TouchLogger: Inferring Keystrokes on Touch Screen from Smartphone Motion

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Security Problems on Smartphones

- Old problems
  - Malware
  - Software bugs
  - Information leak
  - …
- New problems
  - How can attackers exploit sensors?

Sensors on Smartphones

- Privacy-sensitive sensors
  - Microphones
  - Cameras
  - GPS
- Are motion sensors privacy-sensitive?
  - Accelerometers
  - Gyroscopes

Traditional Keyloggers

- Intercepting key events
  - E.g., Trojan programs
- Using out of channels
  - Acoustic frequency signatures of keys
  - Timing between keystrokes
  - Electromagnetic emanations of keystrokes
- Work well on physical keyboards
  - But not on software keyboards

Keylogger for Soft Keyboard

- New out of band channel on smartphones
  - Accelerometers
  - Gyroscopes
- Insight: motion sensor data can infer keystrokes

Threat Model

- Keylogger can read motion sensor
  - Most users do NOT regard motion sensors as sensitive data source
  - W3C's DeviceOrientation Event Specification allows web applications to read motion sensors via JavaScript
    - supported by both Android 3.0 and iOS 4.2
- User does NOT place phone on fixed surface

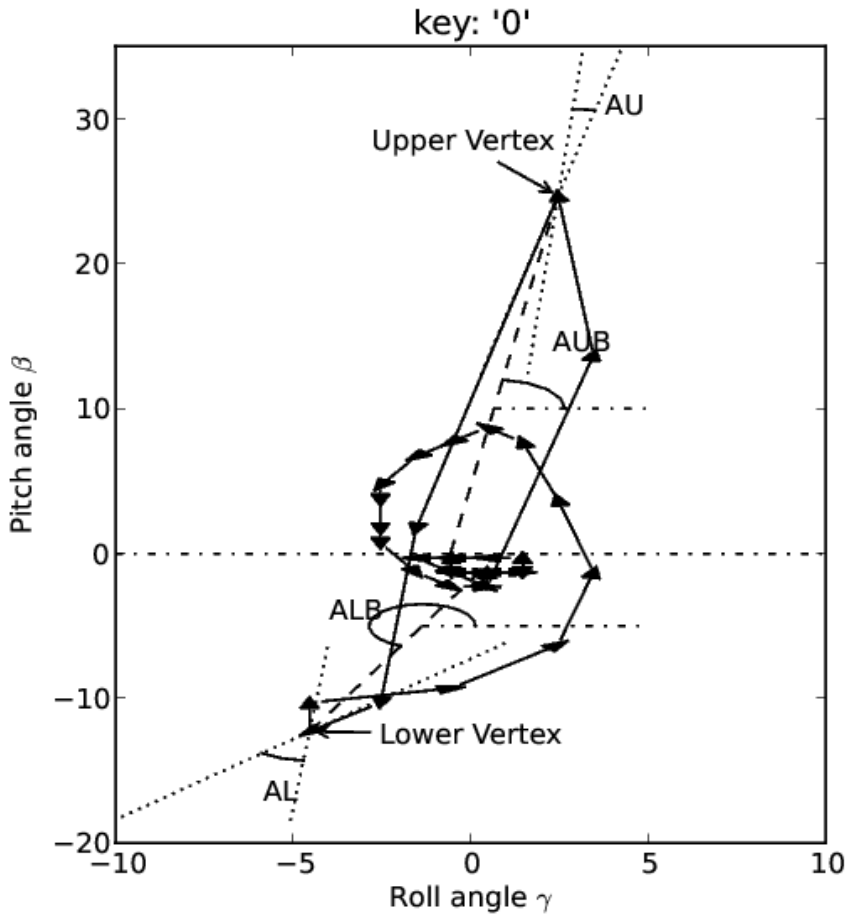
Modeling Typing-Induced Motion

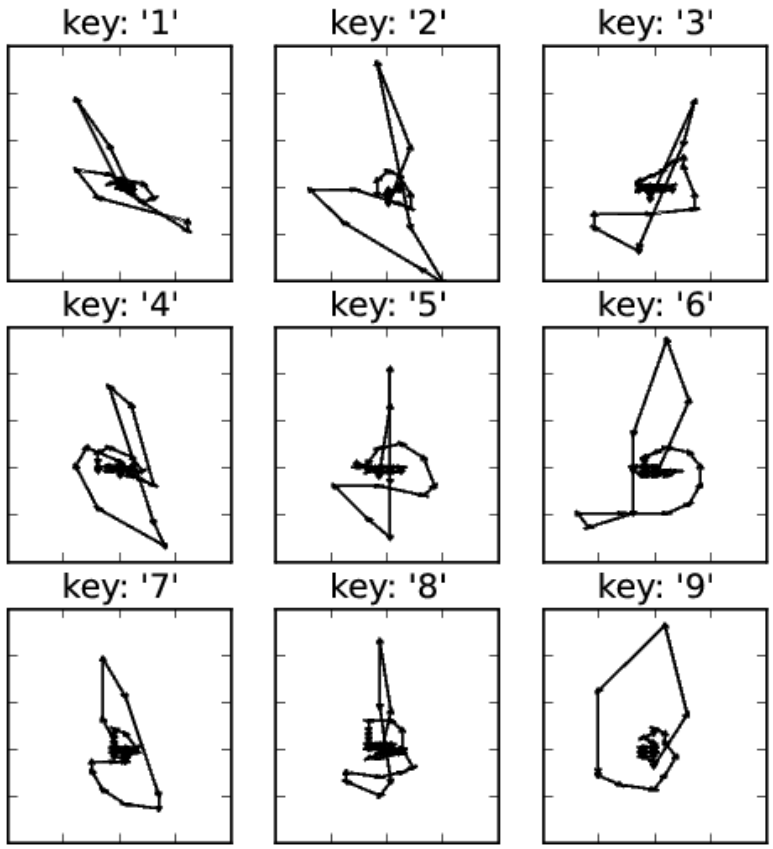
- Shift is affected by
  - Striking force of the typing finger
  - Resistance force of the supporting hand
- Rotation is affected by
  - Landing location of the typing finger
  - Location of the supporting hand on the phone
- We observe
  - Shift is more likely user dependent
  - Rotation is more likely user independent

Device Orientation

- Device orientation event consists of
  - α: Device rotates along z-axis (perpendicular to the screen plane)
  - β: Device rotates along x-axis (parallel to the shorter side of screen)
  - γ: Device rotates along y-axis (parallel to the longer side of screen)
- We use only β and γ

Feature Extraction





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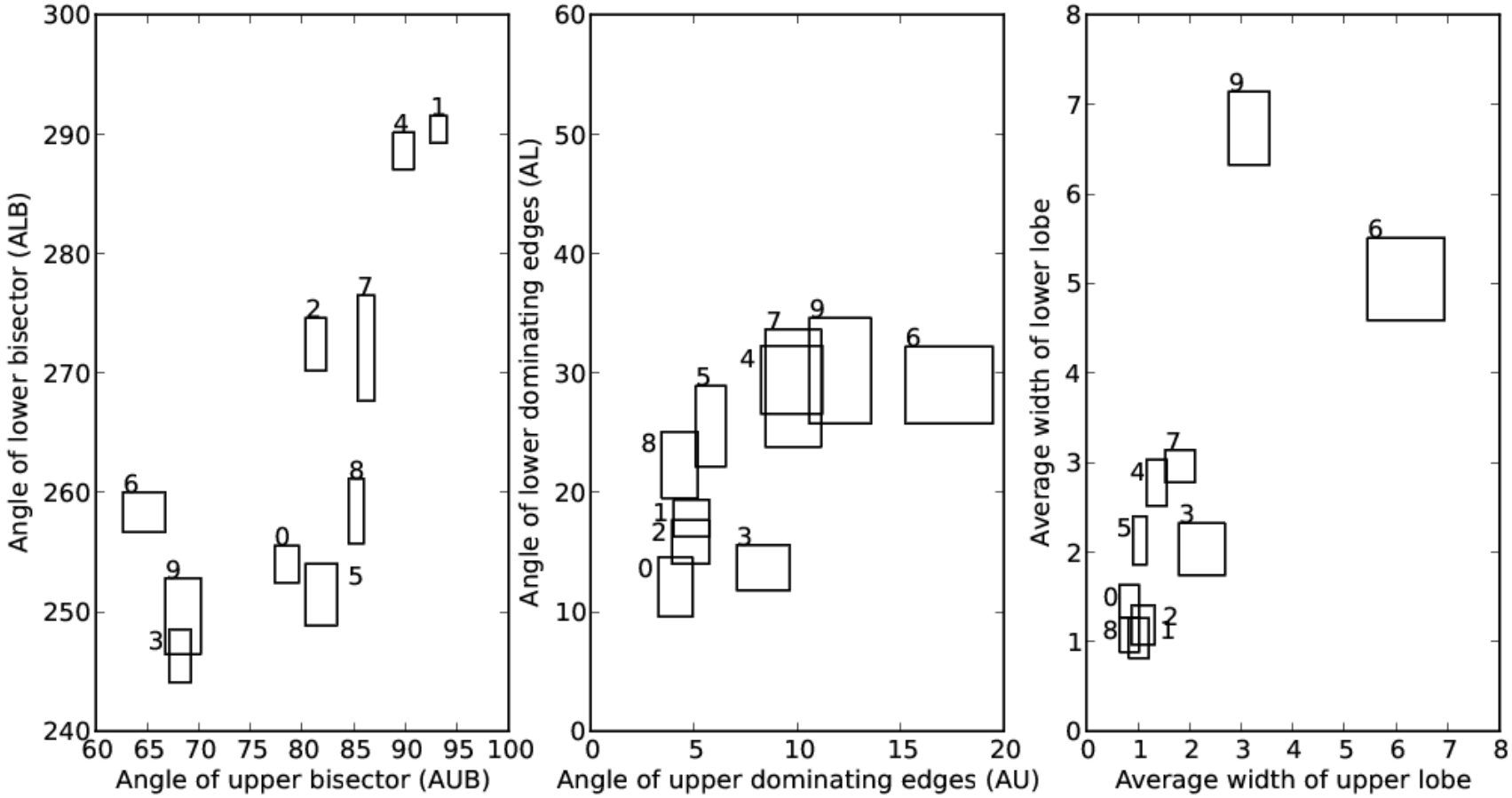


Evaluation

- HTC Evo 4G smartphone
- Digits 0 … 9 on number-only soft keyboard

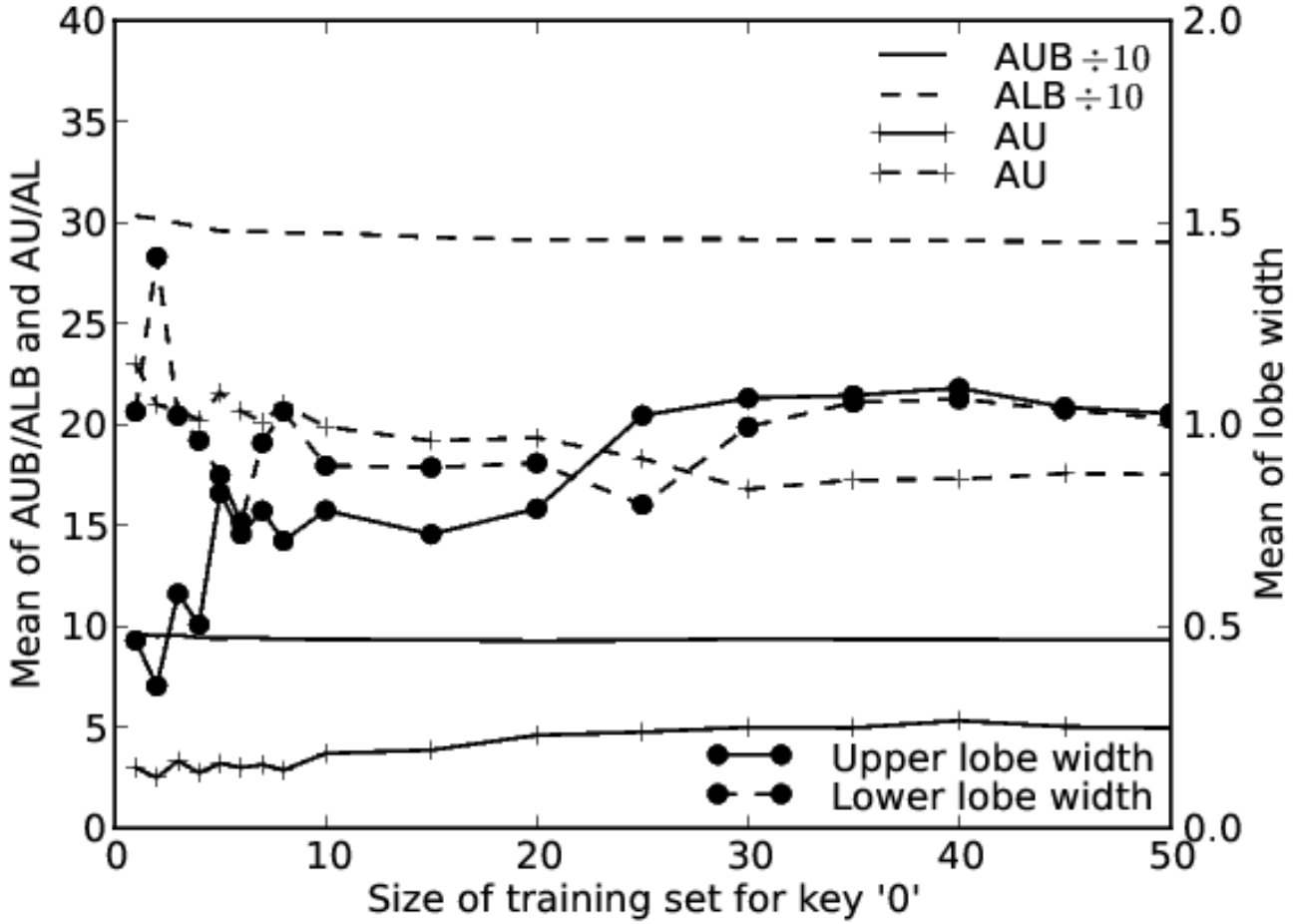
Results

- Collected 3 datasets
  - 2 smaller datasets for training
  - The largest dataset (449 keystrokes) for testing
- Correctly inferred 321 out of 449 (71.5%) keystrokes.

Detailed Inference Results

Actual Key	Inferred Key									
	0	1	2	3	4	5	6	7	8	9
0	64%	-	6%	10%	-	12%	-	-	8%	-
1	-	86.3%	-	-	13.7%	-	-	-	-	-
2	8.3%	4.2%	68.8%	4.2%	-	2.1%	3.1%	4.2%	6.2%	-
3	18%	-	-	70%	-	-	6%	-	-	6%
4	-	10%	8%	-	72%	2%	-	8%	-	-
5	8%	4%	4%	8%	-	60%	-	4%	12%	-
6	-	-	1.9%	7.5%	-	1.9%	77.4%	-	-	11.3%
7	2%	-	4%	-	16%	14%	-	56%	8%	-
8	-	-	10%	-	-	15%	-	-	75%	-
9	-	-	-	3.8%	-	3.8%	11.5%	-	-	80.8%

Training Set Size



Conclusion

- Motion sensors on smart phones may reveal keystrokes
- Need to protect motion sensors as diligently as other sensors