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## The Blossom of the Mobile Computing Era



- Presentations / briefing notes.
- Address book information.
- Personal photos, movies, and email.
- Personal health, salary, and benefits information.
- Access credentials for networks and applications.
- Credit card and e-banking information.



























#### Mobile Authentication

- Password/PIN/Pattern-based authentication.
  - Simple and widespread.
  - × No continuous authentication.
  - × Prone to guessing attacks (not mobile specific).
  - × Prone to smudge [WOOT'10] and shoulder-surfing [CCS'13] attacks.
- Biometric authentication.
  - A viable option for many mobile users.
  - Amenable to continuous authentication.
  - Several existing mechanisms: gaits, gestures, keystroke dynamics.
  - Poor accuracy (> 5% EER) or prone to statistical attacks [CCS'13].



#### WWW: What We Want

- High-accuracy biometric authentication for mobile devices.
- Robustness against human attacks.
- Robustness against statistical attacks.
- Static authentication capabilities.
- Continuous authentication capabilities.
- Robustness against uncontrolled settings.



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High-accuracy biometric authentication for mobile devices.

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## Soft keyboard on a mobile device



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# Scenario: User typing 'HELLO'





User 1 KeyDowns - User 1 KeyUps



## **Keystroke dynamics**







User 1 KeyDowns - User 1 KeyUps



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## **Keystroke dynamics**





- User 1 - User 1 KeyDowns - User 1 KeyUps









- User 1 - User 1 KeyDowns - User 1 KeyUps



## Sensor-enhanced keystroke dynamics





- User 1 - User 1 KeyDowns - User 1 KeyUps









- User 1 - User 1 KeyDowns - User 1 KeyUps







- User 1 - User 1 KeyDowns - User 1 KeyUps









- User 1 - User 1 KeyDowns - User 1 KeyUps









- User 1 - User 1 KeyDowns - User 1 KeyUps









- User 1 - User 1 KeyDowns - User 1 KeyUps









- User 1 - User 1 KeyDowns - User 1 KeyUps









#### Sensor-enhanced keystroke dynamics



I Sensed It Was You: Authenticating Mobile Users with Sensor-enhanced Keystroke Dynamics





- User 1 - User 1 KeyDowns - User 1 KeyUps









- User 1 - User 1 KeyDowns - User 1 KeyUps



## Sensor-enhanced keystroke dynamics



#### UNAGI





I Sensed It Was You: Authenticating Mobile Users with Sensor-enhanced Keystroke Dynamics



- Modified Android keyboard intercepts and records keystroke events.
- Records only events of interest (i.e., alphanumeric characters).
- KD time: Timestamp associated to key-down events.
- KU time: Timestamp associated to key-up events.



#### Gathering Sensor Data



- Relies on the Android API to record sensor values while typing.
- Can sample sensor values at a high frequency (e.g., 17 Hz).
- Gyroscope: measures device orientation on the 3 axes.
- Accelerometer: measures device acceleration on the 3 axes.





#### Feature Extraction



#### Traditional keystroke dynamics



I Sensed It Was You: Authenticating Mobile Users with Sensor-enhanced Keystroke Dynamics



#### Feature Extraction



- 1 feature for each *n-graph* between KD/KU events.
- Keystroke dynamics: time interval associated to each *n*-graph.
- Sensor dynamics: statistical metrics associated to each *n*-graph.



#### Detection

- Features gathered in a labeled vector and normalized.
- Feature vectors used to train a binary classification algorithm.

#### Algorithms:

- Once-class Support Vector Machines (SVM).
- Naive Bayes.
- k-Nearest Neighbors (kNN).
- Mean algorithm.

#### Distance metrics:

- Euclidean.
- Euclidean normed.
- Manhattan.
- Manhattan scaled.
- Mahalanobis.





#### **Experimental Setup**

- Fixed-text authentication system in a controlled setting.
- 2 predetermined passwords: "internet" and "satellite".
- 20 test subjects, 40 (typo-free) password repetitions.
- Samsung Nexus S with a soft landscape keyboard.
- Trained detector for each user using leave-one-out cross-validation.
- Measured FAR, FRR, EER and averaged results across users.
- Factors considered: window size, algorithm, sampling frequency.





#### Accuracy vs. Window Size







#### Accuracy vs. Detection Algorithm





I Sensed It Was You: Authenticating Mobile Users with Sensor-enhanced Keystroke Dynamics

## Accuracy vs. Sampling Frequency





I Sensed It Was You: Authenticating Mobile Users with Sensor-enhanced Keystroke Dynamics



## Summary

- Sensor-enhanced Keystroke Dynamics (SKD): A new biometric authentication mechanism for mobile devices.
- UNAGI: A fixed-text authentication system based on SKD.
- Key results:
  - Movement sensors are suitable for biometric authentication purposes.
  - Sensors can drastically enhance keystroke dynamics accuracy.
  - Effective even with short passwords and low sampling frequencies.

#### Future work:

- Applicability to free-text authentication and uncontrolled settings.
- Robustness against statistical attacks.



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#### Thank you! Any questions?

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