Left and Right Hand Distinction for Multi-Touch Tabletop Interactions
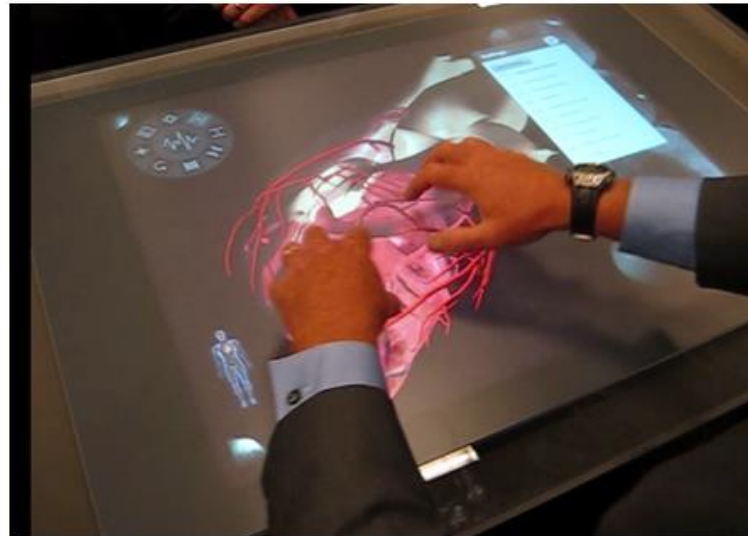
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2014

Outline

- Introduction
- Related Work
- Our Approach
- Experiment
- Discussion & Conclusion

Introduction

Related Work

- Hardware based
  - [DiamondTouch, Dietz, P. and Leigh, D. 2001]
  - [Fiduciary-Tagged Gloves, Marquardt, N. et al. 2010]
- Distance based
  - [Ewerling, P. et al. 2012]
  - [Au, O.K. and Tai, C. 2010]
- Finger orientation based
  - [Malik, S. and Laszlo, J. 2004]
  - [Wang, F. et al. 2009]
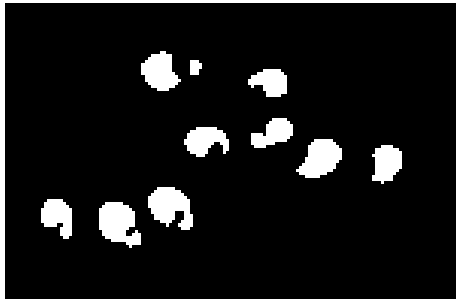 - [Dang, C.T. et al. 2009]
  - [Walther-Franks, B. et al. 2011]
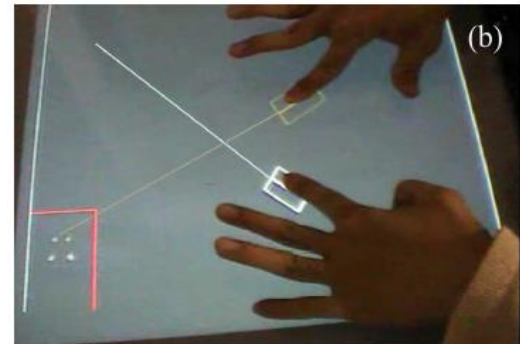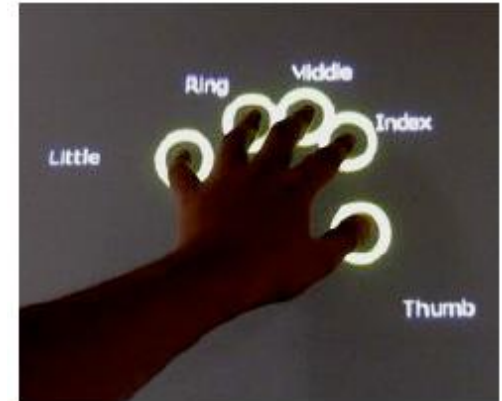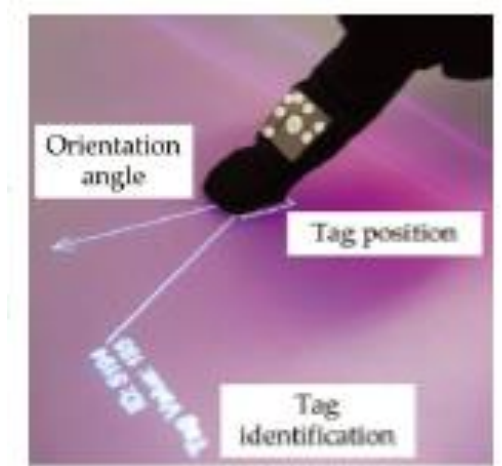
Motivation

- Provide additional handedness information
- Map the touch points to their associated joined hand
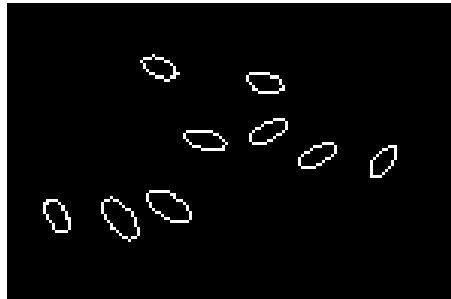- Assign different work to different hands, enable asymetric bimanual interaction

Our Approach

Raw image → Preprocess → Calculate finger orientations → Classify finger contacts → Hand distinction
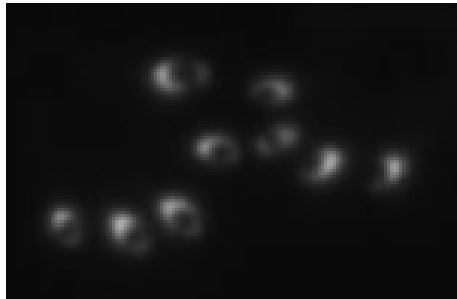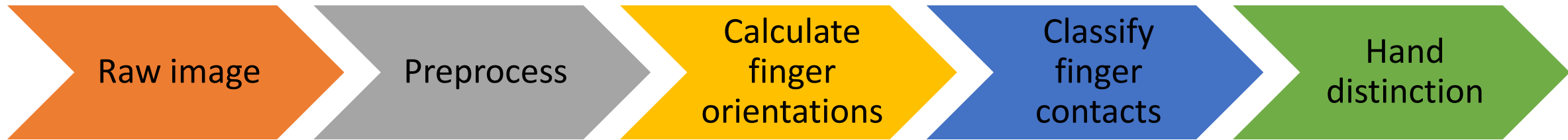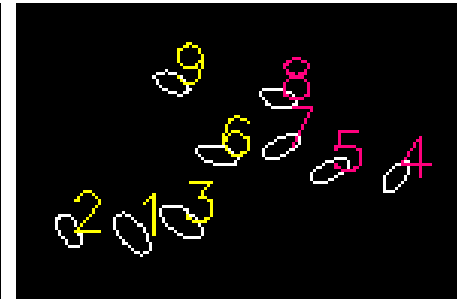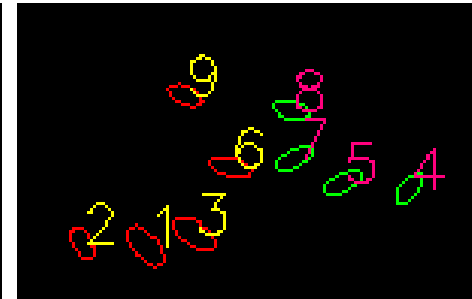
(a)   (b)   (c)   (d)   (e)

Basic Assumptions

Radial deviation | Ulnar deviation

20°   30°

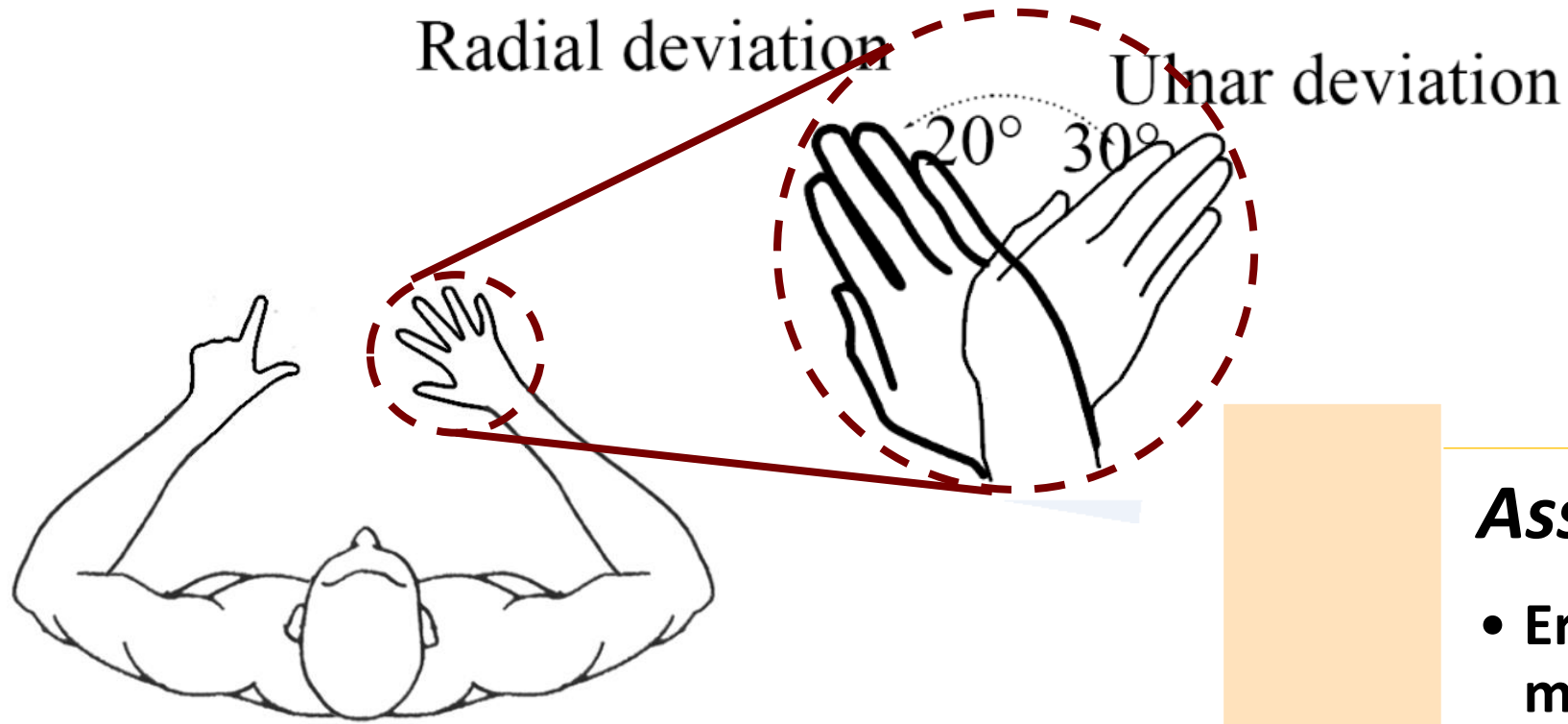## *Assumption* 1

- **Ergonomics forearm movements assumption**

Basic Assumptions

Assumption 2

- **Work area assumption**

Basic Assumptions

Body forearm triangle model

Assumption 3

- **Body-forearm triangle assumption**
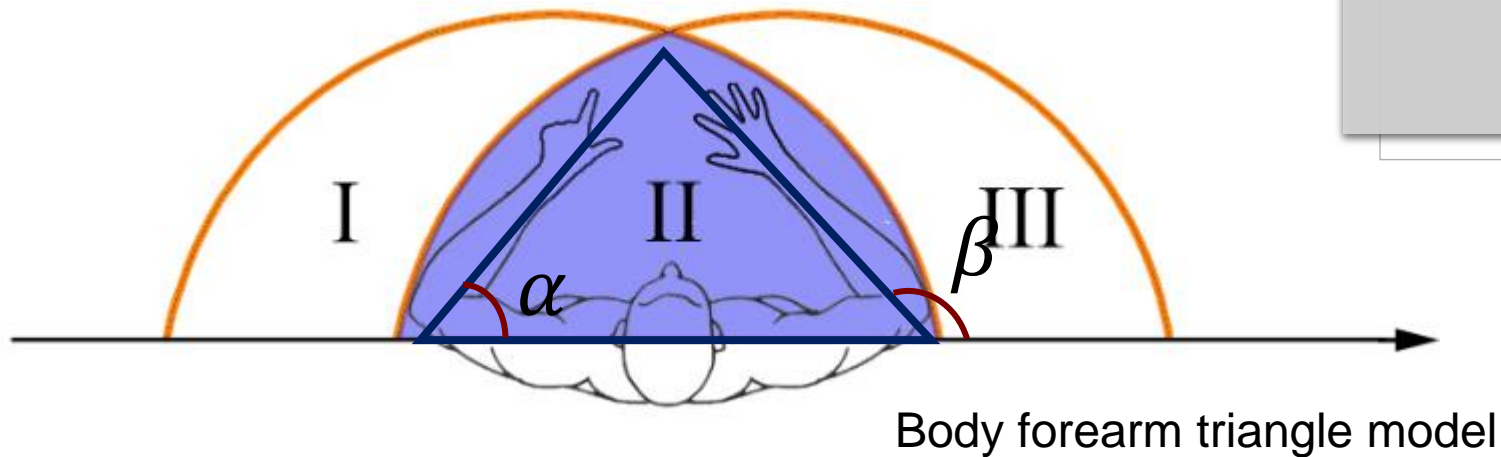
Finger Orientation Detection

- [Wang, F. and Ren, X. *Proc. CHI 2009*]

$$\frac{[(x-P_x)\cos\omega+(y-P_y)\sin\omega]^2}{a} + \frac{[(y-P_y)\cos\omega-(x-P_x)\sin\omega]^2}{b} = 1 \qquad \text{Eq.(1)}$$

$$\begin{cases} area = t_a \\ aspect\ ratio = \dfrac{A}{B} = t_s \end{cases} \qquad \text{Eq.(2)}$$
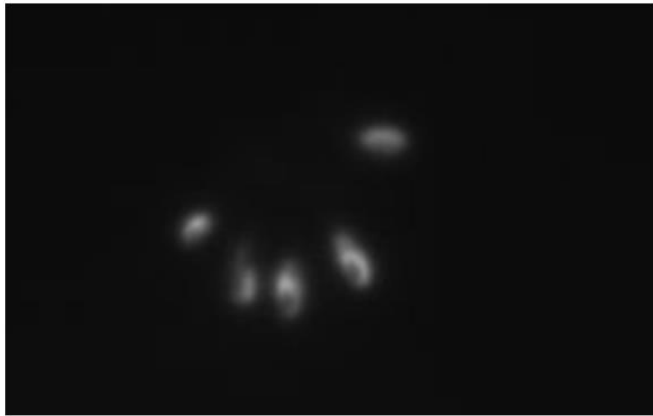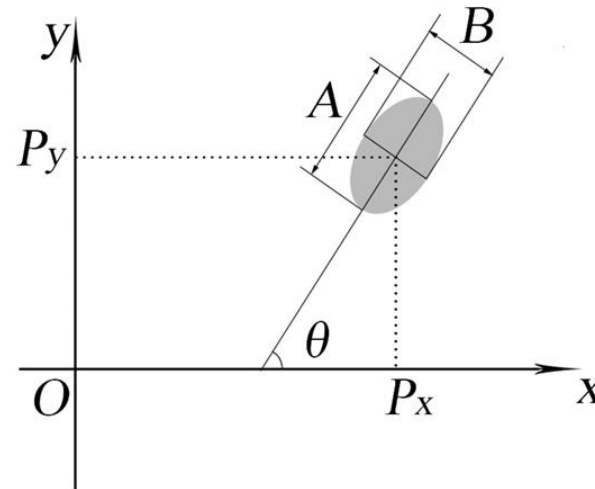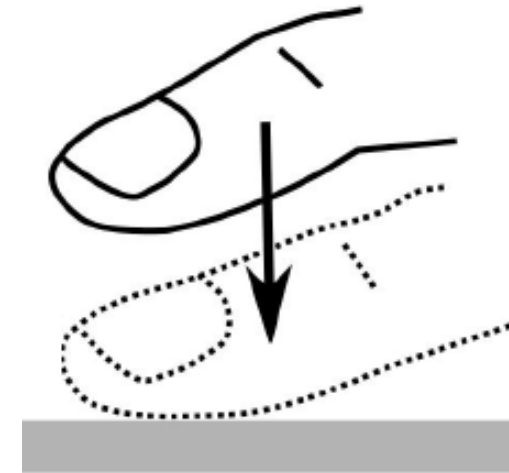

(a)   (b)   (c)

Finger Contacts Grouping

Constraint 1
- Consistent area constraint
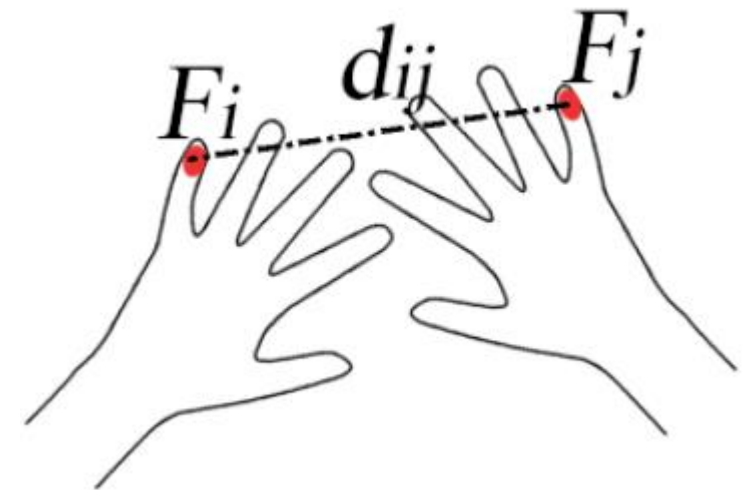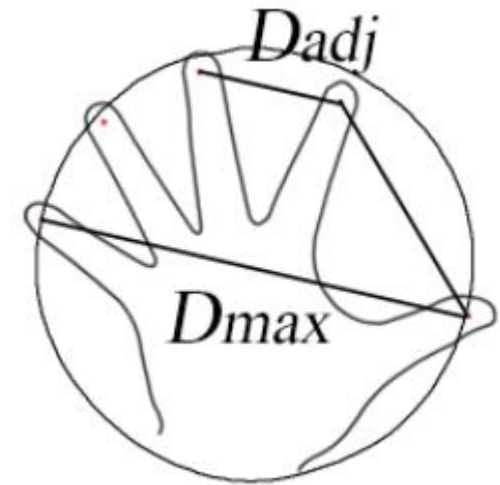
Constraint 2
- Maximum distance constraint

Constraint 3
- Minimum distance constraint

Constraint 4
- Angle constraint

Finger Contacts Grouping
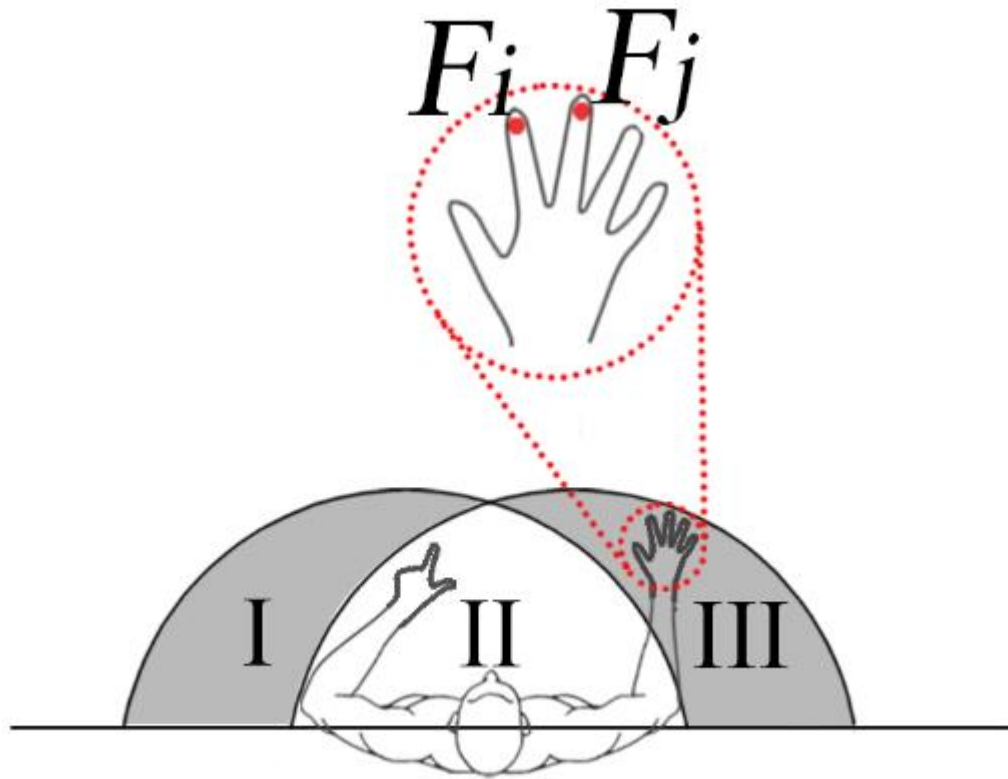
Constraint 1

- **Consistent area constraint**

Finger Contacts Grouping
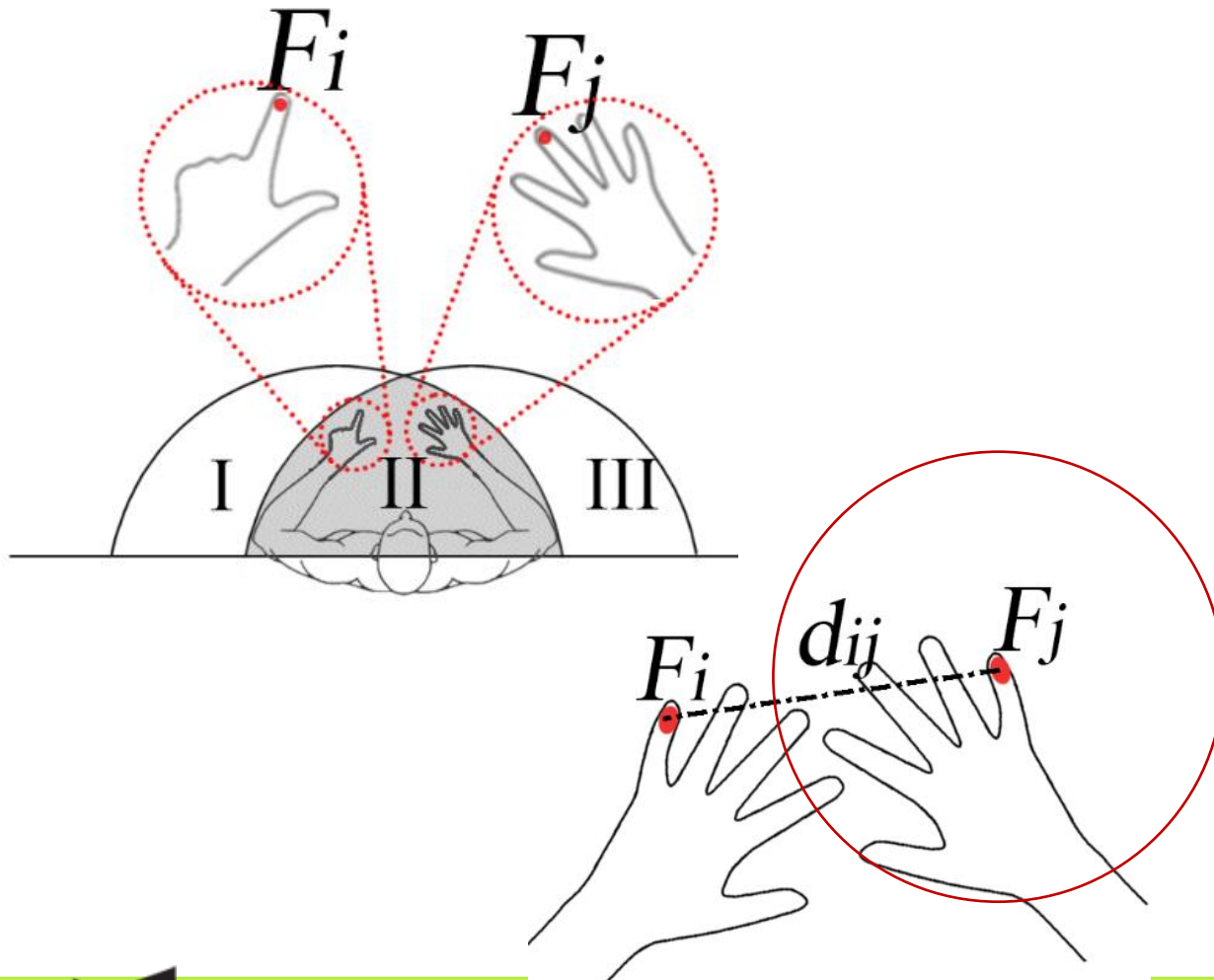
Constraint 2

- **Maximum distance constraint**
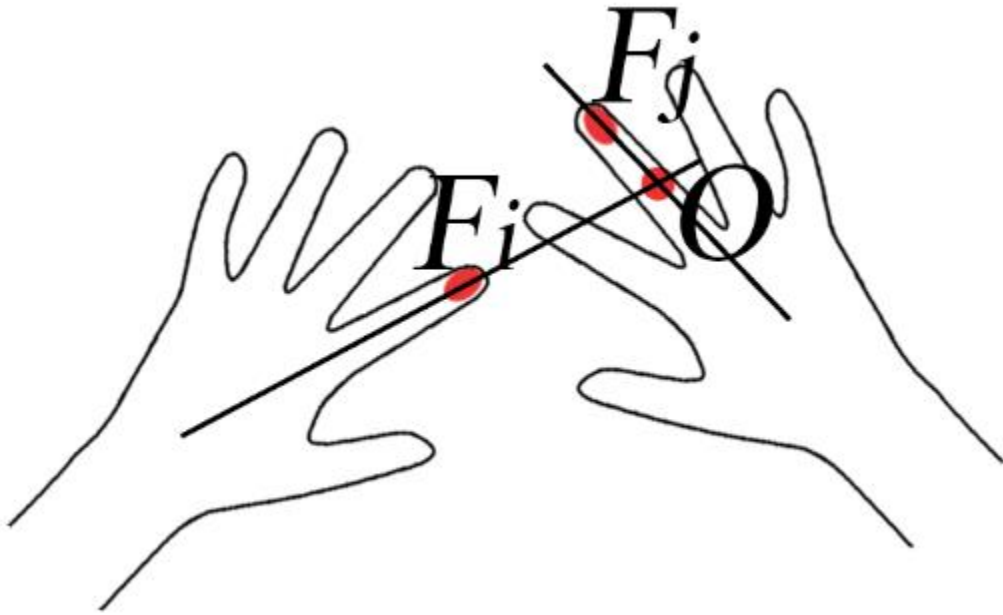
Finger Contacts Grouping

Constraint 3

- **Minimum distance constraint**
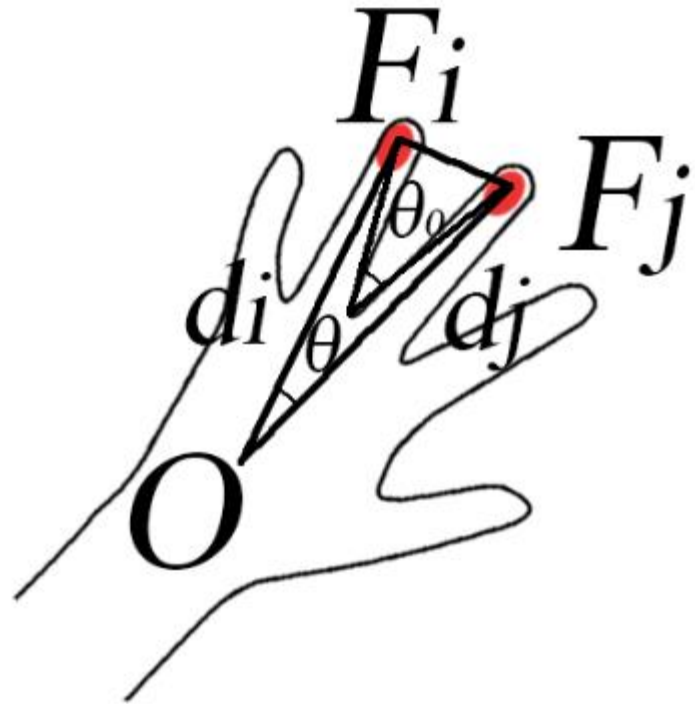
Finger Contacts Grouping

$$\theta = \arccos\left(\frac{d_i^2 + d_j^2 - d_{ij}^2}{2 \cdot d_i \cdot d_j}\right) \qquad \text{Eq.(3)}$$

Constraint 4

- **Angle constraint**

Left and Right Hand Distinction

Step 1

Figure out the **centroid** of the either group of touch contacts.

Left and Right Hand Distinction

Step 1

Step 2

Figure out the **centroid** of the either group of touch contacts.

Compute the **orientation** of the group while the centroid of the group of touch contacts locates in the public work area.

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Left and Right Hand Distinction

(a)

(b)

(c)

(d)

Left and Right Hand Distinction

Step 1

Step 2

Step 3

Figure out the **centroid** of the either group of touch contacts.

Compute the **orientation** of the group while the centroid of the group of touch contacts locates in the public work area.
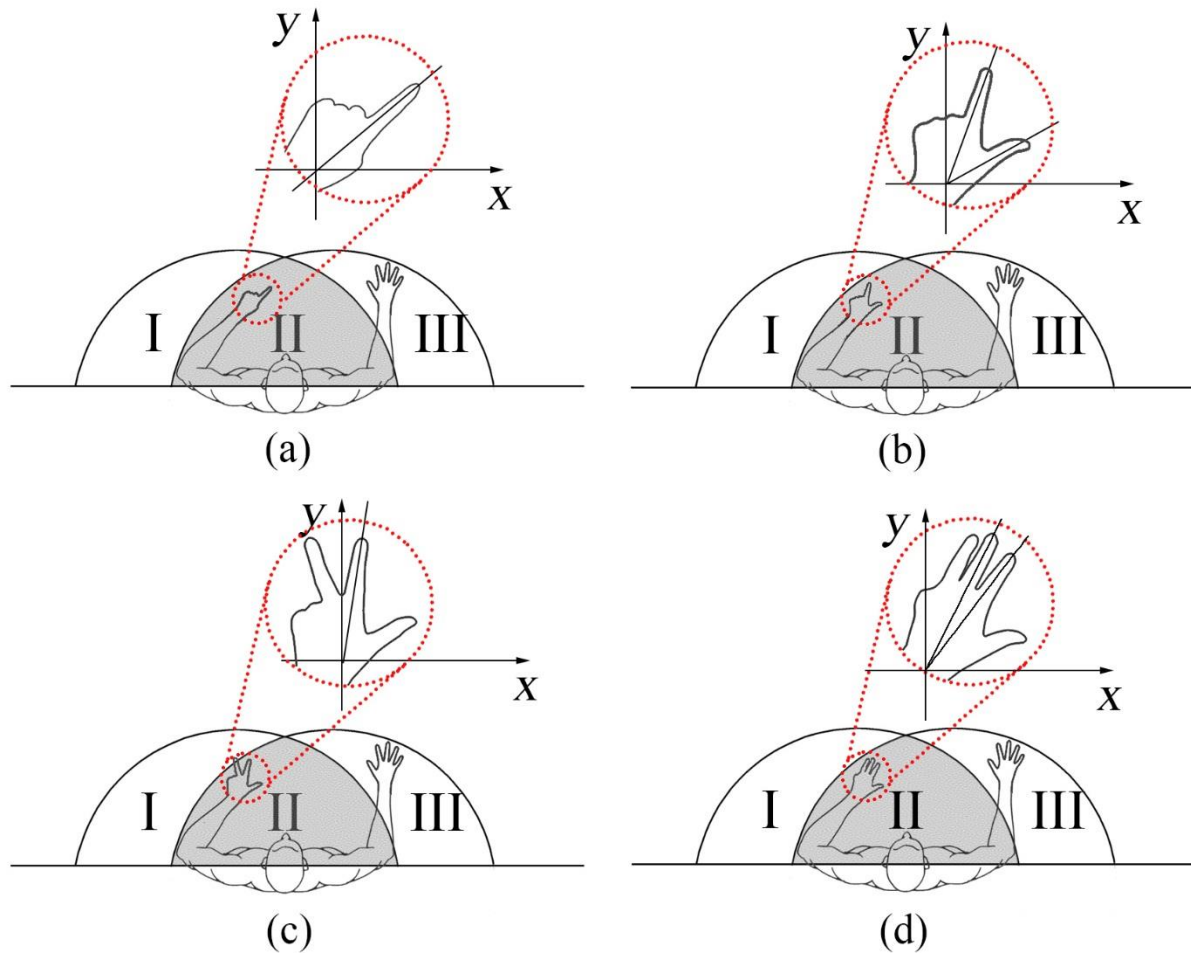
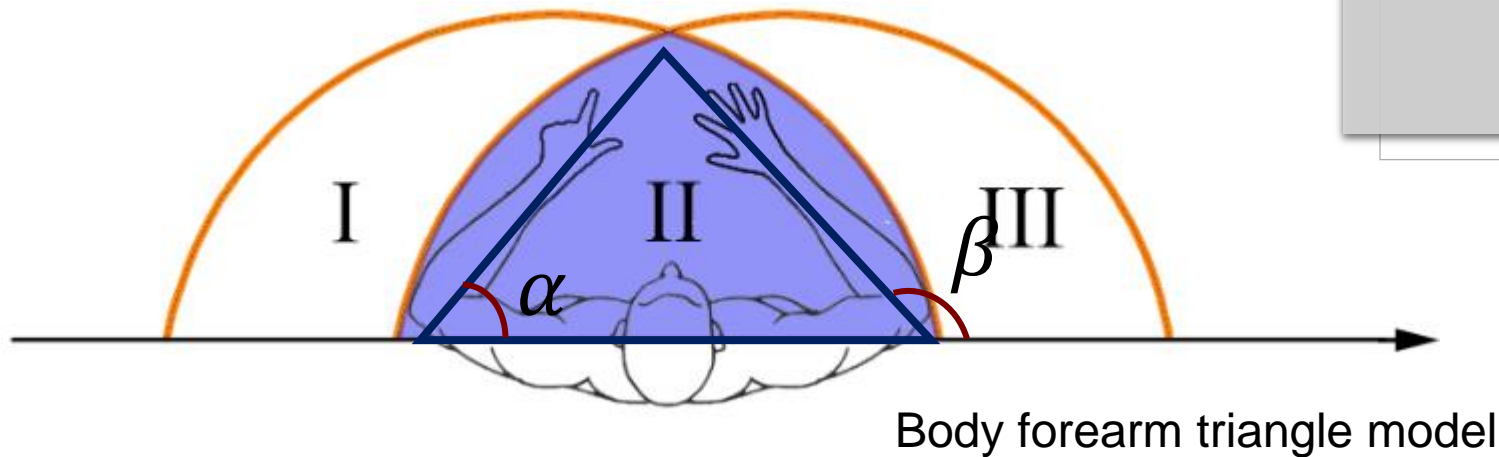distinguish left hand from right hand based on the **body-forearm triangle assumption**.

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Left and Right Hand Distinction

Body forearm triangle model

Assumption 3

- **Body-forearm triangle assumption**

Experiment

- Apparatus: Laser Light Plane Illumination based multi-touch interactive tabletop
- 12 person × 80 gestures × 3 trials = 2880 images
- Result
  - 2873 annotated images with 15501 touch contacts
  - 14759 contacts were grouped correctly, the precision in clustering contacts was 95.2%
  - 14165 contacts were correctly mapped to their associate joined hand, the accuracy rate was 96.0%
  - the average recognition rate of our proposed method was about **91.4%**

(a)
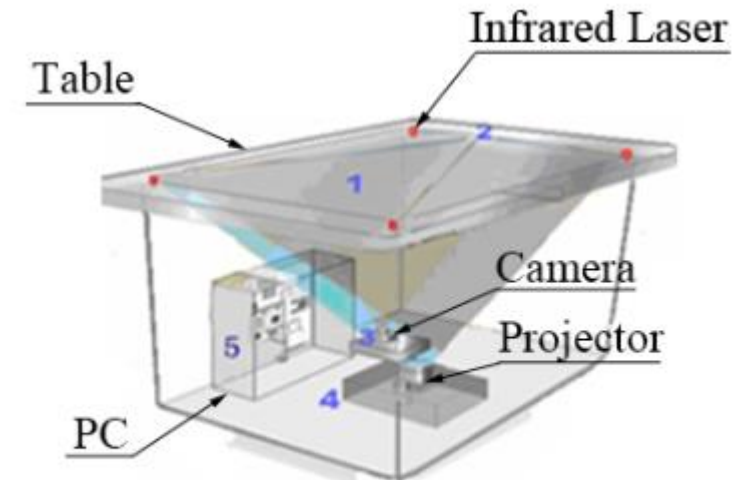
(b)

Experiment

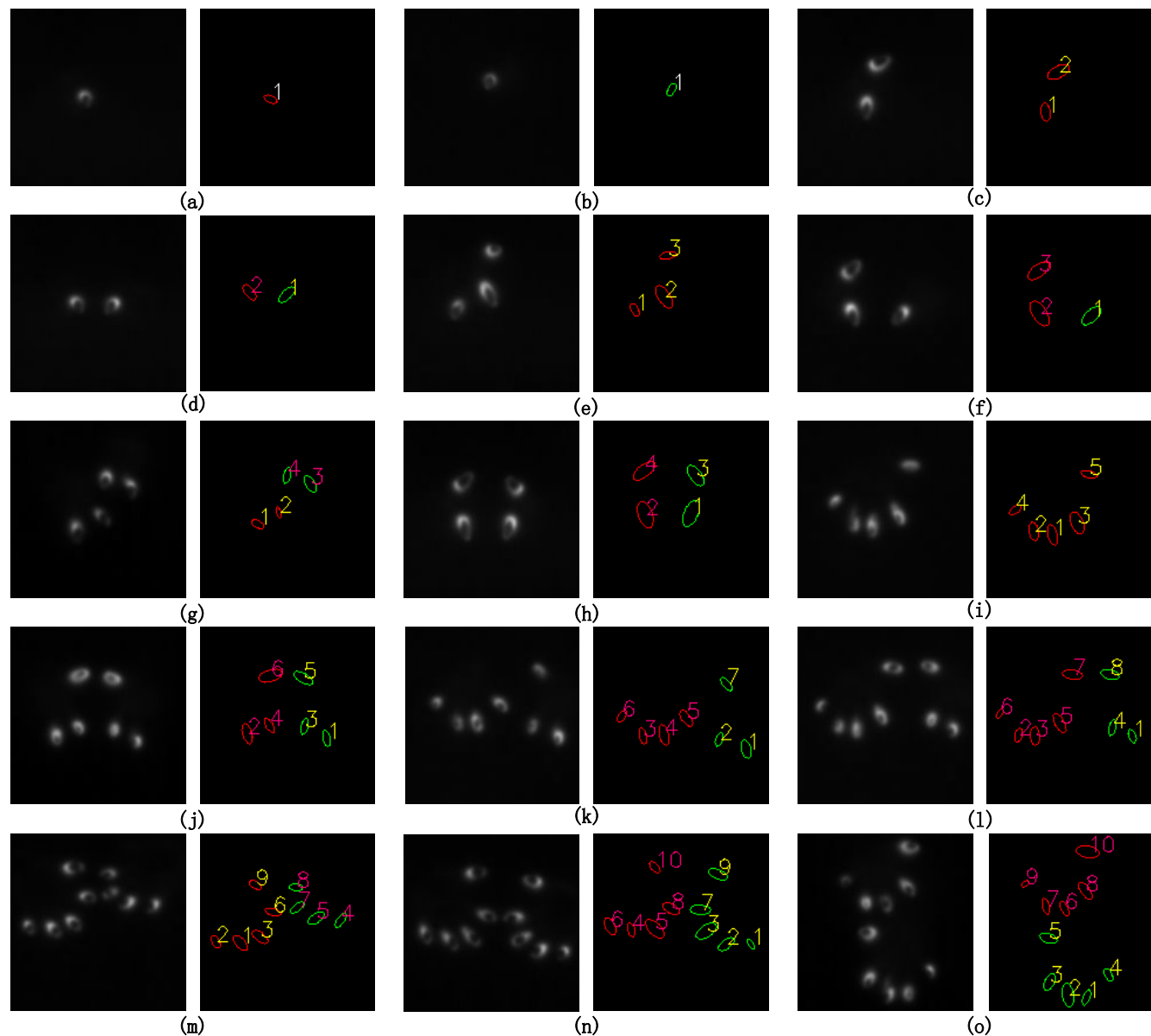Experiments of finger grouping and left-right hand distinction.

Experiment

- The hand discrimination accuracy and time performance are assessed with the following criteria:
    - Grouping Accuracy (**GA**): GA = (the number of correctly grouped fingers) / (the number of all contacts)
    - The Precision in left-right hand Distinction after Grouping contact points (**PDG**): PDG = (the number of contacts that are successfully mapped to their joined hands) / (the number of correctly grouped fingers)
    - The Overall Handedness Identification Accuracy (**OHIA**): OHIA = GA $\times$ PDG = (the number of contacts that are successfully mapped to their joined hands) / (the number of all contacts)
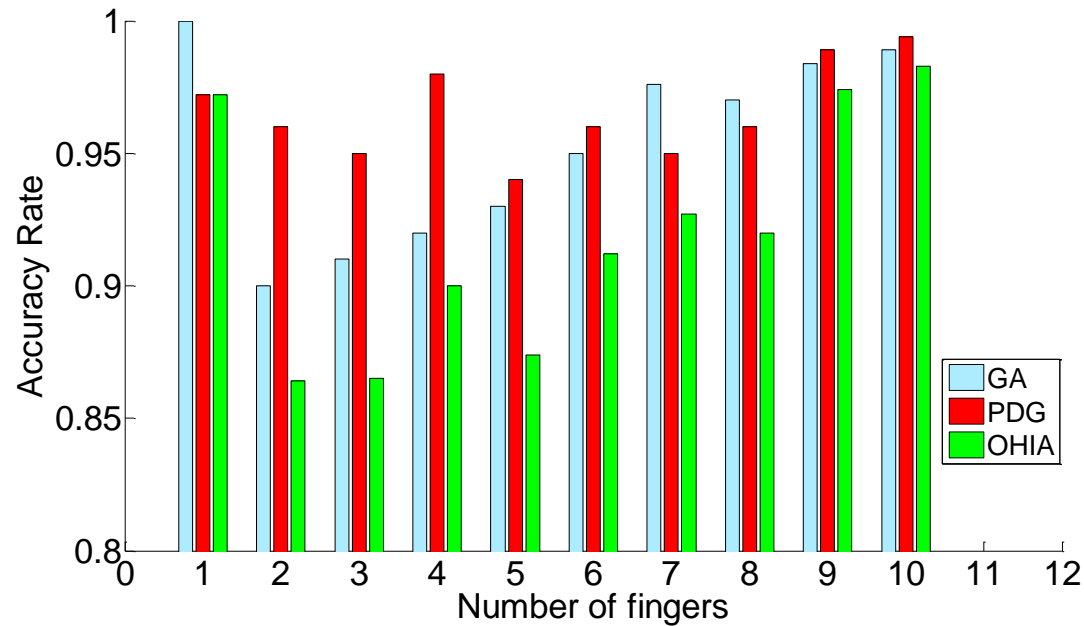   - Execution Time (**ET**).

ISCAS

Experiment

Figure 5. The precision in clustering contacts and mapping contacts to their associate joined hands.
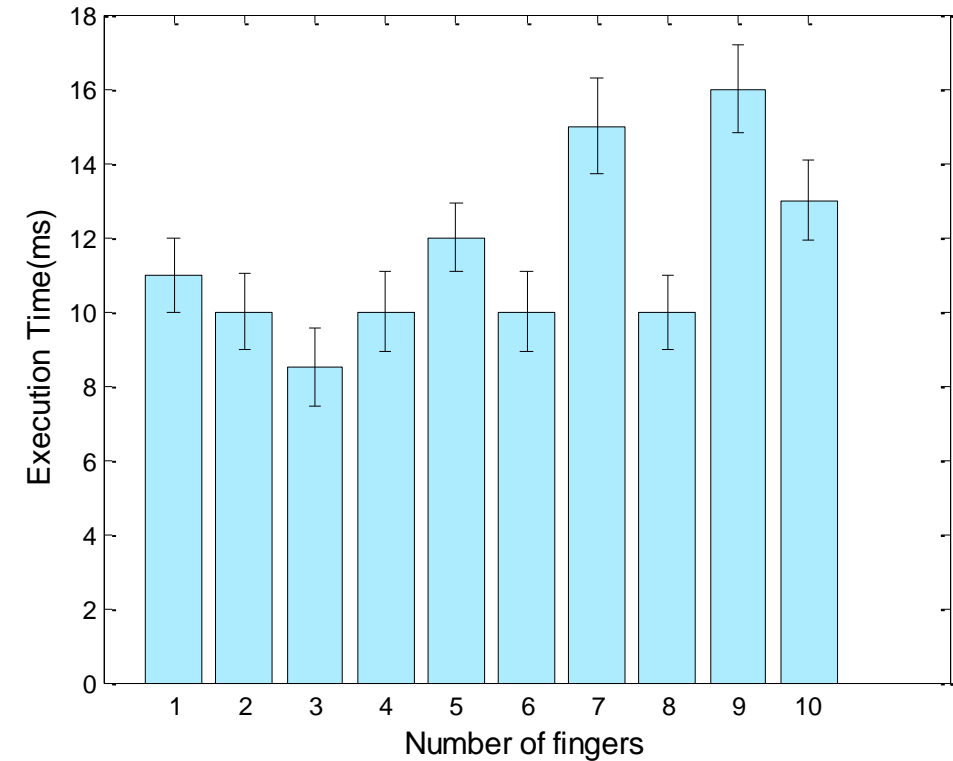

Figure 6. Execution times with respect to the simultaneous number of contacts involved in the processing.

Discussion

- When the number of contacts is less than five
  - Only one contact
  - Two contacts
- The accuracy increases as the number of finger contacts increases
  - May be affected by adhesion
- Limitations
  - Only deals with one user
  - Do not consider continuous frames
  - Relies heavily on the detection of finger

Conclusion

- Simple but robust software-based method
- Take both the contacts and the complete arm-hand-chain into consideration
- Achieved an accuracy of 91.4% in detecting finger handedness.

Thank You !

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