WATERLOO HCI
CHERITON SCHOOL OF COMPUTER SCIENCE

WRIST:
Wearables for Rich, Subtle, Gestural Interactions in Ubiquitous Environments

Edward Lank

With:

Yang Li, Sylvain Malacria, Mathieu Nancel,

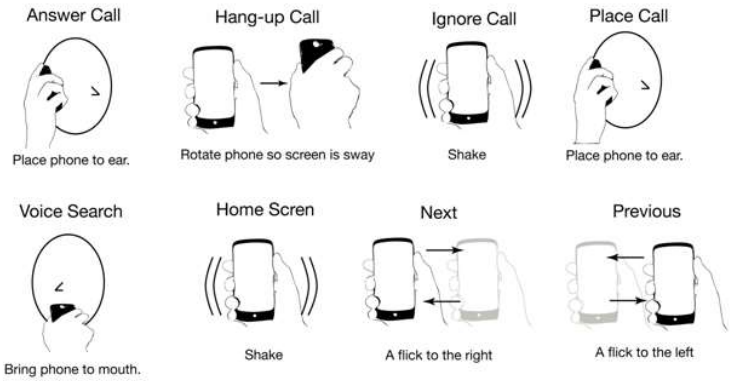
Keiko Katsuragawa, James Wallace, Dan Vogel, Jaime Ruiz,
Krzysztof Pietroszek, Matt Negulescu, Ankit Kamal, Alec Azad,
Shaishav Siddhpuria, Edmund Liu, Jay Henderson

Motion Gestures

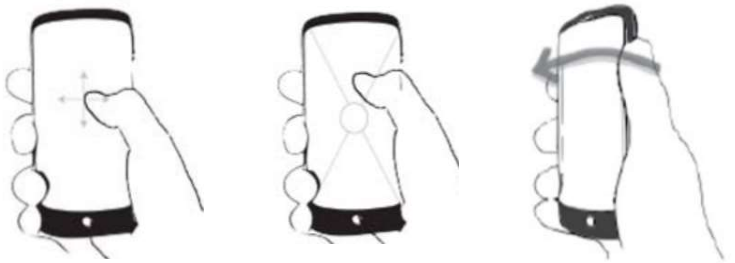
A gesture performed by physically translating or/and rotating the device.

Shake to Shuffle

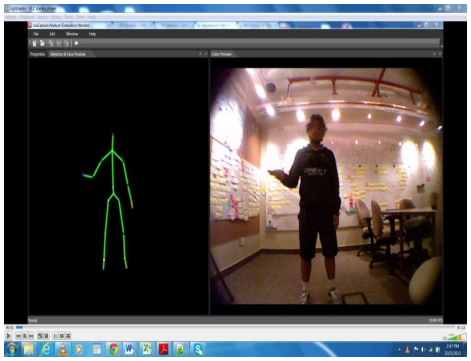
Mapping:
Motion Gesture Design



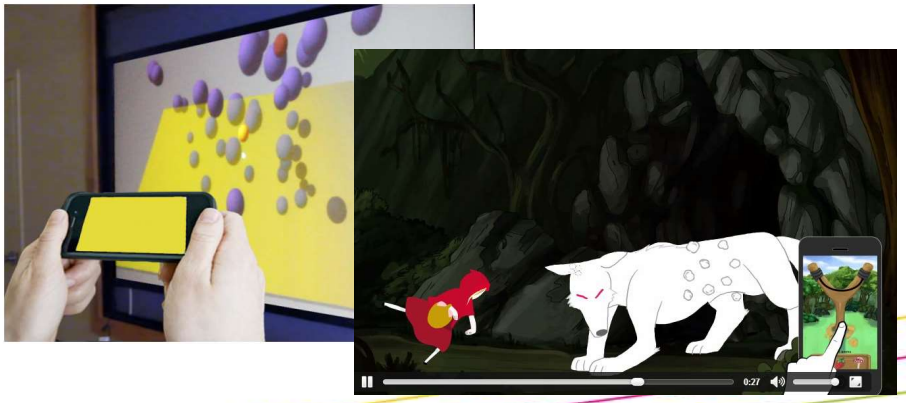
Eyes-Free Input:
Tap/Swipe/Motion Gestures



Scaffolding:
Training Mechanisms



Multi-Display
Interactions



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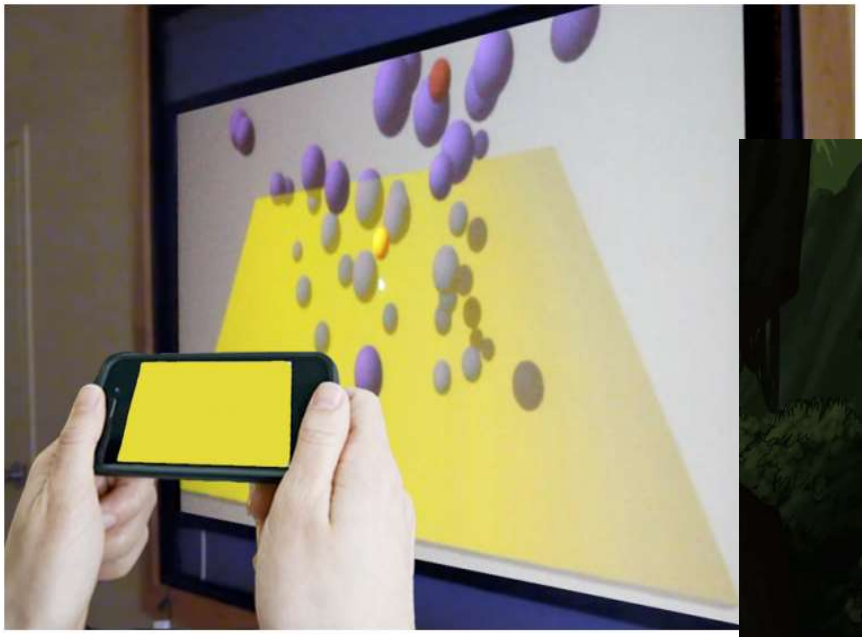
Smartphones Wearables + Motion Gestures + UBICOMP/IoT



Killer App for Wearables?

Josh Constantine, “Apple Watch Review: After 2 Months…”
https://techcrunch.com/2015/07/08/apple-watch-review-after-2-months/

Killer App for Wearables?

Embedded Interaction is the technological and conceptual phenomena of seamlessly integrating the means for interaction into everyday artifacts.

- Sensing, actuation, processing, and networking.
- Interaction into users' everyday tasks.

- Kranz, Holleis, & Schmidt, (2010). Embedded interaction: Interacting with the internet of things. *IEEE Internet Computing*, *14*(2), 46-53.

Why Wearables?

- Embedded devices (vs interactive devices)
- Invisibility dilemma
- Implicit vs Explicit interaction and the Midas touch phenomenon
- Sensing and tracking

Beyond being there

by Jim Hollan and Scott Stornetta

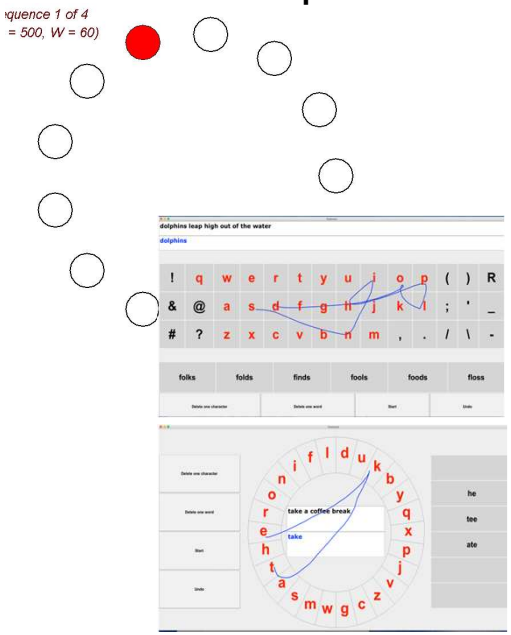
CHI '92

"The mismatch between what we actually have and what we can deliver."

- Andy Wilson, Graphics Interface 2017 Keynote

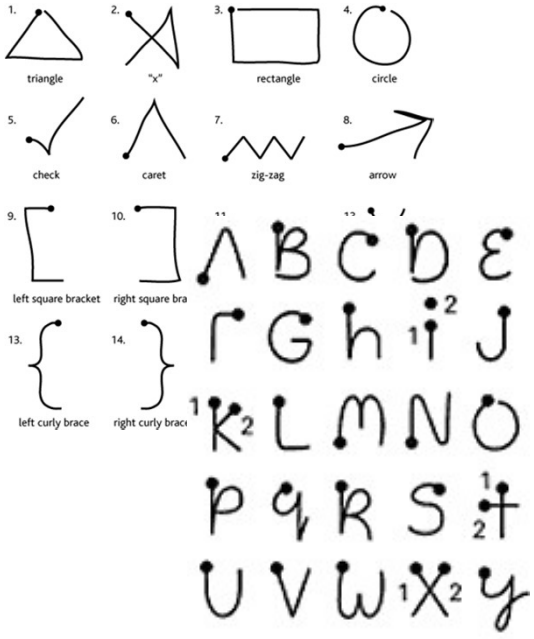
Wearables (Smartwatches) for Rich, Subtle, Gestural Interactions

Manipulation and Text Input



AVI 2016, CHI 2018

Ideographic Gestures

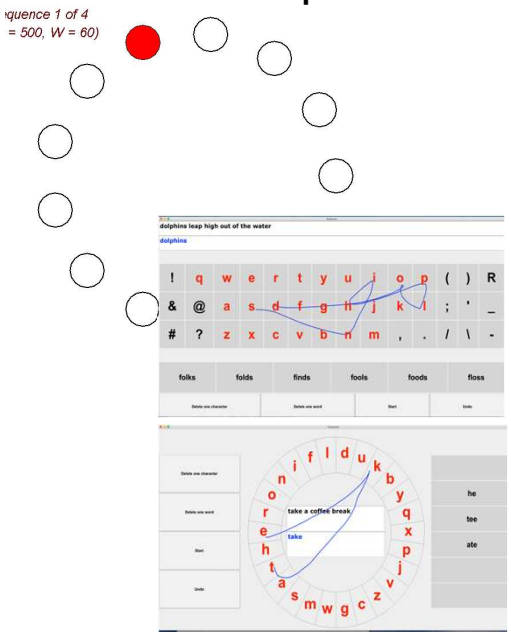


DIS 2017

Finger Gestures

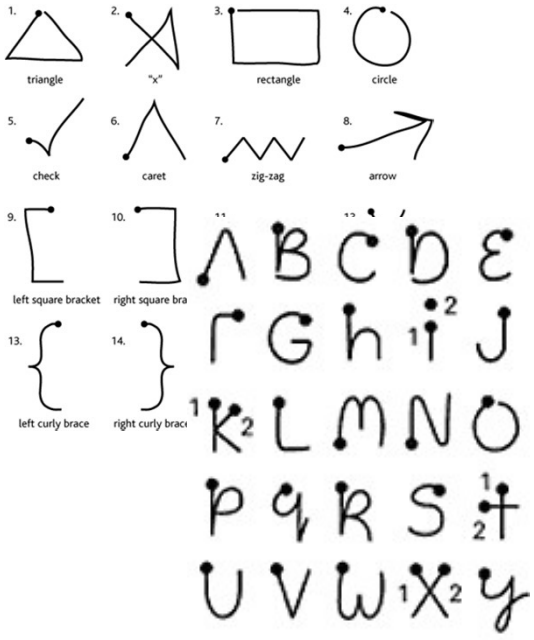
Wearables for
Transient, Subtle, Reliable Interactions

Manipulation and Text Input



AVI 2016, CHI 2018

Ideographic Gestures

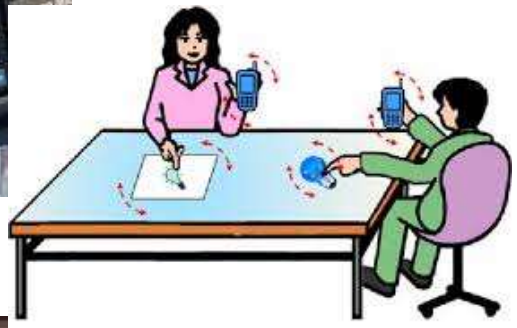


DIS 2017

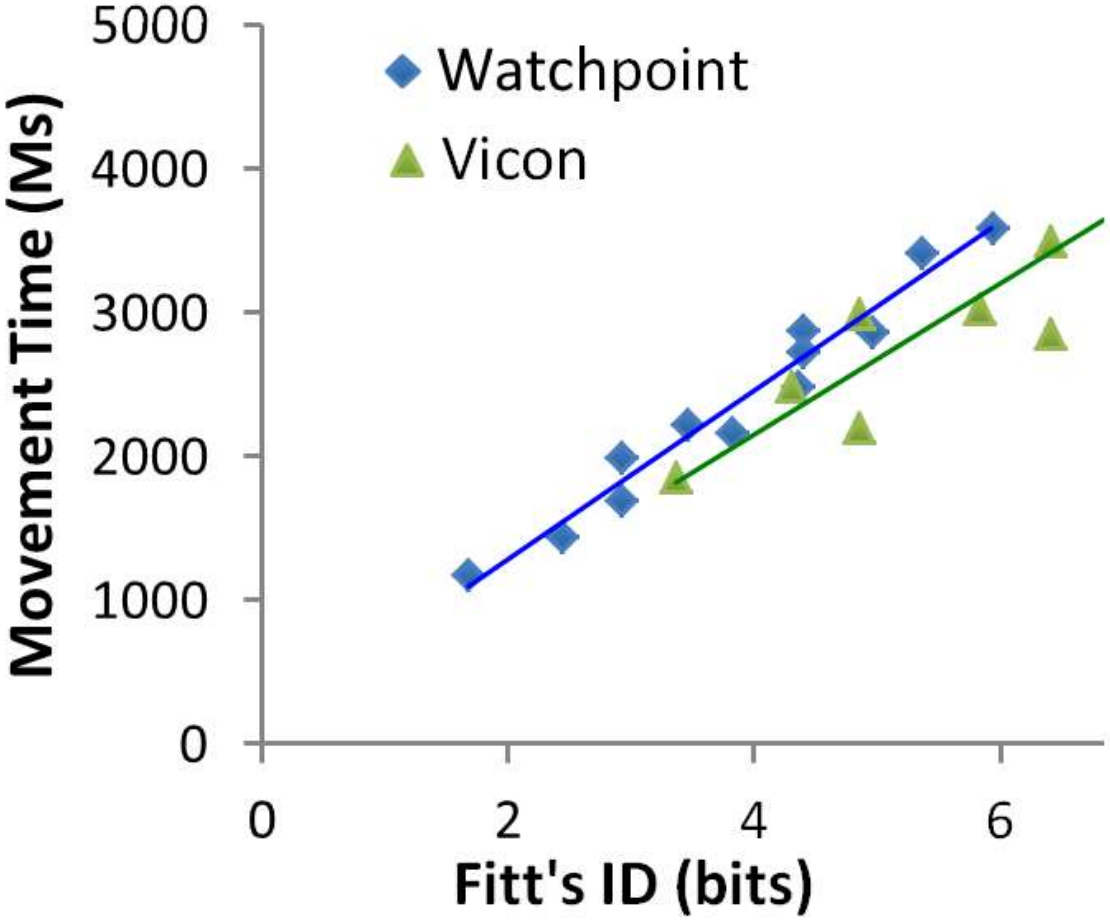
Finger Gestures

TIIS 2018

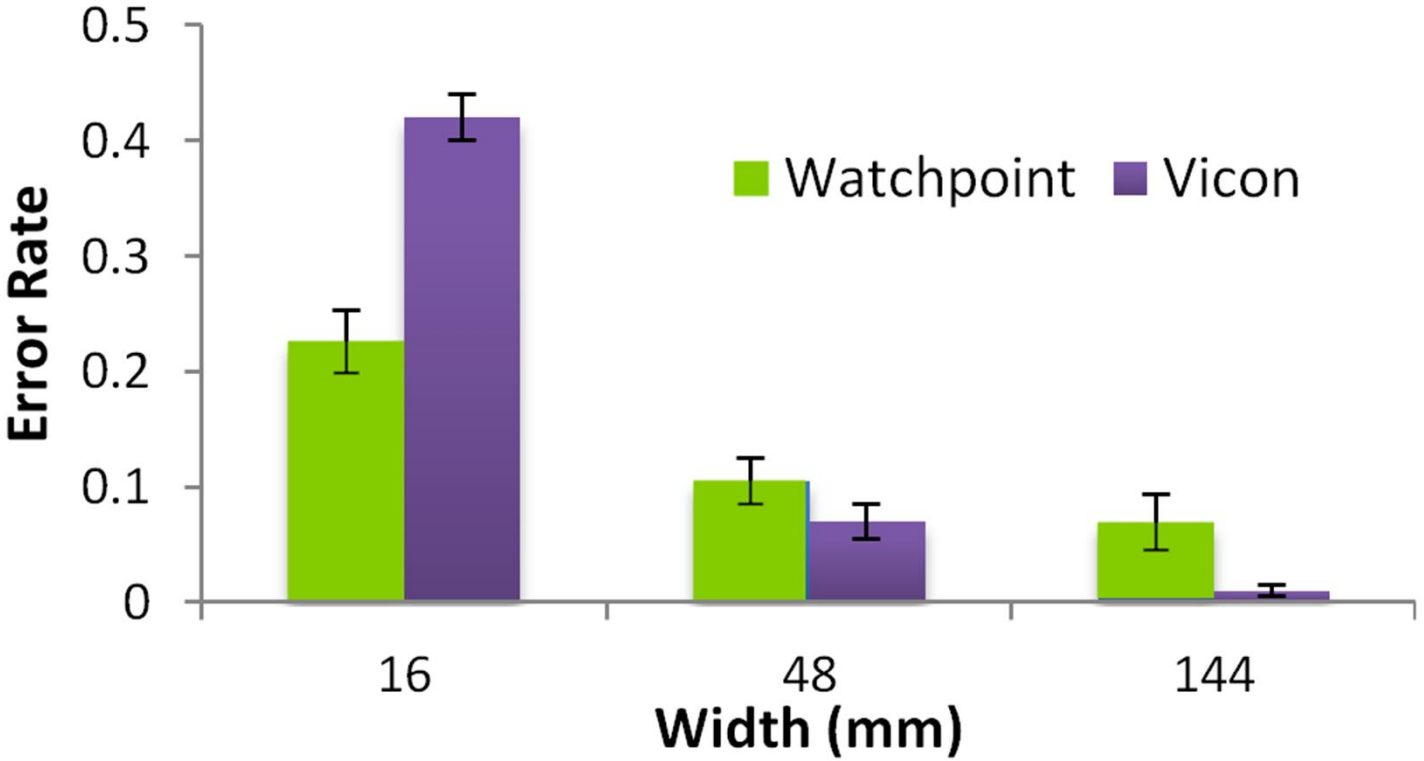
Displays Everywhere



Evaluation

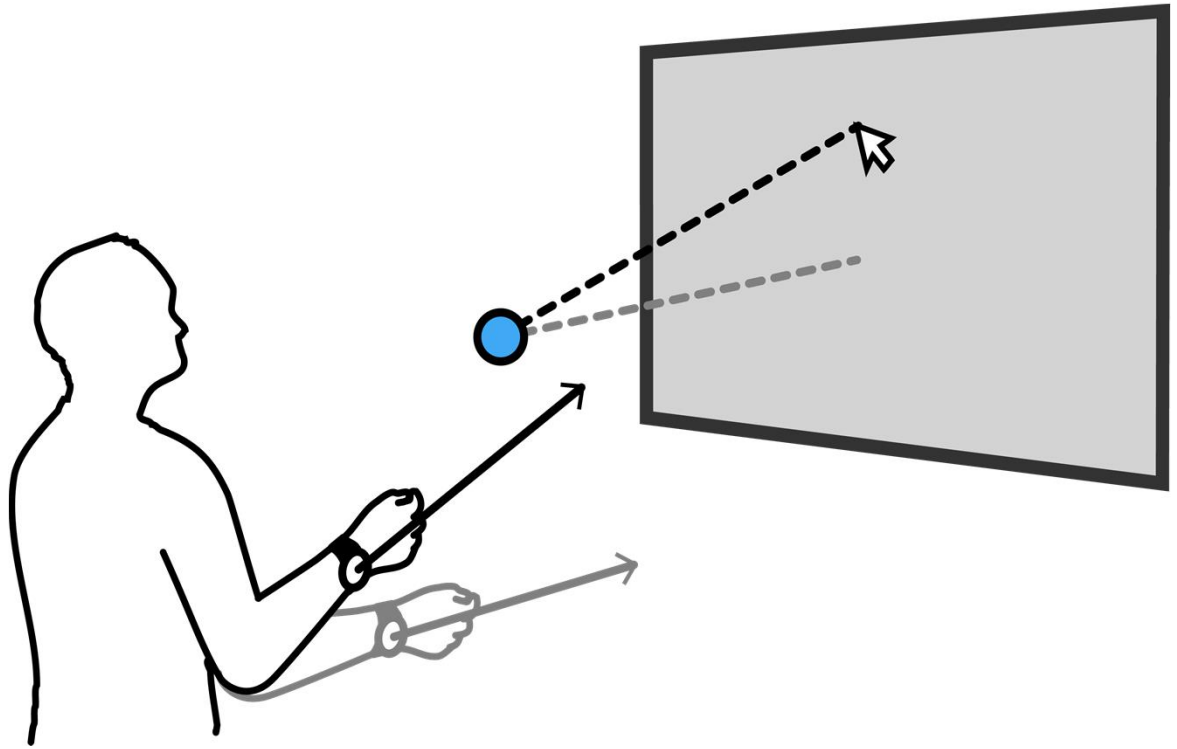

Watchpoint
Vicon
Movement Time (Ms)
5000
4000
3000
2000
1000
0
0
2
4
6
Fitt's ID (bits)

Evaluation



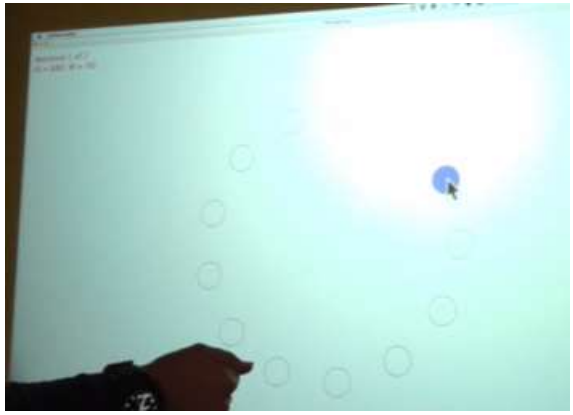
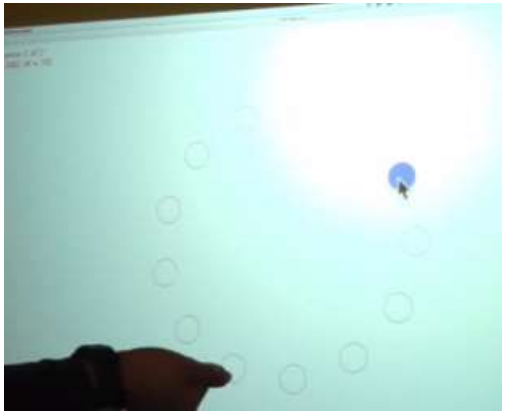
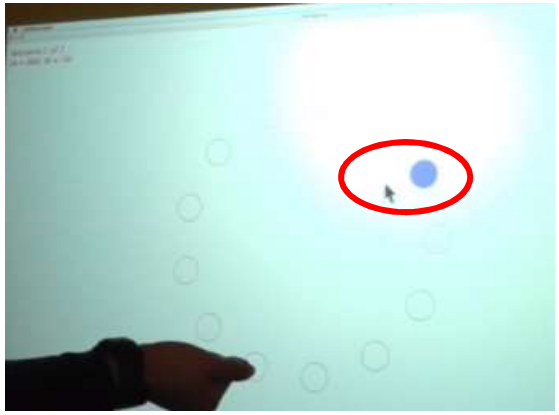
CD-Gain/Cursor Acceleration

- Trade-off

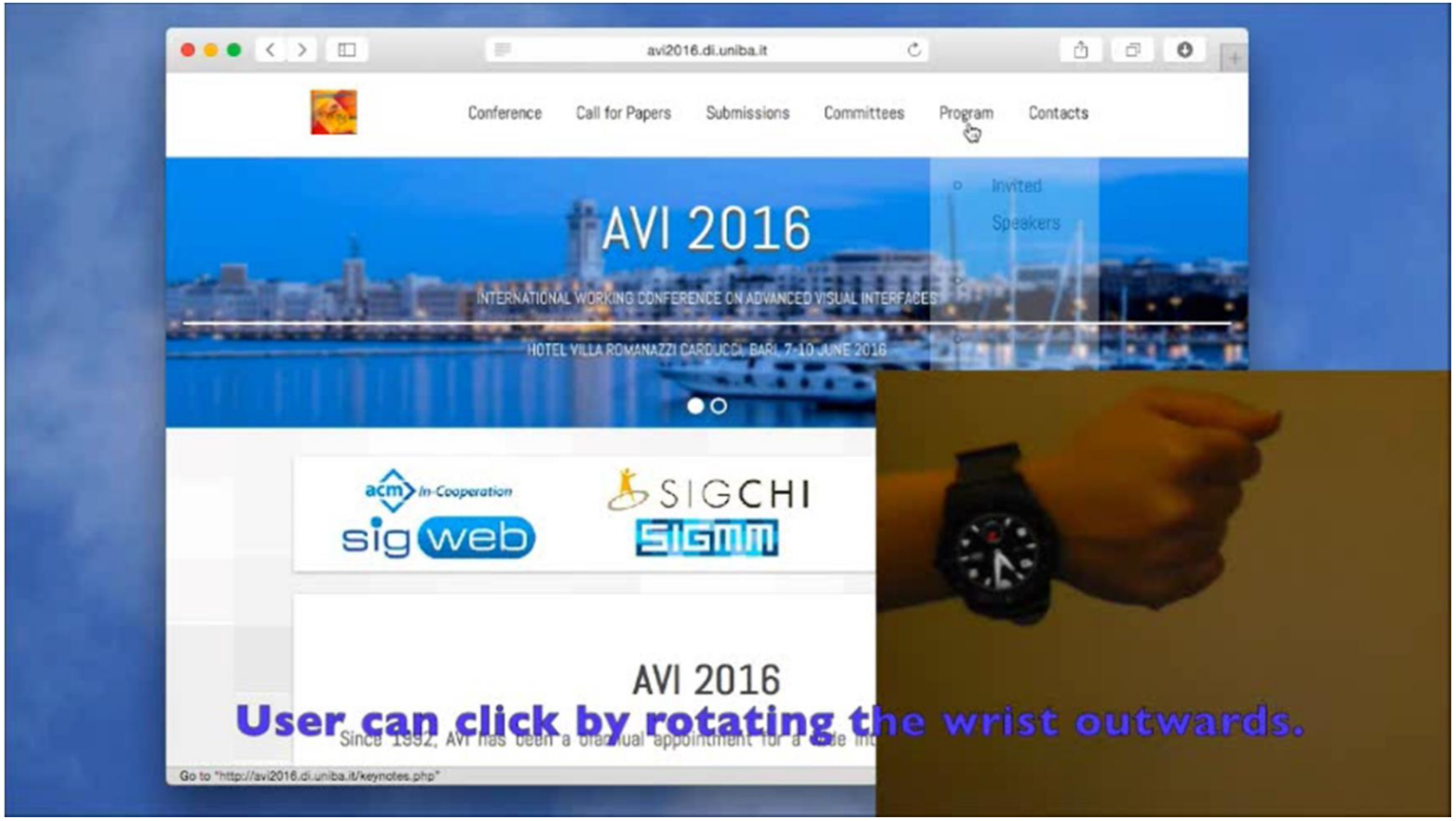


Stability and Small Targets

- Advantage Watchpoint

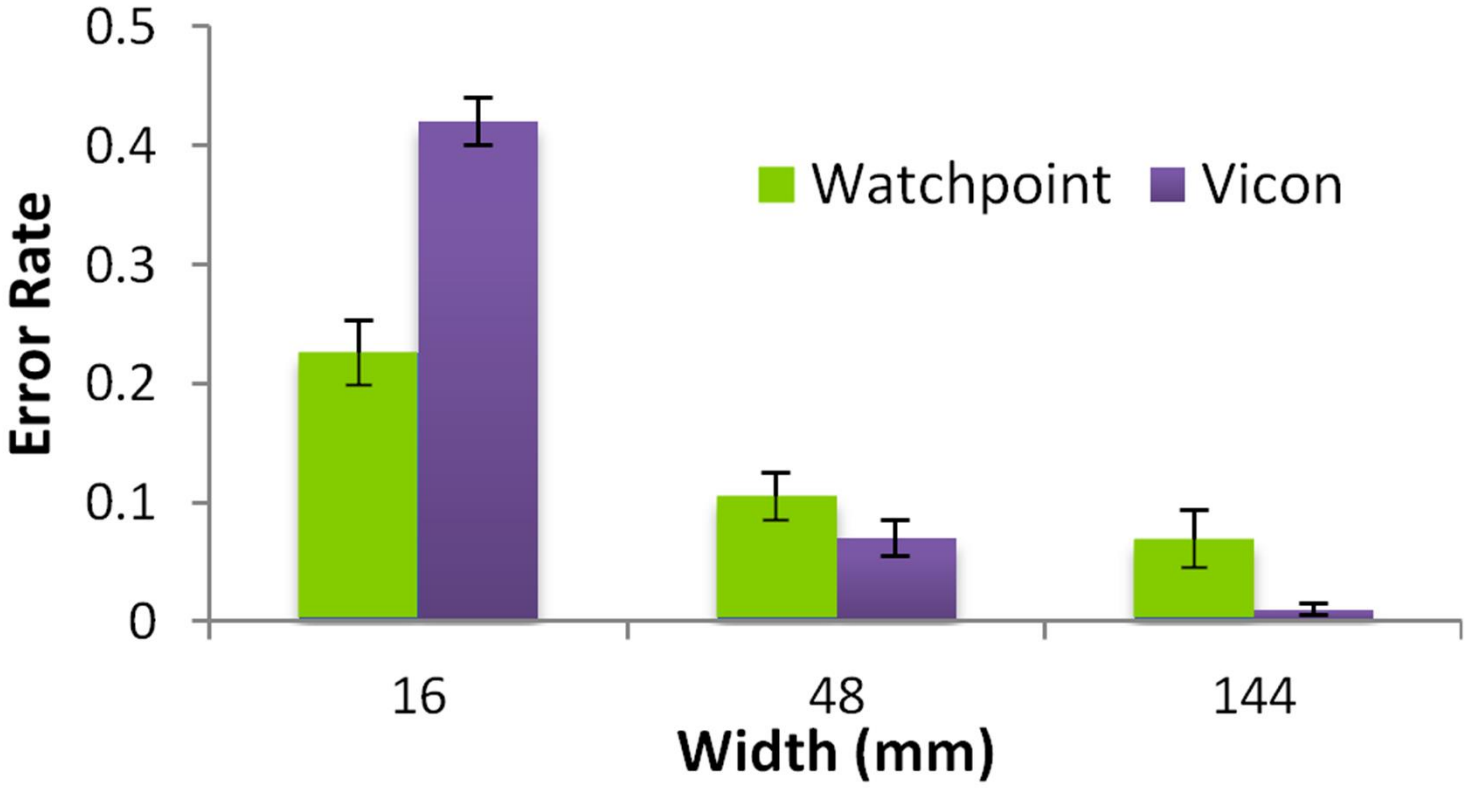




Stability


avi2016.di.uniba.it
Conference
Call for Papers
Submissions
Committees
Program
Contacts
AVI 2016
INTERNATIONAL WORKING CONFERENCE ON ADVANCED VISUAL INTERFACES
HOTEL VILLA ROMANAZZI CARDUCCI, BARI, 7-10 JUNE 2016
Invited Speakers
acm In-Cooperation
sig web
SIGCHI
SIGMM
AVI 2016
User can click by rotating the wrist outwards.
Go to "http://avi2016.di.uniba.it/keynotes.php"

Beyond Being There

Hollan and Stornetta



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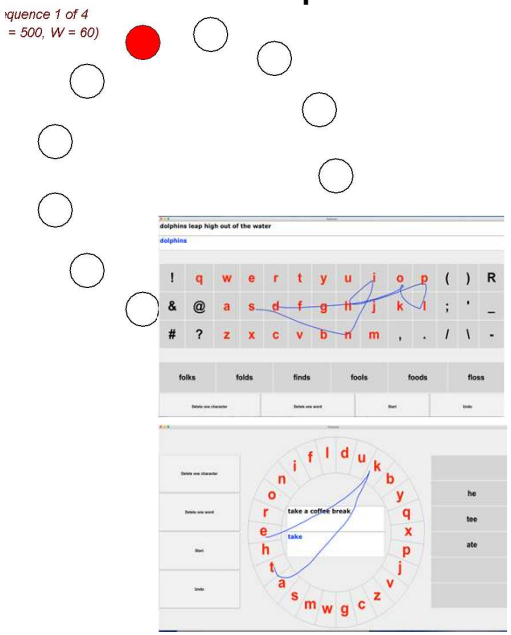
“Pointing at a Distance with Everyday Smart Devices”

9am, Thursday,

Public Large and Shared Displays
518C, first talk.

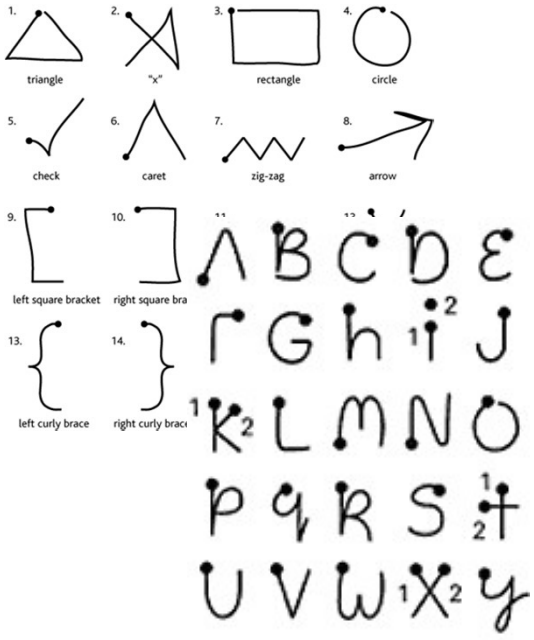
Wearables for
Transient, Subtle, Reliable Interactions

Manipulation and Text Input



AVI 2016, CHI 2018

Ideographic Gestures

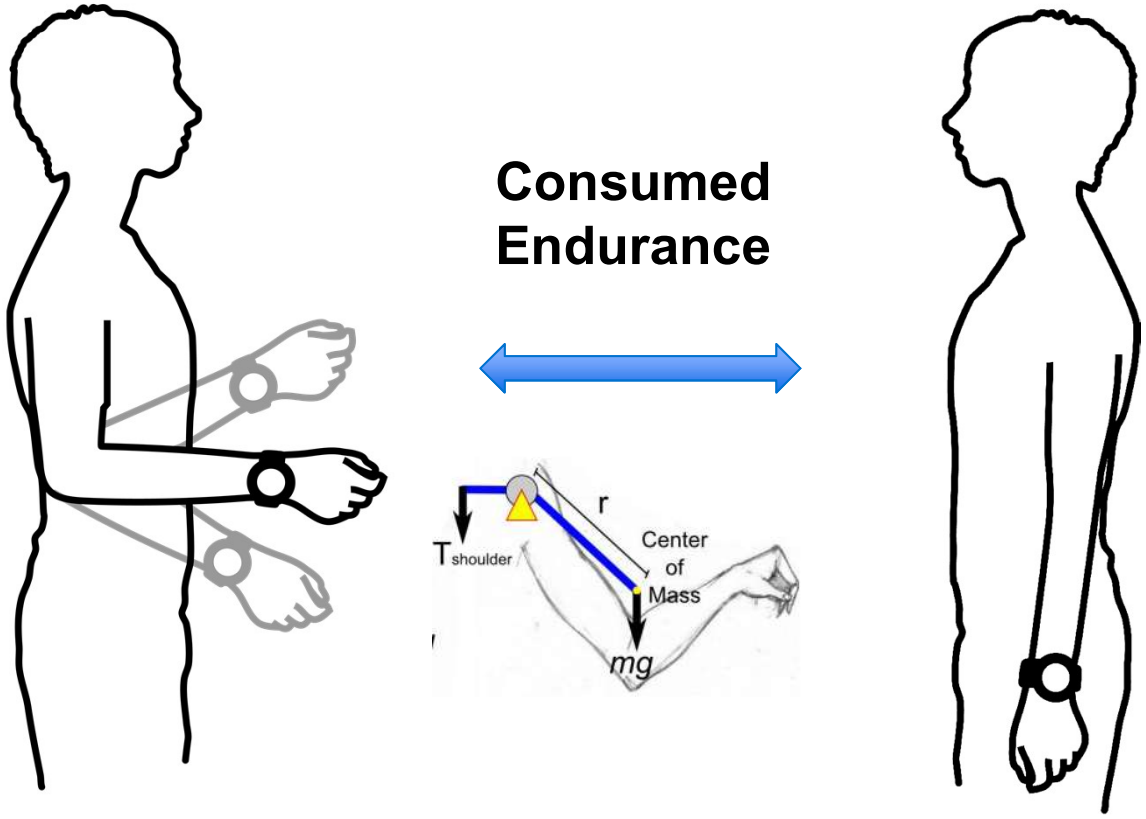


DIS 2017

Finger Gestures

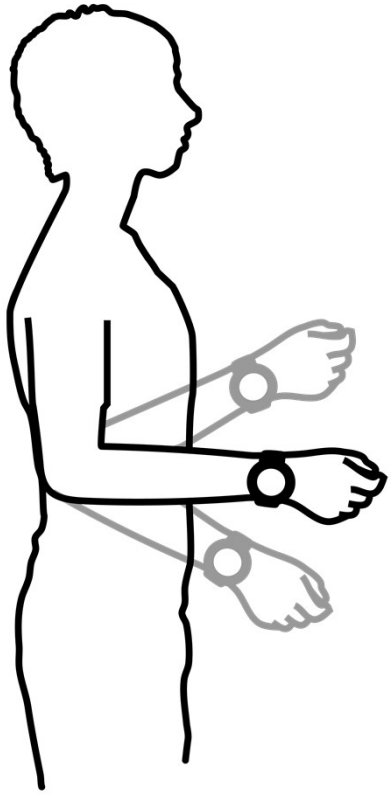
TIIS 2018

Gorilla Arm and Gestural Input

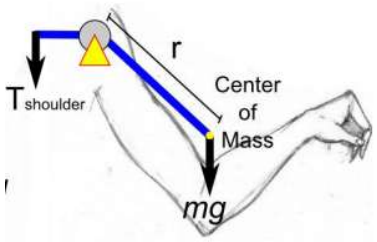


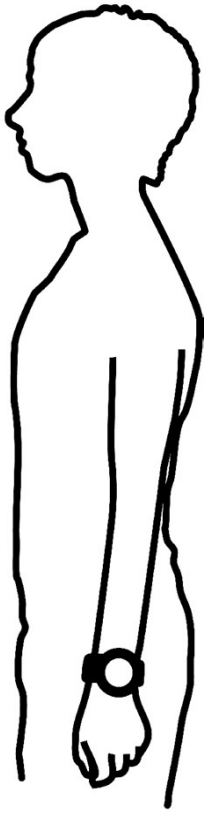
Hincapié-Ramos, Guo, Moghadasian, & Irani, Consumed endurance: a metric to quantify arm fatigue of mid-air interactions. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1063-1072). ACM.

Gorilla Arm and Gestural Input

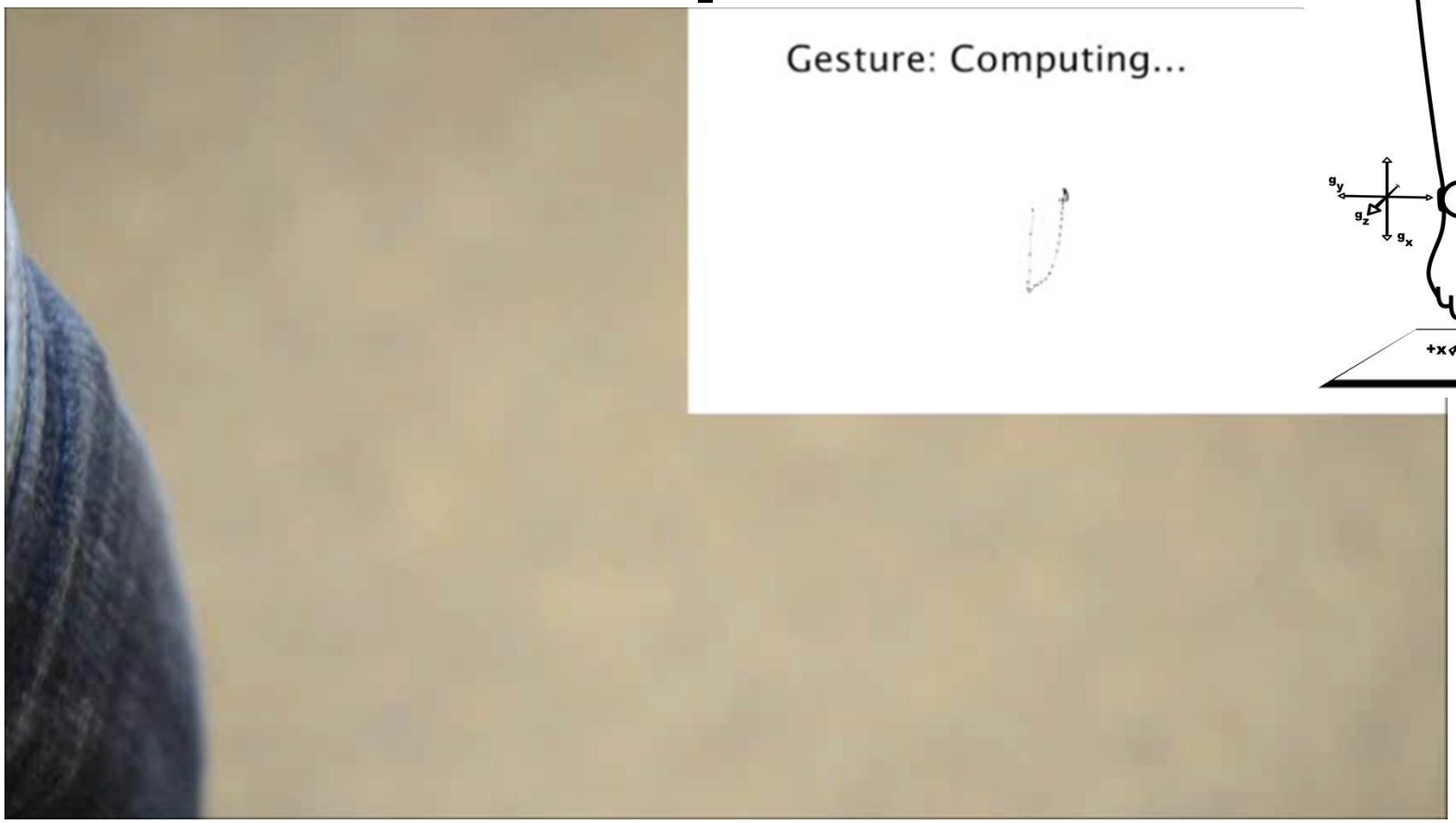


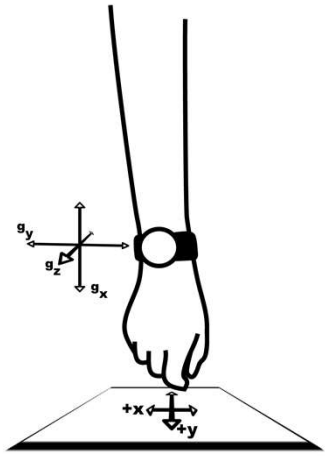
Consumed Endurance





Side-of-Body, Rich Gesture Input

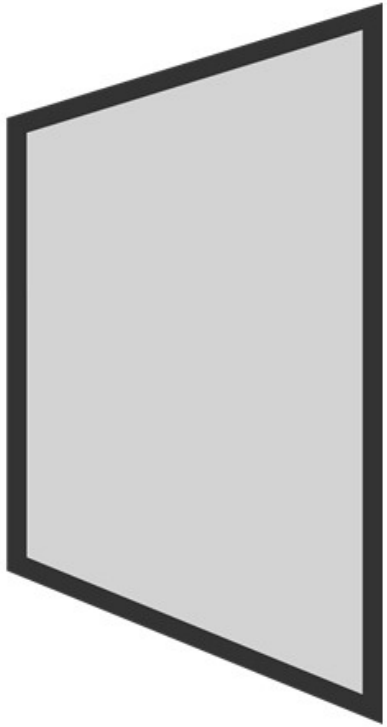




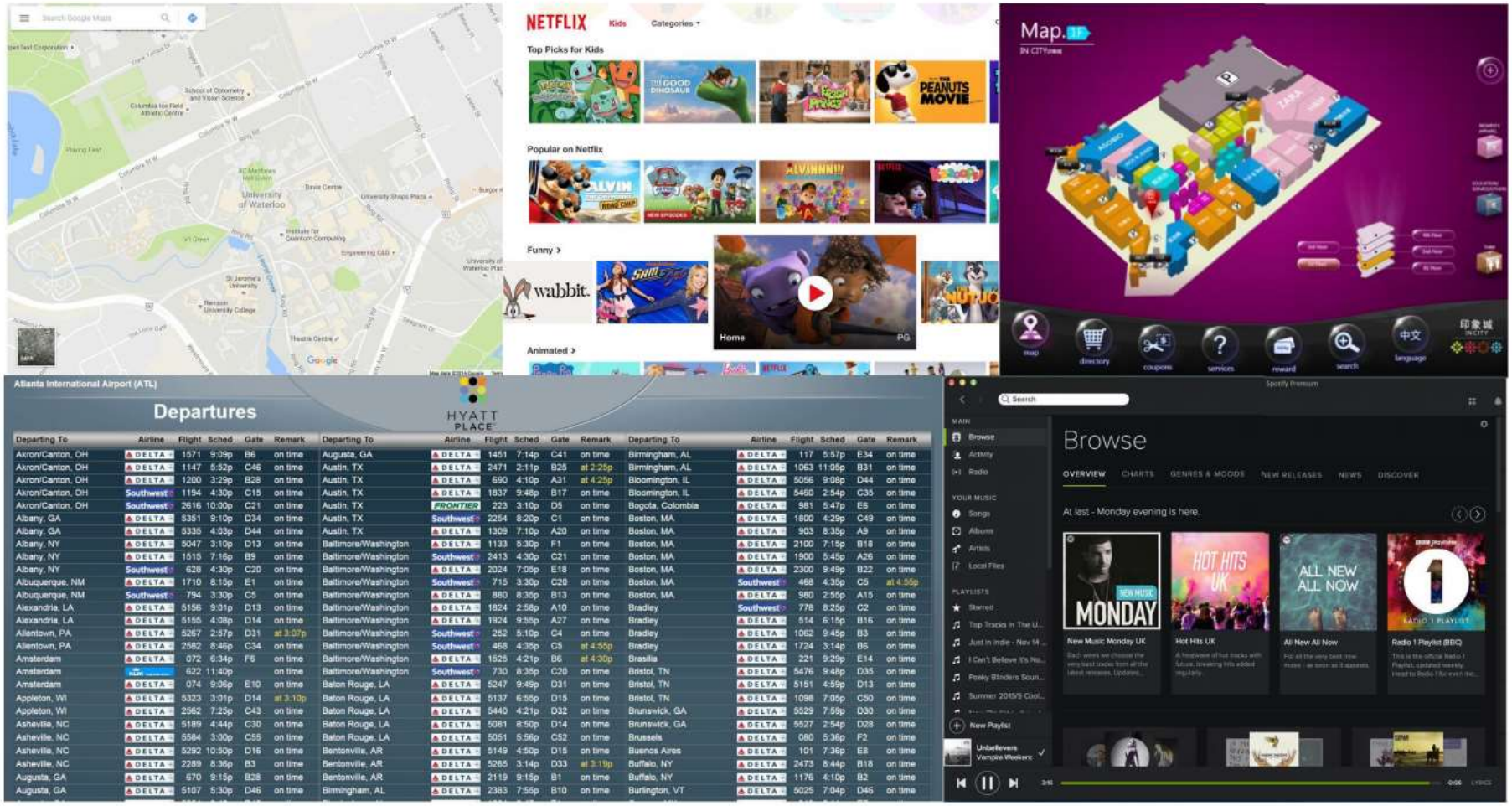
Elicitation Study

- Given participant a task
  - How would they perform the task?
  - Perform the task
  - Measure characteristics of performance

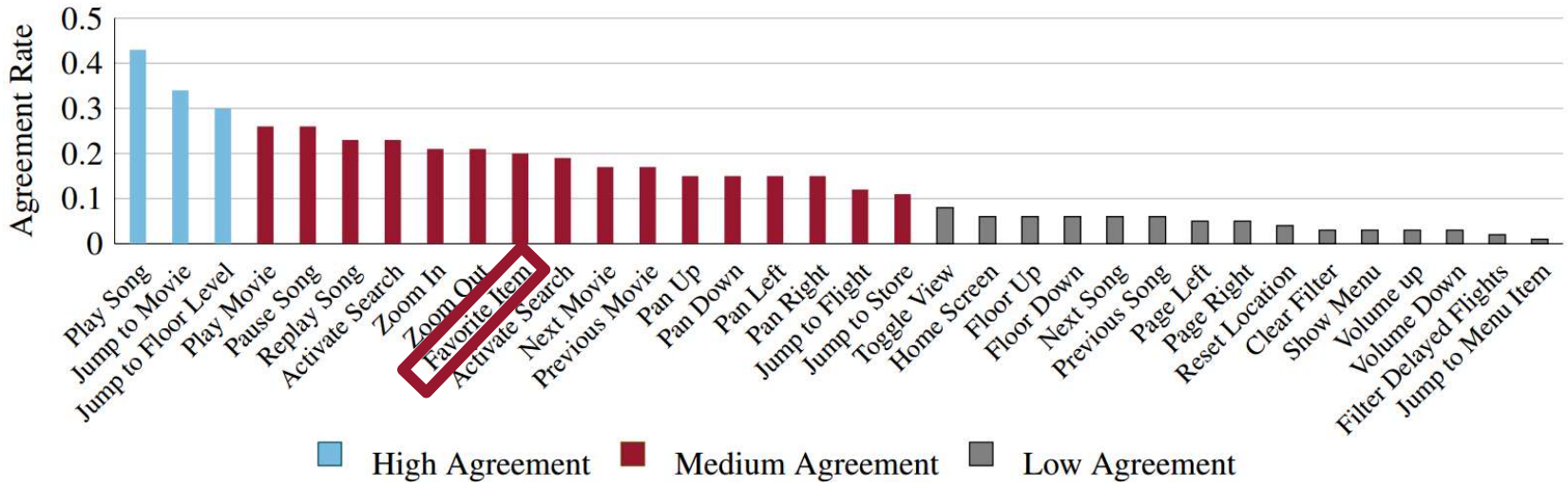
$$AR(r) = \frac{|P|}{|P|-1} \sum_{P_i \subseteq P} \left(\left| \frac{P_i}{P} \right| \right)^2 - \frac{1}{|P|-1}$$



Tasks

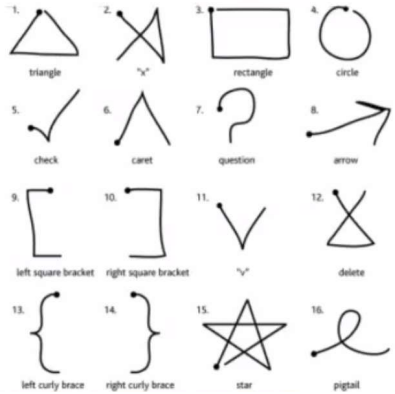

NETFLIX
Kids
Categories
Top Picks for Kids
Popular on Netflix
Funny
Animated
Home
Map.
Departures
HYATT PLACE
Browse
OVERVIEW
CHARTS
GENRES & MOODS
NEW RELEASES
NEWS
DISCOVER
At last - Monday evening is here.
MONDAY
HOT HITS UK
ALL NEW ALL NOW

Agreement

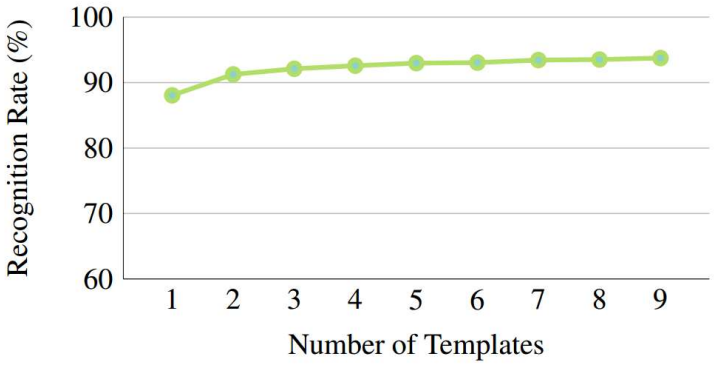


ELICITED GESTURES FOR "FAVORITE ITEM"

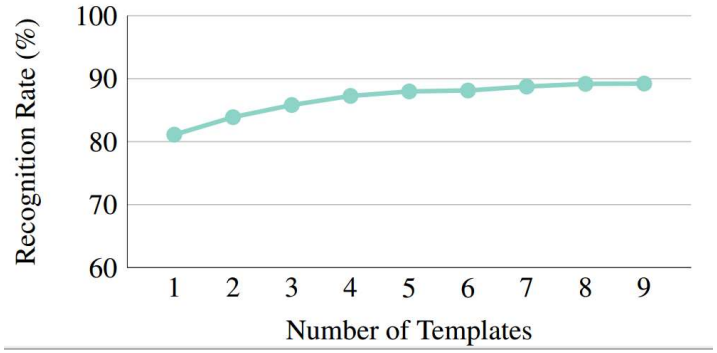
Ideographic & Alphabetic



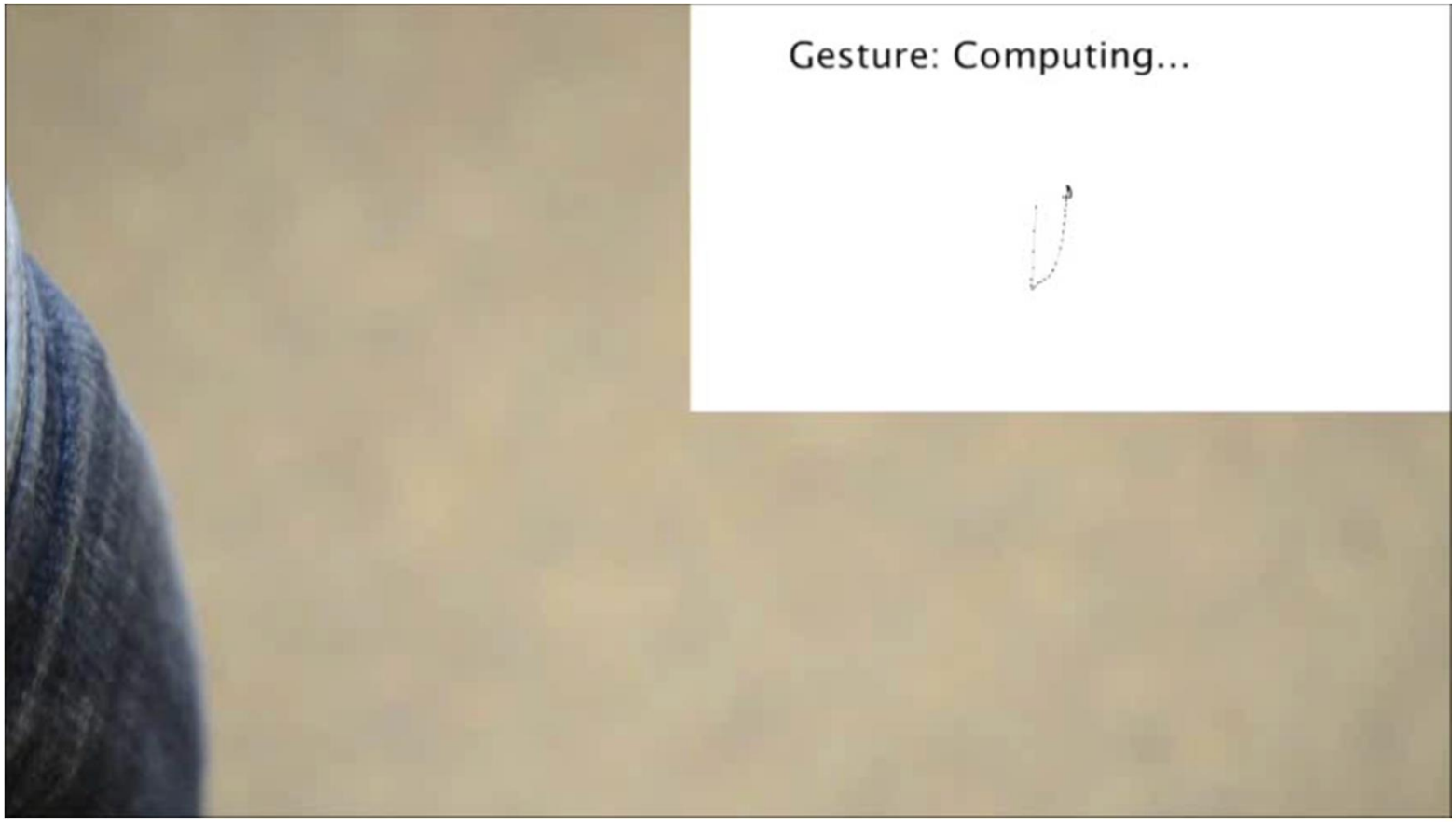
$1 Gesture Set



Palm Graffiti

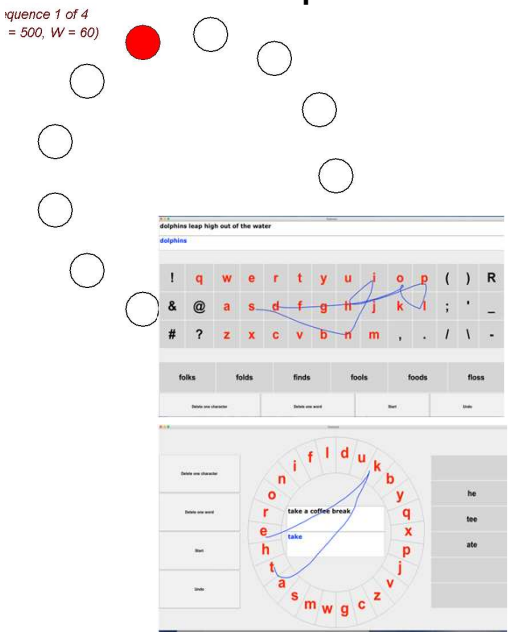


Side-of-Body, Rich Gesture Input



Wearables for
Transient, Subtle, Reliable Interactions

Manipulation and Text Input



AVI 2016, CHI 2018

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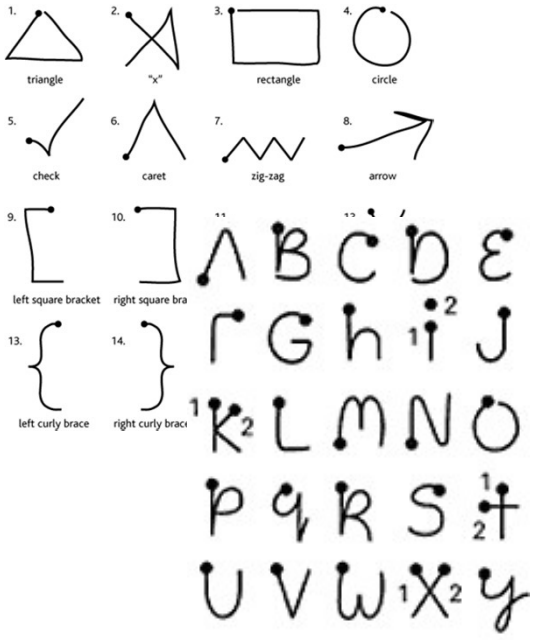


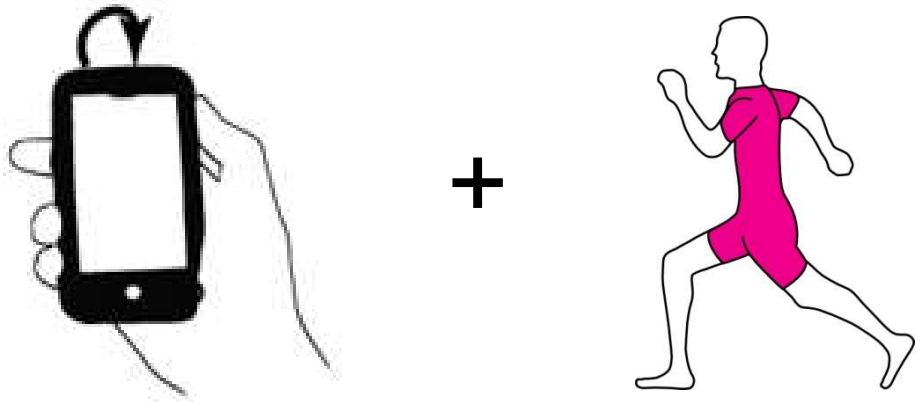
DIS 2017

Finger Gestures

TIIS 2018

Recognition Challenge

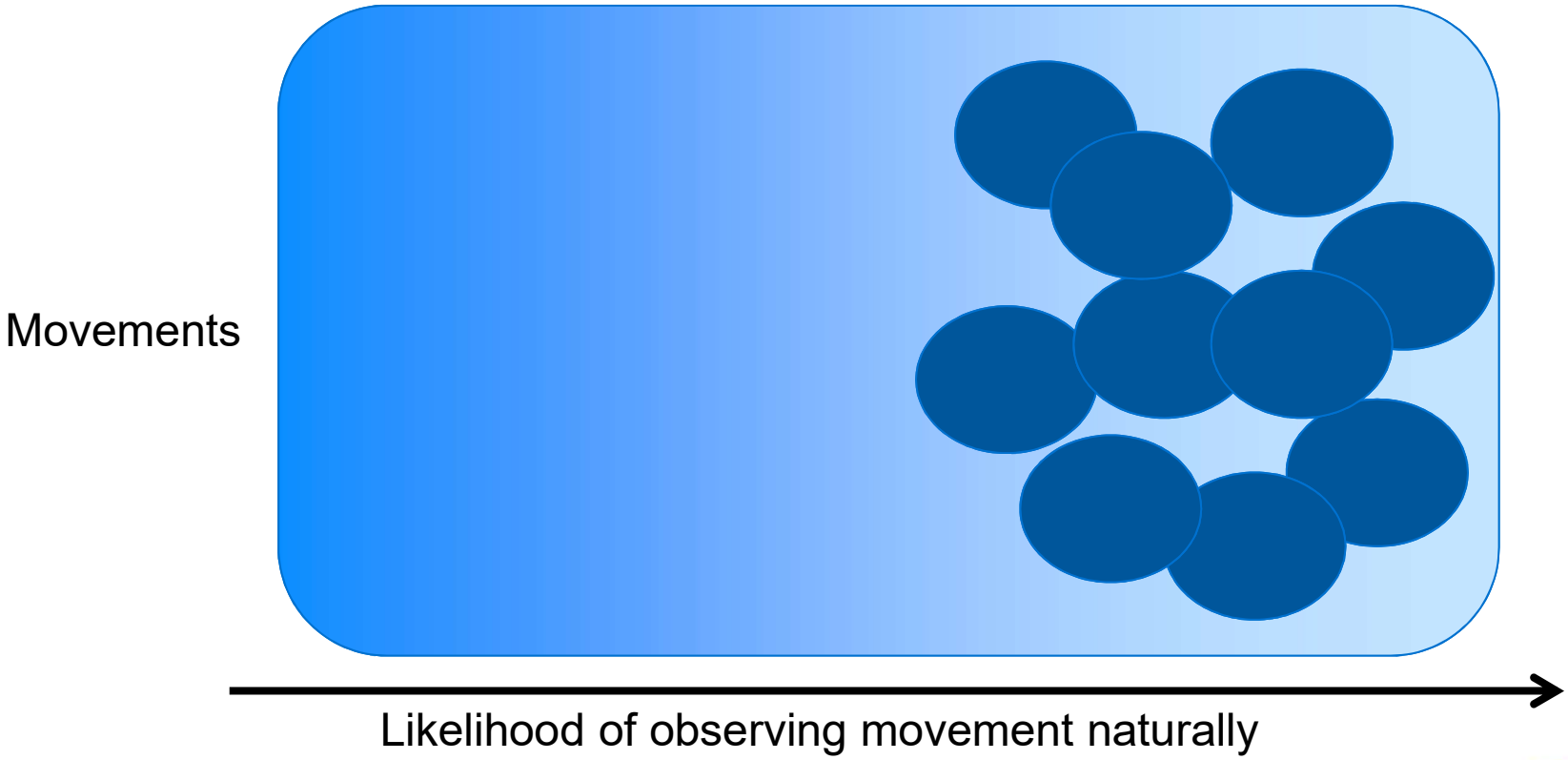
Gestures tend to be simple discrete gestures involving one (maybe two) axis with low kinematic impulse Ruiz, Li, and Lank, CHI 2011



Solutions for Reliable Input?

- **Better gestures**
  - But limited in number …
- **Delimiters**
  - Like a mode switch
- **Recognition strategies**
  - Tighter thresholding

Challenge => Tighter Thresholding



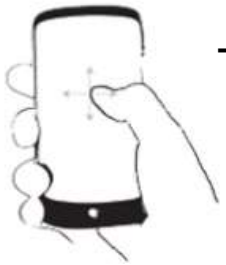
How can we preserve both

***high recall** and **high precision** when*

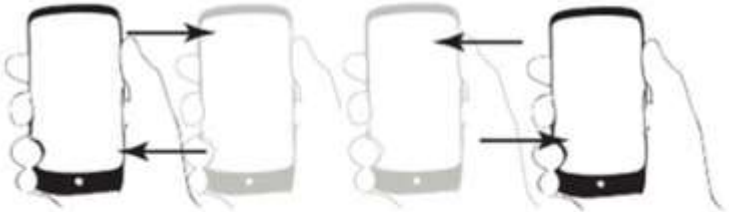
gestures collide with everyday motion?

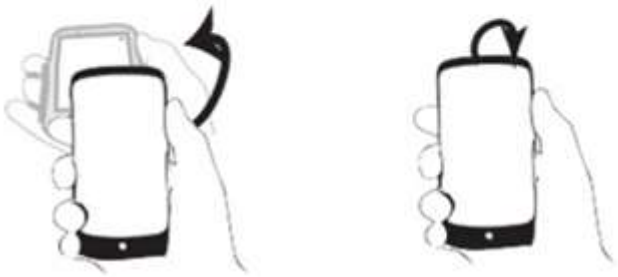
Conceptualization: Eyes-Free Interaction

"Tap, Swipe, Move" by Negulescu, Ruiz, Li and Lank, AVI 2012

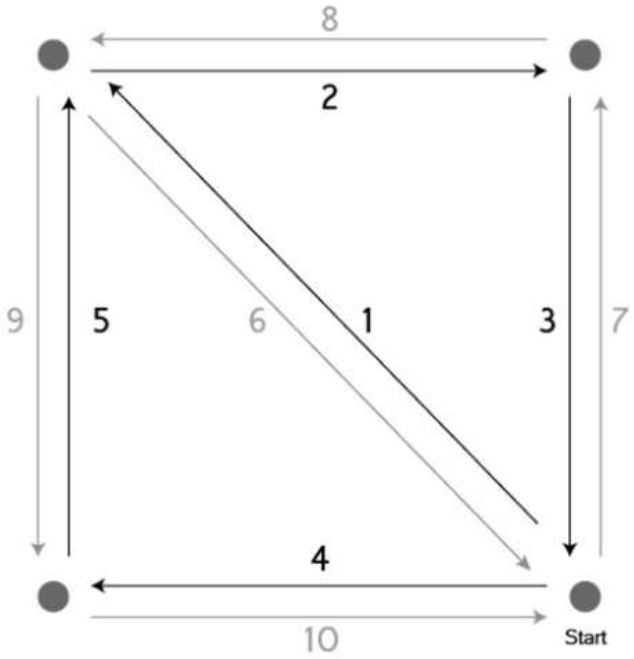


Tap or Swipe





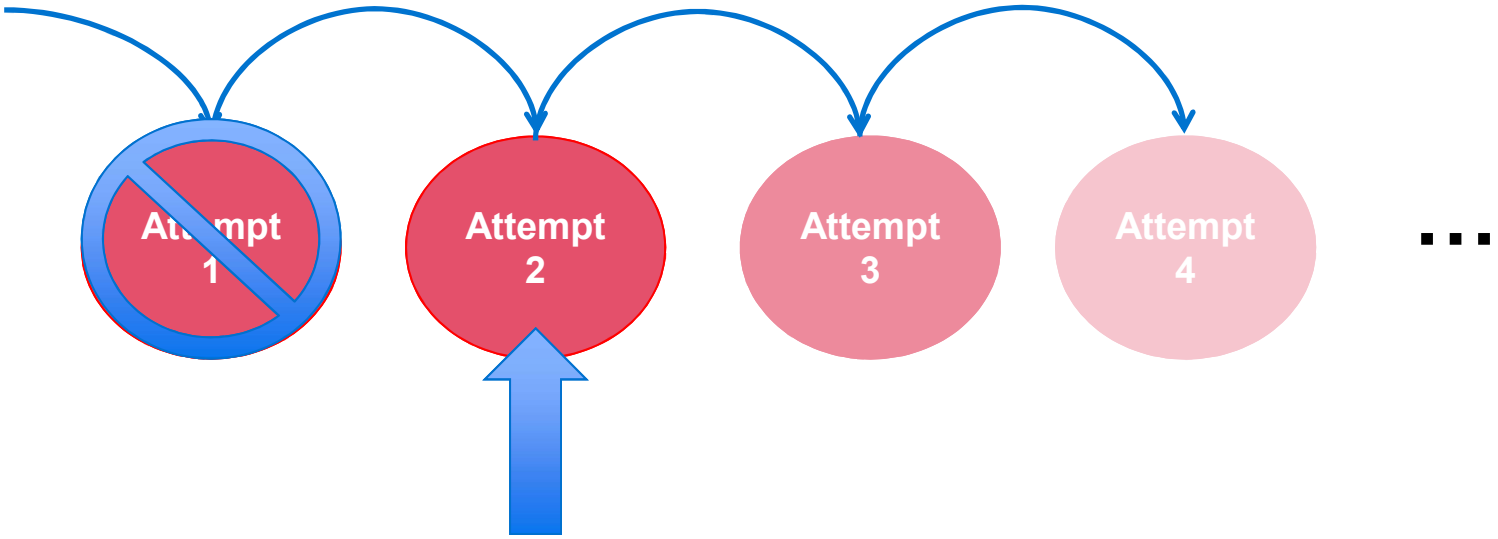
Motion gestures



Take-Aways

- Main take-away:
  - Even when touch/swipe designed for eyes-free, gestural input still better.
- Additional observation:
  - Effect of recognition errors
  - In particular, single error appears to have ~0 cost!
    - User just repeats gesture.

Cost of Errors



Reliability** vs **Perceived Reliability

Bi-Level Thresholding

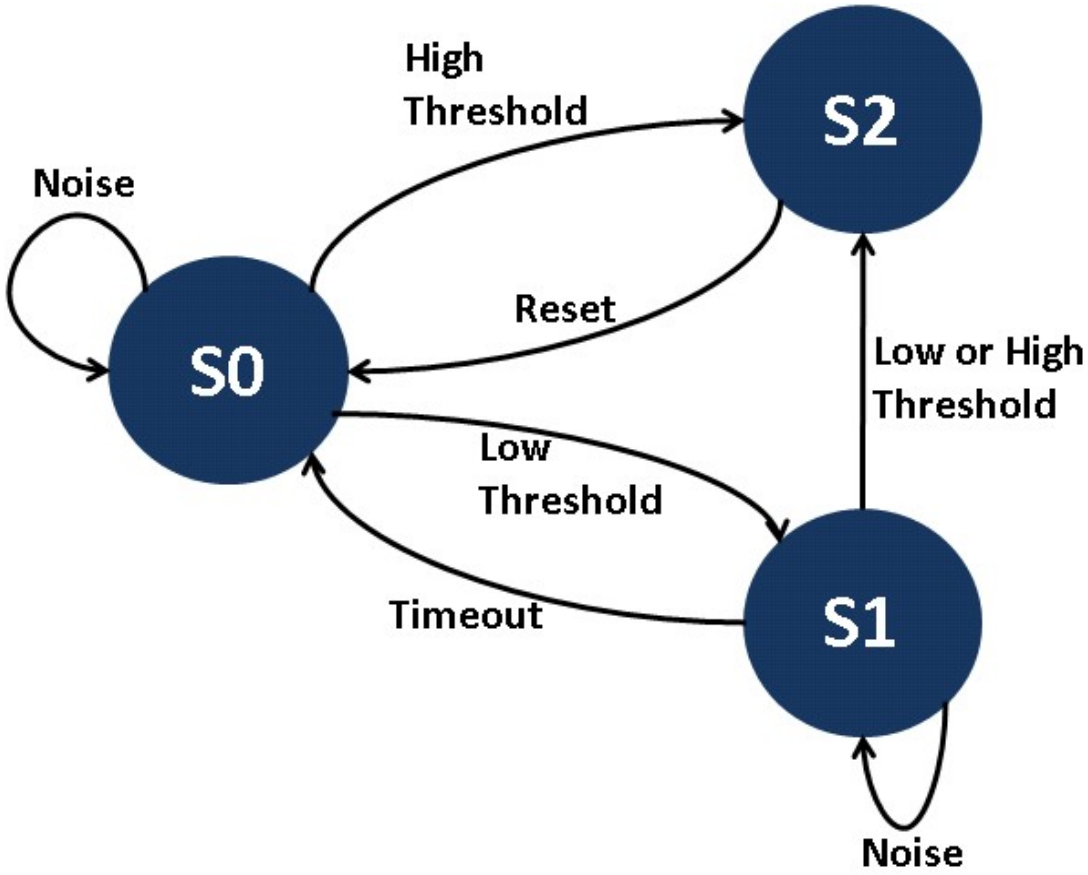
Observation:

On false negative, user repeats gesture

Safety Net

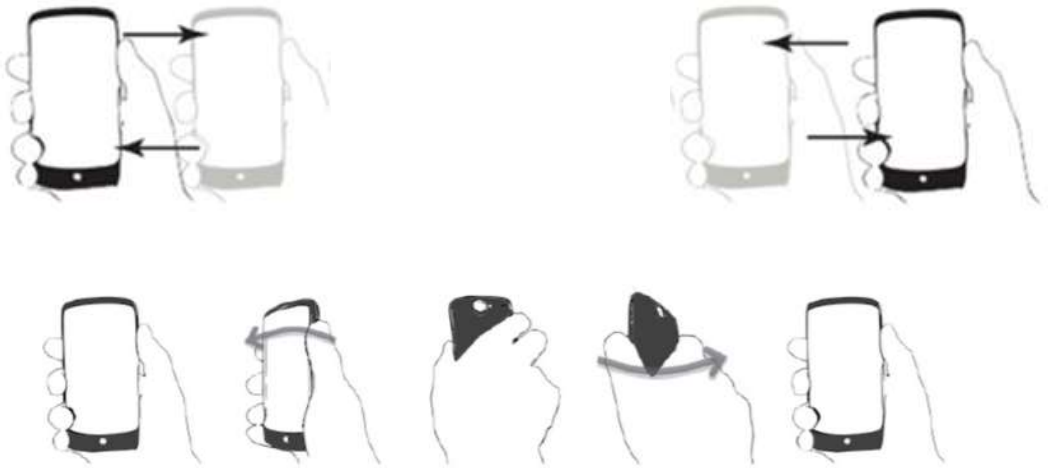
- Observing two possible gestures = observing one highly probable gesture
- One tightly thresholded initial model
- One loosely thresholded double model

Bi-level Thresholding Recognition



Preliminary Study

- Built a simple double-threshold recognizer
  - 3 gestures – flick left, flick right, double-flip



  - Constructed HMM-based recognizer

Preliminary Study

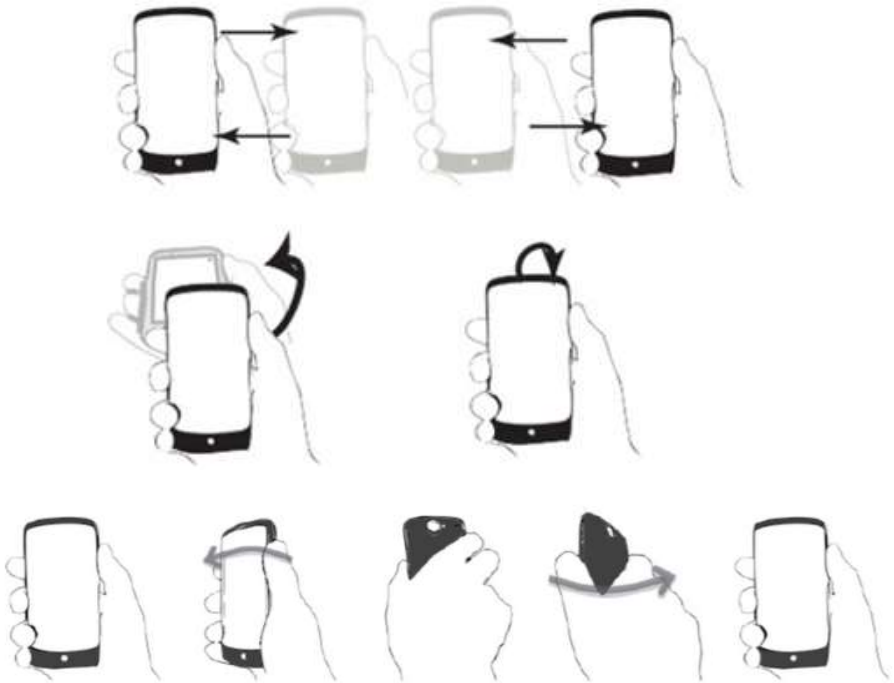
- Bi-level threshold recognizer achieved 93% recall with 95.3% precision for 2 attempts
- 65% of gestures captured with double threshold
  - Vs 35% with single threshold (26% first attempt + 9% second attempt)

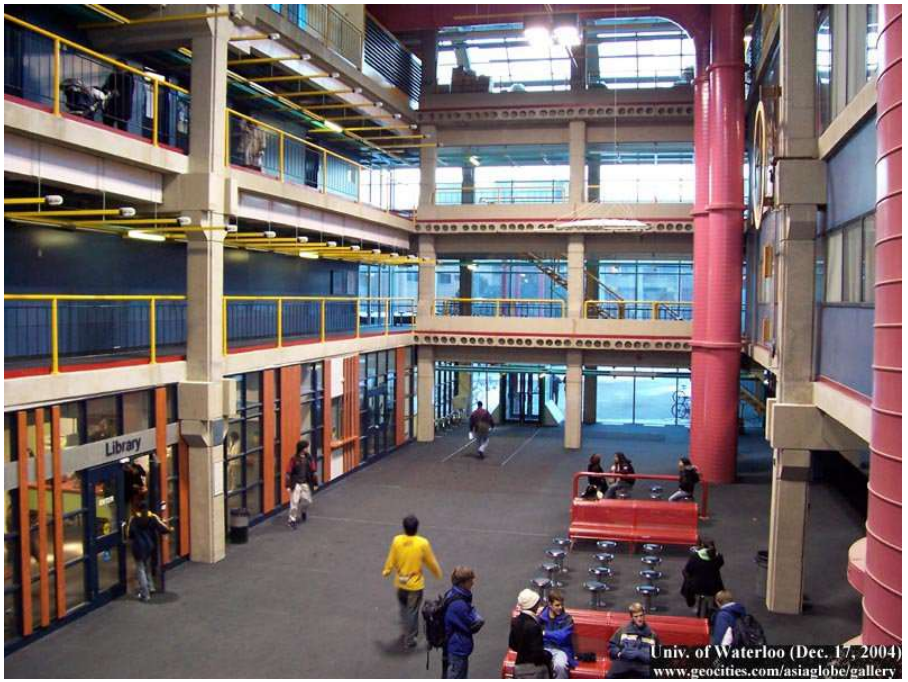
Evaluating Bi-Level Thresholding

- Reliability or perceived reliability …
  - Is it higher recognition or recognition strategy?
- Bi-level behavior …
  - How does bi-level thresholding perform on larger gesture sets?

User Reaction

- 5-gesture walking experiment





Just Noticeable Difference Experiment

- *Wizard-of-Oz Recognizer*
  - Controlled recognition rates of 50%, 60%, 70% for single threshold
  - Ensured *identical recognition rates* for bi-level thresholding

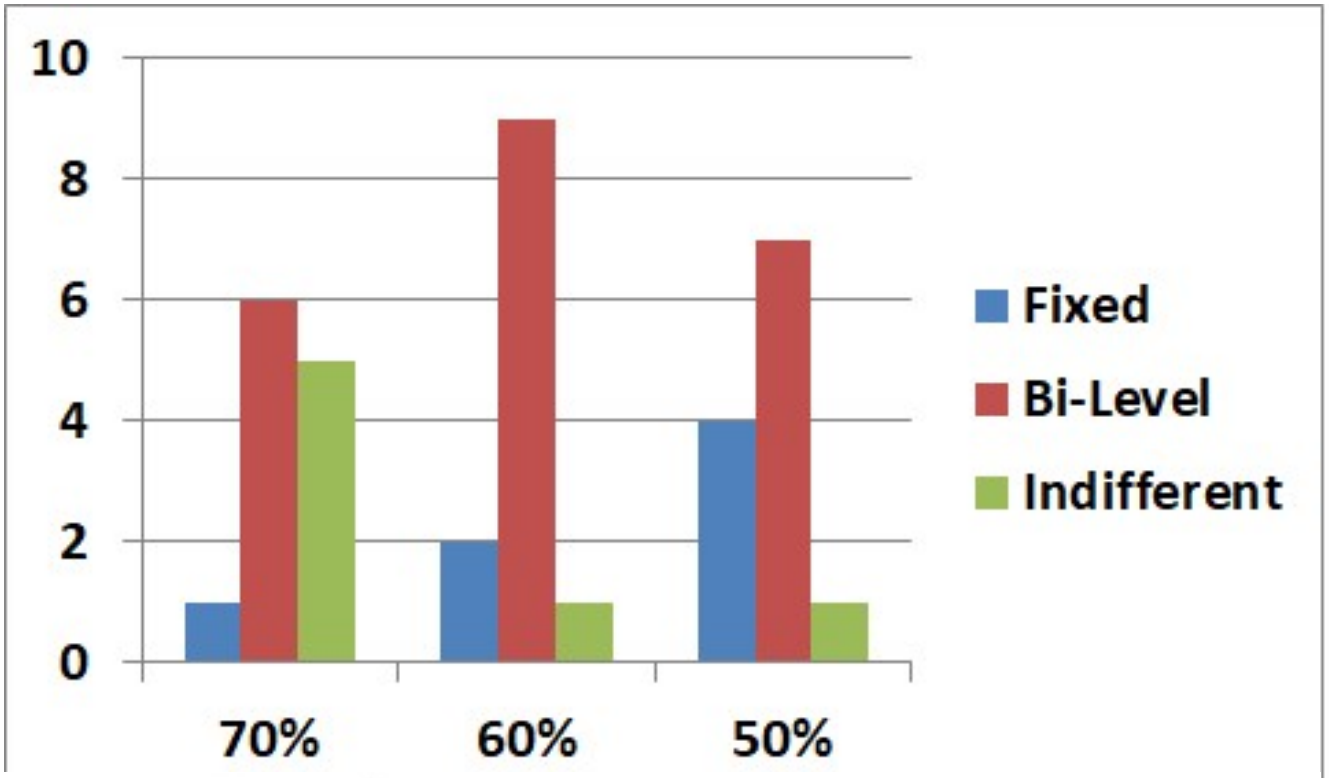
Experimental Design (2)

	Required attempts						total attempt
	1	2	3	4	5	6	
70%-Fixed	35	11	3	1			70
70%-Bi-level	30	20					70
60%-Fixed	30	12	5	2	1		82
60%-Bi-level	18	32					82
50%-Fixed	25	13	6	3	2	1	97
50%-Bi-level	0	50					100

Results: TLX

	Fixed	Bi-level	F	p
WWL	34.3	29.2	4.478	<.05
Mental Demand	25.1	25.2	0.003	.96
Physical Demand	31.1	29.5	0.267	.609
Temporal Demand	31.7	28.3	1.371	.250
Performance	28.9	19.2	8.352	<.01
Effort	33.0	28.0	2.198	.148
Frustration	32.8	29.1	1.304	.261

Results: User Preference

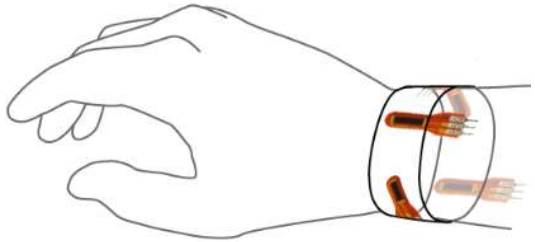


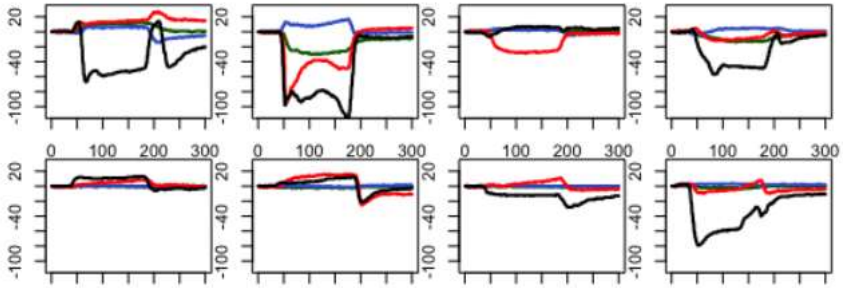
50%-Fixed	25	13	6	3	2	1
50%-Bi-level	0	50				

Same Work, Varied Preference

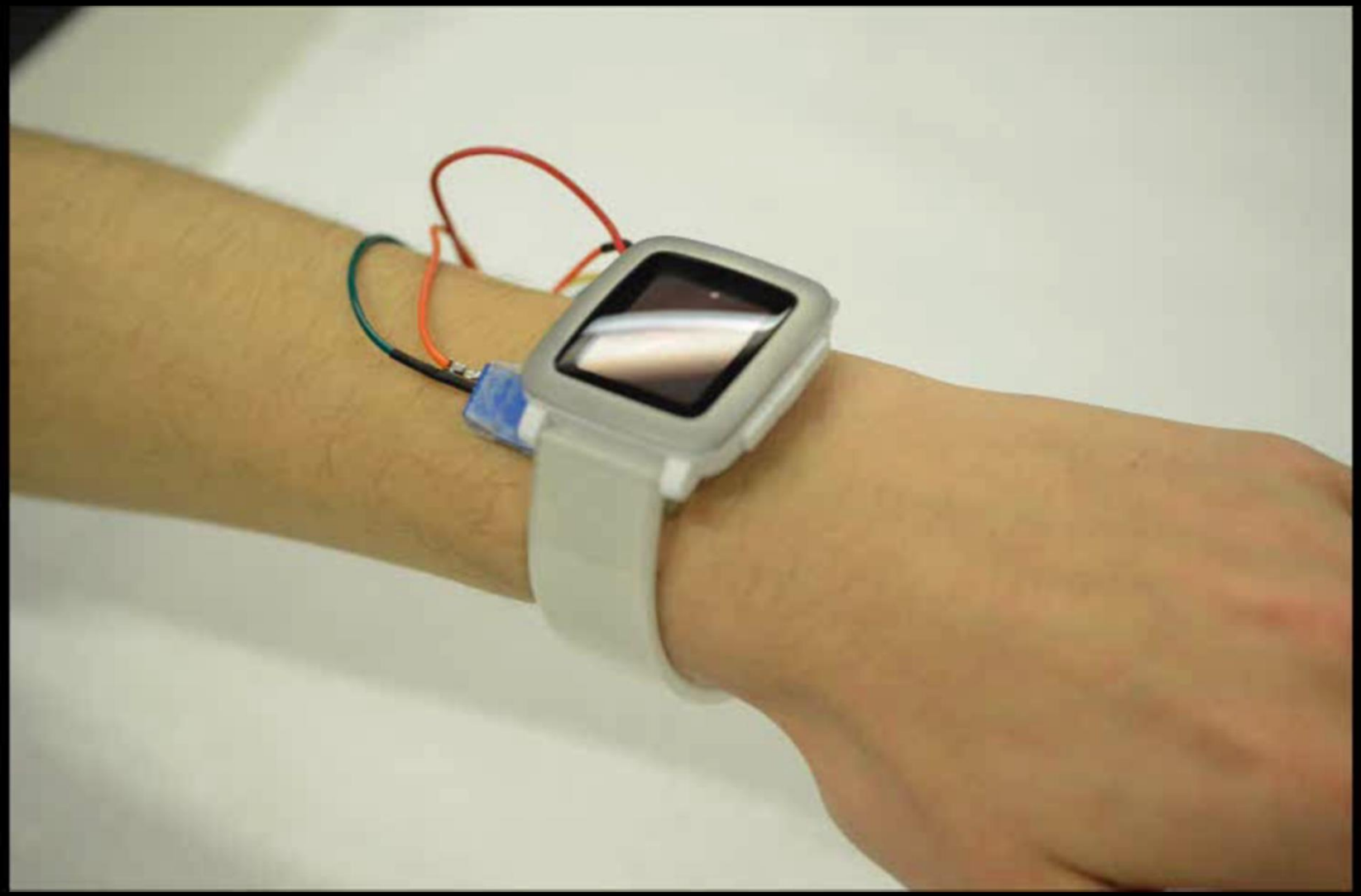
	Required attempts						total attempt
	1	2	3	4	5	6	
70%-Fixed	35	11	3	1			70
70%-Bi-level	30	20					70
60%-Fixed	30	12	5	2	1		82
60%-Bi-level	18	32					82
50%-Fixed	25	13	6	3	2	1	97
50%-Bi-level	0	50					100

Behavior: Hand Gestures



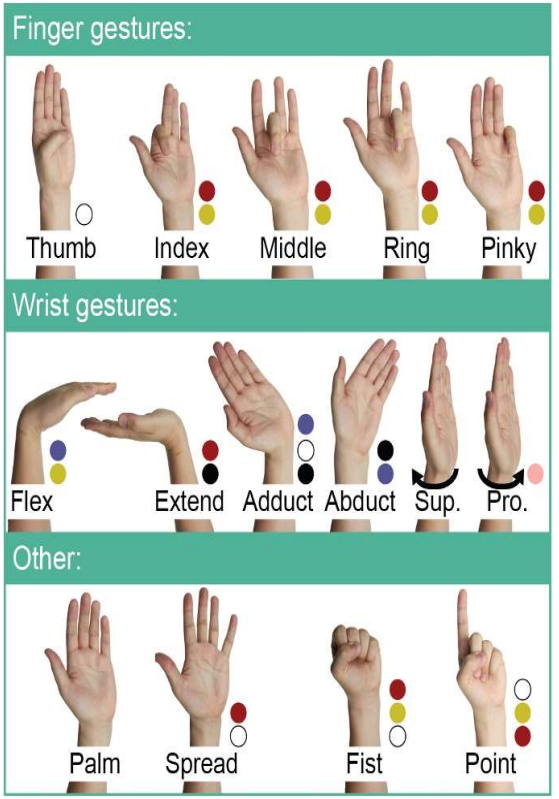


Subtle Hand/Finger Gestures

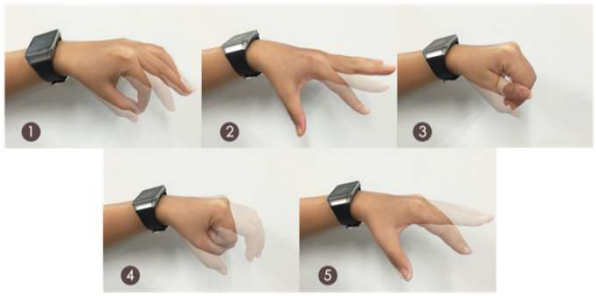


Gesture Set

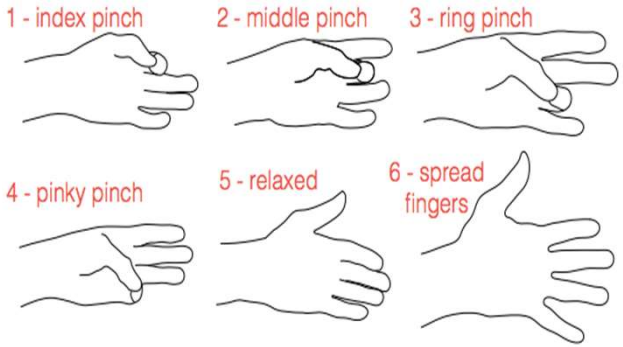
Empress, CHI 2016



Serendipity, CHI2016



WristFlex, UIST 2014

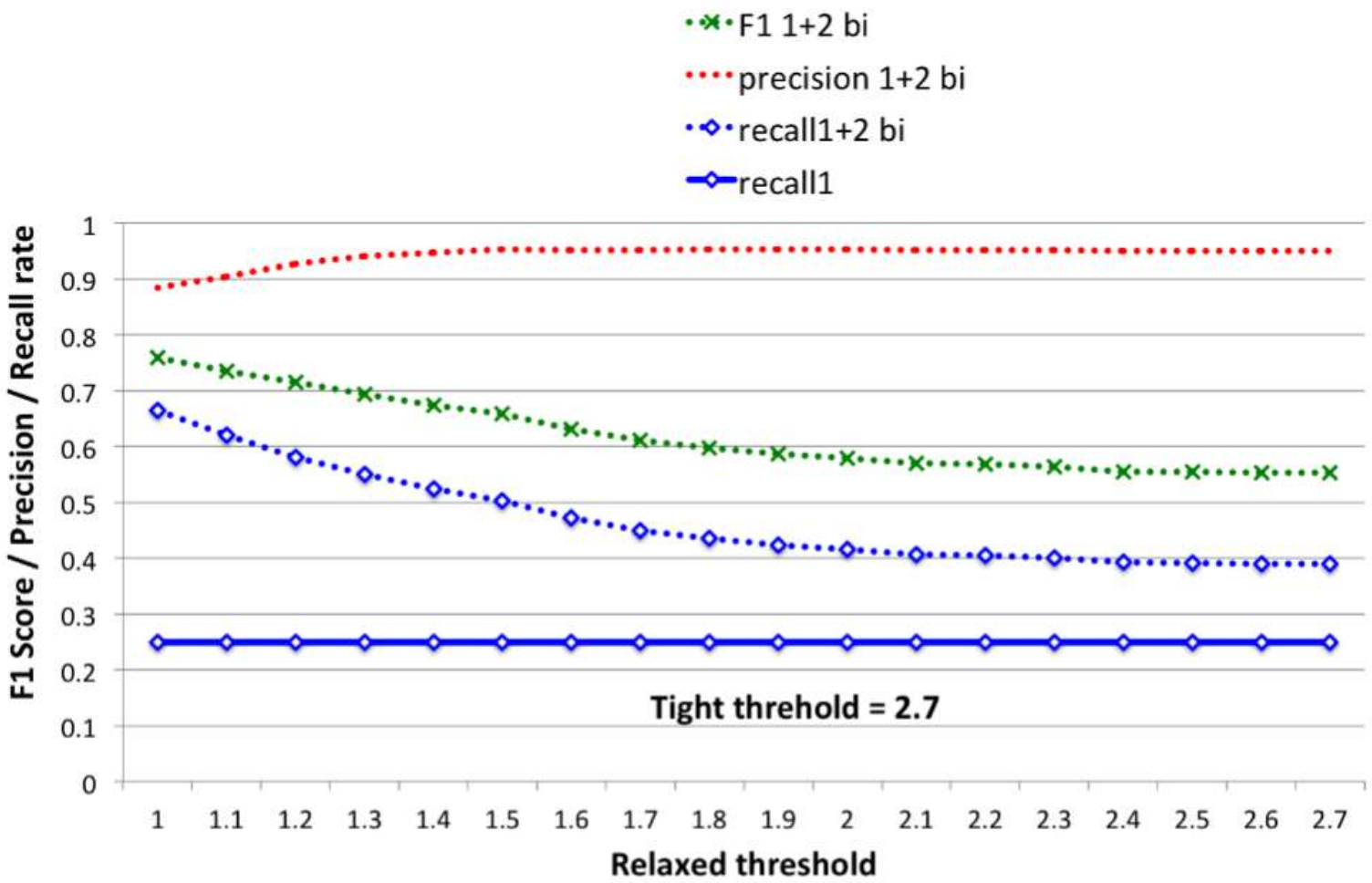


Tomo, UIST2016

Gesture Set

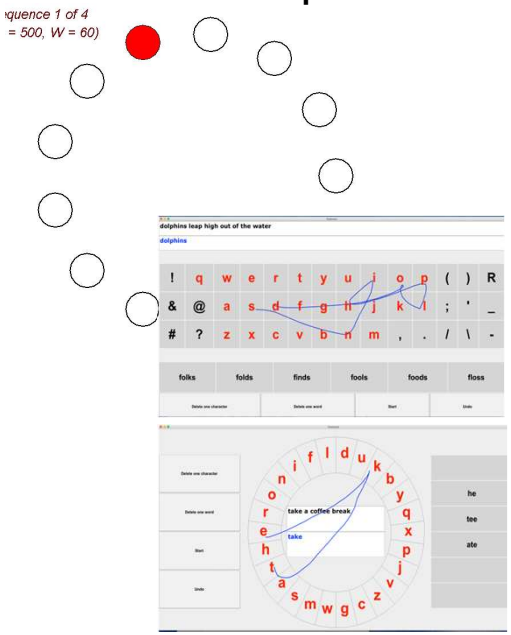

Finger Bends Gestures
1.Bend Thumb
2.Bend Index
3.Bend Middle
4.Bend Ring
5.Bend Pinky
Wrist Gestures
6.Flex
7.Extend
8.Adduct
9.Abduct
10.Sup.
11.Pro.
Hand Gestures
12.Relax
13.Spread
14.Fist
15.Point
16.Thumb-up
17.Spiderman
Tap and Dynamic Gestures
18.Tap Index
19.Tap Middle
20.Tap Ring
21.Tap Pinky
22. Rub
23.Wave
Finger to Thumb Pinch Gestures
24.Pinch Index
25.Pinch Middle
26.Pinch Ring
27.Pinch Pinky

Bi-Level Behavior



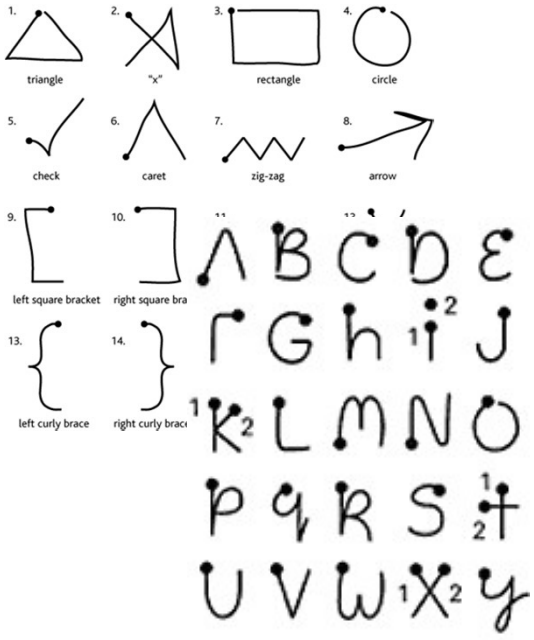
Wearables for
Transient, Subtle, Reliable Interactions

Manipulation and Text Input



AVI 2016, CHI 2018

Ideographic Gestures



DIS 2017

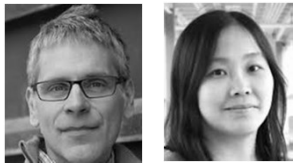
Finger Gestures

TIIS 2018

Colleagues + Students/Post-Docs

LOKI

Waterloo



Grad Students and Post-Docs

Wearables for Rich Subtle Transient Interactions

Yang Li, Sylvain Malacria, Mathieu Nancel, Keiko Katsuragawa, Dan Vogel, Jim Wallace, Krzysztof Pietroszek, Shaishav Siddhpuria, Edmund Liu, Jaime Ruiz, Ankit Kamal, Alec Azad, Matei Negulescu, Jane Henderson.

Questions?