Thumb Movement:

Designing for One-Handed Use of Small Devices

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Background:

Mobile Device Trends

- Increasing...
  - Power
  - Speed
  - Storage
  - Personalization
  - Services
  - Market Penetration
  - Functions
Background:
Mobile Device Trends

- Increasing...

**Role in users’ lives!**
Background:

**Device Styles & Use Patterns**

- **Cell phone style**
  - Compact keypad
  - Display for output only
  ➡️ One Hand

- **PDA style**
  - Minimal buttons
  - Touch sensitive display
  ➡️ Two Hands
Motivation:

Single Handed Use

- Mobile Scenarios

- Web Survey: Hands Used

<table>
<thead>
<tr>
<th></th>
<th>Current</th>
<th>Preferred</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phone</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>PDA</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

www.cs.umd.edu/hcil/mobile/survey/
Motivation:

Case In Point

Standard data access applications can be unusable with thumbs.

- Start menu too far
- Many widgets too far
- Many widgets too small

Pocket PC Contacts
Motivation: One-Handed Device Research

- Spatial Orientation (e.g., tilt to scroll)
  - [Rekimoto, 1996]
  - [Harrison, Fishkin, et al., 1998]
  - [Hinckley, Pierce, et al., 2000]
  - [Widgor and Balakrishnan, 2003]

- Minimal Attention Interfaces
  - [Kristoffersen and Ljungberg, 1999]
  - [Pascoe, Ryan, et al., 2000]
  - [Brewster, Lumsden, et al., 2003]
  - [Pirhonen, Brewster, et al., 2002]
Approach:

Foundations in Thumb Movement

- Goal: Capture thumb capabilities
- Measure: Tapping Speed
- Hypotheses: Performance depends on...
  - Device **Size**
  - Movement **Direction**
  - Interaction **Location**
Approach:

Device Sizes

- Four typical devices
- Varying sizes and shapes

Small Candy bar  Flip Phone  Large Candy bar  PDA

Increasing Size
Approach:

Device Sizes

- Four typical devices
- Varying size and shape

Increasing Size
Study:

Device Models

- Models remove tactile features
Study:

Capturing Thumb Movement

Light Emitting Diodes

3D spatial positions tracked with a motion analysis system
Study:

Formal Study Design

- Participants: 20
- Devices: 4
- Tasks: Reciprocal Tapping
  - Directions: ↑ ↔ ↘ ↗
  - Locations: All Possible
- Distances:

Measures: Tap **Speed** Easy and **Hard** input areas
Analysis:

Deriving Tap Speed

- Middle 3 seconds
- Low points as taps
  - Automated
  - Verified by hand

Avg. Tap Speed = \frac{\text{Time of Last Tap} - \text{Time of First Tap}}{\text{Total Taps} - 1}

\[2.52 - 0.31 = 0.32\text{ sec}\]

\[\frac{0.32}{7} = 0.0457\text{ sec}\]
Results:

Does device size affect performance?

- No time diff. between comparable areas

- Still, we are cautious about large devices:
  - Heavier devices → more strain over time?
  - Observed much more grip re-adjustment
Results:

Does movement direction affect performance?

11%-14% faster than
Results:

Does *movement direction* affect performance?

Note: participants were all *right* handed
Does interaction location affect performance?

Subjective Preferences

Small Candy bar

Flip Phone

Large Candy bar

PDA

Easiest  Hardest
Results: Does interaction location affect performance?

Fastest regions 7%-12% faster than slowest regions, per device.
Examples:

Better One-Handed Interfaces?

- Application navigation
- Hardware

LaunchTile

AppLens

Compact navigation & control

www.cs.umd.edu/hcil/mobile/

Palm Treo 700w
Lessons

- **For all** devices
  - Avoid diagonal movement for **repetitive** tasks

- **For larger** devices
  - Strive for interaction targets toward the **center** of the device
  - To minimize re-gripping, keep total interaction area **compact**

Supports left and right-handed use
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  CS, HCIL
- Kent Norman  
  Psychology
- Study Participants

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Questions?

- Contacts
  - Amy Karlson (akk@cs.umd.edu)
  - Ben Bederson
  - Jose Contreras-Vidal

- Resources
  - One-handed application navigation
  - Device usage survey