Presentation Attack Detection for Smartphone Finger Image Recognition

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Agenda

- Access Control
- Biometric authentication on Smartphones
- Presentation Attack Detection
- Are the metrics in 30107-3 applicable?
Access Control
Traditionally we place between

- individuals
- and objects
- a token (i.e. key)
But in reality individuals
- do not have just one
- but many keys
- granting access to many doors
It won’t take long

- that NFC enabled Smartphones will interact with most doors

The Smartphone is a major threat!

Source: Association of key manufacturers
(as of 2011-12-07)
Do we use Access Control before we unlock our Smartphone?
End-User Survey

Data in mobile devices is often insufficiently protected

- No PIN-authentication required after stand-by phase
  - Survey-result with 962 users: only 18% use PIN code or visual pattern to unlock
- All data on the phone is freely available
  - Emails, addresses, appointments, photos
  - PINs etc.

Reason for this:

- PIN-authentication is too much effort (30%)
- People are self-responsible for their phones

Biometrics on Smartphones

Is the integration of fingerprint sensors in Smartphones a security gain?

- Chaos Computer Club: NO
- cb: YES - it motivated many users to activate access control in the first place

Preliminary assessment:

- Apples introduction of iPhone 5s offers a convenience solution that satisfies the security requirements for authentication for low volume transaction.
- For the experienced attacker the sensor has shown weaknesses
Smartphone Access Control

Foreground authentication (user interaction)

- Deliberate decision to capture (wilful act)
- Camera-Sensor
  - Fingerprint recognition
    - Apple iPhone 5S
    - Fingerphoto analysis
  - Face recognition
  - Iris recognition

Background authentication (observation of the user)

- Microphone
  - Speaker recognition
- Accelerometer
  - Gait recognition
  - concurrent - unobtrusive
Biometric Gait Recognition

Offer an **unobtrusive** authentication method

- Use **accelerometers** - already embedded in mobile devices to record the gait
  - Many phones contain **accelerometers**
  - No extra hardware is necessary
  - Acceleration measured in 3-directions

**First paper on this topic:**

- **EER 20% at that time**
Biometric Gait Recognition

Data capture process
- periodical pattern in the recorded signal

Best result
- now at 6.1% EER
The following is prehistoric work.
The following is prehistoric work (before the Apple iPhone5 arrived)
but as always:
we can learn from history
Master Thesis Chris Stein 2012: Finger recognition

- Smartphone **camera** as sensor
- Authentication based on photo of the finger

**Challenges**

- Translation and rotation

- Distance finger to camera

- Uncontrolled background and illumination
Smartphone Access Control

Capture process

- Camera operating in macro modus

Preview image of the camera with LED on (left) and LED off (right)

- LED permanent on

Finger illuminated

Fingerprint recognition

- Preprocessing, minutiae extraction and comparison are performed on the phone
- Results of 18% EER are based on DigitalPersona FingerJetFX OSE (Open Source Edition) and home-made-minutiae comarator

see video at: http://www.dasec.h-da.de/research/biometrics/mbassy/
Finger recognition study - 2012/2013

- Objectives:
  - Replace home-made comparator (and the Digital Persona extractor) by COTS standard technology to increase performance
  - Investigate Presentation Attack Detection capabilities with reflection analysis and video recordings
Finger recognition study - 2012/2013

- Results: biometric performance at 1.2% EER

Finger recognition study - 2012/2013

- Presentation Attacks
  - 1: replay from Smartphone display (simple)
  - 2: self generated print-outs (not critical to detect)
  - 3: Ralph Breithaupt’s / BSI best artefacts (very challenging)
Finger recognition study - 2012/2013

- Observation
  - significant strong light reflection near the fingertip
  - from the cameras LED

- Reflection depends on
  - Shape of the finger
  - Consistency of the finger
  - Angle of the finger to the camera

- Attack detection, as light reflection differs from artefacts to genuine fingers

Finger recognition study - 2012/2013

- Results: Presentation Attack Detection

- Conclusion: better Presentation Attack Detection than capacitive sensors
Reporting about the PAD using ISO/IEC WD 30107

- **artefact**
  artificial object or representation presenting a copy of biometric characteristics or synthetic biometric patterns.

- **artefact species**
  artefacts based on sources whose biometric characteristics differ but which are otherwise identical (e.g. based on a common medium and production method but with different biometric characteristic sources)

- **attack potential** *(this definition is from CC terminology)*
  attribute of a biometric presentation attack expressing the effort expended in the preparation and execution of the attack in terms of elapsed time, expertise, knowledge about the capture device being attacked, window of opportunity and equipment, graded as “no rating“, “minimal”, “basic”, "enhanced-basic,” “moderate” or “high."
Metrics in ISO/IEC 30107 PAD - Part 3: Testing and reporting and classification of attacks

- **Attack presentation classification error rate (APCER)**
  
  proportion of attack presentations incorrectly classified as normal presentations in at the component level a specific scenario

- **Normal presentation classification error rate (NPCER)**
  
  proportion of normal presentations incorrectly classified as attack presentations at the component level in a specific scenario
Applying ISO/IEC 30107-3 Metrics

Do the metrics currently in ISO/IEC 30107 PAD - Part 3: serve to provide a meaningful report?

- [SBB12] - Publication: The reported number of attack presentations incorrectly classified as normal presentations was one out of five artefacts.

- Thus the APCER to be reported is

\[ APCER = \frac{1}{5} = 0.2 \]

- but there were in fact 27 artefact species, that were used in the background but not reported as they are not challenging.

\[ APCER = \frac{1}{27} = 0.04 \]
Refining ISO/IEC 30107-3 Metrics

Findings

• The size of the corpus with the artefact species is essential

• The APCER should be based on presentation attack instrument (PAI) and not only on artefacts, which includes both artefacts and lifeless biometric characteristics (i.e. stemming from dead bodies)
  - 30107-1: **PAI** - biometric trait or object used in a presentation attack.

• The CC-related attack potential should be included in the definition
  - 30107-1: **attack potential** - attribute of a biometric presentation attack expressing the effort expended in the preparation and execution of the attack in terms of elapsed time, expertise, knowledge about the capture device being attacked, window of opportunity and equipment, graded as “no rating“, “minimal”, “basic”, "enhanced-basic,” “moderate” or “high.

• The known success rate of an artefact species is relevant
Refining ISO/IEC 30107-3 Metrics

Suggested augmented metric for ISO/IEC 30107-3

- **Attack presentation classification error rate (APCER)**
  
  *proportion of attack presentations incorrectly classified as normal presentations at the component level a specific scenario* - taking the **attack potential** and the known artefact species success rate into account.

- **Attack potential (AP)** = {0.2 for “minimal”, 0.4 for “basic”, 0.6 for “enhanced-basic,” 0.8 for “moderate” . 1.0 for “high.”}

- **Presentation attack instrument success rate (PAISR)**
  
  Proportion of evaluated capture devices that could be spoofed by the specific PAI (i.e. artefact).
  
  - would start with a value of 1 for a new discovered artefact species and could be reduced over time (as more sensors become robust)
Suggested refined metrics for ISO/IEC 30107-3

- The APCER could thus be expressed as

\[
APCER = \frac{\sum_{i=1}^{NAS} RES_i \times AP_i \times PAISR_i}{NAS}
\]

\[NAS\] number of presentation attack instruments (PAI) (i.e. artefact species) in the corpus

\[RES_i\] result of attack with \(i^{th}\) PAI

\{0 for detected attack, 1 for successful attack\}

\[AP_i\] attack potential of the \(i^{th}\) PAI

(close to zero, if artefact is easy to produce)

\[PAISR_i\] presentation attack instrument success rate

(close to zero, if all sensor can detect this artefact)
Open Question

To be clarified

- Should there be a fixed-size of the corpus, such that all labs use a minimum number of artefact species?
- Can one expect that a testing lab has access to non-artefact PAI (from dead bodies)?
- What happens with the new sensor? The success rates start with 1 and is decrease as robust sensor do appear.
- How can evaluation labs have an equivalent set of PAI with all the same attack potential?
Conclusion

• **Smartphones** without biometric access control are a risk today and will be a **critical factor** tomorrow
  - once they will open doors via NFC
• The iPhone5 has changed this
• Biometric sensors are available in Smartphones at **zero cost**
  - even though they were built-in for other purposes
• Gait recognition shows reasonable biometric performance
• Currently defined metrics in ISO/IEC 30107-3 deserves refinement
Credits

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  - Chris Stein (Presentation Attack Detection)
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