Smartwatch/Wearable Interaction

Huaishu Peng | UMD CS | Fall 2023
1972, first digital watch
Hamilton Watch Company and
Electro/Data Inc

1985, Epson RC-20 Wrist Computer
Calculator, Memo, 2K RAM and a
Touchscreen

1999, Samsung SPH-WP10
Smartwatch that can make calls
Fat-finger syndrome
Small screen
One hand operation
Between devices interaction
Anything that a smartwatch can do but a smartphone can’t?

2015, Apple Watch
What if your hand is occupied

Your solution?
Electromyography (EMG) Sensor

2008, Daito Manabe
https://www.youtube.com/watch?v=YxdIYFCp5Ic
EMG Sensor

Enabling Always-Available Input with Muscle-Computer Interfaces

T. Scott Saponas1, Jonny D. Tiu1, Dan Morris2, Karin Bikelidh2, Ian Turner1, James A. Landay1
1Computer Science and Engineering, Microsoft Research
2Department of OBE/Group, University of Washington
jonny.d.tiu@microsoft.com

ABSTRACT
Previous work has explored hand-free and improrunitive technique based on a variety of methods, including EMG. This paper presents a flexible, lightweight, and portable interactive interface that can be used to control computers and other devices. The interface allows users to move their arms in real-time and interact with the system by moving their arms. The system can be used to control devices such as keyboards, mice, and touchpads. The system is designed to be easy to use and to be compatible with existing systems.

UIST 2009
Saponas et al. from MSR
MyoWare 2.0 Muscle Sensor

$39.95

Volume sales pricing

We do not currently have an estimate of when this product will be back in stock. Notify Me

Note: If this item is available for backorder it is subject to price changes at any time; additionally, we are unable to guarantee time frame for shipping or availability.

Quantity discounts available

DESCRIPTION

Using our muscles to control things is the way that most of us are accustomed to doing it. We push buttons, pull levers, move joysticks... but what if we could take the buttons, levers and joysticks out of the equation and control it with our muscles? The MyoWare® 2.0 Muscle Sensor is an Arduino-compatible, all-in-one electromyography (EMG) sensor from Advancer Technologies that allows you to do just that! The MyoWare 2.0 Muscle Sensor has been redesigned from the ground up with a

Myo Wristband ~$300+
What if your hand is occupied

Your solution?
Contribution

One hand input

Continuous 2D input

Keeping the screen stable
WristWhirl: One-handed Continuous Smartwatch Input using Wrist Gestures

Will the wrist input be useful?
Study before building
    -- using external Vicon Tracker
WristWhirl: One-handed Continuous Smartwatch Input using Wrist Gestures

Exploring the concept feasibility before implementation

8 gestures
Hand down while standing/walking
Hand up while standing/walking
WristWhirl: One-handed Continuous Smartwatch Input using Wrist Gestures

Exploring the concept feasibility before implementation

Time takes to complete each task

![Graph showing mean time for different hand positions and gestures]
WristWhirl: One-handed Continuous Smartwatch Input using Wrist Gestures

Exploring the concept feasibility before implementation
Implementation

What are the possible techniques we can use to detect wrist gestures?

- IR arrays
- Liton LT E-301

Piezo Vibration Sensor - Small Horizontal

$2.95

Volume sales pricing

ADD TO CART

DESCRIPTION

The Minisense 100 from Measurement Specialties is a low-cost cantilever-type vibration sensor loaded by a mass to offer high sensitivity at low frequencies. Useful for detecting vibration and ‘tap’ inputs from a user. A small AC and large voltage (up to +/-90V) is created when the film moves back and forth. A simple resistor should get the voltage down to ADC levels. Can also be used for impact sensing or a flexible switch.

Comes with machine pins that allows for horizontal mounting.
WristWhirl: One-handed Continuous Smartwatch Input using Wrist Gestures

Implementation
WristWhirl: One-handed Continuous Smartwatch Input using Wrist Gestures

Recognition -> $1 Unistroke Recognizer

http://depts.washington.edu/madlab/proj/dollar/index.html
WristWhirl: One-handed Continuous Smartwatch Input using Wrist Gestures

Application
WristWhirl: One-handed Continuous Smartwatch Input using Wrist Gestures

Application
Killer app?
Fat-finger syndrome
Small screen
One hand operation
Between devices interaction
Anything that a smartwatch can do but a smartphone can’t?
SkinTrack: Using the Body as an Electrical Waveguide for Continuous Finger Tracking on the Skin

Interaction on skin
Continuous touch tracking
Non-obtrusive
SkinTrack: Using the Body as an Electrical Waveguide for Continuous Finger Tracking on the Skin

Will IR array work?
SkinTrack: Using the Body as an Electrical Waveguide for Continuous Finger Tracking on the Skin

Solution
SkinTrack: Using the Body as an Electrical Waveguide for Continuous Finger Tracking on the Skin

Sensing principle
SkinTrack: Using the Body as an Electrical Waveguide for Continuous Finger Tracking on the Skin

Sensing principle

\[ \lambda = \text{wave speed/frequency} \]

or

\[ \lambda = \frac{v}{f} \]

- Frequency: 80MHz AC signal
- Speed: \( 7.3 \times 10^7 \) m/s
- Length: 91cm wavelength
- 1cm equals 4 degree phase shift
SkinTrack: Using the Body as an Electrical Waveguide for Continuous Finger Tracking on the Skin

Hardware

Ring: 80MHz oscillator
110 mAh
15h battery life

Band: 4 electrode pairs
SkinTrack: Using the Body as an Electrical Waveguide for Continuous Finger Tracking on the Skin

Evaluation

![Diagram showing different body parts and button diameters](image)

- Back Arm
- Back Hand (Palm Down)
- Front Arm
- Front Hand (Palm Up)
SkinTrack: Using the Body as an Electrical Waveguide for Continuous Finger Tracking on the Skin

Application
Fat-finger syndrome
Small screen
One hand operation
Between devices interaction
Anything that a smartwatch can do but a smartphone can’t?
ViBand: High-Fidelity Bio-Acoustic Sensing Using Commodity Smartwatch Accelerometers

Gesture detection

Object detection

All with built-in sensors
ViBand: High-Fidelity Bio-Acoustic Sensing Using Commodity Smartwatch Accelerometers

Sensing principle

Existing Accelerometers: 100Hz
ViBand: High-Fidelity Bio-Acoustic Sensing Using Commodity Smartwatch Accelerometers

Sensing principle

At this incredibly high speed, we can detect micro-vibrations propagating through the arm.

Typical Use: 100Hz
ViBand: 4000Hz
3900% Increase
ViBand: High-Fidelity Bio-Acoustic Sensing Using Commodity Smartwatch Accelerometers

Sensing principle

Use the high-speed mode of existing accelerometer

Only need to modify it’s kernel – pure software solution!
ViBand: High-Fidelity Bio-Acoustic Sensing Using Commodity Smartwatch Accelerometers

Implementation
ViBand: High-Fidelity Bio-Acoustic Sensing Using Commodity Smartwatch Accelerometers

Implementation

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>Units</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUPPLY VOLTAGES</td>
<td></td>
<td>1.71</td>
<td>1.6</td>
<td>3.45</td>
<td>V</td>
<td>1</td>
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<tr>
<td>VDD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>VDDIO</td>
<td></td>
<td>1.71</td>
<td>1.6</td>
<td>3.45</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>SUPPLY CURRENTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Normal Mode</td>
<td>6-axis</td>
<td></td>
<td>3.4</td>
<td>mA</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3-axis Gyroscope</td>
<td></td>
<td>3.2</td>
<td>mA</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-Axis Accelerometer</td>
<td></td>
<td>450</td>
<td>μA</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>Acclerometer Low Power Mode</td>
<td>0.06 Hz update rate</td>
<td></td>
<td>7.27</td>
<td>μA</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>31.25 Hz update rate</td>
<td></td>
<td>16.65</td>
<td>μA</td>
<td>1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standby Mode</td>
<td></td>
<td>1.6</td>
<td>mA</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>Full-Chip Sleep Mode</td>
<td></td>
<td>6</td>
<td>μA</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| TEMPERATURE RANGE | | | | | | |
| Specified Temperature Range | Performance parameters are not applicable beyond Specified Temperature Range | -40 | +85 | °C | 1 |

Table 3: D.C. Electrical Characteristics

Notes:
1. Derived from validation or characterization of parts, not guaranteed in production.
2. Accelerometer Low Power Mode supports the following output data rates (ODRs): 0.24, 0.49, 0.98, 1.95, 3.91, 7.81, 15.63, 31.25, 62.50, 125, 250, 500Hz. Supply current for any update rate can be calculated as:
   a. Supply Current in μA = 6.9 + Update Rate * 0.376
ViBand: High-Fidelity Bio-Acoustic Sensing Using Commodity Smartwatch Accelerometers

Implementation
ViBand: High-Fidelity Bio-Acoustic Sensing Using Commodity Smartwatch Accelerometers

Gestures
ViBand: High-Fidelity Bio-Acoustic Sensing Using Commodity Smartwatch Accelerometers

Gestures
ViBand: High-Fidelity Bio-Acoustic Sensing Using Commodity Smartwatch Accelerometers

Object detections

<table>
<thead>
<tr>
<th>ID</th>
<th>OBJECT</th>
<th>BIO-AcouSTIC SIGNAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Seagull S6 Acoustic Guitar</td>
<td><img src="image1.png" alt="Graph" /></td>
</tr>
<tr>
<td>B</td>
<td>Oster BRYL07-B Blender</td>
<td><img src="image2.png" alt="Graph" /></td>
</tr>
<tr>
<td>C</td>
<td>Wagner HT100 Heat Gun</td>
<td><img src="image3.png" alt="Graph" /></td>
</tr>
<tr>
<td>D</td>
<td>2015 Dodge Avenger</td>
<td><img src="image4.png" alt="Graph" /></td>
</tr>
<tr>
<td>E</td>
<td>Krups Fast Coffee Grinder</td>
<td><img src="image5.png" alt="Graph" /></td>
</tr>
<tr>
<td>F</td>
<td>Dremel 300 EZ Twist</td>
<td><img src="image6.png" alt="Graph" /></td>
</tr>
<tr>
<td>G</td>
<td>Ryobi Drill Press DP102L</td>
<td><img src="image7.png" alt="Graph" /></td>
</tr>
<tr>
<td>H</td>
<td>Craftsman Motion Sander</td>
<td><img src="image8.png" alt="Graph" /></td>
</tr>
<tr>
<td>I</td>
<td>BH9600 Dust Buster</td>
<td><img src="image9.png" alt="Graph" /></td>
</tr>
<tr>
<td>J</td>
<td>Lasko 12” Table Fan</td>
<td><img src="image10.png" alt="Graph" /></td>
</tr>
<tr>
<td>K</td>
<td>Ryobi BGS12G Grinder</td>
<td><img src="image11.png" alt="Graph" /></td>
</tr>
<tr>
<td>L</td>
<td>Metal Hack Saw</td>
<td><img src="image12.png" alt="Graph" /></td>
</tr>
<tr>
<td>M</td>
<td>Conei Ionic Hair Dyer</td>
<td><img src="image13.png" alt="Graph" /></td>
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<tr>
<td>N</td>
<td>Black&amp;Decker Hand Drill</td>
<td><img src="image14.png" alt="Graph" /></td>
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<tr>
<td>O</td>
<td>Wood Hand File</td>
<td><img src="image15.png" alt="Graph" /></td>
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<td>P</td>
<td>Hamilton Hand Mixer</td>
<td><img src="image16.png" alt="Graph" /></td>
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<tr>
<td>Q</td>
<td>Apple iPhone 5C</td>
<td><img src="image17.png" alt="Graph" /></td>
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<tr>
<td>R</td>
<td>HP LaserJet 9050</td>
<td><img src="image18.png" alt="Graph" /></td>
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<tr>
<td>S</td>
<td>LG Motion 4G</td>
<td><img src="image19.png" alt="Graph" /></td>
</tr>
<tr>
<td>T</td>
<td>Shop-Vac Micro 202100</td>
<td><img src="image20.png" alt="Graph" /></td>
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<tr>
<td>U</td>
<td>Panasonic 950 Microwave</td>
<td><img src="image21.png" alt="Graph" /></td>
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<tr>
<td>V</td>
<td>Honda 250C Motorcycle</td>
<td><img src="image22.png" alt="Graph" /></td>
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<td>W</td>
<td>Swingline Staple Gun</td>
<td><img src="image23.png" alt="Graph" /></td>
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<tr>
<td>X</td>
<td>Irwin Wood Saw</td>
<td><img src="image24.png" alt="Graph" /></td>
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<tr>
<td>Y</td>
<td>DeWalt Power Drill</td>
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<tr>
<td>Z</td>
<td>B&amp;D Mouse Sander</td>
<td><img src="image26.png" alt="Graph" /></td>
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<tr>
<td>α</td>
<td>Sonicare Toothbrush</td>
<td><img src="image27.png" alt="Graph" /></td>
</tr>
<tr>
<td>β</td>
<td>Shop-Vac 5 Gallon</td>
<td><img src="image28.png" alt="Graph" /></td>
</tr>
<tr>
<td>γ</td>
<td>Hot Wheels Toy Car</td>
<td><img src="image29.png" alt="Graph" /></td>
</tr>
</tbody>
</table>
ViBand: High-Fidelity Bio-Acoustic Sensing Using Commodity Smartwatch Accelerometers

Object detections
Cito: An Actuated Smartwatch for Extended Interactions

Gong et.al. from Dartmouth
Cito: An Actuated Smartwatch for Extended Interactions

Will this concept be useful?

Generate design space  ➔  Create low-fi model  ➔  Study before implementation
Cito: An Actuated Smartwatch for Extended Interactions

Exploring the concept feasibility before implementation
Cito: An Actuated Smartwatch for Extended Interactions

Exploring the concept feasibility before implementation

Scenarios:

Carry heavy obj
Exposure to dust
Covered with sleeve
Gaming with notification
Missing notification
Multitasking
Sharing
...

[Image of a person holding papers or scrolls]
Cito: An Actuated Smartwatch for Extended Interactions

Exploring the concept feasibility before implementation

Scenarios:

Potential solutions for each of the scenarios – 7 point Likert scale rating

T1 (reorienting face)
Cito: An Actuated Smartwatch for Extended Interactions

Exploring the concept feasibility before implementation

Scenarios:

Using videos allowed our study to be highly controlled as participants had to saw the same demos.

The videos also encouraged “suspension of disbelief”, allowing them to focus on the Cito concept, rather than implementation details.

Potential solutions for each of the scenarios – 7 point Likert scale rating
Cito: An Actuated Smartwatch for Extended Interactions

Exploring the concept feasibility before implementation

Scenarios:

Potential solutions for each of the scenarios – 7 point Likert scale rating
Cito: An Actuated Smartwatch for Extended Interactions

Implementation

The hinge-translate module
Cito: An Actuated Smartwatch for Extended Interactions

Implementation

The orbit-rotate module
Cito: An Actuated Smartwatch for Extended Interactions

Plastic Planetary Micro DC Motor with OD: 6mm L: 16.3/18.8/21mm 3VDC / L: 16.3mm / Gear Ratio: 26
from Firgelli Automations

These micro planetary motors are made with plastic gears at low speed and low noise but high torque comparatively speaking. They are commonly used in medical field. However, ...

See more details at Firgelli Automations »

$12.20

+$14.88 shipping. No tax

Firgelli Automations

Visit site
Cito: An Actuated Smartwatch for Extended Interactions

Plastic Gear Package 62 Kinds Of Motor Gear Gearbox Robot Model Accessories Diy
from eBay - 0059627
plastic gear package 62 kinds of motor gear gearbox robot model accessories DIY 0059627
Description: 62 kinds of gear pack: Spindle motor gear: 12 kinds Single gear: 19 kinds ...
See more details at eBay - 0059627 »

$4.89
+$1.60 shipping. No tax
eBay - 0059627

Visit site
Cito: An Actuated Smartwatch for Extended Interactions
Fat-finger syndrome
Small screen
One hand operation
Between devices interaction
Anything that a smartwatch can do but a smartphone can’t?
We present the first fully-functional and self-contained projected touch interface, LumiWatch, that directly projects graphics and touch input on the back of a user's arm. LumiWatch is a wearable device that projects interactive applications onto the user’s arm, enabling users to interact with the projected content using their fingers. This new form factor for projected interfaces offers several advantages over traditional touch interfaces, including increased privacy and reduced clutter. Our approach leverages the natural interaction space and the unique properties of the human arm to enable intuitive and engaging interaction with projected content. LumiWatch demonstrates the feasibility and potential of using the human body as an interface, opening up new possibilities for wearable and interactive computing.
LumiWatch: On-Arm Projected Graphics and Touch Input

Previous “work”

With the Cicret Bracelet,
LumiWatch: On-ArmProjected Graphics and Touch Input

System overview

Adafruit VL6180X Time of Flight Distance Ranging Sensor (VL6180)

$13.95 from Adafruit Industries 89% positive (4,446)

The VL6180X (sometimes called the VL6180) is a Time of Flight distance sensor like no other you've used! The sensor contains a ...
LumiWatch: On-Arm Projected Graphics and Touch Input

System overview

Adafruit VL6180X Time of Flight Distance Ranging Sensor (VL6180)
$13.95 from Adafruit Industries 89% positive (4,446)

The VL6180X (sometimes called the VL6180) is a Time of Flight distance sensor like no other you've used! The sensor contains a ...

Time of Flight Principle (simplified)

light bounces of nearby objects and reflects back
measure time until the light hits the sensor
closer objects = less time until the light reaches them
far away objects = more time until the light reaches them
LumiWatch: On-Arm Projected Graphics and Touch Input

System overview

Adafruit VL6180X Time of Flight Distance Ranging Sensor (VL6180)

$13.95 from Adafruit Industries 89% positive (4,446)

The VL6180X (sometimes called the VL6180) is a Time of Flight distance sensor like no other you've used! The sensor contains a ...

$$d = \frac{c \times \Delta t}{2}$$

Time of Flight Principle (simplified)
LumiWatch: On-Arm Projected Graphics and Touch Input

System overview

Time of Flight Principle (simplified)
### System overview

**mini Interactive projector module make any projector interactive for kids**

<table>
<thead>
<tr>
<th>Place of Origin</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brand Name</td>
<td>Hivista</td>
</tr>
<tr>
<td>Model Number</td>
<td>IM-300</td>
</tr>
<tr>
<td>Certification</td>
<td>CE, FCC, RoHS</td>
</tr>
<tr>
<td>Focus length</td>
<td>long focus</td>
</tr>
<tr>
<td>Function</td>
<td>make any projectors to interactive</td>
</tr>
<tr>
<td>Projected size</td>
<td>10~150 inch</td>
</tr>
<tr>
<td>Strength</td>
<td>Small volume, easy to carry, for teaching</td>
</tr>
<tr>
<td>Interface</td>
<td>USB port</td>
</tr>
<tr>
<td>Max users</td>
<td>64 person</td>
</tr>
<tr>
<td>Transmission FPS</td>
<td>65~70 frame/sec</td>
</tr>
<tr>
<td>Positioning accuracy</td>
<td>4096*4096</td>
</tr>
<tr>
<td>Application</td>
<td>education and business</td>
</tr>
<tr>
<td>OEM</td>
<td>welcome</td>
</tr>
<tr>
<td>Usage</td>
<td>education in school</td>
</tr>
<tr>
<td>Price</td>
<td>55-98 dollars per pc</td>
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<td>Packaging Details</td>
<td>negotiable</td>
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<td>Delivery Time</td>
<td>negotiable</td>
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<tr>
<td>Payment Terms</td>
<td>T/T, Western Union, PayPal</td>
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<tr>
<td>Supply Ability</td>
<td>3000/month</td>
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<tr>
<td>MOQ</td>
<td>50</td>
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</tbody>
</table>
LumiWatch: On-Arm Projected Graphics and Touch Input

System overview
LumiWatch: On-Arm Projected Graphics and Touch Input

Finger tracking
LumiWatch: On-Arm Projected Graphics and Touch Input

We present the first fully functional and self-contained projection smartwatch.
Recap

IR array for 1D sensing

IR ToF for 2D sensing

EM wave for 2D sensing

High frequency Accelerometer for micro-vibration sensing

(all very affordable, and you can try with your Arduino)

Material is in part based on the lectures by Prof. Cheng Zhang at Cornell
Calico: Relocatable Oncloth Wearables with Fast, Reliable, and Precise Locomotion

ANUP SATIYA, University of Maryland, College Park, USA
JAMSHIDI, University of Maryland, College Park, USA
TALHIDUR RAHMAN, University of California, San Diego, USA
G. GAO, University of Maryland, College Park, USA
HUMPHU FENG, University of Maryland, College Park, USA

Fig. 1: Calico system deployed on a user. (a) Calico wearable on the outer, (b) Calico robot moving on the pants. Different colored tracks can be used to blend into clothing. (c) Calico moving towards a target to switch tracks. (d) Running while wearing the Calico system.

We explore Calico, a locomotive relocatable wearable system with fast and precise locomotion for on-body interaction, actuation and sensing. Calico consists of a smart chest robot and an on-body track mechanism or "tracks" on which the robot travels. The robot is self-contained, small in size, and has additional torso actuation options. The body tracks affect the robot's motion and body feedback such as pressure and vibration. A user can control the robot's moving direction, speed and shape in real-time. We developed a novel control approach for Calico, combining two different control techniques for system performance. We then present a few application scenarios, and user studies to demonstrate the potential of Calico as a novel wear and also exploits the qualitative perception of our users to evaluate future research in this space.

CCS Concepts: Human-centered computing → Ubiquitous and mobile devices; Interaction devices; Mobile computing.

Additional Key Words and Phrases: wearable computing, eligant computing, artistic wearable, wearable computing, interactive computing.

Authors: Sathiya, University of Maryland, College Park, Department of Computer Science, USA; Sanghavi, University of Maryland, College Park, Department of Computer Science, USA; Hui, University of Maryland, College Park, Department of Computer Science, USA; Song, University of Maryland, College Park, Department of Computer Science, USA; Jia, University of Maryland, College Park, Department of Computer Science, USA; Peng, University of Maryland, College Park, Department of Computer Science, USA;

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IMWUT 22

Sathiya et.al.
Duet: Exploring Joint Interactions on a Smart Phone and a Smart Watch

Xiang \textit{Anthony} \textsuperscript{1} Chen \textsuperscript{1,2}, Tort Goomaan \textsuperscript{1,2}, Daniel Wigdor \textsuperscript{2}, George Fitzmaurice \textsuperscript{1}

\textsuperscript{1}User Interface Group, Autodesk Research
\textsuperscript{2}RI Institute, Carnegie Mellon University

ABSTRACT
The emergence of smart devices (e.g., smart watches and smart eyewear) is reinventing mobile interaction from the solo performance of a smart phone, to a symphony of multiple devices. In this paper, we present Duet—an innovative system that explores a design space of interactions between a smart phone and a smart watch. Based on the devices’ spatial configurations, Duet coordinates that motion and touch input, and combines their visual and tactile output to one another. This transforms the watch into an active element that enhances a wide range of phone-based interactive tasks, and enables a new class of multi-device gestures and sensing techniques. A technical overview shows the accuracy of these gestures and sensing techniques, and a subjective study on Duet provides insights, observations, and guidelines for future work.

CHI 2014

chen et.al. from CMU & Autodesk

BeamBand: Hand Gesture Sensing with Ultrasonic Beamforming

Yasha Iravantchi Mayank Goel Chris Harrison

Carnegie Mellon University, Human-Computer Interaction Institute
3800 Forbes Avenue, Pittsburgh, PA 15213

ABSTRACT
BeamBand is a wrist-worn system that uses ultrasonic beamforming for hand gesture sensing. Using an array of small transducers, arranged on the wrist, we can ensemble acoustic wavefronts to project acoustic energy at specified angles and focal lengths. This allows us to interrogate the surface geometry of the hand with insensate sound in a raster-scanner-like manner, from multiple viewpoints. We use the resulting, characteristic reflections to recognize hand pose at 8 FPS. In our user study, we found that BeamBand supports a six-class hand gesture set at 94.6% accuracy. Even across sessions, when the sensor is removed and re-worn later, accuracy remains high: 89.3%. We describe our software and hardware, and future avenues for integration into devices such as smartwatches and VR controllers.

CCS CONCEPTS
Human-centered computing → Human-computer interaction (HCI) → Interaction techniques → Gestural input

KEYWORDS
Hand Input, Hand Gesture, Acoustic Reflectionometry, Acoustic Beamforming, Acoustic Interaction Techniques, Wristbands

Optional readings

Session: Watches and Small Devices

CHI 2014, One of a CHFrid, Toronto, ON, Canada

CHI 2019

Irvantchi et.al.