

# Exploring Non-touchscreen Gestures for Smartwatches

Shaikh Shawon Arefin Shimon

Courtney Lutton

Zichun Xu

Sarah Morrison-Smith

Christina Boucher

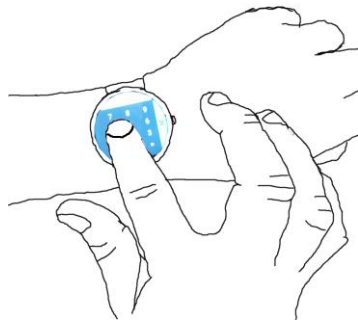
Jaime Ruiz

Colorado  
State  
University

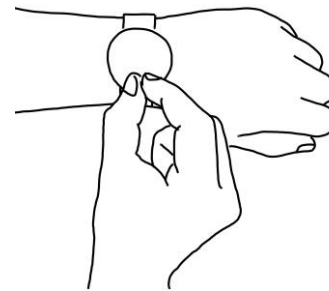


# Motivation

- Small touchscreens limit interaction
  - Fat finger and occlusion problem



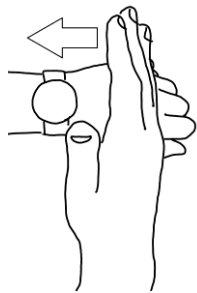
Fat finger problem  
with on-screen keyboard:  
error in small target  
acquisition on screen



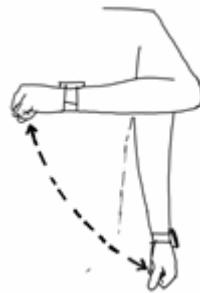
Occlusion problem:  
large areas of screen  
occluded due to relative  
size of finger and screen

# Motivation

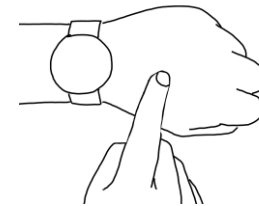
- How can fat finger and occlusion problem be reduced?
  - Extend input space beyond touchscreen using non-touchscreen based gestures.



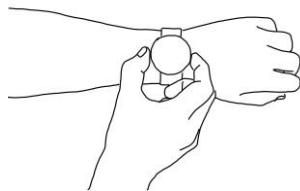
Above device gestures



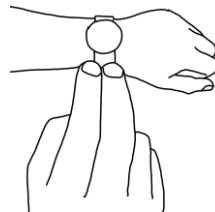
Arm/forearm gestures



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

CHI 2009 ~ Tabletop Gestures

April 7th, 2009 ~ Boston, MA, USA

## User-Defined Gestures for Surface Computing

Jacob O. Wobbrock  
The Information School

Meredith Ringel Morris, Andrew D. Wilson

Microsoft Research  
One Microsoft Way  
Redmond, WA 98052 USA  
{merrie, awilson}@microsoft.com

Exploring Gestures

MobileHCI'15, August 24–27, Copenhagen

## Exploring User-Defined Back-Of-Device Gestures for Mobile Devices

Shaikh Shawon Arefin Shimon, Sarah Morrison, et al.

Touch Fundamentals

ITS'13, October 6–9, 2013, St. Andrews, U

## Towards User-Defined Multi-Touch Gestures for 3D Object

Sarah Buchanan  
University of Central Florida  
4000 Central Florida Blvd.  
Orlando, FL 32816  
sarahb@cs.ucf.edu

C.H. Bourke Floyd IV  
JHT, Inc.  
2710 Discovery Dr.  
Orlando, FL 32826  
cfloyd@jht.com

Will Holderness  
University of Central Florida  
4000 Central Florida Blvd.  
Orlando, FL 32816  
wholdern@cs.ucf.edu

2011 • Session: Mid-air Pointing & Gestures

May 7–12, 2011 • Vancouver, BC, Canada

## User-Defined Motion Gestures for Mobile Interaction

Jaime Ruiz\*  
University of Waterloo  
Waterloo, ON, Canada  
jgruiz@cs.uwaterloo.ca

Yang Li  
Google Research  
Mountain View, CA

Edward Lank

Interaction: Tablets, Gestures, and Tables

TVX 2014, June 25–27, Newcastle Upon Tyne, UK

## Leap Gestures for TV: Insights from an Elicitation Study

Radu-Daniel Vatavu  
University Stefan cel Mare of Suceava  
Suceava, Romania

Ionuț-Alexandru Zaiți  
University Stefan cel Mare of Suceava  
Suceava 720229, Romania

Short Papers

IDC 2013, New York, NY, USA

## A Wizard-of-Oz Elicitation Study Examining Child-Defined Gestures With a Whole-Body Interface

Sabrina Connell, Pei-Yi Kuo, Liu Liu, Anne Marie Piper  
Northwestern University  
School of Communication  
Evanston, IL 60208 USA

{sconnell,pykuo,liuliu2012}@u.northwestern.edu, ampiper@northwestern.edu

### ABSTRACT

This paper explores the use of a guessability study to examine

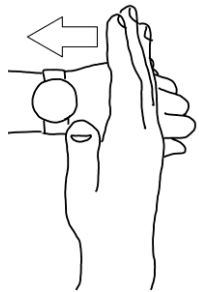
means of prototyping touch-free interactive games with children [9]. Participants were asked to provide gestures for 22 referents while being shown a series of prompts and directives. Gestures

# Why Elicitation Study?

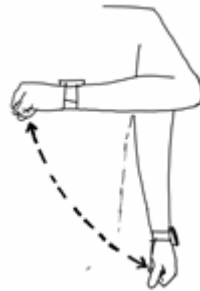
- Designers' gestures vs end-users' gestures
  - Easier to perform [Morris et al. (2010)]
  - Easier to learn/recall [Wobbrock et al. (2005)]
  - Rated more suitable/better [Wobbrock (2006); Morris et al. (2010)]

# Research Goals

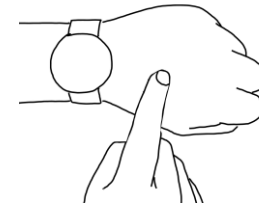
- Understand of end-user mapping of gestures to device action
  - **Is there agreement?**



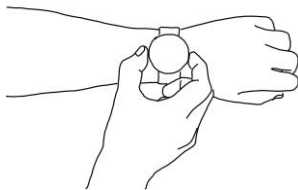
Above device gestures



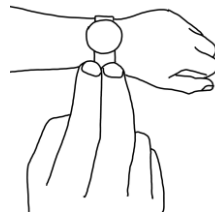
Arm/forearm gestures



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

- **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 “design-space” or taxonomy that designers can leverage?

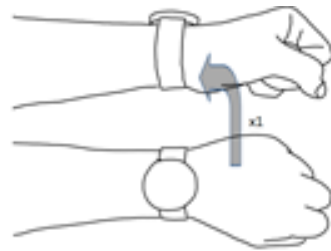
# Task Agreement

- 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



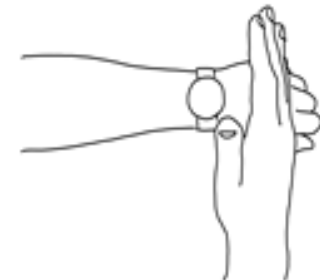
Single tap on outer half rim of watch ( half near hand):  
Start/stop stopwatch/  
Confirm time



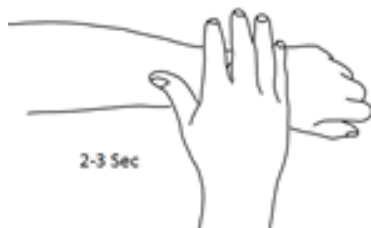
Quick twist wrist away from body once:  
View time / Home screen



Single tap on bottom half of watch rim:  
Open Context Menu



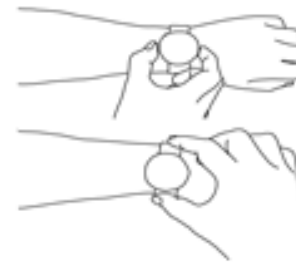
Take watch face covering open palm off:  
Unmute Microphone (Call)



Short hover open palm above watch (2-3 seconds):  
Switch application



Long hover open palm above watch (5-6 seconds):  
Lock screen



2 finger pinch on opposite side of watch:  
Copy



Above device air long press (1/2 finger):  
Paste/

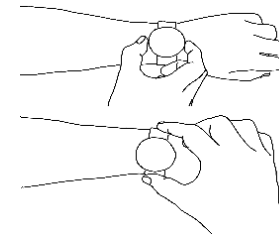
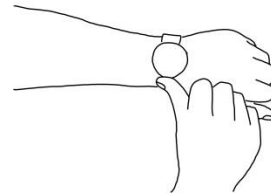
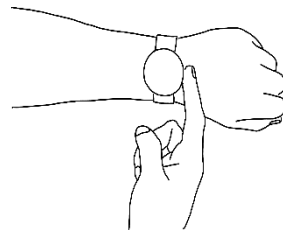
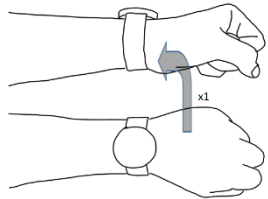
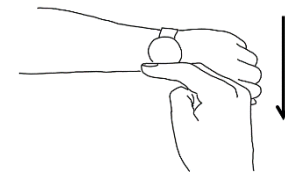
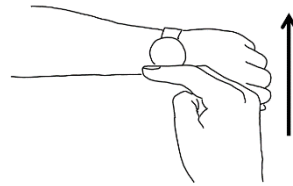
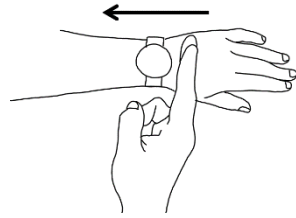
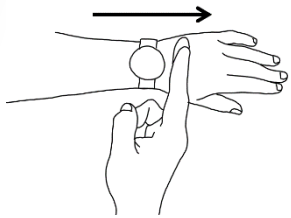


Drawing in air above-device:  
Setting Hr/Min/AM-PM



Cut

# 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

- 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 “design-space” or taxonomy that designers can leverage?**

# Gesture Taxonomy

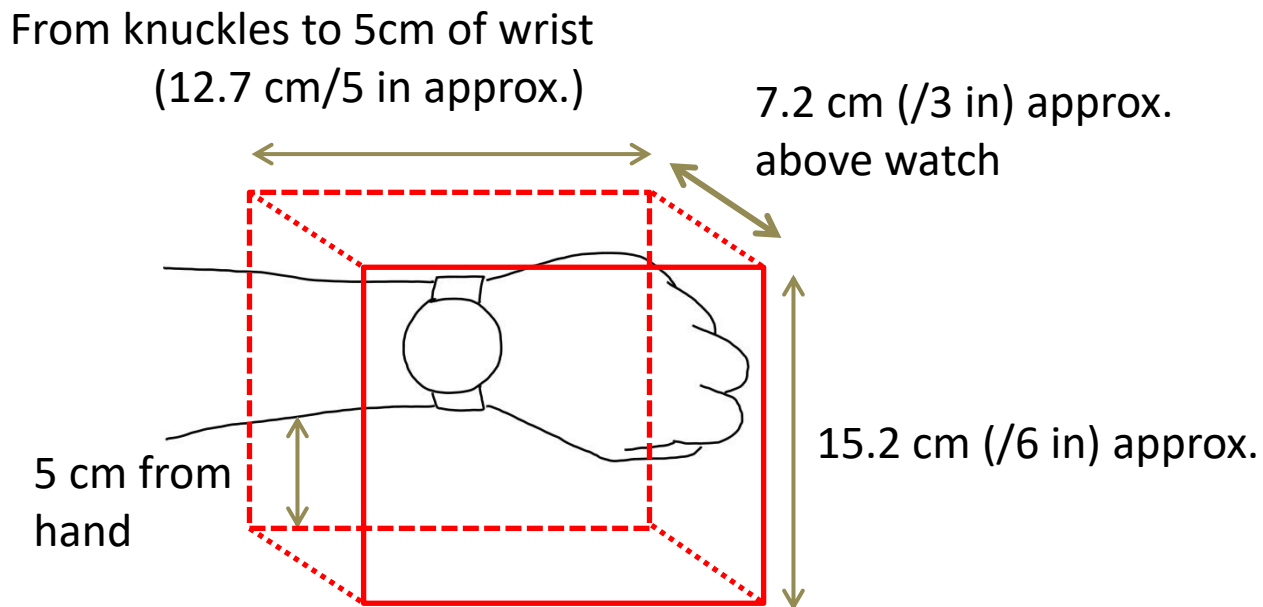
- Two classes of taxonomy dimensions
  - Gesture mapping
    - **Nature** – physical mapping to objects, symbols or actions.
    - **Context** – does the gesture require a specific context?
    - **Temporal** – does the action occur during or after a gesture is performed?

# 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

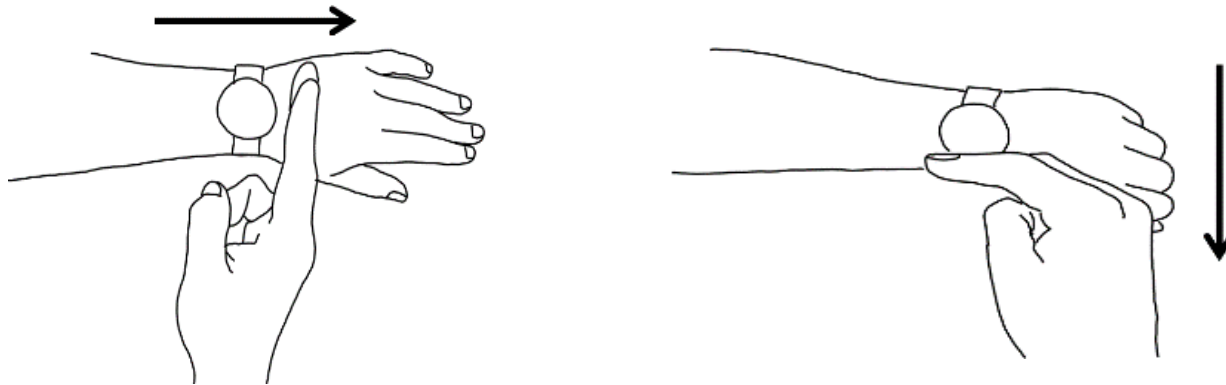


Most elicited gestures can be constrained inside this space

# Additional Observations

# Task Orientation

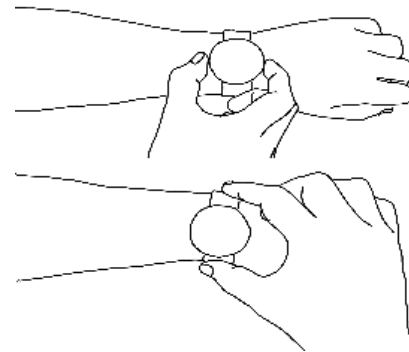
- Task orientation influences gesture direction



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



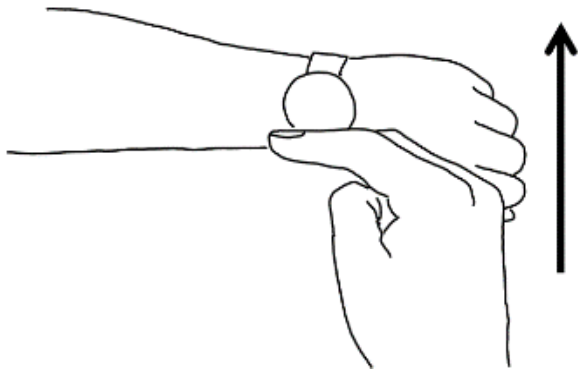
# Opposite Task Pairs

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

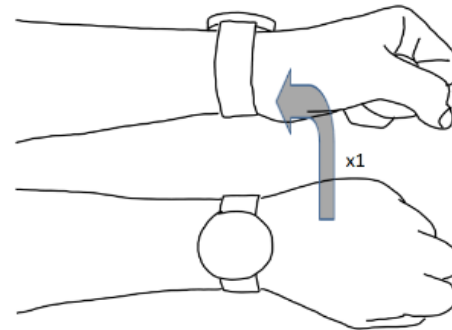
Unary Transition Task pairs	Binary Transition Task pairs
Mute/unmute mic	Pan left-right
Turn on/off speaker	Pan up-down
Start/stop stopwatch	Zoom in-out
Answer/hangup call	Next-previous (horizontal)
	Next-previous (vertical)

# Moving Content vs. Viewport

- Moving content preferred over moving viewport



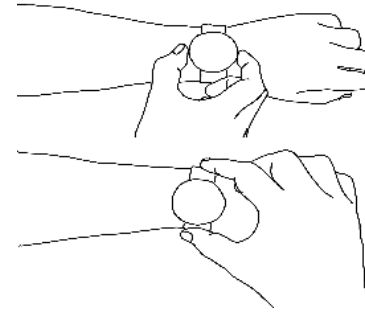
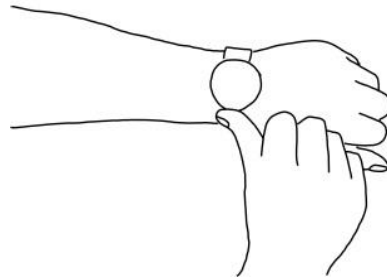
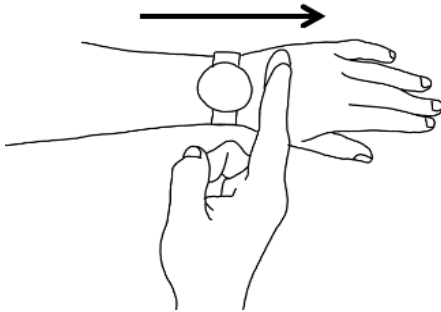
Moving content to go  
to next item in list



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

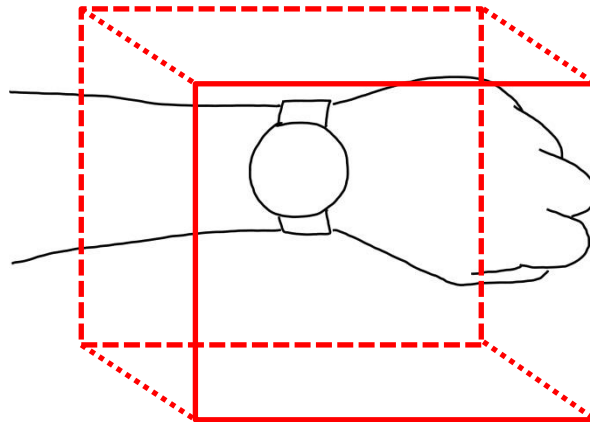


# Feedback & Accidental Input

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

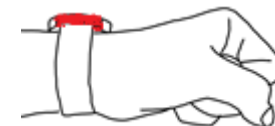
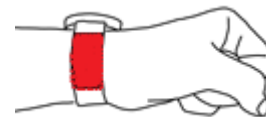
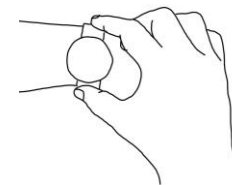
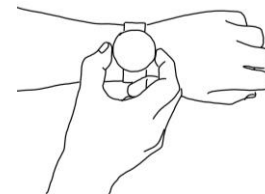
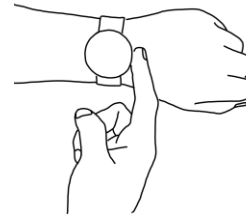
# Social Acceptability

- 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](mailto:skshimon@colostate.edu)

# References

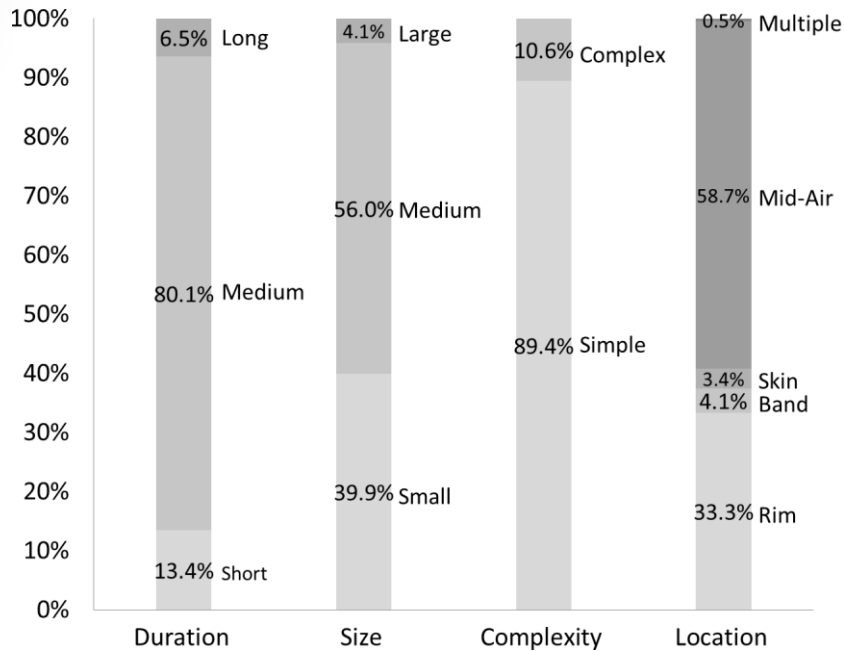
- [1] The Gesture Watch: A Wireless Contact-free Gesture Based Wrist Interface. ISWC 2007
- [2] WristRotate: A Personalized Motion Gesture Delimiter for Wrist-worn devices. MUM 2015
- [3] Skinput: Appropriating the body As an Input Surface. CHI 2010
- [4] BandSense: Pressure-sensitive Multi-touch Interaction 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

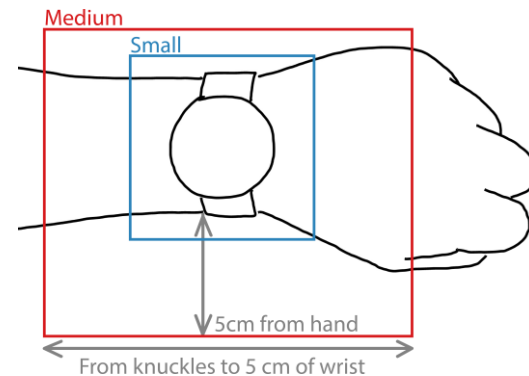
- How difficult was it for a participant to understand and visualize a task.
- Used another group who were given the tasks and asked to rate their difficulty

# Taxonomy of collected gestures

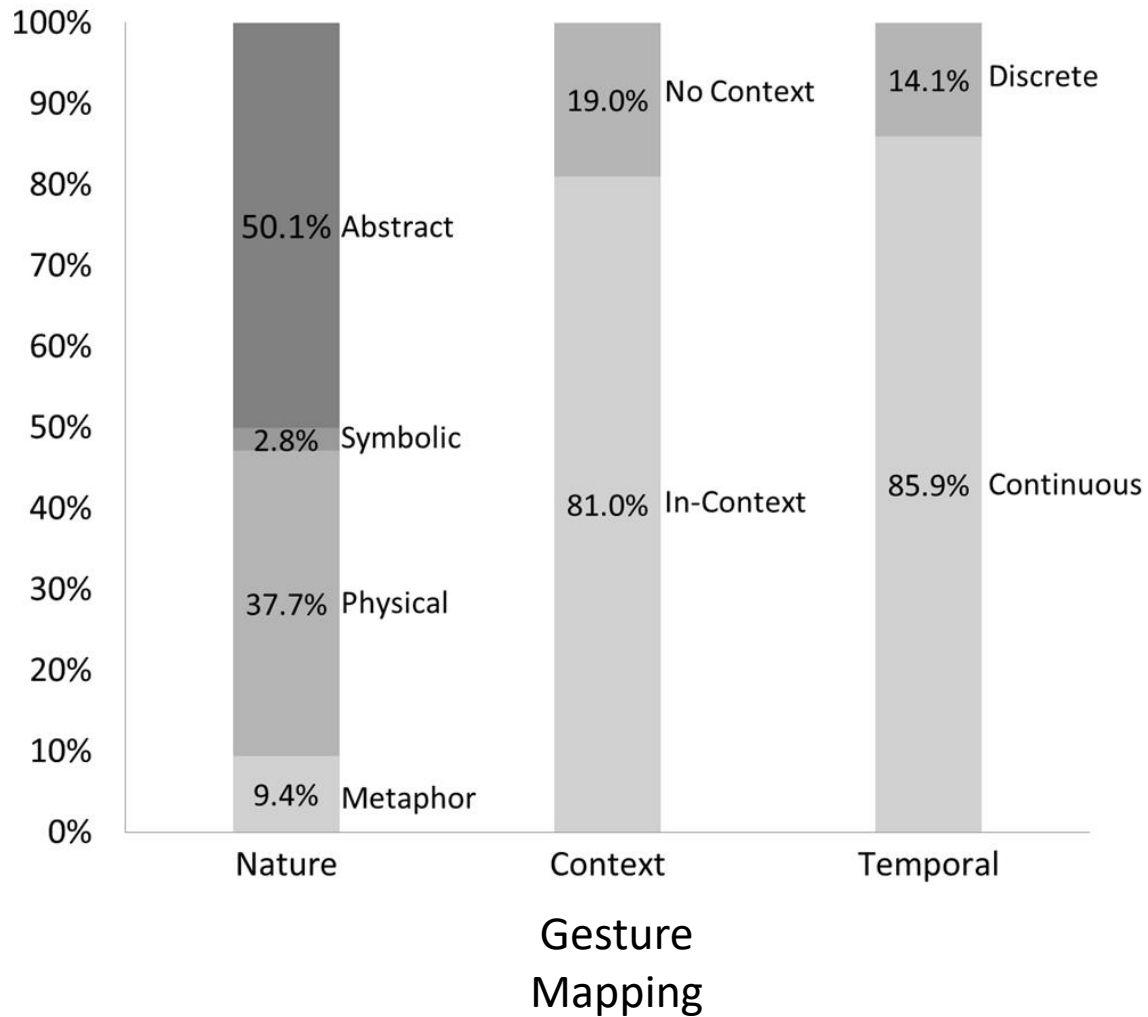


Physical Characteristics

- Duration:
  - Short ( $\leq 0.5s$ )
  - Medium ( $0.5 < x \leq 1.5s$ )
  - Long ( $> 1.5s$ )
- Size
  - Small ( $< 439 \text{ cm}^3$ )
  - Medium ( $439 \leq x \leq 1467 \text{ cm}^3$ )
  - Large ( $> 1467 \text{ cm}^3$ )



# Taxonomy of collected gestures



# Text entry

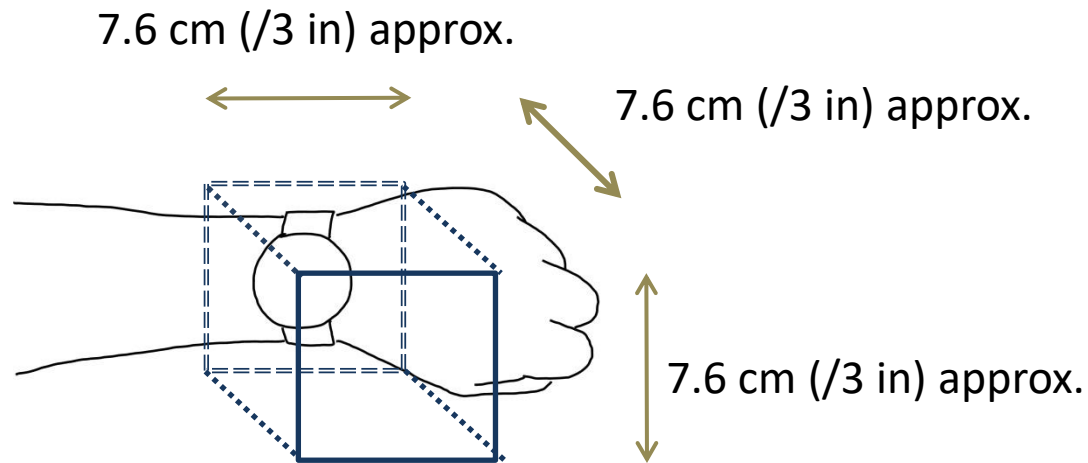
- While we do not recommend doing text entry on smartwatch, some watches do support features like cut copy and paste , and we wanted to make sure our tasks were representative of current smartwatches.

# Data Analysis and coding

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

# Small Gestures

- Approximately  $439 \text{ cm}^3$



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.