Exploring Non-touchscreen Gestures for Smartwatches

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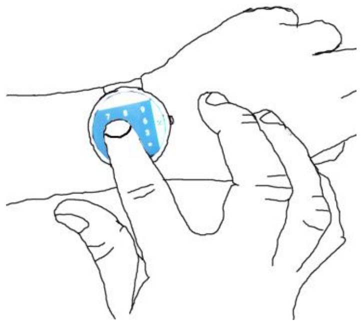
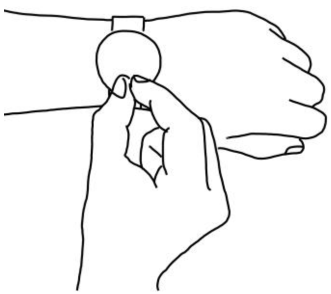
Motivation

- Small touchscreens limit interaction
  - Fat finger and occlusion problem



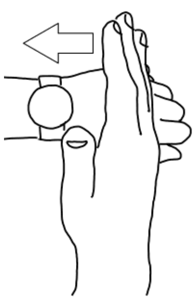
Fat finger problem
with on-screen keyboard:
error in small target
acquisition on screen



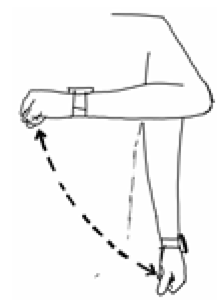
Occlusion problem:
large areas of screen
occluded due to relative
size of finger and screen

Motivation

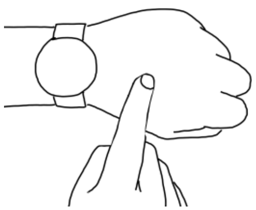
- How can fat finger and occlusion problem be reduced?
  - Extend input space beyond touchscreen using non-touchscreen based gestures.



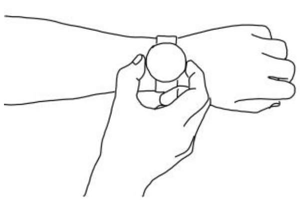
Above device gestures



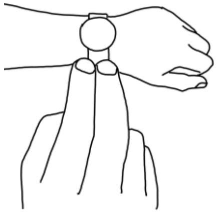
Arm/forearm gestures



Skin input



Watch rim gestures



Watch band gestures

Finger movement gestures

Research on Non-touchscreen Gestures

- Some proposed input space extensions
  - Mid-air gestures above device [Kim et al. (2007)]
  - Motion gestures on watch wearing hand [Kerber et al., 2007]
  - Skin-based input [Harrison et. al. (2010)]
  - Watch band-based input [Ahn et al. (2010)]
  - Watch rim-based input [Oakley & Lee (2014)]
  - Muscle interaction-based input [Morganti et al. (2012)]
  - Facial glance and gaze based input [Akkil et al. (2012)]

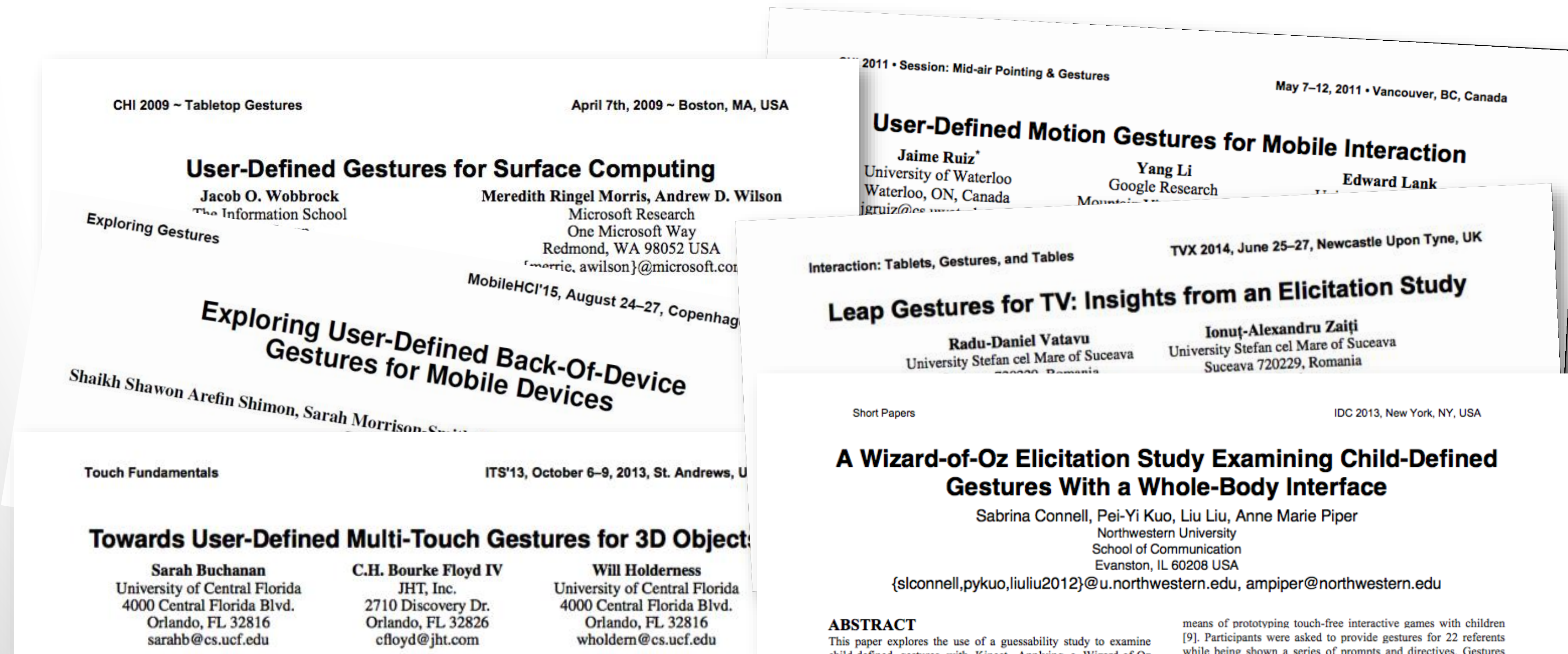
Limitations in Existing Literature

- Focused on developing hardware and algorithms for gesture recognition using designer gestures.

- End-users' gesture preference and mapping of gestures to device action not explored.

Elicitation Studies

- Show participants a system action (“referent”)
- Ask participants to propose a gesture
- Compute agreement among proposed gestures

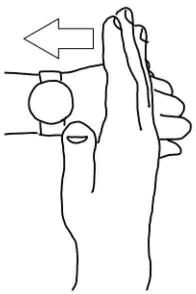


Why Elicitation Study?

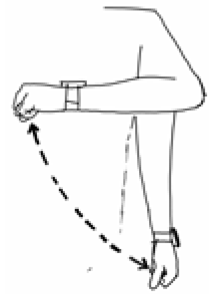
- Designers' gestures vs end-users' gestures
  - Easier to perform [Morris et al. (2010)]
  - Easier to learn/recall [Wobbrock et al. (2005)]
  - Rated more suitable/better [Wobbrock (2006); Morris et al. (2010)]

Research Goals

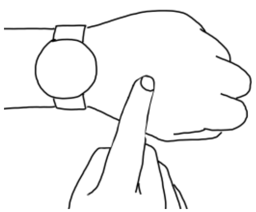
- Understand of end-user mapping of gestures to device action
  - **Is there agreement?**



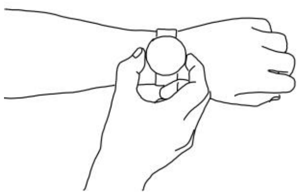
Above device gestures



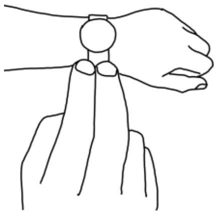
Arm/forearm gestures



Skin input



Watch rim gestures



Watch band gestures

Finger movement gestures

Research Goals

- Understand of end-user mapping of gestures to device action
  - **Is there agreement?**
- Understand the properties end-users manipulate to create gestures
  - **What parameters do users manipulate?**
- Formalize how to characterize and describe gestures
  - **Is there a “design-space” or taxonomy that designers can leverage?**

Study Design

- Elicitation study with twenty-five participants
  - 15 male, 10 female
  - From local university (12) and community (13)
  - Between the ages of 22-42 (mean=25, SD = 6)
  - All used a smartphone as their primary mobile device, but none had experience with a smartwatch
- Apparatus
  - Moto 360 Smartwatch

Tasks

Navigation-based

Sub-Category	Task Name
System/ Smartwatch	Previous (Vertical)
	Next (Vertical)
	Previous (Horizontal)
	Next (Horizontal)
	Go to Home Screen
Application	Pan Left
	Pan Right
	Pan Up
	Pan Down
	Zoom In
	Zoom Out

Action-based

Sub-Category	Task Name
System/ Smartwatch	Set Hr/Min/AM-PM
	Switch Between Hr/Min/AM/PM
	Confirm Time
	Start Stopwatch
	Stop Stopwatch
	View Time
	Act On Selection
Application	Answer Call
	Hang up Call
	Ignore Call
	Mute Microphone (Call)
	Unmute Microphone (Call)
	Turn on Speaker (Call)
	Turn off Speaker (Call)
	Open Context Menu
	Switch Application
	Lock Screen
	Copy
	Cut
	Paste

Procedure

- Participant presented with a task
- Participant asked to come up with a gesture while thinking aloud
- Rated the gesture proposed:
  - The gesture I picked is a good match for it’s intended use
  - The gesture I picked is easy to perform
  - The gesture I picked is easy to remember
  - I am comfortable performing the gesture …

Research Goals

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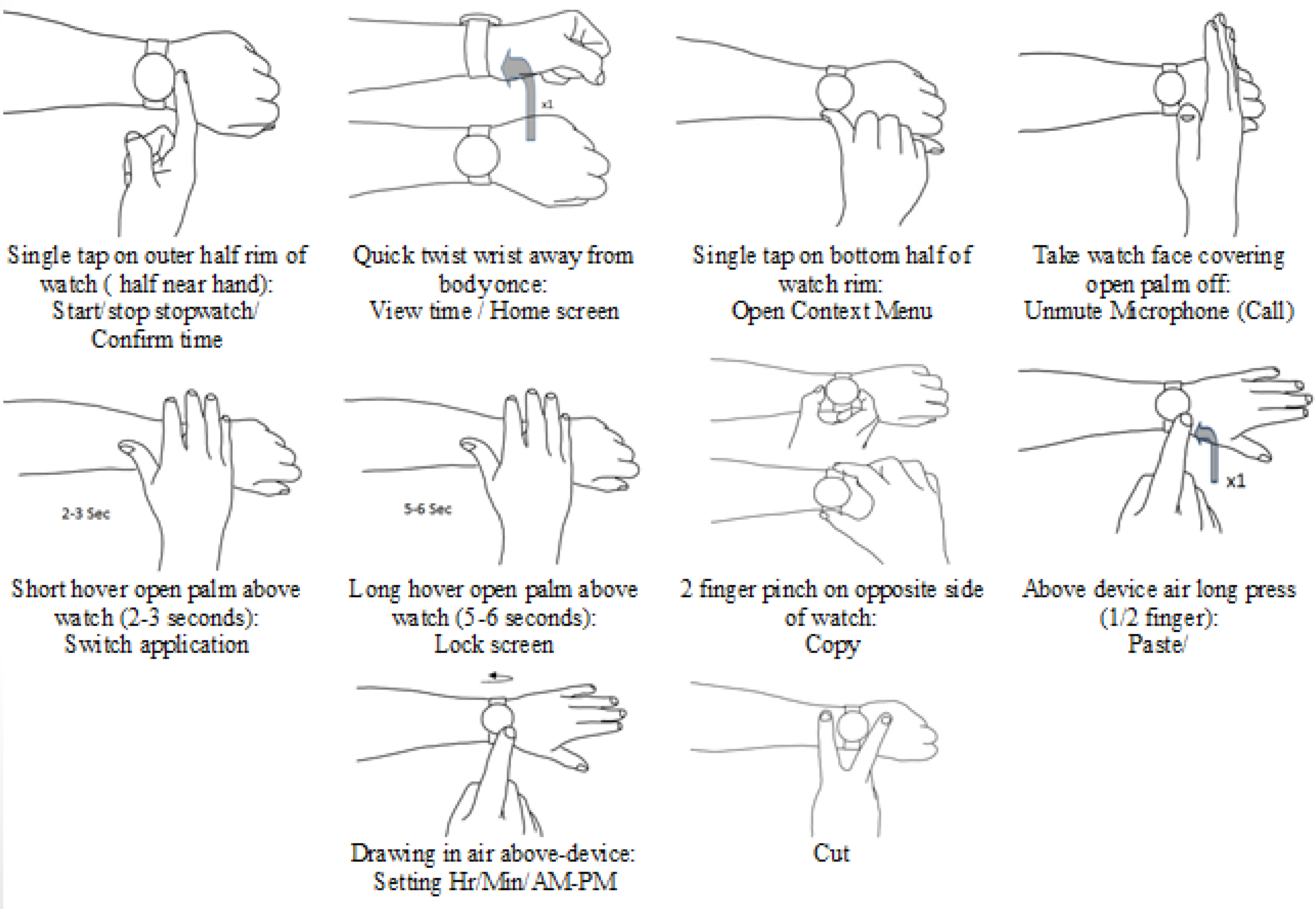
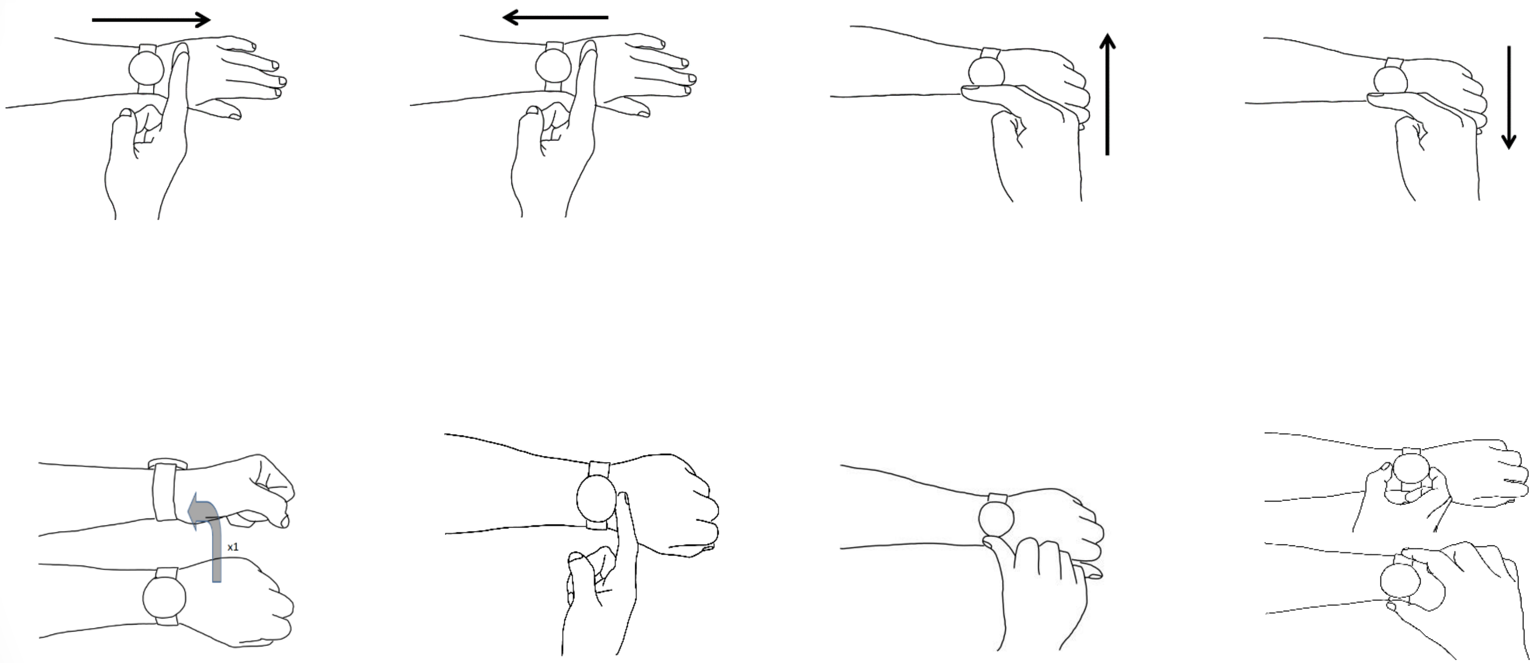
Task Agreement

- Identical gestures for same referent grouped together
- Group with largest consensus chosen to be representative gesture for task
- Ties broken using subjective ratings
- Used agreement score standard [Vatuvu & Wobbrock et al. (2014)]

Common Gestures



Common Gestures



Some Gesture – Action Mapping

Pan left / Previous / Receive call / Switch clock hand from hrs to minutes

Some Gesture – Action Mapping

Pan right / Next / Hang-up call / Ignore call /
Switch clock hand from minutes to hrs

Some Gesture – Action Mapping

View time / Go to home screen

Some Gesture – Action Mapping

Start stopwatch / Stop stopwatch / Confirm time

Some Gesture – Action Mapping

Copy

Research Goals

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  - Is there agreement?
- **Understand the properties end-users manipulate to create gestures**
  - **What parameters do users manipulate?**
- **Formalize how to characterize and describe gestures**
  - **Is there "design-space" or taxonomy that designers can leverage?**

Gesture Taxonomy

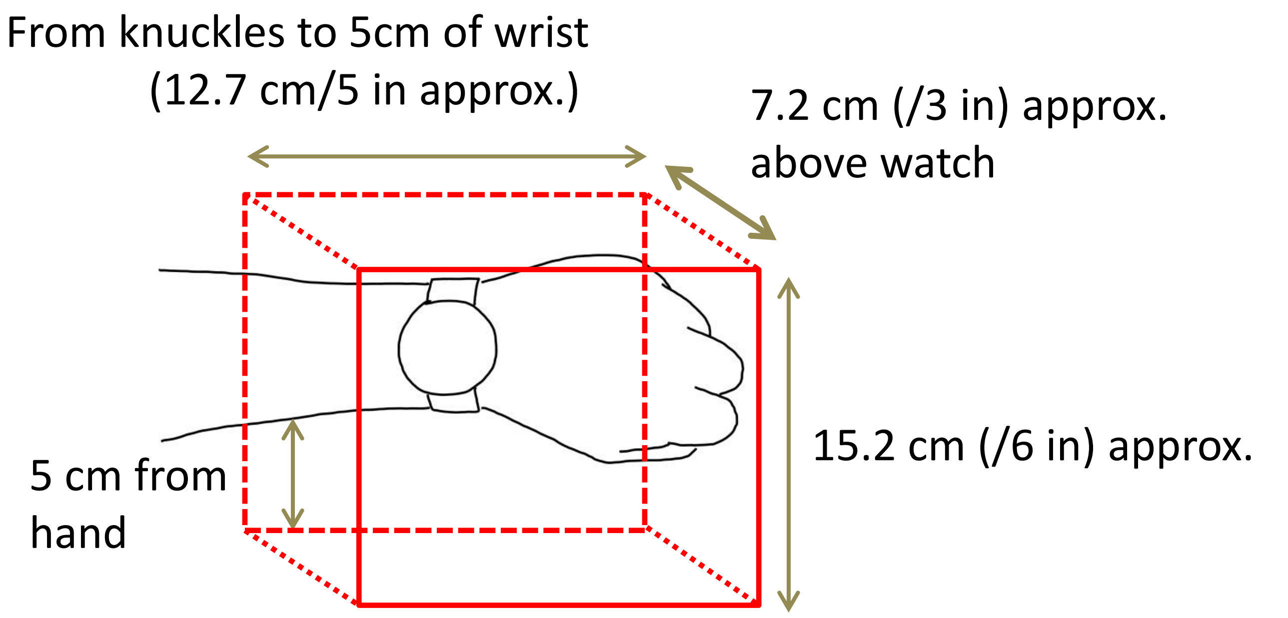
- Two classes of taxonomy dimensions
  - Gesture mapping
    - Nature – physical mapping to objects, symbols or actions.
    - Context – does the gesture require a specific context?
    - Temporal – does the action occur during or after a gesture is performed?

Gesture Taxonomy

- Two classes of taxonomy dimensions
  - Gesture mapping
    - Nature – physical mapping to objects, symbols or actions.
    - Context – does the gesture require a specific context?
    - Temporal – does the action occur during or after a gesture is performed?
  - Physical characteristics
    - Complexity – simple or compound gesture
    - Duration – the temporal requirements of performing a gesture
    - Location – where, in relation to the user's body, a gesture is performed
    - Size – the physical space required to perform the gesture

Gesture Taxonomy

- Gestures tend to be **simple**, **short** movements constrained within a defined region

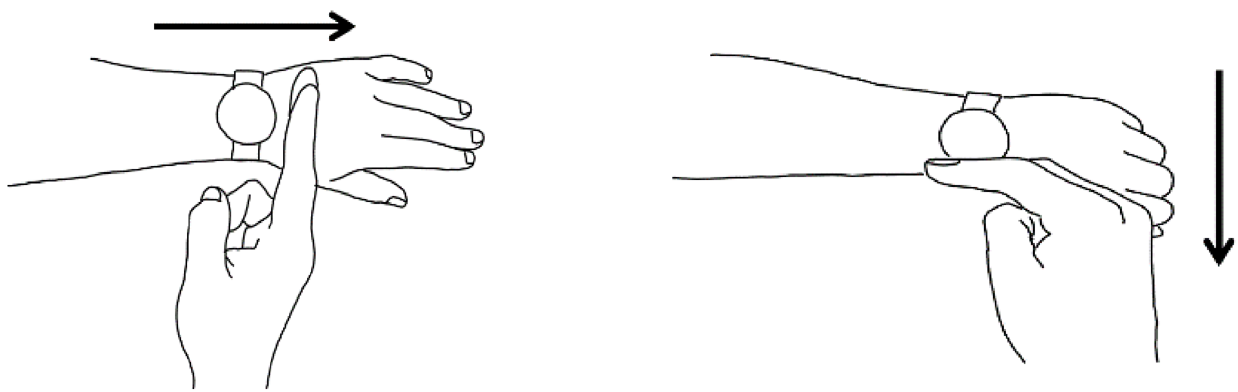


Most elicited gestures can be constrained inside this space

Additional Observations

Task Orientation

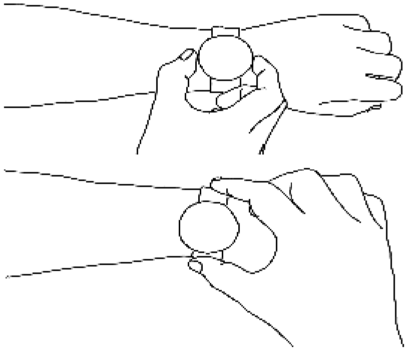
- Task orientation influences gesture direction



Gesture direction change when performing
Previous task in horizontal and vertical direction

Legacy Bias and Prior Wristwatch Use

- Legacy bias (Morris et. al. 2014)
  - Map pan / zoom operation
    - Similar gestures to touchscreen interaction
  - Answering / rejecting / ignoring calls
    - Swiping left / right
- Influence of analog watch use
  - Adjusting time
    - Two finger pinch and wind
  - Confirming time
    - Two finger pinch on watch rim



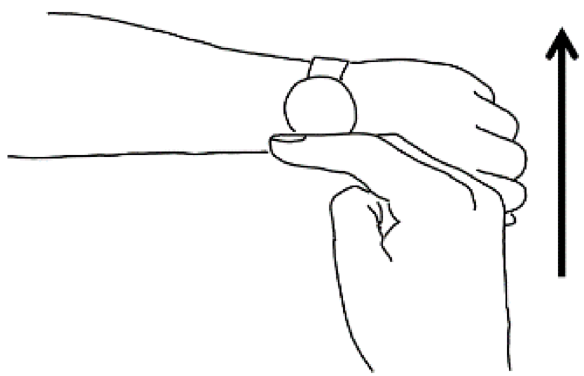
Opposite Task Pairs

- Natural and consistent mapping of gestures
  - Unary transition – same gesture
  - Binary transition – similar gesture in opposite direction

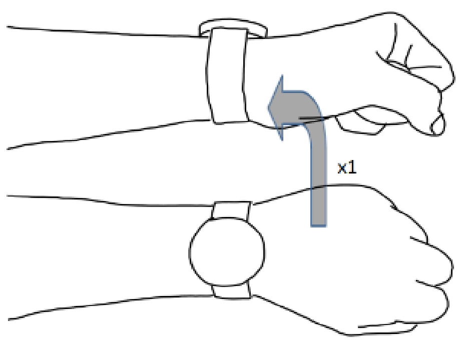
Unary Transition Task pairs	Binary Transition Task pairs
Mute/unmute mic	Pan left-right
Turn on/off speaker	Pan up-down
Start/stop stopwatch	Zoom in-out
Answer/hangup call	Next-previous (horizontal)
	Next-previous (vertical)

Moving Content vs. Viewport

- Moving content preferred over moving viewport



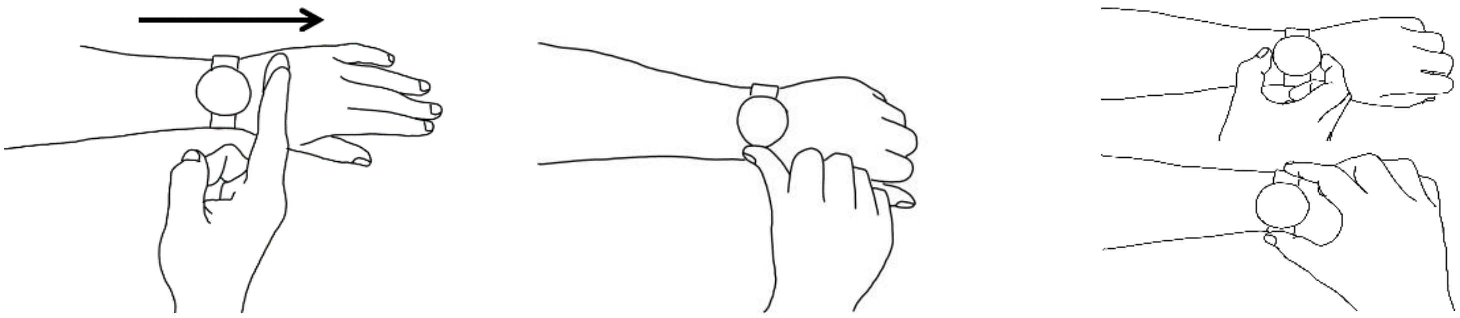
Moving content to go
to next item in list



Moving viewport to go
to next item in list

Alternate Hand Preferred

- When both hands free?
  - Alternate (non watch wearing) hand preferred to create gesture



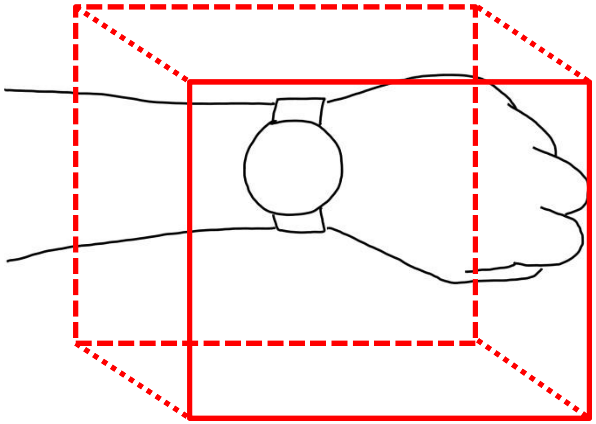
Feedback & Accidental Input

- Additional non-visual feedback expected
  - For specific tasks – Act on selection, Hang up call etc.
  - Haptic feedback preferred over sound

- Concern for accidental input

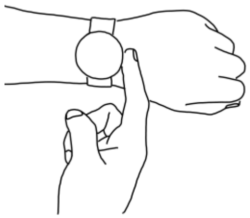
Social Acceptability

- Gestures rated for acceptability in different social environment and context
- High social acceptability for all settings for rim/band touch
- Large gestures socially acceptable only in non-public settings.

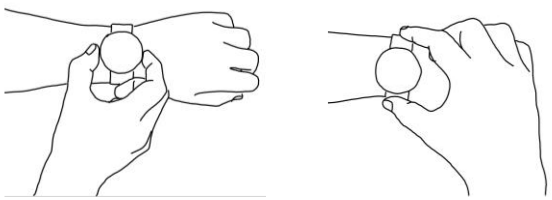


Physical Touch Preference

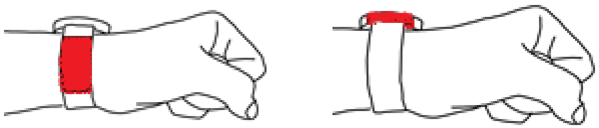
- Location
  - Rim > Band > Skin
- Action
  - Tapping
    - Outer half watch rim



  - Pinching
    - Opposite halves – X or Y axis
    - X (along arm) preferred over Y



  - Vertical & horizontal swipe
    - Shaded regions preferred on band and rim



Conclusion and Future Work

- ✓ Explored end-user preference for non-touchscreen gestures and gesture mapping with different smartwatch actions

- ✓ Obtained insight into the mental model of designing non-touchscreen smartwatch gestures.

- Study did not consider gesture tracking techniques, and was limited by cultural and social demographics.

- Plan to continue this study across different culture to determine a user-defined non-touchscreen gesture set that is appropriate for other cultures as well.

Thank you!

Questions?

- skshimon@colostate.edu

References

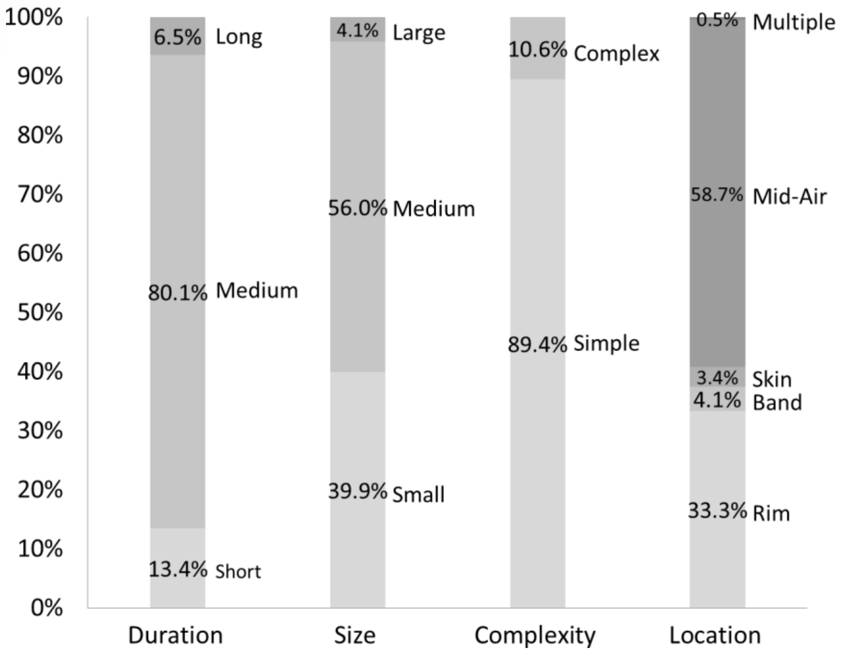
- [1] The Gesture Watch: A Wireless Contact-free Gesture Based Wrist Interface. ISWC 2007
- [2]WristRotate: A Personalized Motion Gesture Delimiter for Wrist-worn devices. MUM 2015
- [3] Skinput: Appropriating the body As an Input Surface. CHI 2010
- [4] BandSense: Pressure-sensitive Multi-touch Interaction on a Wristband. CHI EA 2015
- [5] Interaction on the Edge: Offset Sensing for Small Devices. CHI 2014
- [6] A smart watch with embedded sensors to recognize objects, graphs and forearm gestures. Procedia Engineering 41 (2012)
- [7] Glance Awareness and Gaze Interaction in Smartwatches, CHI EA 2015
- [8] Understanding Users' Preferences for Surface Gestures, GI 2010
- [9] Maximizing the guessability of symbolic input. CHI EA 2005

Possible questions?

Conceptual complexity

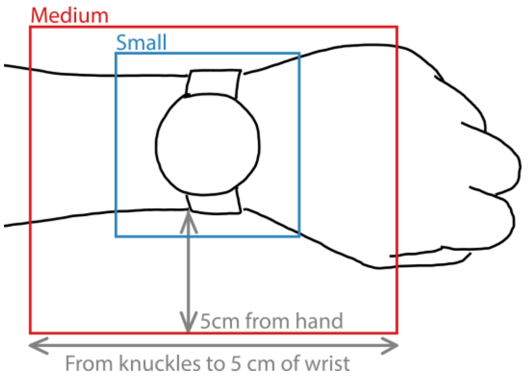
- How difficult was it for a participant to understand and visualize a task.
- Used another group who were given the tasks and asked to rate their difficulty

Taxonomy of collected gestures



Physical Characteristics

- Duration:
  - Short(≤.5s)
  - Medium(.5 <x ≤1.5s)
  - Long (>1.5s)
- Size
  - Small (<439 cm^3)
  - Medium(439 ≤ x ≤ 1467 cm^3)
  - Large (> 1467 cm^3)



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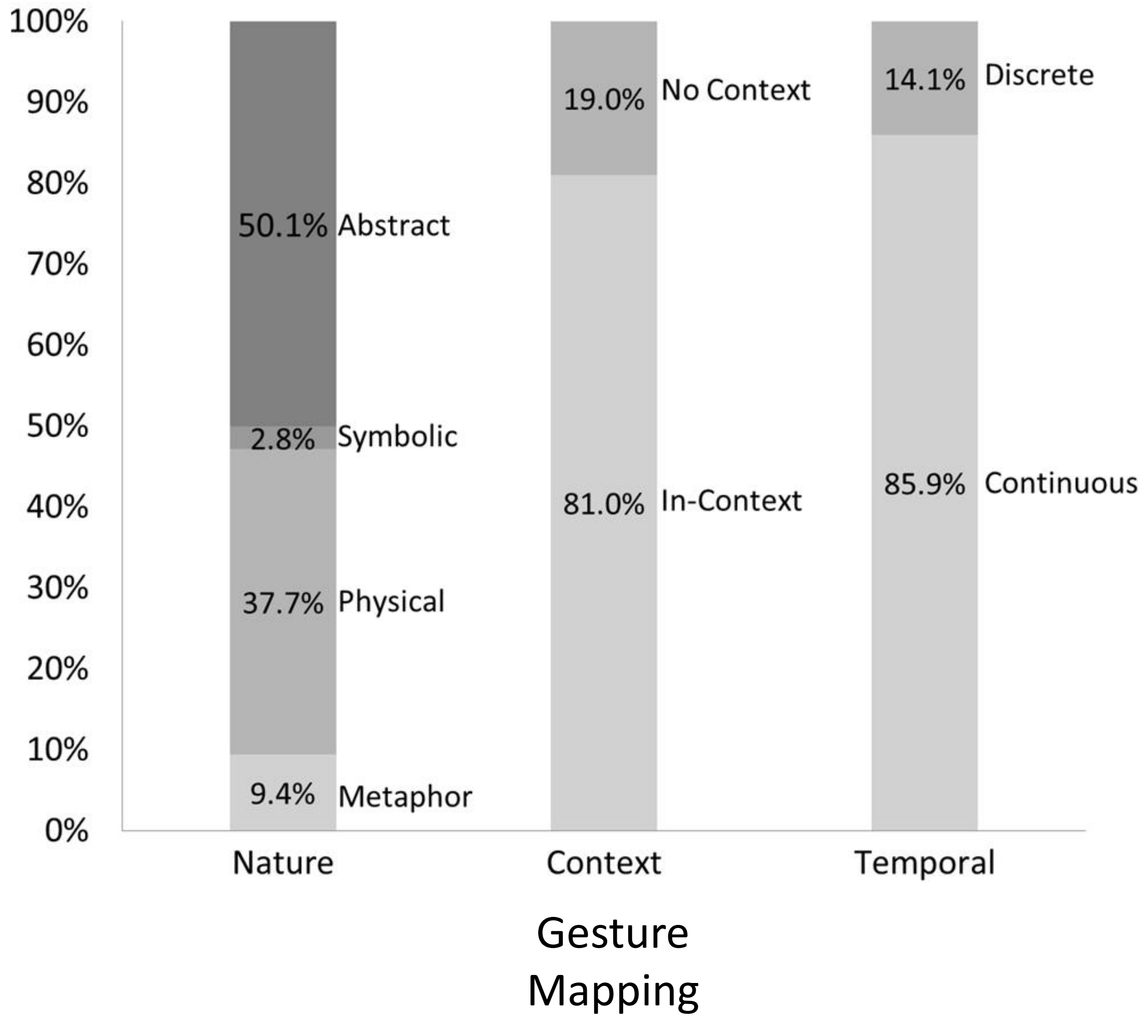


Text entry

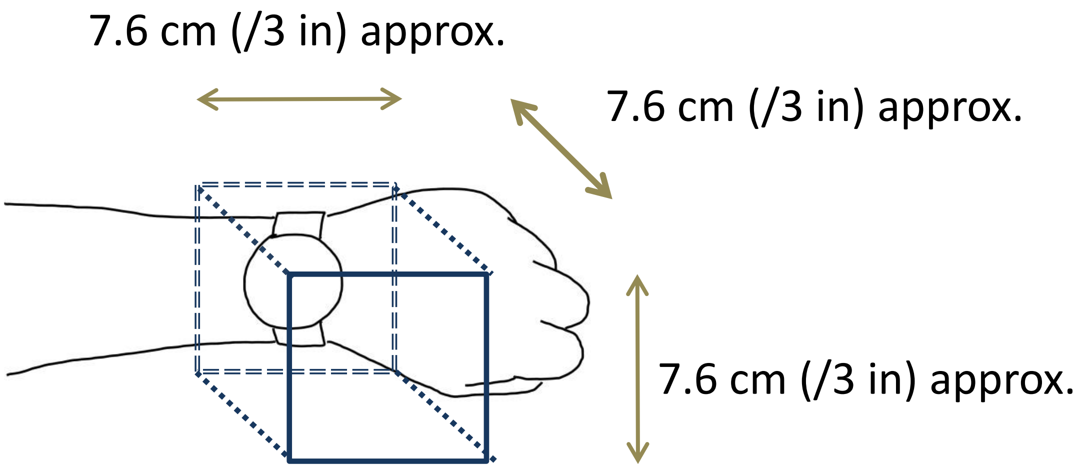
- While we do not recommend doing text entry on smartwatch, some watches do support features like cut copy and paste , and we wanted to make sure our tasks were representative of current smartwatches.

Data Analysis and coding

- Two researchers coded gestures independently.
- Transcipts were analyzed using grounded theory and affinity diagram

Small Gestures

- Approximately 439 cm^3



Most small gestures can fit inside this cube with each side = 7.6 cm / 3 inch. Like tapping / scrolling on rim/band/skin, single/two finger tap above watch, two/three finger pinch using watch wearing hand.

Why Cultural Context is Important?

2 finger cut gesture had high agreement scores in our study.

This gesture is offensive in some European culture and might not be used in this context.