WatchSense
On- and Above-Skin Input Sensing through a Wearable Depth Sensor

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Selected Previous Work

**Touch**
- **AuraSense (UIST 2016)**
- **SkinTrack (CHI 2016)**
- **WatchMI (MobileHCI 2016)**
- **OmniTouch (UIST 2011)**

**Mid-air**
- **Digits (UIST 2012)**
- **Sridhar et al. (CVPR 2015)**

**Mid-air + Touch**
- **Air+Touch (UIST 2014)**
- **WatchSense (Ours)**
Goals & Challenges

- **3D fingertip positions**
- Fingertip **identities**
- **Touch** on the BOH

- Oblique view of BOH
- Occlusions
- Finger ambiguity
1. FINGERTIP DETECTION

FILTERED DEPTH MAP

2. TOUCH DETECTION

Technical Implementation
1. Fingertip Detection

TRAINING DATA

Hand segmentation: 20,000 images
Fingertip detection: 60,000 images

HAND SEGMENTATION

without: **76%**
with: **84%**

FINGERTIP DETECTION FOREST

\[ f(I, x) = \frac{d_I \left( x + \frac{u}{d_I(x)} \right) - d_I \left( x + \frac{v}{d_I(x)} \right)}{\tau} \]

2. Touch Detection

MID-AIR + MID-AIR

FLOOD FILLING

MID-AIR + TOUCH

TOUCH + MID-AIR

TOUCH TOLERANCE

1-10 mm

OmniTouch (UIST 2011)
20 mm
**6.8 mm average deviation**

**OmniTouch (UIST 2011)**

16.2 mm
Real-time Performance

INTEL REALSENSE

CREATIVE SENZ3D

PMD PICOFLEXX
INPUT SENSING

- Index Finger
- Thumb

Back of the Hand (BOH)

Depth Sensor

NOVEL INPUT CAPABILITIES

- Thumb Touch
- Thumb Mid-Air
- Index Touch
- Index Mid-Air
Interaction Opportunities

Thumb Touch

Index Mid-Air

Thumb Mid-Air

Index Touch
3D Input for AR/VR

CARDBOARD BOXES
3D Input for VR/AR
Limitations / Future Work

**ONLY TWO FINGERS**

Index Finger

Thumb

**BULKY PROTOTYPE**

Back of the Hand (BOH)

Depth Sensor

**BOH PROJECTION**

1 2 3
4 5 6
7 8 9
0
Extend input space
  • On and above the back of the hand
  • Always available

Input sensing
  • 3D fingertips
  • Touch detection
  • Fingertip identity

New expressive input
  • Touch
  • Mid-air
  • Mid-air + Touch
Thank you!

handtracker.mpi-inf.mpg.de/projects/WatchSense

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Live demo after the session!

ACKNOWLEDGMENTS

• European Research Council (ERC)

European Union’s Horizon 2020 Research and Innovation Programme
(grant agreements 335545, 648785, and 637991)

• Sebastian Schuon, Franziska Mueller