OPEN LAB DAY
05.12.13, 18:00 bis 22:00
Amalienstraße 17
www.medien.ifi.lmu.de/openlab
Correction: CD-gain

• control-display gain = unit free coefficient that maps the movement of the pointing device to the movement of the display pointer
  – gain = 1: display pointer moves exactly the same distance and speed as the control device
  – gain < 1: display pointer moves slower, covering less distance than the control device
  – gain > 1: display pointer moves proportionality farther and faster than the control device cursor movement.

\[ \text{CDgain} = \frac{V_{\text{pointer}}}{V_{\text{device}}} \]

Mobile Technologies

context and task

challenges

input technologies

challenges in interaction design

output technologies
Theories and Models

• Device Support
  – how HCI research started to consider the kinematic chain
  – spatial relationship to the device affects interaction performance and perceived comfort
    • BiTouch Design Space, extension of Guiard’s theory

• Gestural Input
  – what we lose when moving from keyboard and mouse and direct touch interaction
  – missing standards, how to describe gestures?
    • gesture documentation
    • physical approach to gestures

• Hand Occlusion
  – how a controlled experiment can help you to come up with an approximate model of your hand occlusion
  – how that inspires design of interaction techniques
  – how to describe the imprecision by extending Fitt’s law
Complex Multi-limb Coordination

- Bimanual interaction
  - is not the sum of two uni-manual actions
  - remember sketchpad!
- Whole body interaction

Mobile context and task

Device Support

input technologies

challenges in interaction design

output technologies

Bimanual interaction

- symmetric bimanual action
- asymmetric bimanual action

Complex Multi-limb Coordination

Bimanual interaction

- is not the sum of two uni-manual actions
- remember sketchpad!

Whole body interaction

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Complex Multi-limb Coordination

Bimanual interaction

- symmetric bimanual action
- asymmetric bimanual action

Whole body interaction

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bimanual interaction

symmetric bimanual action: the two hands have the same role

asymmetric bimanual action: the two hands have different roles
Guiard’s Kinematic Chain

“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

**challenges**

input technologies

challenges in interaction design

output technologies

Mobile

context and task

challenges

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• 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.

How do people naturally hold tablets?

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

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gestures

chords

taps


<table>
<thead>
<tr>
<th>Technique</th>
<th>Degrees of freedom</th>
<th>Independence</th>
<th>Location</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-hand Palm Support</td>
<td>0% – 100% body movement</td>
<td>0% – 100% body support</td>
<td>0% – 100% body support</td>
<td></td>
</tr>
<tr>
<td>One-hand Forearm Support</td>
<td>0% – 100% body movement</td>
<td>0% – 100% body support</td>
<td>0% – 100% body support</td>
<td></td>
</tr>
<tr>
<td>Two-hand Palm Support</td>
<td>0% – 100% body movement</td>
<td>0% – 100% body support</td>
<td>0% – 100% body support</td>
<td></td>
</tr>
</tbody>
</table>
Mobile context and task challenges

input technologies

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frame interaction

Dominant arm

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

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frame support

Dominant arm Non-dominant arm

Support -affected

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

<table>
<thead>
<tr>
<th><strong>Framing</strong></th>
<th></th>
</tr>
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<tbody>
<tr>
<td><strong>Location:</strong></td>
<td>proximal link in the kinematic chain</td>
</tr>
<tr>
<td><strong>Distribution:</strong></td>
<td>1 – n body parts</td>
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<th><strong>Support</strong></th>
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<tbody>
<tr>
<td><strong>Location:</strong></td>
<td>none or middle link in the kinematic chain</td>
</tr>
<tr>
<td><strong>Distribution:</strong></td>
<td>0 – n body parts</td>
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<tr>
<td><strong>Independence:</strong></td>
<td>0% – 100% body support</td>
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<td><strong>Location:</strong></td>
<td>distal link in the kinematic chain</td>
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<td><strong>Distribution:</strong></td>
<td>1 – n body parts</td>
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<tr>
<td><strong>Degrees of freedom:</strong></td>
<td>0% – 100% body movement</td>
</tr>
<tr>
<td><strong>Technique:</strong></td>
<td>touch, deformation,...</td>
</tr>
</tbody>
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**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

Performance > Comfort

Support Distribution Support
high low

Degree of Freedom

context and task
challenges
input technologies
challenges in interaction design
output technologies
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
  - 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?
Mobile

context and task

challenges

Device Support

Gestural Input

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Proton++

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

Mobile

context and task

challenges

Device Support

Gestural Input

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Proton++

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

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

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

\[ M^s:\overset{W}{1} \]

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

Proton++ Gesture

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

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

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

\[
D^{s:N}_{1} M^{s:N}_{1} \star U^{s:N}_{1}
\]

consider attributes:
hit-target shape, direction

Proton++ Gesture

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

$$E_{TID}^A:A_2:A_3...$$

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

\[ E_{TID}^{A_1:A_2:A_3...} \]

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

\[ D_1^{s:N|S} M_1^{s:N|S} \ast U_1^{s:N|S} \]

\((D_1^{s:N} | D_1^{s:S})(M_1^{s:N} | M_1^{s:S}) \ast (U_1^{s:N} | U_1^{s:S})\)

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

Further Attributes

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

→ Let’s practice that in the exercise

But: how can we represent this?

Mobile context and task challenges

input technologies

challenges in interaction design

output technologies
Shape-based interaction

• Interaction in the real world uses not just contact points
• We use whole hands, arms, tools
• Cannot be adequately expressed using just contact points
• How can we deal with this?

• Remember the lava lamp in Jeff Han‘s TED talk? (http://www.youtube.com/watch?v=QKh1Rv0PlOQ)
• Seriously: How can we do useful stuff with this?
Idea: Interaction using a physics simulation

• Take a ready-made physics engine for games
• Represent every interface object as a 3d physical object
• Assign proper weight and friction
• Entire interface behaves like real physics

• How do we deal with shape input?
• Idea: proxy objects

• Material on the following slides by Otmar Hilliges
Approach: Proxy Objects

- [Otmar Hilliges, UIST2008 best paper]

- Special objects introduced into the simulation per contact point

- Incarnation of fingertips in the virtual world

- Collide with other objects and push them aside.
Leveraging Collision Forces
Leveraging Friction Forces
Particle Proxies

• Idea: model contact shape with many proxy objects (particles)
• Collisions obey shape of the contact (e.g., flat or side of the hand)
• Distribution of forces is modeled more accurately (e.g., conforms to 3D shape)
From Tracking to Flow
Occlusion

- problem: system generated messages may be positioned under the user’s hand.
- one approach: experimental study using a novel combination of video capture, augmented reality marker tracking, and image processing techniques to capture occlusion silhouettes.
- result: five parameter geometric model which matches the silhouette with larger precision than the simple bounding box approach
- useful for occlusion aware interfaces

Mobile

context and task

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Device Support

Gestural Input

Occlusion

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Vogel’s Controlled Experiment

- goal: measure size and shape of occluded area of a tablet-sized display.
- home target: on the far right side
- measurement target: positioned somewhere on an invisible grid (7 x 11 = 77 different locations)

Mobile

context and task

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• Frame extraction: video frames taken between successful down and up pen event.
  – synchronize video and data log similar to a movie clapperboard: blend in a large red square containing a unique number.

• Rectification: track fiducial and determine screen corners

• Isolation: blur filter (noise reduction) + extract blue color channel + applied threshold to create an inverted binary image.

Image Processing

- Frame extraction: video frames taken between successful down and up pen event.
  - synchronize video and data log similar to a movie clapperboard: blend in a large red square containing a unique number.
- Rectification: track fiducial and determine screen corners
- Isolation: blur filter (noise reduction) + extract blue color channel + applied threshold to create an inverted binary image.

Results

- largest occlusion when tapping the top left corner (occlusion rate: 38.8%)
- identified 3 grips
- large within-subject consistency in occlusion shape.
- “can we find a simple geometric model that could describe the general shape and position of the occlusion silhouettes?”

Scalable Circle and Pivoting Rectangle Model

Mobile context and task

challenges

Device Support

Gestural Input

Occlusion

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challenges in interaction design

output technologies

Bézier spline

bounding rectangle model

Scalable Circle and Pivoting Rectangle Model

- 5 parameters:
  - q offset from pen position to circle edge
  - r radius of the circle
  - \( \phi \) rotation angle of circle around \( p \)
  - \( \Theta \) rotation angle of rectangle around the center of the circle
  - w width of rectangular representation of forearm.

---

**Literature:** Vogel, D. et al. (2009). *Hand Occlusion with Tablet-sized Direct Pen Input*, CHI’09
Occlusion-aware techniques

Occlusion-Aware Interfaces

Daniel Vogel\(^{1,2}\) and Ravin Balakrishnan\(^{1}\)

\(^{1}\)Dept. of Computer Science
University of Toronto, CANADA

\(^{2}\)Dept. of Math & Computer Science
Mount Allison University, CANADA

http://www.youtube.com/watch?v=4sOmlhEJ2ac
Occlusions and the Fat Finger Problem

• Fingers and hands can occlude screen objects
  – minimize by adapting the screen layout!
• Fingers may hit several small objects
  – just use large objects ;-) 
• Exact hit point is occluded, precision limited!

Try to read this text. It is partly occluded!
To read it?
Fat Fingers and FFitts law

- For small targets and fat fingers, there is a limit to pointing precision!
  - Fitt’s law fails to predict performance in this situation

- Modify Fitt’s law formula to account for precision
  - think of it like of Newtonian and relativistic physics:
    - at small speeds, both are the same
    - towards the speed of light, they differ

$$T = a + b \log_2 \left( \frac{A}{W} + 1 \right) = a + b \log_2 \left( \frac{A}{\sqrt{2\pi e\sigma}} + 1 \right)$$

$$T = a + b \log_2 \left( \frac{A}{\sqrt{2\pi e(\sigma^2 - \sigma_a^2)}} + 1 \right)$$

Precision

Mobile

context and task

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output technologies

Take-away message

• Three on-going research challenges with touch and pen input
  – device support
  – gestural input
  – occlusion & fat fingers

• Approaches:
  – analyzing interaction using the kinematic chain
  – apply, extend and test existing theories from other fields (psychology, mathematics, linguistics, physics)

• In particular: the body’s spatial relationship affects interaction performance and perceived comfort (was that the case in desktop env.?)
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