Mensch-Maschine-Interaktion 2

Mobile Environments

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Mensch-Maschine Interaktion 2

Desktop Environments

Mobile Technology

Interactive Environments
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)
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

Bimanual Interaction

SPad enables fast 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

the task of a shoulder surfer.
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?)
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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: 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
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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

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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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Design Implications

First, tablets can feel heavy and users are more comfortable

...
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Dominant arm

KC: frame + interaction

Non-dominant arm

BiTouch: frame + support + interaction
Role of Support

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Figure 4. The user creates a spatial frame with it. Different holds offer different trade-offs with respect to comfort and interactive power and comfort.

Guizard argues that the relationships between the non-dominant and dominant hands are similar to those between proximal and distal elements: the former provides the spatial frame of reference, e.g. the elbow, which together make up a specific kinematic chain as a general model, in which the shoulder, elbow, wrist and fingers work together as a series of abstract motors. Each action of the distal element or dominant hand cedes the movements of the higher frequency, more detailed actions of the non-dominant hand. They are generally less frequent and less precise and usually precede the movements of the former. In addition, the responsibility for the detailed action of the latter is almost always distributed between the two hands. The non-dominant arm, since the two are physically attached.

Framing functions of the kinematic chain. Each is affected by the distribution of the interaction or omitted, e.g. interacting on a freestanding interactive table. Even within the kinematic chain, support links are always intermediate between framing and interaction links; and the most distal link in the kinematic chain is handled at the most distal location. Note that comfort is subjective, influenced not only by the physical details of the device, such as its weight, thickness and size of the bezels, but also by how the tablet is held. For example, shifting between landscape and portrait orientations is tiring and less stable.

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

BiTouch DESIGN SPACE

Support
Interact
Non-dominant arm

One-hand Palm Support

Support
Interact
Dominant arm

One-hand Forearm Support

Support
Interact

Two-hand Palm Support

Support
Interact

(c)

(b)

(a)
Create further hypotheses

Inverse correlation: performance & comfort

Support

Distribution

high

low

Degree of Freedom
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?

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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
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 $X_r$
• Finger imprecision as another distribution $X_a$
• Combine $X = X_r + X_a$ 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!

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
Buxton’s 3 state model


- 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/

- 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
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gestures interaction techniques in/output technologies

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

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

http://thomas.baudel.name/Morphologie/These/images/V111.gif
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

Taxonomy of Gesture styles
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?
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.

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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


Proton++

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

\[ \text{move-with-first-touch-on-star-object-in-west-direction} \]

Proton++ Gesture

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

\[ E^{A_1:A_2:A_3...}_{T_{ID}} \]

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

Proton++ Gesture

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

\[ E^{A_1:A_2:A_3 \ldots}_{T_{1D}} \]

where \( E \in \{D,M,U\} \), 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,
direction

Proton++ Gesture

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

\[ E^{A_1:A_2:A_3 \ldots}_{T_{ID}} \]

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

\[ D^{s:N|S}\ M^{s:N|S} \star U^{s:N|S} \]

\[ (D_1^{s:N}|D_1^{s:S})(M_1^{s:N}|M_1^{s:S})\star(U_1^{s:N}|U_1^{s:S}) \]

consider attributes:
hit-target shape, direction

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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
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.

![Diagram showing custom attributes and pinch gesture](image-url)
Further Attributes

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

→ Let’s practice that in the exercise