TwistIn: Tangible Authentication of Smart Devices via Motion Co-analysis with a Smartwatch

Ho Man Colman Leung, Chi Wing Fu, Pheng Ann Heng

The Chinese University of Hong Kong, Hong Kong

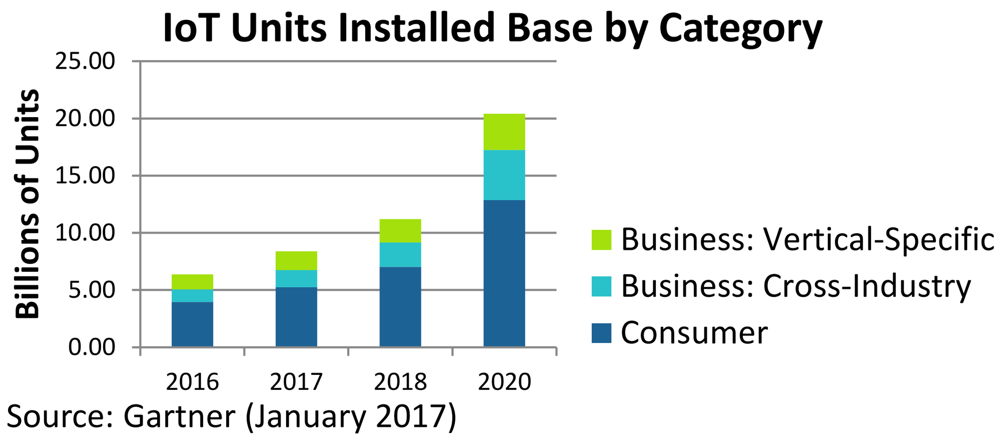
Shenzhen Key Laboratory of Virtual Reality and Human Interaction Technology, SIAT, CAS, China

UBICOMP 2018

8-12 October 2018 SINGAPORE

Motivation

Observation: There will be more connected devices in the future with smaller size and limited interface,



Source: Gartner (January 2017)

Bluetooth Tracker, Smart Glasses, Bluetooth Toy, Speaker, 360 Camera

but existing methods are ineffective.

Android Swipe Pattern, Apple's TouchID, Amazon Alexa, BB-8 Toy, Apple Watch Unlocking

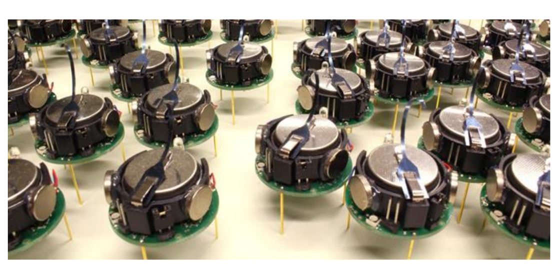
This motivates us to propose a simple gesture that takes a smartwatch as an authentication token for fast access and control of other smart devices.

Potential Applications

1. A smart mouse that can log into a computer without typing the username and password

Nintendo Switch Controller

2. A game controller (e.g., a Nintendo Switch controller) that allows a player to join in a game immediately with the player's profile and preference loaded automatically.



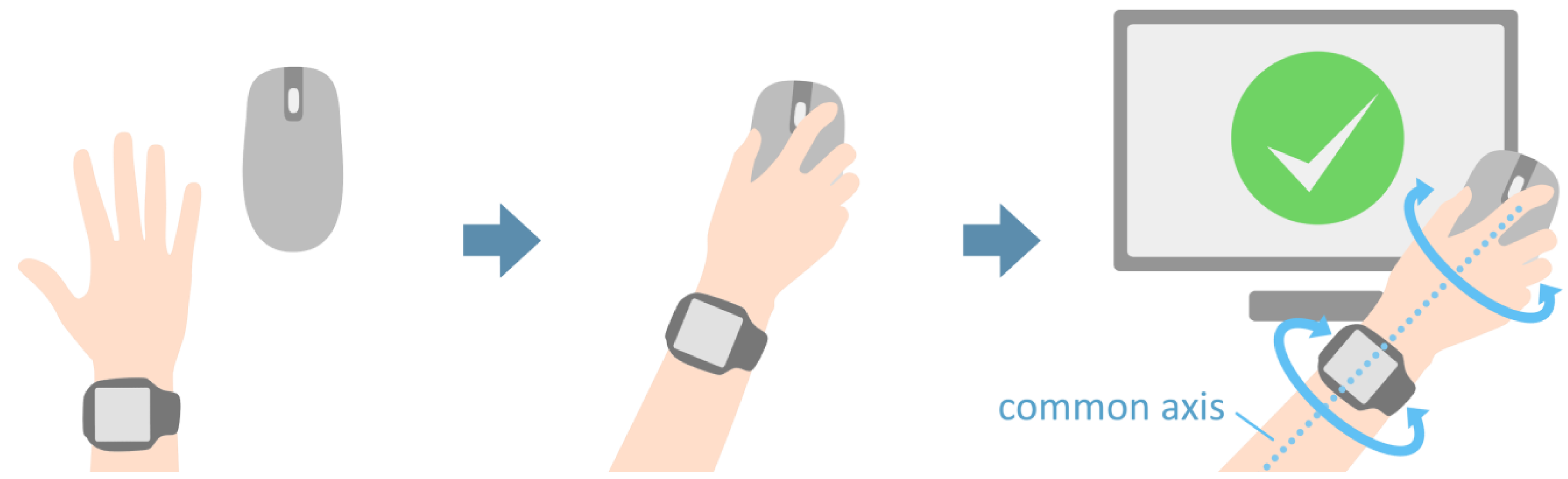
Kilobots Mike Rubenstein/Harvard University

3. Control and manipulate robot swarms

Mage Knight Board Game

4. A board game with the pieces embedded with electronics to support TwistIn and other tangible interactions

Method



1. The user is wearing an already-authenticated smartwatch
2. A smart device is picked up by the user
3. The user performs the TwistIn gesture simultaneously on both devices
4. The motions of the devices are co-analyzed
5. The smart device is authenticated

Challenges

People hold the devices differently and each device has its own reference frame.

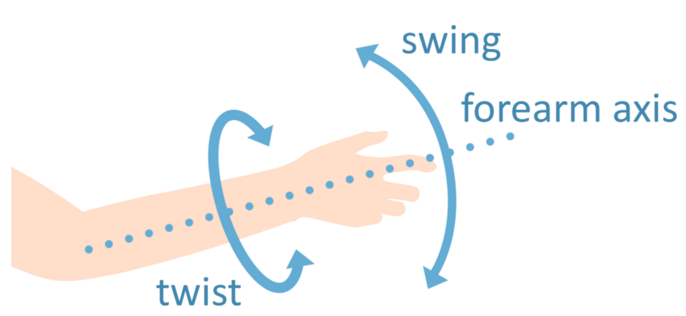
→ Optimize a transformation matrix to align two devices' motion data

$$\max_{r} \sum_{t \in T_{\text{basis}}} \langle \Delta q_A^t, r\ \Delta q_B^t\ r^{-1} \rangle$$

$$\text{subject to} \quad ||r|| = 1\ .$$

The data is noisy due to motion of the wrist joint

→ Filter out the unwanted motion by extracting the forearm rotation using rotation decomposition



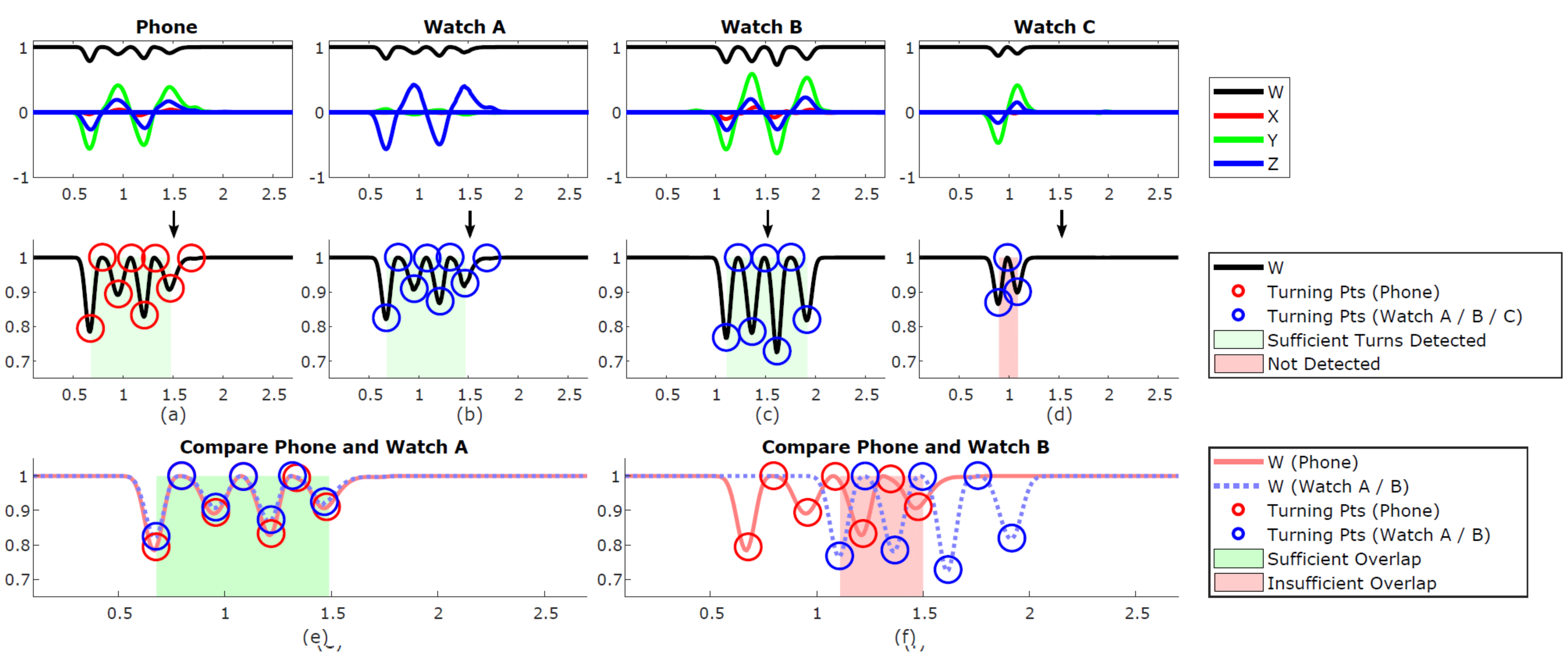
$$\max_{\vec{a_A}, \vec{a_B}, r} \sum_{t \in T_{\text{basis}}} \langle p_A^t, r\ p_B^t\ r^{-1} \rangle$$

$$\text{subject to} \quad ||\vec{a_A}|| = 1, ||\vec{a_B}|| = 1, \text{ and } ||r|| = 1,$$

$$\text{where } p_A^t = \frac{[w_A^t, (\vec{a_A} \cdot \vec{q}_A^t)\vec{a_A}]}{\sqrt{(w_A^t)^2 + (\vec{a_A} \cdot \vec{q}_A^t)^2}} \text{ and } p_B^t = \frac{[w_B^t, (\vec{a_B} \cdot \vec{q}_B^t)\vec{a_B}]}{\sqrt{(w_B^t)^2 + (\vec{a_B} \cdot \vec{q}_B^t)^2}}.$$

Devices that are stationary or not twisted at the same time should not be co-analyzed

→ A fast algorithm to prune away candidates having the gestures performed at different times.



Experiments

	Scenario	TPR	FPR	FNR	TNR
(i)	Sitting (w/ preferred hand)	0.9833	—	0.0167	—
(ii)	Sitting (w/ non-preferred hand)	0.9750	—	0.0250	—
(iii)	Standing (w/ preferred hand)	0.9833	—	0.0167	—
(vi)	Attacking (w/ preferred hand)	—	0.0583	—	0.9417
(v)	Sitting (w/ preferred hand)	0.9917	—	0.0083	—
	Overall	0.9833	0.0583	0.0167	0.9417

Method	TPR	TNR	EER
ShakeUnlock	0.637	0.677	0.343
TwistIn	0.983	0.941	0.037

User Study

- Users enjoyed using TwistIn to log in and access devices.
- Our method is preferred over many other existing methods
- Provides an alternative method that can complement each other

The work is supported by the Shenzhen Science and Technology Program (No. JCYJ20170413162617606), Shenzhen Key Laboratory (No. ZDSYS201605101739178), the Hong Kong Research Grants Council under General Research Fund - Project No. 14225616, and the CUHK strategic recruitment fund.