MMI 2: Mobile Human-Computter Interaction
Small and Large Display Interaction
Prof. Dr. Michael Rohs
michael.rohs@ifi.lmu.de
Mobile Interaction Lab, LMU München
## Lectures

<table>
<thead>
<tr>
<th>#</th>
<th>Date</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>19.10.2011</td>
<td>Introduction to Mobile Interaction, Mobile Device Platforms</td>
</tr>
<tr>
<td>2</td>
<td>26.10.2011</td>
<td>History of Mobile Interaction, Mobile Device Platforms</td>
</tr>
<tr>
<td>3</td>
<td>2.11.2011</td>
<td>Mobile Input and Output Technologies</td>
</tr>
<tr>
<td>4</td>
<td>9.11.2011</td>
<td>Mobile Input and Output Technologies, Mobile Device Platforms</td>
</tr>
<tr>
<td>5</td>
<td>16.11.2011</td>
<td>Mobile Communication</td>
</tr>
<tr>
<td>6</td>
<td>23.11.2011</td>
<td>Location and Context</td>
</tr>
<tr>
<td>7</td>
<td>30.11.2011</td>
<td>Mobile Interaction Design Process</td>
</tr>
<tr>
<td>8</td>
<td>7.12.2011</td>
<td>Mobile Prototyping</td>
</tr>
<tr>
<td>9</td>
<td>14.12.2011</td>
<td>Evaluation of Mobile Applications</td>
</tr>
<tr>
<td>10</td>
<td>21.12.2011</td>
<td>Visualization and Interaction Techniques for Small Displays</td>
</tr>
<tr>
<td>11</td>
<td>11.1.2012</td>
<td>Mobile Devices and Interactive Surfaces</td>
</tr>
<tr>
<td>12</td>
<td>18.1.2012</td>
<td>Camera-Based Mobile Interaction</td>
</tr>
<tr>
<td>13</td>
<td>25.1.2012</td>
<td>Sensor-Based Mobile Interaction 1</td>
</tr>
<tr>
<td>14</td>
<td>1.2.2012</td>
<td>Sensor-Based Mobile Interaction 2</td>
</tr>
<tr>
<td>15</td>
<td>8.2.2012</td>
<td>Exam</td>
</tr>
</tbody>
</table>
Aktuelles

• Klausur am 8.2.2012
  – Anmeldung

• Fragen zur Klausur
  – jeweils zu Beginn der nächsten Vorlesungen (ab 18.1.)
Review

• How to visualize the relevant of a POI to a query?
• Why is screen navigation important for small displays?
• Mechanisms to indicate objects beyond the screen?
• How to improve touch screen accuracy?
Preview

• Touch Screen interaction techniques
• Behind-the-device interaction
• Mobile devices and interactive surfaces
TOUCH SCREEN INTERACTION TECHNIQUES
Precision Touch Input: ThumbSpace

ThumbSpace: User-defined space which thumb can reach

- One-handed thumb operation of handheld touch interfaces
- Not all of screen reachable → reduce thumb interaction space
- Selection on lift-off (as with Offset Cursor)

Precision Touch Input: ThumbSpace

Precision Touch Input: TapTap and MagStick

TapTap: Tapping the screen twice
- tap 1: select area of interest
- area zooms in, centered on screen
- tap 2: select magnified target
- zoomed target typically close to screen: fast selection
- works in border areas (c.f. Shift)

Precision Touch Input: TapTap and MagStick

MagStick: “magnetized telescopic stick”
- Initial touch position is reference point
- Moving away from target extends stick in opposite direction
- End of stick is “magnetically” attracted by target

Is moving away from the target intuitive?

Is MagStick better than simple Offset Cursor?

## Precision Touch Input: Comparison Experiment

<table>
<thead>
<tr>
<th>Overview</th>
<th>Direct Touch</th>
<th>Offset Cursor</th>
<th>Adaptive Offset</th>
<th>Thumbspace</th>
<th>Shift</th>
<th>TapTap</th>
<th>MagStick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target Accessibility</td>
<td><img src="image" alt="Direct Touch" /></td>
<td><img src="image" alt="Offset Cursor" /></td>
<td><img src="image" alt="Adaptive Offset" /></td>
<td><img src="image" alt="Thumbspace" /></td>
<td><img src="image" alt="Shift" /></td>
<td><img src="image" alt="TapTap" /></td>
<td><img src="image" alt="MagStick" /></td>
</tr>
</tbody>
</table>

Grayed areas are difficult to reach – Hatched areas are impossible to reach

<table>
<thead>
<tr>
<th>Thumb Occlusion</th>
<th>Everywhere</th>
<th>None</th>
<th>None</th>
<th>Center (if same relative and absolute positions)</th>
<th>On top left</th>
<th>None</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pointing Accuracy</td>
<td>Coarse</td>
<td>Medium (net correction distance time)</td>
<td>Medium (net correction distance time)</td>
<td>Fine (facilitated by Object Pointing)</td>
<td>Medium (small targets) and coarse (large targets)</td>
<td>One coarse and one fine (increase target size)</td>
<td>Fine (facilitated by Semantic Pointing)</td>
</tr>
</tbody>
</table>

- **Dependent variables**
  - Time
  - Error rate
  - Questionnaire results
  - Ranking of techniques

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Precision Touch Input: Comparison Experiment

Precision Touch Input: Comparison Experiment

• Ranking (first to last): TapTap, MagStick, Shift, Offset Cursor, Thumbspace, Direct Touch

MicroRolls: Expanding Touch-Screen Input by Distinguishing Rolls vs. Slides of the Thumb

- Input vocabulary for touchscreens is limited
- MicroRolls: thumb rolls without sliding
  - Roll vs. slide distinction possible
  - No interference
- Enhanced input vocabulary
  - Drags, Swipes, Rubbings and MicroRolls

MicroRolls: Expanding Touch-Screen Input by Distinguishing Rolls vs. Slides of the Thumb

Kinematic Traces of Different Touch Gestures

Drag

Up

Left

Right

Down

Swipe

Up

Left

Right

Down

MicroRoll

Clockwise

Counterclockwise

Rubbing

Mapping MicroRoll Gestures to Actions

- Menu supports gesture learning
  - Menu only appears after 300ms timeout
  - Experts execute gestures immediately
- Precision: selecting small targets
- Quasi-mode: modify subsequent operation

Bezel Swipe: Conflict-Free Scrolling and Selection on Mobile Touch Screen Devices

- Drag from screen edges through thin bars
- Edge bar encodes command
- Multiple commands without interference
  - Selection, cut, copy, paste
  - Zooming, panning, tapping

Bezel Swipe: Conflict-Free Scrolling and Selection on Mobile Touch Screen Devices

Bezel

Rubbing and Tapping: Multiple Fingers on Single-Touch Screens

• Zooming on single-touch displays
  – Cursor “jumps” when second finger touches screen
  – Hardware averages touch point in center

• Proposed interaction techniques
  – Rub-Pointing: diagonal rubbing gesture for pointing and zooming in a single-handed technique
  – Zoom-Tapping: dominant hand points, non-dominant hand taps

Rubbing and Tapping: Multiple Fingers on Single-Touch Screens

Xpaaand: Interaction Techniques for Rollable Displays

• Concept of a future rollable display
  – Physical resizing of the display as an interaction technique
  – Semantic zooming

• Metaphors
  – Content locked in viewport
  – Content locked in hand

Xpaaand: Interaction Techniques for Rollable Displays

Effects of Structural Holds on Pointing and Dragging with Flexible Displays

• How do users point and drag with a paper-like display?
  – Study: common holds and force patterns
  – Observed holds: grip zone, rigid / flexible zone

• Efficiency: Rigid areas (produced by holds) had 12% higher pointing and dragging performance

Effects of Structural Holds on Pointing and Dragging with Flexible Displays

PaperPhone: Bend Gestures in Mobile Devices with Flexible E-Paper Display

Use device as watch…  
…detach, use as PDA

PaperPhone: Bend Gestures in Mobile Devices with Flexible E-Paper Display

BEHIND-THE-DEVICE INTERACTION
LucidTouch

• Behind-the-device multitouch input
• Pseudo transparency
  – Enabling back of the device pointing
  – 3 states + visual feedback
    = land-on selection
• Form-factor
  – Enabling multi-touch with all ten fingers

Why Behind-the-Device Interaction?

- Avoid occlusion
- “Fat finger” problem

Pseudo Transparency

Show finger “shadows” as cues

gray: “shadow”
red: touch
blue: hovering

LucidTouch Camera See-Through

- Finger shapes and positions tracked by camera
  - Hovering / tracking state
- (Multi-)touch detected by pad
  - Dragging state

Buxton’s Three-State Model of Input

Two-State Model for Touch Input

LucidTouch: Three Input States

State 0: Out of Range
State 1: Hovering / Tracking
State 2: Dragging

Finger Behind Back
Remove Finger
Release Contact
Contact

LucidTouch Applications: Map

LucidTouch Applications: Text Input

LucidTouch Issue: Finger Reachability

Back-of-Device Interaction Works for Very Small Screens

• Jewelry, watches, etc.

• Pseudo transparency
  – Capacitive touch pad
  – Clickable touch pad

Back-of-Device Interaction Works for Very Small Screens

Side-of-Device Interaction: SideSight

- Useful if device is placed on table
- Distance sensors along device edges
  - Multipoint interactions
- IR proximity sensors
  - Edge: 10x1 pixel “depth” image

Side-of-Device Interaction: SideSight

Pressure-Sensitive Map Zooming

Pressure Sensitive Input: Multiple States

State 0
- Out of range
- Contact

State 1
- Tracking
- Decrease pressure
- Increase pressure

State 2+
- Decrease pressure
- Increase pressure
- Dragging

Extension of Virtual Trackball to Back of Device

Full sphere operated from both sides instead of hemisphere operated from front
Virtual Trackballs for 3D Object Rotation

x,y,z-axis rotation

z-axis rotation
MOBILE DEVICES AND
INTERACTIVE SURFACES
Motivation for Combining Mobile and Large Displays

- Support kinesthetic and spatial memory of users
  - Locate information in space
  - Assign application semantics to spatial arrangements

- Focus & context displays

- Private & public displays

- Drag’n’drop in the physical world
  - Movement of data between devices
  - Carry out one task across multiple devices

- Collaboration

- Capturing information on public space
Fitzmaurice 1993: Spatially Aware Palmtop Computers

“Ubiquitous Graphics”

- **Focus & context displays**
  - Wall display for low resolution overview
  - Handheld display for high resolution details

- **Ultrasonic tracking**
  - Mimio XI ultrasonic pens attached to display
  - Pen emits ultrasonic signal when touching wall

- Users can add annotations and objects

Sanneblad, Holmquist. Ubiquitous graphics: Combining hand-held and wall-size displays to interact with large images. AVI '06.
http://www.youtube.com/watch?v=uw0a7Zd1JVM
“Pick-and-Drop” and “Hyper Palette”

• Pick-and-Drop
  – Direct manipulation for smart environments
  – Extended “drag-and-drop” concept
  – Create text on PDA, pick-and-drop to whiteboard

• Hyper Palette
  – PDA as interaction device for table
  – Electromagnetic 6D trackers
  – Scoop-and-spread: tilting plus movement


“Pick-and-Drop”

Augmented Surfaces

- Interchanging information between mobile devices, interactive surfaces, and physical objects
  - Camera-based object recognition
  - Projected displays as extensions of device screens

- Hyperdragging
  - Move information across boundary of devices and surfaces

Rekimoto, Saitoh: Augmented surfaces: A spatially continuous work space for hybrid computing environments. CHI '99.
Augmented Surfaces

Rekimoto, Saitoh: Augmented surfaces: A spatially continuous work space for hybrid computing environments. CHI '99.
Interaction with Large Public Displays

- Train stations, airports, museums, shopping malls

Content associated with menu item is transferred to the mobile phone

Selection of menu item (code coordinate system)
C-Blink: Visual Communication

- Camera on top of display
- Cell phone screen blinks in different colors
- Hue-difference signal
  - Hue in HSV color space

Touch Projector: Mobile Interaction-Through-Video

- Touch Projector: Interact with remote screens through a live video image on the mobile device
  - Position tracking w.r.t. surrounding displays
  - Project image onto target display
- Select targets, drag targets between displays

http://www.youtube.com/watch?v=ITMAKHzbI1E

Touch Projector

Deep Shot: Migrating Tasks Across Devices Using Mobile Phone Cameras

- User tasks often span multiple devices
- Deep Shot supports migrating tasks across devices
  - Take a picture
  - Recognize content
  - Recreate content on mobile

Deep Shot: Migrating Tasks Across Devices Using Mobile Phone Cameras


With Deep Shot, Bob moves the interactive map to his phone by simply
BlueTable: Connecting Wireless Mobile Devices on Interactive Surfaces

• Association of a mobile device with an interactive surface
• Camera detects objects as connected components (blobs) of a certain size and shape
• BlueTable checks whether detected blob is a mobile device
  – Sends Bluetooth request to blink IRDA port to each device in turn
  – Downside: slow

Mobile Devices and Interactive Tabletops

- Camera-projector system
  - Works with regular tables
  - Pubs, cafés, meeting rooms

- Map spatial configurations to application-specific semantics
  - Proximity regions around devices

- Dynamic marker

Marker Recognition Algorithm

• Find corner stone candidates
  – Convolve image with 7x7 “Gaussian” kernel

\[ k(x, y) = b \exp(a(x^4 + y^4)), \quad x, y = -3..3 \]
\[ a = -(2s^2)^{-1}, b = -(s\sqrt{2\pi})^{-1}, s = 1.9 \]
  – Separable in two 1D kernels

• Thresholding (cross-correlation \( \geq 0.72 \))
• Non-maximum suppression
• Find pairs of corner stone candidates
• Compute homography and sample data area
• Determine orientation
• Decode value, compute position, rotation, size
Camera Image (1024x768 pixels)
Convolution
Thresholding and Non-Maxima Suppression
Low Contrast Display Images
Low Contrast Display Image
The End