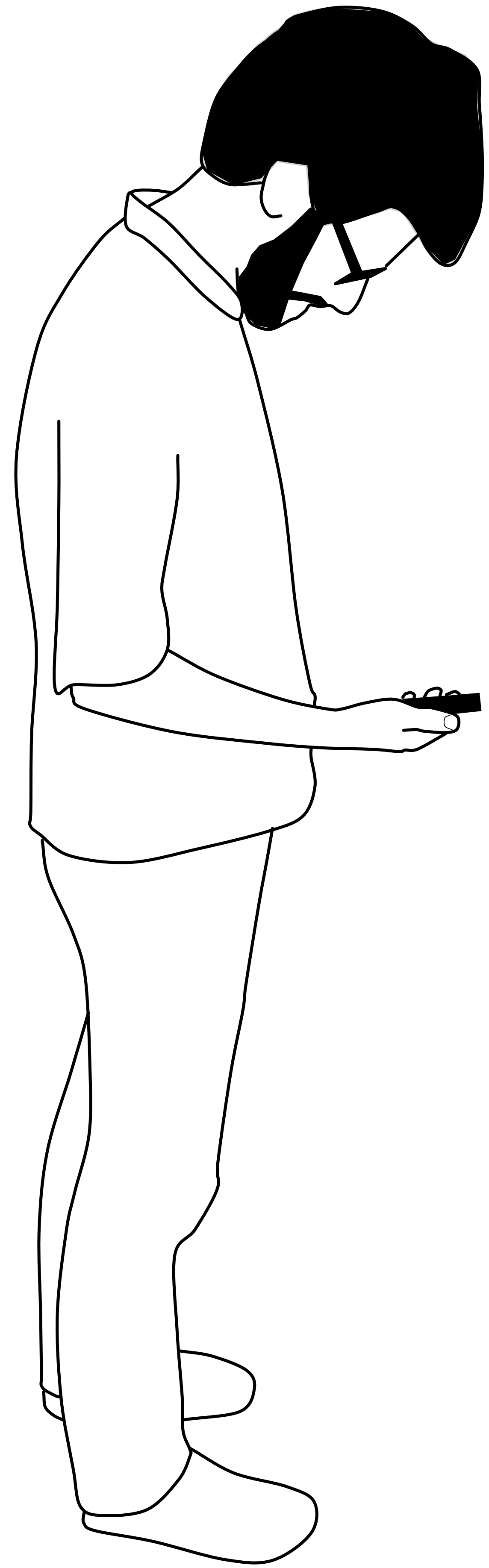
Mensch-Maschine-Interaktion 2

Mobile Environments

Prof. Dr. Andreas Butz, Dr. Julie Wagner

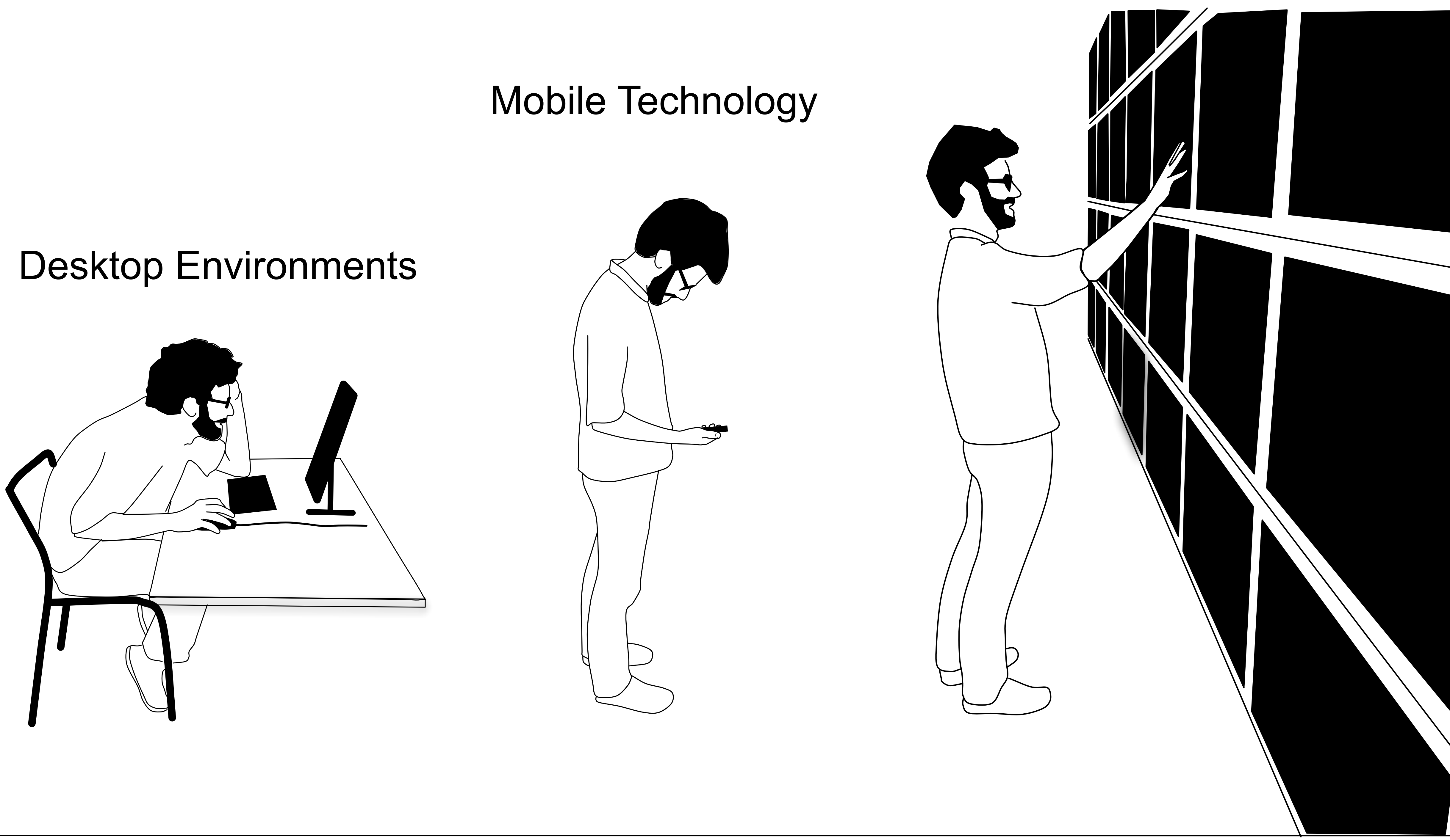


Mensch-Maschine Interaktion 2

Interactive Environments

Mobile Technology

Desktop Environments

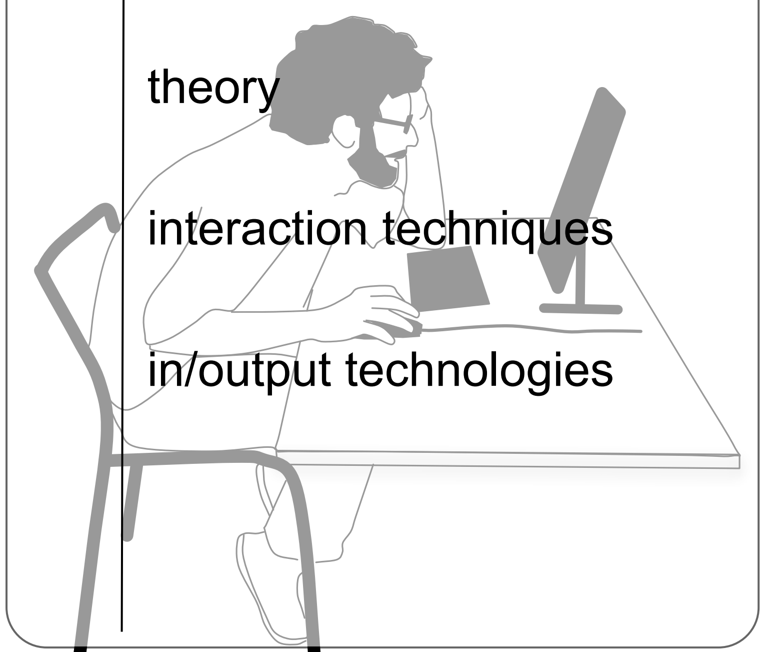


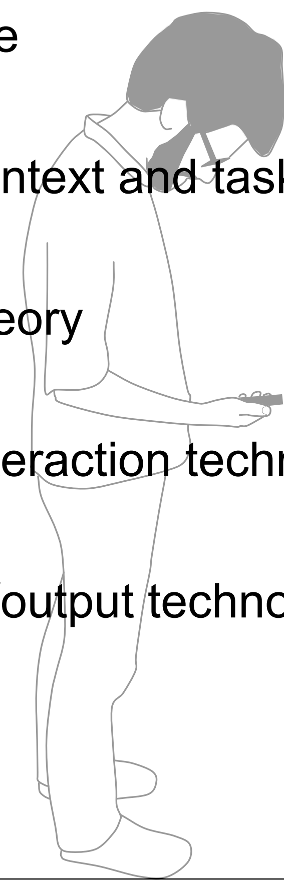
Human-Computer Interaction 2

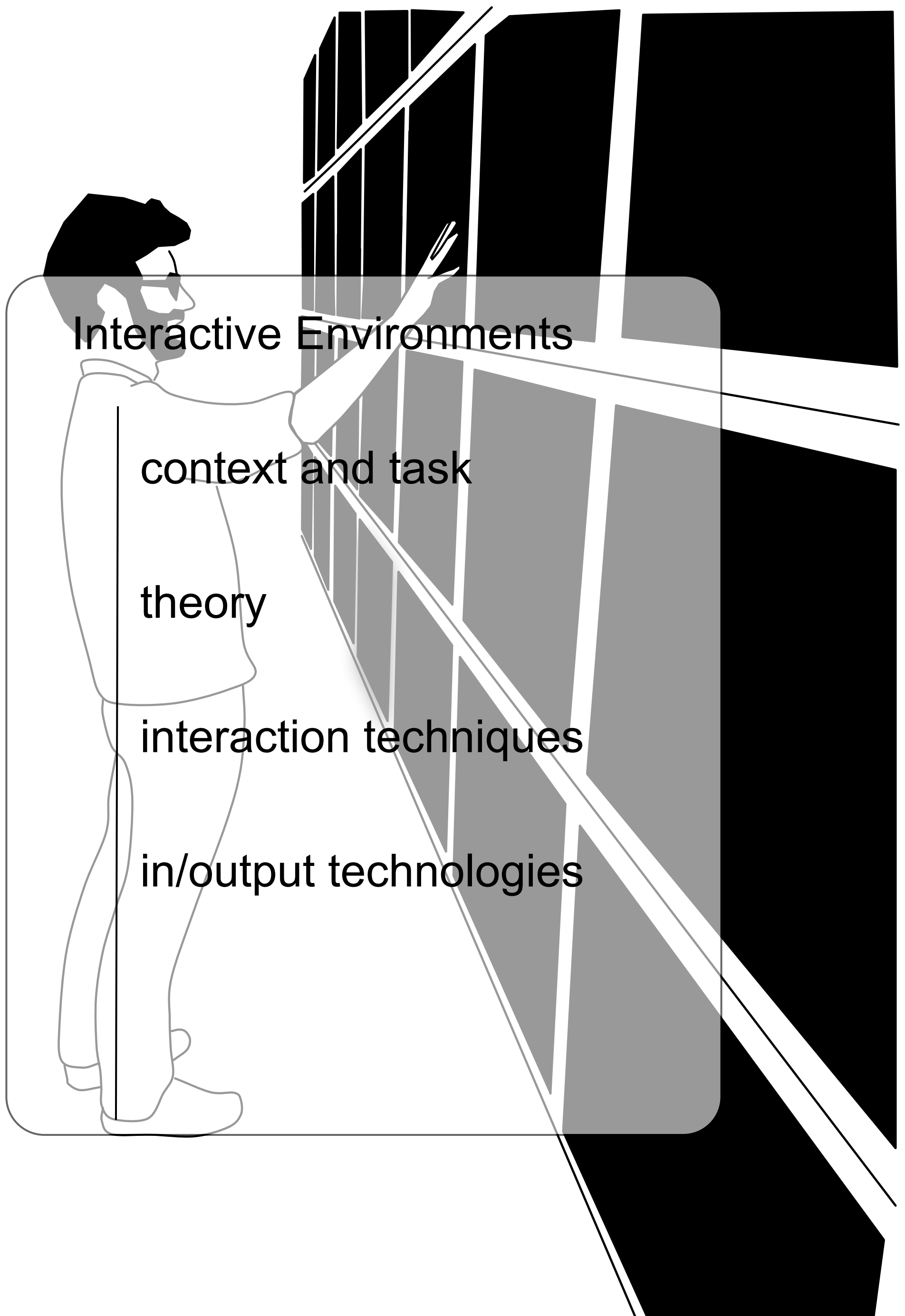
Interactive Environments

Mobile Technology

Desktop Environments







Desktop	Mobile	Interactive Environments
context and task	context and task	context and task
theory	theory	theory
interaction techniques	interaction techniques	interaction techniques
in/output technologies	in/output technologies	in/output technologies

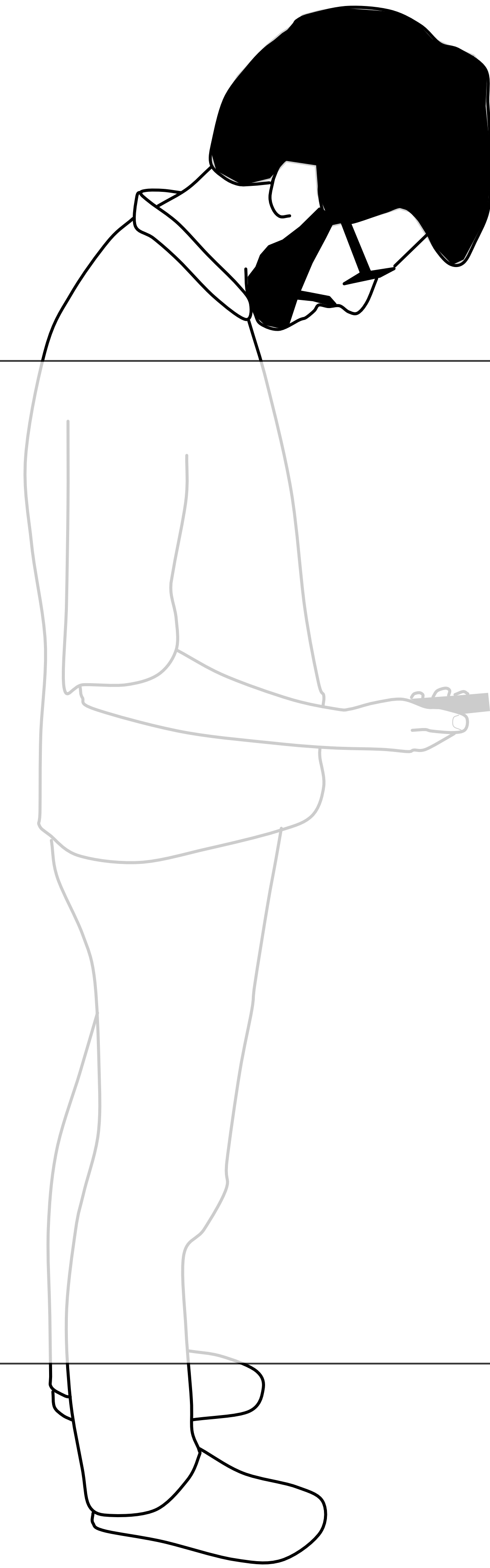
Mobile Technologies

context and task

theory

interaction techniques

in/output technologies



Designing for mobile technologies

- technological perspective:
  - It's technology that we can carry around (portable)
    - phones, smart watches, google glasses, interactive cloth, etc.
- body-centric perspective
  - It's an interface where input/output is performed *relative to the body*.
    - same technology needs to be designed depending on its position on the body
    - same technology can be controlling objects fixed in the world

The body's spatial relationship with an input device effects interaction design (how you hold a phone effects touch interaction)

http://turkeytamam.com/wp-content/uploads/2014/04/Smart-Phones.jpg

Is a notebook mobile technology?

- technological perspective
  - yes. It’s portable!
- body-centric perspective
  - no. the interaction is restrictively designed to support sitting in front of it
  - does not consider the dynamic shift of body positions we interact in with technology

New Body configurations

- standing
  - device held in hand, i.e. no fixed support
  - will desktop models still work???
- walking
  - everything is in motion (precision??)
  - „secondary“ task of not running into things
- lying on the sofa...

overview: designing for....

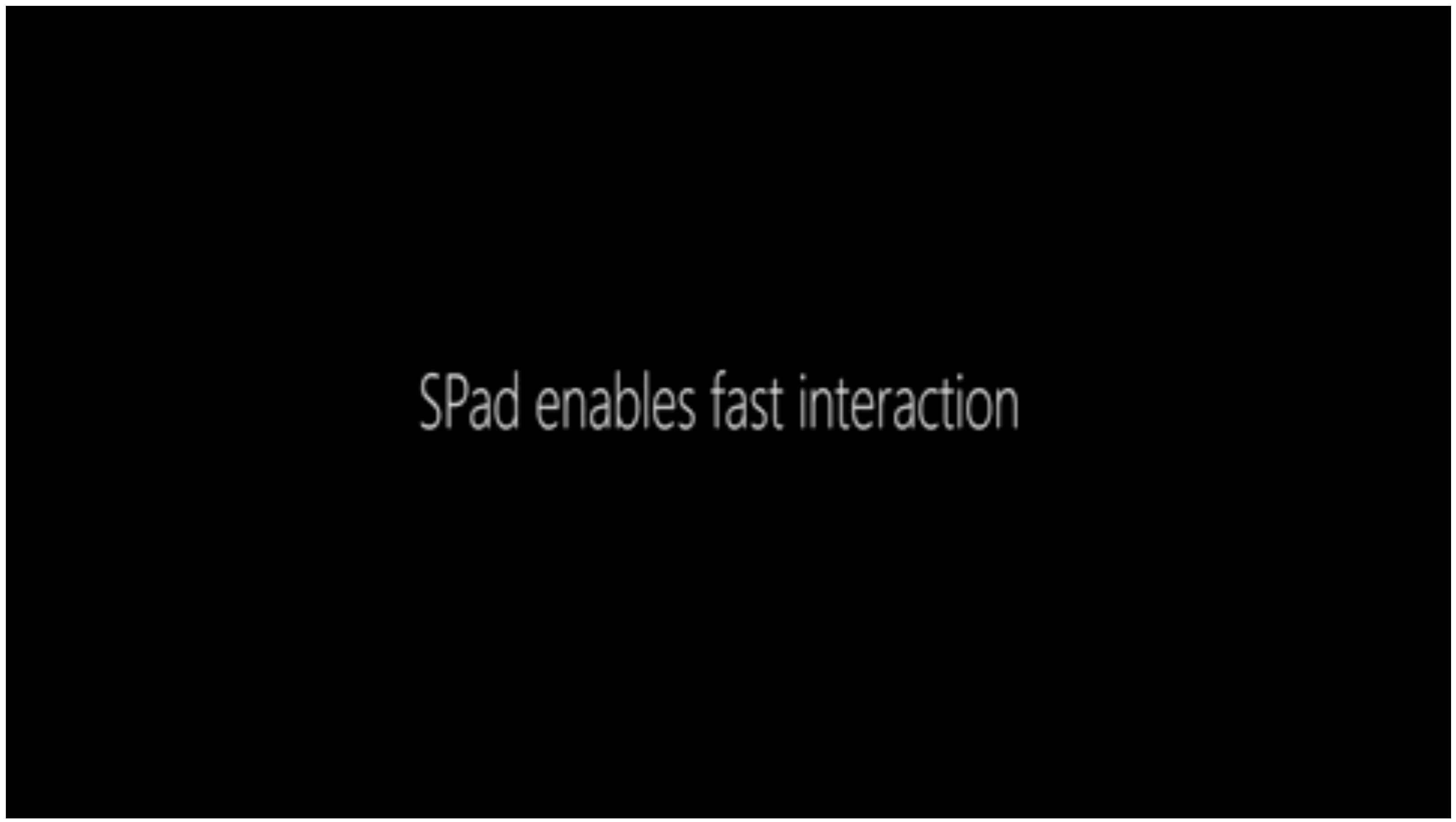
- device support
- bimanual interaction
- touch input problems
  - midas touch
  - occlusion
  - input precision
- mid-air/hands-free gestures
  - fatigue effects
- limited screen real estate
- social issues

Device Support

- Device support restricts your input movements.
  - free-hand gestures
  - device attached to your body
  - holding a device
- manual multi-tasking

Literature: Ease-of-juggling: Studying the effects of manual multi-tasking, CHI 2011

Bimanual Interaction



Literature: Foucault et al. SPad Demo: A bimanual Interaction technique for productivity applications on multi-touch tablets, CHI14

touch input

- midas touch problem:
  - no hover state. Touching is selecting.
  - specific location and selection. Touch conveys both at the same time. Mouse device separates both information.
- occlusion problem:
  - touching means covering information through your finger
- input precision:
  - finger is an area, not a pixel.
  - in current interfaces, developers need to work with pixels.

Mobile phones: social issues

- https://www.youtube.com/watch?v=OINa46HeWg8

Let‘s discuss these issues:

- (un)divided attention
- not living in the moment, instead trying to capture the moment
- hyper-multi-tasking?

- privacy issues
  - e.g., current research of Alina Hang and Emanuel von Zezschwitz
  - e.g., http://pleaserobme.com/why

Example: fake cursors

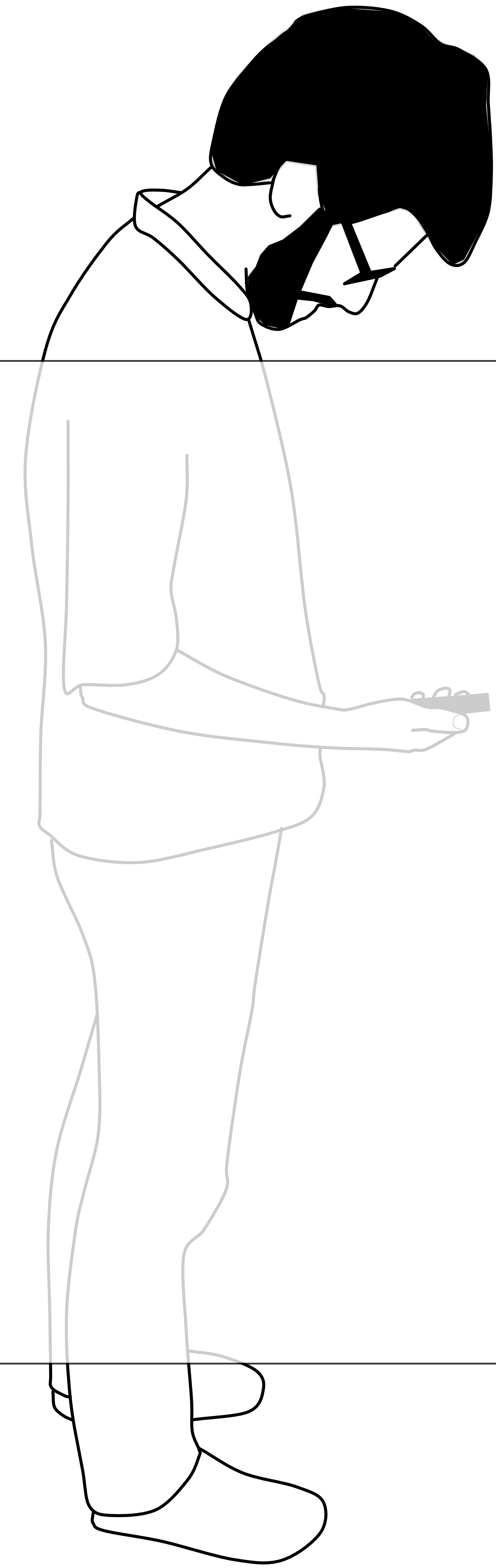
Example: back-of-device authentication

http://www.youtube.com/watch?v=sToX-v4TmRg

Take-away message

- designing mobile technology faces the challenge to design for
  - dynamic shift of human's body position (is user seated, walking etc?)
  - dynamically changing focus of attention between multiple tasks
  - dynamically changing external context (is user seated, but in a driving (hence shaking) bus?)

Mobile Technologies



context and task

theory

interaction techniques

in/output technologies

context and task

theory

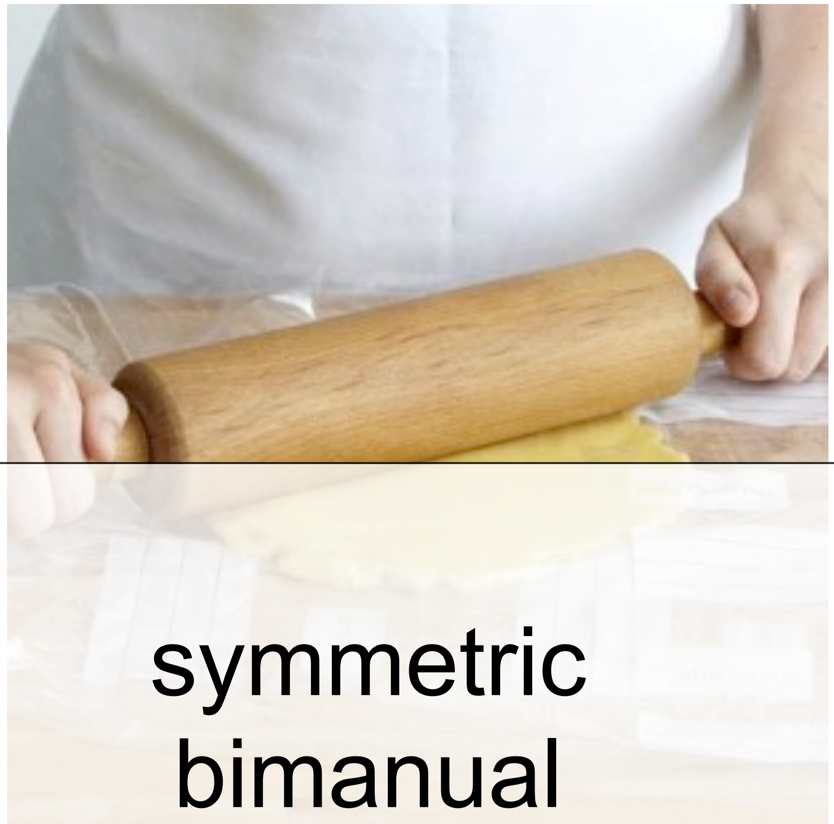
interaction techniques

in/output technologies

Overview

- Device Support
  - Guiard’s Kinematic Chain Theory
  - BiTouch Design Space, extension to Guiard’s theory
- Pointing
  - FFitts’ Law
  - targeting behavior studies
- Gestural interaction
  - Gesture taxonomy
  - how to formally describe gestures?
  - how to communicate gestures? how to support learning of gestures?
  - methods to produce gestures sets
  - do intuitive gestures exist?

Bimanual interaction



symmetric bimanual action

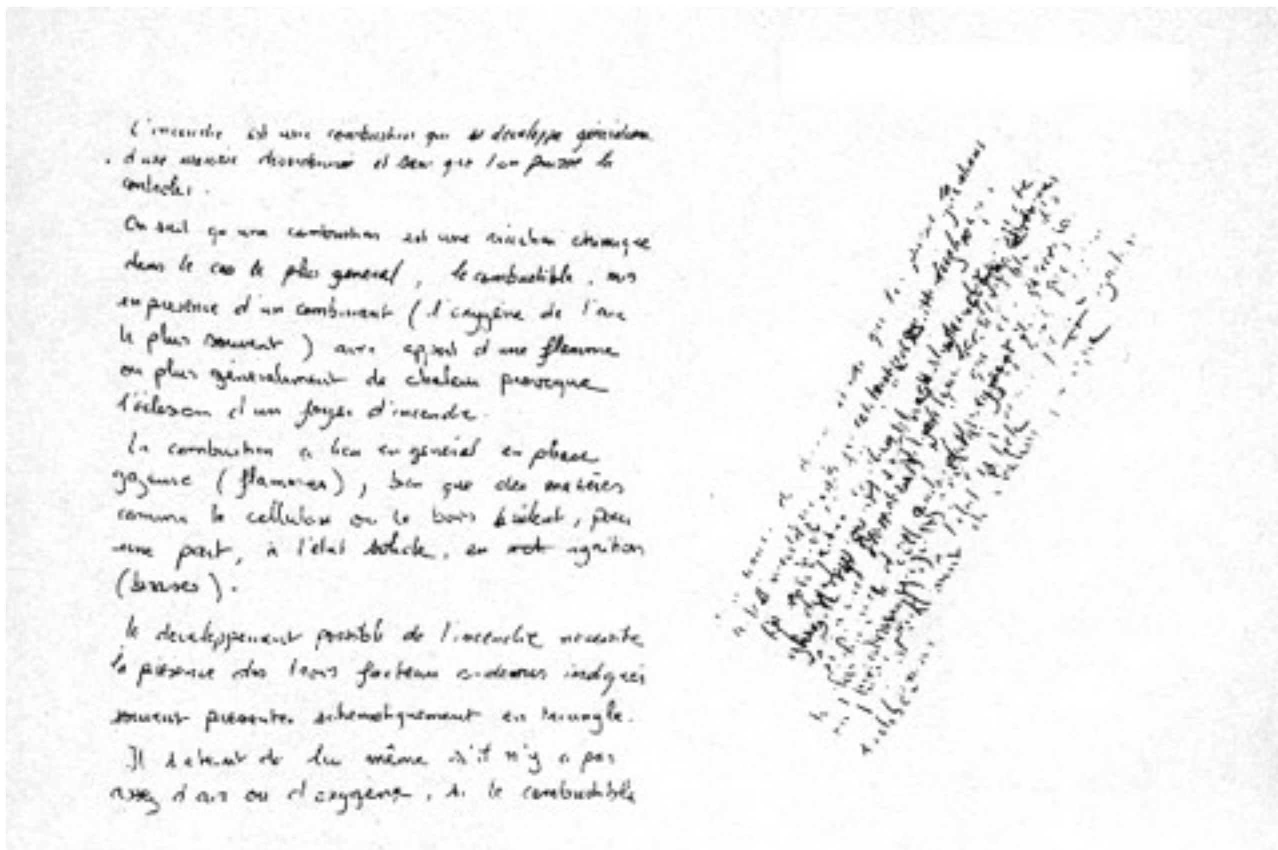
http://www.leckerde/.../redaktionell/leckerde/backen_1/weihnachten_10/plaetzchenbacken/hbv_1382/muerbeteig-ausrollen_img_308x0.jpg

asymmetric bimanual action

- symmetric bimanual action: the two hands have the same role
- asymmetric bimanual action: the two hands have different roles

Kinematic Chain Theory (KC)

“Under standard conditions, the spontaneous writing speed of adults is ***reduced*** *by some* ***20%*** *when instructions* ***prevent the non-preferred hand*** *from manipulating the page”*



Literature: Yves Guirad (1987). Asymmetric Division of Labor in Human Skilled Bimanual Action: The Kinematic Chain as a Model

Mobile

context and task

theory

bimanual interaction

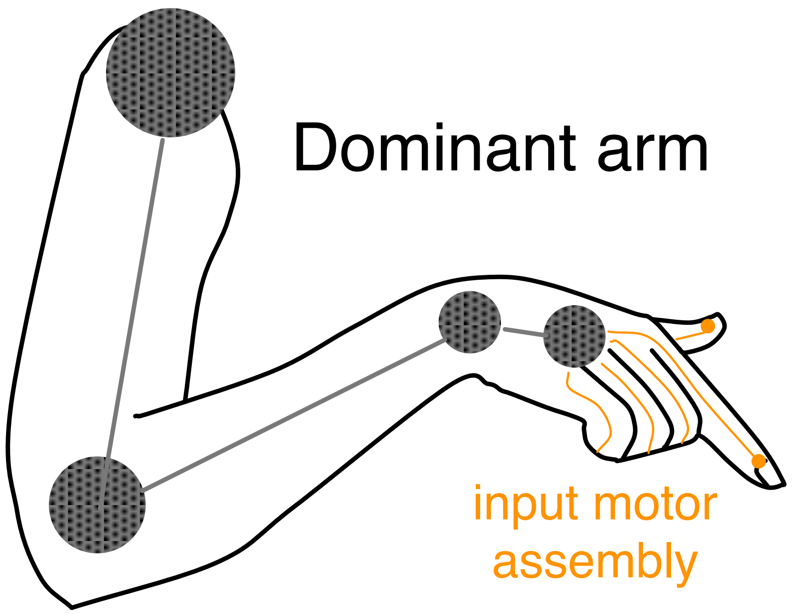
interaction techniques

in/output technologies

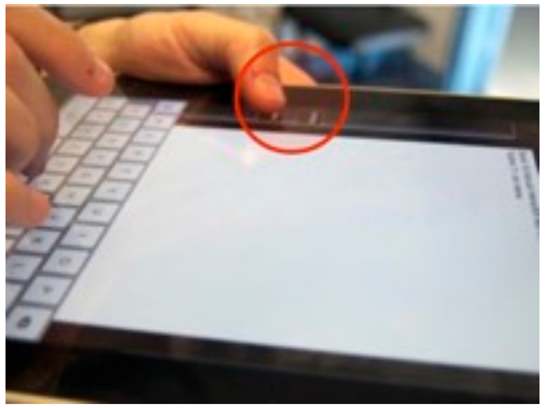
http://www.lobshots.com/wp-content/uploads/2011/08/lobster_560x375.jpg

Kinematic Chain Theory

- Guiard's principles
  - *Right-to-left spatial* reference
    - The non-dominant hand sets the frame of reference for the dominant hand
  - Left-right contrast in the spatial-temporal scale of motion
    - Non-dominant hand operates at a coarse temporal and spatial scale
  - *Left hand precedence* in action
- Kinematic chain
  - each limb a motor if it contributes to the overall input motion.
- Kinematic chain theory
  - although separated, the two hands behave like being linked within the kinematic chain.

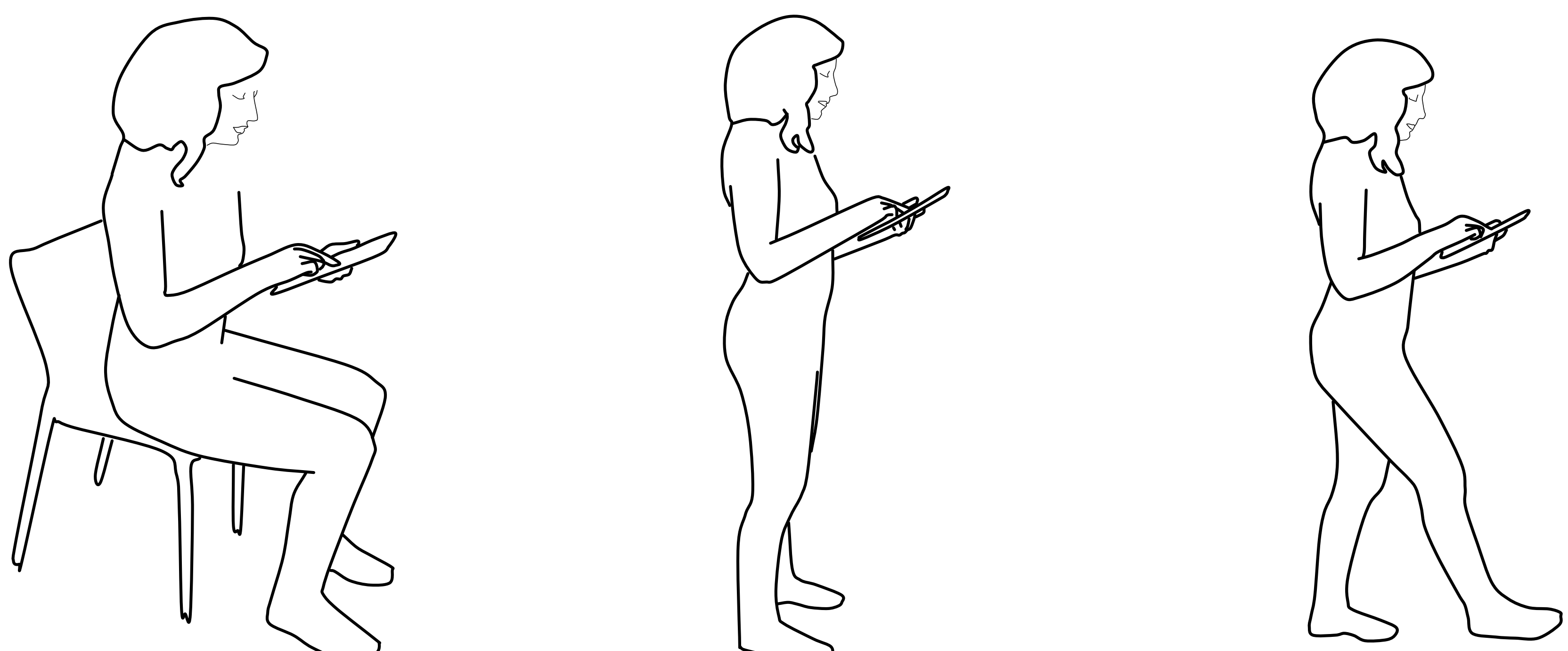


Bimanual interaction with hand-helds



Literature: Wagner, J. et al. (2012). *BiTouch and BiPad: Designing Bimanual Interaction for Hand-held Tablets.* CHI'12

How do people naturally hold tablets?



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context and task

theory

bimanual interaction

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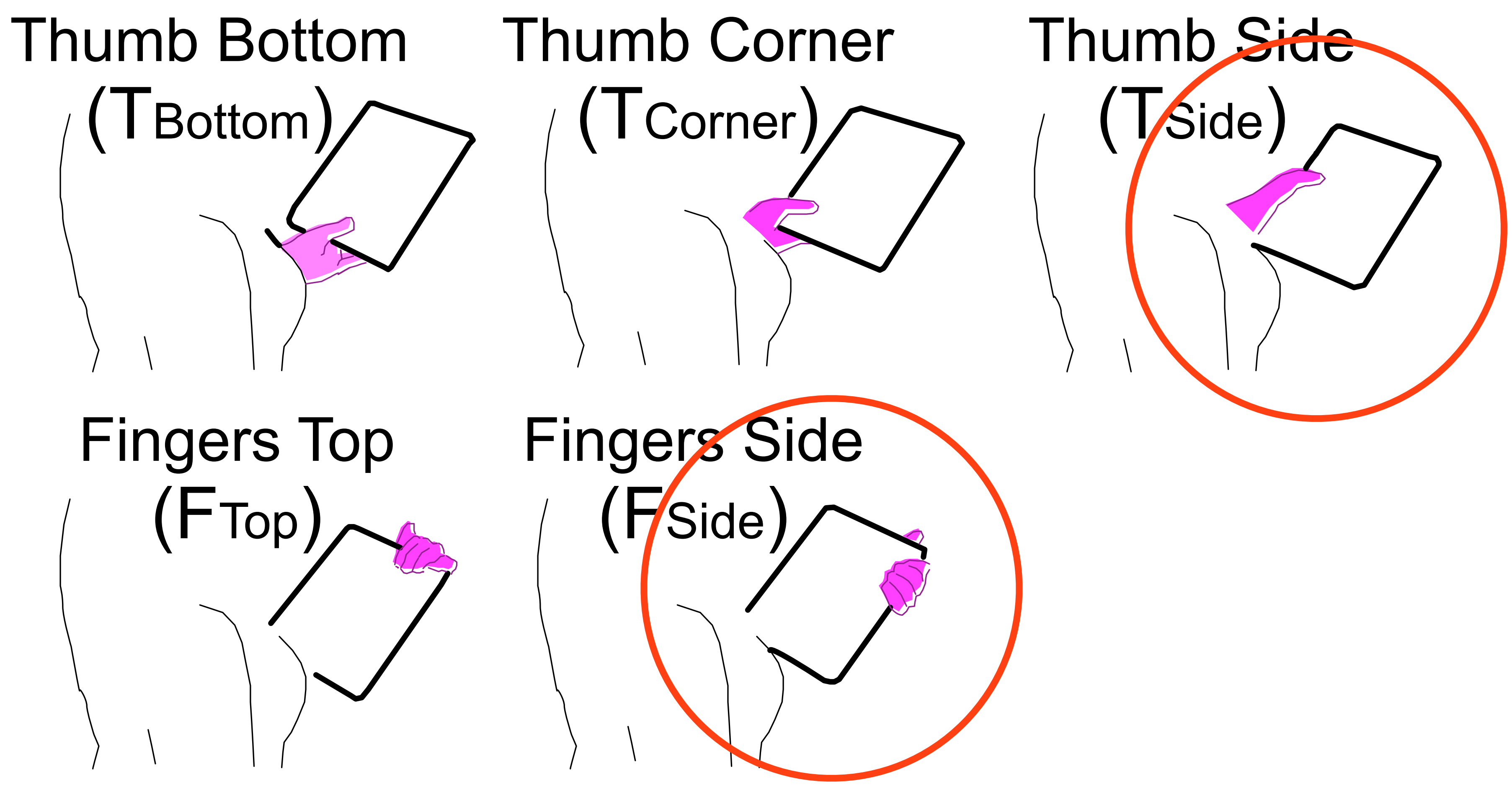


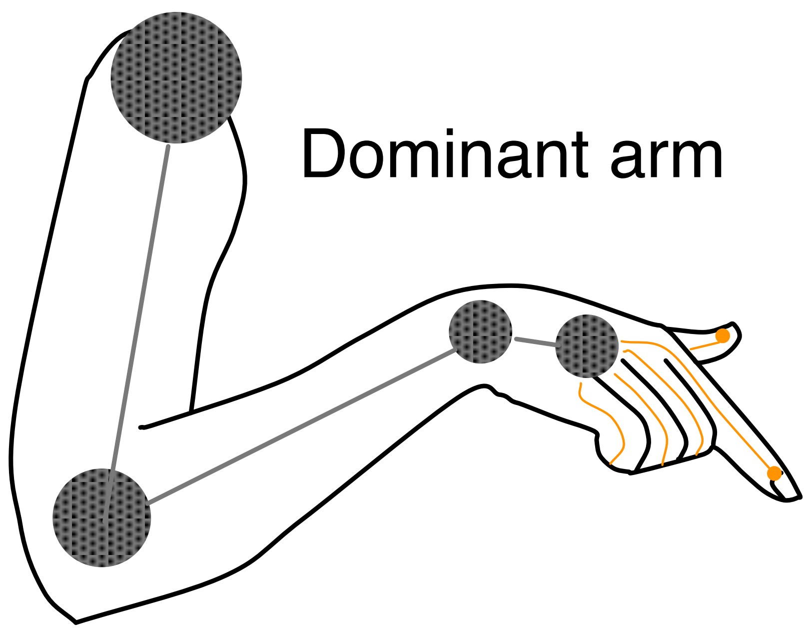
context and
task

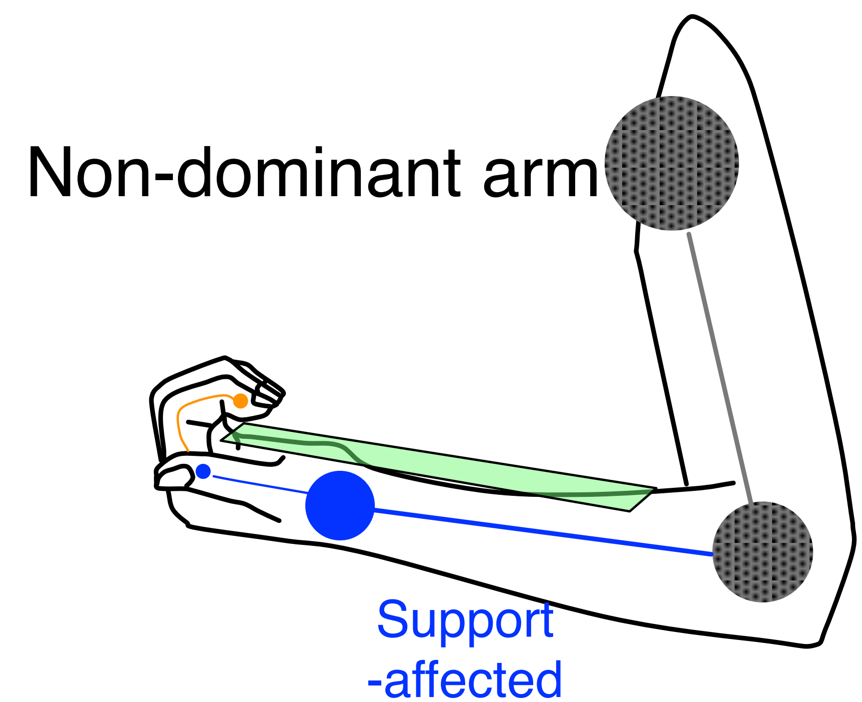
theory

**bimanual
interaction**

interaction
techniques

in/output
technologies

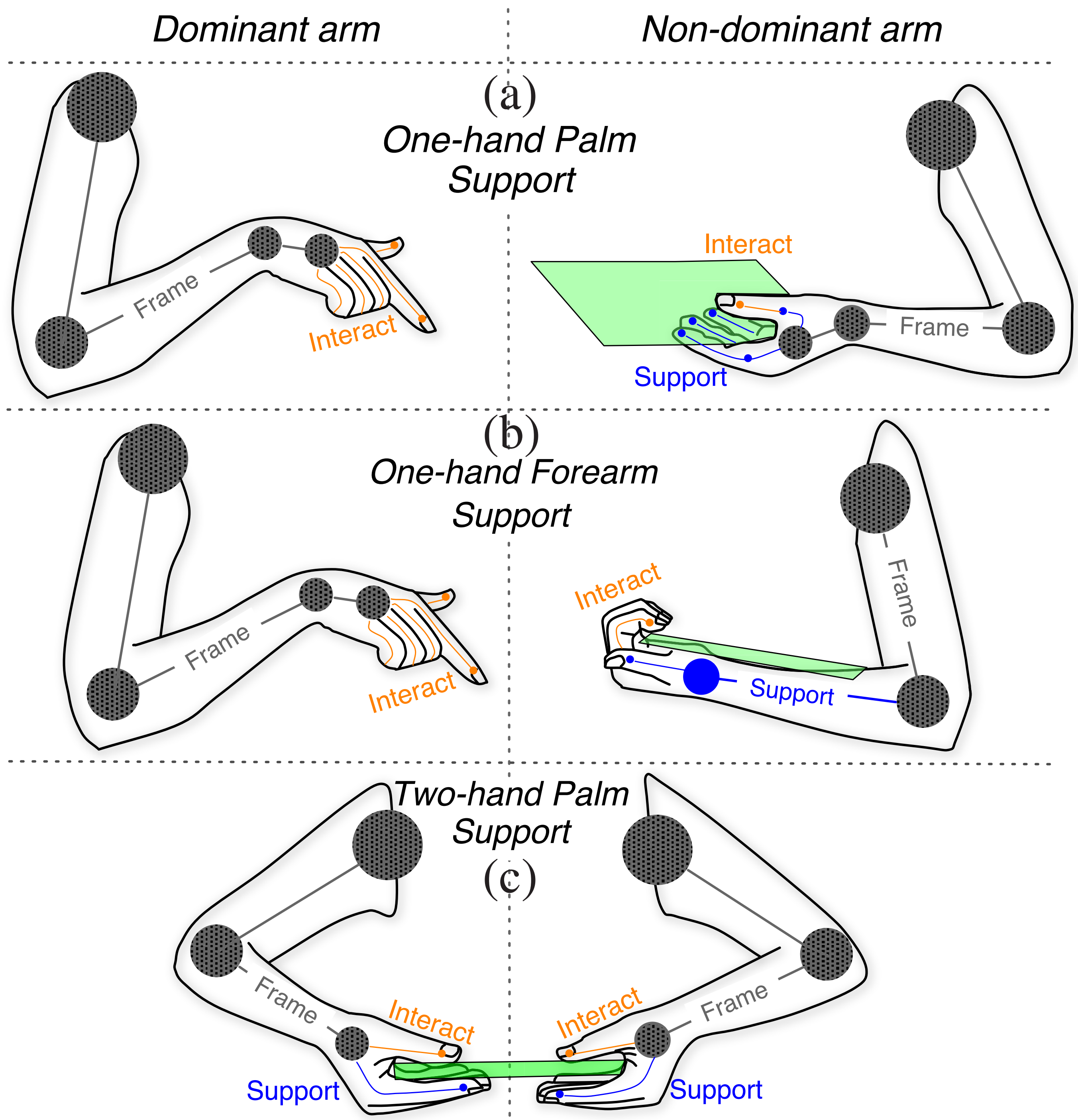




KC:
frame + interaction

BiTouch:
frame + support +
interaction

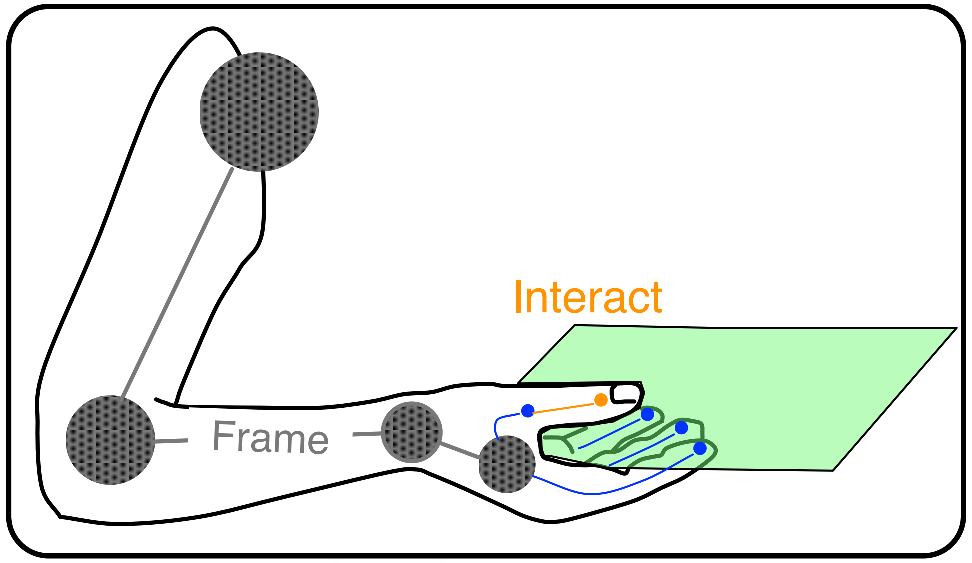
Role of Support



Literature: Wagner, J. et al. (2012). *BiTouch and BiPad: Designing Bimanual Interaction for Hand-held Tablets.* CHI'12

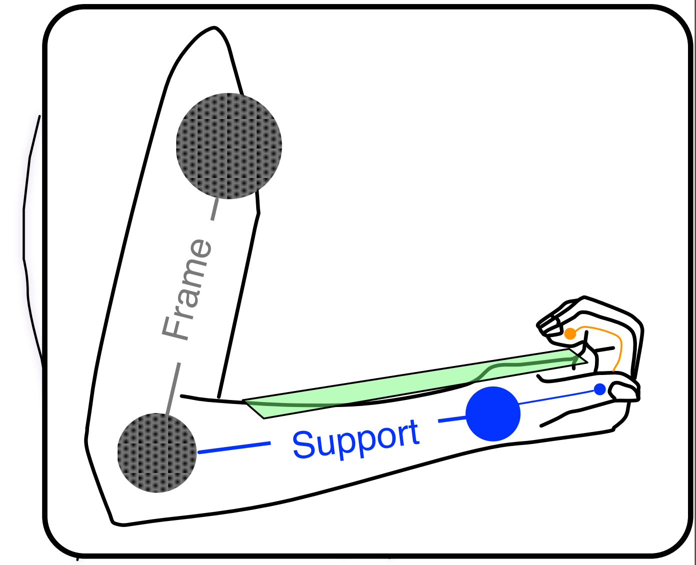
Create further hypotheses

Inverse correlation: performance & comfort



Comfort $<$

Performance $>$



Support	Distribution	Support
high	Degree of Freedom	low

Mini-Brainstorming: what is Touch?

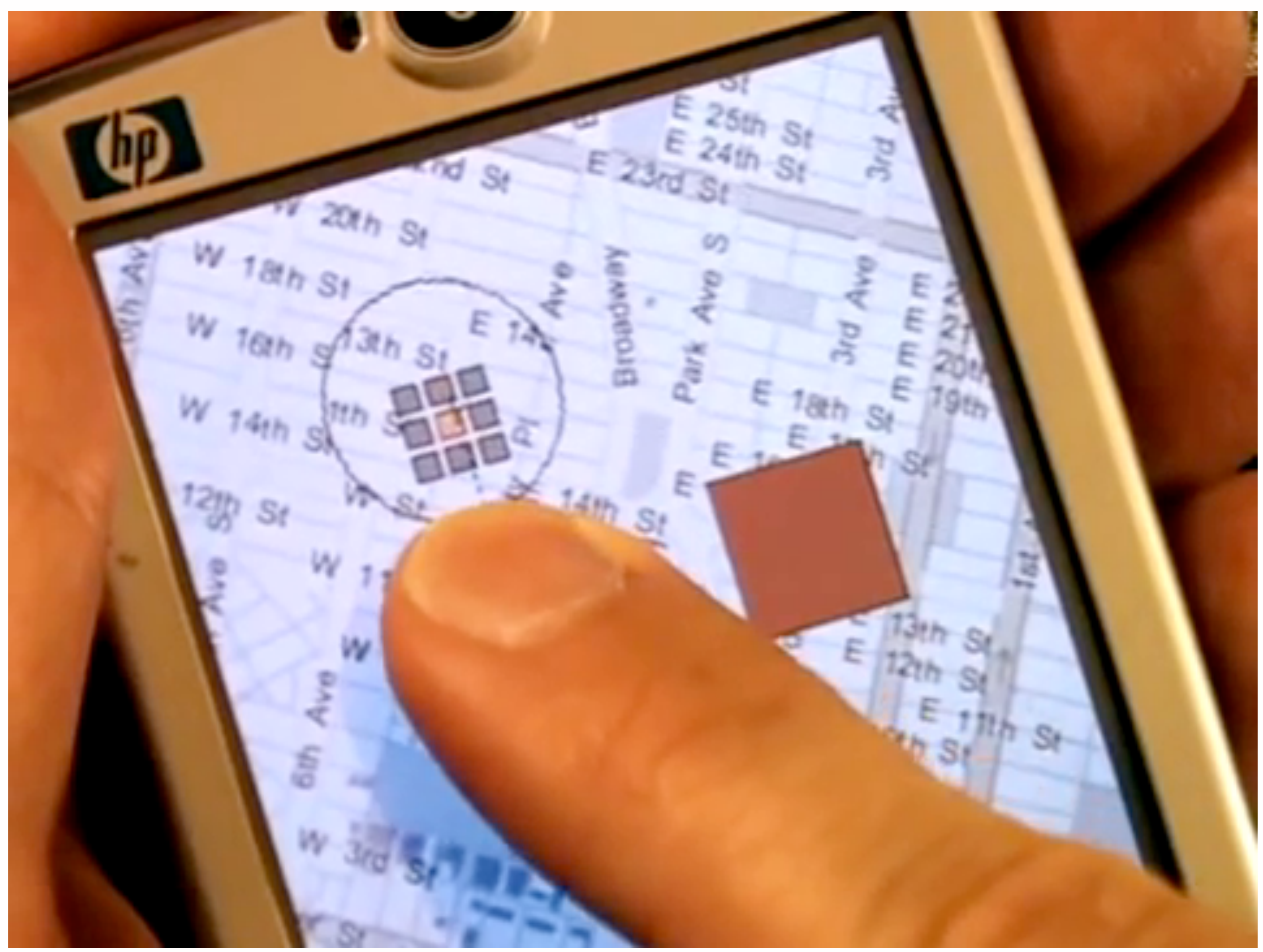
- Think about how we touch a planar surface
  - touching as opposed to grasping…
- What do we mean by it?
- What can we measure on the screen?

Challenges with pointing

- Occlusion:
  - The hand covers parts of the display…
  - …while the mouse didn't
- Precision & Fat Finger Problem:
  - The finger area is not a pixel…
  - …but the mouse pointer was!
- Midas Touch Problem:
  - the finger can only touch or release…
  - …while the mouse was able to hover

Dealing with Occlusion

- Hand: Choose a fitting screen layout
  - selection choices not appearing under the hand!
  - e.g., bottom-up or right to left strategy
- Finger: Things appear from under the cursor
  - offset cursor, shift [Vogel, D. and Baudisch, P.: „Shift: A Technique for Operating Pen-Based Interfaces Using Touch“, In Proceedings of CHI 2007]



Imprecision & Fat Finger Problem

- Problem: small screens with small targets

- Comparatively large fingers
- Fingers will occlude the actual touch point
- Unclear, which point is actually intended

- Also: Limited accuracy of finger touch
- Touch positions are not exact, but random with a normal distribution

Dealing with Imprecision: FFitts' law

- Look at Fitts' law as a normal distribution Xr
- Finger imprecision as another distribution Xa
- Combine X = Xr + Xa to get a better Match
- holds for small targets

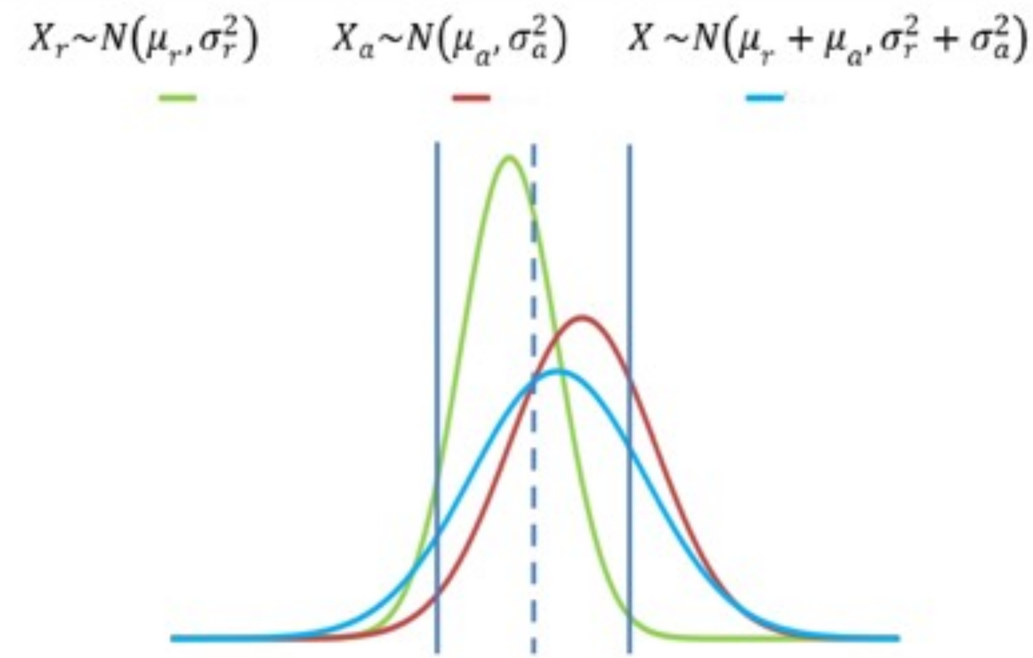
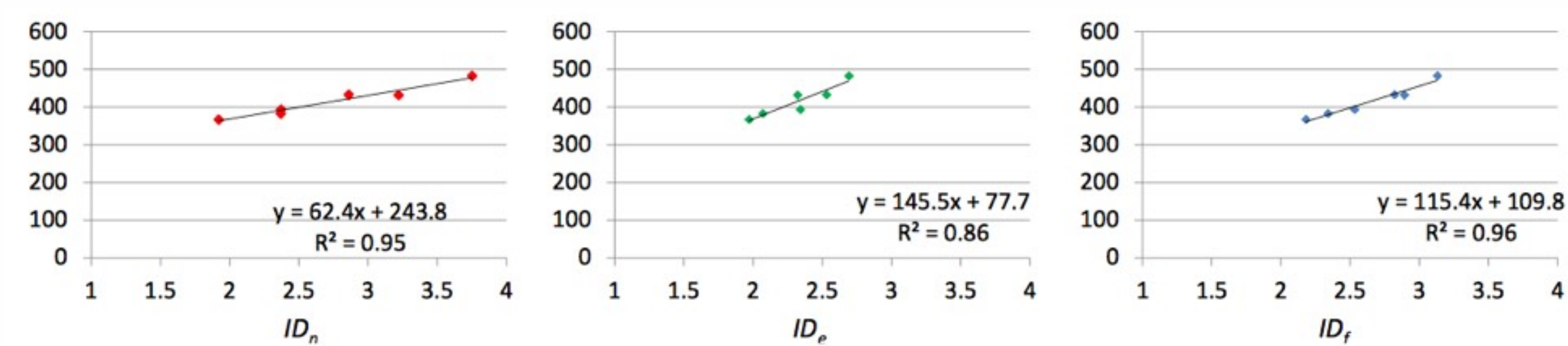


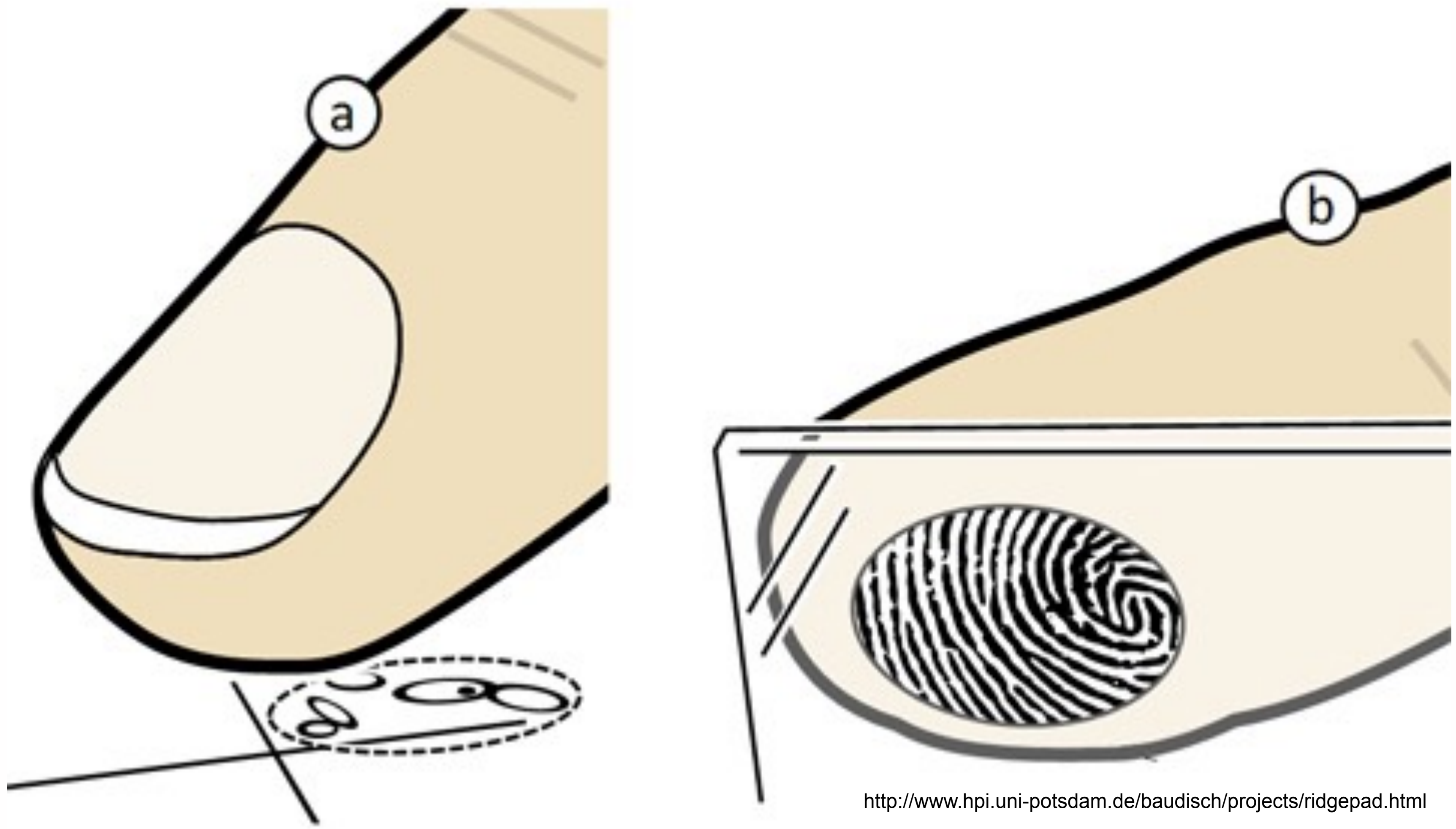
Figure 1. Dual distribution hypothesis in 1D Fitts' tasks. The two solid vertical lines represent the target, and the dashed line is the target center. The green, red and light blue curves show distributions of X_r, X_a, and X.

FFitts law: modeling finger touch with fitts' law, Xiaojun Bi, Yang Li, Shumin Zhai, Proceedings CHI '13



Perceived Input Point Model

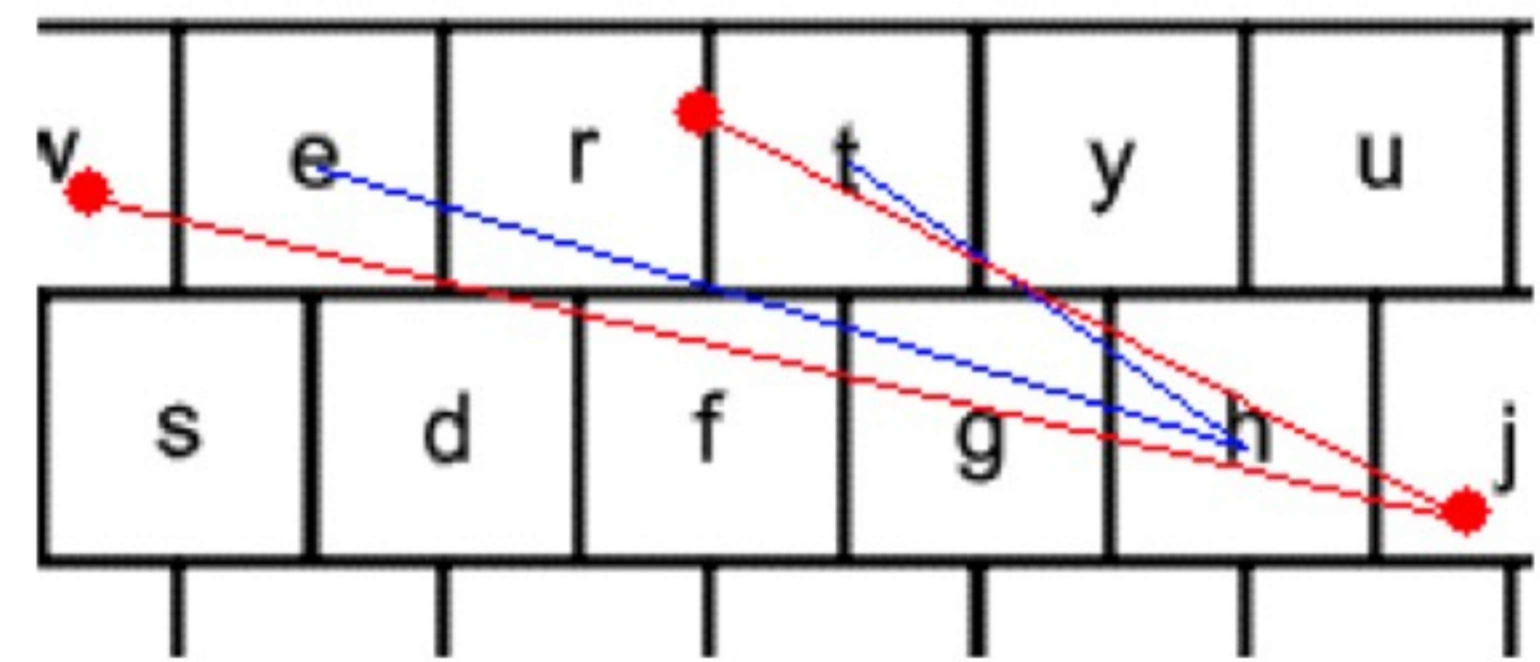
- Assume we can sense touch position and angles!
- Depending on angles, we can say more exactly what point a user „means“!
- Distribution is very individual per user!
  - [Holz, C. and Baudisch, P. 2010. The Generalized Perceived Input Point Model and How to Double Touch Accuracy by Extracting Fingerprints. In Proceedings of CHI'10, 581–590.]

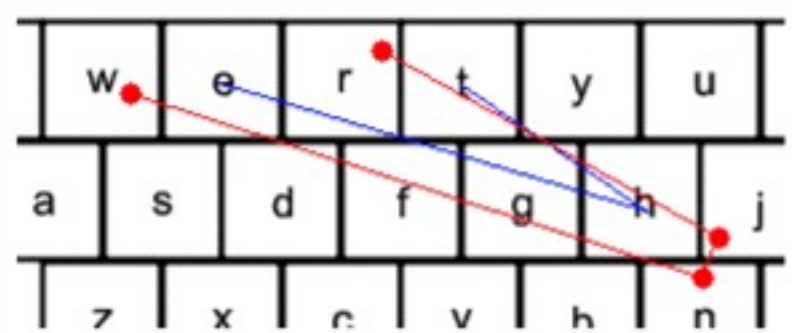


http://www.hpi.uni-potsdam.de/baudisch/projects/ridgepad.html

Dealing with Imprecision: another example

- Observation: language contains a lot of redundancy
- Idea: match geometric patterns, not character sequences
- method: compare input paths to stored ones
- [Relaxing stylus typing precision by geometric pattern matching, Per-Ola Kristensson, Shumin Zhai, Proceedings IUI ’05]





Midas Touch Problem

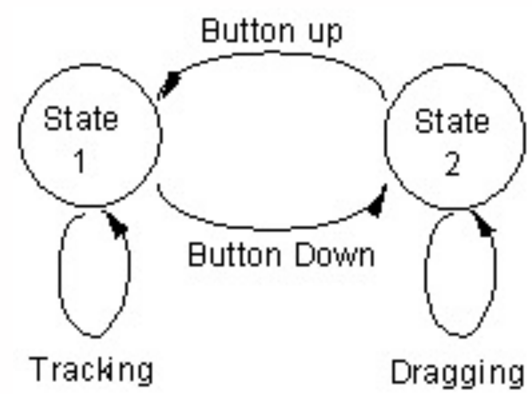
- Story of king Midas:
  - wished that everything he touched turned into gold
  - problems with food ;-)
  - all kinds of problems…
- exists in touch interfaces
- also in eye tracking interfaces

http://upload.wikimedia.org/wikipedia/commons/d/d6/Midas_gold2.jpg

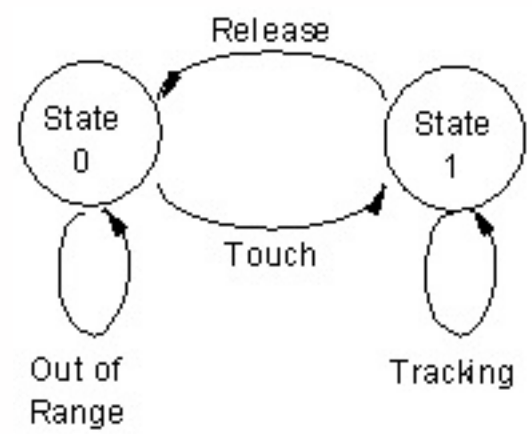
Buxton’s 3 state model

- Buxton, W. (1990). A Three-State Model of Graphical Input. In Proceedings INTERACT ’90

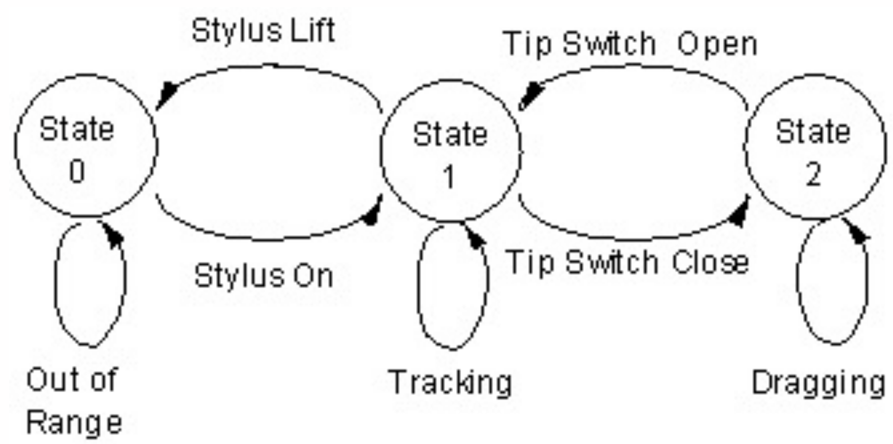
- Mouse button switches between tracking (hover) and dragging



- Stylus and finger suffer from midas touch problem



- Stylus with button solves the problem



Lift-off strategy (1988)

- see http://www.cs.umd.edu/hcil/touchscreens/
- Potter, R.L., Weldon, L.J., Shneiderman, B. „Improving the accuracy of touch screens: an experimental evaluation of three strategies“, Proc. CHI `88

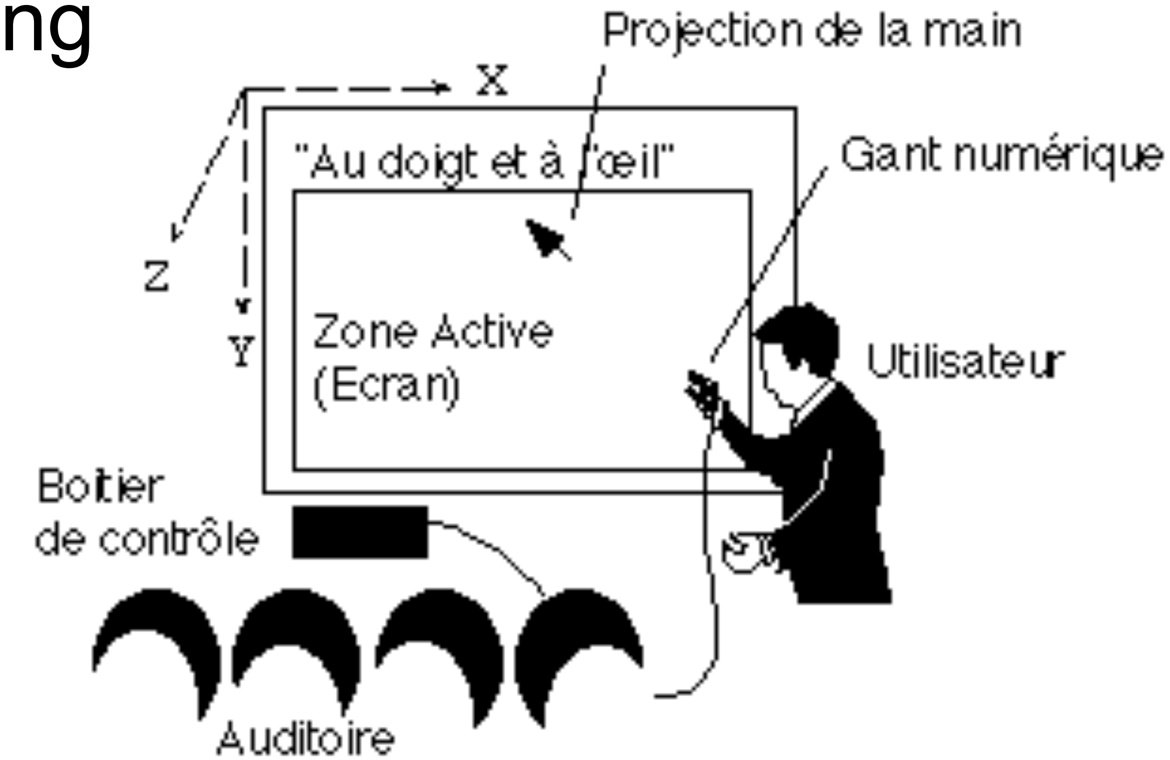
- everybody: take out your phones and try!

- finger touches -> screen provides feedback
- finger can still move -> still feedback
- finger lifts off -> target is selected

- Seems very natural today (used everywhere)
- Only becomes apparent when violated

Taxonomy of Gesture styles

- sign language
- gesticulation
  - communicative gestures made in conjunction with speech
  - know how your users gesture naturally and design artificial gestures that have no cross-talk with natural gesturing



http://thomas.baudel.name/Morphologie/These/images/VI11.gif

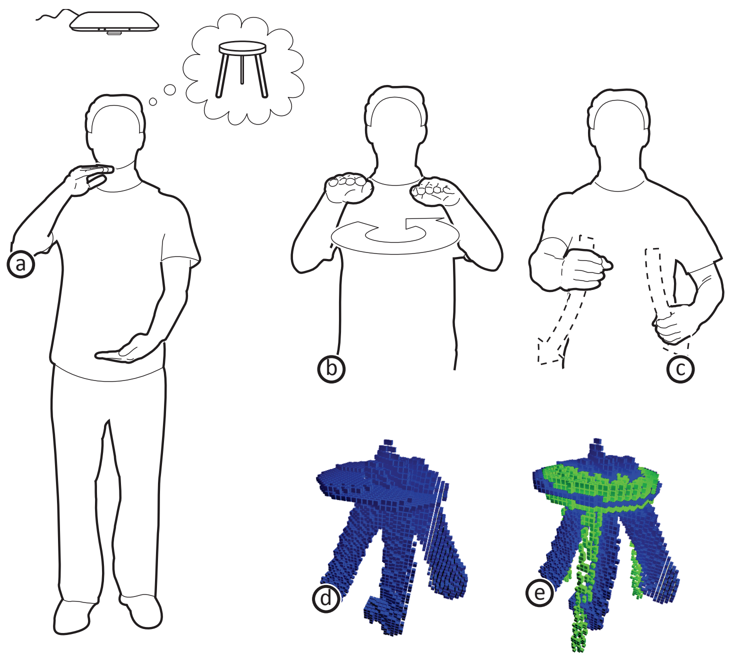
Literature: Baudel et al. Charade: remote control of objects using free-hand gestures, Communications of the ACM 1993

Taxonomy of Gesture styles

- manipulative
  - gestures which tightly related movements to an object being manipulated
    - 2D Interaction: mouse or stylus
    - 3D Interaction: free-hand movement to mimic manipulations of physical objects
- deictic gestures (aimed pointing)
  - establish identity or spatial location of an object.
- semaphoric gestures (signals send to the computer)
  - stroke gestures, involve tracing of a specific path (marking menu)
  - static gestures (pose), involving no movement
  - dynamic gestures, require movement

Taxonomy of Gesture styles

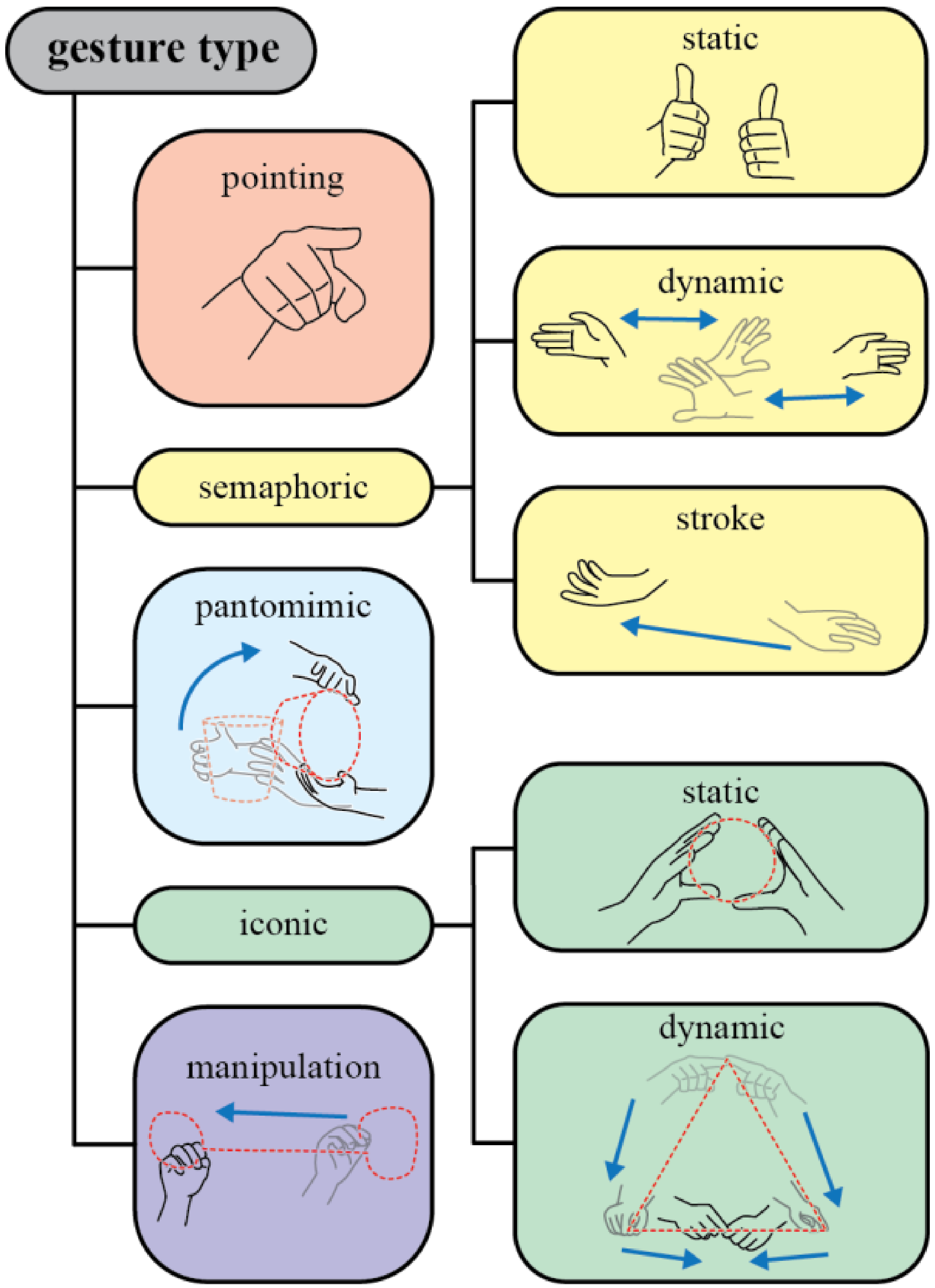
- pantomimic gestures:
  - demonstrate a specific task to be performed or imitated
  - performed without object being present.
- iconic
  - communicate information about objects or entities (e.g. size, shapes and motion path)
    - static
    - dynamic



Literature: Aginer et al.: Understanding Mid-air Hand Gestures: A Study of Human Preferences in Usage of Gesture Types for HCI, Tech Report Microsoft Research

Literature: Holz et al. Data Miming: Inferring Spatial Object Descriptions from Human Gesture, CHI 2011

Taxonomy of Gesture styles



Literature: Aginer et al.: Understanding Mid-air Hand Gestures: A Study of Human Preferences in Usage of Gesture Types for HCI, Tech Report Microsoft Research

Gestural Input vs. Keyboard+Mouse

- loosing the hover state
- gesture design
  - 'natural' gestures
    - dependent on culture
  - multi-finger chords (what does that remind you of?)
- memorability, learnability
  - short-term vs. long-term retention
- gesture discoverability
- missing standards
- difficult to write, keep track and maintain gesture recognition code
  - detect/resolve conflicts between gestures
- and how to communicate and document a gesture?

MORE INFORMATION

Windows system key combinations

- F1: Help
- CTRL+ESC: Open **Start** menu
- ALT+TAB: Switch between open programs
- ALT+F4: Quit program
- SHIFT+DELETE: Delete item permanently
- Windows Logo+L: Lock the computer (without using CTRL+A

Windows program key combinations

- CTRL+C: Copy
- CTRL+X: Cut
- CTRL+V: Paste
- CTRL+Z: Undo
- CTRL+B: Bold
- CTRL+U: Underline
- CTRL+I: Italic

Mouse click/keyboard modifier combinations

- SHIFT+right click: Displays a shortcut menu containing alter
- SHIFT+double click: Runs the alternate default command (th
- ALT+double click: Displays properties
- SHIFT+DELETE: Deletes an item immediately without placin

General keyboard-only commands

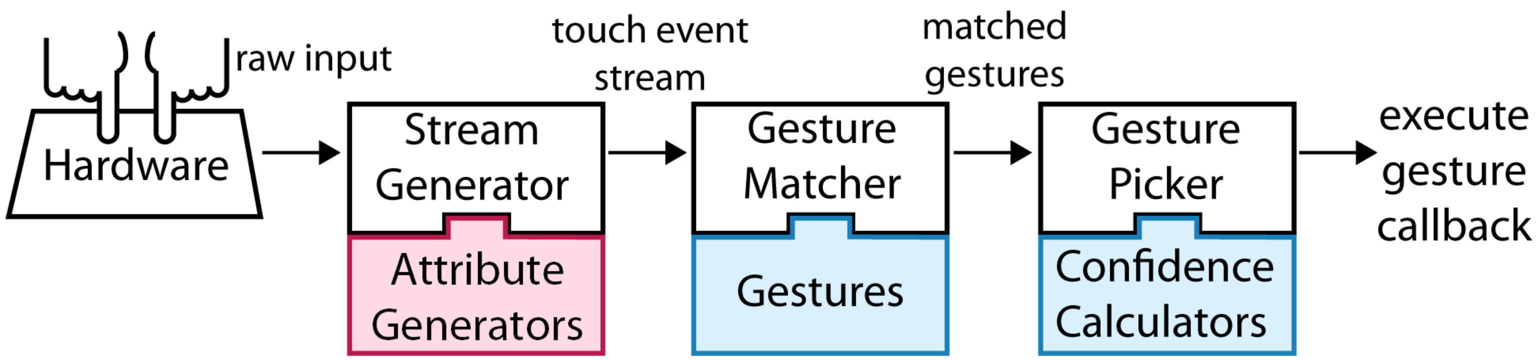
- F1: Starts Windows Help
- F10: Activates menu bar options
- SHIFT+F10 Opens a shortcut menu for the selected item (th
- CTRL+ESC: Opens the **Start** menu (use the ARROW keys t
- CTRL+ESC or ESC: Selects the **Start** button (press TAB to
- CTRL+SHIFT+ESC: Opens Windows Task Manager
- ALT+DOWN ARROW: Opens a drop-down list box
- ALT+TAB: Switch to another running program (hold down the

Proton++

- declarative multitouch framework
- enables Multitouch gesture description as regular expression of touch event symbols
- generates gesture recognizers and static analysis of gesture conflicts
- note:
  - "*" kleene star indicates that a symbol can appear zero or more consecutive times.
  - "|" denotes the logical *or* of attribute values
  - " · " wildcard, specifies that an attribute can take any value.

Literature: Kin,K. et al. "Proton++: A Customizable Declarative Multitouch Framework", UIST 2012

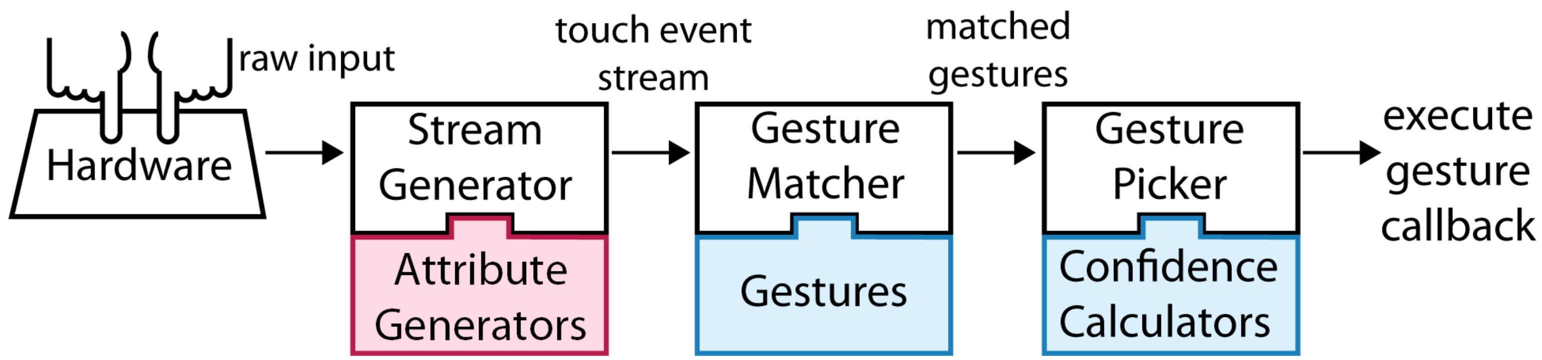
Proton++ - formal description language



- touch event:
  - touch action (down, move, up)
  - touch ID (1st, 2nd, etc.)
  - series of touch attribute values
    - direction = NW, hit-target = circle

Literature: Kin,K. et al. "Proton++: A Customizable Declarative Multitouch Framework", UIST 2012

Proton++



- stream generator
  - converts each touch event into a touch symbol of the form

$$E_{T_{ID}}^{A_1:A_2:A_3\ldots}$$

where E ∈ {D,M,U}, attribute values A_1:A_2:A_3, A_1 corresponds to first attribute etc.

$$M_1^{s:W}$$

move-with-first-touch-on-star-object-in-west-direction

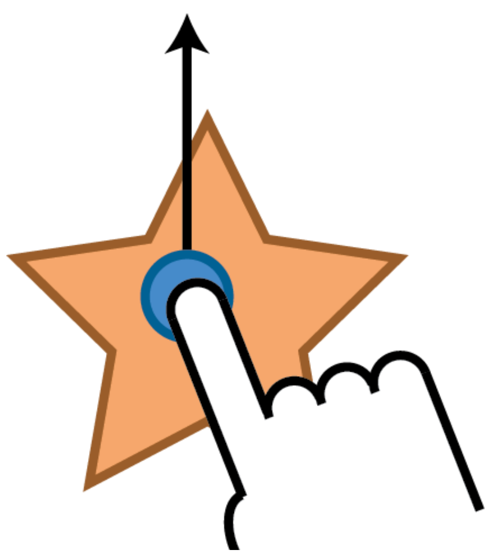
Literature: Kin,K. et al. ”Proton++: A Customizable Declarative Multitouch Framework”, UIST 2012

Proton++ Gesture

- describe a gesture as regular expression over these touch event symbols

$$E_{T_{ID}}^{A_1:A_2:A_3\ldots}$$

where $E \in \{D,M,U\}$, attribute values $A_1:A_2:A_3$, A_1 corresponds to first attribute etc.



consider attributes: hit-target shape, direction

$$D_1^{s:N} M_1^{s:N} {*} U_1^{s:N}$$

Literature: Kin,K. et al. ”Proton++: A Customizable Declarative Multitouch Framework”, UIST 2012

Mobile

- context and task
- theory
  - bimanual interaction
  - pointing
  - **gestures**
- interaction techniques
- in/output technologies

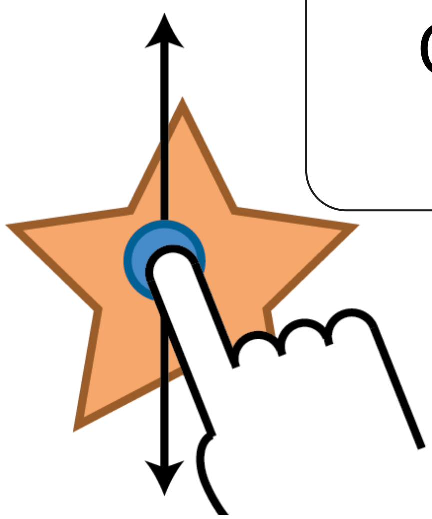
Proton++ Gesture

- describe a gesture as regular expression over these touch event symbols

$$E_{T_{ID}}^{A_1:A_2:A_3\ldots}$$

where E ∈ {D,M,U}, attribute values A_1:A_2:A_3, A_1 corresponds to first attribute etc.

1 Minute Micro Task:
Create the regular expression for this gesture



consider attributes:
hit-target shape,
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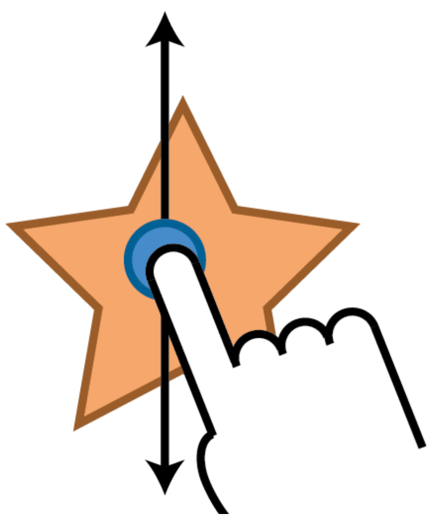
Proton++ Gesture

- describe a gesture as regular expression over these touch event symbols

$$E_{T_{ID}}^{A_1:A_2:A_3\ldots}$$

where E ∈ {D,M,U}, attribute values A_1:A_2:A_3, A_1 corresponds to first attribute etc.



$$D_1^{s:N|S} M_1^{s:N|S} {*} U_1^{s:N|S}$$

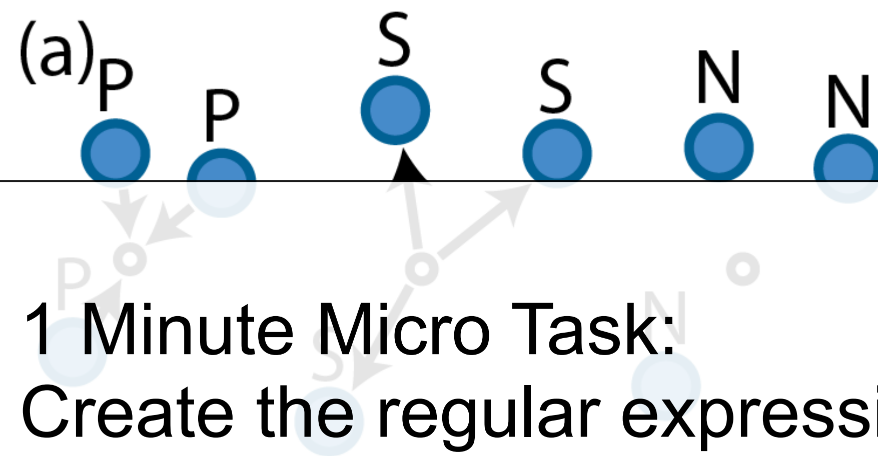
$$(D_1^{s:N}|D_1^{s:S})(M_1^{s:N}|M_1^{s:S})^*(U_1^{s:N}|U_1^{s:S})$$

consider attributes: hit-target shape, direction

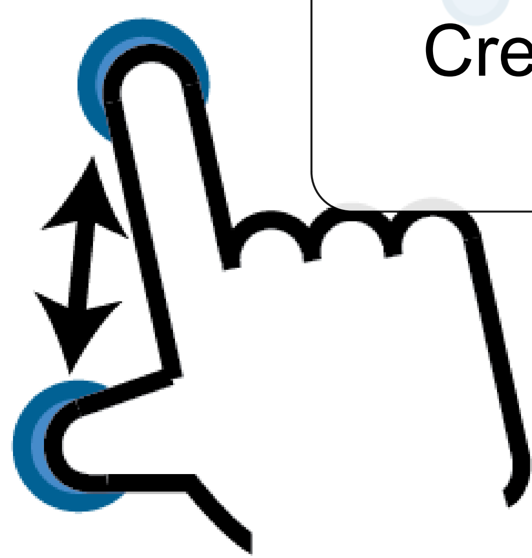
Literature: Kin,K. et al. "Proton++: A Customizable Declarative Multitouch Framework", UIST 2012

Custom Attributes

- for example a pinch attribute:
  - relative movements of multiple touches
  - touches are assigned a ‘P’ when on average the touches move towards the centroid, an ‘S’ when the touches move away from the centroid and an ‘N’when they stay stationary



1 Minute Micro Task:
Create the regular expression for this gesture



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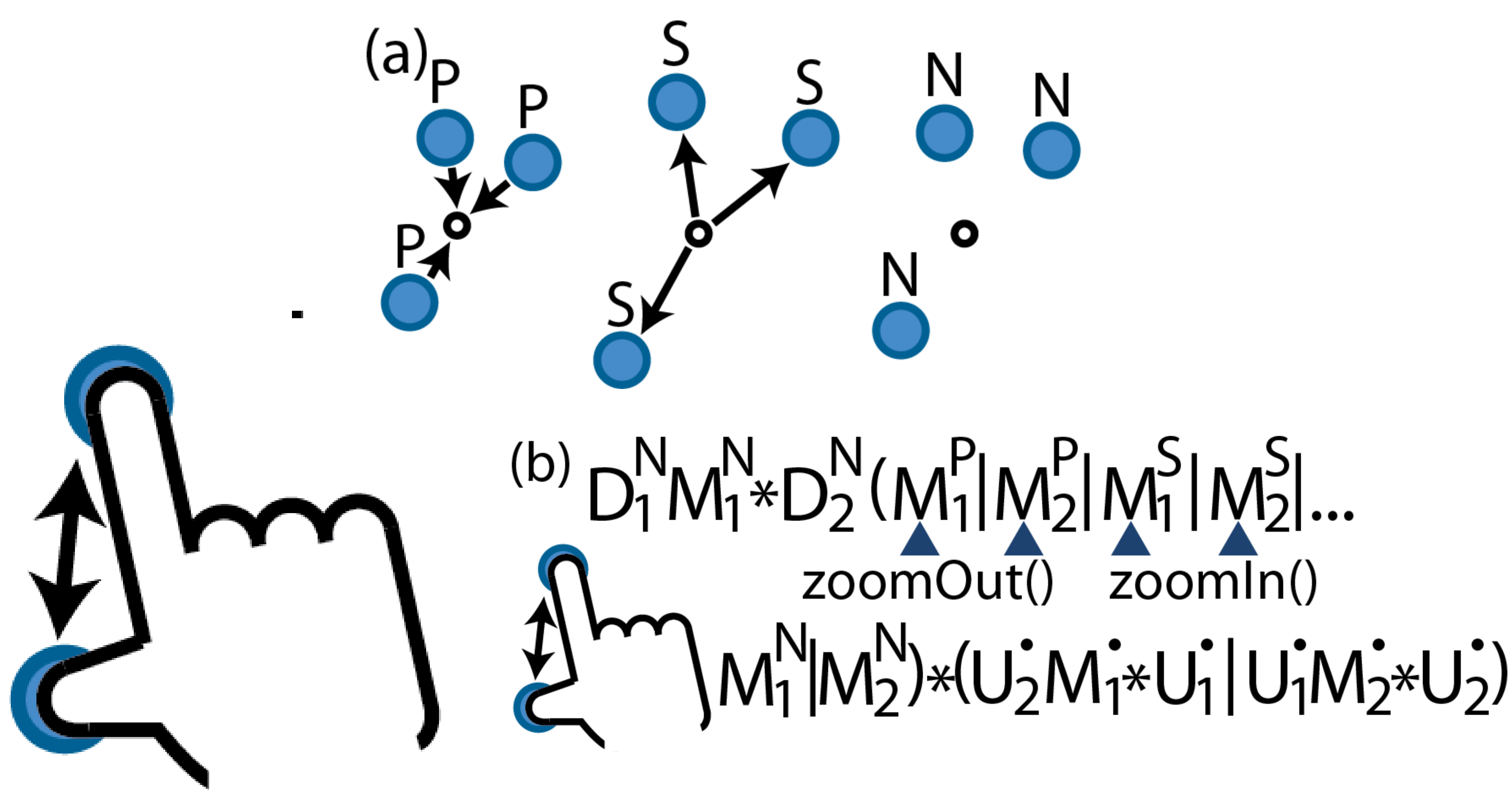

Further Attributes

- Direction Attribute
- Touch Area Attribute
- Finger Orientation Attribute
- Screen Location Attribute

→ Let’s practice that in the exercise