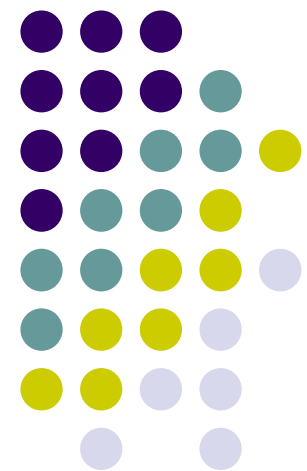


# Ubiquitous and Mobile Computing

## CS 403x: Duet: Exploring Joint Interactions on a SmartPhone and SmartWatch

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# 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?**



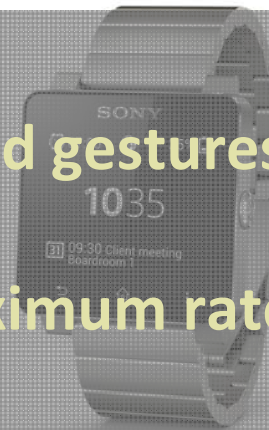
**3-axis accelerometer**

**Bluetooth connection**



**API with 7 pre-defined gestures**

**Accelerator with maximum rate of 10Hz**





**Dorsal Side**

**Ventral Side**

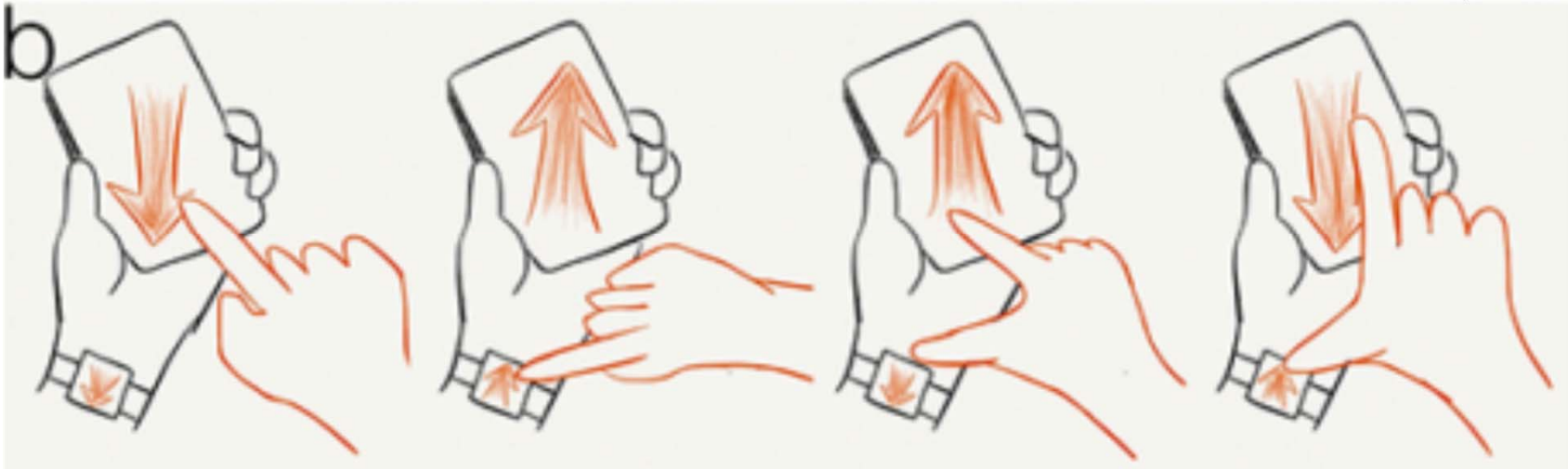
# Gestures



Double Bump

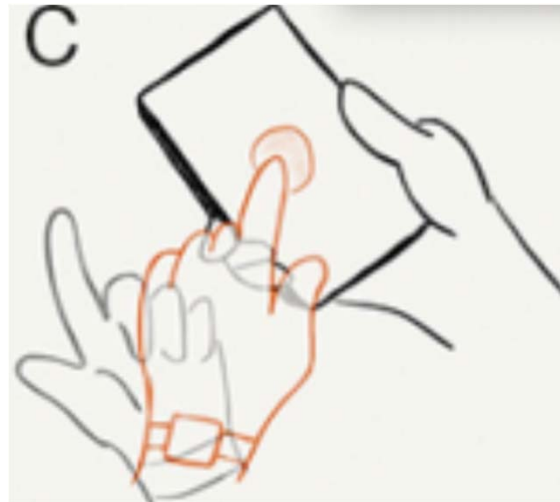


# Gestures



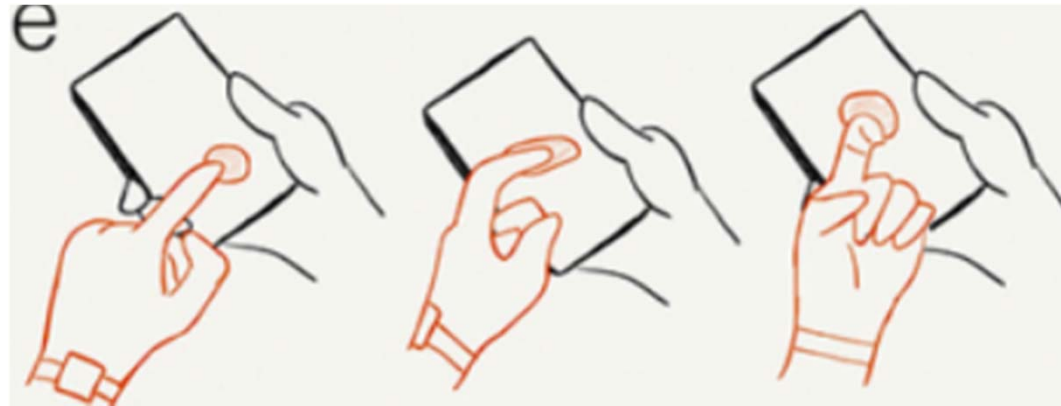
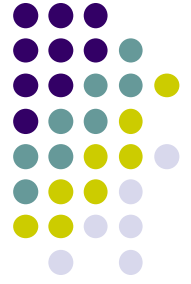
## Multi-device Gesture

# Gestures



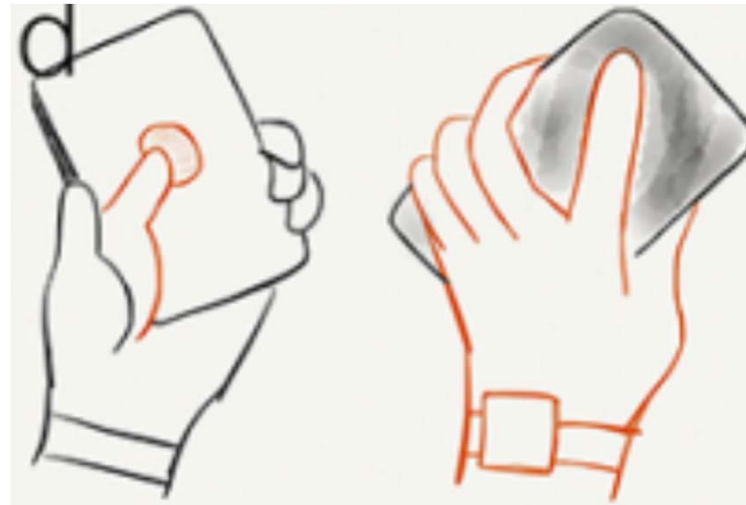
Flip and Tap

# Gestures



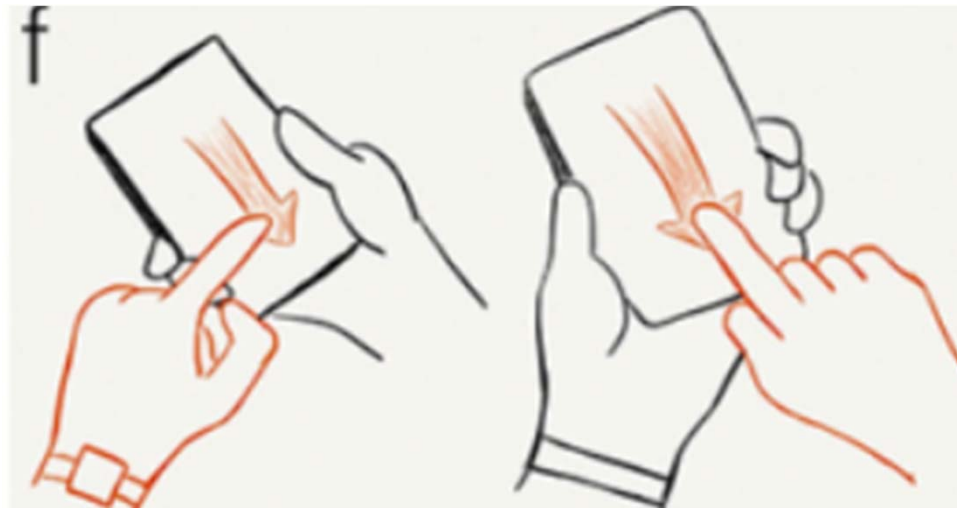
## Finger Gesture Recognition

# Gestures



Hold and Flip

# Gestures



## Handedness Recognition



# Accuracy Evaluation

	<b>Double bump</b>	<b>Flip and tap</b>	<b>Hold and flip</b>	<b>Handedness recognition</b>	<b>Finger posture recognition</b>
<b>10-fold cross val.</b>	93.87%	97.90%	97.56%	99.06%	99.34%
<b>Per user classifiers</b>	92.10% (5.34%)	95.92% (2.89%)	90.11% (11.24%)	97.33% (1.92%)	97.95% (0.80%)
<b>General classifiers</b>	88.33% (9.89%)	94.38% (9.91%)	85.29% (10.90%)	98.23% (2.64%)	93.33% (9.07%)
<b>Pinch to open</b>	<b>Pinch to close</b>		<b>Phone to watch</b>	<b>Watch to phone</b>	
97.69% (5.67%)	98.61% (2.32%)		95.83% (3.83%)	96.76% (3.25%)	

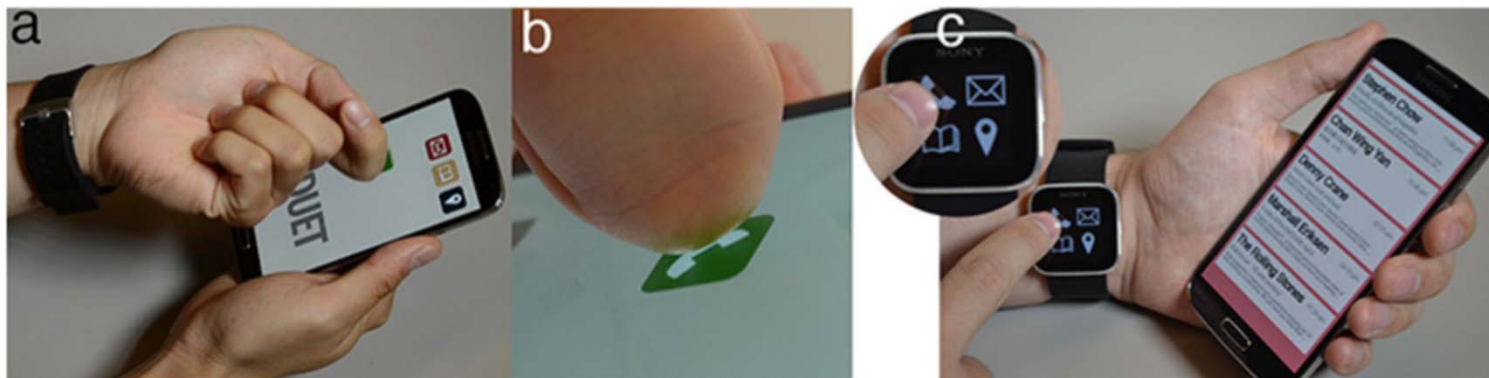


# Duet - Home Screen

- Hold and flip to unlock



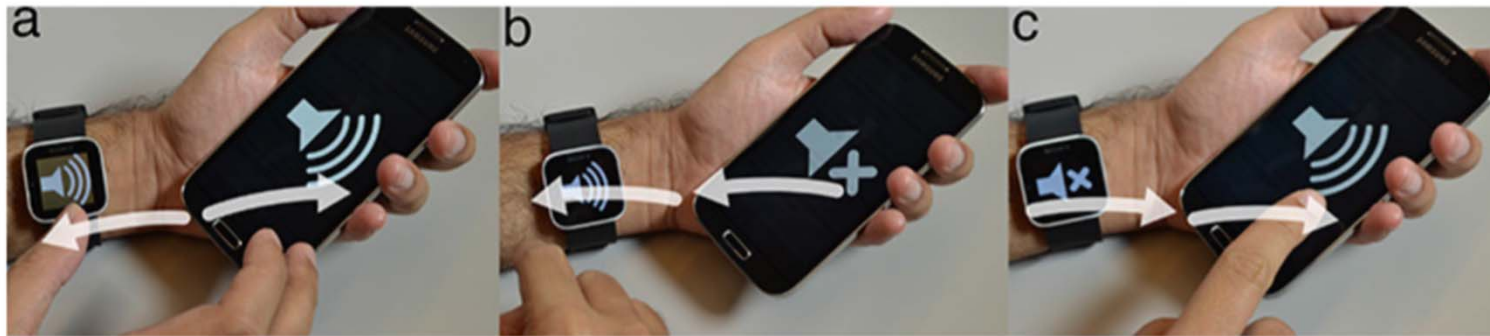
- App arrangement and selection shortcut





# Duet - Email

- List Management
- Notification Management



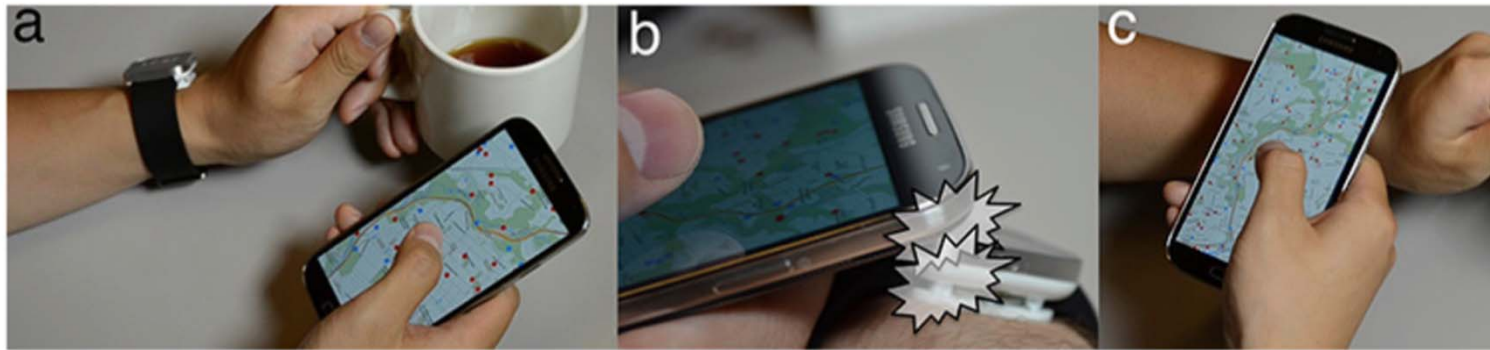
**Figure 6. In Email, Multi-device gestures are used to manage new email notifications on both devices.**





# 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 caused by the following file: SESSION5\_INITI... If this is the...

A central green silhouette of a person is surrounded by four icons representing different devices: a desktop monitor, a smartphone, a laptop, and another smartphone. Green arrows point from each device icon towards the person, indicating a multi-device environment.

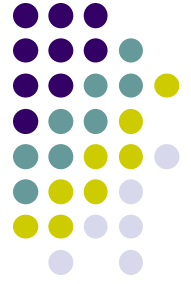
C

A close-up photograph of a person's wrist wearing a silver smartwatch with a white band.

Technical info  
\*\*\* STOP: 0x53...  
\*\*\* asyncmac...

A close-up photograph of a hand holding a smartphone, with a red circle highlighting a specific area on the screen.

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