aLeak: Privacy Leakage through Context-Free Wearable Side-Channel

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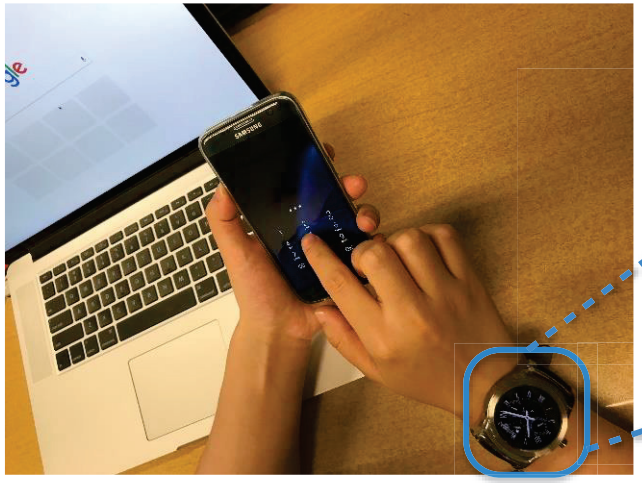
One day…

Gyro.



Acc.

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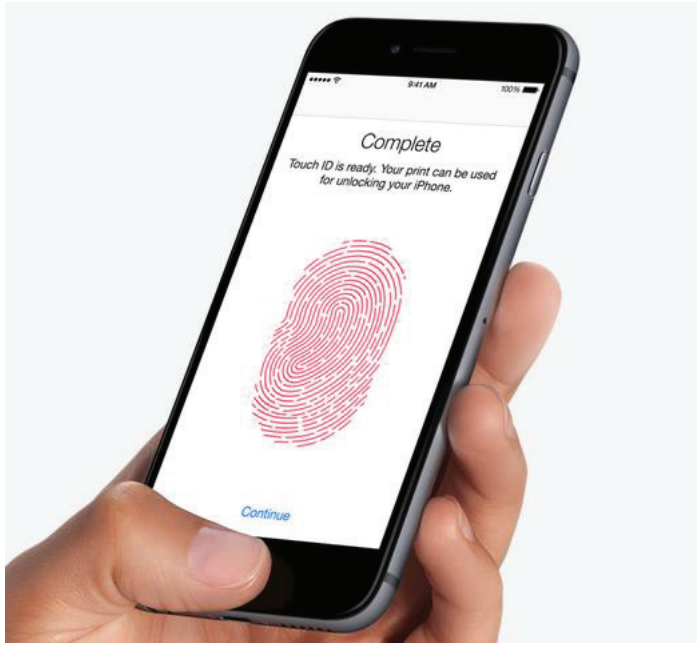
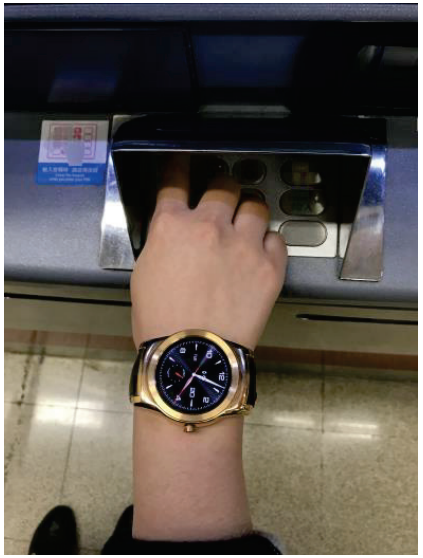
Any countermeasure?

Touch ID



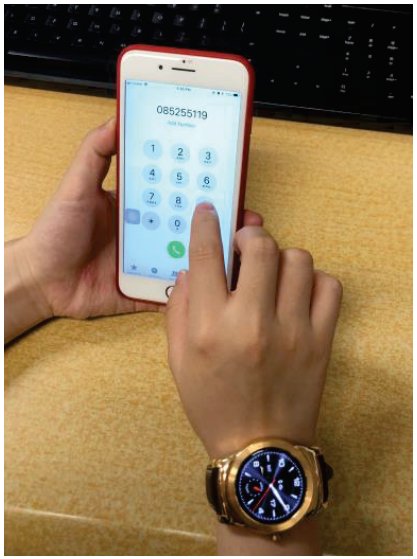
Face ID

But…

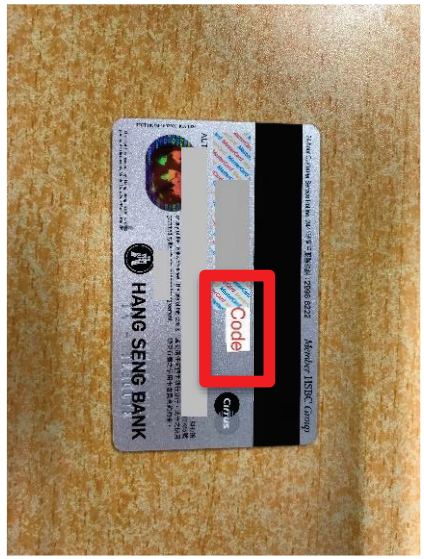


ATM or POS

Door entrance



Telephone



Secure code

Explicitly typing cannot be avoided

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Existing works

[ASIA CCS'16]

[CCS'15]

[MobiCom'15]

- **Horizontal keypad plane**
- **Known keyboard layout**
- **Fixed "Enter" button**

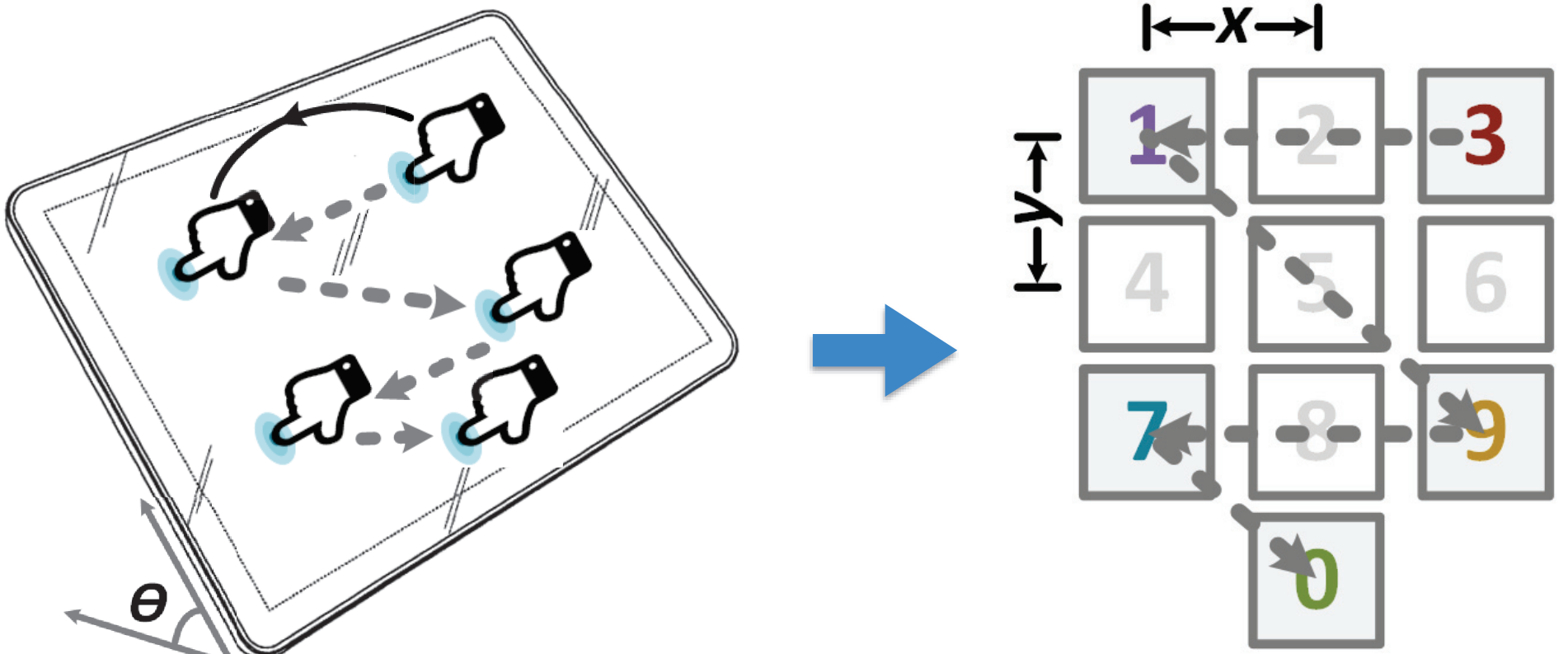
Context-free

?

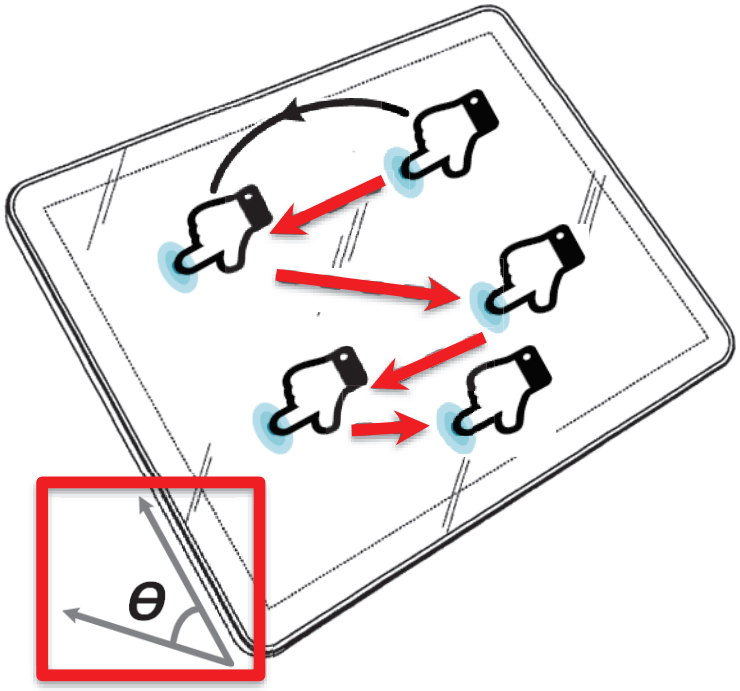
Arbitrary attitude

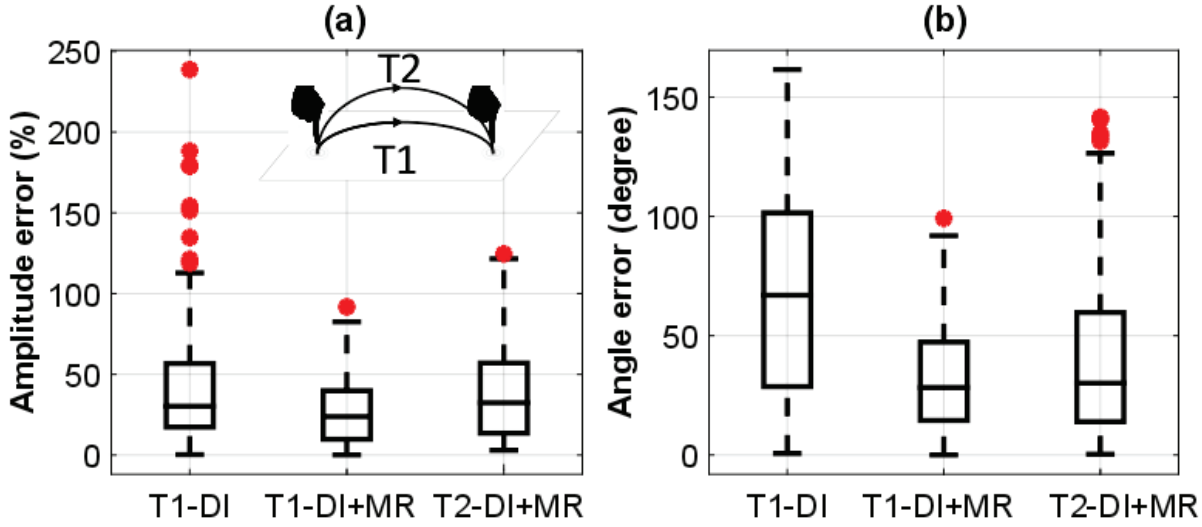
Unknown keyboard size

Attack process



Challenge-I: motion recovery





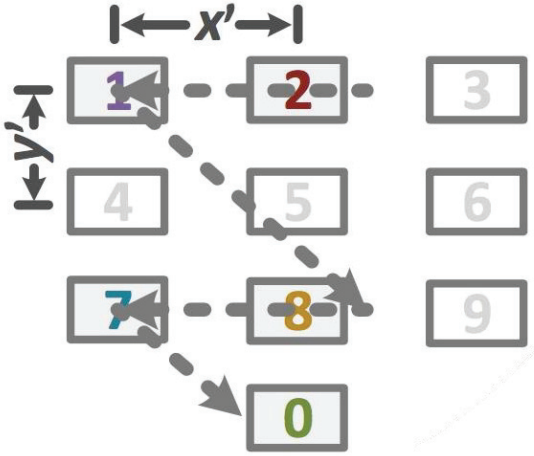
Cannot reliably reconstruct

Challenge-II: Unknown keyboard

x: 21	x: 15	x: 14	x: 21
y: 21	y: 14	y: 10	y: 20

Range of x: 19 ~ 91 (mm)

Range of y: 19 ~ 97 (mm)

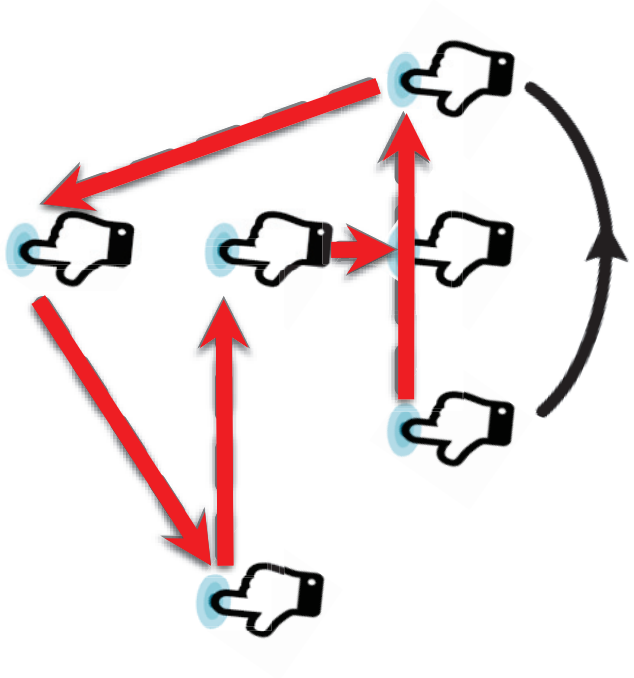


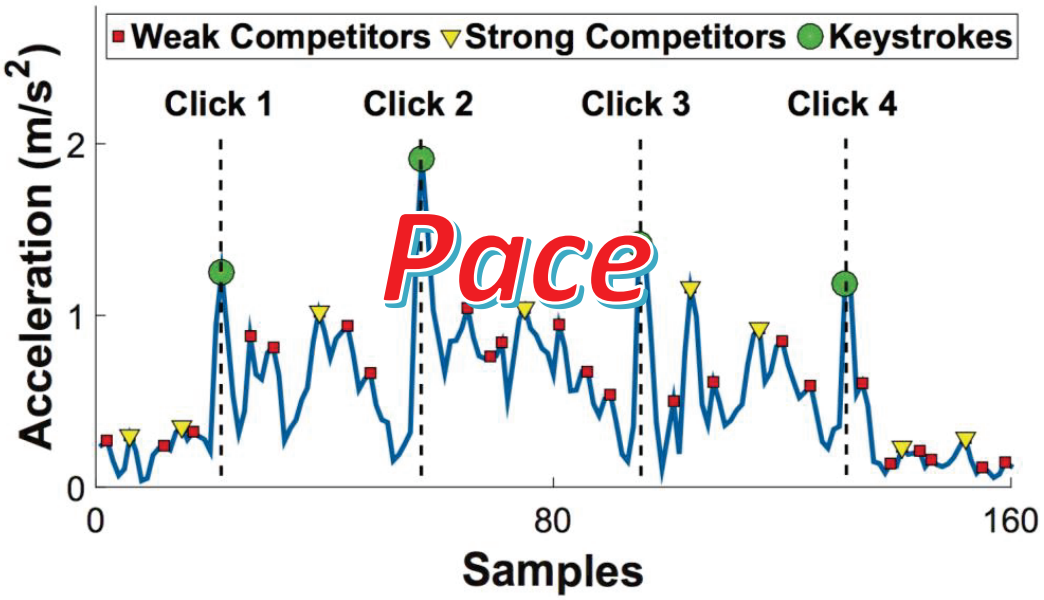
Correct result: 31970

Wrong result: 12780

System Design

Motion recovery: segmentation

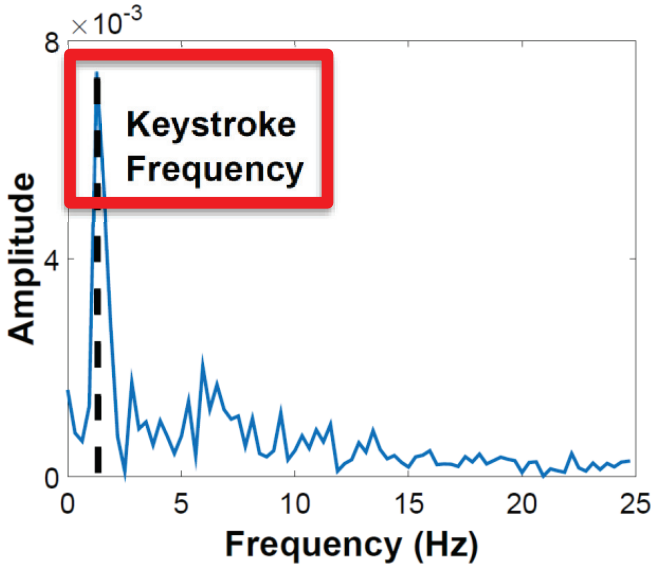




Motion data

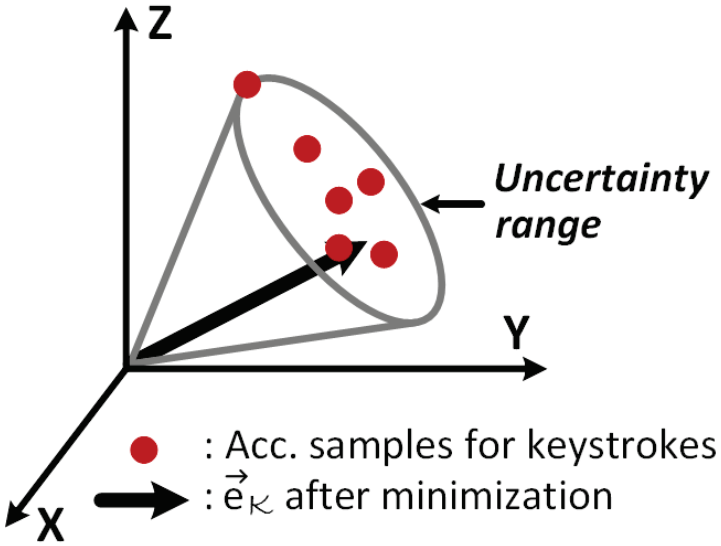
Segment

Displacement vectors



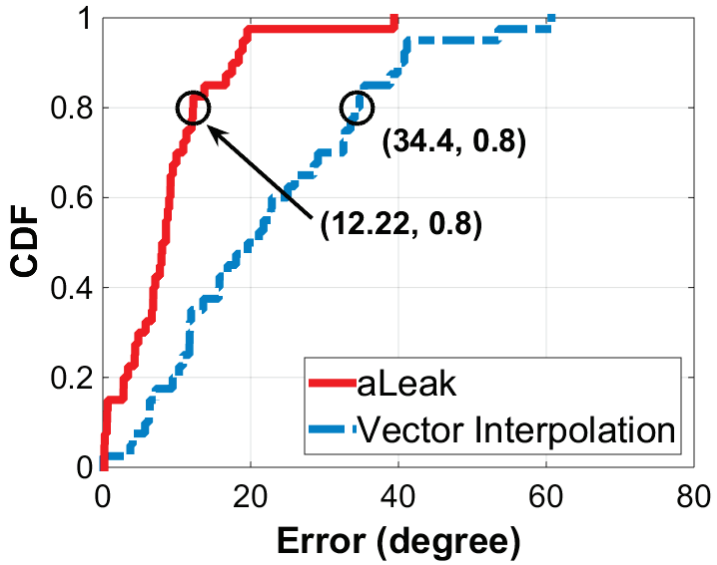
$$t_{pace} = 1/f_{type}$$

Motion recovery: plane reconstruction



Keystroke is perpendicular to the keypad plane

$$max_{\vec{e}_K \in cone} \sum_l ||g(s_j, \vec{e}_K)||_2$$



No error accumulation

Now

Derived keypad plane

Moving trajectory on the plane

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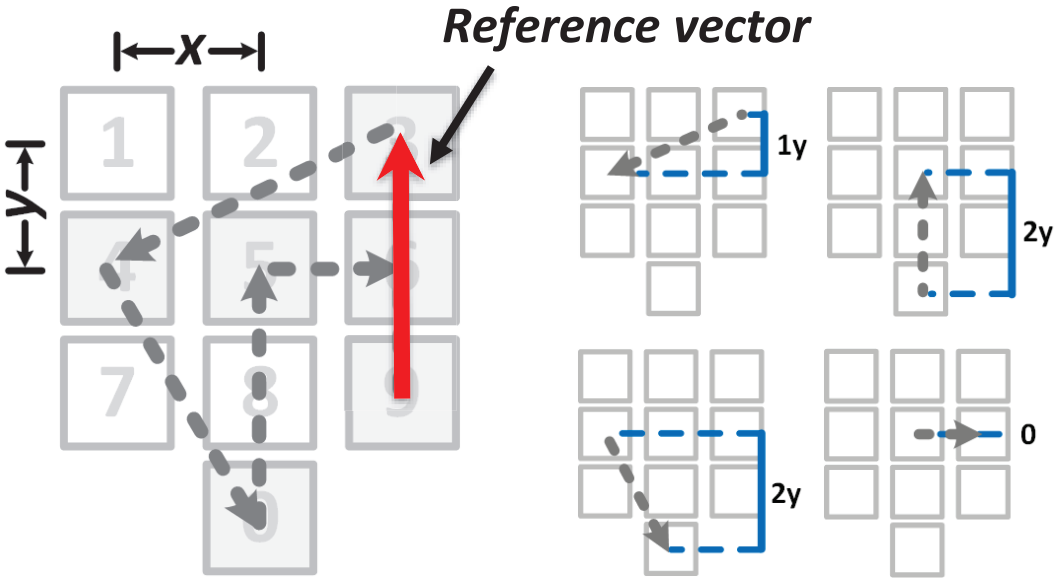
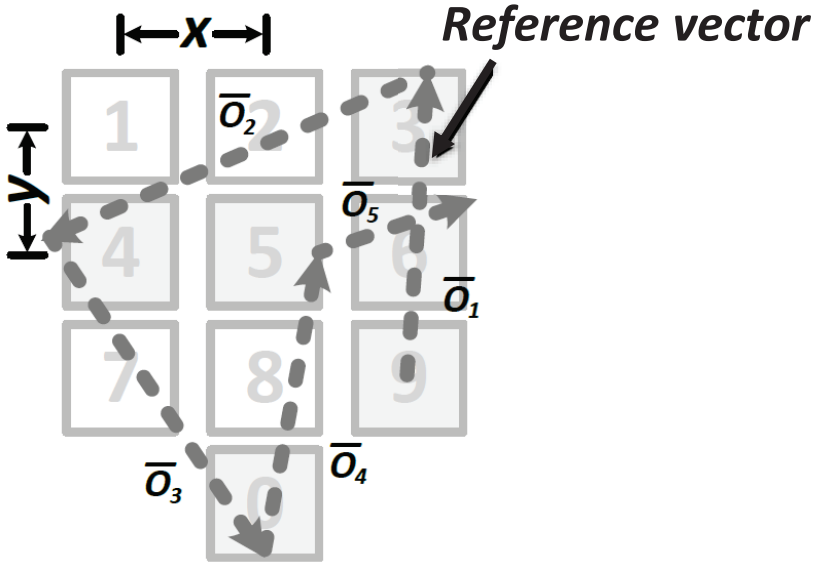
Keyboard size derivation



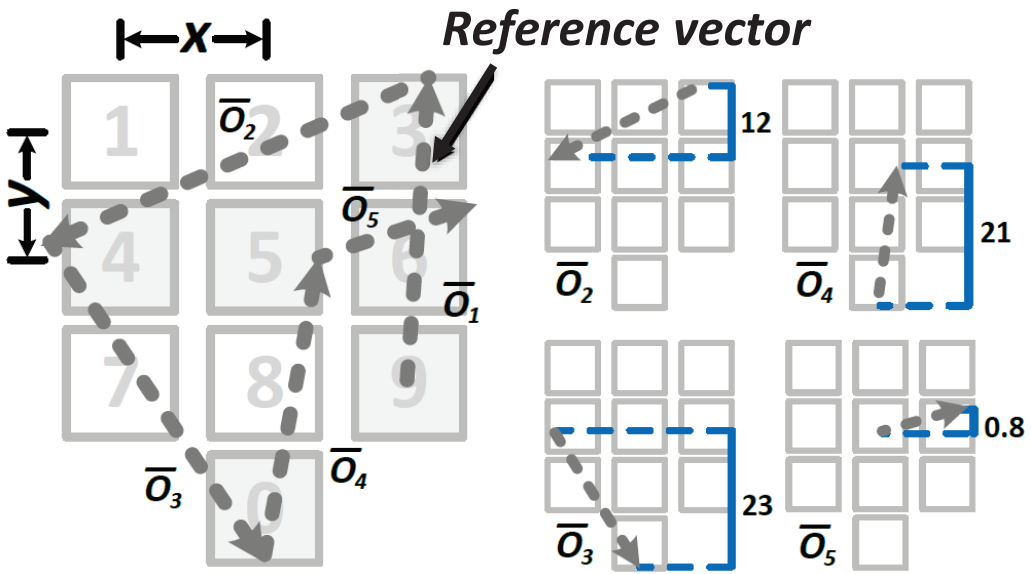
Key observation:

Integral multiples of x and y



Errors in trajectory

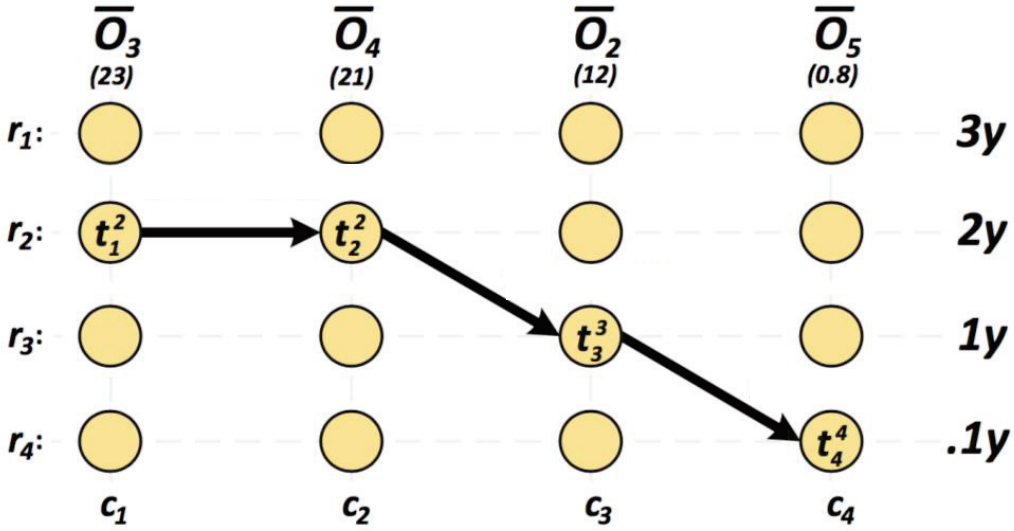
Keyboard size derivation



Our solution:

Projected lengths ➡ **constraints**

Search with a best match

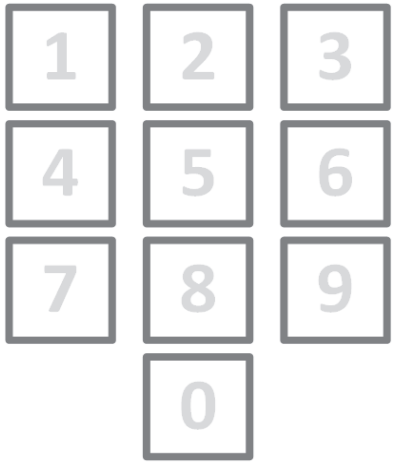


$$w(t_j^i, t_{j+1}^{i'}) = \left| \frac{len(c_{j+1})}{len(c_j)} - \frac{len(r_{i'})}{len(r_i)} \right|$$

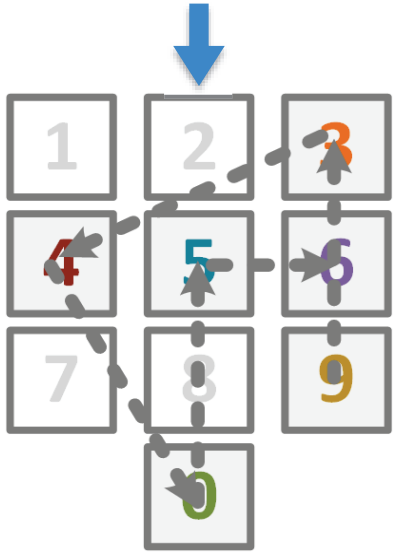
$$0.09 = \left| \frac{21}{23} - \frac{2y}{2y} \right|$$

Typed information inference

Moving trajectory



Keyboard



Inference result

- **Position of reference vector**
- **Computation overload reduction**
- **Handling “enter” cases**

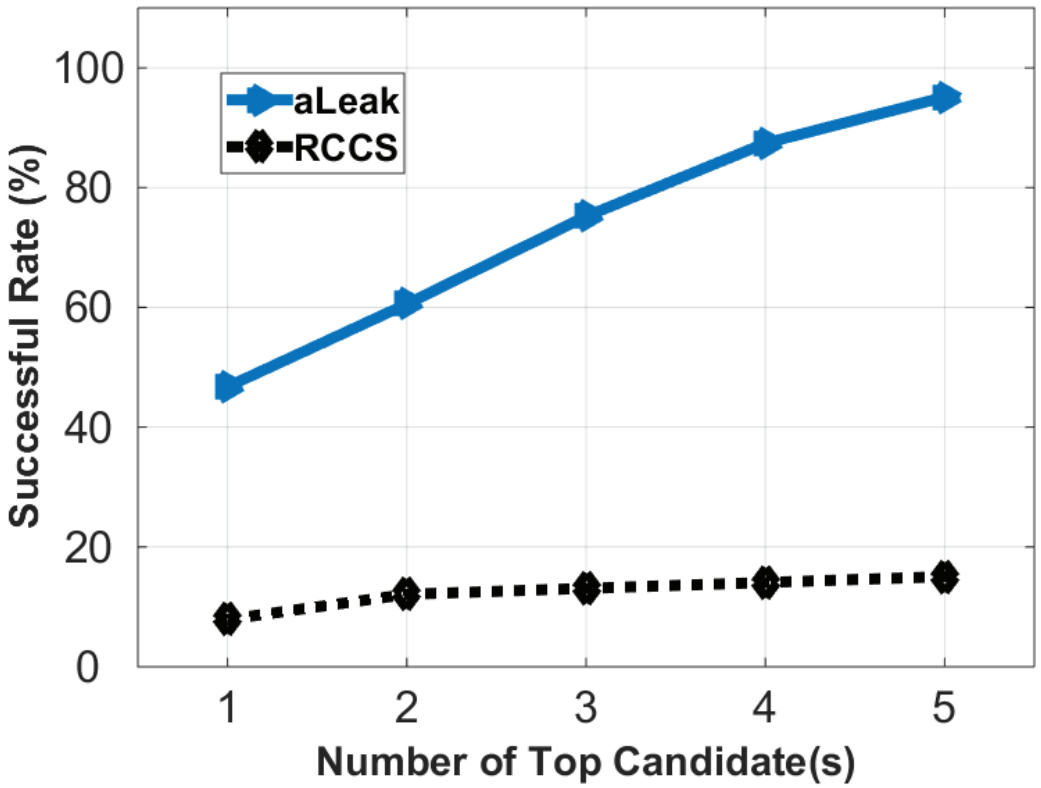
Evaluation

Experiments setup

- **LG W150**
- **4 common types of keyboards**
- **More than 300 rounds with 5 users**
- **Compared with [ASIA CCS'16]**

Evaluation results

- **Overall Performance**



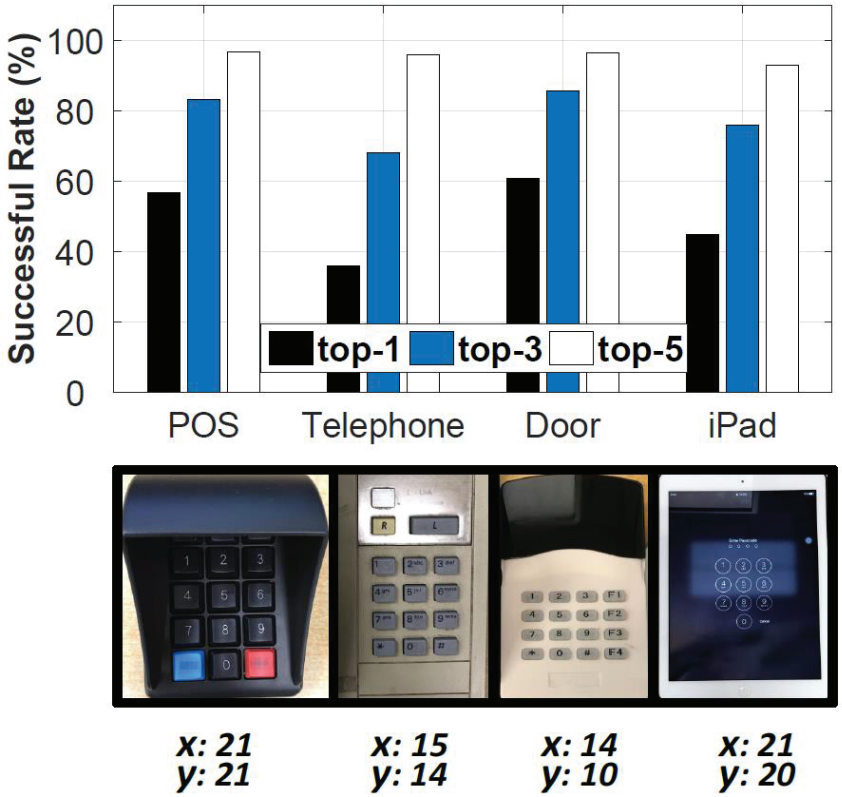
Keypad posture: 0 ~ 90°

top-1: 45%

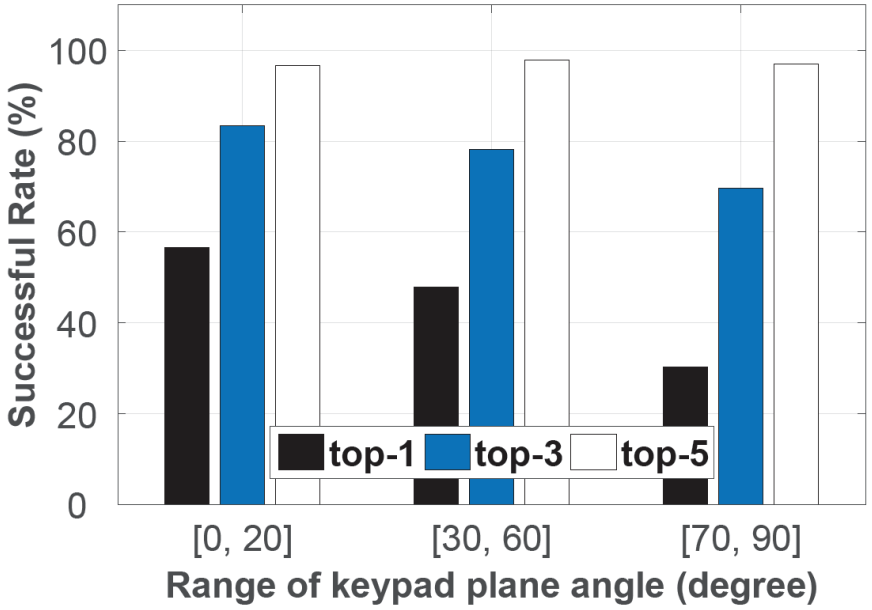
top-5: 94%

Evaluation results

- **Different keyboards**



- **Different keypad postures**

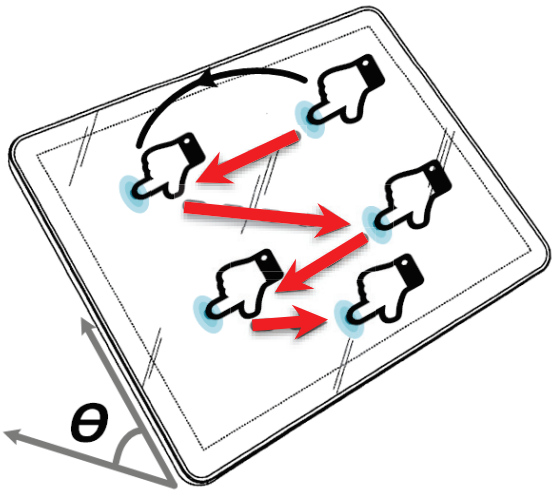


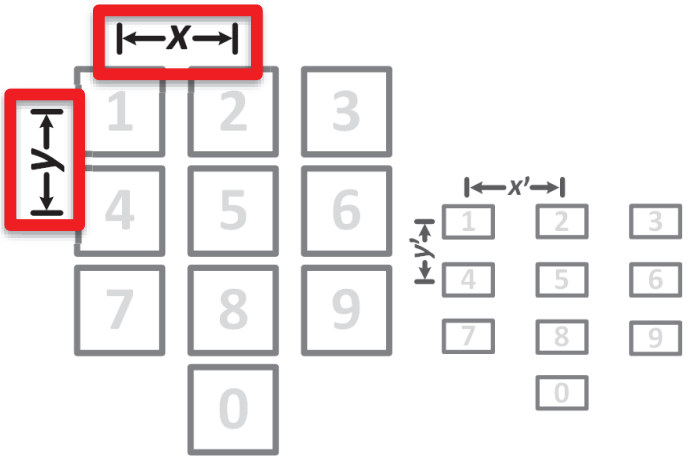
Conclusion 1,2,3

1. **Side-channel attack is possible in context-free scenarios**

2. **Challenges**
   - **2.1 Inaccurate motion recovery**
   - **2.2 Unknown keyboard size**

3. **Techniques**





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Q&A

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