HandPad: Enabling On-the-Go Writing on Your Hand via Human Capacitance

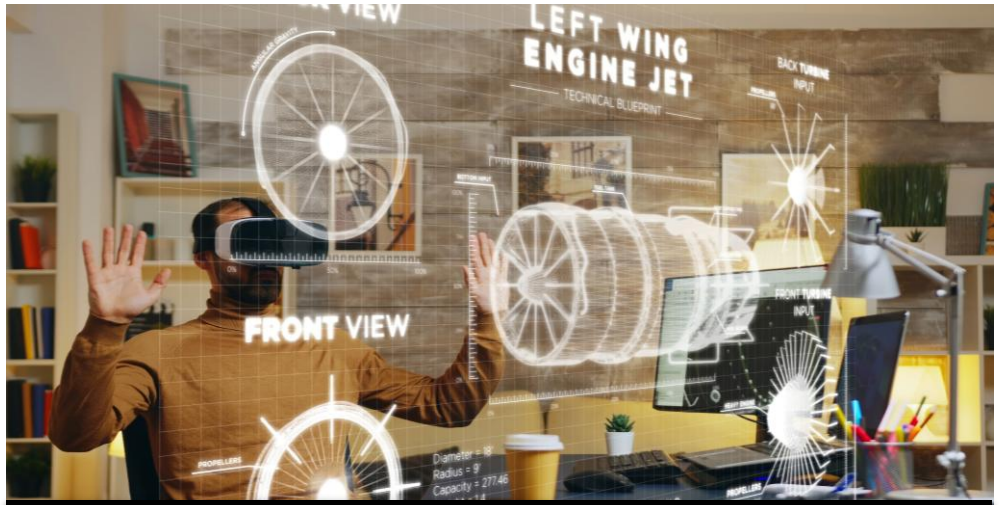
Yu Lu[†], Hao Pan[†], Dian Ding[†*], Yijie Li[†], Juntao Zhou[†],
Yongjian Fu [♦], Yongzhao Zhang[‡], Yi-Chao Chen[†], Guangtao Xue[†]

Shanghai Jiao Tong University[†]
Central South University [♦]
University of Electronic Science and Technology of China[‡]

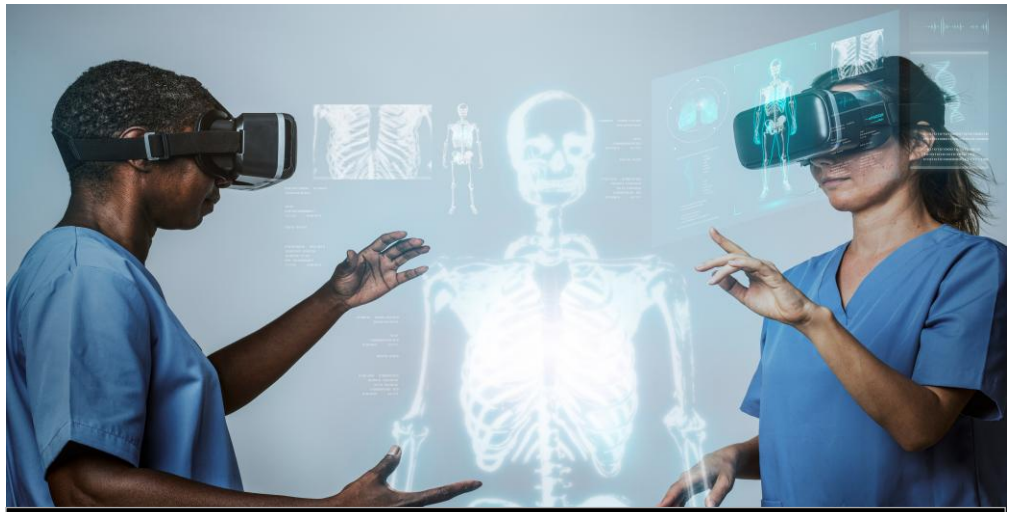
VR/AR is Everywhere

Immersive Entertainment

Education and Researches

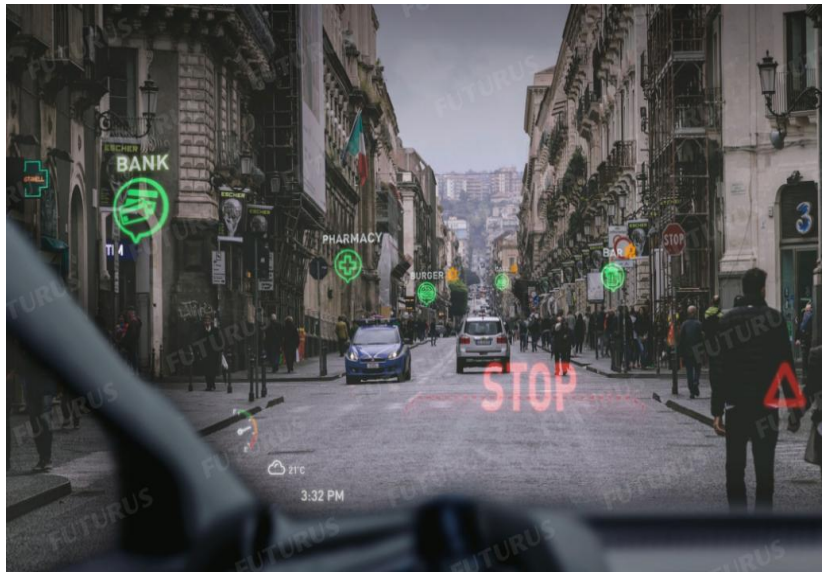


Training and Simulation



Medical Treatment and Remote Inquiry

Text Input is Critical for VR/AR



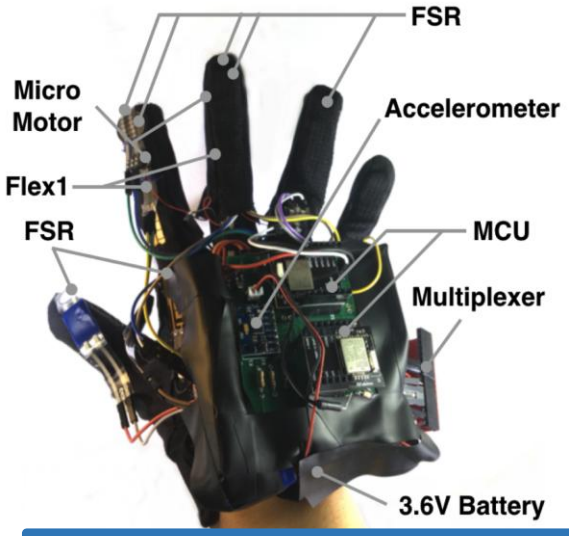
- **Precision**
- **Customization**
- **Privacy**

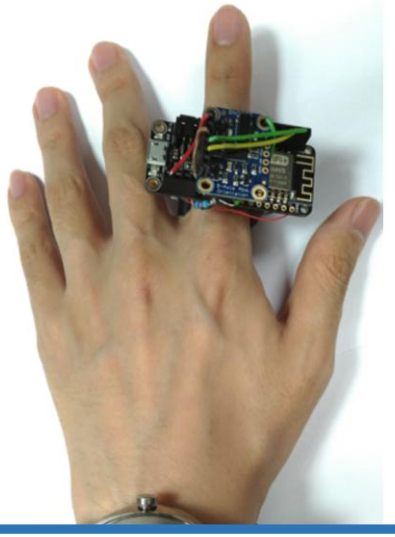
Existing Methods

Wireless Signal

◆ Privacy & Disturbance

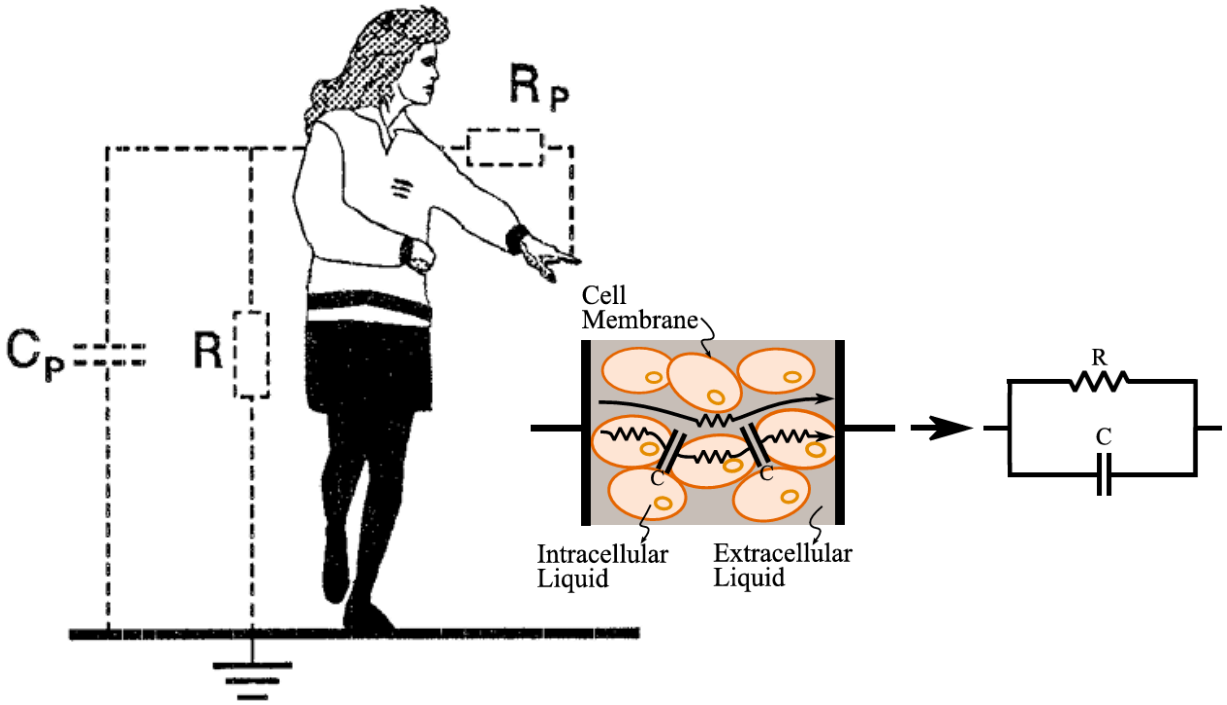
Inertial Sensor





◆ Complex Deployment

More Suitable Method ?

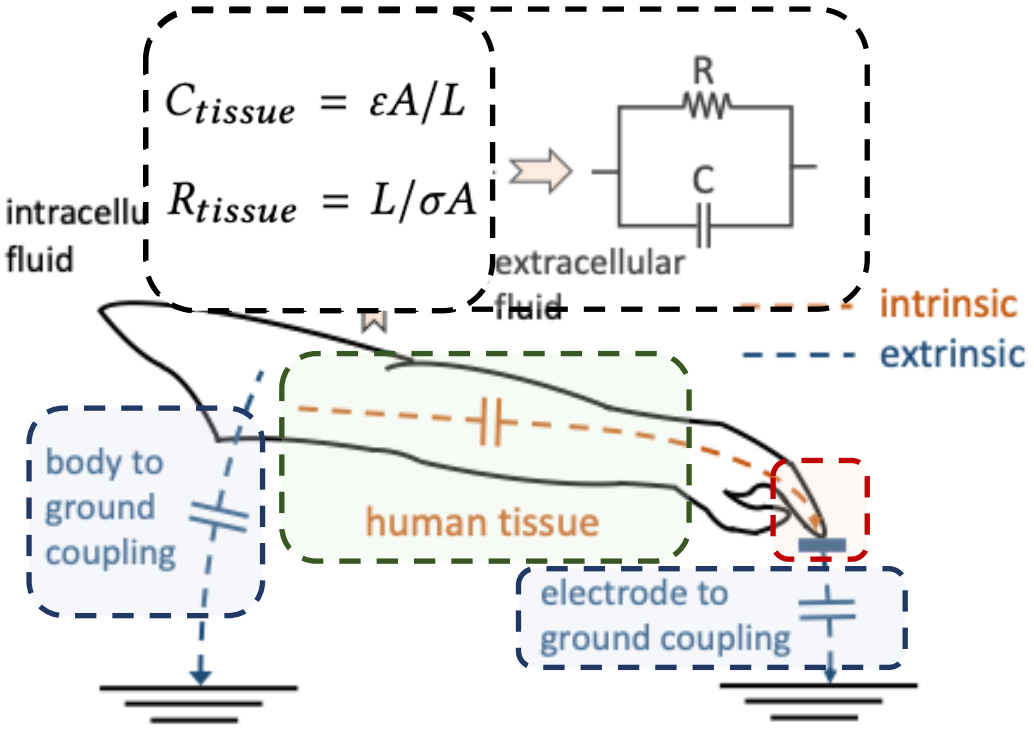


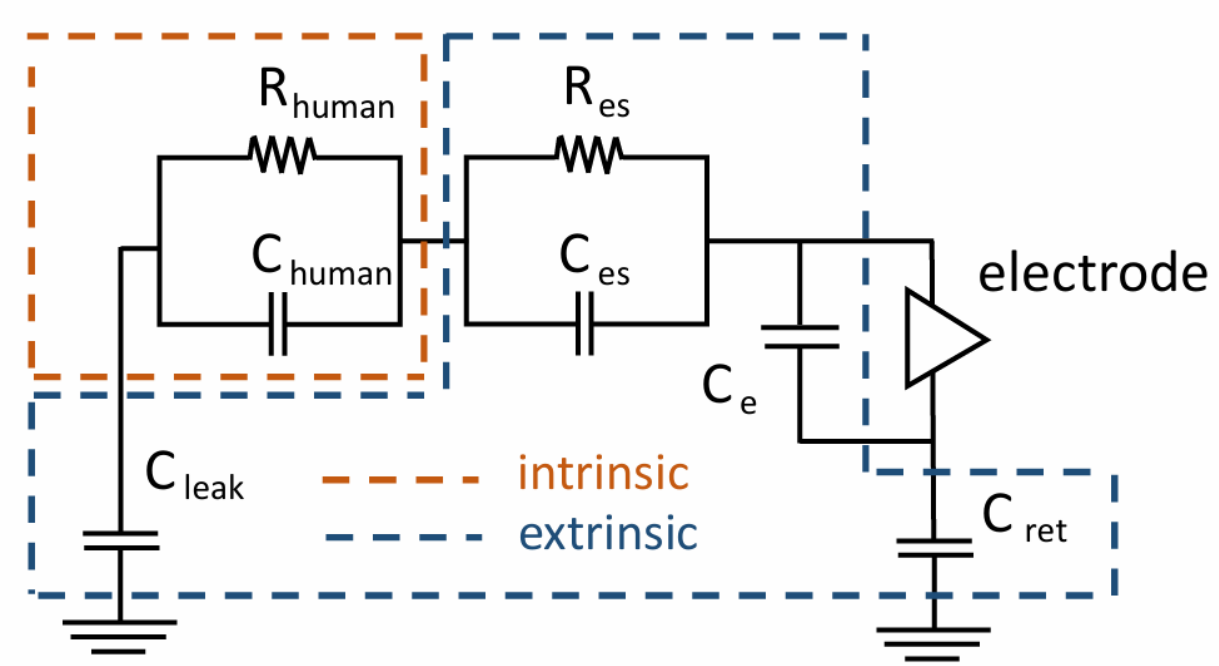
◆ **Traditional Touchscreen**

◆ **Human Capacitance**

Modeling Human Capacitance

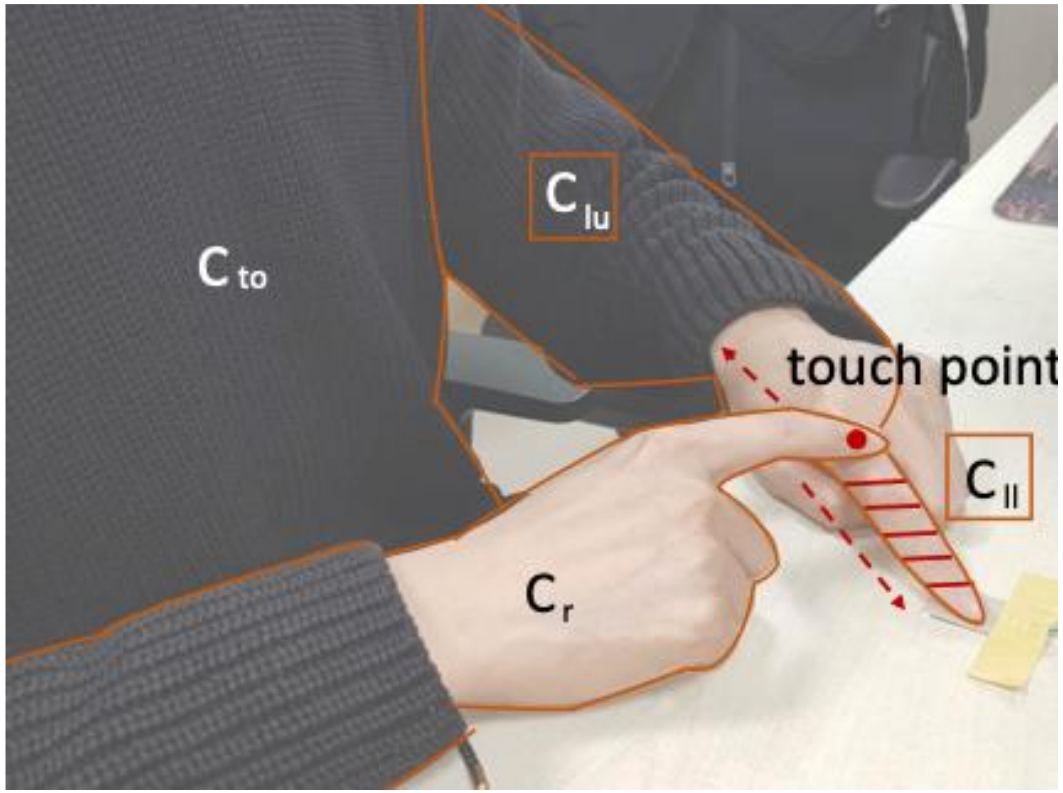
Human Arms Capacitance Model





Modulation of Human Capacitance

Extrinsic capacitance remains constant, we can modulate measured capacitance value by changing the **intrinsic capacitance (i.e., touch on human body)**



intrinsic

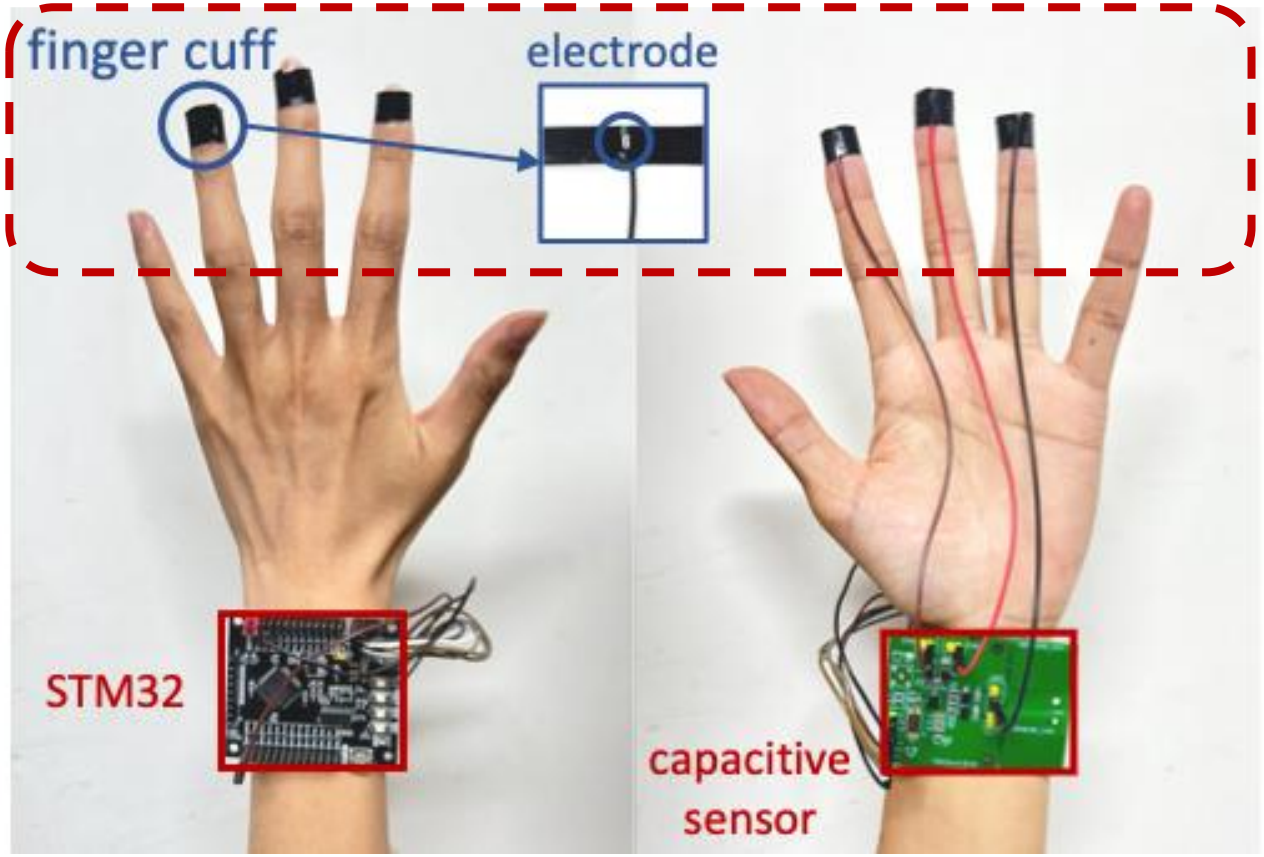
$$C_{tissue} = \varepsilon A/L$$

$$C_{in} = \frac{1}{\frac{1}{C_{to}} + \frac{1}{C_r + C_{lu}} + \frac{1}{C_{ll}}}$$

change with the touch point

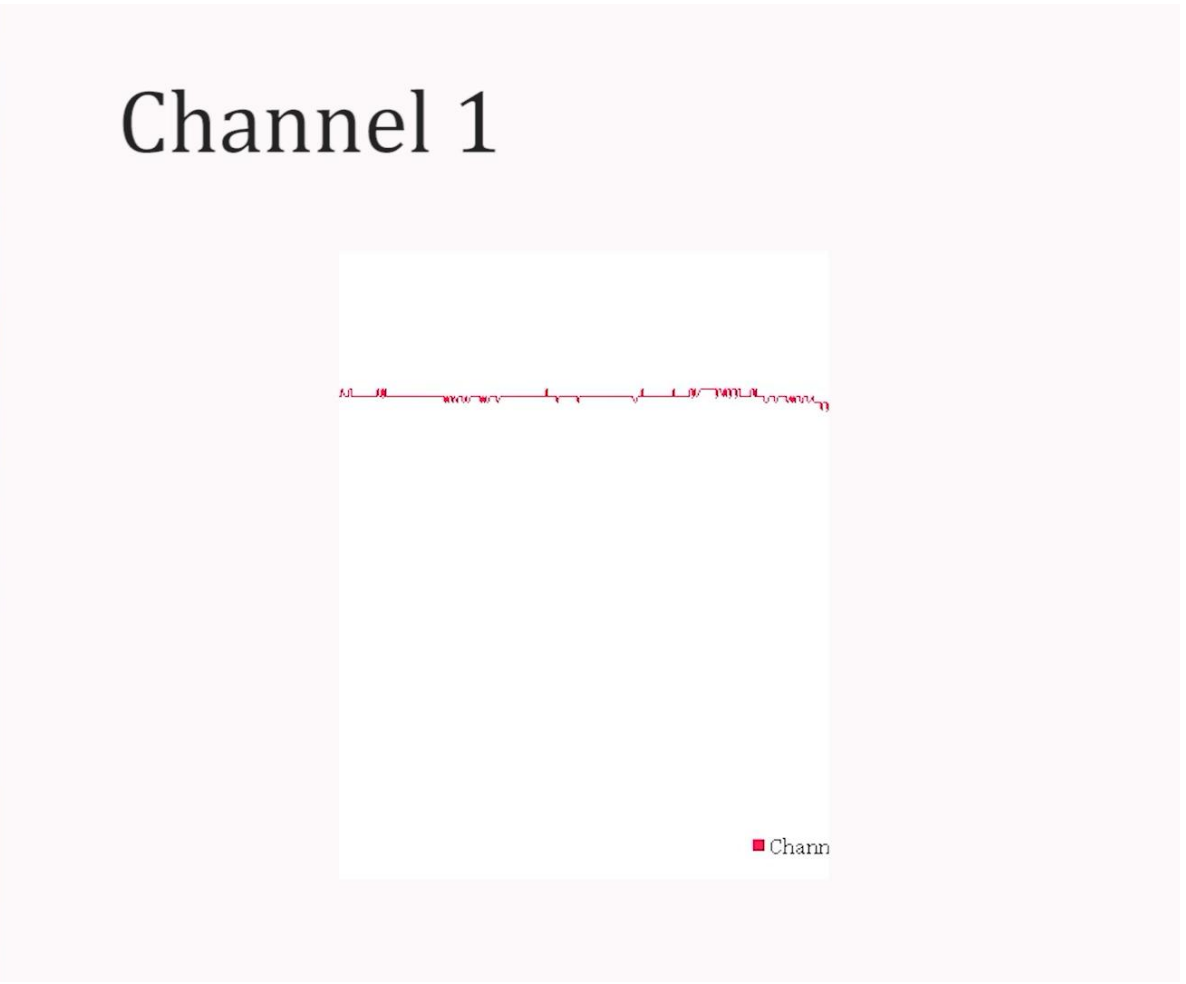
HandPad Setup

Turn your hands into a handwriting interface



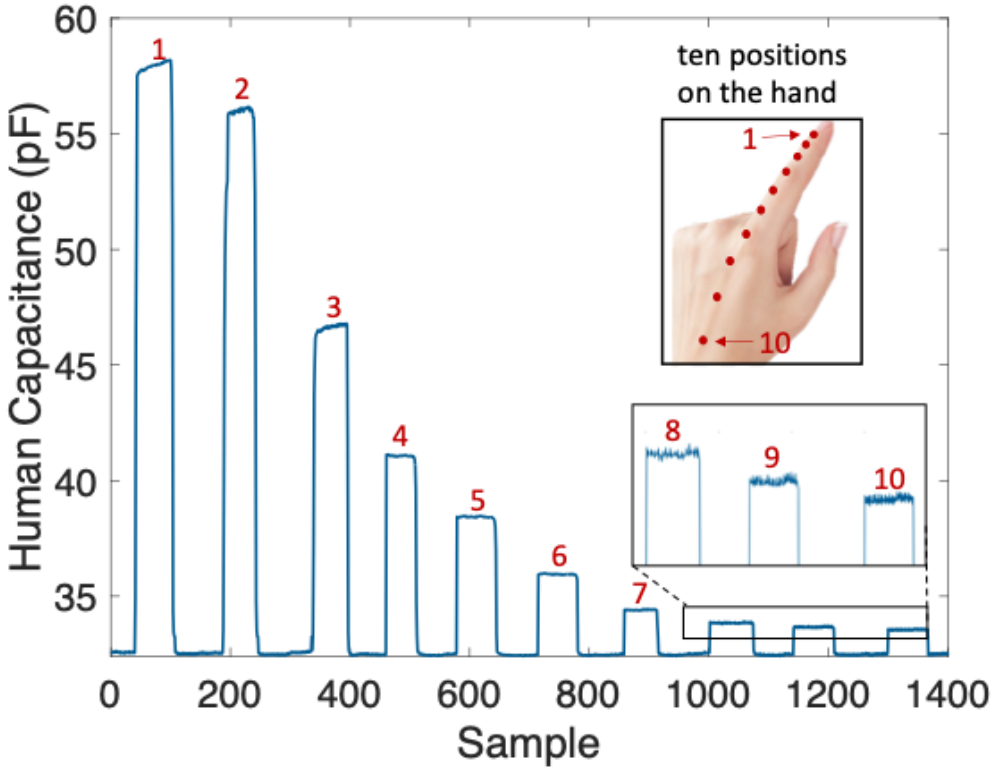
Demo Video

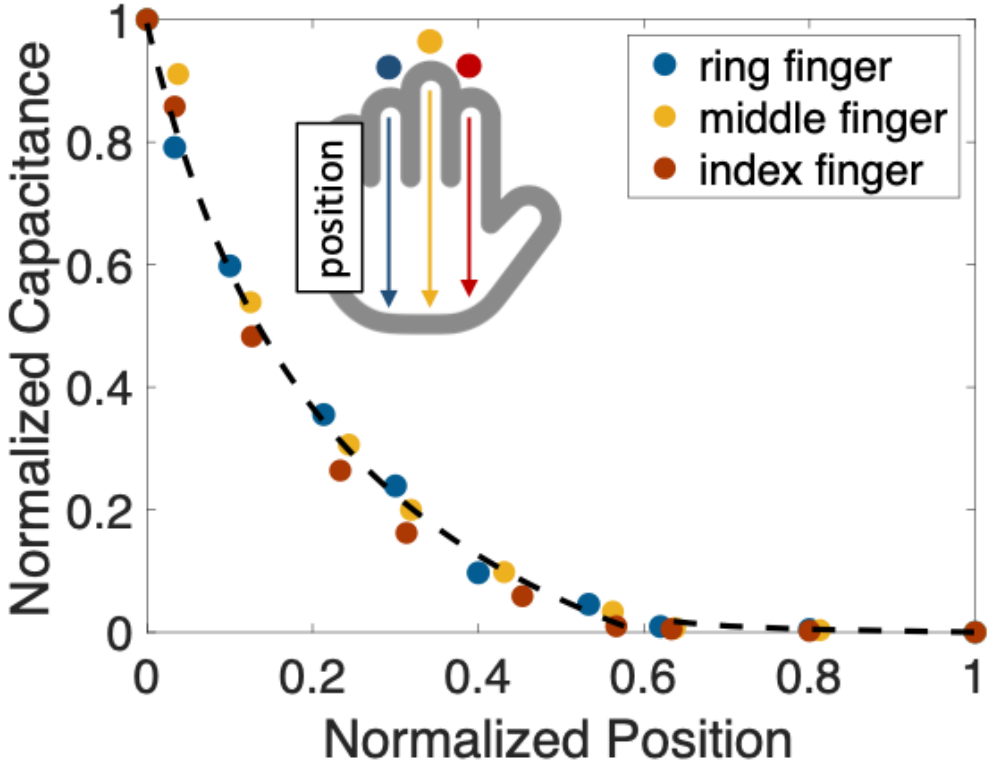
Human Capacitance Modulated by Touching Point



Input Mode I: Keystroke

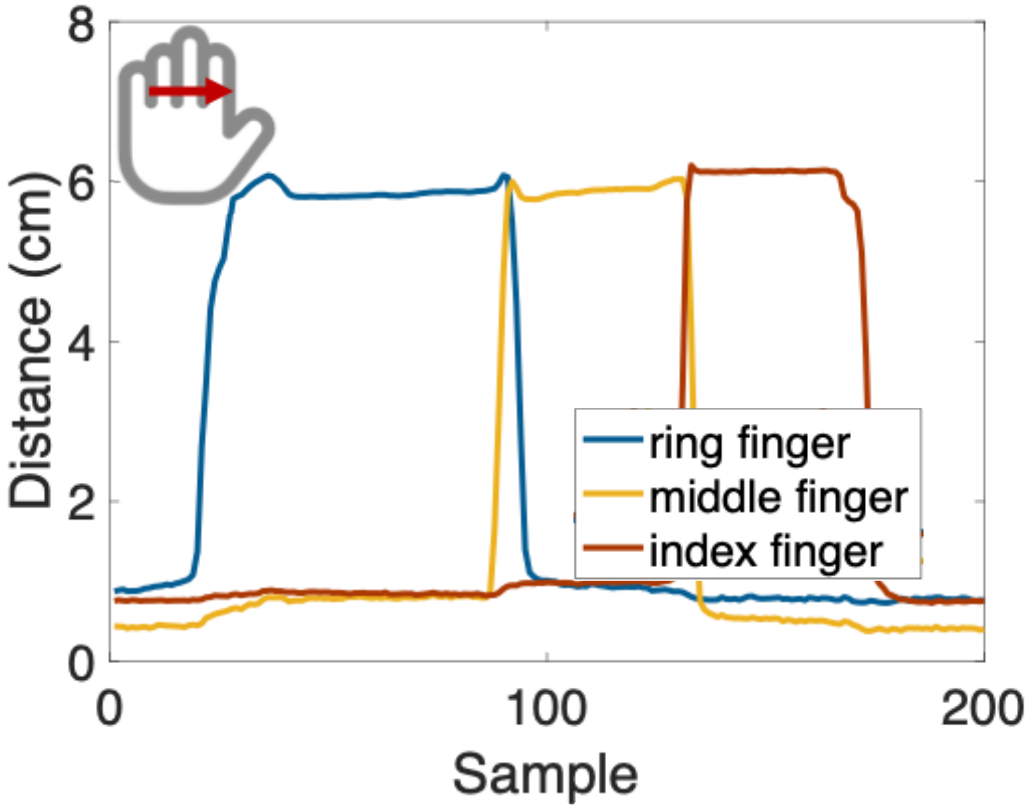
Capacitive Sensor can Locate Touching Point

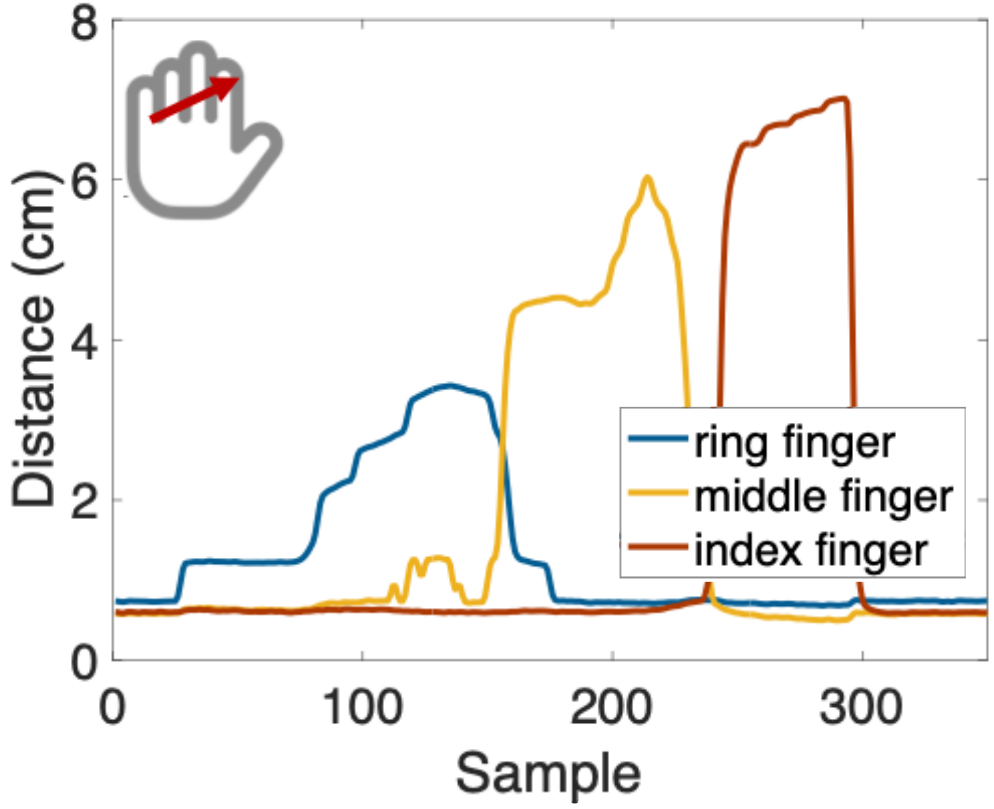




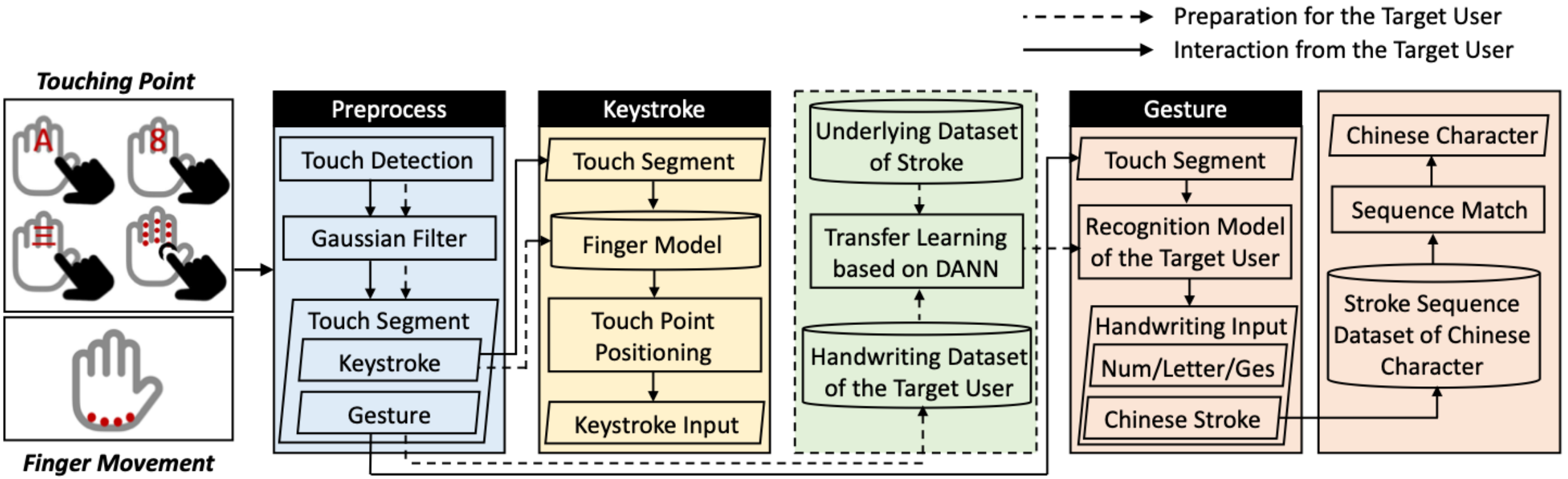
Input Mode II: Handwriting

Human Capacitance Modulated by Touching Point

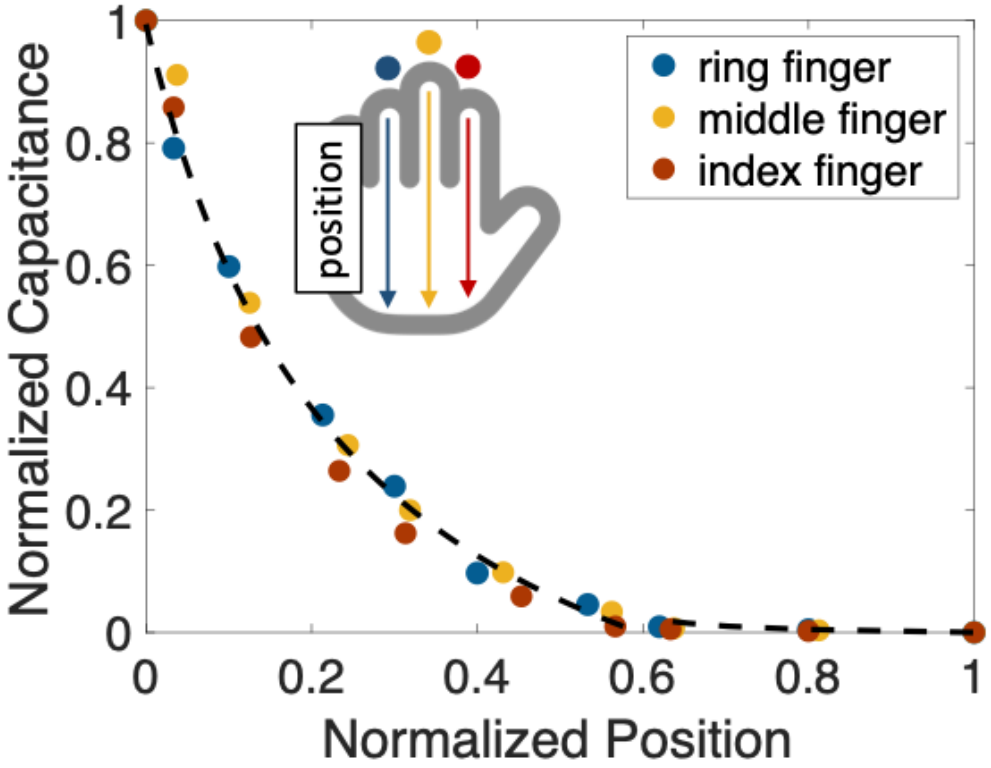




System Overview of HandPad



Signal Preprocess



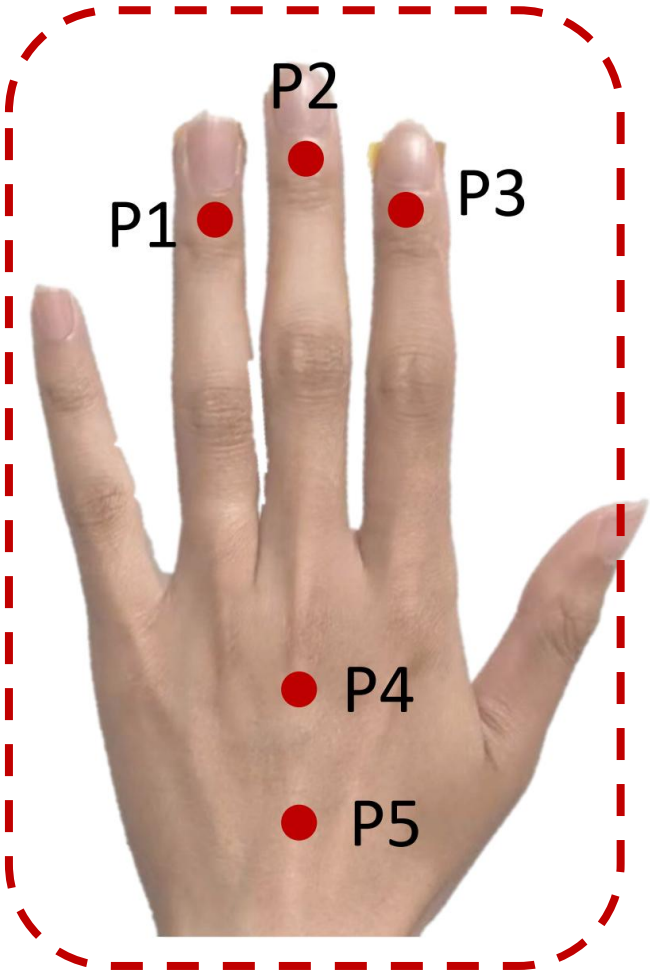
1. Finger Model

$$d = \frac{\alpha_i}{b * C_{human} + 1} + \beta_i$$

2. Preprocess

Gaussian Filter

Keystroke



1. **Calibration**

   Finger Model

2. **Keystroke**

   Preprocess
   Segmentation
   Recognition

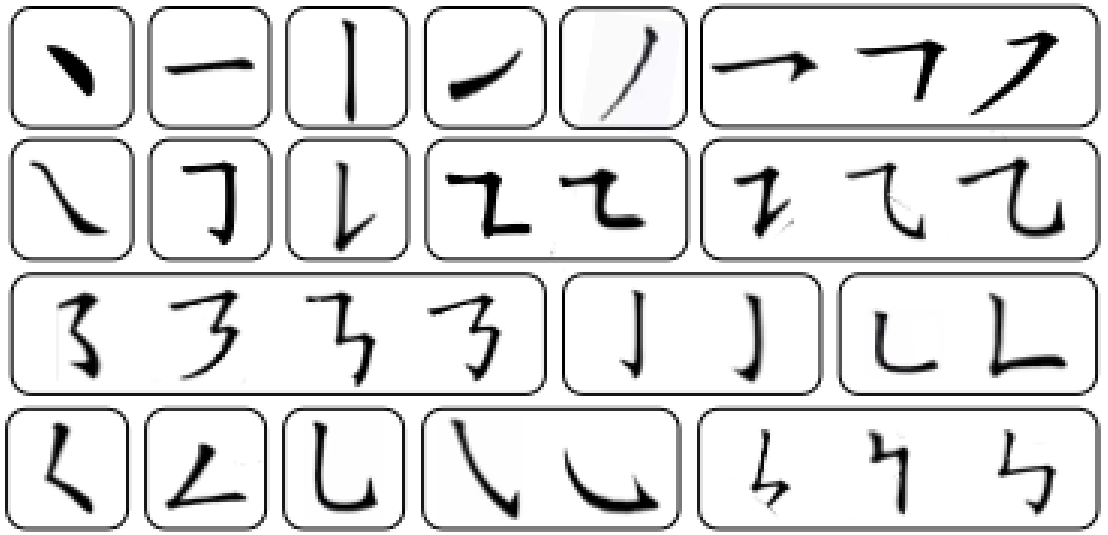
Handwriting Input

1. Dataset Collection *(underlying dataset)*

Handwriting Number (0 - 9)

Handwriting Letter (A - Z)

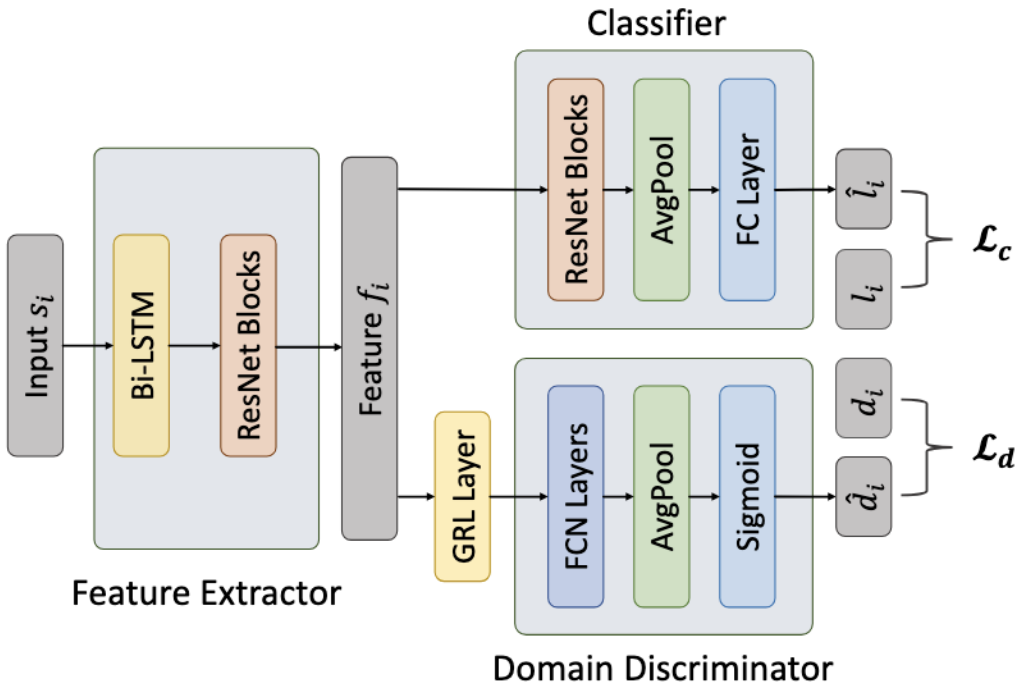
Handwriting Chinese Stroke

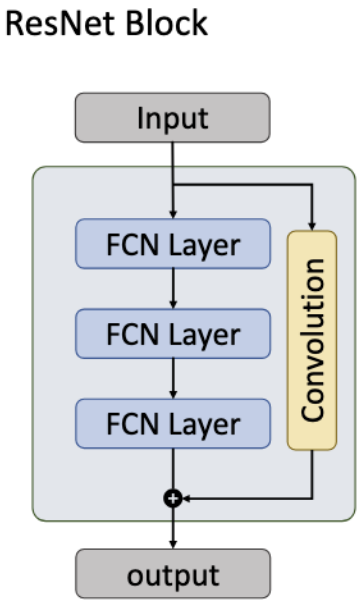


26 strokes to 19 classes

Handwriting Input

2. Signal Recognition





1. Underlying Model

2. Domain Adversarial Neural Network

Target User

Dataset

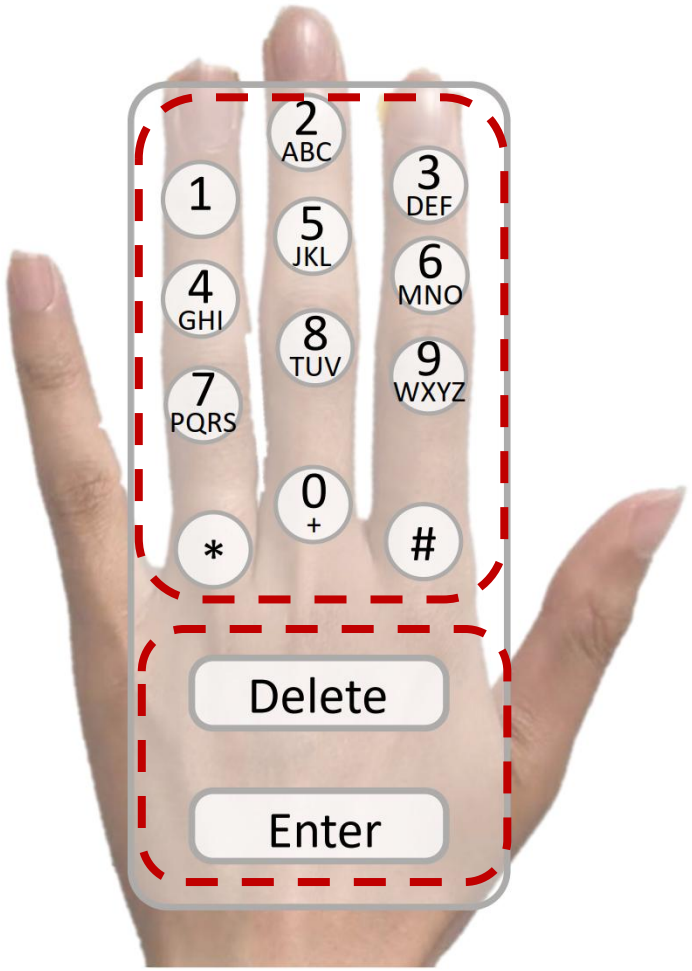
3 samples for each input

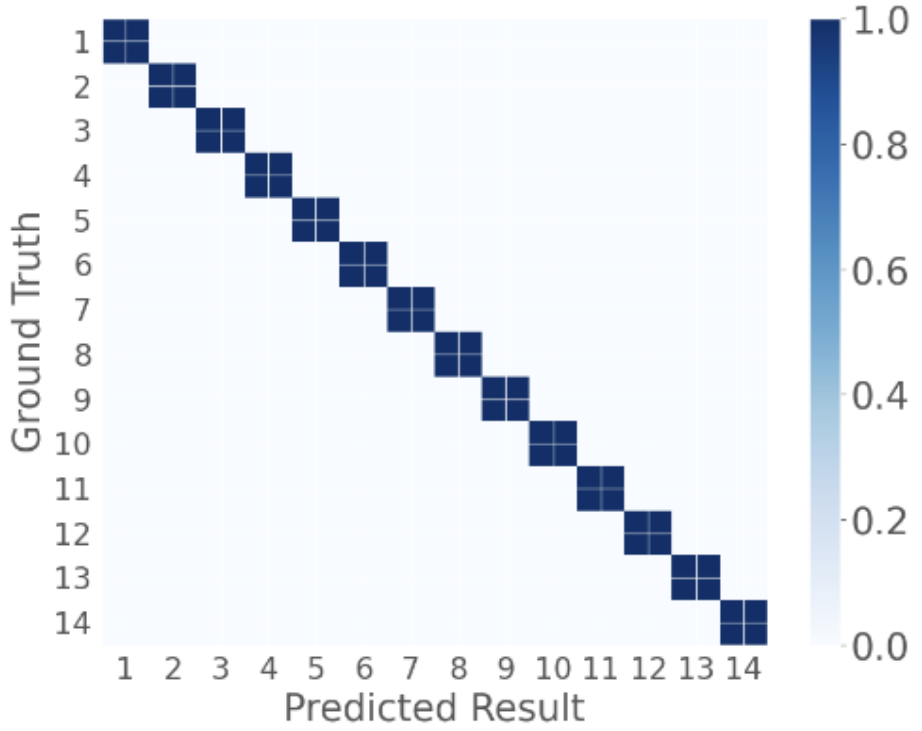
Domain Transfer

3. Sequence Matching

Chinese Character

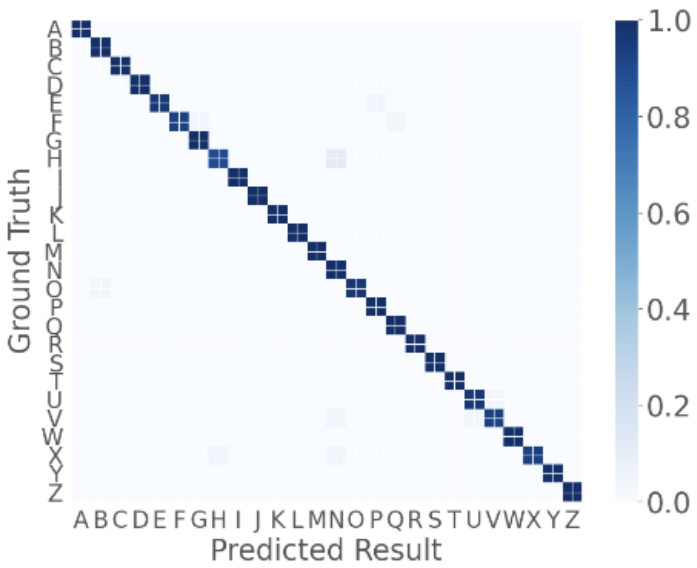
Evaluation - *Keystroke*



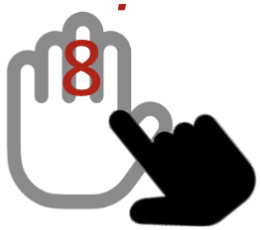


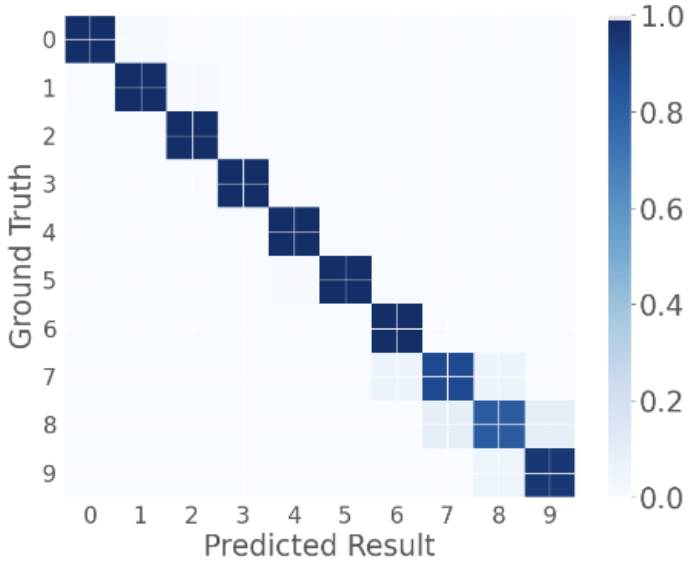
Average Accuracy: 100%

Evaluation - *Letter and Number*



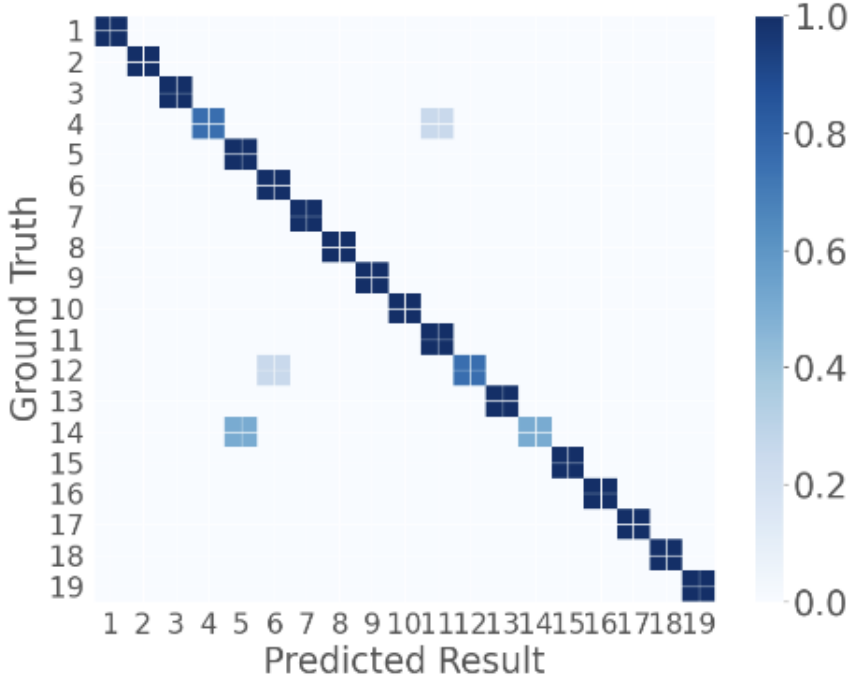
Letter Accuracy
99.1%





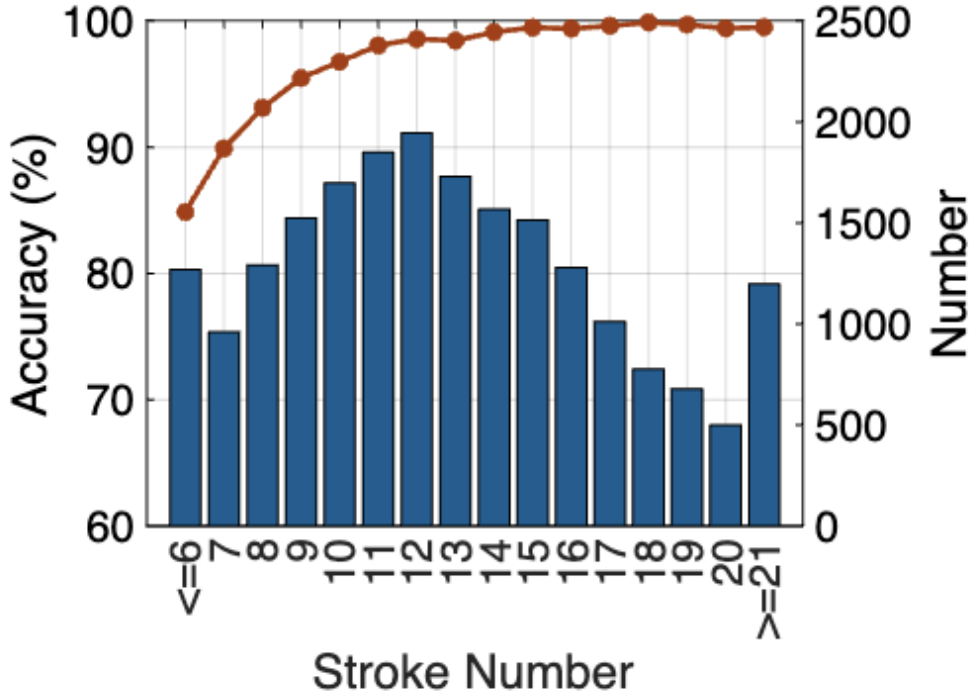
Number Accuracy
97.6%

Evaluation – *Chinese Character*



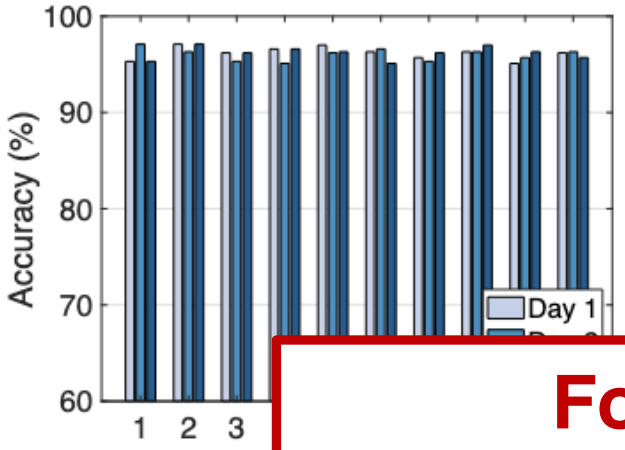
Stroke Accuracy
94.6%

20795 Chinese Character

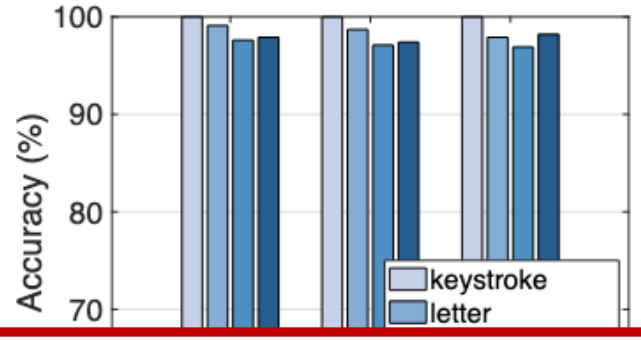


Character Accuracy
97.9%

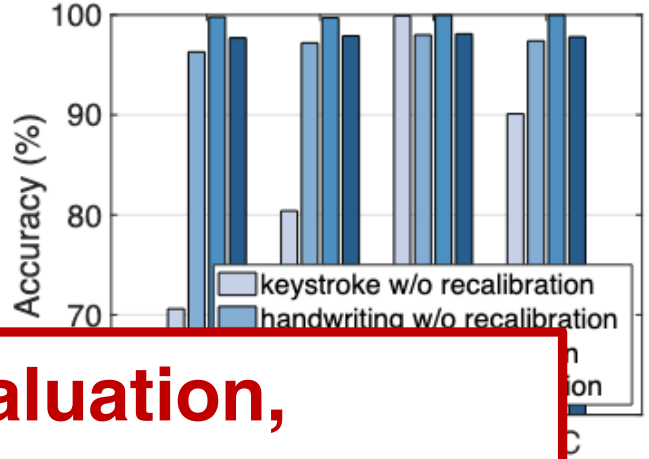
Evaluation



Influence of different user



Influence of different environment

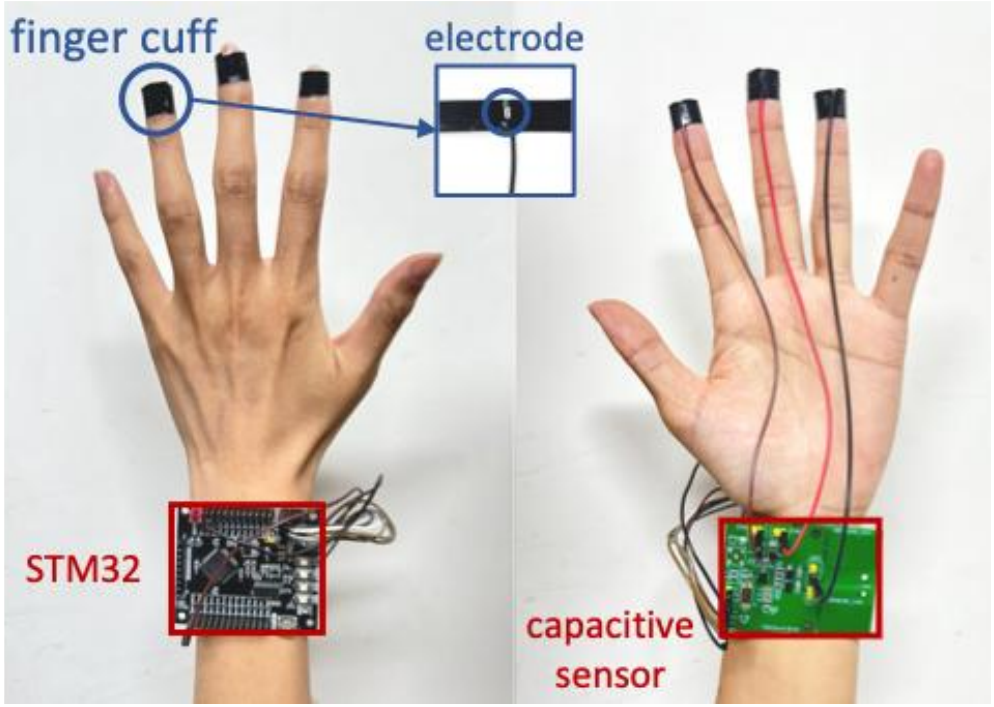


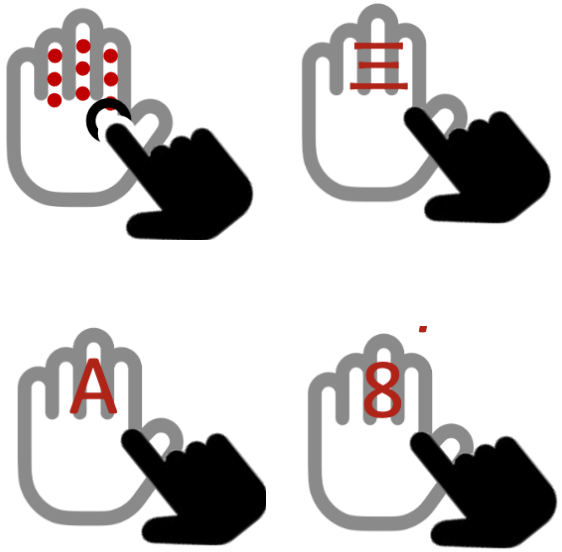
Influence of different temperature

For more detail about the evaluation, please refer to our paper.

Conclusion

- We built the **capacitive sensing system** **for text input**.
- We validate **human capacitance based** **finger touching**.
- HandPad achieves **High accuracy for** **keystroke and handwriting input**.





Thanks for listening!

Any questions, you can contact:

Dian Ding,

dingdian94@sjtu.edu.cn