Sensing Tablet Grasp + Micro-mobility for Active Reading

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Physical Manipulation of Objects
Supporting Active Reading

Proactive knowledge construction tasks:
Supporting Active Reading

Proactive knowledge construction tasks:
Nonlinear Navigation
Supporting Active Reading

Proactive knowledge construction tasks:
Nonlinear Navigation
Cross-referencing content
Supporting Active Reading

Proactive knowledge construction tasks:
- Nonlinear Navigation
- Cross-referencing content
- Working together over a document

https://www.flickr.com/photos/pennstatelive
Supporting Active Reading

Maintaining the Flow of Reading

Needs for effective UI
Embodied Interactions for Active Reading
Embodied Interactions for Active Reading

Turning pages
Embodied Interactions for Active Reading

Turning pages
Lifting for a closer look
Embodied Interactions for Active Reading

Turning pages
Lifting for a closer look
Multiple document layout
Embodied Interactions for Active Reading

Turning pages
Lifting for a closer look
Multiple document layout
Orienting toward others
Micro-mobility: Orienting and repositioning physical artifacts
Grasp in Micro-mobility:
‘Hand grips’ coming into play
Grasp + Micro-mobility Interactions
Grasp + Micro-mobility Interactions
Grasp + Micro-mobility Interactions
Formative Study:

We Know Too Little About *Grasp + Micro-mobility Actions*. 

Observing *Naturally Occurring Grasp + Micro-mobility in Document Work*

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**Presentation**
- reading and explaining infographics

**Cooperation**
- discussion over a shared infographics

**Competition**
- memorization / guessing games
Formative Study:
Observing Grasp + Micro-mobility in Solo / Dyadic Document Work

Capturing *naturally occurring behavior without digital bias*

Acrylic tablet mock-ups (iPad air or mini sized and weighted)
Observed Behaviors:
Lateral swing for face-to-face handoff
Observed Behaviors:

Bimanual symmetric grip for immersive reading
Observed Behaviors:

Bimanual symmetric grip for immersive reading

Thumbing indicates locus of attention
Sensing System for Grasp + Micro-mobility Interactions

Tablet (11.6” Samsung ATIV tablet, 337×197×16 mm, 1.4 kg)
Capacitive Sensor Array (Back and Edges) (44×26, 50Hz)
Inertial Sensors (3-DOF, 100Hz)
Recognizing Multi-hand Grasp

De-noise

Segment

Classify

Thumb Left Edge

Thumb Right
## Designing Interactions: Design space

<table>
<thead>
<tr>
<th>Single Device</th>
<th>Multiple Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single User</td>
<td>Multiple User</td>
</tr>
</tbody>
</table>

Marquardt et al.’s Micro-mobility Interaction (2012)
Face-to-Face Handoff (Multi-User, Single-Device)
Face-to-Face Handoff (Multi-User, Single-Device)
Face-to-Face Handoff (Multi-User, Single-Device)
Immersive Reading (Single-User, Single-Device)
Immersive Reading (Single-User, Single-Device)
Thumb Bookmark with ‘Tip-to-Flip’
(Single-User, Single-Device)
Thumb Bookmark with ‘Tip-to-Flip’
(Single-User, Single-Device)
Fine-Grained Reference + Hold to Refer Back
(Single-user, Multi-device)
Fine-Grained Reference + Hold to Refer Back
(Single-user, Multi-device)
Evaluation Results and Design Insights:
Familiarity of Natural Grasp + Micro-mobility Interactions
Evaluation Results and Design Insights:
Context sensing vs. Gesture interaction
Evaluation Results and Design Insights:
Capturing flexibility and diversity of behaviors

Comprehensive recognition technique,
or
Not recognizing it by design

Side-by-side hand-off
Conclusion and Takeaway

Capturing Naturally Occurring Grasp + Micro-mobility behaviors provides a Mutually Reinforcing Signal of User Context

Observational Findings from the Behavioral Study
   Handoff, Immersive reading, Thumbing

Design Space and Interaction Techniques
   Single / Multi-user, and Single / Multi-device

Combination of Grasp and Micro-mobility
   Not just about grip, nor just about movements
Supplementary Slides
Related Work

**Micro-mobility:** Orienting and repositioning in collaboration
   (Luff and Heath, 98, Marquardt et al., 2012, Greenberg et al., 99)
   
   + Grasp, + Individual level micro-mobility

**Grasp Sensing:** Bezel, Back-of-device touch
   (Kim et al., 2013)  (Wolf et al., 2012, Noor et al., 2014)
   
   *Entire back surface and sides touch + inertial motion*

**Grasp Applications:** Handedness, Screen orientation and virtual keyboard,
   (Wimmer et al., 2009)  (Cheng et al., 2012, Cheng et al., 2013)
   
   Grip-dependent functions, Front + back gestures
   (Kim et al., 2006, Taylor et al., 2009, Wimmer, 2011)  (Wolf et al., 2012, Noor et al., 2014)
   
   *Active reading contexts*
Observed Behaviors: Grips

Thumb Left grip

Thumb Left-Edge grip

Tray grip
Observed Behaviors: with a Pen
Recognizing Multi-hand Grasp

De-noise
Segment
Classify
Stabilize

Sensor Signal → De-noised → Segmented

Result

Stabilizer

Shape + Geometry Features
Side-by-Side Micro-Territoriality (Multi-User, Single-Device)
Preliminary Evaluation:  
Assessing Reactions to Grasp + Mobility Interaction Techniques

Procedure
- Instruction and demonstration (total 5 min)
- Participant practicing (total 10 min)
- Tasks (total 45 min)
- Interview (30 min)

Tasks
- Reading and navigating a document (single-user, single-device interactions)
- Archiving information in a document (single-user, multi-device interactions)
- Cooperative discussion and markup (multi-user, multi-device interactions)

Participants
- 16 people (8 pairs, all right-handed, 4 female, 25-48 years old, M = 28.5)