Ubiquitous and Mobile Computing
CS 403x: Duet: Exploring Joint Interactions on a SmartPhone and SmartWatch

Qiaoyu Liao, Yang Xu and Ziyao Xu

Computer Science Dept.
Worcester Polytechnic Institute (WPI)
Background

- Interactive computing technology is becoming increasingly ubiquitous.
  - palms and pockets, wrist-worn, head-mounted, smart cloth...
- Interaction techniques making use of Interactive computing technology is underexplored
Pervious work

- Handle Devices
  - Touch, tilt, freehand gesture, etc.
  - location

- Wrist-worn devices
  - Touch – fat hand
  - Better motion detection
  - Microphone for fingertip gestures

- Device-to-device interaction
  - Synchrony
  - Proxemic interactions
  - Distributed gesture
About Duet

- Symphony of interaction between multiple smart mobile devices
  - Two smart mobile devices as a joint interactive platform
  - Enables interaction between smartphone and smartwatch, motion and touch input
How does it work?
3-axis accelerator

Bluetooth connection

API with 7 pre-defined gestures

Accelerator with maximum rate of 10Hz
Gestures

Double Bump
Multi-device Gesture
Gestures

Flip and Tap
Gestures

Finger Gesture Recognition
Gestures

Hold and Flip
Gestures

Handedness Recognition
## Accuracy Evaluation

<table>
<thead>
<tr>
<th></th>
<th>Double bump</th>
<th>Flip and tap</th>
<th>Hold and flip</th>
<th>Handedness recognition</th>
<th>Finger posture recognition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>10-fold cross val.</strong></td>
<td>93.87%</td>
<td>97.90%</td>
<td>97.56%</td>
<td>99.06%</td>
<td>99.34%</td>
</tr>
<tr>
<td><strong>Per user classifiers</strong></td>
<td>92.10%</td>
<td>95.92%</td>
<td>90.11%</td>
<td>97.33%</td>
<td>97.95%</td>
</tr>
<tr>
<td></td>
<td>(5.34%)</td>
<td>(2.89%)</td>
<td>(11.24%)</td>
<td>(1.92%)</td>
<td>(0.80%)</td>
</tr>
<tr>
<td><strong>General classifiers</strong></td>
<td>88.33%</td>
<td>94.38%</td>
<td>85.29%</td>
<td>98.23%</td>
<td>93.33%</td>
</tr>
<tr>
<td></td>
<td>(9.89%)</td>
<td>(9.91%)</td>
<td>(10.90%)</td>
<td>(2.64%)</td>
<td>(9.07%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Pinch to open</th>
<th>Pinch to close</th>
<th>Phone to watch</th>
<th>Watch to phone</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pinch to open</strong></td>
<td>97.69%</td>
<td>98.61%</td>
<td>95.83%</td>
<td>96.76%</td>
</tr>
<tr>
<td></td>
<td>(5.67%)</td>
<td>(2.32%)</td>
<td>(3.83%)</td>
<td>(3.25%)</td>
</tr>
</tbody>
</table>
Duet - Home Screen

- Hold and flip to unlock

- App arrangement and selection shortcut
Duet - Email

- List Management
- Notification Management

Figure 6. In Email, Multi-device gestures are used to manage new email notifications on both devices.
Duet - Map

- One Hand Zoom
- Toggle View Mode
Duet - Map

- Multi-Device Target Selection
Duet - Reader

- Menu Access
- Implicit Tool Selection

- Multi-device Clipboard and Tool Palette
Duet - Call

- Information Retrieval

Figure 12. Enabling basic app access on the watch while using making a phone call.
Duet – User Feedback

- 10 Participants
- Demonstrate + Tryout
- Overall positive feedback
  - Lightweight interaction, watch as extended display and auxiliary sensor, devices complement each other
  - No significant improvement, some features cause occlusion
  - Different mapping and fall back
Recognition Techniques

Machine Learning

Decision Tree

Table of features
Discussion & Future work

A problem has been detected and Windows has been shut down to prevent damage to your computer.
The problem seems to be related to the following:

- SESSIONS_INIT

If this is the first time you have seen this message, try turning your computer off and on again.

Multi-device?
References

- *Duet: Exploring Joint Interactions on a Smart Phone and a Smart Watch* Xiang 'Anthony' Chen, Tovi Grossman, Daniel J. Wigdor, George Fitzmaurice in Proc CHI 2014