NPL

# Evaluating Attack Resistance Levels of Biometric Systems

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CPNI
Centre for the Protection of National Infrastructure

# Outline

1. Rationale/Scope/Terminology
2. NPL / CPNI evaluation of biometric terminals for automated access control
3. Attack levels of the CPNI Grading System, with examples
4. General findings on attack resistance of biometric systems from th NPL / CPNI evaluation
5. Issues in evaluating attack resistance

# Rationale

**Quotes on the web**

- *We claim that we can fake every sensor …*
- *Fingerprints in particular are laughably easy to spoof.…*

**But …**

- Are some systems harder to spoof than others
  - e.g. systems with fake finger detection
- Are biometrics easier to spoof than other components of your system?
- Are these attacks relevant for your use case?

**Measures of attack resistance are needed that ….**

- Distinguish between good and poor attack resistance
  - Broad equivalence of metrics over different biometric technologies
- Relate attack resistance to the use case & risk assessment
  - Commensurate with security levels of other system components

# Terminology

## Attack

- This talk focuses on attacks at the sensor / terminal, including:
  - Artefact
  - Tamper
  - Bypass

## Level of an attack

- Difficulty or level of sophistication of the attack

## System resistant to an attack

- Prob[ Attack Succeeds ] is sufficiently low
- Prob[ Attack detected & alerted ] is sufficiently high

## Level of attack resistance

- Attack resistance at level $n$ implies the system is resistant to attacks at level $n$ or lower.

# CPNI Classification for  Security Products

CPNI
Centre for the Protection of National Infrastructure

**Guidance, standards & evaluation for …**

- Automated access control
- Intruder detection
- Barriers
- …
- Biometrics used in access control

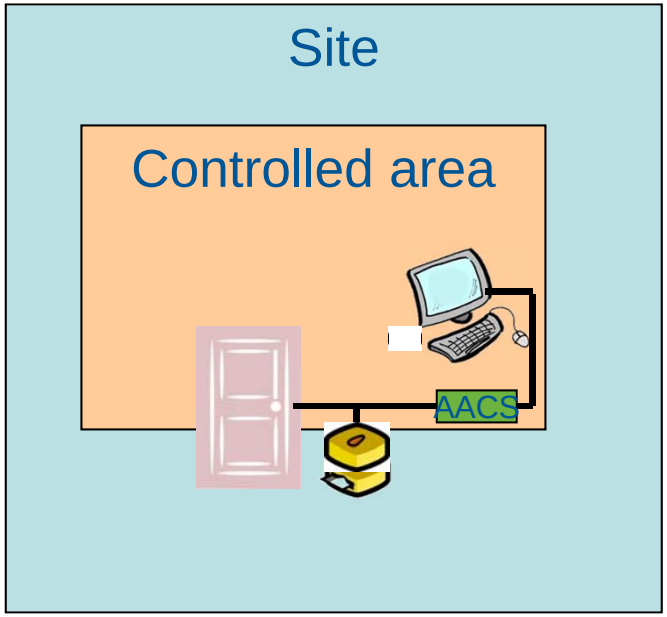
# CPNI/NPL Evaluation of Biometric Authentication for Automated Access Control Systems (AACS)

## Use case

- Access to controlled area within site
- Biometrics as 2nd authentication factor
  - combined with prox card
  - independent of prox card
- Trusted administration staff
  - Attacker must impersonate a properly enrolled identity

## Evaluation

- Evaluate biometric subsystem only
  - Security of dependent AACS system evaluated separately
  - Assure security at the same level as the rest of the AACS



# CPNI Evaluation Standard for Biometric Access Control

1. **Security-related functionality**
   - Admin & operator access*: (i) Authenticated (ii) NOT at terminal*
   - Reference storage: *(i) NOT in device at portal (ii) NOT on card*
   - Communications with AACS: *(i) Protected (ii) Alert on tamper, spoof*
   - Check on installation
2. **Biometric performance requirements**
   - *FAR < 0.1%* & requirements on *FRR, FTE, Transaction times*
   - Scenario test
3. **Attack resistance**
   - CPNI Grading depends on level of attack resistance
     - Spoofing
     - Tamper
     - …
   - Practical assessment

# Testing Attack Resistance

**Variety of types of attack**

- Zero-effort impostor – e.g. targeting lookalike
- Fake finger, fake iris, …
- Tamper
  - Remove from wall, Connect attacker's PC to terminal or AACS
- Exploiting poor quality enrolment, …

**Attack assumptions for the evaluation (based on use case)**

- Attacker has obtained possession of a user's prox card
- User is known and accessible to acquire a biometric image
- Attacks to be made at same security settings as used in determining verification performance

**Attack resistance**

- System considered resistant to an attack if < 5% of attacks of that type succeed

# Attack Levels of CPNI Grading System

| | | Resource level | | |
|---|---|---|---|---|
| | | Low | Medium | High |
| **Skill & knowledge level** | | Domestic / High Street | Trade / Specialist | Bespoke |
| Low | None | **1** | **2** | **3** |
| Medium | Knowledge of Product / Techniques | **2** | **4** | **5** |
| High | Expert | **3** | **5** | **6** |

# CPNI Grading System

| Attack Level | Protection System |
|---|---|
| 1 | Base |
| 2 | |
| 3 | Enhanced |
| 4 | |
| 5 | High |
| 6 | |

# Example Attack Levels: Fake Fingerprint

| | Home / High St. resources | Trade / specialist supplier | Bespoke resource |
|---|---|---|---|
| Novice<br>No special knowledge/skill |  1 |  2 |  3 |
| Knows product & techniques | 2 |  4 | 5 |
| Expert | 3 | 5 | 6 |

# Knowledge and Resource Requirements to Fake Fingerprints

| Step | Resource | Knowledge/Skill |
|---|---|---|
| Acquire fingerprint image | | |
| *Latent print* | Low | Med |
| *Fingerprint scanner* | Med | Low |
| *Generate from template* | | High |
| Make mould | | |
| *Direct impression* | Low-Med | Low |
| *Engrave / etch from image* | High | Low |
| | Med | Med |
| Make fingerprint artefact | | |
| | Depends on material | Depends on mould |
| Present artefact at terminal | | |
| *Without practice* | | Low |
| *With practice & knowledge of device* | | Med-High |

# Knowledge and Resource Requirements to Fake Iris

| Step | Resource | Knowledge/Skill |
|---|---|---|
| Acquire iris image | | |
| *Camera phone / SLR* | Low | Low |
| *Iris camera* | Med | Low |
| *Generate from iriscode* | | High |
| *Image enhancement/selection* | | Med - High |
| Reproduce iris image | | |
| *Print* | Low | Low |
| *Film* | Low | Med |
| *Contact Lens / Glass eye* | High | High |
| Present fake eye(s) at terminal | | |
| *Without practice* | | Low |
| *With practice & knowledge of device* | | Med .. |

# Example attack levels: Fake iris

| | Home / High St. resources | Trade / specialist supplier | Bespoke resource |
|---|---|---|---|
| Novice<br>No special knowledge/skill |  | | 3 |
| Knows product & techniques | |  | 5 |
| Expert | 3 | 5 |  6 |

# General Findings: Liveness / Artefact Detection

**Different methods of preventing use of fakes**

- "Liveness/non-artefact" properties required to enable image capture
- Built in sensor measures properties associated with real characteristic
- Algorithmic processing of captured images

**Choosing the setting for fake detection**

- If enabled: Level of attack resistance generally higher
- Stricter settings: Reduced chance of successful attack (but not to 0)
  Can also significantly increase FRR

**Successful attacks at level 3 & 4 (fingerprint)**

- Finding "right" material for device – catastrophe: all attacks succeed
- Tuning of methods – attack success rate increases with experience
  - Sometimes indirect signal that a fake is detected

**Our use case eliminates some of the easier spoofing attacks**

- E.g. recognition against an enrolled artefact

# General Findings: Security Functionality & Tamper Protection

**Many biometric terminals provide configuration options which would render the system less secure**

- Door relay on device
- Templates stored on device – on removable media
- Admin controls on device at portal for enrolment / disable spoof-detection

**Better tamper protection often needed**

**Knowledge of product/techniques:**

- Available on the internet (for the medium level attacker)
  - Tutorials on basic fake fingerprint attacks
  - Manuals for several biometric systems with details of e.g.:
    - tamper switch location
    - default passwords
  - Software for some systems

# Issues in Evaluating Attack Levels

**Sufficient coverage of types of attack at each level?**

- Determined by expert review (incl. CPNI & Test Organisation)
- Difficulty to thoroughly test new/novel biometric modalities

**Limits to what can be tested through real use:**

- No skin transplants, or severed fingers in our evaluation
- Skill level of test personnel quickly increases from novice level as more attacks are made

**Attacks get easier over time – need to review levels regularly**

- New vulnerabilities are found
- Expert knowledge becomes available on internet
- Black market in helping people spoof systems
- Ways to exploit legitimate services e.g.
  - Mingpao Daily journalist successfully spoofed a biometrics device of the Hong Kong-China self-service immigration clearance channel with fingerprint produced by a HK$110 **fingerprint cast kit** bought on Taobao,

# Your Questions & Comments

## Contact details for offline comment & questions

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