Human-Computer Interaction 2

Prof. Dr. Andreas Butz
Dr. Bastian Pfleging
Chapter 1: Desktop (recap & critique)

- Intro & Organization of the class
- Basic concepts of Desktop UIs
  - Original design rationale & tasks
- Theory: Laws, Models and their limitations
  - KLM
  - Fitts’ Law
  - Steering Law
- Some Interaction Techniques
  - Linear & Pie Menus
  - Marking Menus
- Limitations of Desktop UIs
  - (ab)using desktop UIs for other tasks?
Human-Computer Interaction 2

• Held together with Dr. Bastian Pfleging
• Part of MSc study program at LMU
  – builds on HCI1 in the Bachelor
  – http://mimuc.de/mmi2

• We assume that you have a good fundament in HCI
  – from a Bachelor in Media Informatics & HCI
  – from a different Bachelor, but with relevant HCI courses
  – minimally: HCI1 (LMU) + a relevant thesis topic

• Now we will build a house on this fundament
  – putting what you have learned in perspective
  – looking at several contemporary special fields of HCI
  – moving on from known basics to open issues (-> research)
Current plan for class schedule

- **today**: Intro and desktop recap
- **8.11.**: Web Interfaces 1
- **15.11.**: Web Interfaces 2
- **22.11.**: Mobile & Wearable Interfaces 1
- **29.11.**: Mobile & Wearable Interfaces 2
- **6.-13.12.**: Interactive Environments 1+2
- **20.12.**: Christmas lecture (Surprise ;-)  
- **10.1.**: Guest lecture Natural UI: (TBD)
- **17.1.**: Interactive Environments 3
- **24.+31.1.**: Automotive UI 1+2
- **7.2.**: Guest lecture TBD
Exercises and exam

• Exercises: (Tuesdays 14:00-16:00)
  – Held by Renate Häuslschmid
  – Room: Theresienstr. 39, Room B 139
  – Highly recommended to submit solutions & participate (even though voluntary)
  – Consolidation of lecture, exam preparation
  – Lecture Q&A
  – Collaborative elaboration of (submitted) solutions, no sample solution

• Exam: Probably 2nd half of February 2016
  – will test understanding and practical application of lecture & exercise topics
  – best preparation: participate in lectures & exercises
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Desktop UI: the Design Rationale

http://www.youtube.com/watch?v=zVw86emu-K0
Desktop UI: the resulting HW setup

- 1973 Xerox PARC’s ‘Alto’
- hardware:
  - bit-mapped display
  - mouse
  - chord-keyboard (like 5 piano keys)
- single person setup, seated
- GUI features:
  - WYSIWYG
  - sliders, scrollbars
  - windows
  - icons
  - menus
  - pointer

= WIMP
Xerox Star (1981), commercial product based on Alto

http://www.youtube.com/watch?v=zVw86emu-K0
Xerox Star: Design Rationale & Context

• Who was it designed for?
• What do they do?

• What is their context?
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Laws & Models for describing such a UI

• Quantification:
  – Simple: GOMS / Keystroke-level model
  – More detailed: Fitts‘ law & Steering law

• Particular challenges in HCI:
  – Predictive models
    • Rate and decide between two alternatives.
  – Systematic exploration of design alternatives
    • Why did I choose these two designs? What are their differences?
    • Are there more than two alternatives? What are the other alternatives?
Goals, Operators, Methods & Selection Rules (GOMS)

- **Selection rules**
- **Methods**
- **Operators**
- **Goals**
Keystroke Level Model (KLM)

- Average times based on experiments:

  - **K (Keystroke)**: Pressing a key: $t_K = 0.28s$.
  - **P (Pointing)**: Pointing to a position on screen: $t_P = 1.1s$
  - **B (Button)**: Press a mouse button: $t_B = 0.1s$
    Mouse click: Press + release $→$ BB
  - **H (Homing)**: Switch btw. keyboard + mouse: $t_H = 0.4s$
  - **M (Mental preparation)**: Mental preparation of successive operation: $t_M = 1.35s$
  - **R(t) (Response time)**: Response time of the systems (within $t$ seconds, system-dependent).
KLM example

1. point to file icon \( P \)
2. press and hold mouse button \( B \)
3. drag file icon to trash can icon \( P \)
4. release mouse button \( B \)
5. point to original window \( P \)

Total time = \( 3P + 2B = 3 \times 1.1 + 2 \times 1 = 3.5 \) sec

ftp://www.eecs.umich.edu/people/kieras/GOMS/KLM.pdf
KLM Example: Comparing 3 Methods

• Which of the methods M1, M2, or M3 is faster?

• **M1**: Switch to mouse, move mouse pointer to file icon, clicking the icon, dragging to trash icon and release, switch to keyboard

• **M2**: Switch to mouse, selecting the icon, switch to keyboard, press ‘delete’

• **M3**: Press arrow key once to select the icon, press ‘delete’

• \( t_{M1} = t_H + t_P + t_B + t_P + t_B + t_H = (0.4 + 1.1 + 0.1 + 1.1 + 0.1 + 0.4) \) s = **3.2 s**

• \( t_{M2} = t_H + t_P + t_{BB} + t_H + t_K = (0.4 + 1.1 + 0.2 + 0.4 + 0.28) \) s = **2.38 s**

• \( t_{M3} = t_K + t_K = 2 \times 0.28 \) s = **0.56 s**
Fitts' Law as a Predictive Model

- Robust model of human psychomotor behavior
- Predicts movement time for rapid, aimed pointing tasks
  - Clicking on buttons, touching icons, etc.
- Developed by Paul Fitts in 1954
- Fitts' discovery "was a major factor leading to the mouse's commercial introduction by Xerox" [Stuart Card]

The Predictive Model

\[ MT = a + b \log_2 \left( 1 + \frac{D}{W} \right) \]

- **MT**: movement time
- **a** and **b**: constants dependent on the pointing system (user/input device)
- **D**: distance to the target area
- **W**: width of the target
Importance for HCI

• Inspire interaction techniques for optimizing MT:
  – increase $W$
  – decrease $D$
  – do both
  – improve hardware, reduce $b$
  – reduce $a$?

\[
MT = a + b \log_2 \left(1 + \frac{D}{W}\right)
\]

• Create standards

• Rate a design solution and justify why design A is better than design B.

• Attention: findings can be different between lab studies and field studies.

• Model does not capture complete complexity of a situation.
Building a Concrete Fitts’ Law Model

• Interactive computing systems: manipulating a cursor with the mouse, selecting icons in virtual space using a glove, grabbing tangible objects.

• Determine slope and intercept coefficients
  – Controlled experiment
  – One or more input devices
  – Task condition

• Cover a range of difficulties

• Conduct multiple trials in each condition and measure the required time.

• Perform tests of correlation and linear regression.

http://www.yorku.ca/mack/GI92.html
...But how about these Assumptions:

- one-dimensional movement
- straight line movement
- constant velocity
- undivided attention of movement
Not a one-dimensional movement!

- Two models for fixing that:

  - $W'$ model: substitutes for $W$ the extent of the target along an approach vector through the center
    - + theoretically attractive, retains one-dimensional model
    - - requires angle of movement

  - SMALLER-OF model: substitutes for $W$ either the width or height of the target, whichever is smaller.
    - + easy to apply
    - - but limited to rectangular targets.

MacKenzie et al. (1992): Extending Fitts’ law to two-dimensional tasks. CHI’92

http://www.billbuxton.com/fitts92.html
Not a straight line movement!

- Motion is not always straight: spiral or zig-zag
  - to account for this deviation from ideal trajectory, use length-distance ratio (LD)
  - LD = length of movement/actual distance

No constant velocity!

- Not a single smooth motion
- Motion composed of sequence of one or more sub-movements
  - ballistic phase: first movement is large and fast, covers most of the distance
  - corrective control phase: small and slower movements
- Deterministic iterative-corrections model
  - sub-movements have equal duration, each travels a constant fraction of the remaining distance toward the target and all are executed

Small Experiment: Bimanual pointing

• Perform a bimanual aiming task
  – one hand reaches for target in 10cm distance
  – other hand reached for target in 30cm distance

• What happens? What is MT in this case?

• Bimanual tasks are not just two simultaneously performed uni-manual tasks.
  – inter-limb coordination has tendency towards symmetry
  – limited degree of independence

• von Holst (1939): “Beharrungstendenz”, “Magnetoeffekt”

• more about bimanual interaction in other sections

Steering Law ???
Time for Driving Along a Narrow Road

\[ T = a + b \cdot \int_{S}^{W(s)} \frac{1}{W(s)} \, ds \]
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Linear Pull-Down Menus
Linear Context Menu / Popup Menu

Options
Show Recents
Open

Icon and Text
Icon Only
Hide Toolbar

Customize Toolbar...

Look Up “apprenticeship”
Cut
Copy
Paste

Add Link
Services
Circular Pie Menus and Marking Menus
Marking Menus

Gesture Recognition in Marking Menus

Gordon Kurtenbach, George Fitzmaurice, Azam Khan, and Don Almeida
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Desksops UIs are (ab)used for other tasks

- Understand how we got where we are!
  - Technical and economic constraints (or lack of imagination?)
  - Simply using available tools for new tasks

- There is no single setup for all human tasks.
  - Let’s look closely at the respective contexts and tasks
  - Let’s push the boundaries in shape, functionality and usage.
Multiple “work places”

- example: biologists
- problem: redundancy in working process

Interfaces for Composers

- problem: express your ideas, support creativity

https://www.lri.fr/~fanis/
Exploration of Large Datasets

- example: collaborative data exploration
- problem: social aspects of interaction

http://insitu.lri.fr/Projects/WILD
Extreme working situations

http://www.youtube.com/watch?v=UoMHzX36Gmg
Interfaces for Camera Operators
Summary and take-home message

• The desktop UI is the „swiss knife“ of HCI
  – well established since 1980s
  – reasonably well understood in theory (laws & models)
  – much diluted and modified in practice
• It does its original job (office work) well
  – adequate hardware setup and software tools
  – understandable metaphor
• It is (ab)used for many other tasks
  – often not the best idea, but just a pragmatic approach
• In this class, let’s look at other basic UI concepts!
  – closely look at new contexts and tasks
  – push the boundaries of device shape, functionality & usage
  – understand and formalize the resulting new setups