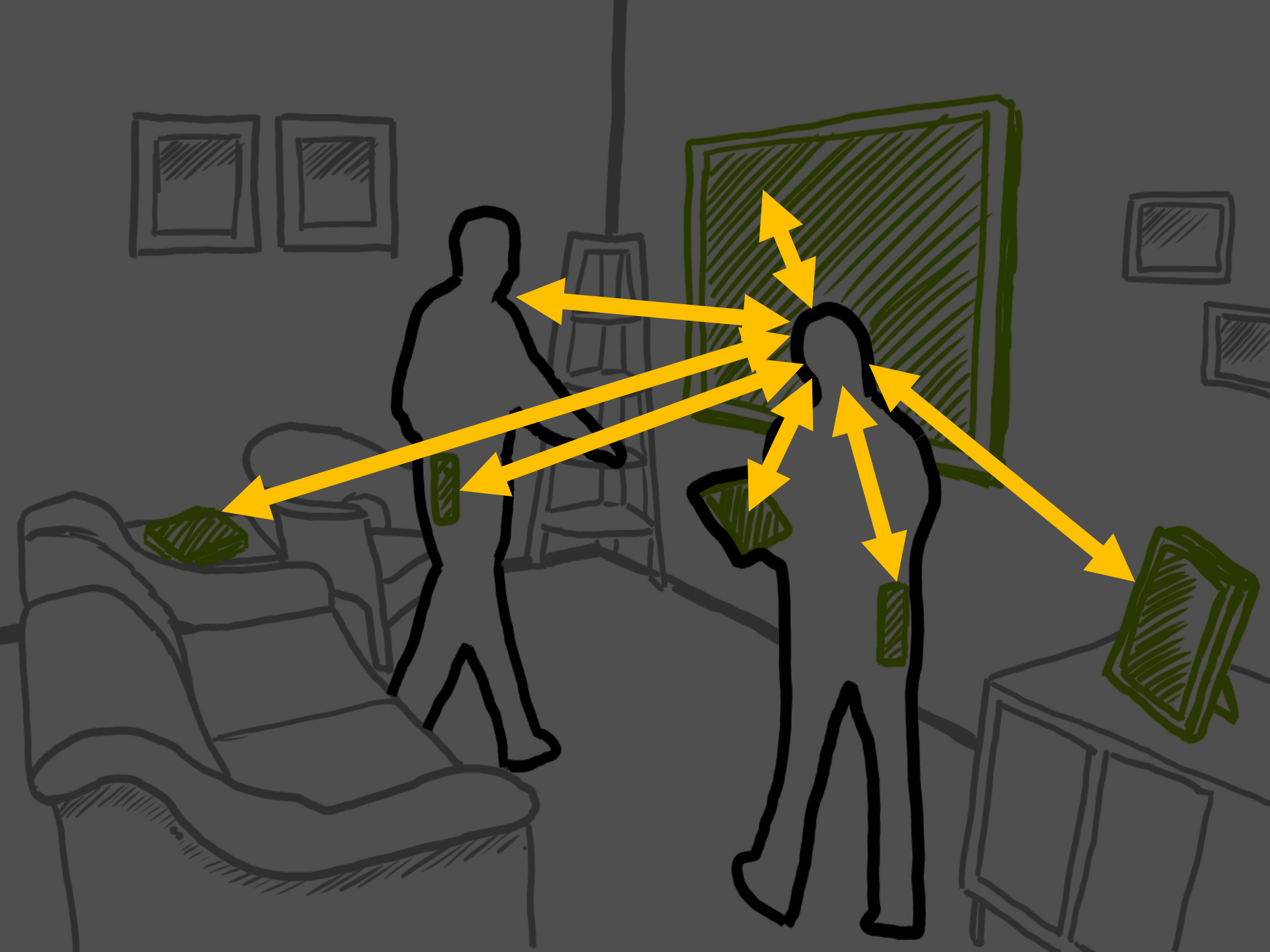


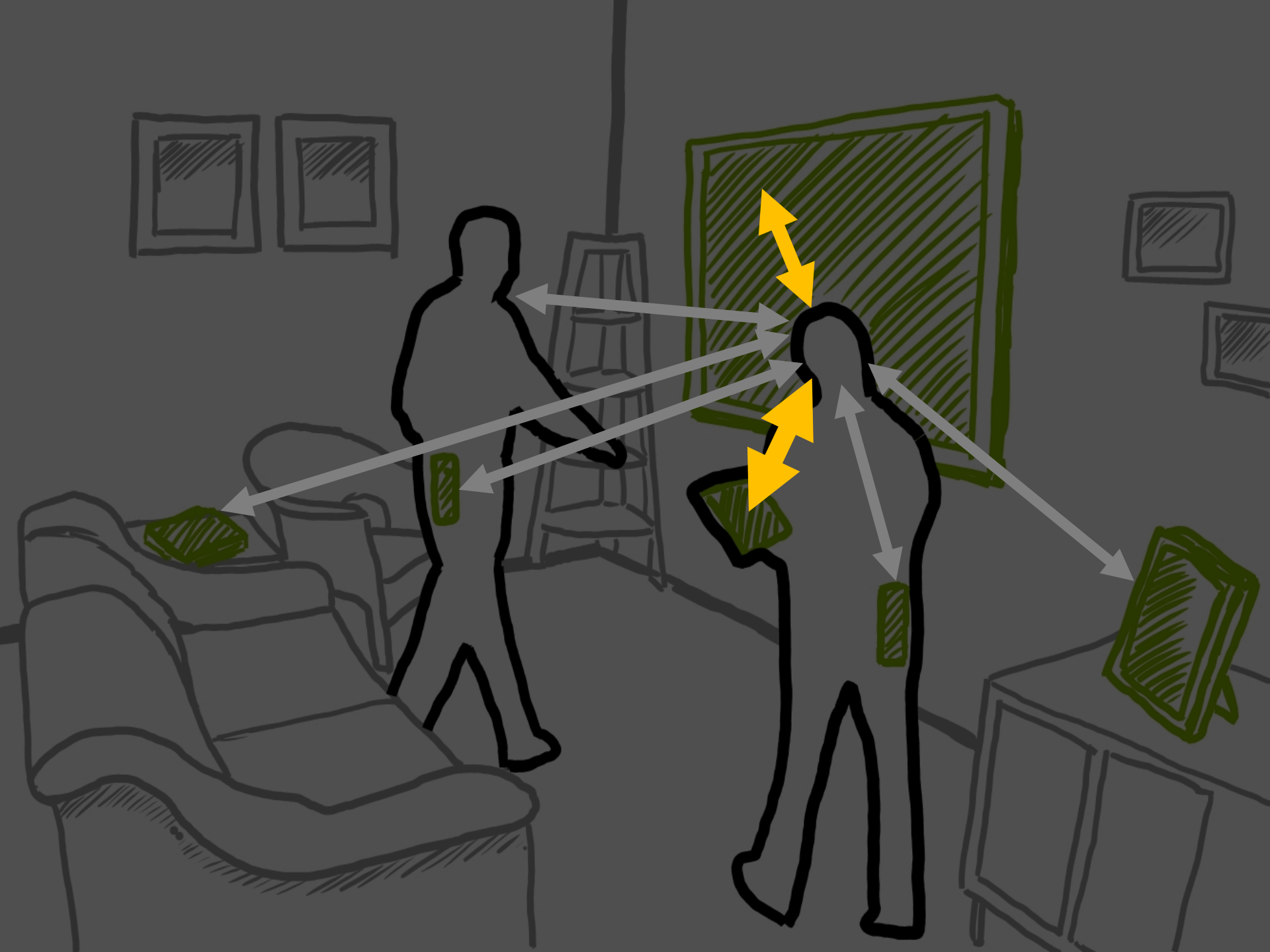

People


Digital surfaces
Portable personal devices
People
Information Appliances

Ubicomp Ecologies







Proxemics

People's understanding and use of personal space

UNSC

Photo source: Allan Rostron

Photo source: Allan Rostron

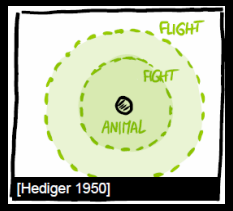
Photo source: Library of Congress

Proxemic Interaction

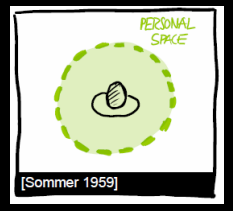
Proxemic Interaction
imagines a world of devices that have **fine-grained knowledge** of nearby **people and other devices**
and how such knowledge can be **exploited in ubicomp interaction design**.

Social Theories about people's use and understanding of personal space

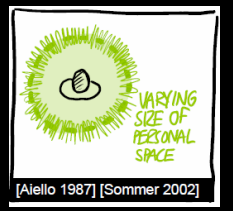
Marquardt, N. and Greenberg, S. (2012) Informing the Design of Proxemic Interactions. In IEEE Pervasive Computing, 11(2):14-23, April-June. Joe Paradiso, Trevor Pering, Albrecht Schmidt, Eds.



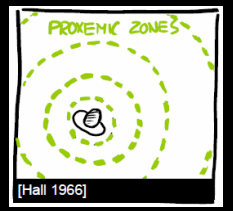
[Hediger 1950]



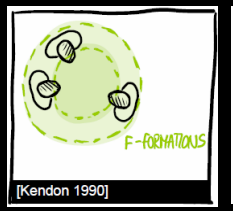
[Sommer 1959]



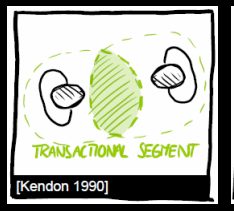
[Aiello 1987] [Sommer 2002]



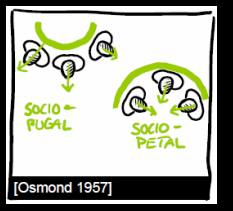
[Hall 1966]



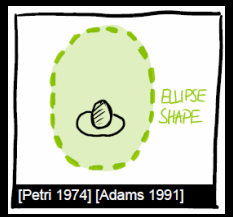
[Kendon 1990]



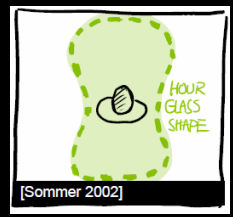
[Kendon 1990]



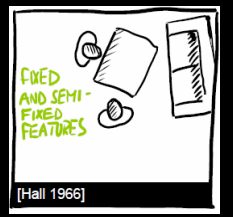
[Osmond 1957]



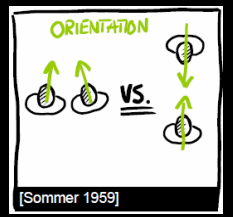
[Petri 1974] [Adams 1991]



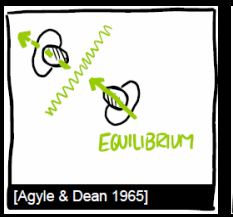
[Sommer 2002]



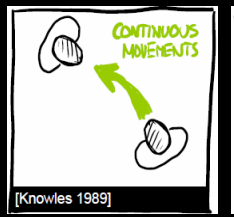
[Hall 1966]



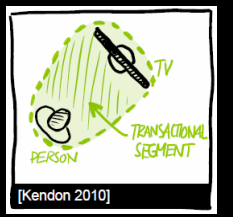
[Sommer 1959]



[Agyle & Dean 1965]

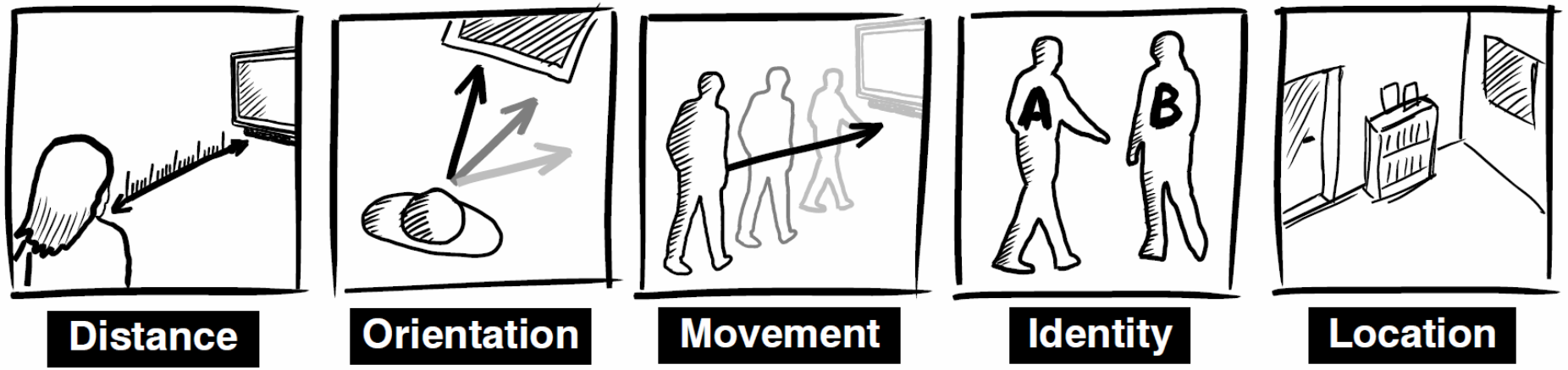


[Knowles 1989]

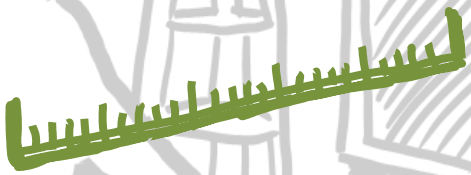


[Kendon 2010]

Operationalizing Proxemics for **Interaction Design**

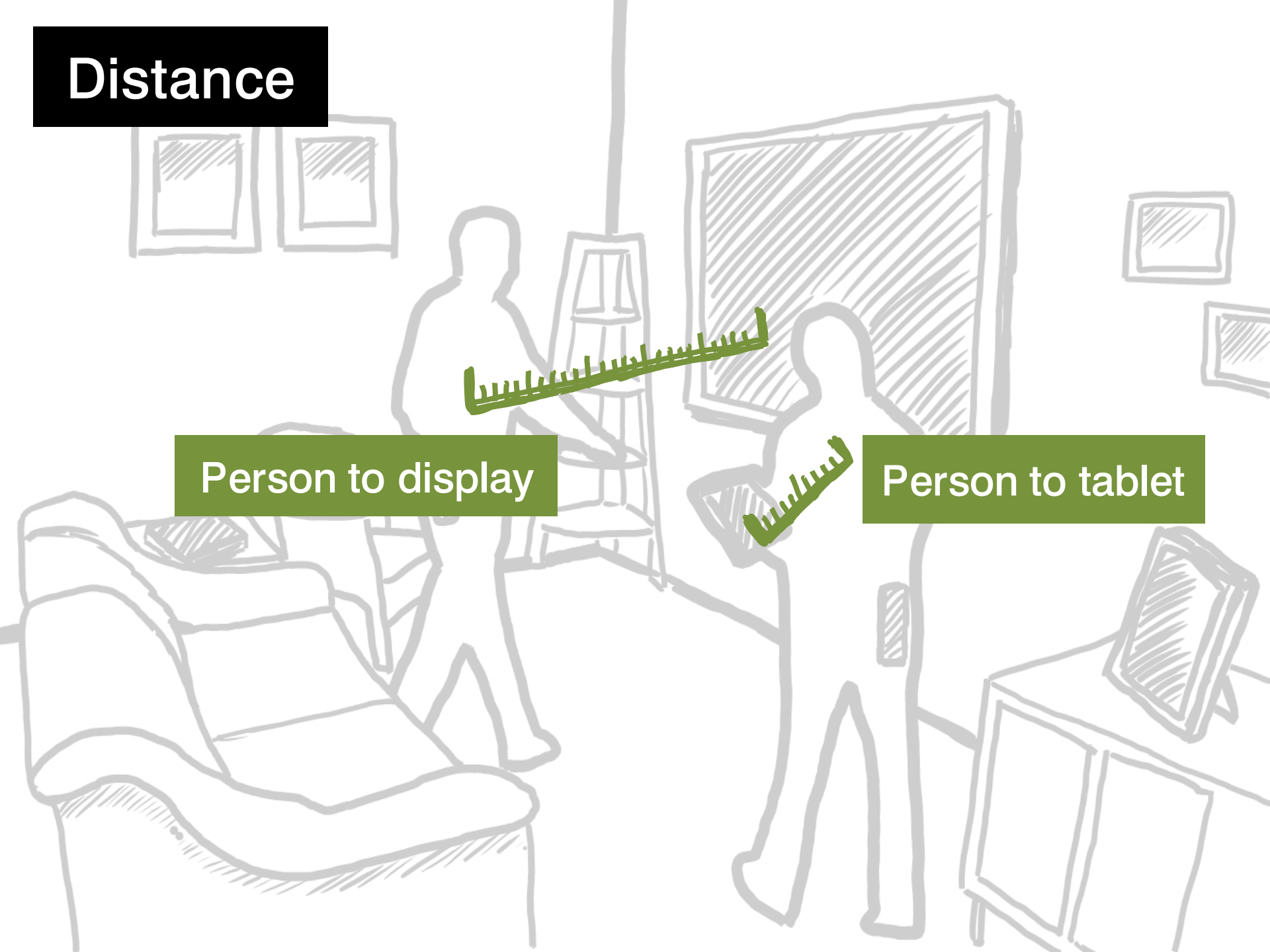


Distance

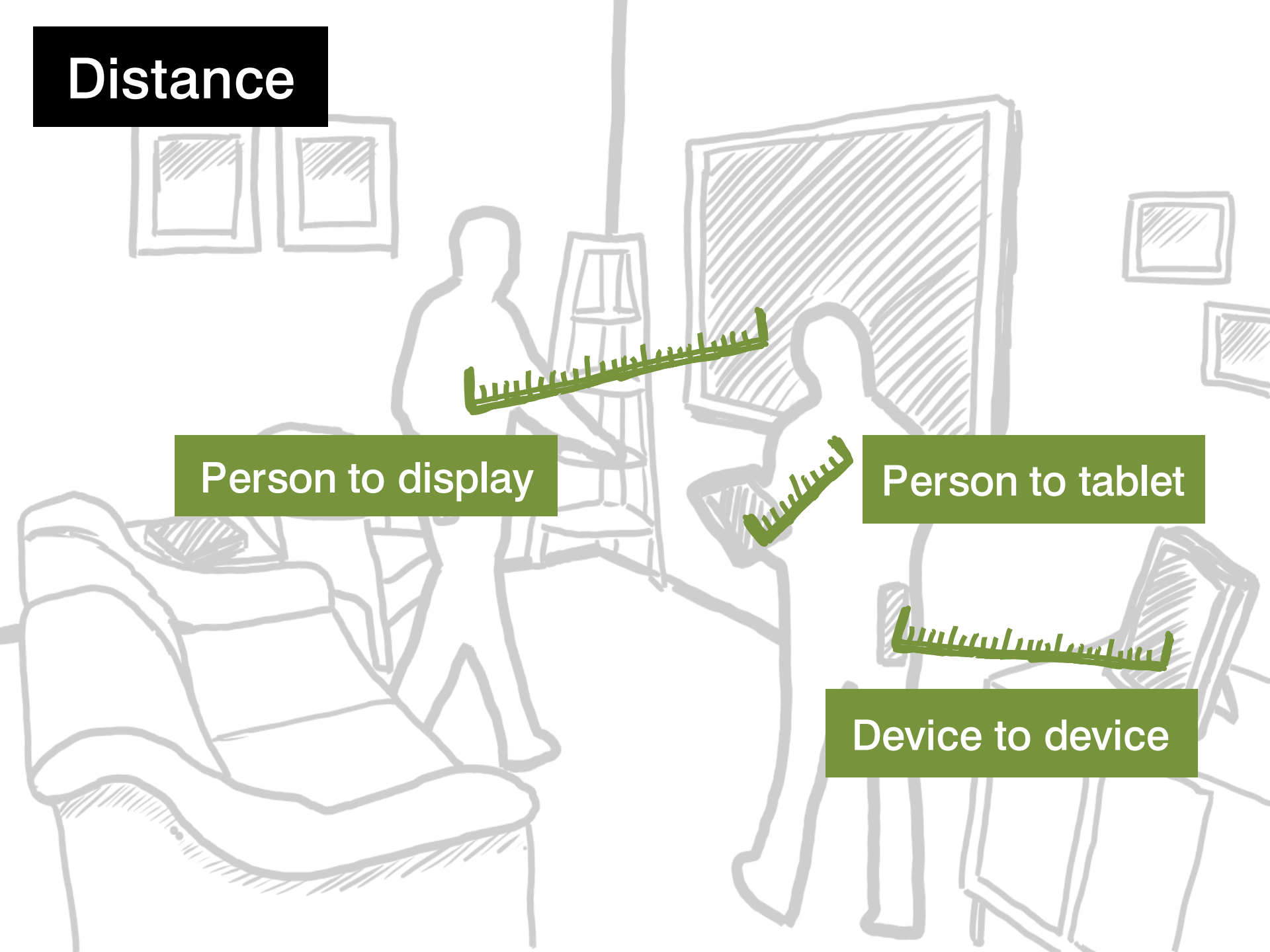


Person to display

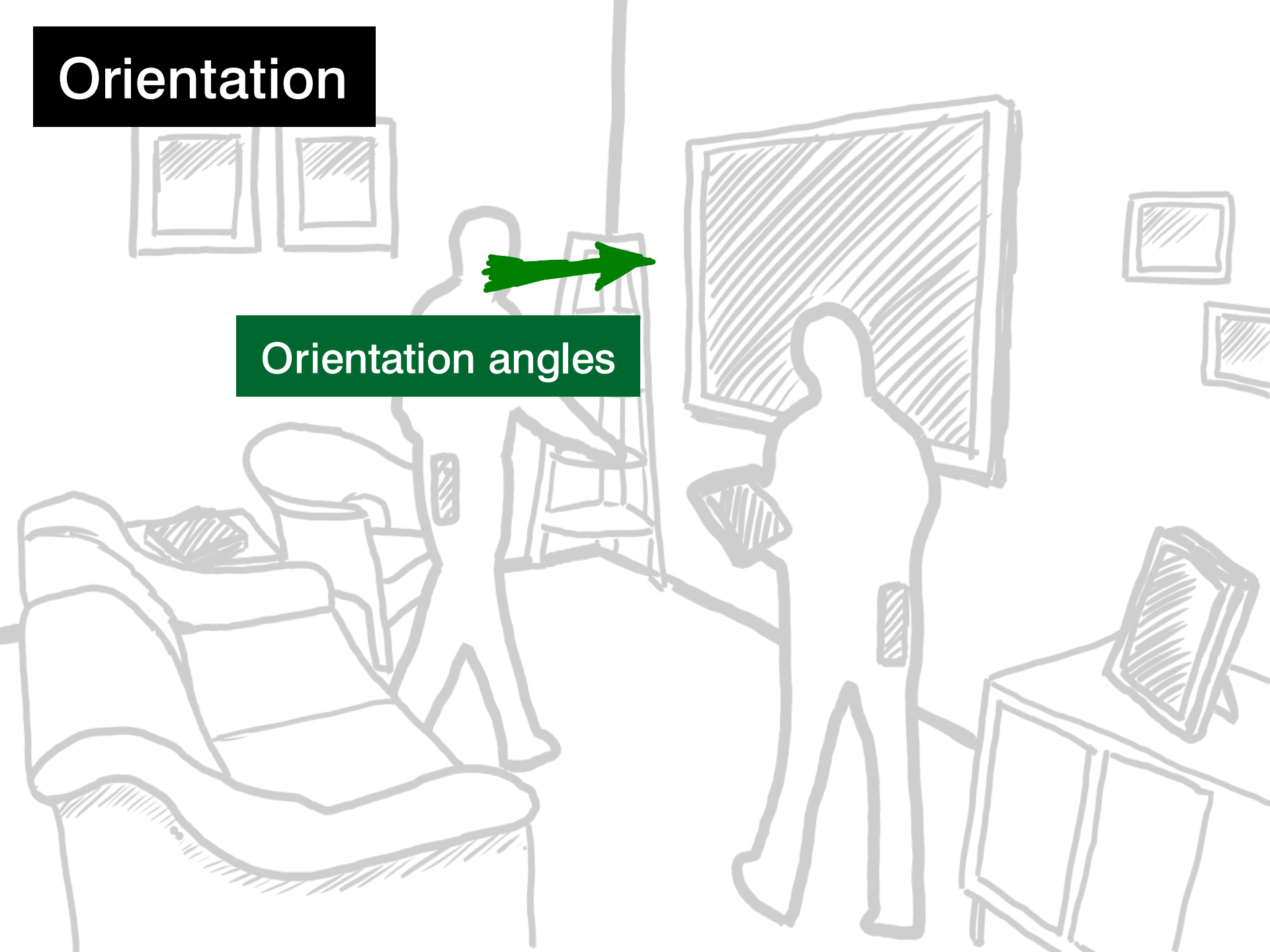
Distance



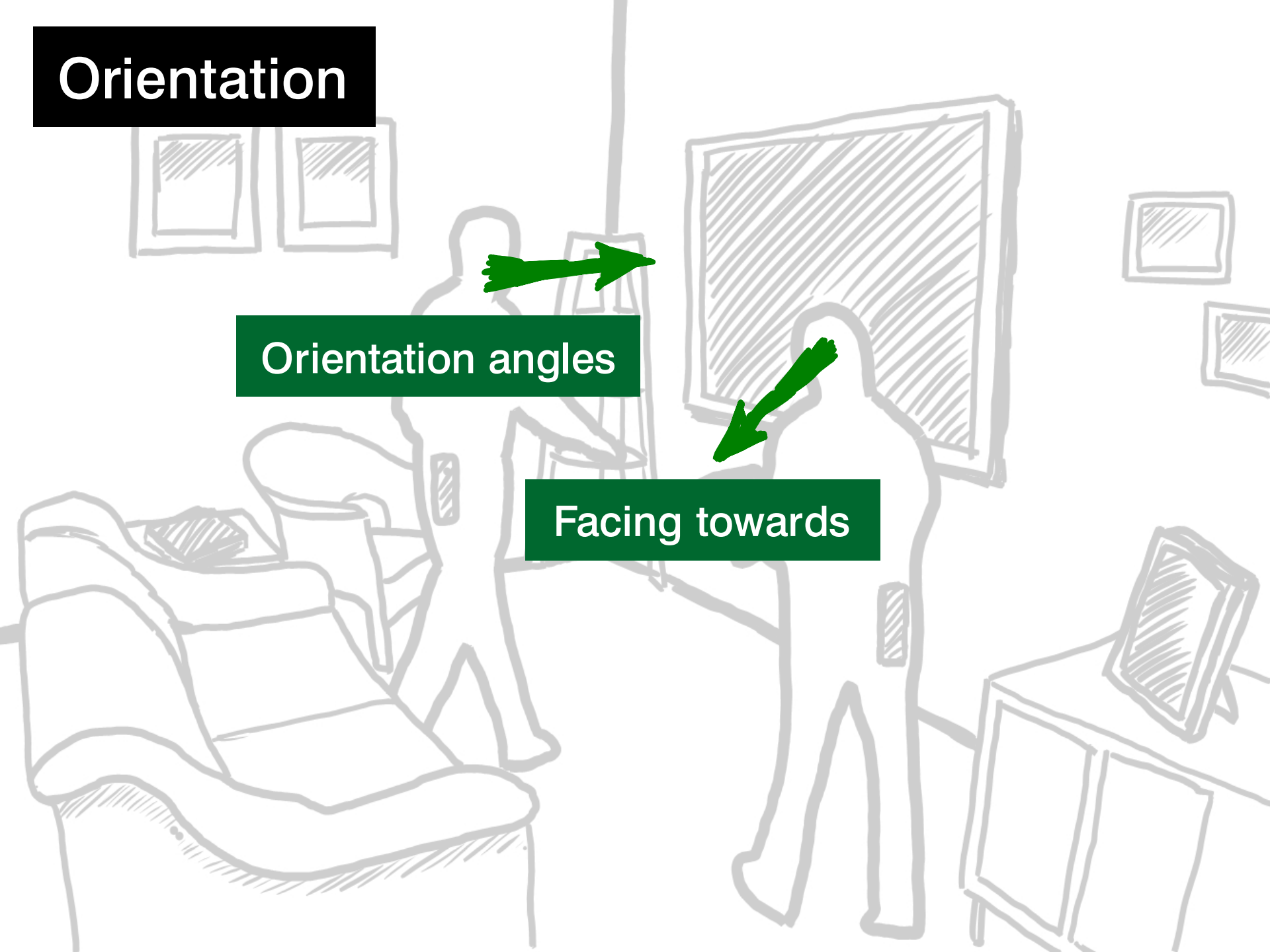
Distance



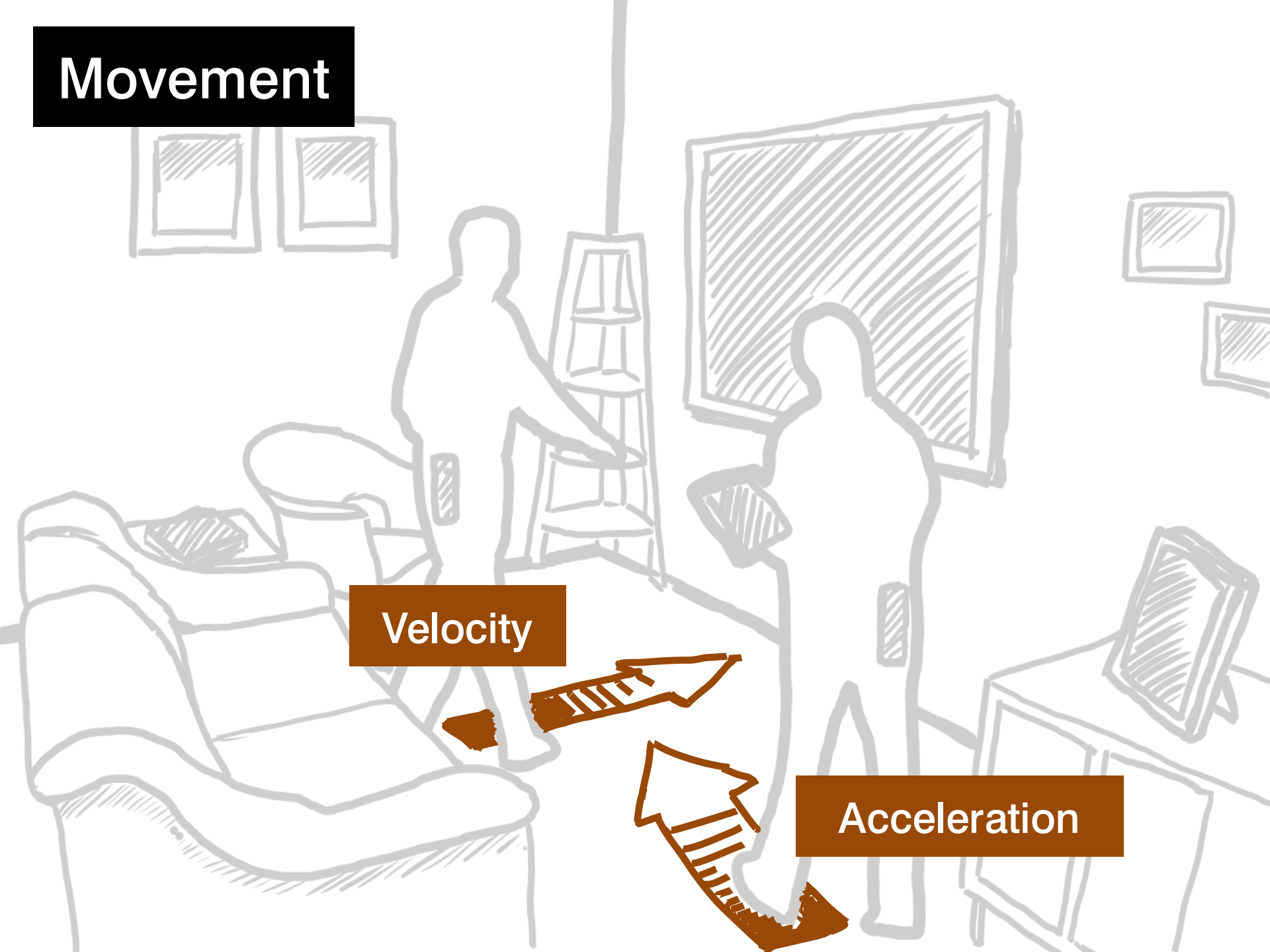
Orientation

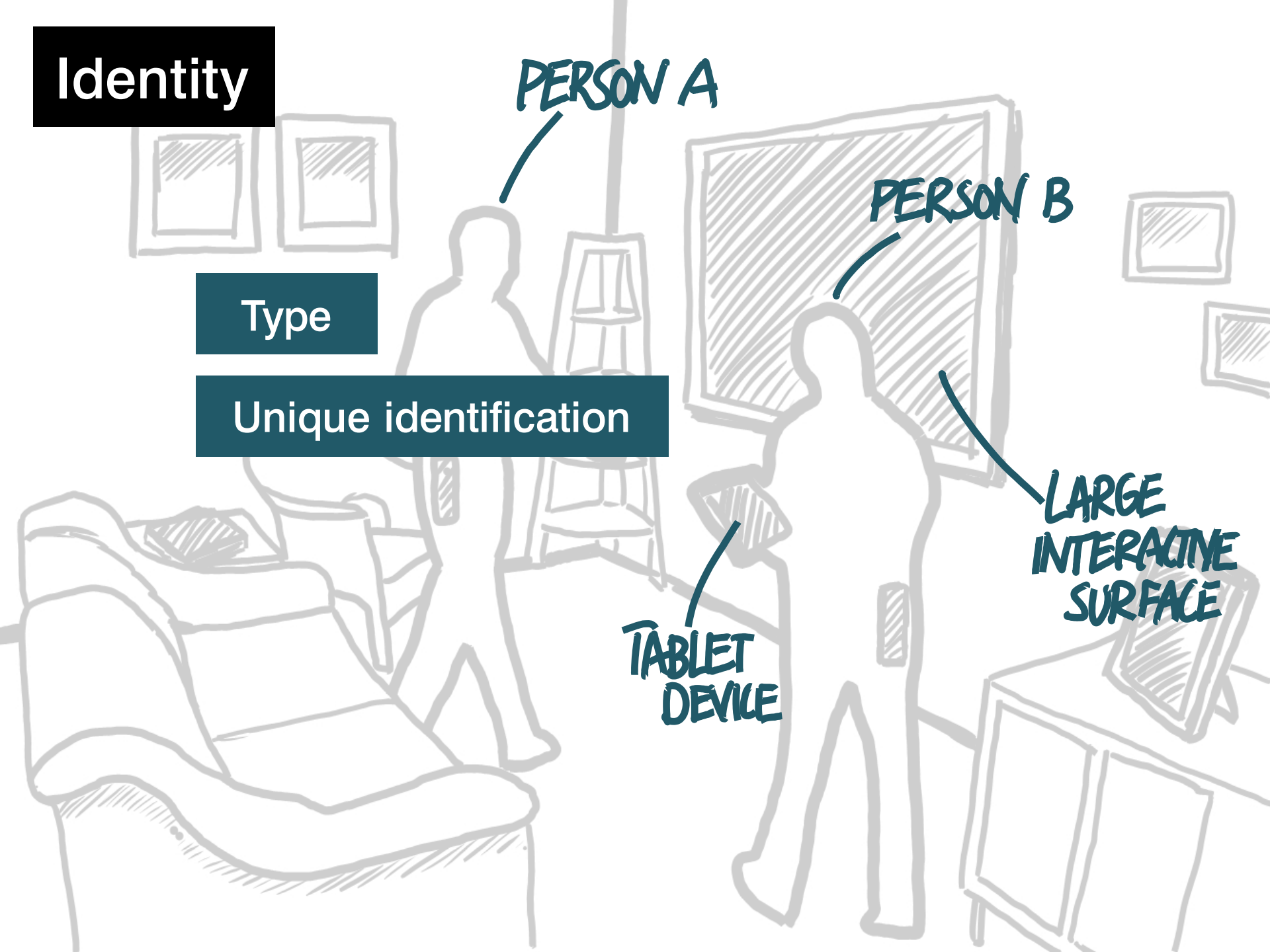


Orientation



Movement

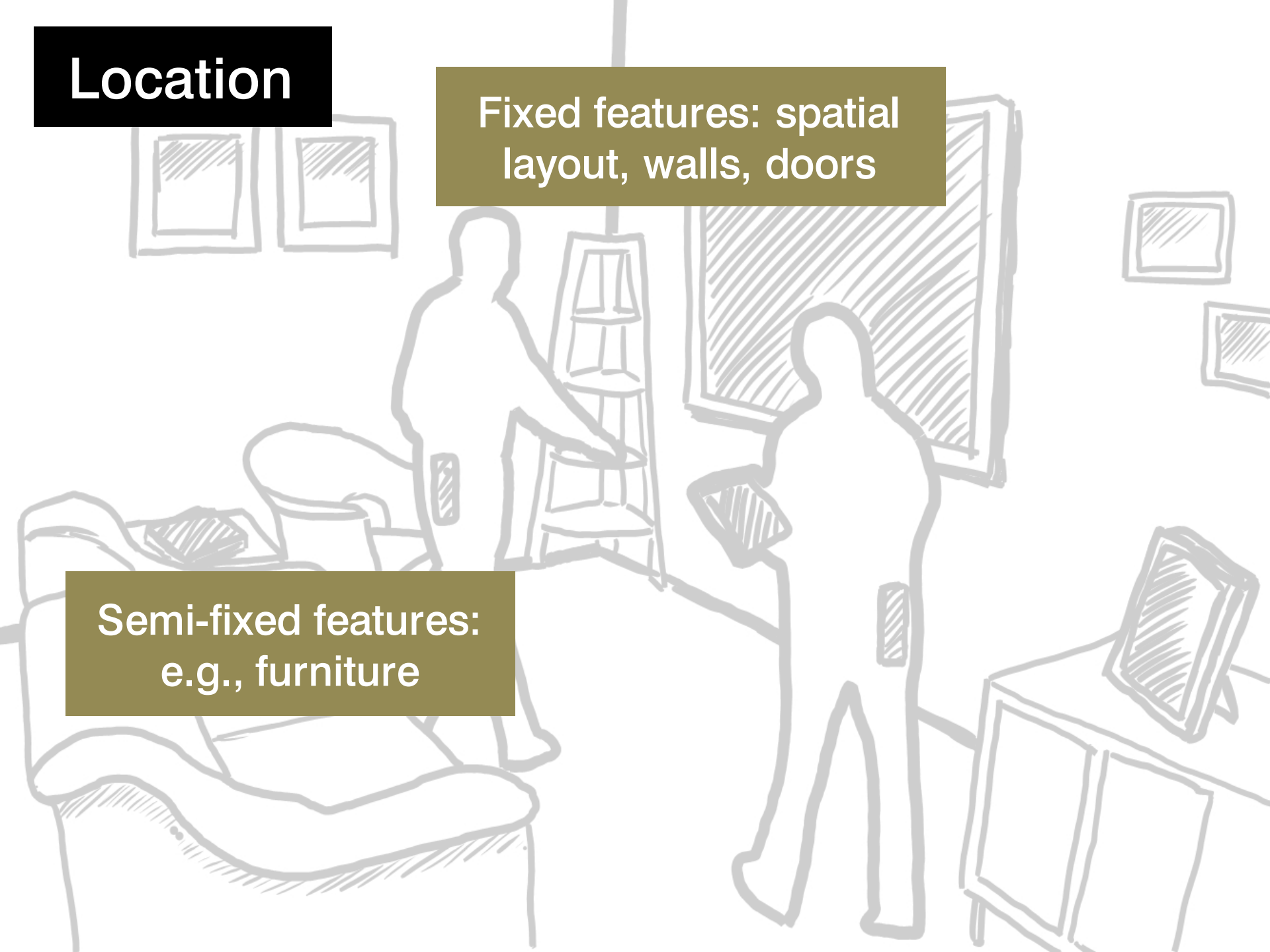


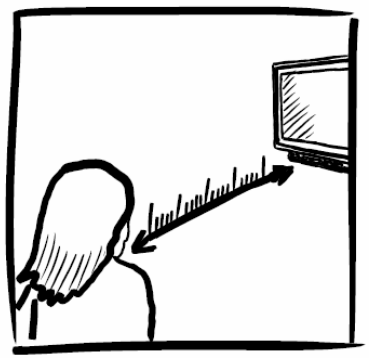

Identity
PERSON A
PERSON B
Type
Unique identification
LARGE INTERACTIVE SURFACE
TABLET DEVICE

Location

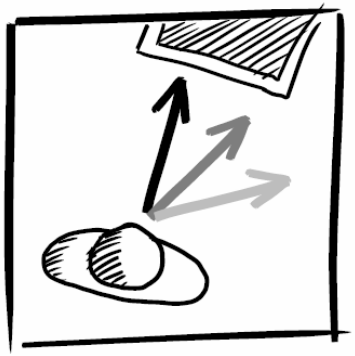
Fixed features: spatial layout, walls, doors

Semi-fixed features: e.g., furniture

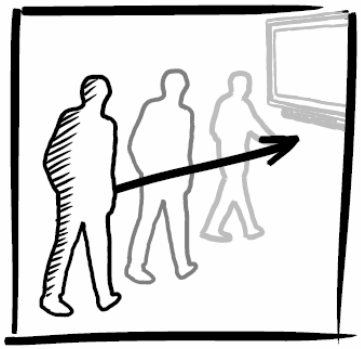




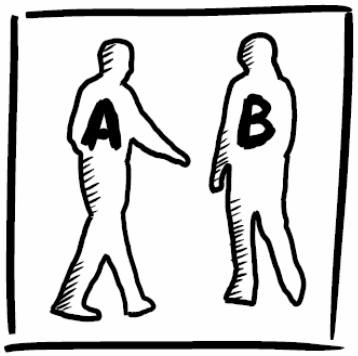
Distance



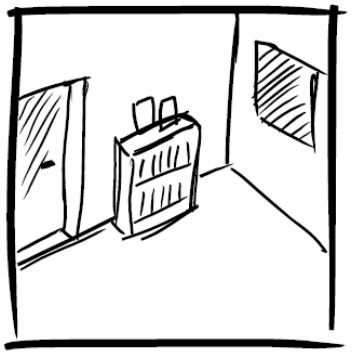
Orientation



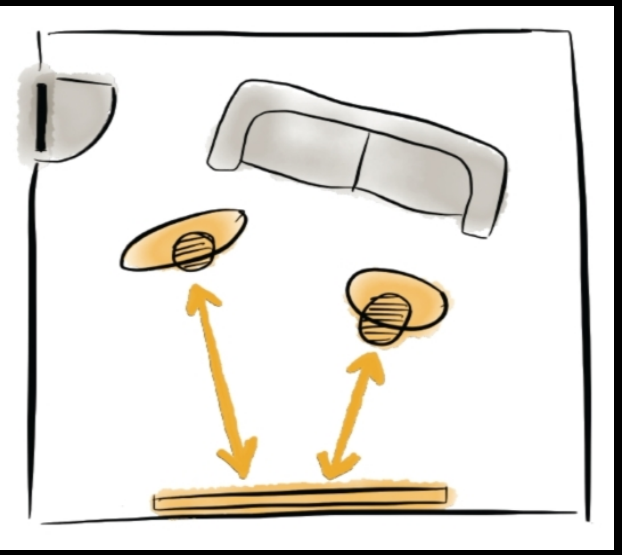
Movement

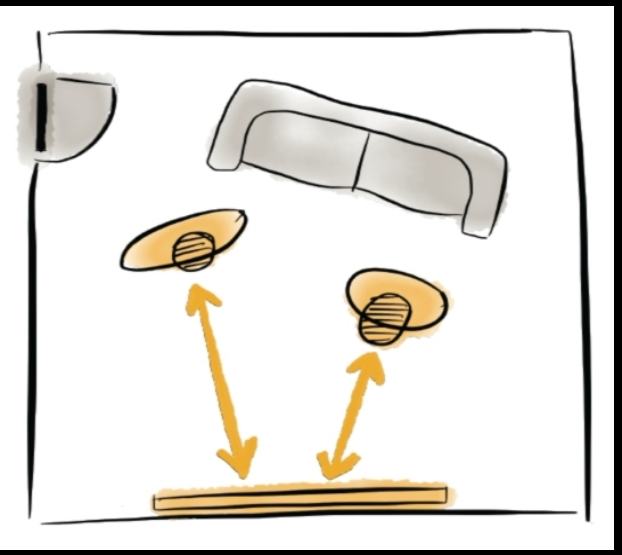


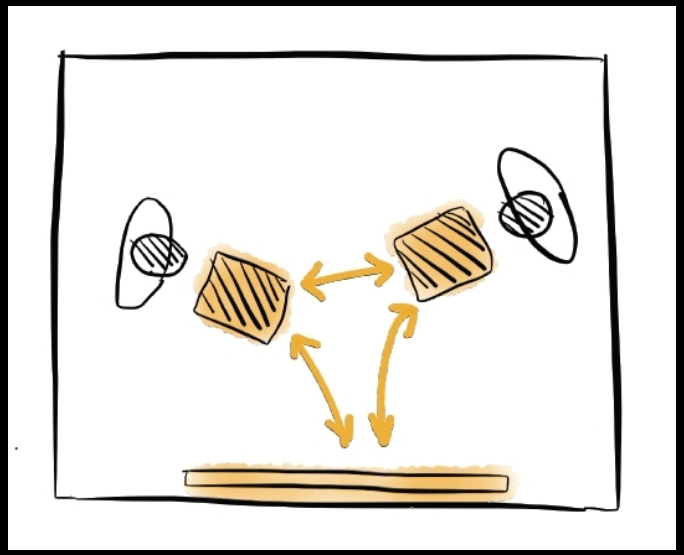
Identity

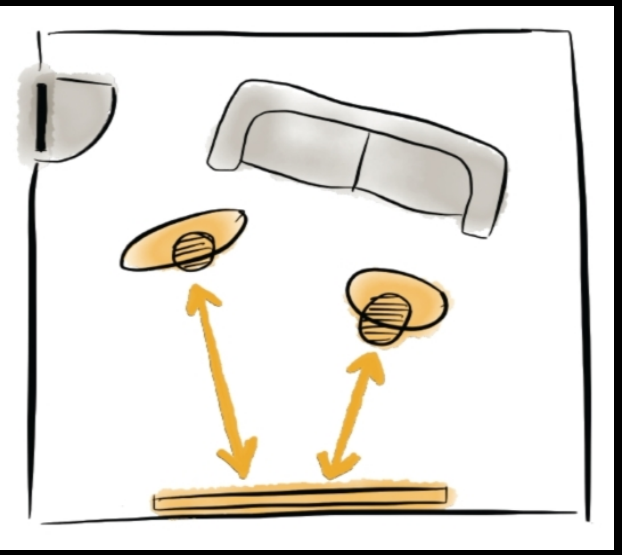


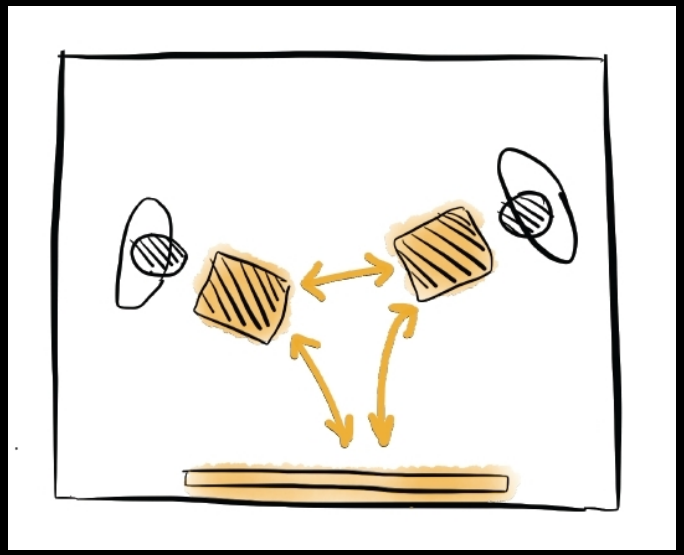
Location

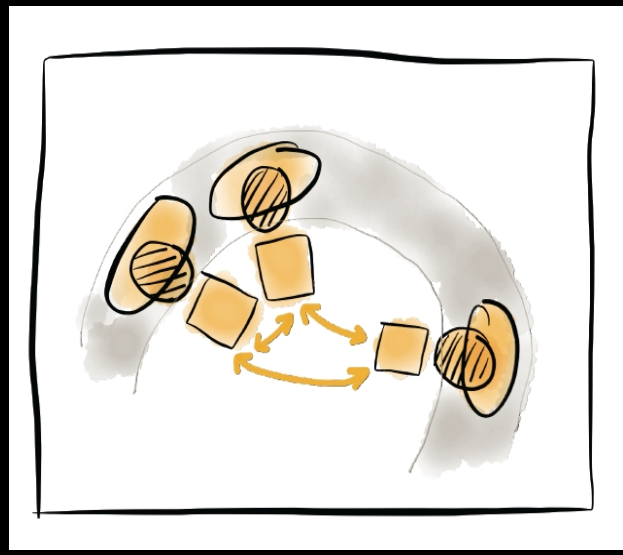


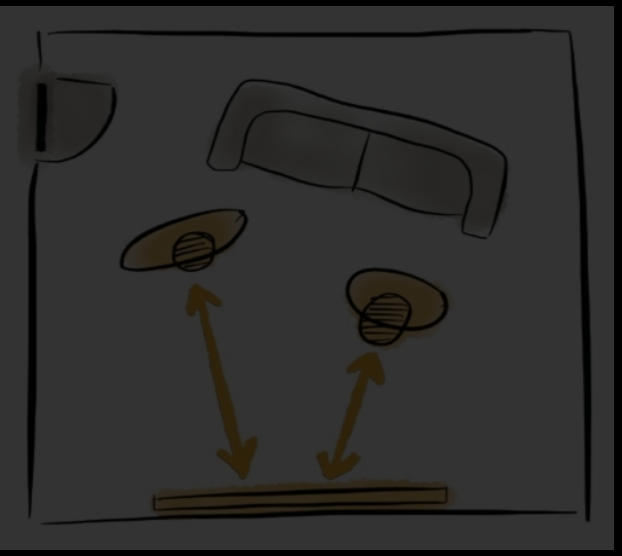


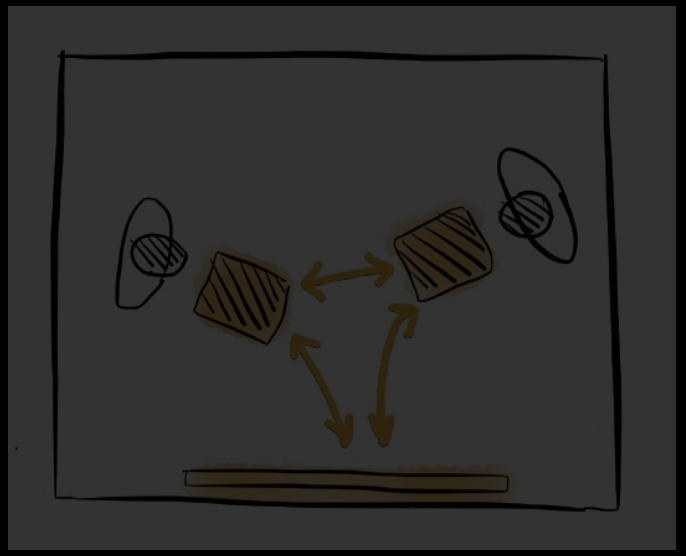


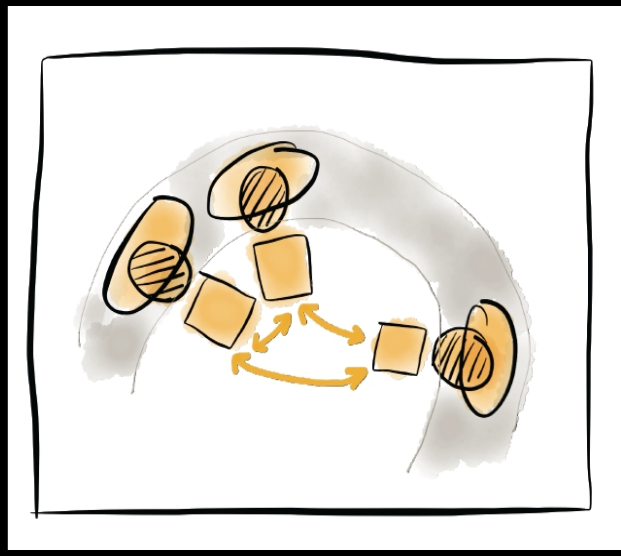






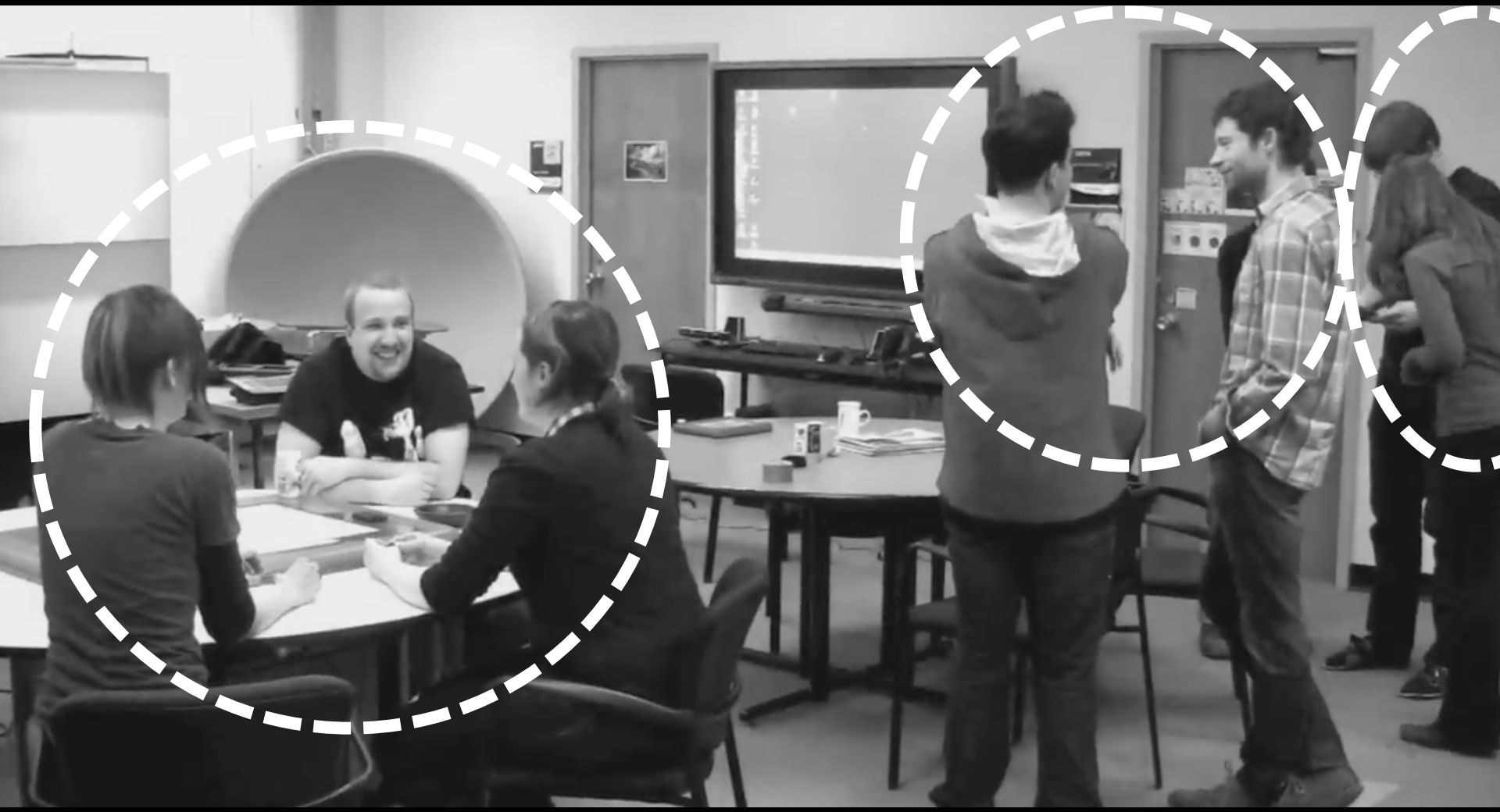




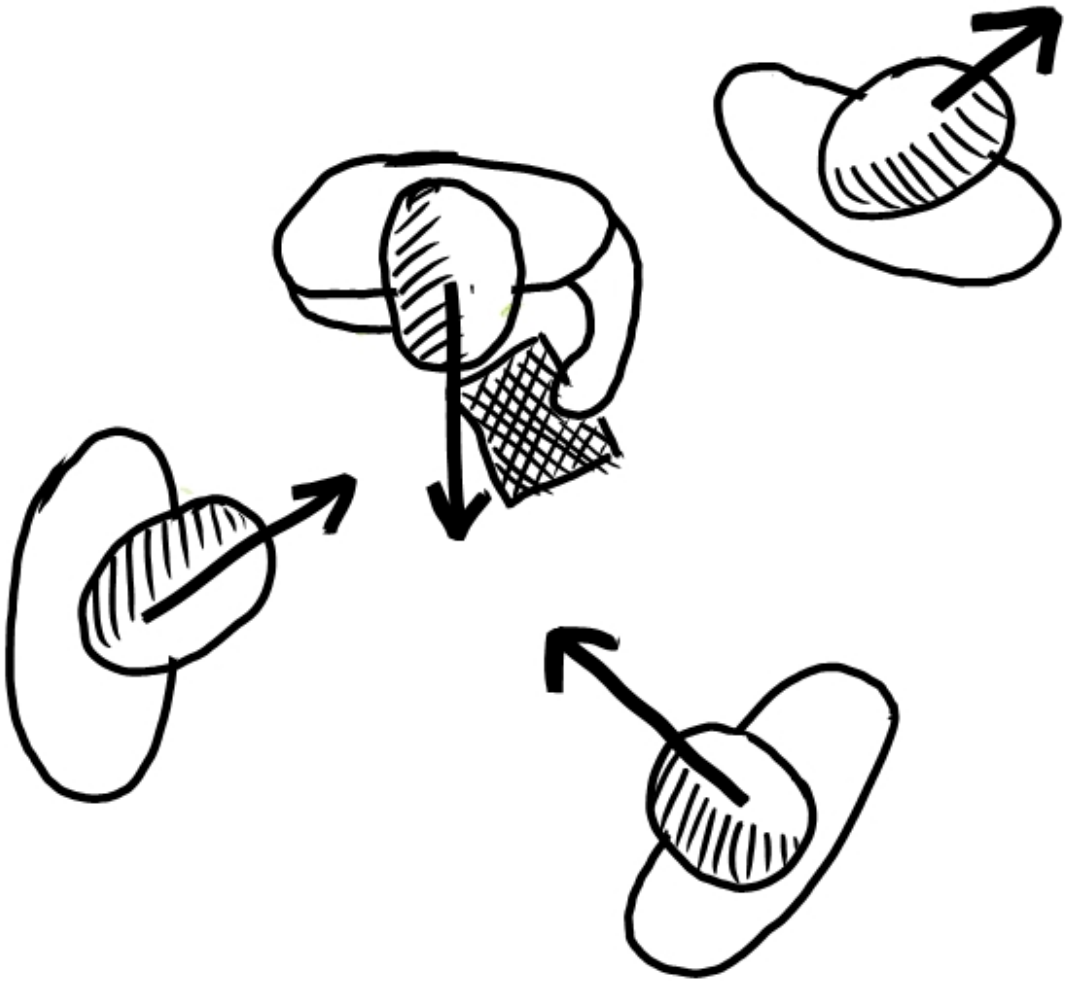


Towards Ad-hoc Collaboration Spaces with Spatially-Aware Devices

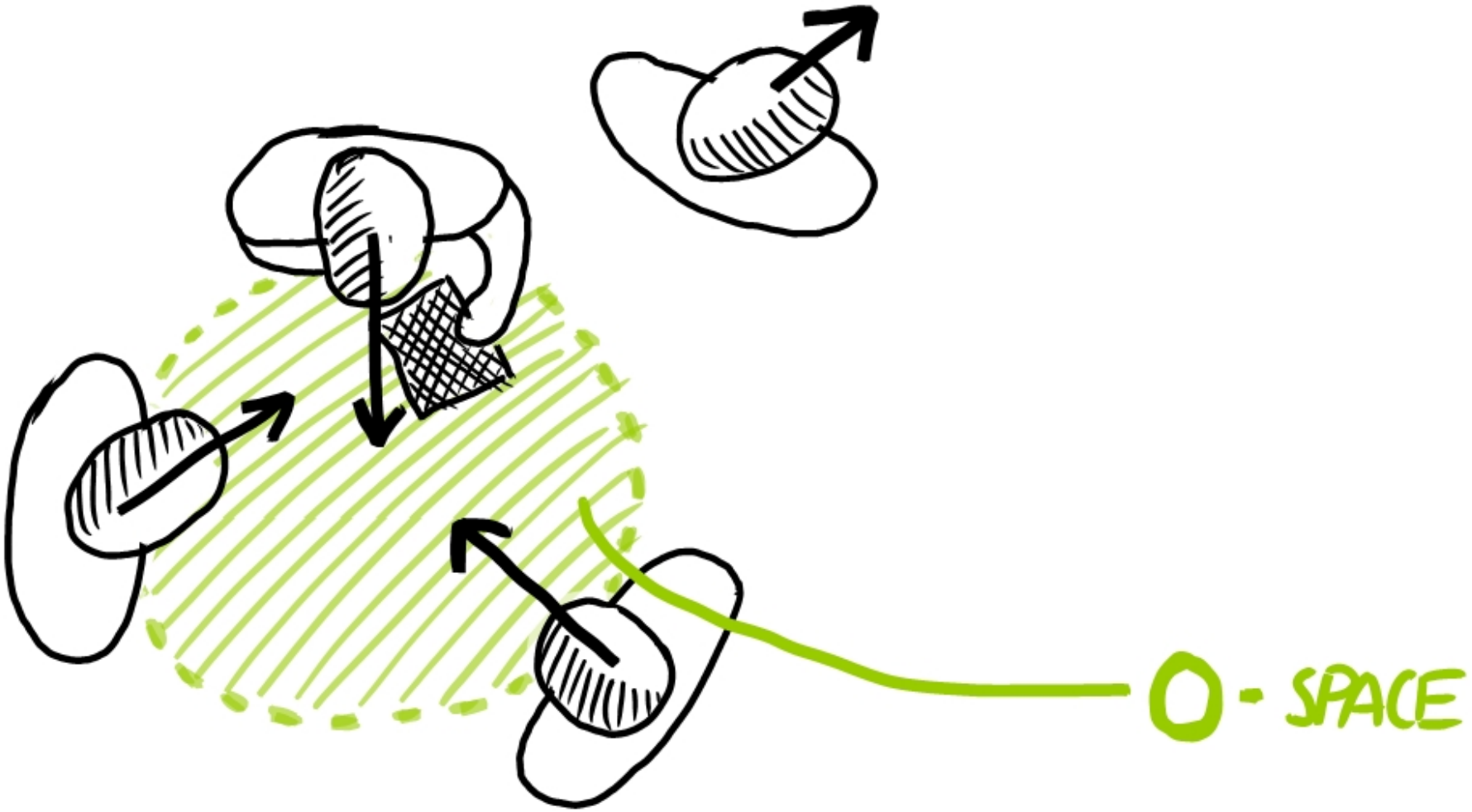
Marquardt, N., Hinckley, K. and Greenberg, S. (2012) Cross-Device Interaction via Micro-mobility and F-formations. *In Proceedings of the ACM Symposium on User Interface Software and Technology – ACM UIST 2012.* (Cambridge, MA), ACM, 13-22, October 7-10.



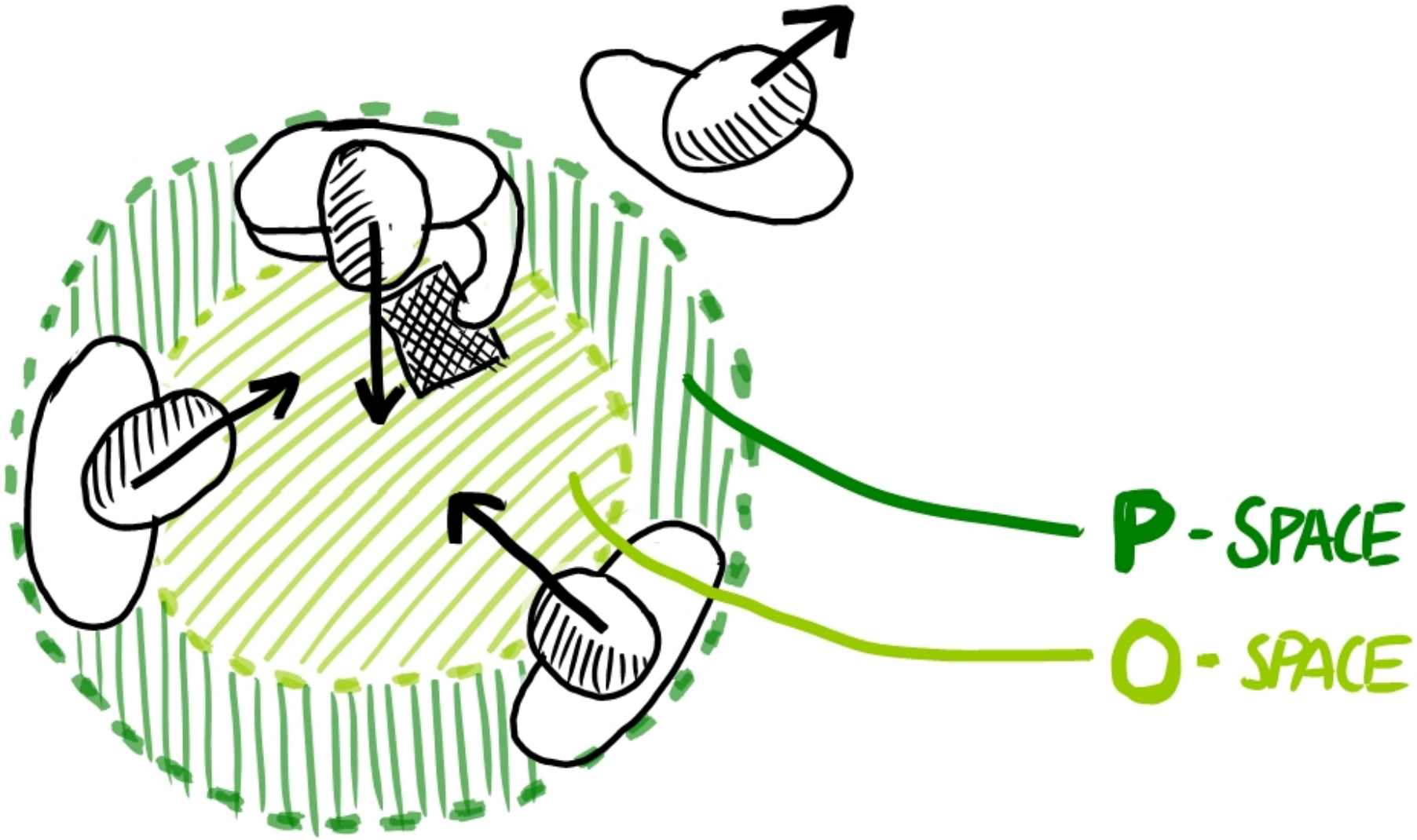
F-formations [Kendon 1990]



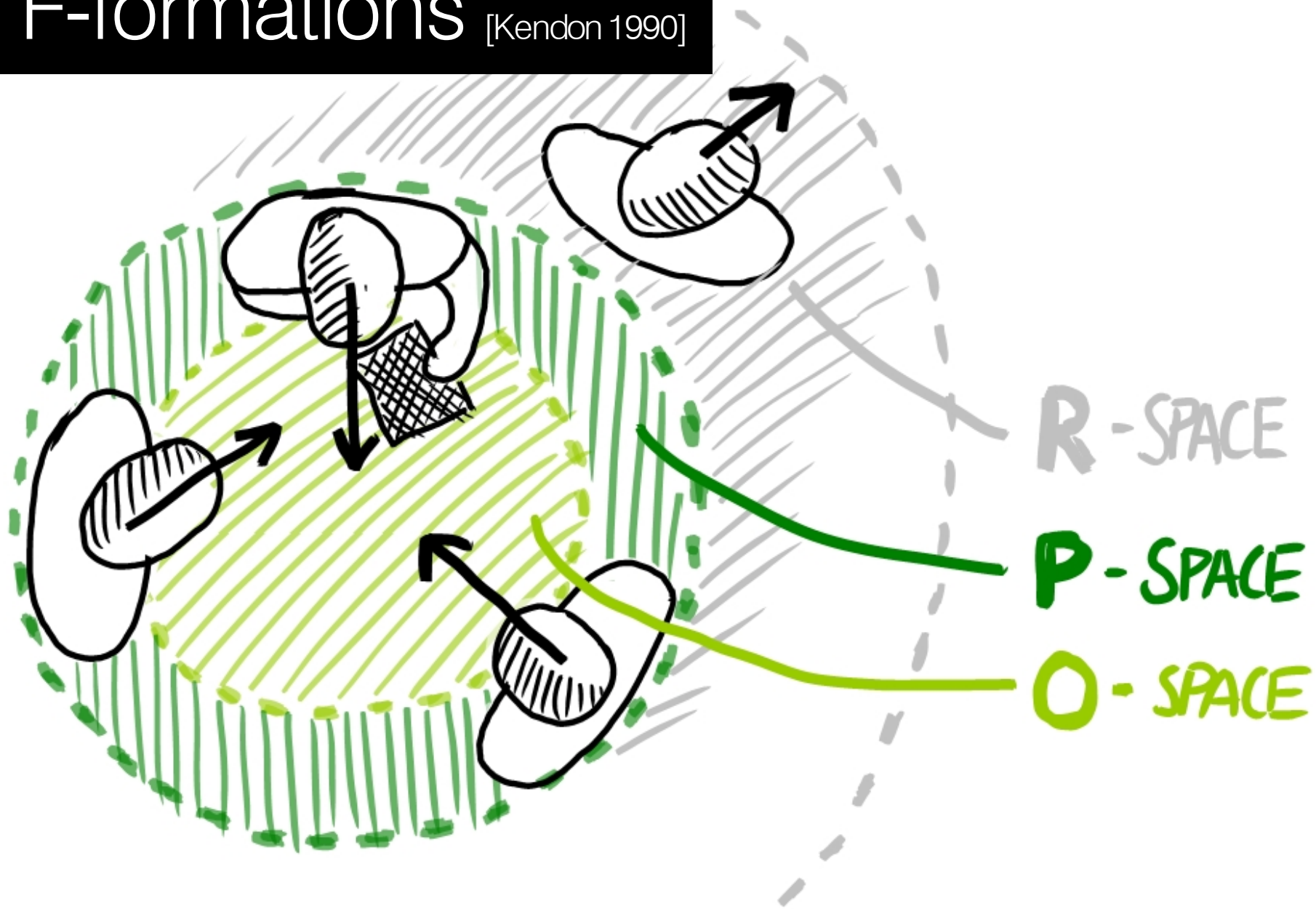
F-formations [Kendon 1990]



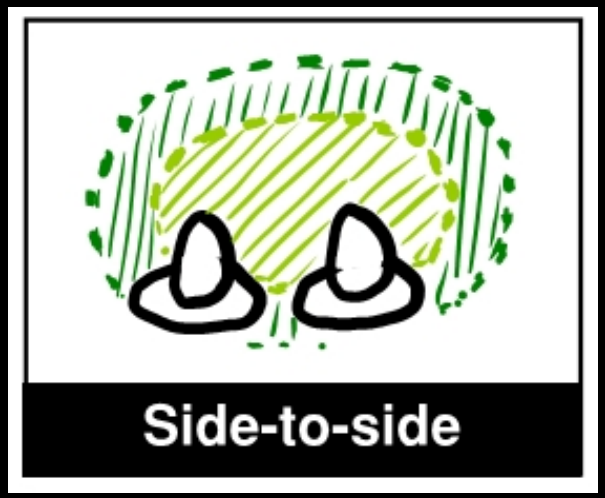
F-formations [Kendon 1990]



F-formations [Kendon 1990]



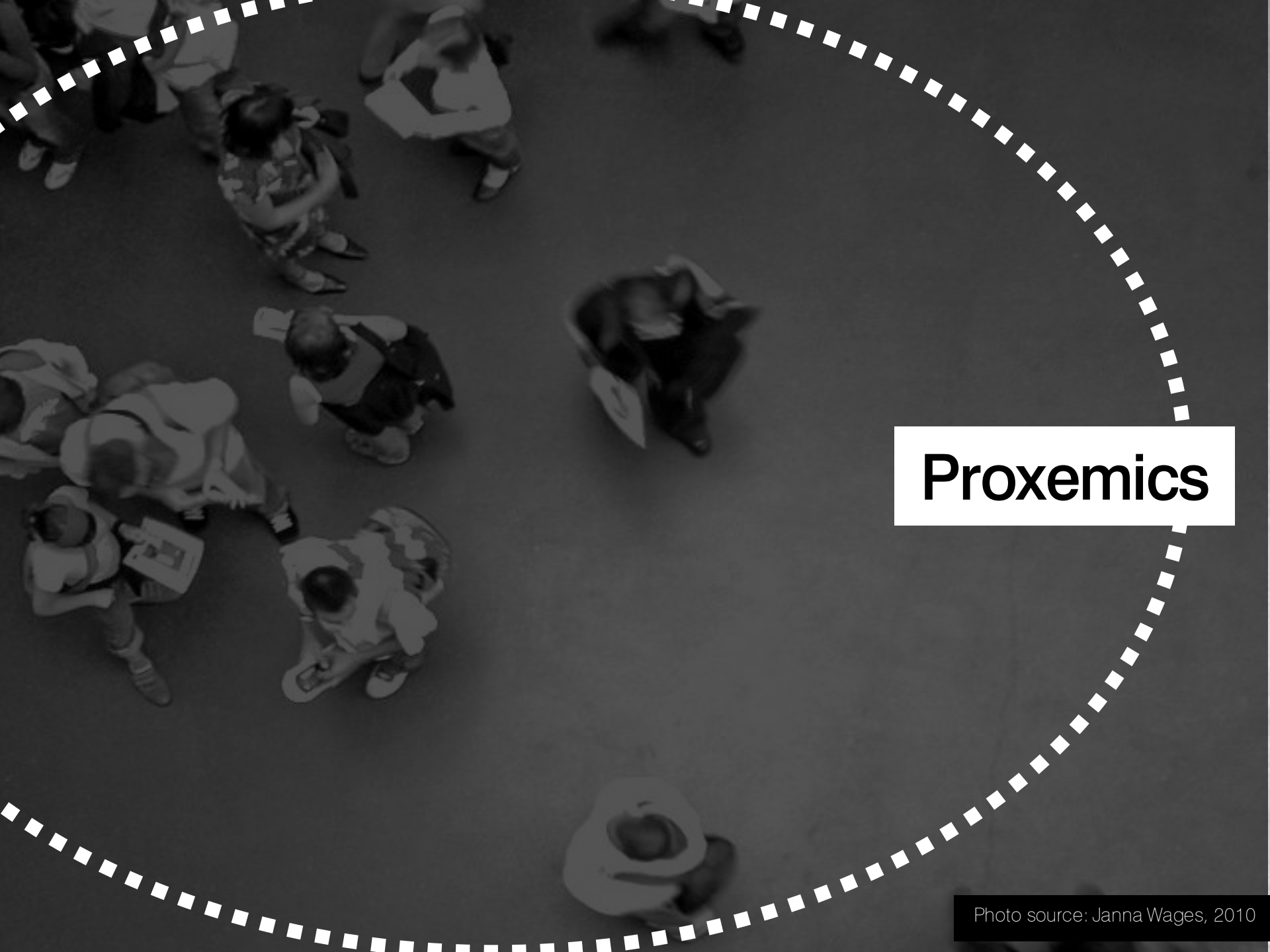
F-formations [Kendon 1990]



Micro-mobility [Luff, Heath 1998]

Photo source: Alsos et al., 2012

Photo source: Janna Wages, 2010



Proxemics

Photo source: Janna Wages, 2010

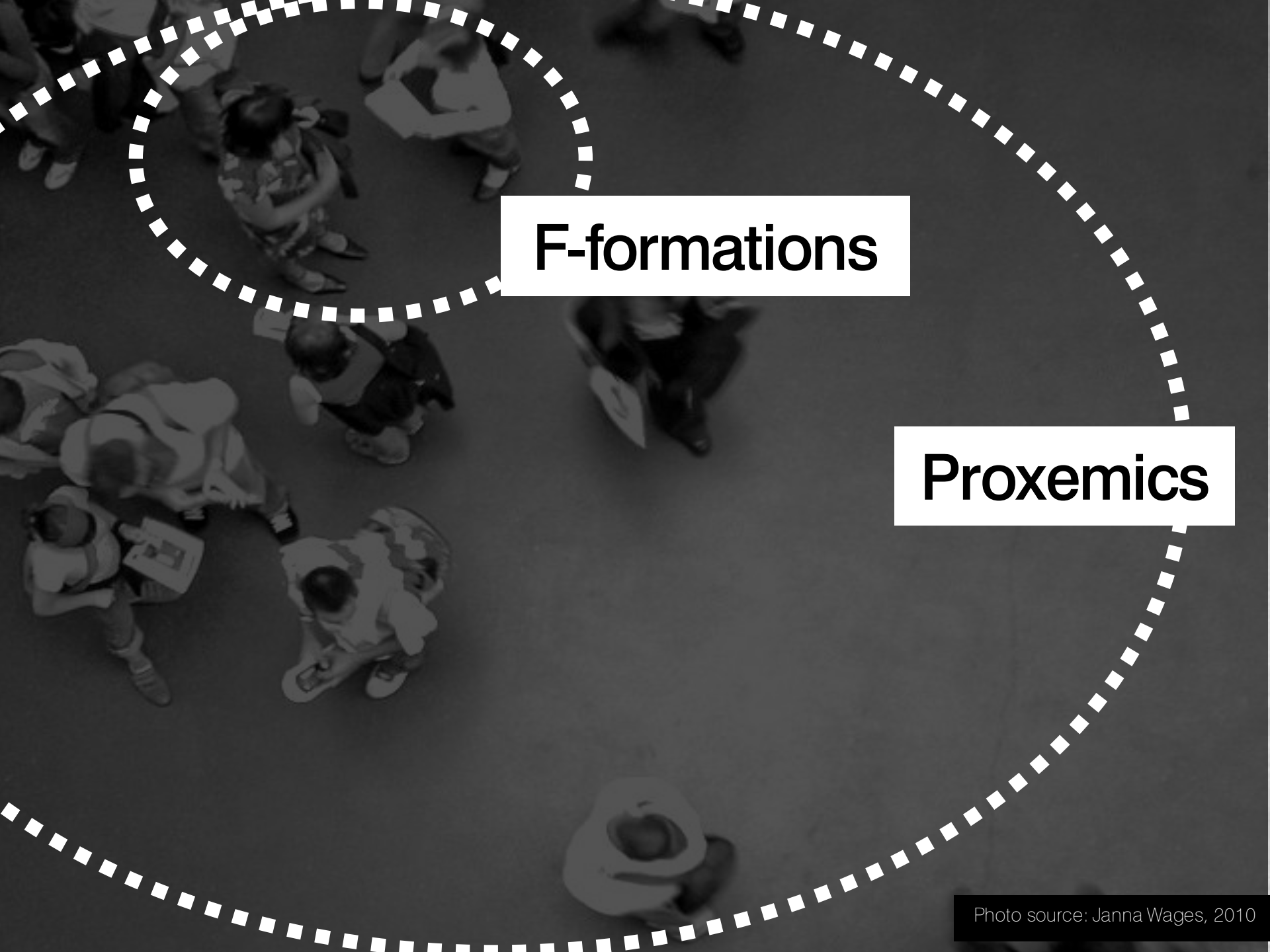


Photo source: Janna Wages, 2010

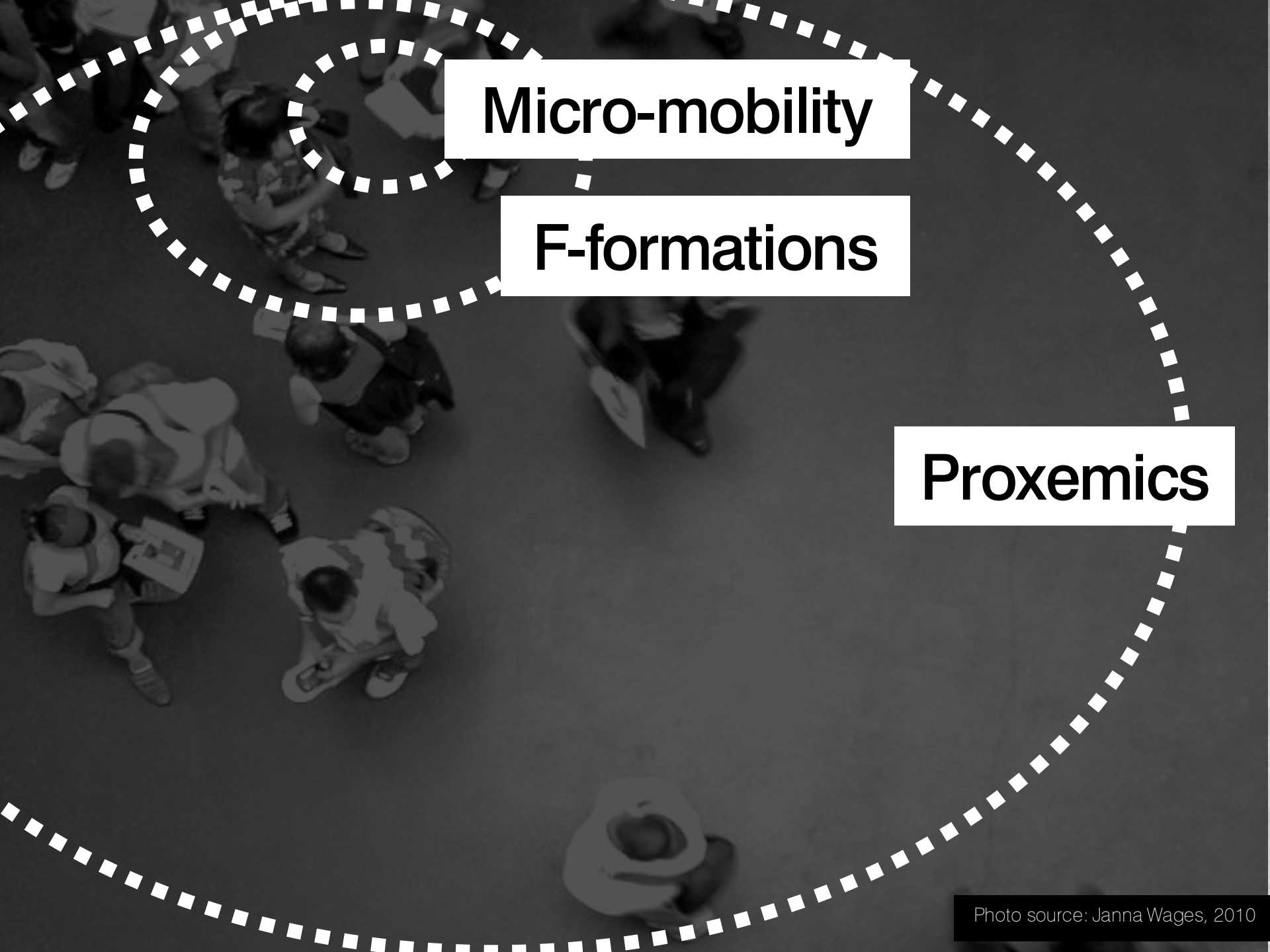
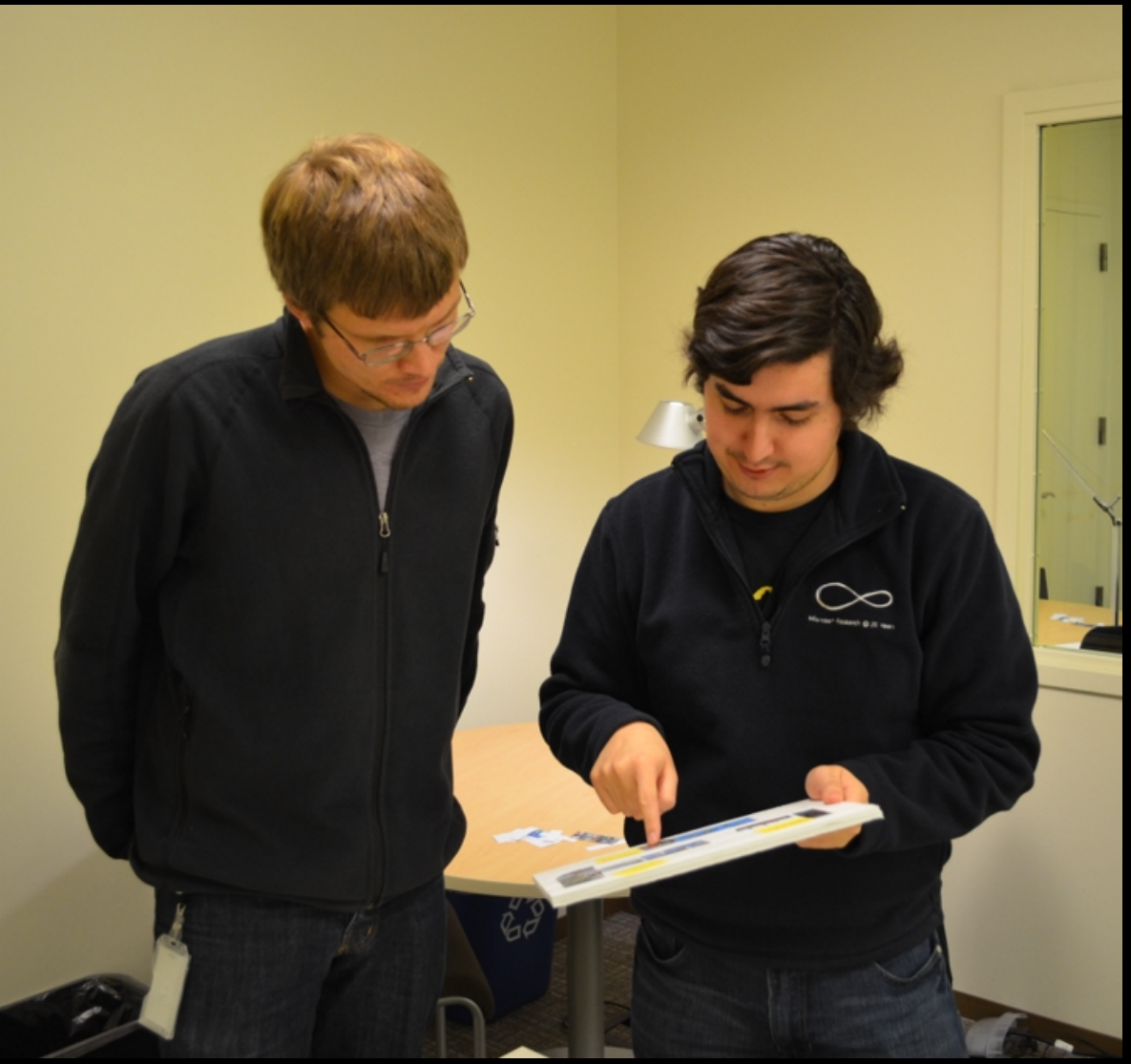


Photo source: Janna Wages, 2010

Design study:
Proxemics of people & devices



Exploratory study:
10 participants

Foam-core mockups
of devices

Tasks

Tasks

collaborative

Tasks

collaborative

competitive

Tasks

collaborative

competitive

individual

Observed behaviors

B1 | Devices as extension of person

B2 | F-formations vary by task

B3 | Moving devices in/out of focal zone

B4 | Incidental tilting

B5 | Pointing while tilting within the o-space

B6 | Reorientation with gradation in response

B7 | Avoid persistent spatial invasion

B8 | Matching pose while side-by-side

Observed behaviors

B1 | Devices as extension of person

B2 | F-formations vary by task

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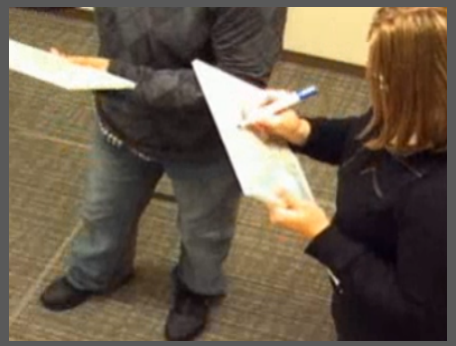
B8 | Matching pose while side-by-side

B2 | F-formations vary by task

Collaborative

B2 | F-formations vary by task

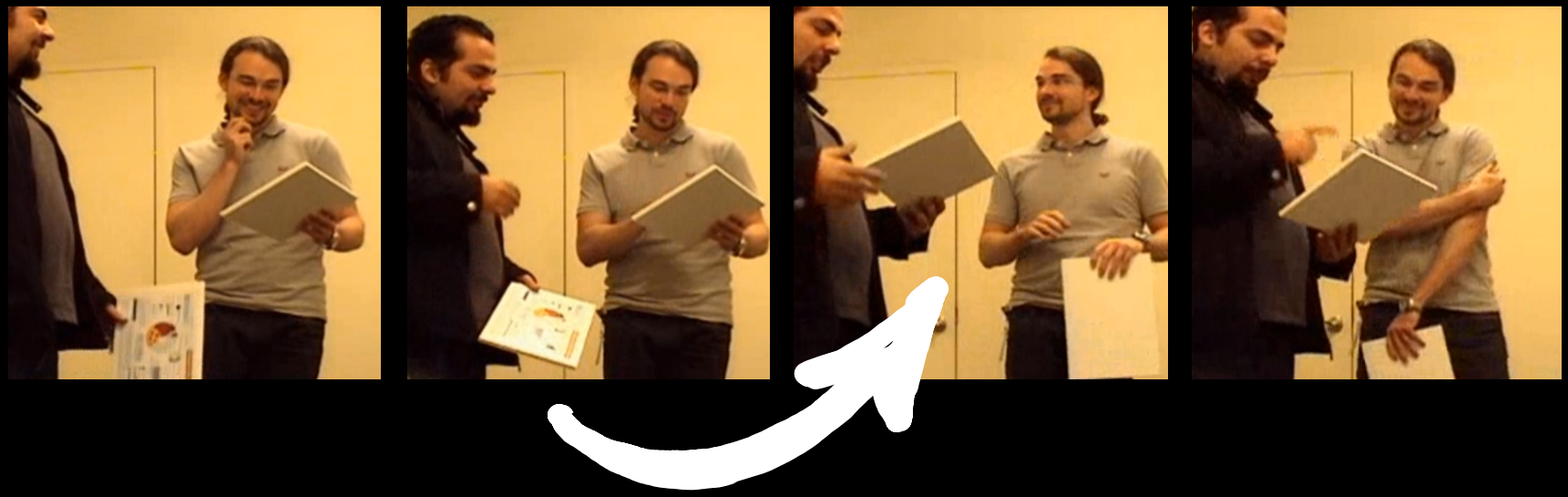
Collaborative



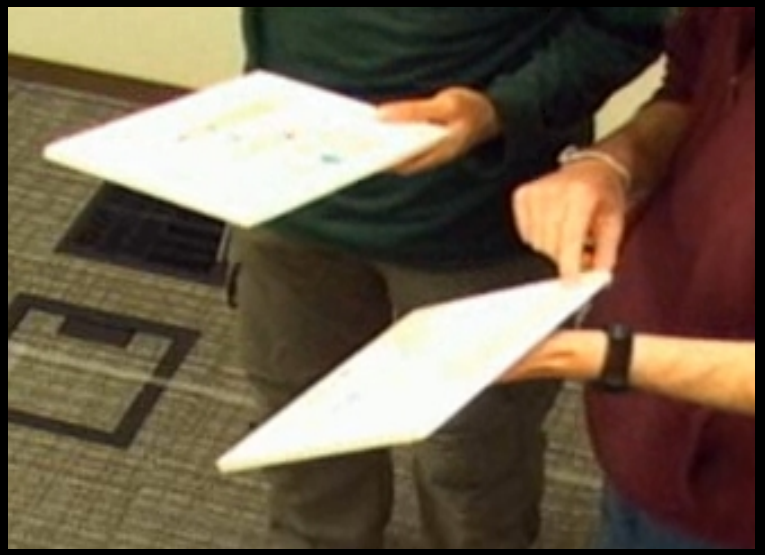
Individual

Competitive

B3| Moving devices in/out of focal zone



B5| Pointing while tilting within o-space



B1 | Devices as extension of person

B2 | F-formations vary by task

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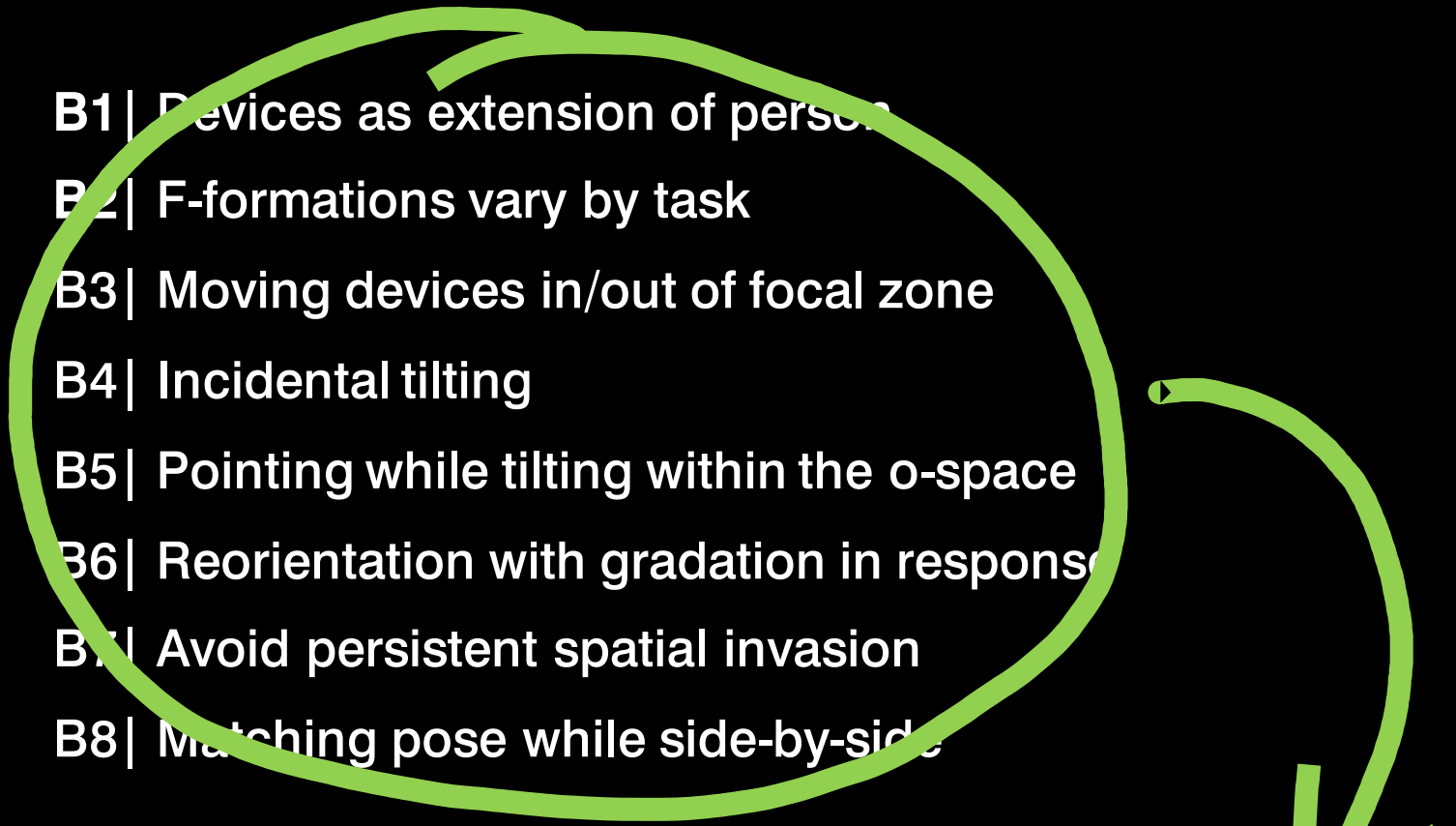
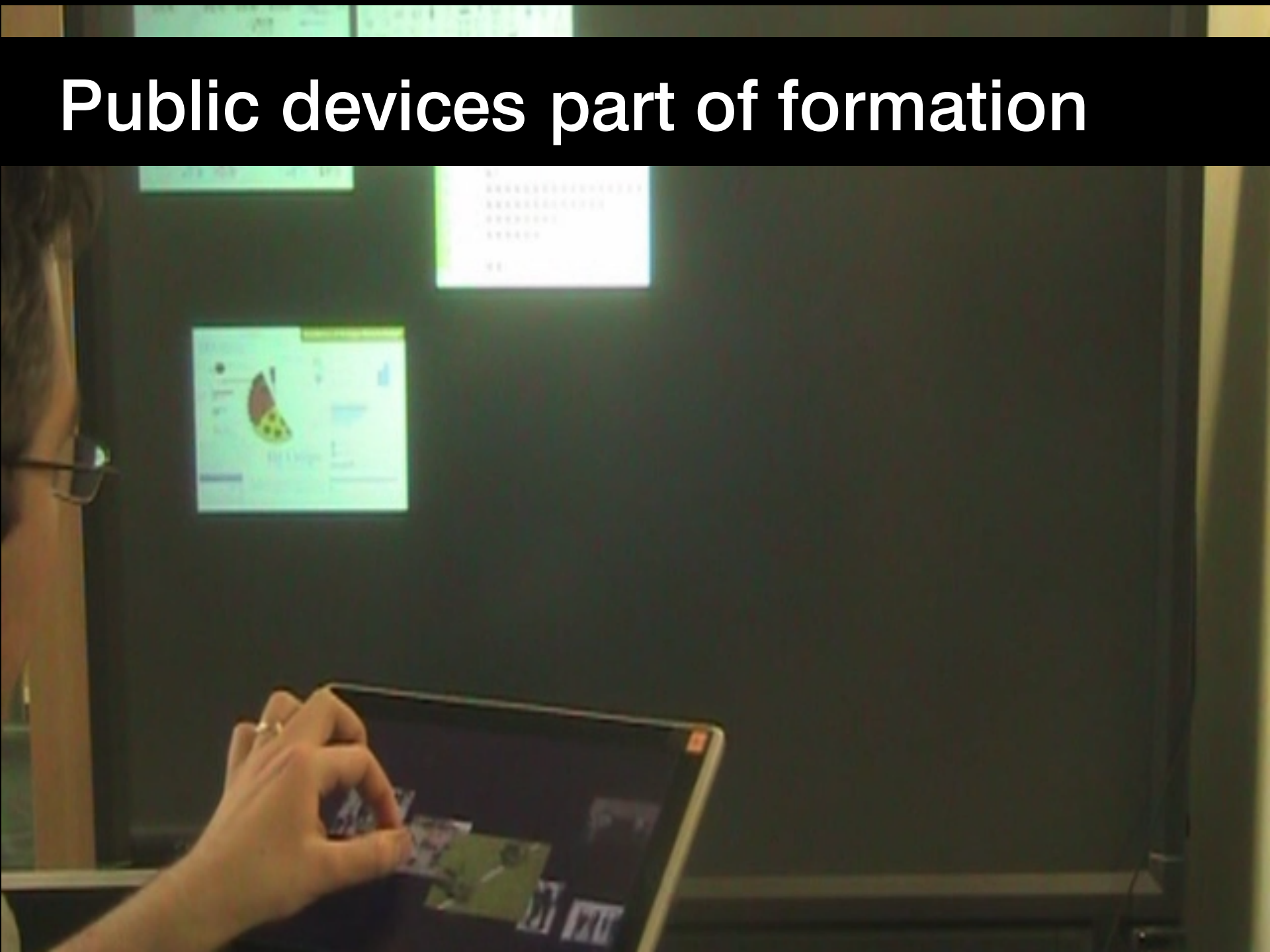


GroupTogether system

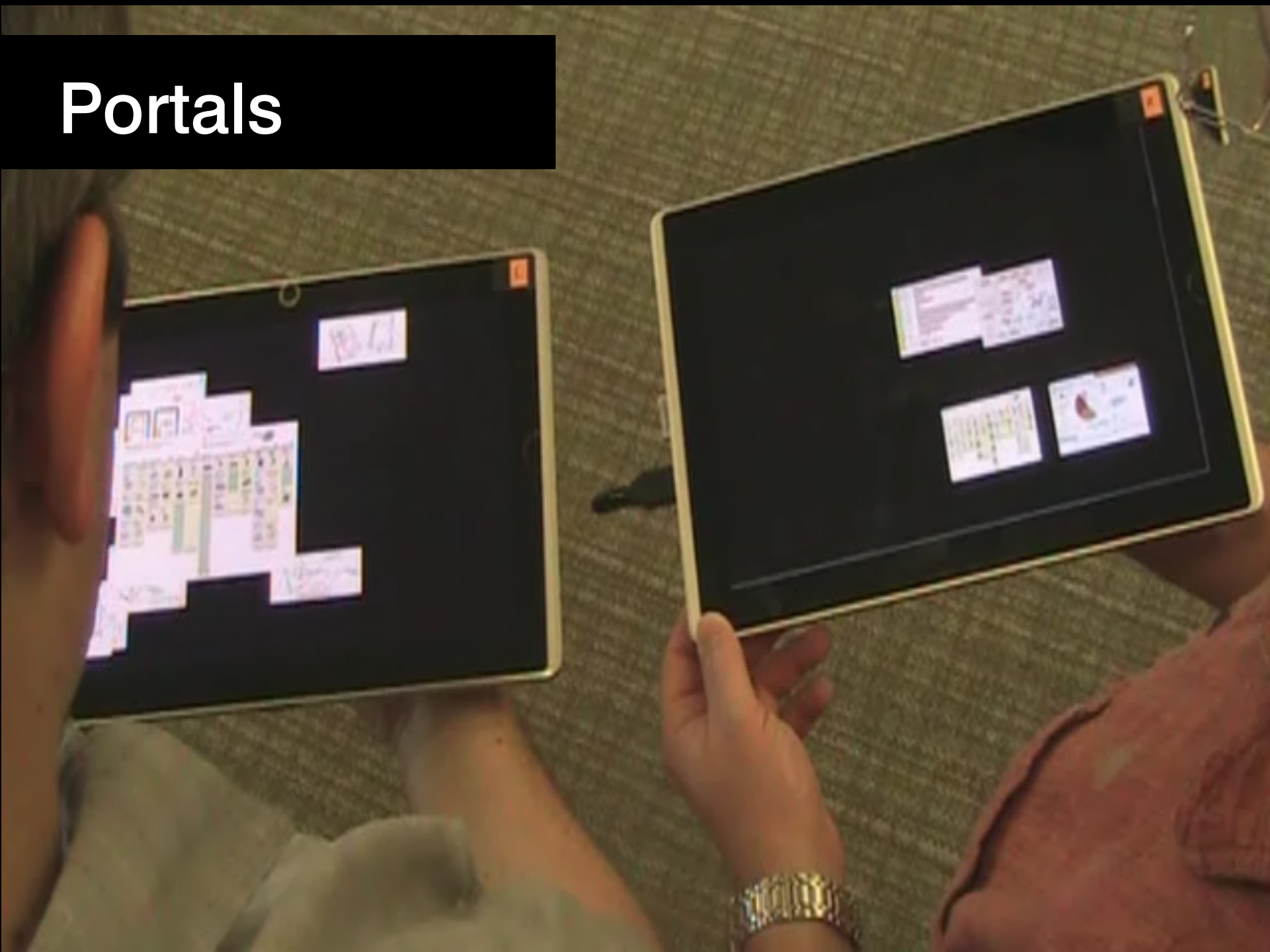
Fluid **cross-device sharing** techniques for co-located collaboration by considering **proxemics of people** and **proxemics of devices**

Tilt-to-preview

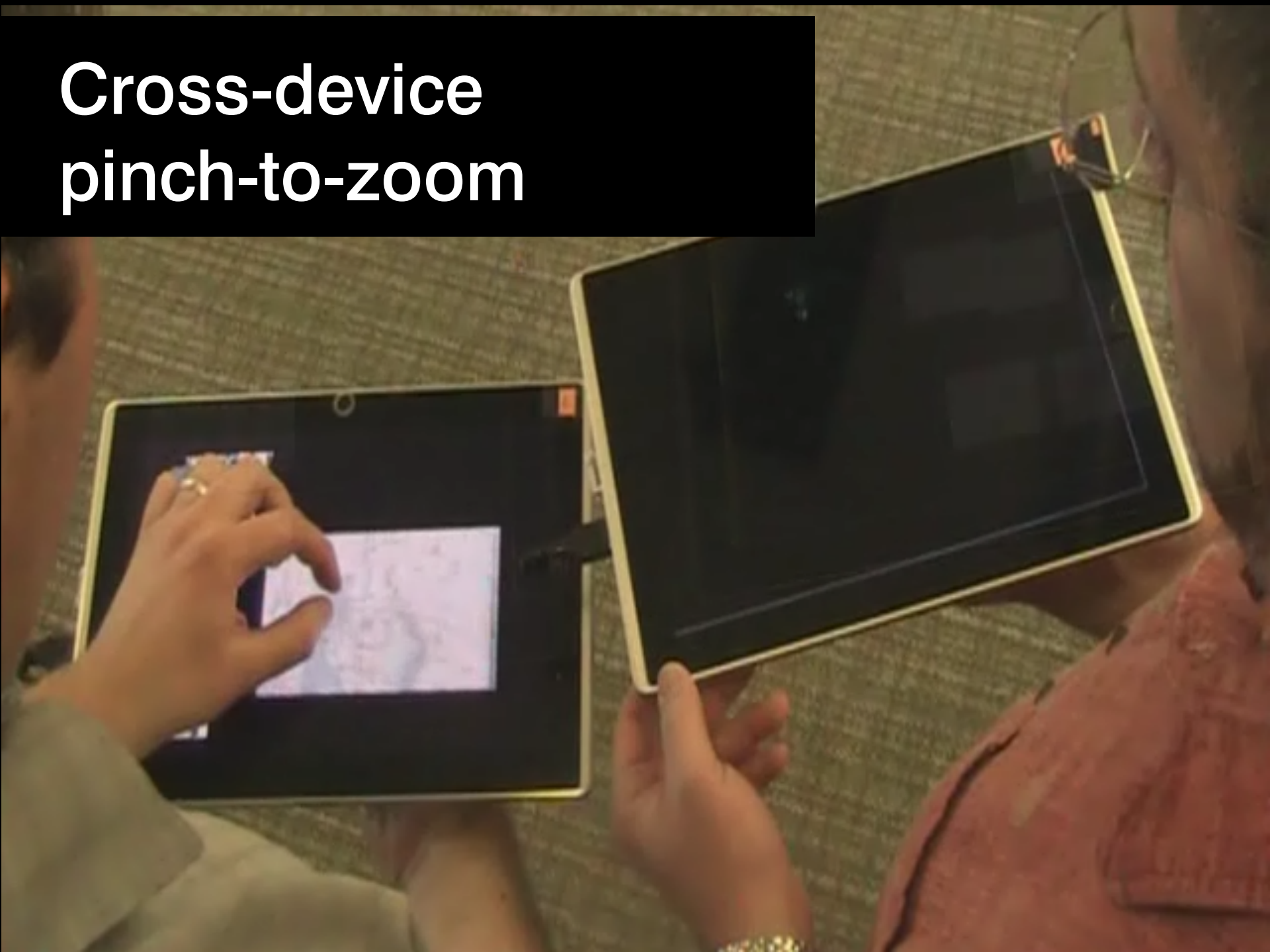
Public devices part of formation



Portals



Cross-device pinch-to-zoom



Implementation

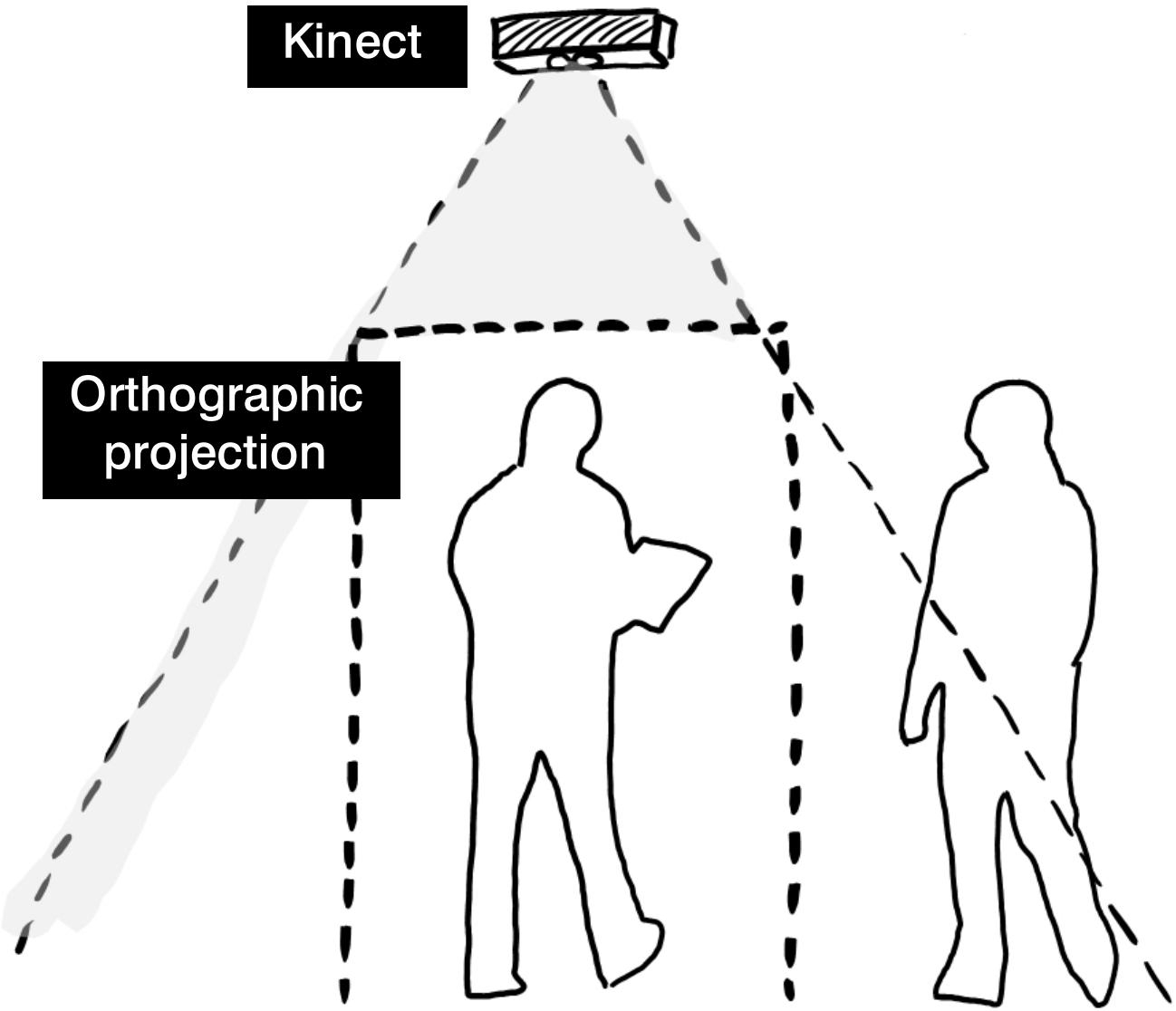
Hybrid sensing approach

Person-to-person proxemics and F-Formations

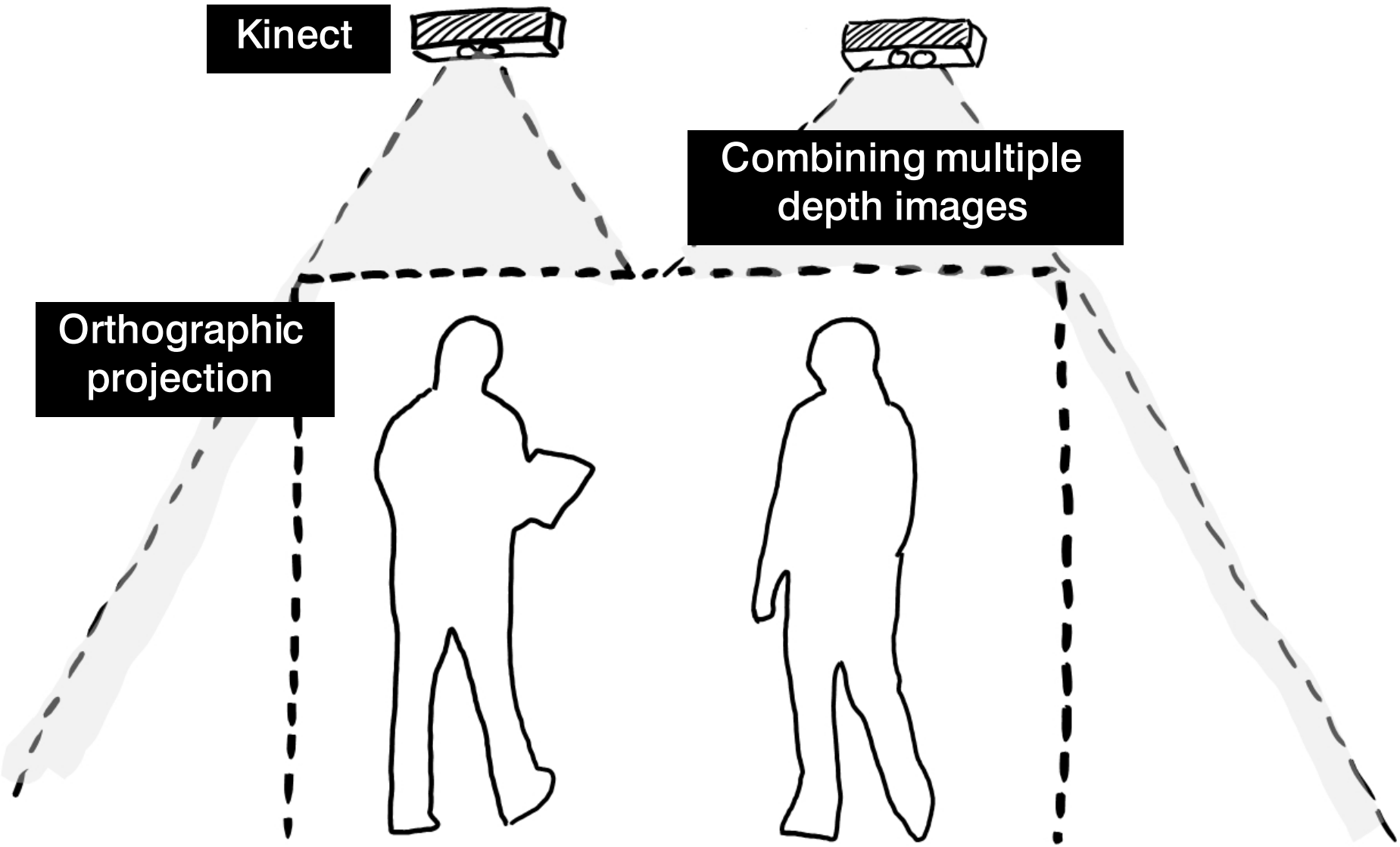
Device-to-device proxemics

Micro-mobility of devices

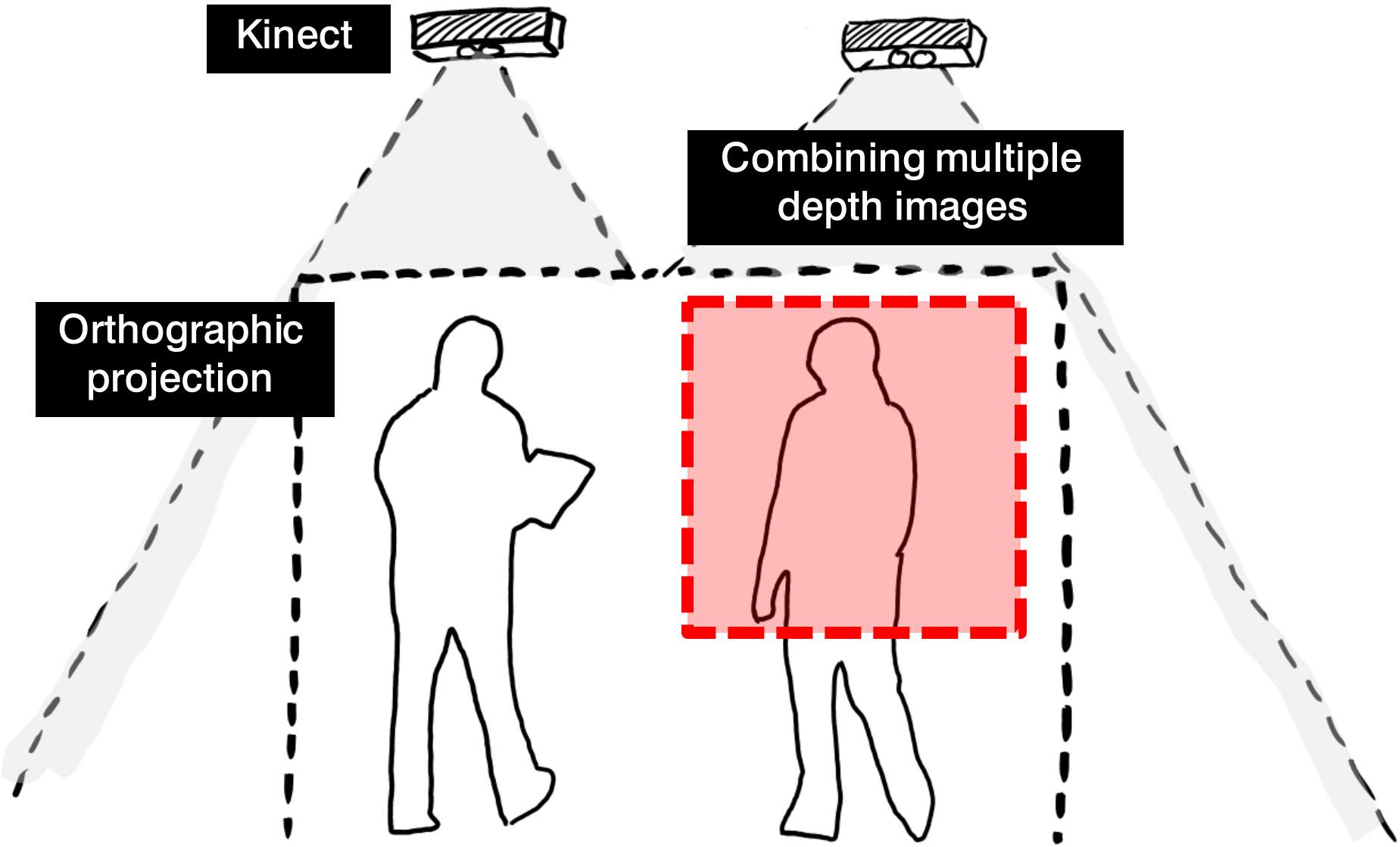
Step 1 | Tracking people's position



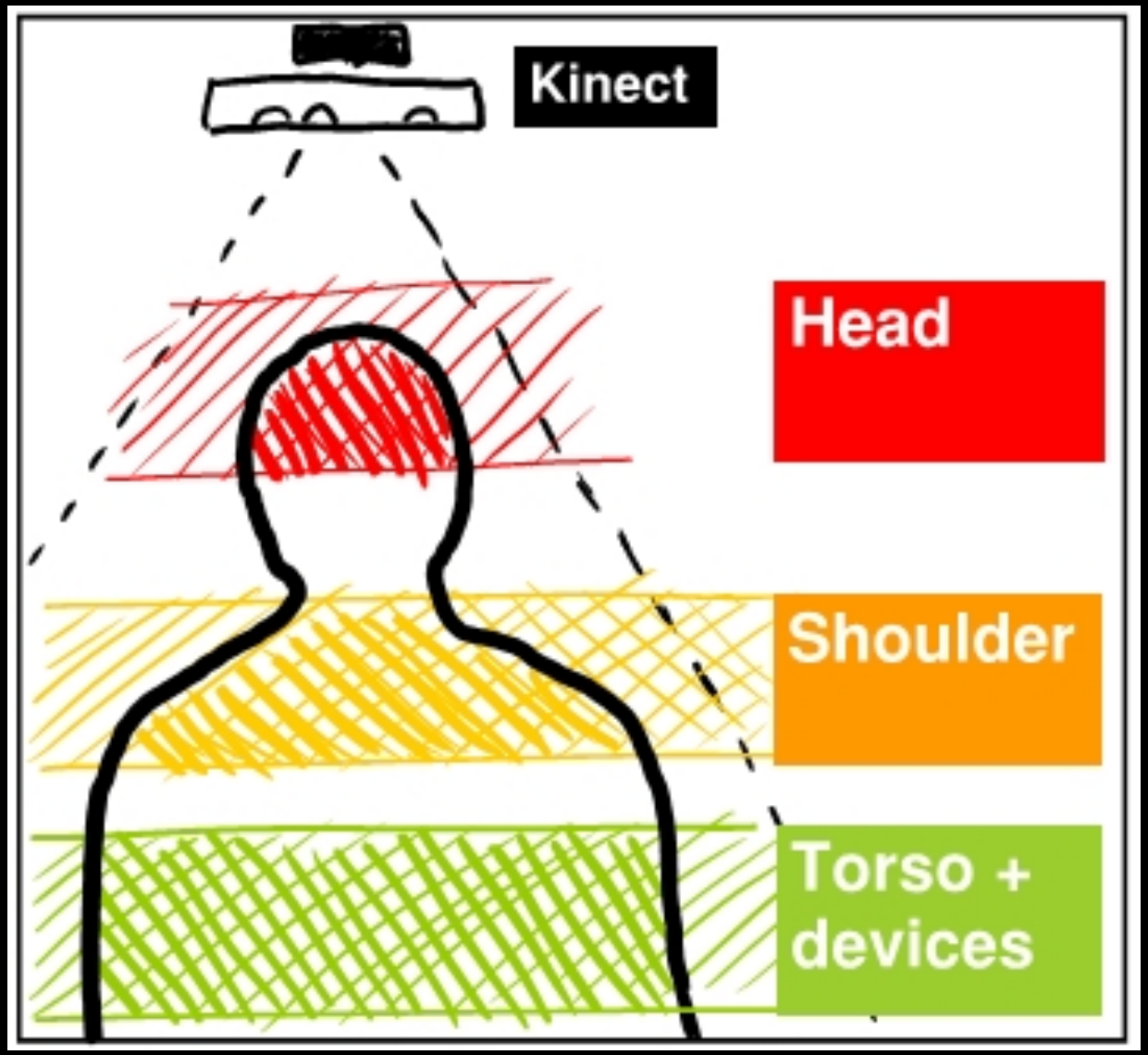
Step 1 | Tracking people's position



Step 1 | Tracking people's position

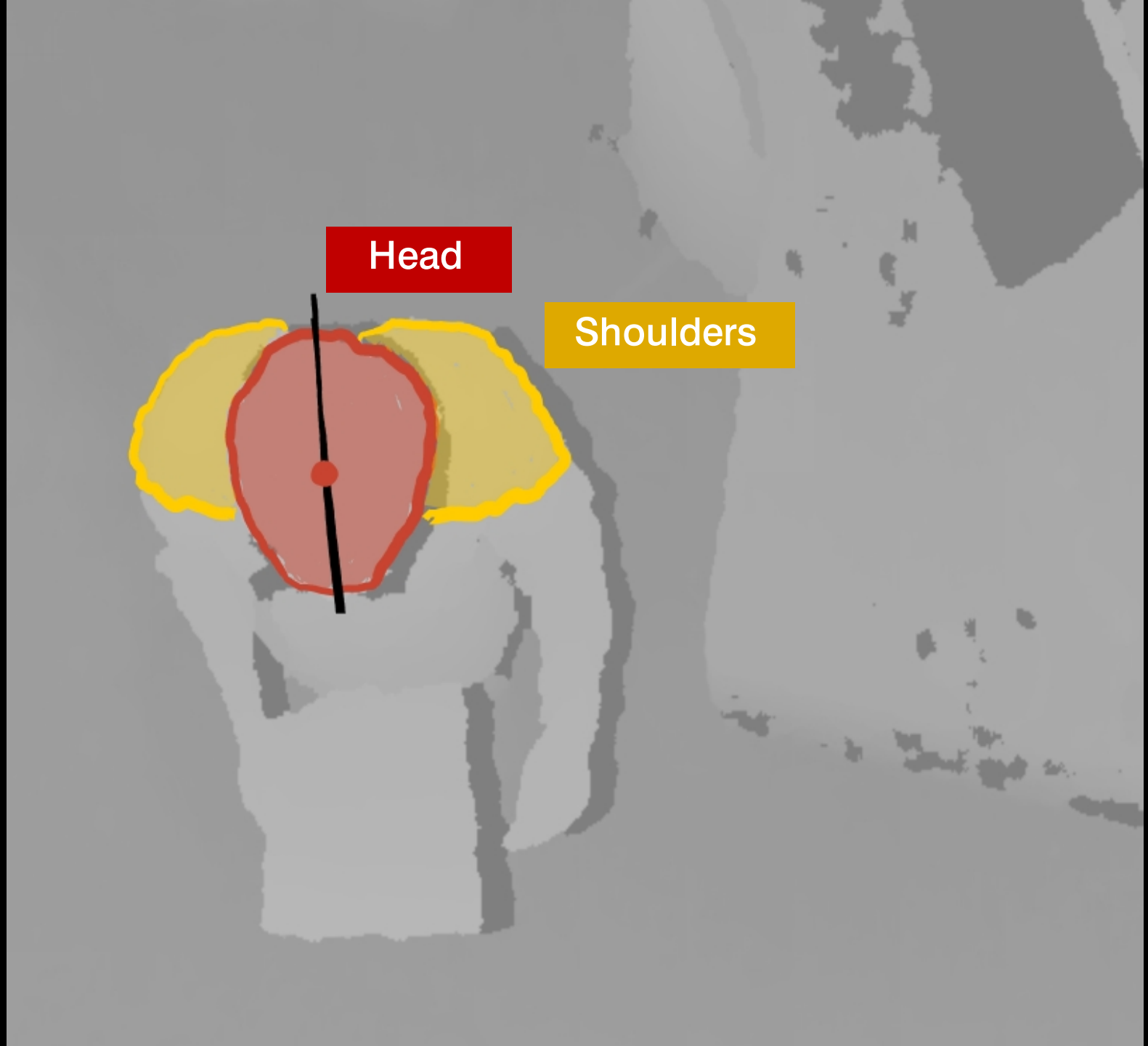


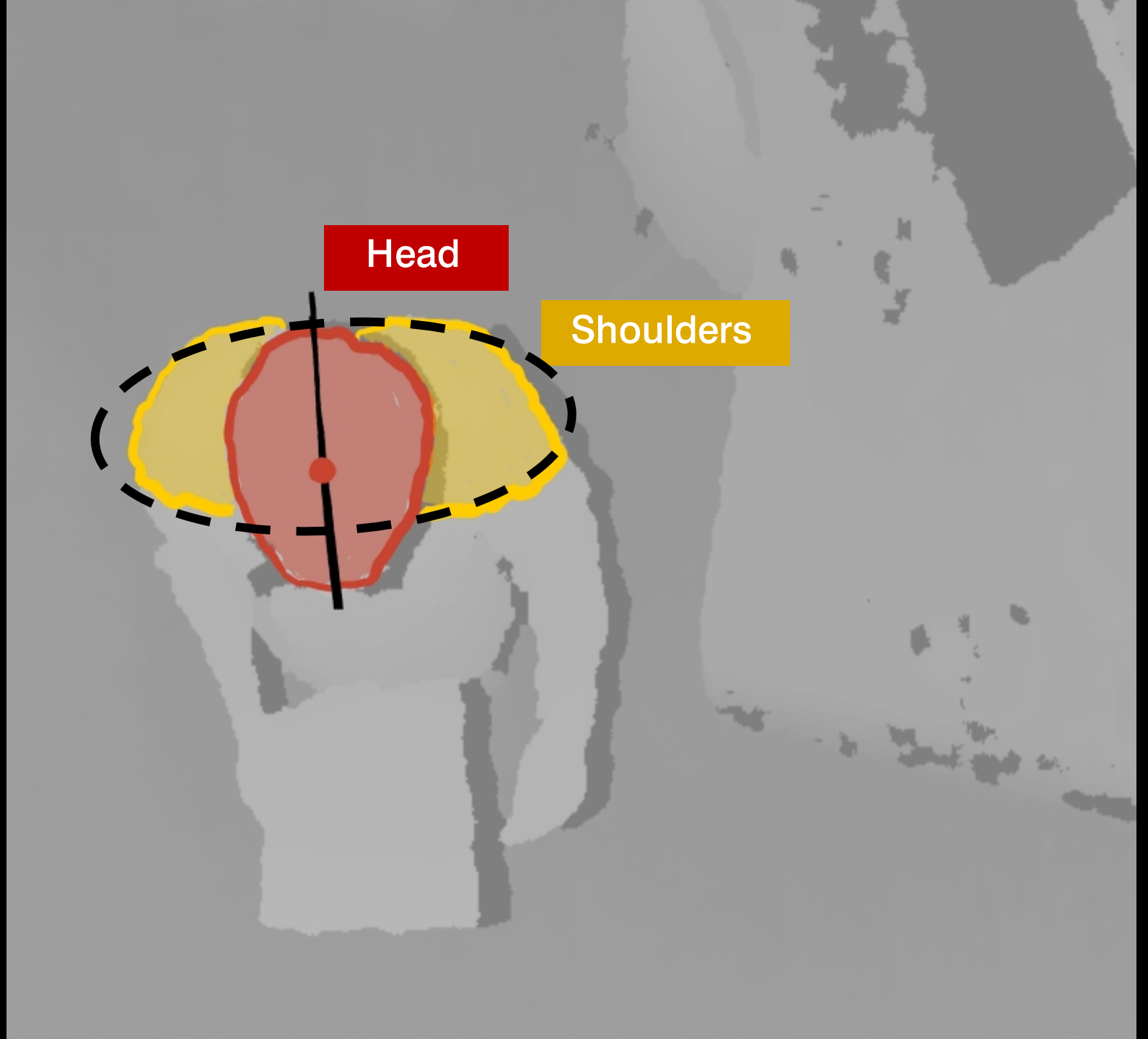
Step 1 | Tracking people's position

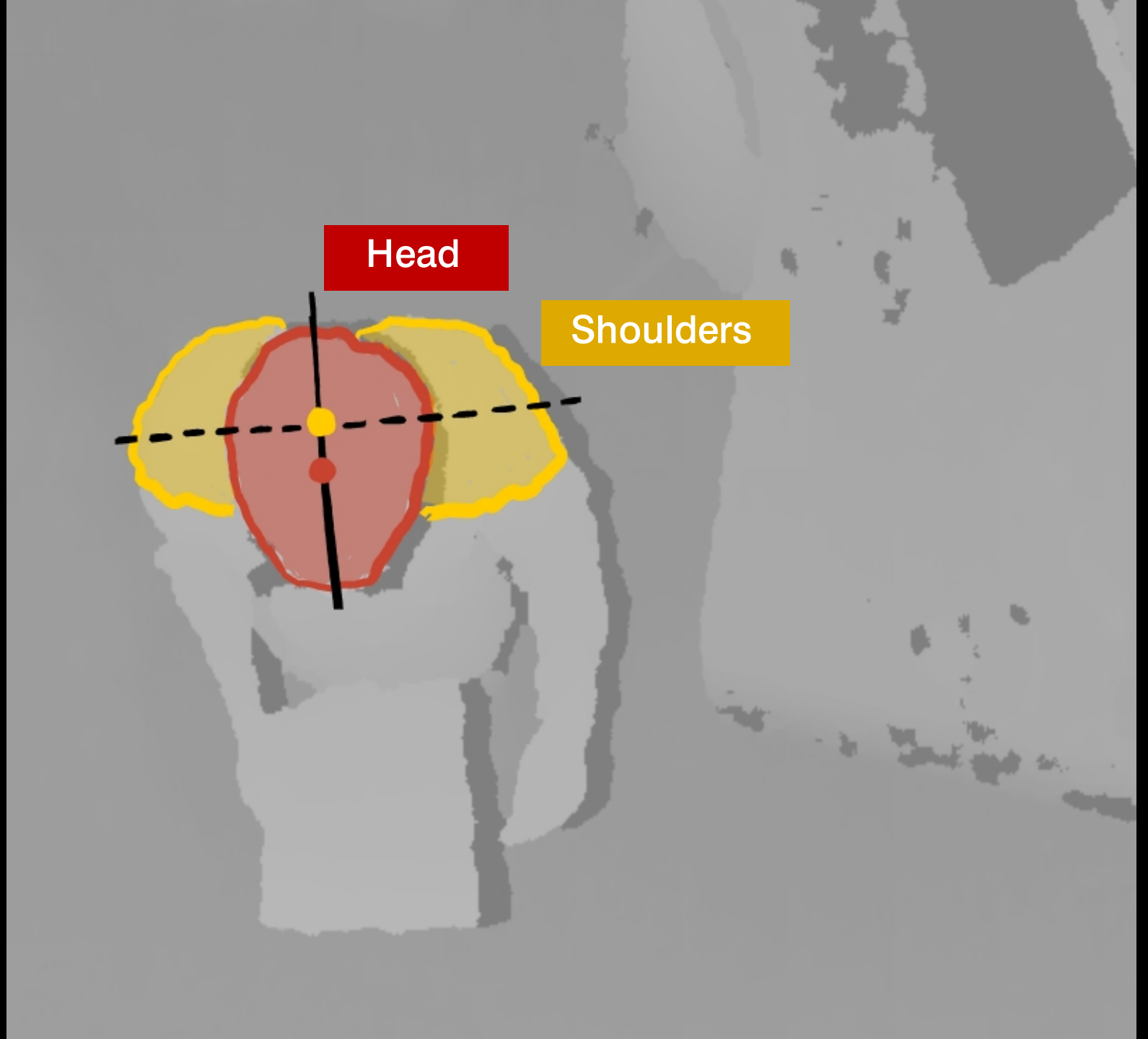


Head

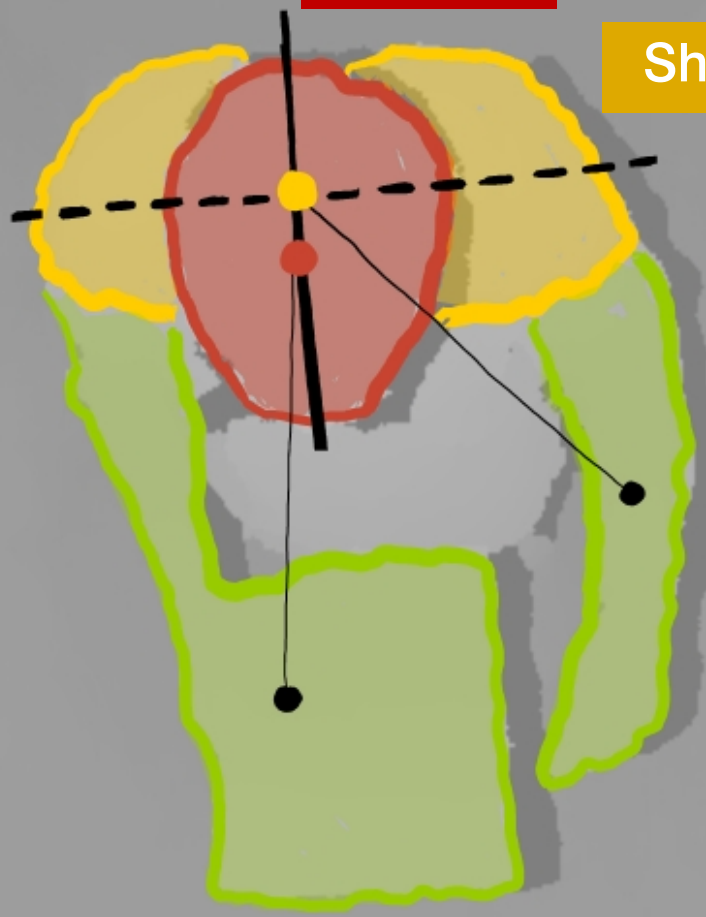
Head

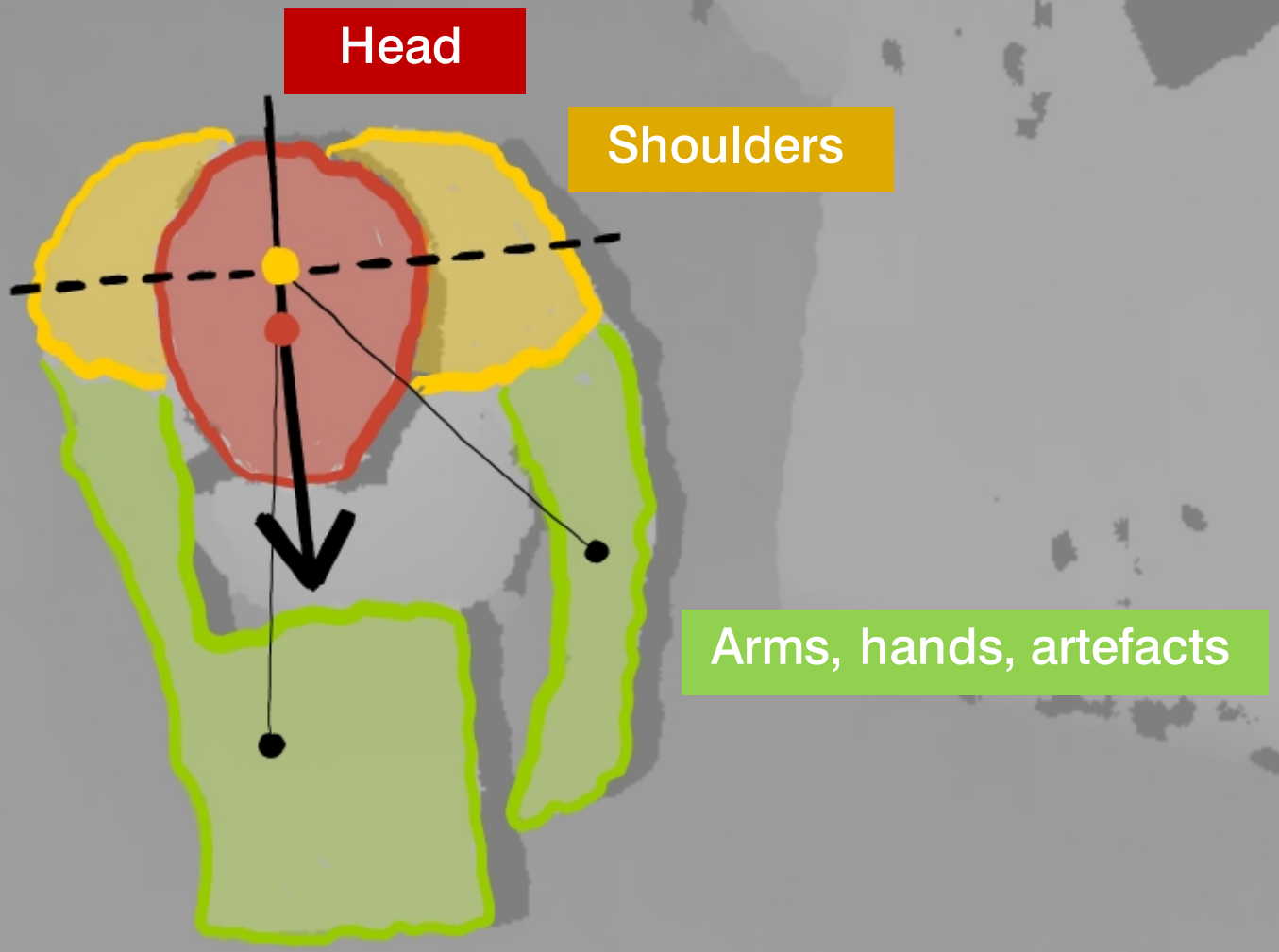

Head
Shoulders

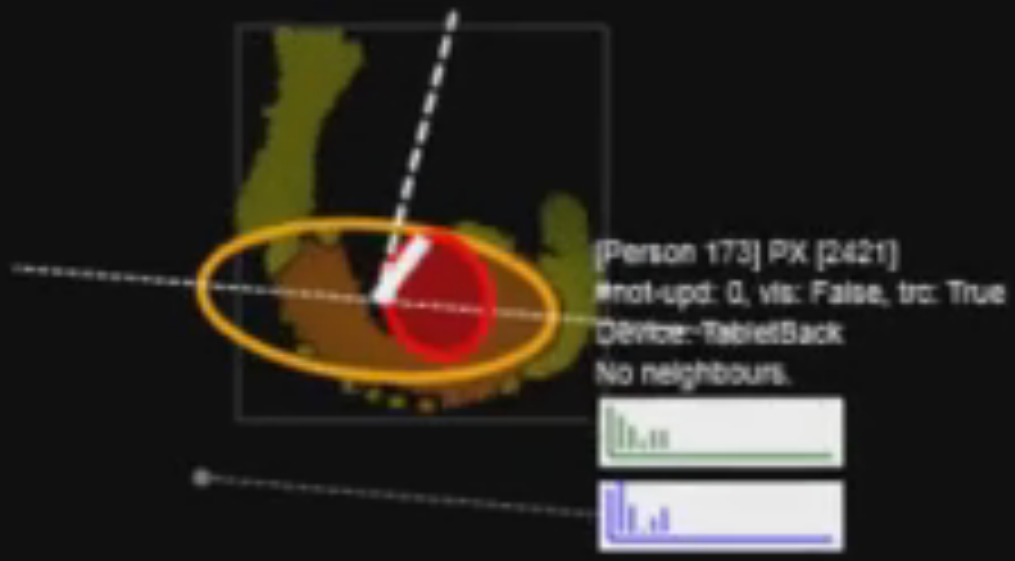

Head
Shoulders

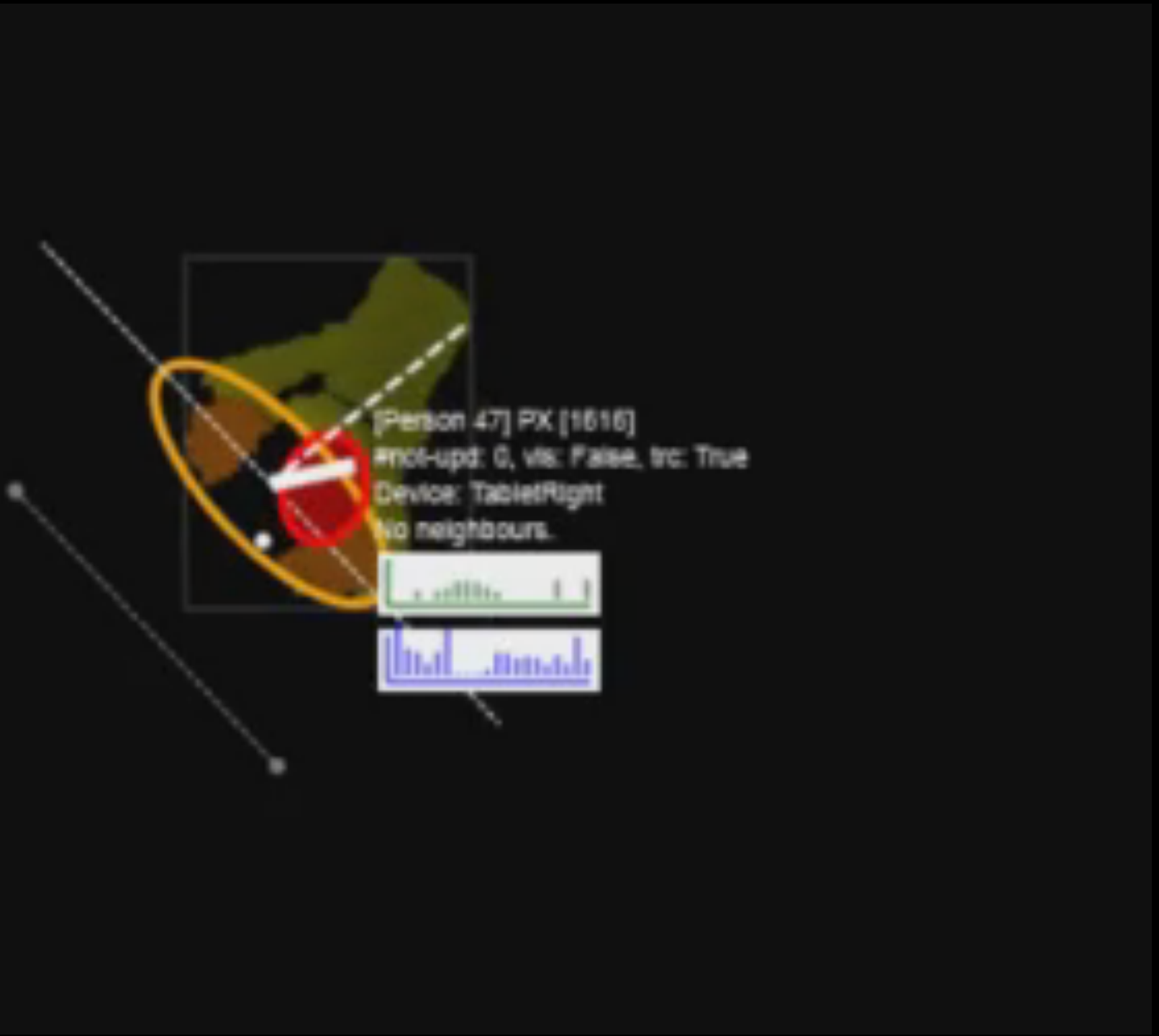

Head
Shoulders

Head
Shoulders
Arms, hands, artefacts


Head
Shoulders
Arms, hands, artefacts


Head
Shoulders
Arms, hands, artefacts

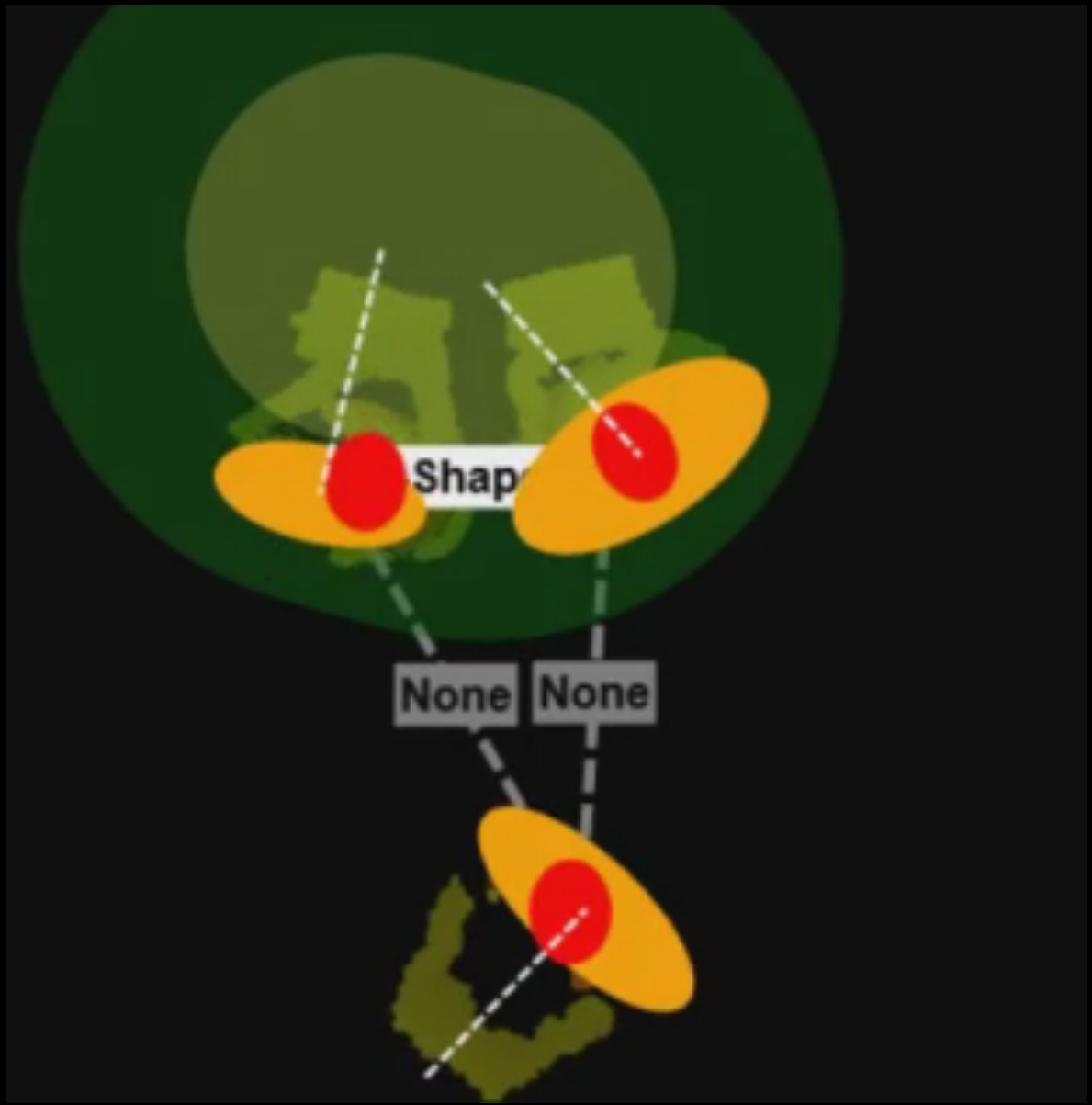

[Person 173] PX [2421]
#not-upd: 0, vis: False, trc: True
Device: TabletBack
No neighbours.


[Person 47] PX [1616]
#not-upd: 0, vis: False, trc: True
Device: TabletRight
No neighbours.

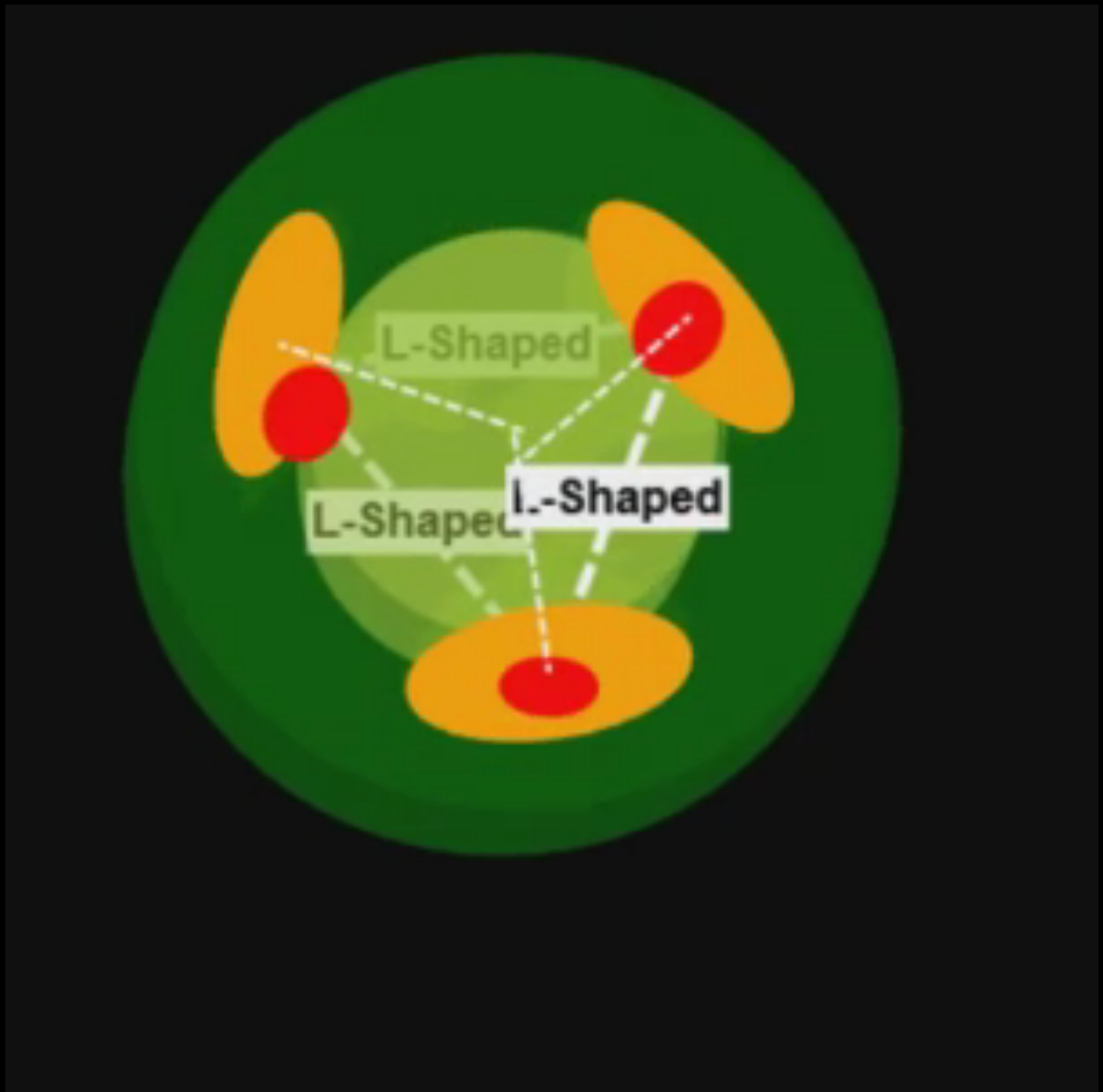
Step 1 | Determining f-formations

Step 1 | Determining f-formations

Step 1 | Determining f-formations

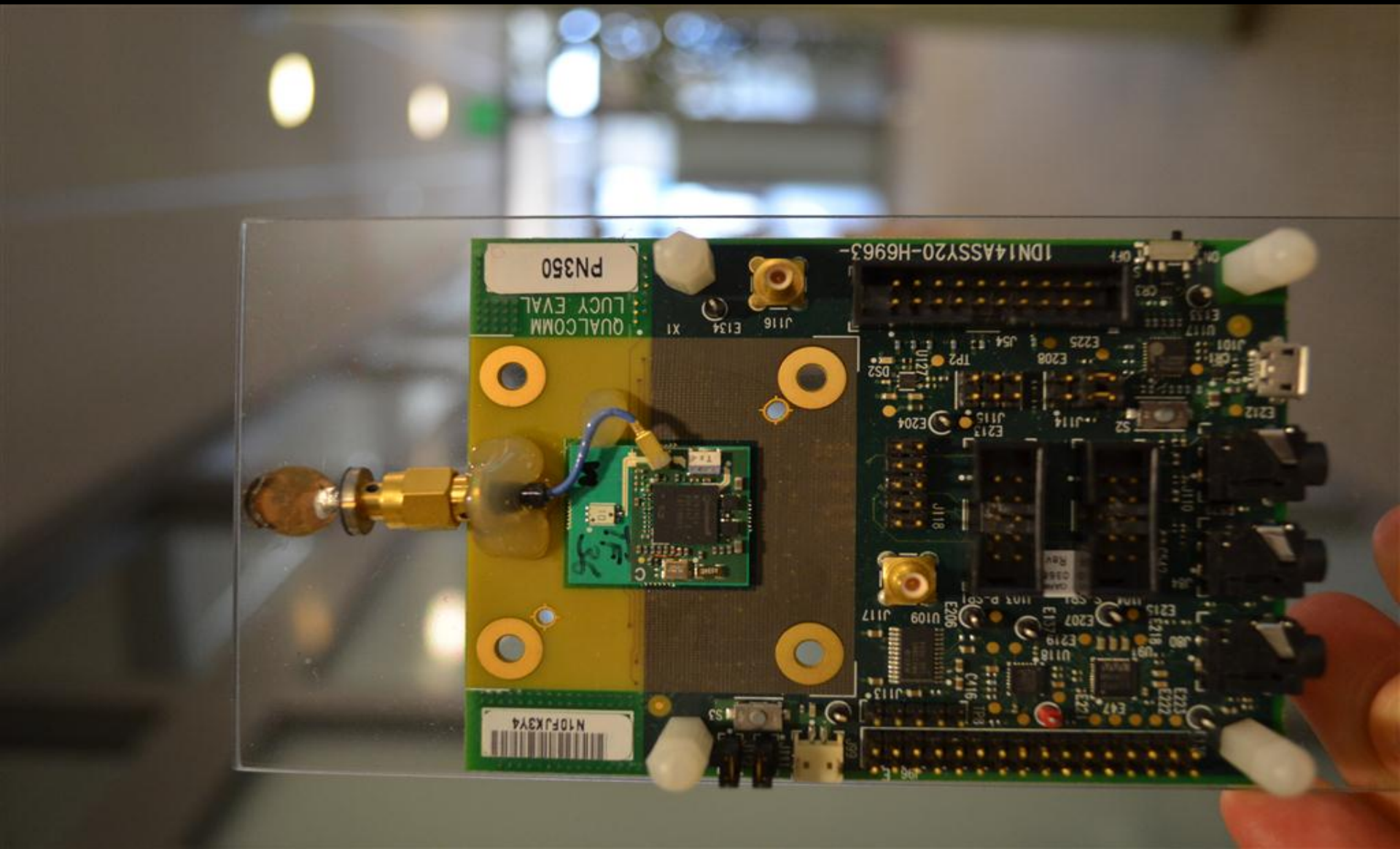


Step 1 | Determining f-formations

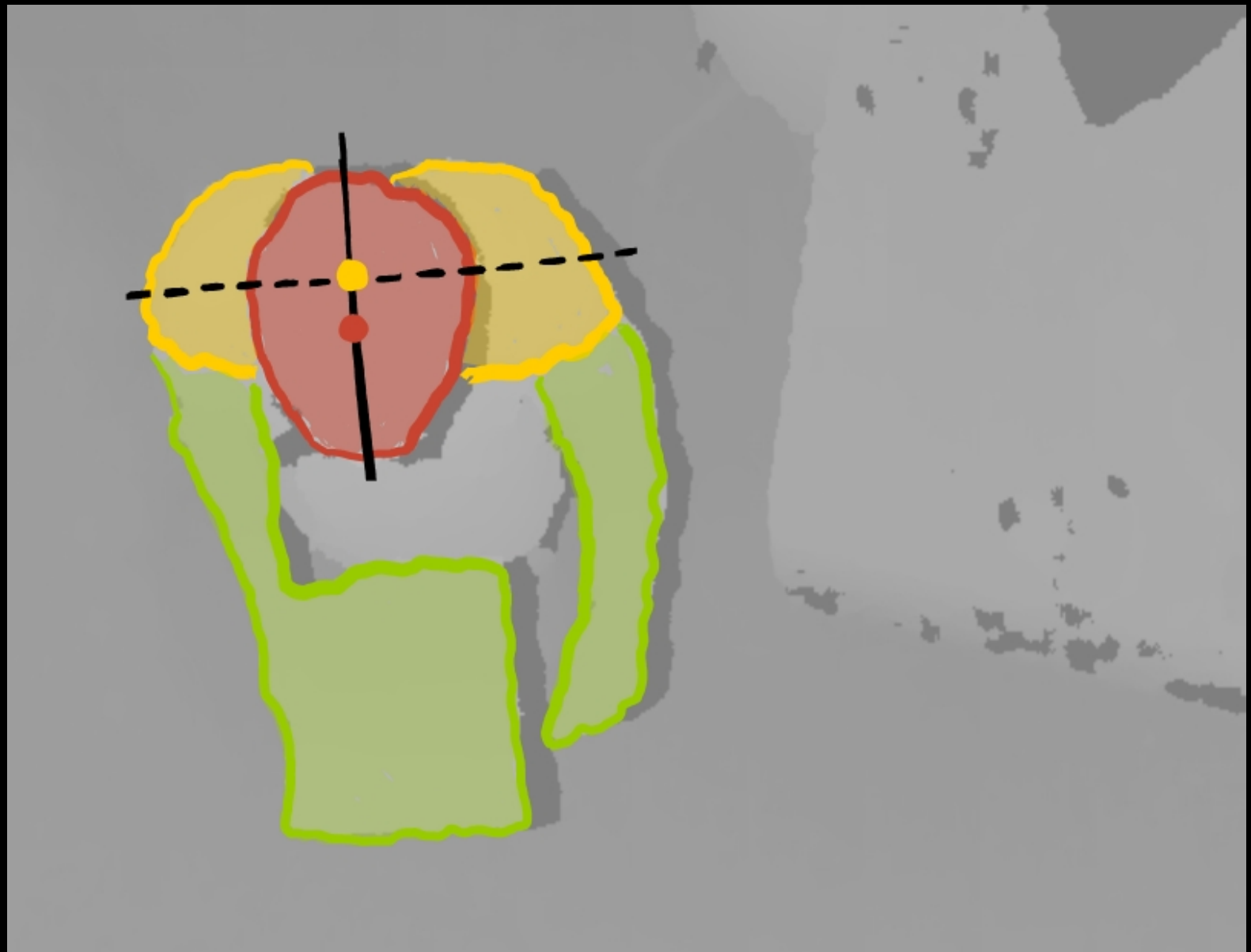


Step 2 | Devices’ spatial relationships

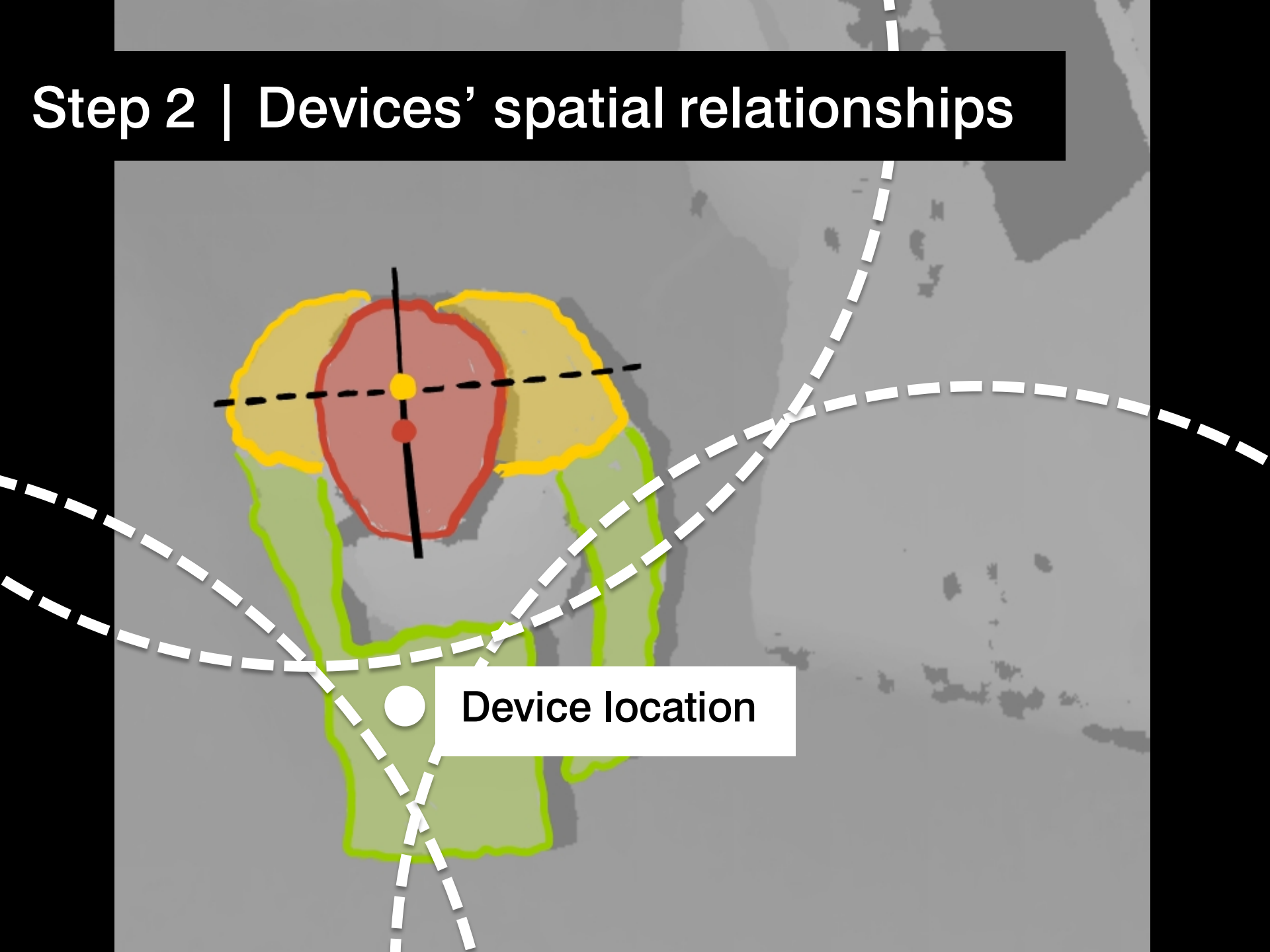
Step 2 | Devices’ spatial relationships



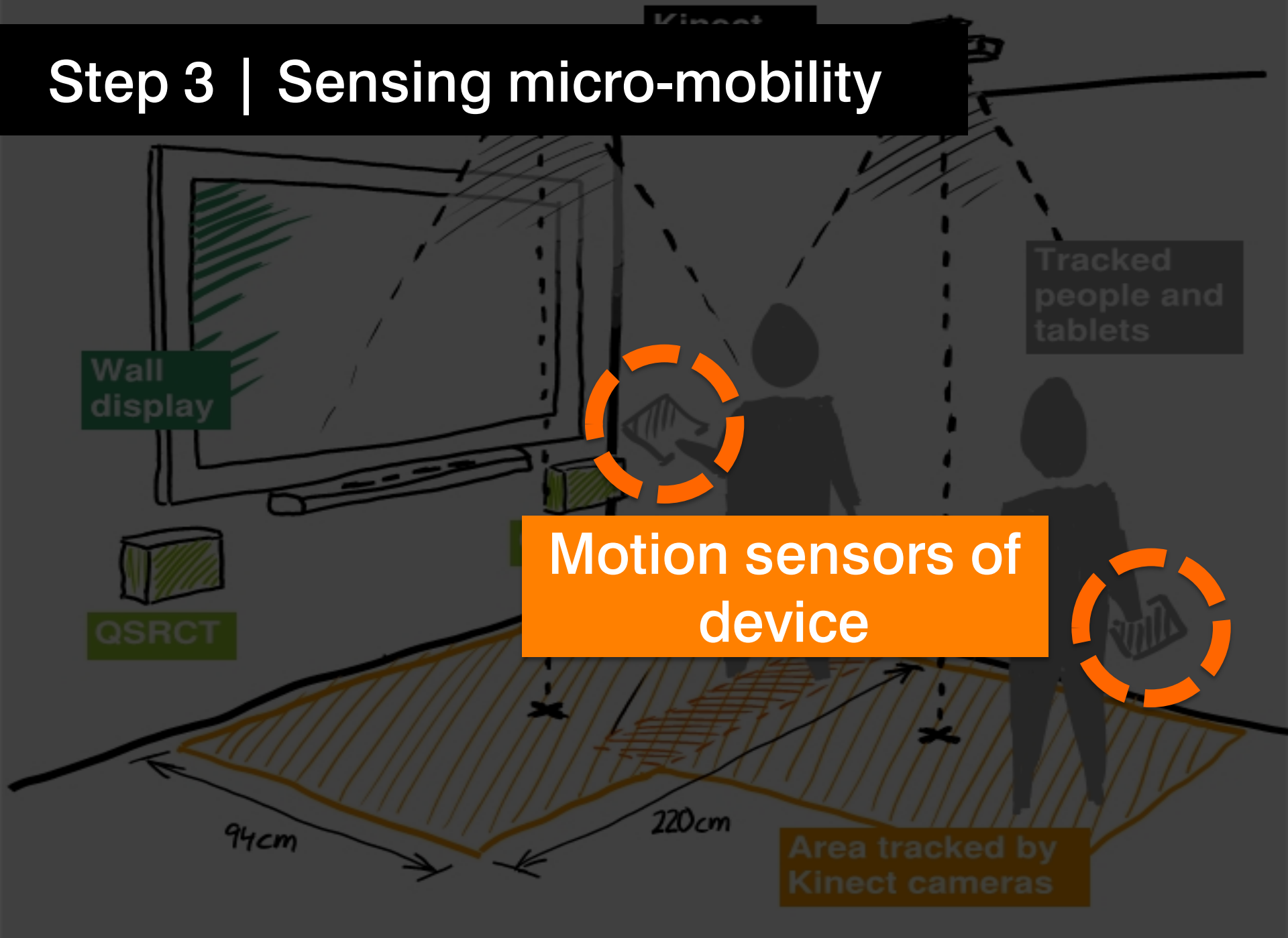
Step 2 | Devices’ spatial relationships

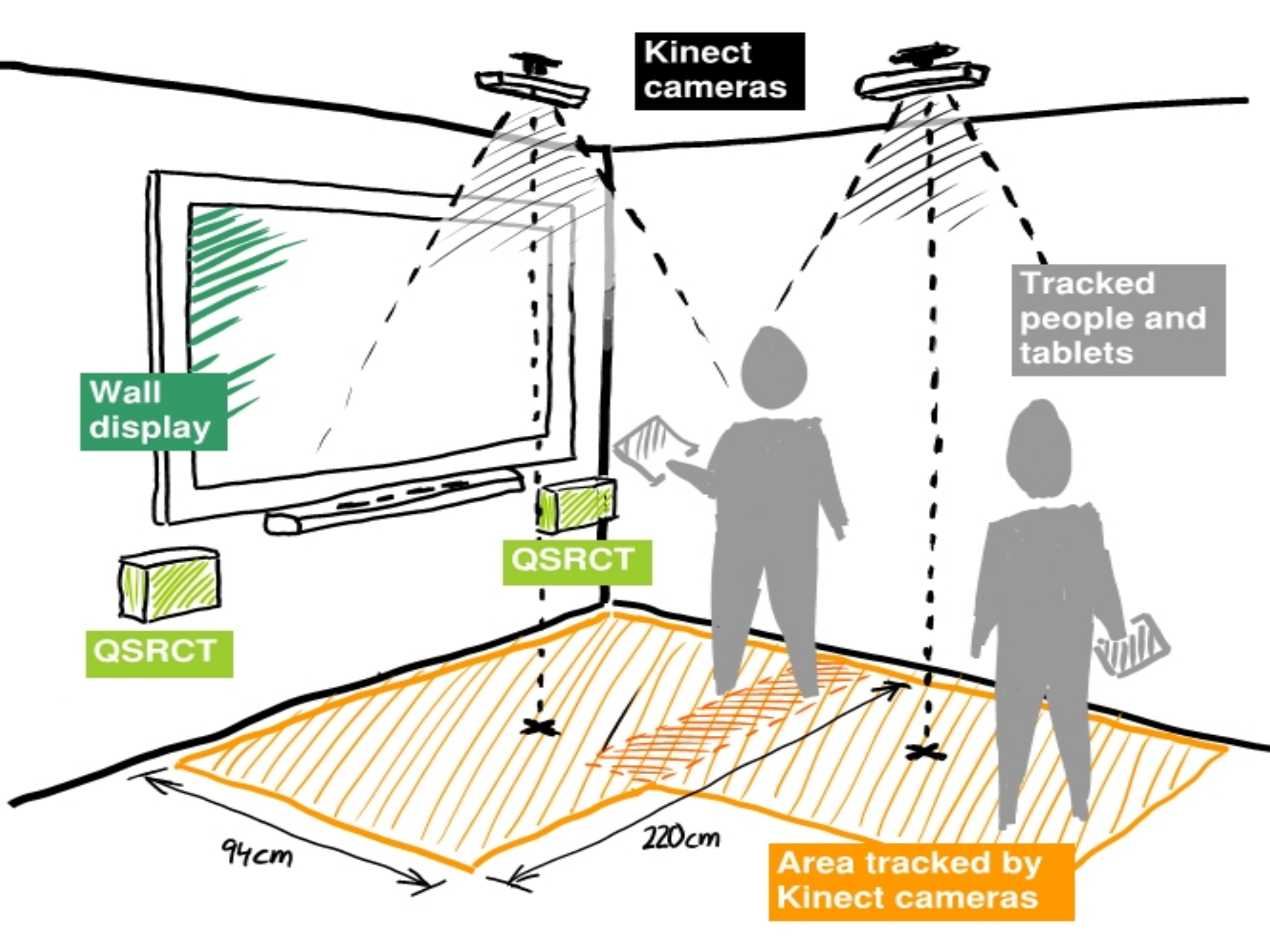


Step 2 | Devices’ spatial relationships



Step 3 | Sensing micro-mobility




Kinect cameras
Tracked people and tablets
Wall display
QSRCT
QSRCT
94cm
220cm
Area tracked by Kinect cameras

Hybrid sensing approach

1. Person-to-person proxemics and F-Formations

2. Device-to-device proxemics

3. Micro-mobility

Hybrid sensing approach

1. Person-to-person proxemics and F-Formations

Overhead KINECT cameras

+

2. Device-to-device proxemics

Radio signal trilateration

+

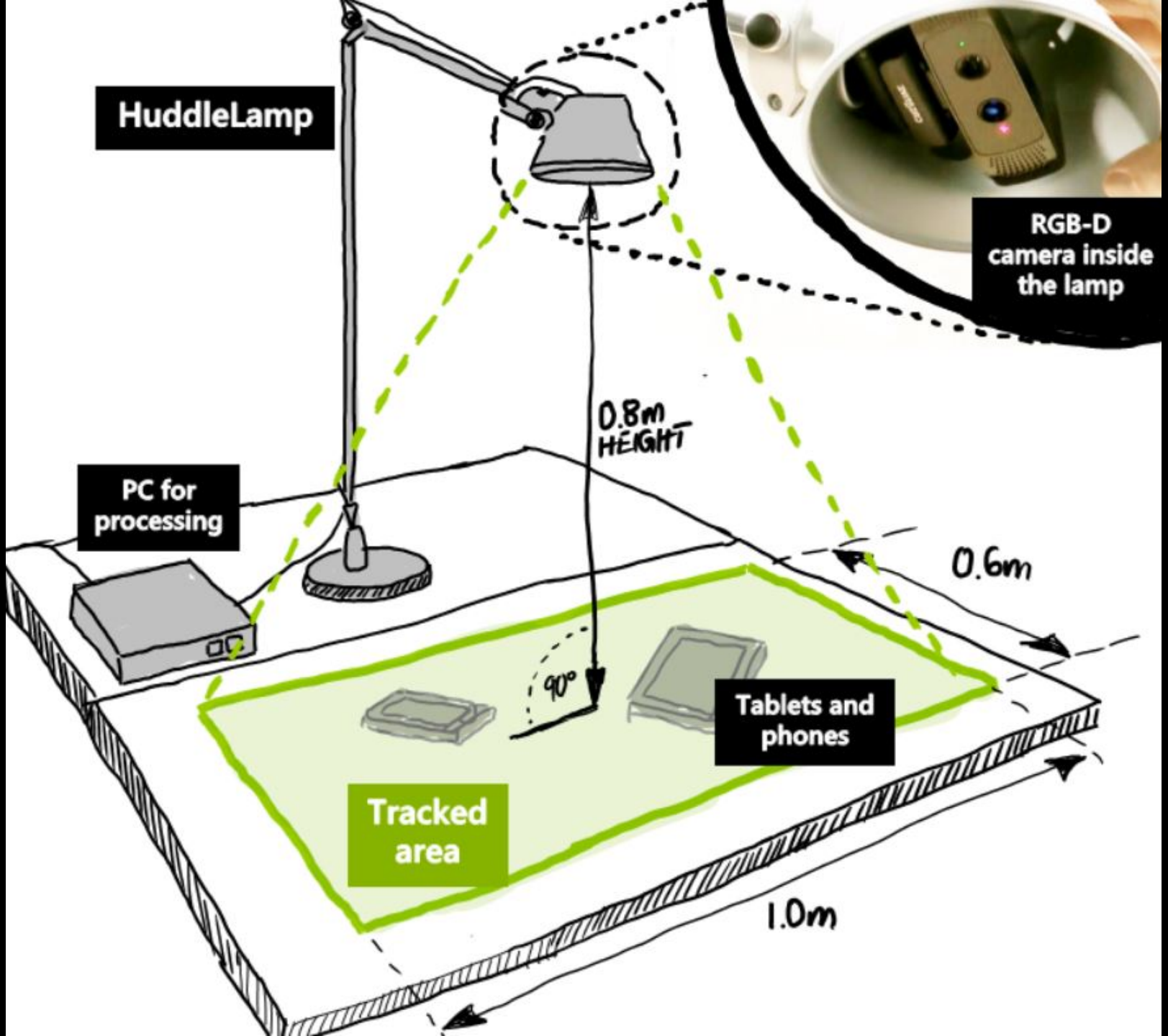
3. Micro-mobility

Motion sensors of device

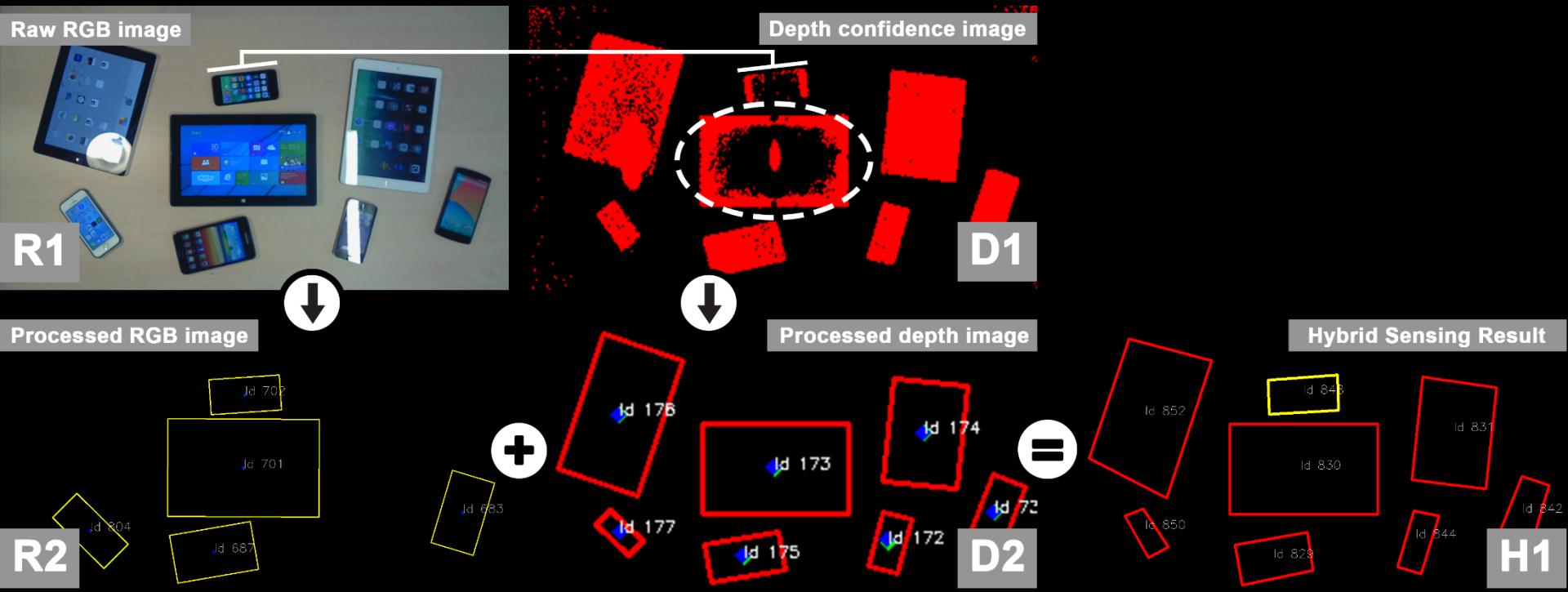
HuddleLamp: Spatially-Aware Mobile Displays for Ad-hoc Around-the-Table Collaboration

Rädle, R. Jetter, H.C., Marquardt, N., Reiterer, H., Rogers, Y. (2014) HuddleLamp: Spatially-Aware Mobile Displays for Ad-hoc Around-the-Table Collaboration. In Proceedings at ITS 2014, ACM (to appear).

Id 4
Id 3
Id 2
Id 179 (d=15)


HuddleLamp
RGB-D camera inside the lamp
0.8m HEIGHT
PC for processing
0.6m
90°
Tablets and phones
Tracked area
1.0m

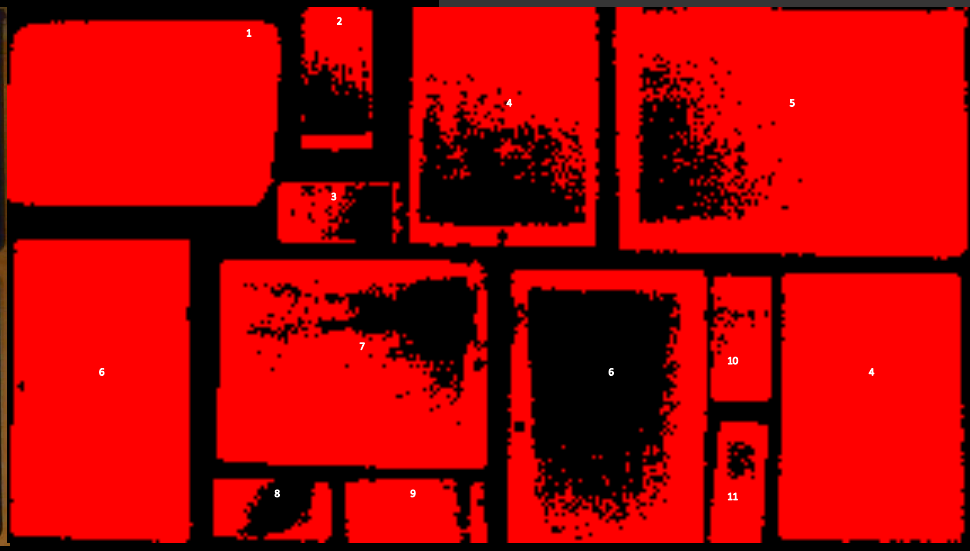
Hybrid Sensing – RGB and Depth Tracking



Reflectance Properties

RGB Image

Confidence Image



Technical Evaluation – Results in Brief

- Accuracy of Hybrid Sensing < 1 cm
- Reliable tracking even when occluded
  100% 1 finger, 99.9% 1 hand, and 89.8% 2 hands
- Unaffected by ambient light ranging
  10 lux, 1600 lux, and 2200 lux
- Tracking framerate between 25 to 30 fps

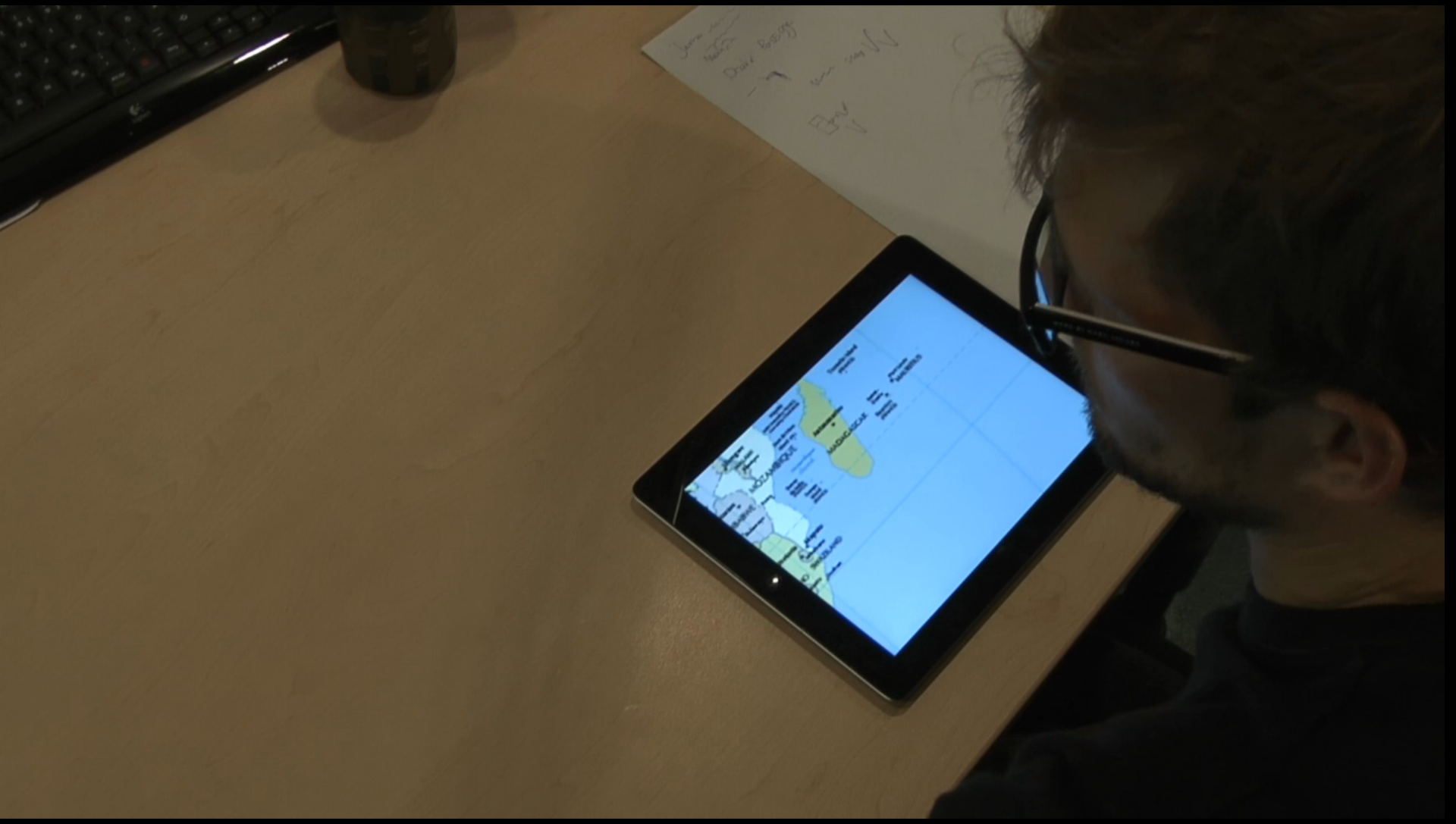
HuddleLamp JavaScript API

Example JavaScript on client device

```
1.var huddle = Huddle.client()
2.   .on("devicefound", function() {
3.     console.log("devicefound");
4.   })
5.   .on("devicelost", function() {
6.     console.log("devicelost");
7.   })
8.   .on("proximity", function(data) {
9.     console.log(data);
10.   })
11.   .connect(host, port);
```

HuddleLamp JavaScript API

Huddle

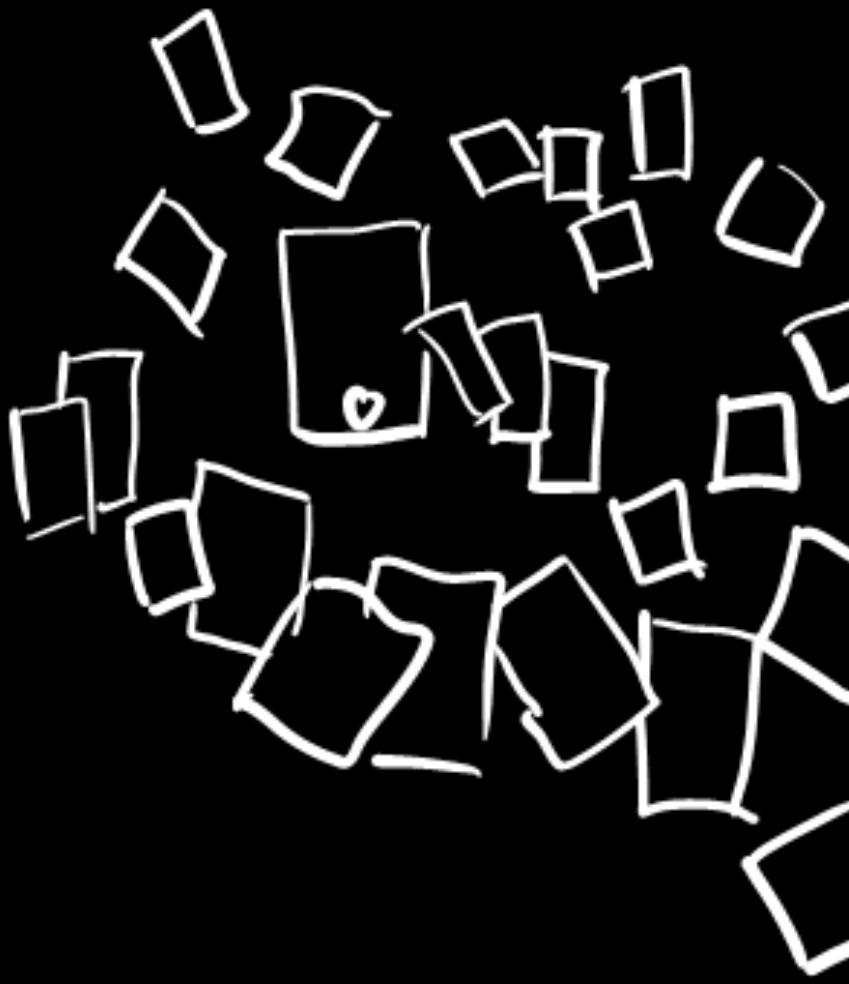

MADAGASCAR

CARD
IMDb
CHEF

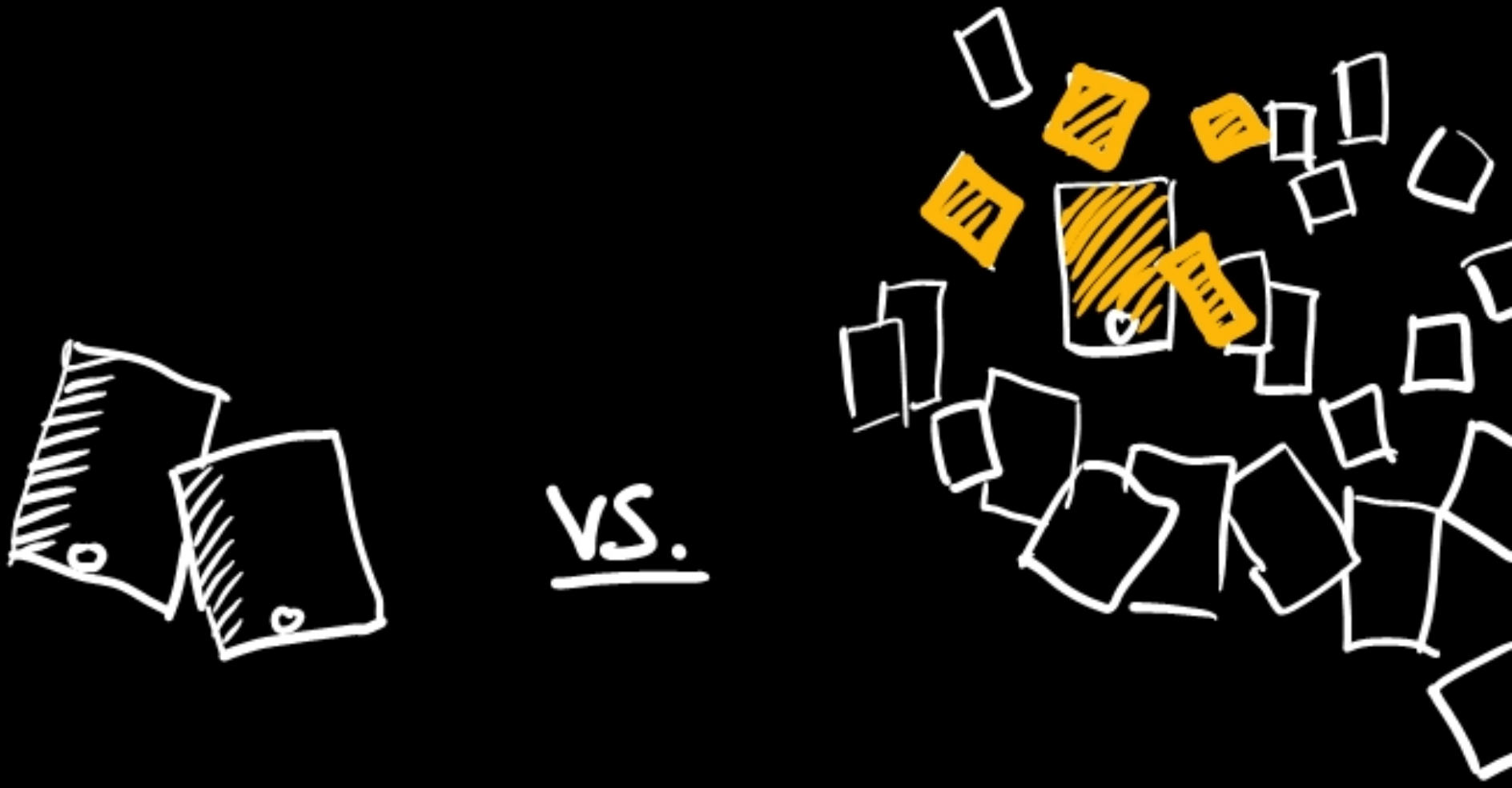
Large Ubicomp Ecologies

Large Ubicomp Ecologies

vs.

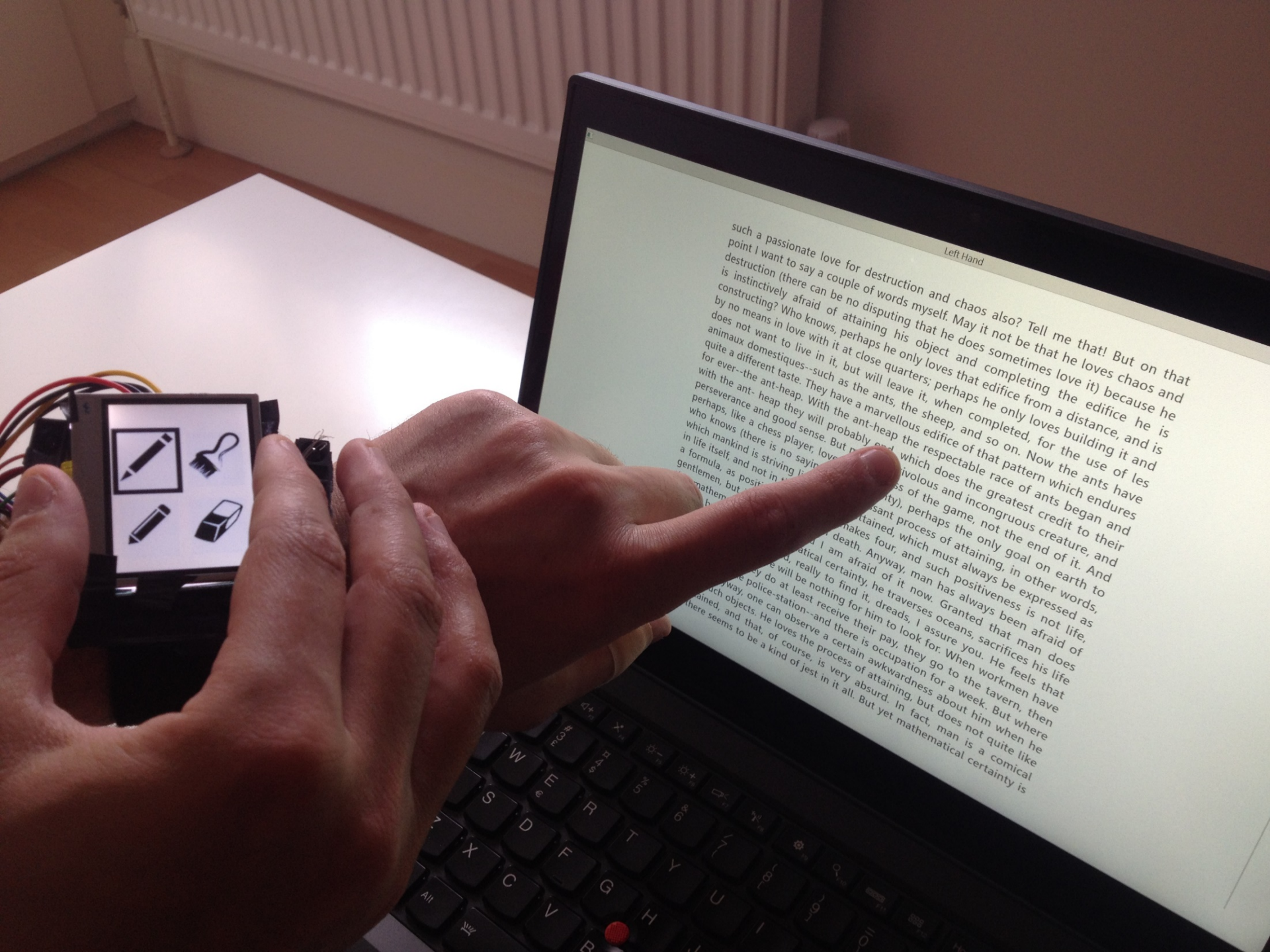


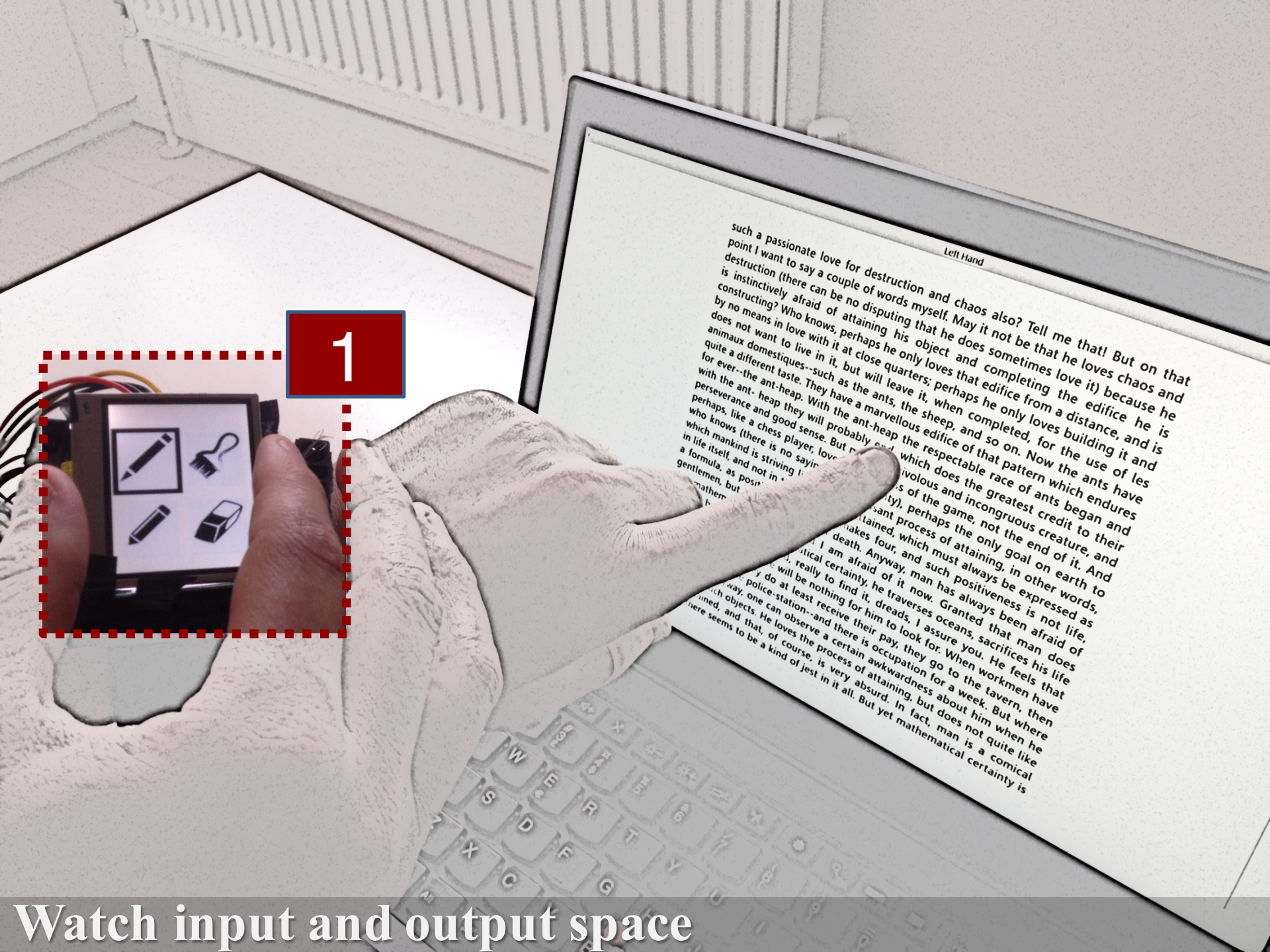
Large Ubicomp Ecologies



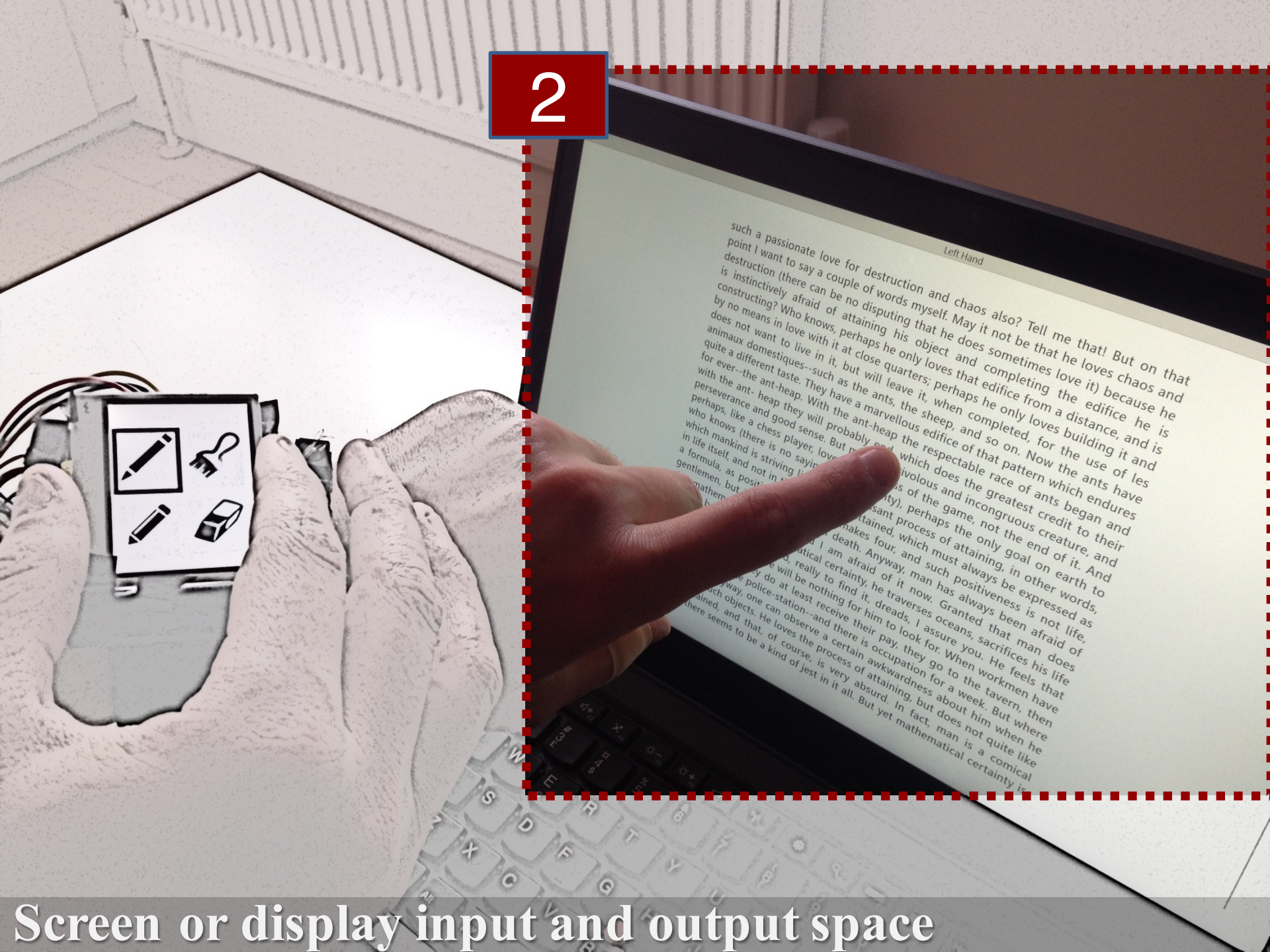
WatchConnect:
Cross-Device Smartwatch Interactions

Houben, S., Marquardt, N. (2015) WatchConnect: A Toolkit for Prototyping Smartwatch-Centric Cross-Device Applications. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15). ACM, New York, NY, USA, 1247-1256.


Left Hand
such a passionate love for destruction and chaos also? Tell me that! But on that
point I want to say a couple of words myself. May it not be that he loves chaos and
destruction (there can be no disputing that he does sometimes love it) because he
is instinctively afraid of attaining his object and completing the edifice he is
constructing? Who knows, perhaps he only loves that edifice from a distance, and is
by no means in love with it at close quarters; perhaps he only loves building it and
does not want to live in it, but will leave it, when completed, for the use of les
animaux domestiques--such as the ants, the sheep, and so on. Now the ants have
quite a different taste. They have a marvellous edifice of that pattern which endures
for ever--the ant-heap. With the ant-heap the respectable race of ants began and
with the ant- heap they will probably end, which does the greatest credit to their
perseverance and good sense. But
perhaps, like a chess player, love
who knows (there is no sayin
which mankind is striving li
in life itself, and not in
a formula, as posit
gentlemen, but
mathem
ivolous and incongruous creature, and
ss of the game, not the end of it. And
nty), perhaps the only goal on earth to
sant process of attaining, in other words,
ttained, which must always be expressed as
makes four, and such positiveness is not life,
death. Anyway, man has always been afraid of
I am afraid of it now. Granted that man does
atical certainty, he traverses oceans, sacrifices his life
d, really to find it, dreads, I assure you. He feels that
e will be nothing for him to look for. When workmen have
y do at least receive their pay, they go to the tavern, then
e police-station--and there is occupation for a week. But where
yway, one can observe a certain awkwardness about him when he
uch objects. He loves the process of attaining, but does not quite like
ained, and that, of course, is very absurd. In fact, man is a comical
there seems to be a kind of jest in it all. But yet mathematical certainty is



Watch input and output space


2
Left Hand
such a passionate love for destruction and chaos also? Tell me that! But on that
point I want to say a couple of words myself. May it not be that he loves chaos and
destruction (there can be no disputing that he does sometimes love it) because he
is instinctively afraid of attaining his object and completing the edifice he is
constructing? Who knows, perhaps he only loves that edifice from a distance, and is
by no means in love with it at close quarters; perhaps he only loves building it and
does not want to live in it, but will leave it, when completed, for the use of les
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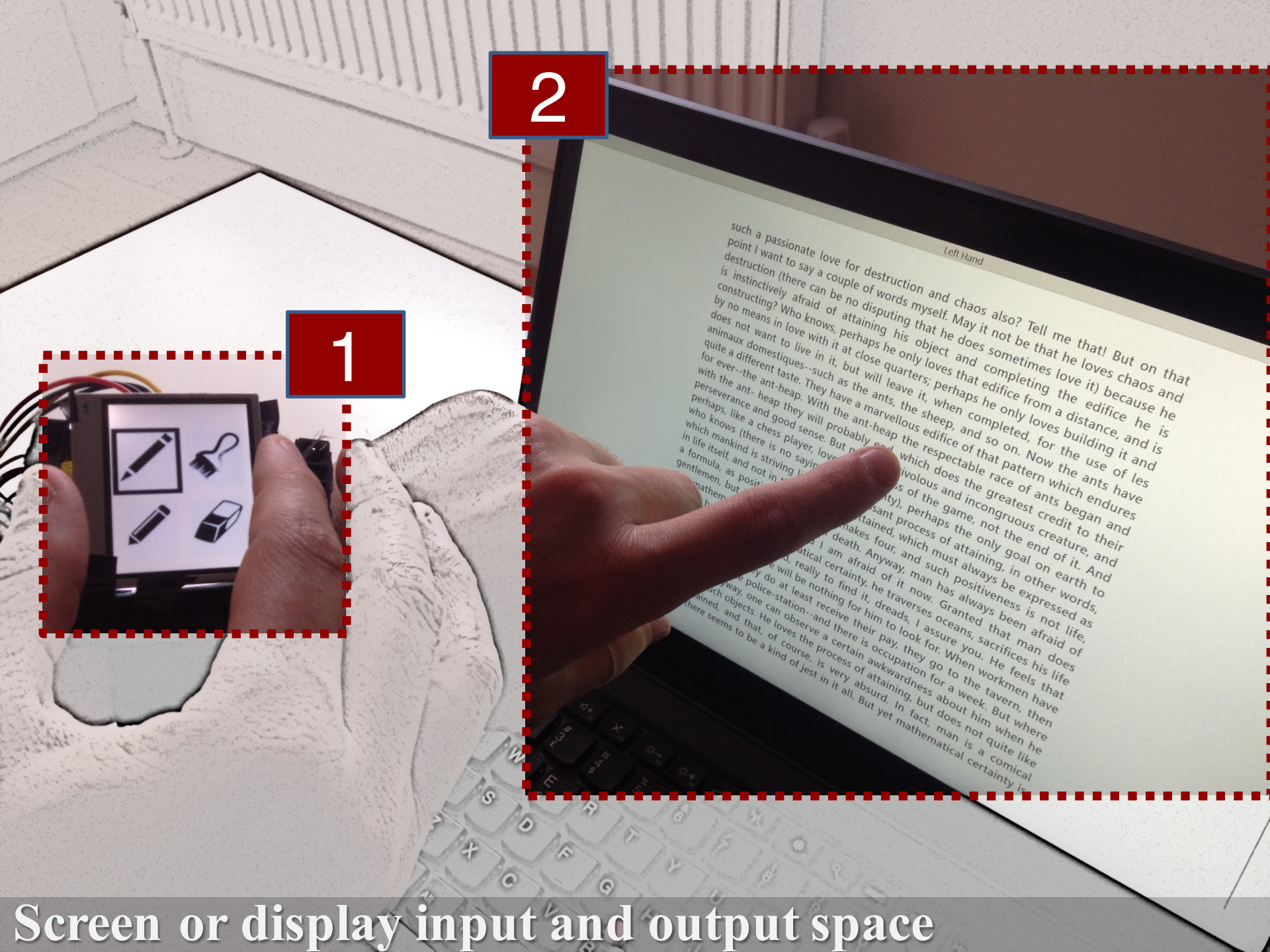
with the ant- heap they will probably end which does the greatest credit to their
perseverance and good sense. But
perhaps, like a chess player, lov
who knows (there is no sayin
which mankind is striving
in life itself, and not in
a formula, as posi
gentlemen, but
Screen or display input and output space


1
2
Left Hand
such a passionate love for destruction and chaos also? Tell me that! But on that
point I want to say a couple of words myself. May it not be that he loves chaos and
destruction (there can be no disputing that he does sometimes love it) because he
is instinctively afraid of attaining his object and completing the edifice he is
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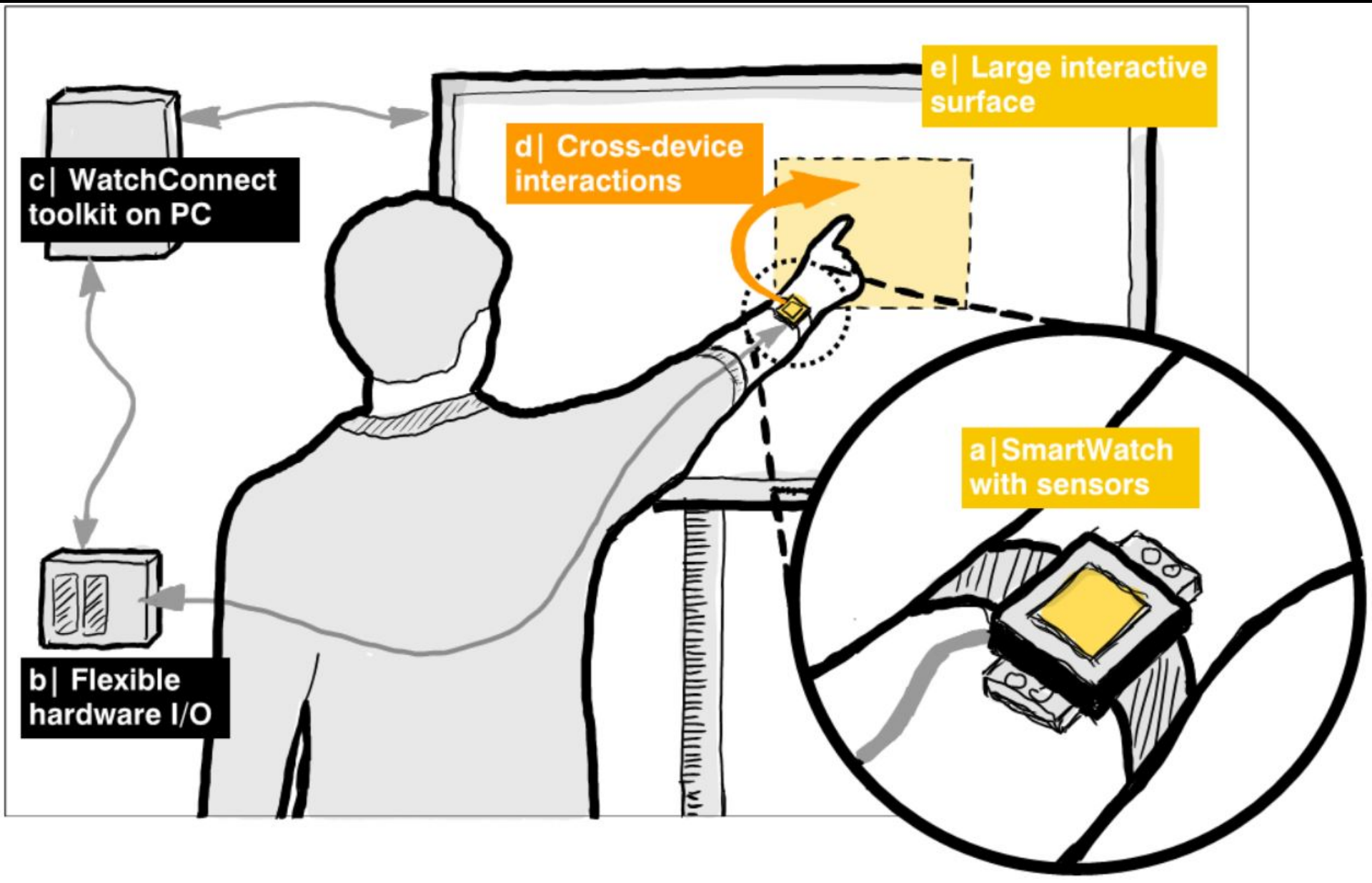
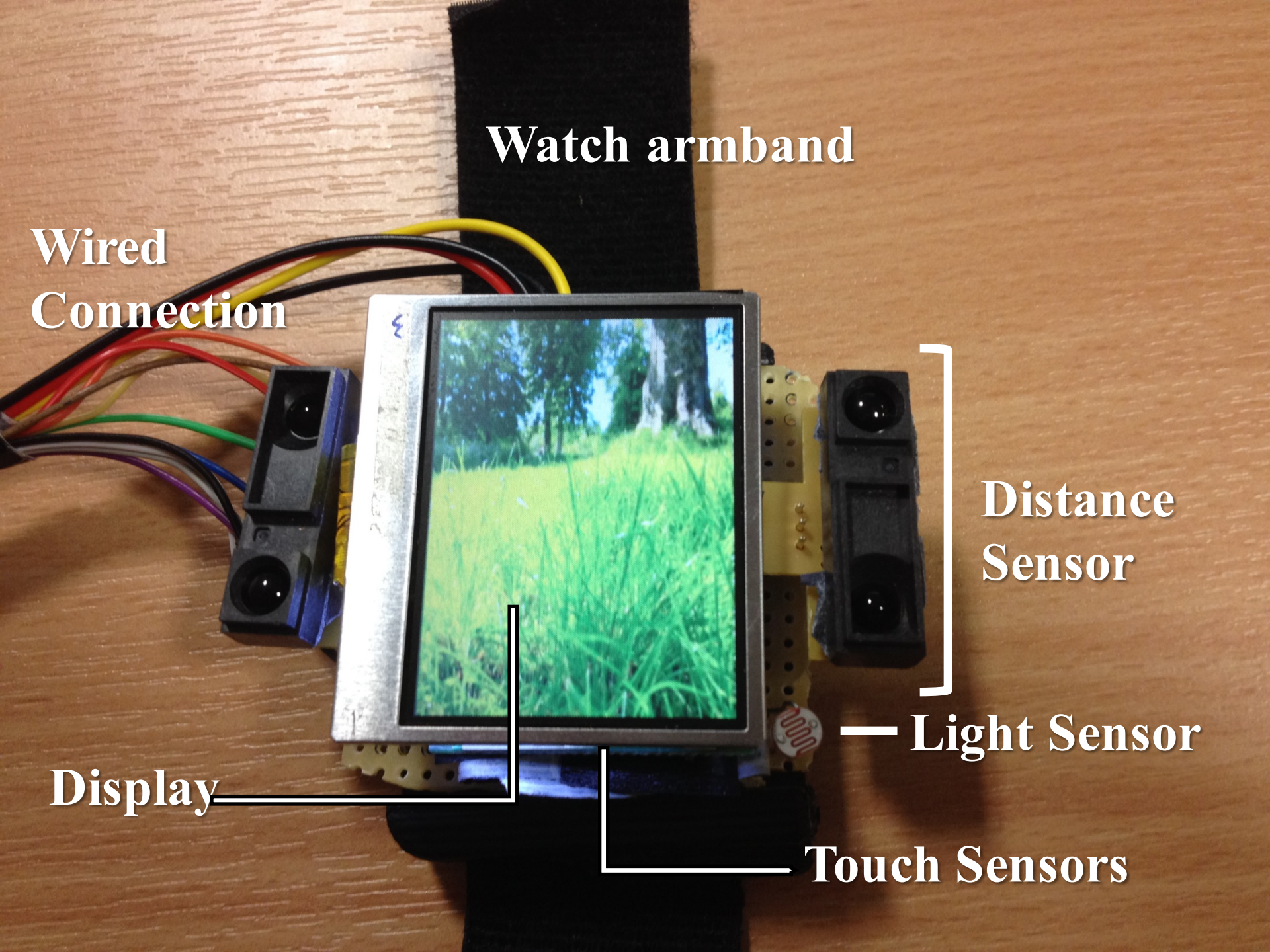
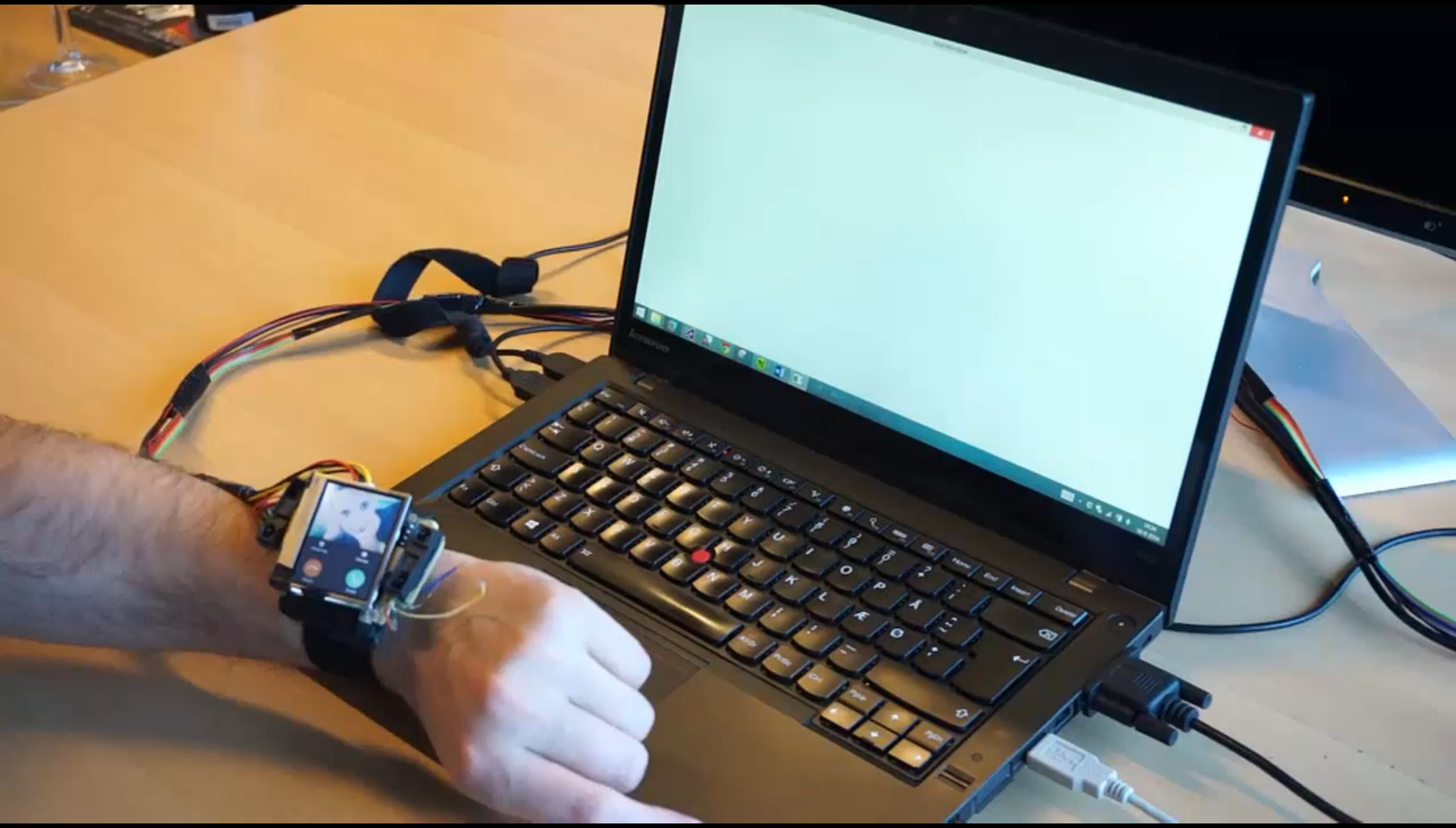
Screen or display input and output space


e| Large interactive surface
d| Cross-device interactions
c| WatchConnect toolkit on PC
a|SmartWatch with sensors
b| Flexible hardware I/O

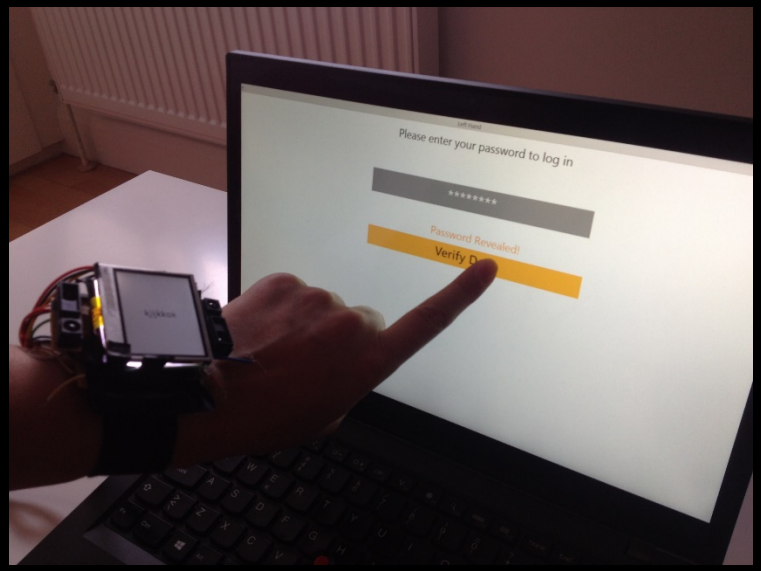

Watch armband
Wired Connection
Distance Sensor
Light Sensor
Display
Touch Sensors

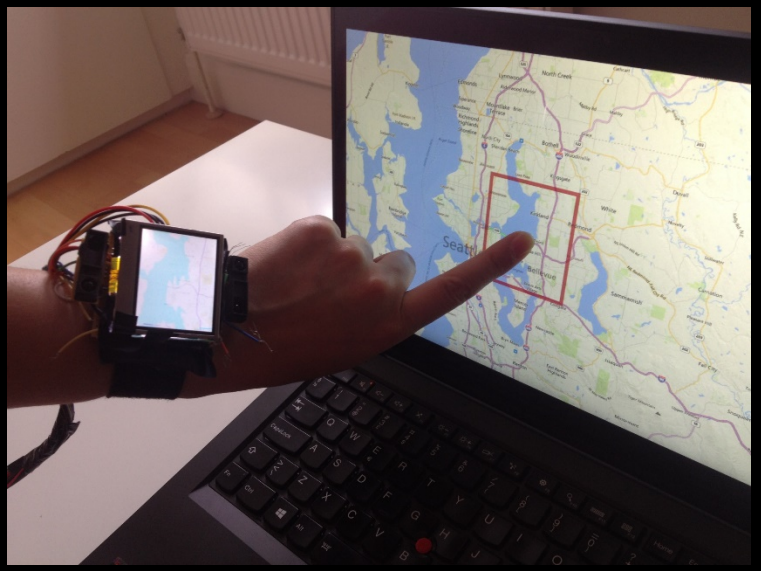
Information exchange

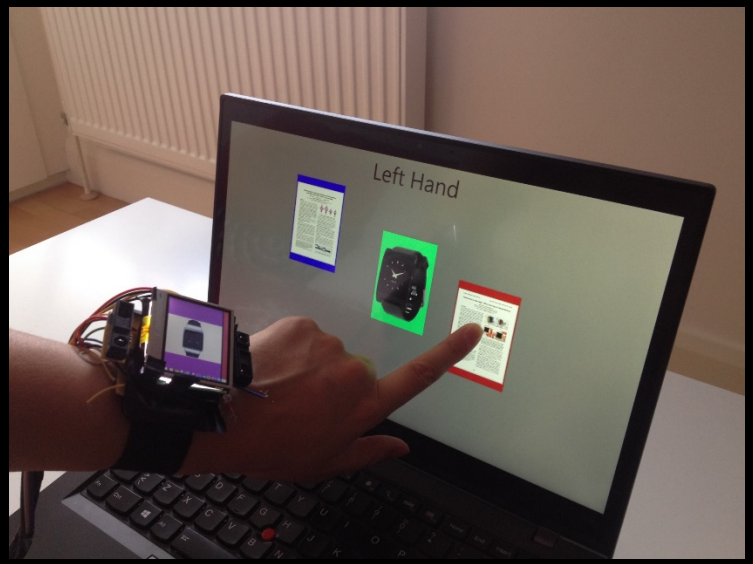
Map interactions



User interface “beaming”


Please enter your password to log in
****
Password Revealed!



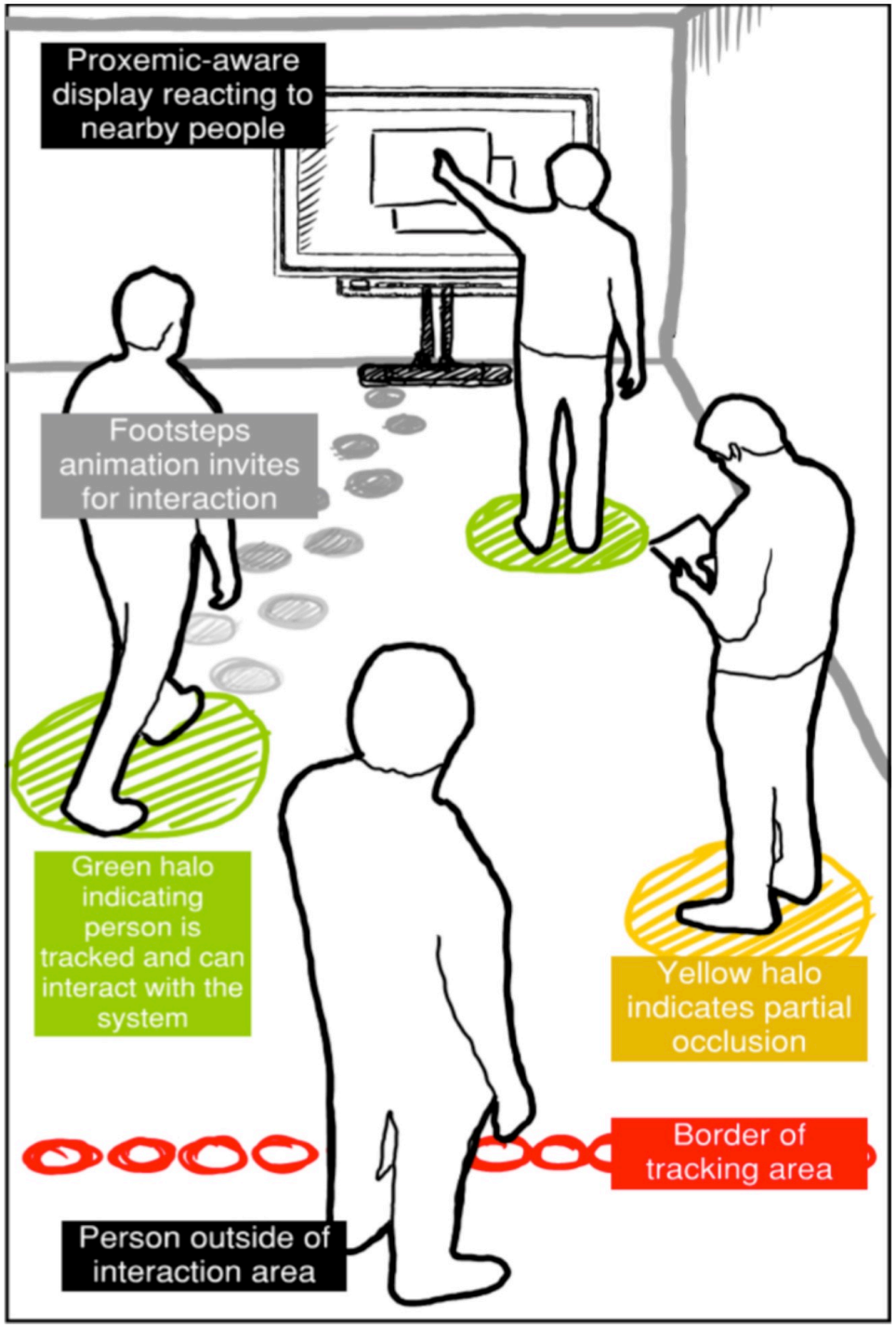

Left Hand

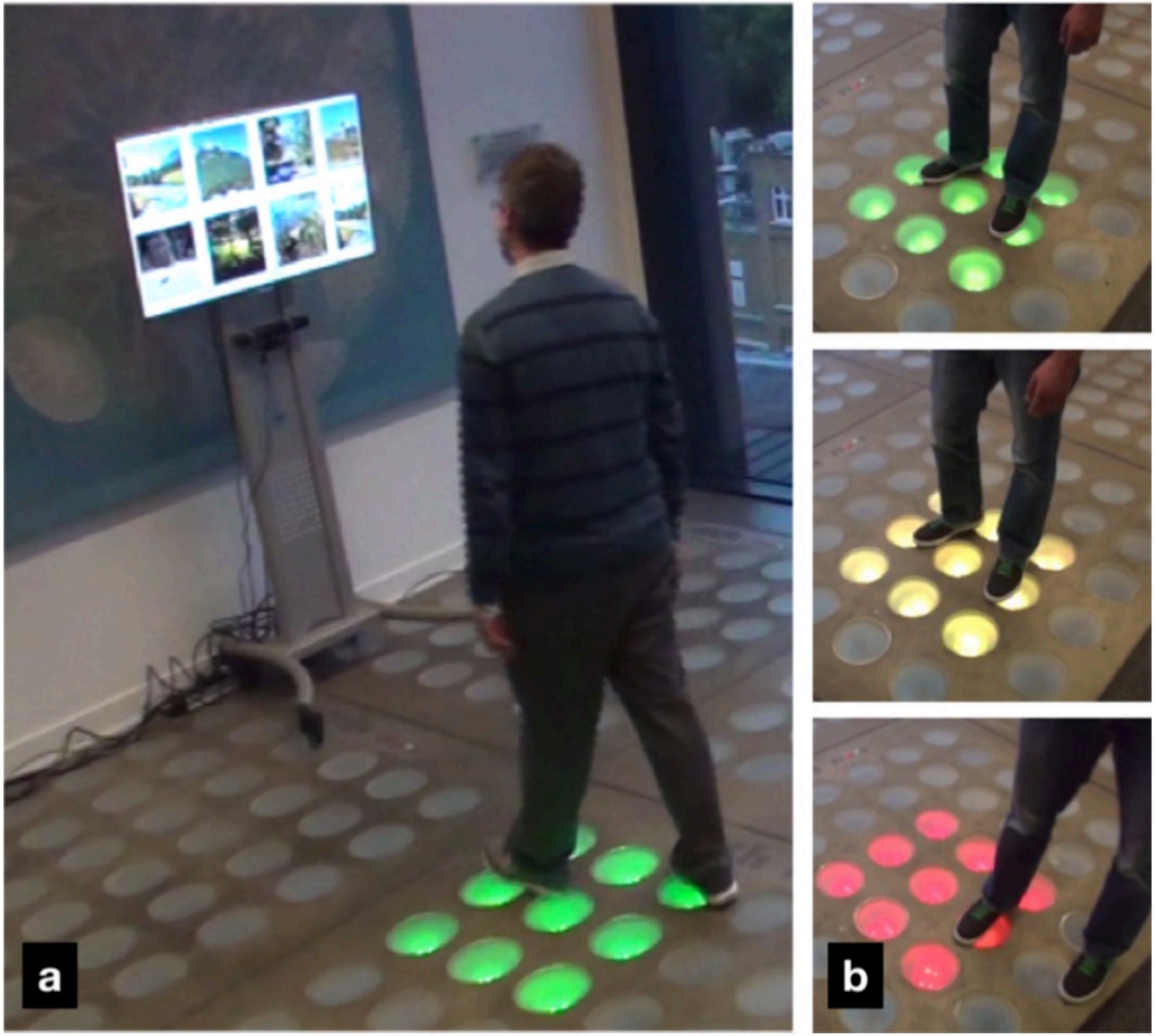
Remind Me
Message
Decline
Accept

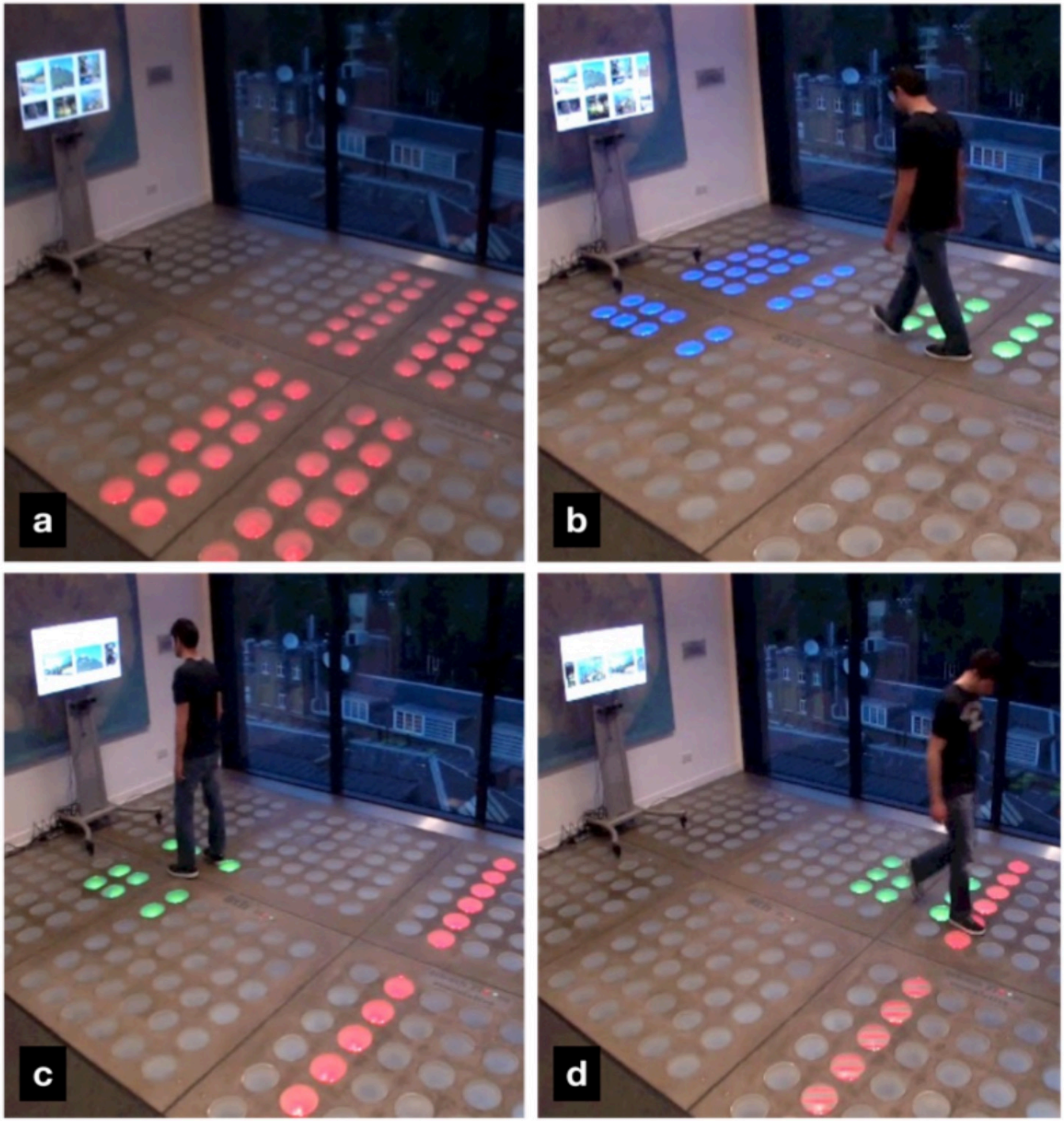
Proxemic Flow:

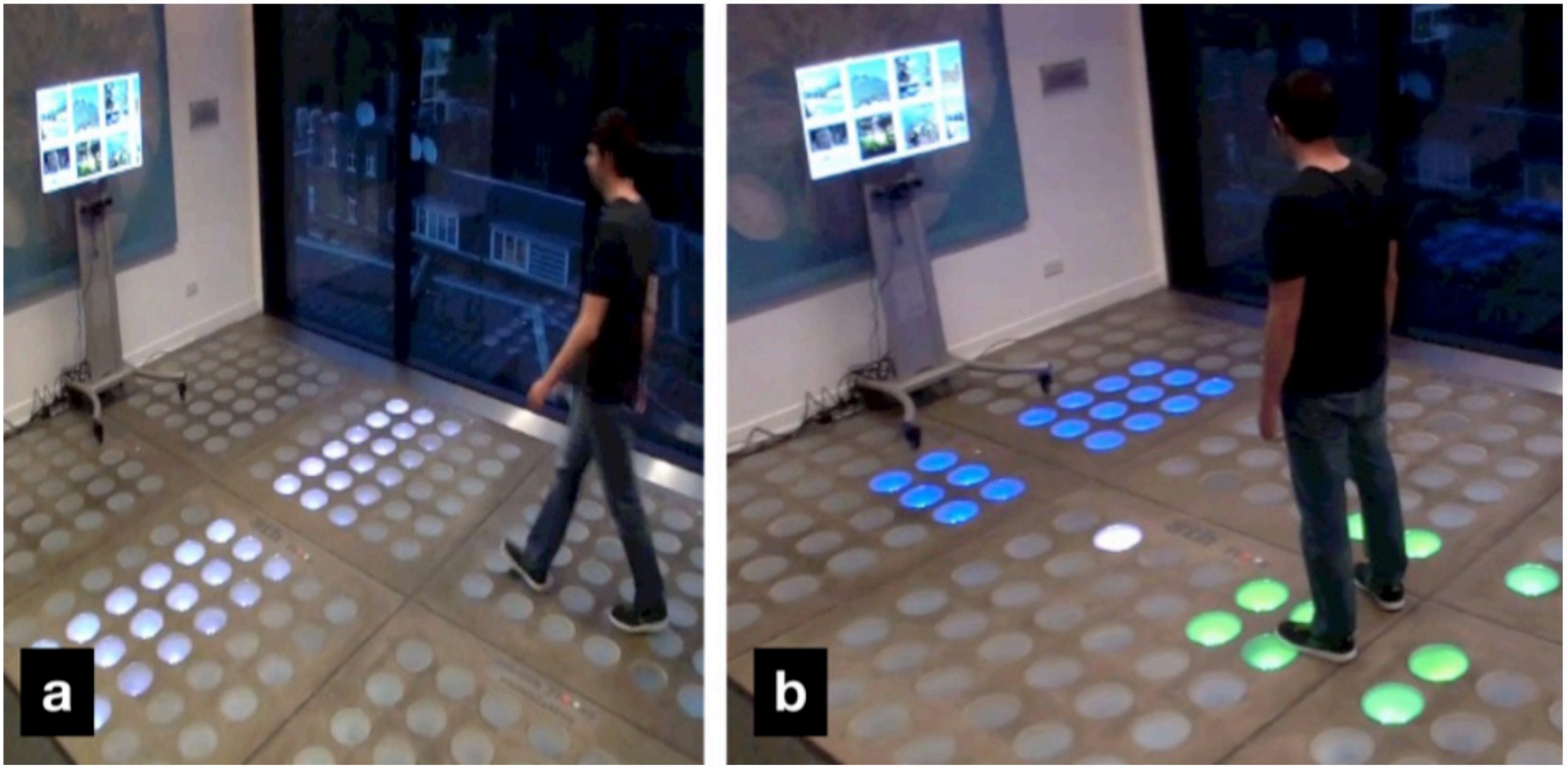
Peripheral Floor Visualisations to Mediate Large Surface Interactions

Vermeulen et al. (2015) ProxemicFlows: Dynamic Peripheral Floor Visualizations for Revealing and Mediating Large Surface Interactions. In Proceedings of INTERACT 2015.


Proxemic-aware display reacting to nearby people
Footsteps animation invites for interaction
Green halo indicating person is tracked and can interact with the system
Yellow halo indicates partial occlusion
Border of tracking area
Person outside of interaction area


a
b

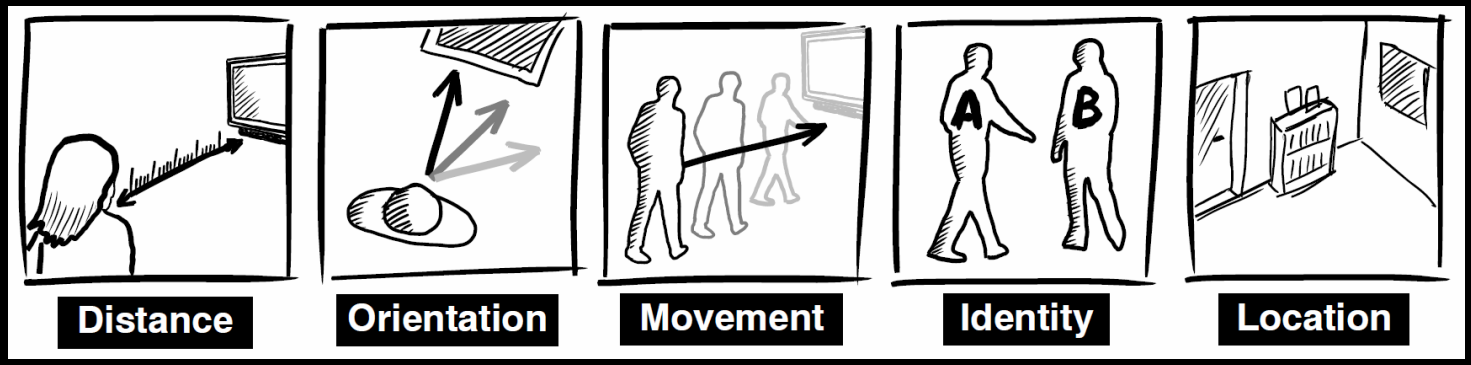

a
b
c
d


a
b

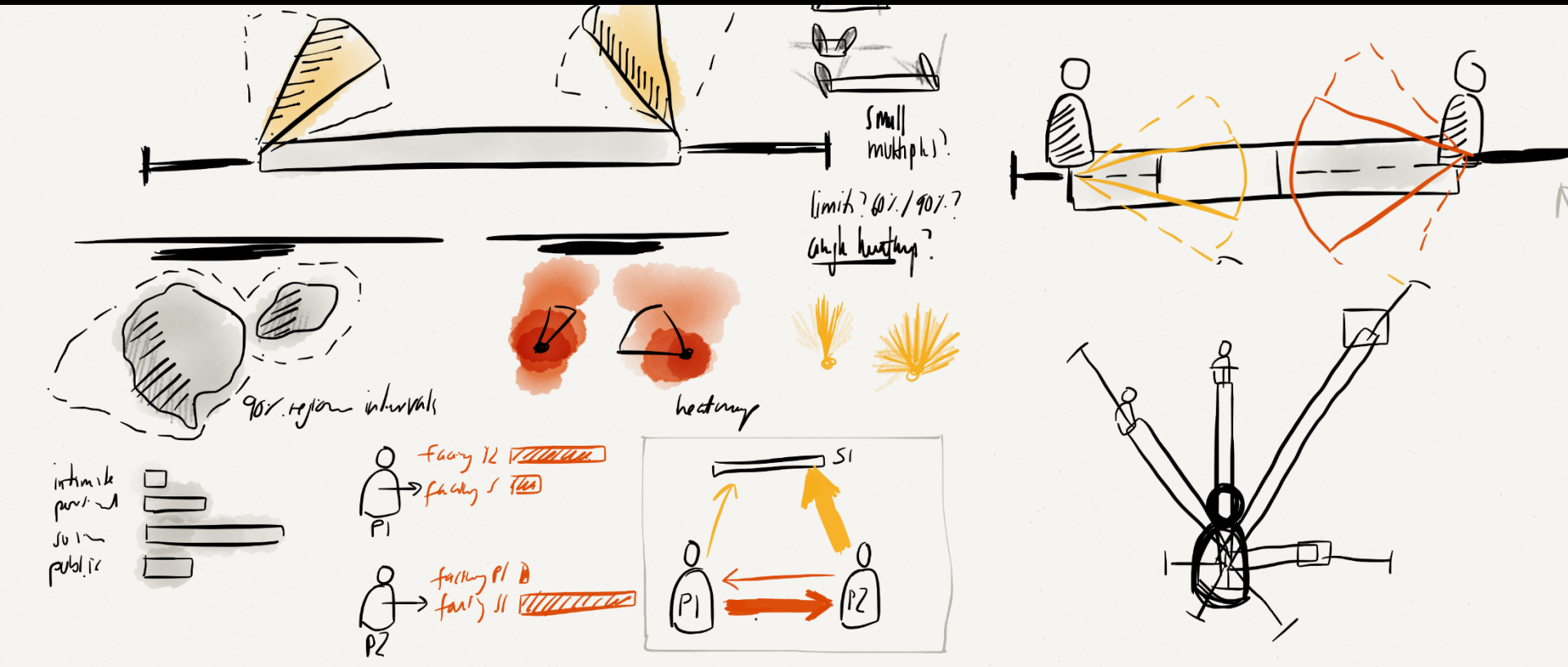
Proxemic Flow:
Dynamic Peripheral Floor Visualizations for Revealing and Mediating Large Surface Interactions

Towards proxemic-aware device ecologies?

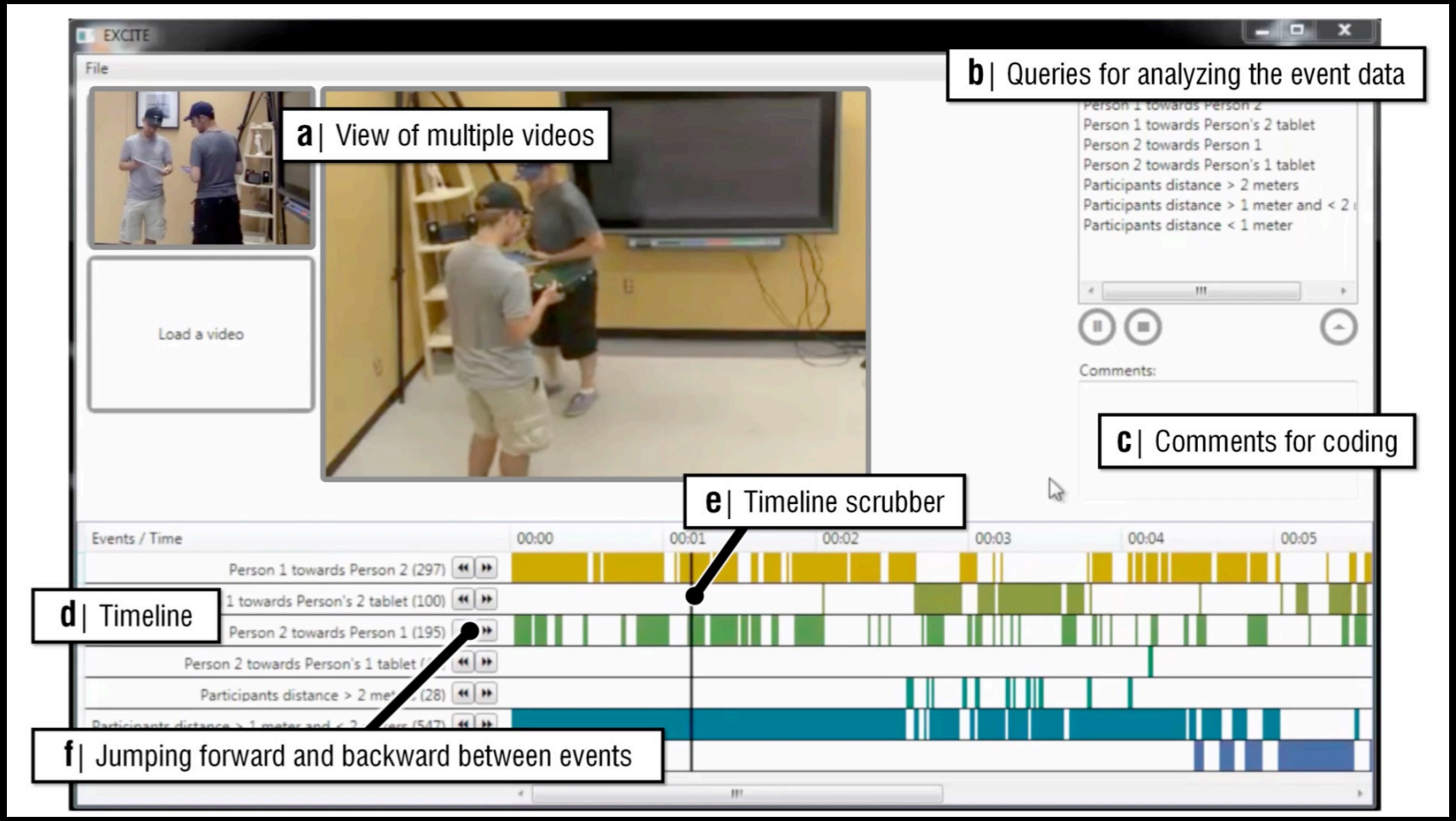
Other dimensions that matter?



Proxemics as Analytical Tool



Proxemics as Analytical Tool

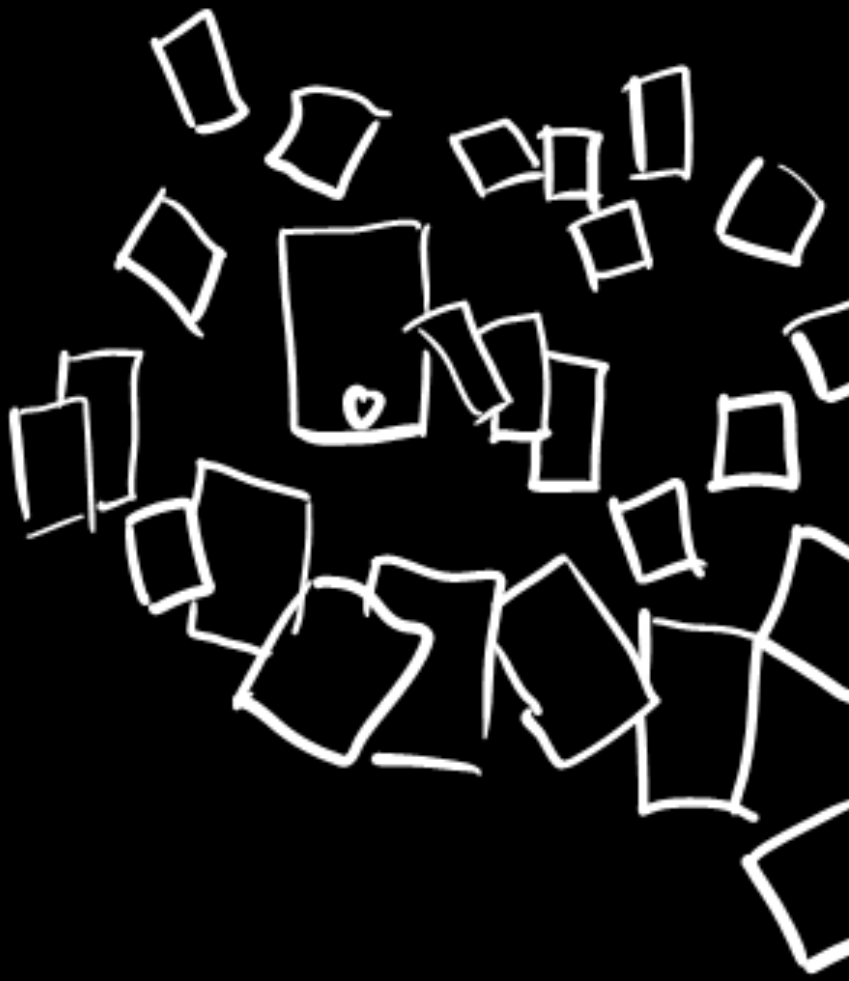


Only for design of new devices and interaction techniques?

Only for design of new devices and interaction techniques?

Proxemic Interactions vs. Interaction Proxemics

vs.



References:

The overview of Proxemic Interaction:
Greenberg, S., Marquardt, N., Ballendat, T., Diaz-Marino, R. and Wang, M. (2011) Proxemic Interactions: The New Ubicomp? In ACM interactions, 18(1):42-50. ACM, January-February. Invited cover story.

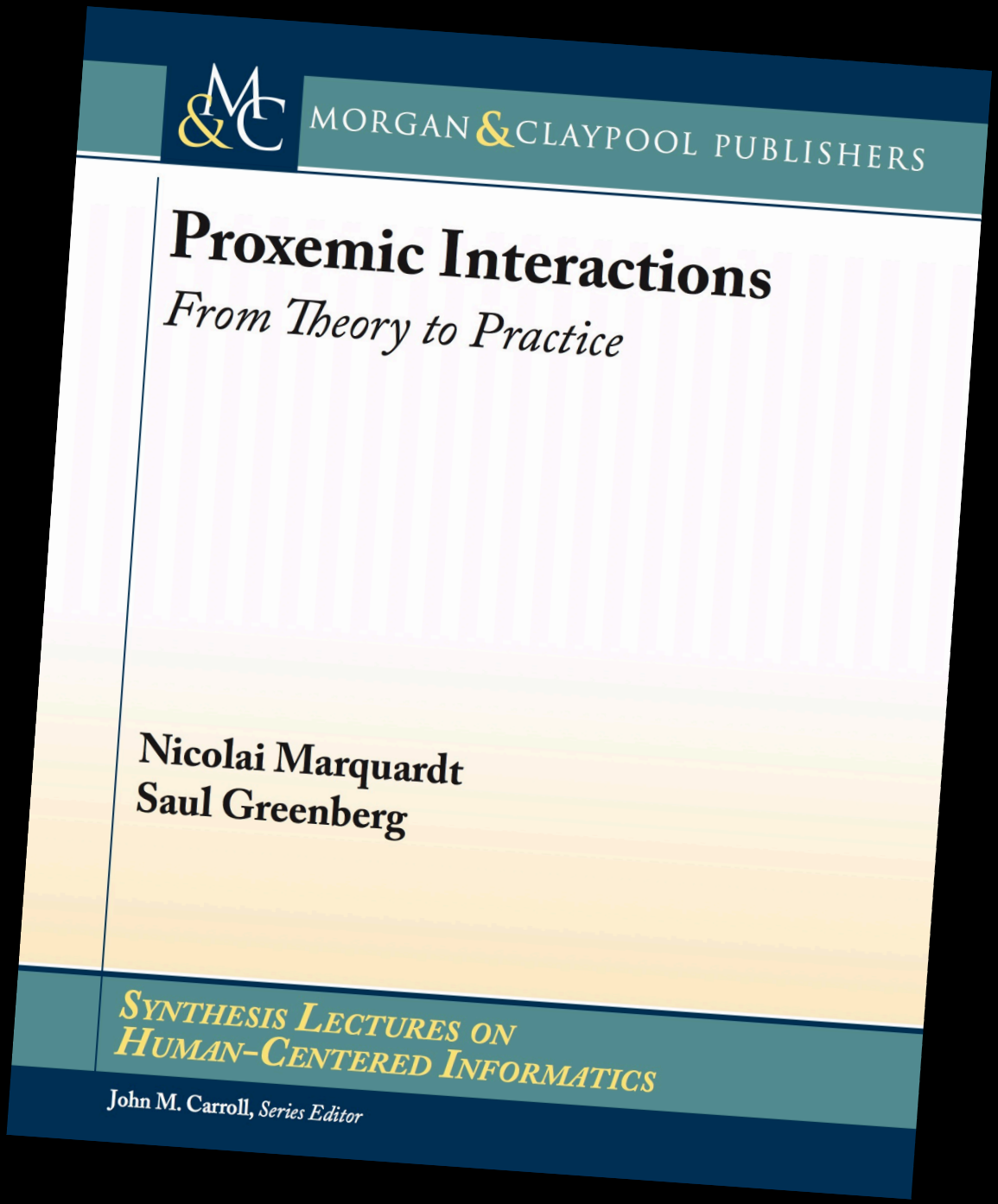
The HuddleLamp technology and ad-hoc collaboration:
Rädle, R. Jetter, H.C., Marquardt, N., Reiterer, H., Rogers, Y. (2014) HuddleLamp: Spatially-Aware Mobile Displays for Ad-hoc Around-the-Table Collaboration. . In Proceedings of ACM ITS 2014, ACM, November.

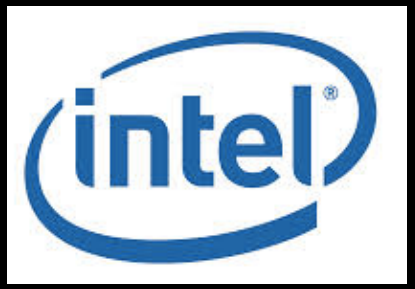
F-formations and micro-mobility:
Marquardt, N., Hinckley, K. and Greenberg, S. (2012) Cross-Device Interaction via Micro-mobility and F-formations. In Proceedings of ACM UIST 2012. (Cambridge, MA), ACM, 13-22, October 7-10.

The social theories:
Marquardt, N. and Greenberg, S. (2012) Informing the Design of Proxemic Interactions. In *IEEE Pervasive Computing, 11(2)*:14-23, April-June. Joe Paradiso, Trevor Pering, Albrecht Schmidt, Eds.

Rapidly prototyping proxemic-aware devices:
Marquardt, N., Diaz-Marino, R., Boring, S. and Greenberg, S. (2011) The Proximity Toolkit: Prototyping Proxemic Interactions in Ubiquitous Computing Ecologies. In Proceedings of ACM UIST 2011. ACM, October 16-18.

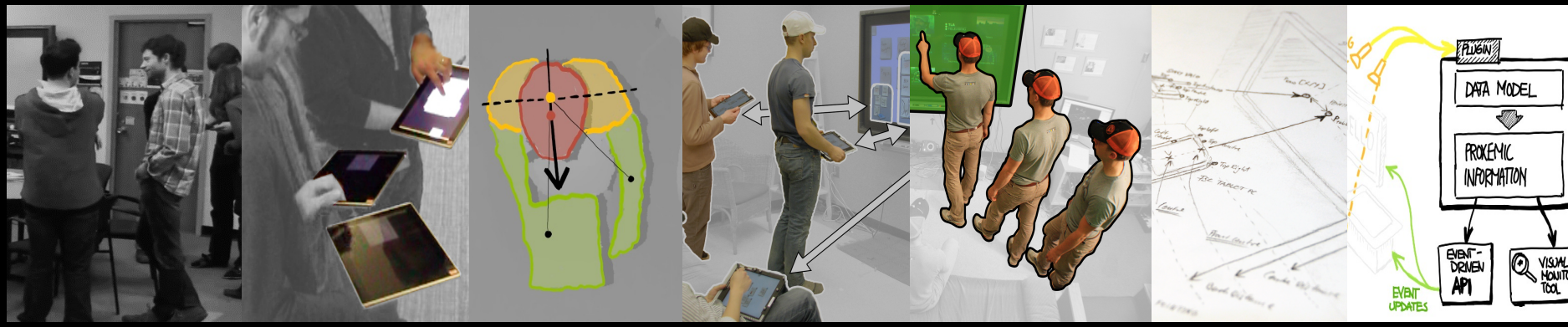
The "hello world" example of proxemic-aware technology:
Ballendat, T., Marquardt, N. and Greenberg, S. (2010) Proxemic Interaction: Designing for a Proximity and Orientation-Aware Environment. In Proceedings of ACM ITS 2010, ACM, 121-130, November 7-10.


MORGAN & CLAYPOOL PUBLISHERS
Proxemic Interactions
From Theory to Practice
Nicolai Marquardt
Saul Greenberg
SYNTHESIS LECTURES ON
HUMAN-CENTERED INFORMATICS
John M. Carroll, Series Editor



Microsoft®
Research

UCL
University College London
Interaction Centre



Towards Ad-hoc Collaboration Spaces with Cross-Device Interaction Techniques

Nicolai Marquardt
University College London
Invited talk at Middlesex University, October 2015