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Information technology — Biometric presentation attack detection —

Part 3: Testing and reporting

Technologies de l'information — Détection d'attaque de présentation en biométrie —
Partie 3: Essais et rapports d'essai

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives or www.iec.ch/members_experts/refdocs).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html. In the IEC, see www.iec.ch/understanding-standards.

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 37, *Biometrics*.

This second edition cancels and replaces the first edition (ISO/IEC 30107-3:2017), which has been technically revised.

The main changes are as follows:

— the relative impostor attack presentation accept rate has been added (13.4.4);

— information on roles in presentation attack detection testing have been added (Annex C);

— general technical clarifications and improvements have been made.

A list of all parts in the ISO/IEC 30107 series can be found on the ISO and IEC websites.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

Introduction

The presentation of an artefact or of human characteristics to a biometric capture subsystem in a fashion intended to interfere with system policy is referred to as a presentation attack. The ISO/IEC 30107 series deals with techniques for the automated detection of presentation attacks. These techniques are called presentation attack detection (PAD) mechanisms.

As is the case for biometric recognition, PAD mechanisms are subject to false positive and false negative errors. False positive errors wrongly categorize bona fide presentations as attack presentations, potentially flagging or inconveniencing legitimate users. False negative errors wrongly categorize presentation attacks (also known as attack presentations) as bona fide presentations, potentially resulting in a security breach.

Therefore, the decision to use a specific implementation of PAD will depend on the requirements of the application and consideration of the trade-offs with respect to security, evidence strength and efficiency.

The purpose of this document is as follows:

— to define terms related to biometric PAD testing and reporting, and

— to specify principles and methods of performance assessment of biometric PAD, including metrics.

This document is directed at vendors or test laboratories seeking to conduct evaluations of PAD mechanisms.

Biometric performance testing terminology, practices and methodologies for statistical analysis have been standardized through ISO and Common Criteria. False accept rate (FAR), false reject rate (FRR) and failure to enrol rate (FTE) are widely used to characterize biometric system performance. Biometric performance testing terminology, practices and methodologies for statistical analysis are only partially applicable to the evaluation of PAD mechanisms due to significant fundamental differences between biometric performance testing concepts and PAD mechanism testing concepts. These differences can be categorized as follows.

a) **Statistical significance**

Biometric performance testing utilizes a statistically significant number of test subjects, representative of the targeted user group. Error rates are not expected to vary significantly when adding more test subjects or using a completely different group.

In PAD testing, many biometric modalities can be attacked by a large or indeterminate number of potential presentation attack instrument species (PAIS). In these cases, it is very difficult or even impossible to have a comprehensive model of all possible presentation attack instruments (PAIs). Hence, it could be impossible to find a representative set of PAIS for the evaluation. Therefore, measured error rates of one set of PAIs cannot be assumed to be applicable to a different set.

PAIS present a source of systematic variation in a test. Different PAIs can have significantly different error rates. Additionally, within any given PAIS, there is random variation across instances of the PAI series. The number of presentations required for a statistically significant test scales linearly with the number of PAIS of interest. Within each PAIS, the uncertainty associated with a PAD error rate estimate depends on the number of artefacts tested and the number of individuals.

EXAMPLE 1 In fingerprint biometrics, many potent artefact materials are known, but any material or material mixture that can present fingerprint features to a biometric capture device is a possible candidate. Since artefact properties such as age, thickness, moisture, temperature, mixture rates and manufacturing practices can have a significant influence on the output of the PAD mechanism, it is easy to define tens of thousands of PAIS using current materials. Hundreds of thousands of presentations would be needed for a proper statistical analysis, and even then, resulting error rates cannot be transferred to the next set of new materials.

PAI presentation can also be source of variation in a test. Variation in pressure, position or even PAI presenter characteristics can impact PAD performance.

b) **Comparability of test results across systems**

In biometric performance testing, application-specific error rates based on the same corpus of biometric samples can be used to compare different biometric systems or different configurations. Results can be used to unambiguously compare and assess system performance. By contrast, when using error rates to benchmark PAD mechanisms, interpreting results can be highly dependent on the intended application.

EXAMPLE 2 In a given testing scenario with 10 PAIS (presented 100 times), $System_1$ detects 90 % of attack presentations and $System_2$ detects 85 %. $System_1$ detects all presentations for 9 PAIS but fails to detect all presentations with the 10th PAIS. $System_2$ detects 85 % of all PAIS. Which is better? In a security analysis $System_1$ would be worse than $System_2$, because revealing the 10th PAIS would orient an attacker such that they could use this method to defeat the capture device all the time. However, if attackers could be prevented from using the 10th PAIS, $System_1$ would be better than $System_2$, because individual rates indicate that it is possible to overcome $System_2$ with all PAIS.

c) **Cooperation**

Many biometric performance tests address applications such as access control in which subjects are cooperative. Errors due to incorrect operation are an issue of a lack of knowledge, experience or guidance rather than intent. Significant uncooperative behaviour in a group is not part of the underlying "biometric model" and would render the determined error rates almost useless for biometric performance testing.

PAD tests include subjects whose behaviour is not cooperative. Attackers will try to find and exploit any weakness of the biometric system, circumventing or manipulating its intended operation. Presentation attack types, based on the experience and knowledge of the tester, can change the success rates for an attack dramatically. Hence it can be difficult to define testing procedures that measure error rates in a fashion representative of cooperative behaviour.

d) **Automated testing**

In biometric performance testing, it is often possible to test comparison algorithms using databases from devices or sensors of similar quality. Performance can be measured in a technology evaluation using previously collected corpora of samples as specified in ISO/IEC 19795-1.

In PAD testing, data from the biometric capture device (e.g. digitized fingerprint images) can in some cases be insufficient to conduct evaluations. Biometric systems with PAD mechanisms often contain additional sensors to detect specific properties of a biometric characteristic. Hence, a database previously collected for a specific biometric system or configuration is not necessarily suitable for another biometric system or configuration.

Even slight changes in the hardware or software could make earlier measurements useless. It is generally impractical to store multivariate synchronized PAD signals and replay them in automated testing. Therefore, automated testing is often not an option for testing and evaluating PAD mechanisms.

e) **Quality and performance**

In biometric performance testing, performance is usually linked directly to biometric data quality. Low-quality samples generally result in higher error rates while a test with only high-quality samples will generally result in lower error rates. Quality metrics are therefore often used to improve performance (dependent on the application).

In PAD testing, even though low biometric quality can cause an artefact to be unsuccessful, there is no reason to assume a certain quality level from artefacts in general. Samples from artefacts can exhibit better quality than samples from human biometric characteristics. Without a model of attacker skill, it seems valid (at least in a security evaluation) to assume a "worst case" scenario where the attacker always uses the best possible quality. That way, one can at least determine a guaranteed minimal detection rate for the specific test set while reducing the number of necessary tests at the same time.

It is then a matter of rating the attack potential of successful artefacts (effort and expertise for the needed quality) in order to assess the security level, as is the practice in Common Criteria evaluations.

Based on the differences in a) through e), the following general comments regarding error rates and metrics related to PAD mechanisms can be derived.

— In an evaluation, PAIS are analysed/rated separately.

— Attack presentation classification error rates other than 0 % for a PAIS only prove that the PAI can be successful. A different tester can potentially achieve a higher or lower attack presentation classification error rate. Further, training to identify the relevant material and presentation parameters could increase the attack presentation classification error rate for this PAIS. The experience and knowledge of the tester, as well as the availability of the necessary resources, are significant factors in PAD testing and are taken into account when conducting comparisons or performance analysis.

Error rates for PAD mechanisms are determined by the specific context of the given PAD mechanism, the set of PAIS, the application, the test approach, and the tester. Error rates for PAD mechanisms are not necessarily comparable across similar tests, and error rates for PAD mechanisms are not necessarily reproducible by different test laboratories.

Information technology — Biometric presentation attack detection —

Part 3: Testing and reporting

1 Scope

This document establishes:

— principles and methods for the performance assessment of presentation attack detection (PAD) mechanisms;

— reporting of testing results from evaluations of PAD mechanisms; and

— a classification of known attack types (Annex A).

Outside the scope are:

— standardization of specific PAD mechanisms;

— detailed information about countermeasures (i.e. anti-spoofing techniques), algorithms or sensors; and

— overall system-level security or vulnerability assessment.

The attacks considered in this document take place at the biometric capture device during presentation. Any other attacks are considered outside the scope of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 2382-37, *Information technology — Vocabulary — Part 37: Biometrics*

ISO/IEC 15408-1, *Information security, cybersecurity and privacy protection — Evaluation criteria for IT security — Part 1: Introduction and general model*

ISO/IEC 15408-2, *Information security, cybersecurity and privacy protection — Evaluation criteria for IT security — Part 2: Security functional components*

ISO/IEC 15408-3, *Information security, cybersecurity and privacy protection — Evaluation criteria for IT security — Part 3: Security assurance components*

ISO/IEC 19795-1, *Information technology — Biometric performance testing and reporting — Part 1: Principles and framework*

ISO/IEC 30107-1, *Information technology — Biometric presentation attack detection — Part 1: Framework*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 19795-1, ISO/IEC 2382-37, ISO/IEC 30107-1 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 Attack elements

3.1.1
presentation attack
attack presentation
presentation to the biometric data capture subsystem with the goal of interfering with the operation of the biometric system

Note 1 to entry: An attack presentation can be a single attempt, a multi-attempt transaction, or another type of interaction with a subsystem.

3.1.2
bona fide presentation
interaction of the biometric test subject and the biometric data capture subsystem in the fashion intended by the policy of the biometric system

Note 1 to entry: Bona fide is analogous to normal or routine, when referring to a bona fide presentation.

Note 2 to entry: Bona fide presentations can include those in which the user has a low level of training or skill. Bona fide presentations encompass the totality of good-faith presentations to a biometric data capture subsystem.

3.1.3
attack type
elements and characteristics of a presentation attack, including presentation attack instrument (PAI) species, concealer or impostor attack, degree of supervision, and method of interaction with the capture device

3.1.4
test approach
totality of considerations and factors involved in presentation attack detection (PAD) evaluation

Note 1 to entry: Elements of a test approach are given in Clauses 6–10.

Note 2 to entry: A test approach refers to all processes, factors and aspects specified in the course of the evaluation.

3.1.5
item under test
IUT
implementation that is the object of a test assertion or test case

Note 1 to entry: The IUT is the equivalent of the "target of evaluation" (TOE) in Common Criteria evaluations.

3.1.6
presentation attack instrument species
PAIS
class of presentation attack instruments (PAIs) created using a common production method and based on different biometric characteristics

EXAMPLE 1 A set of fake fingerprints all made in the same way with the same materials but with different friction ridge patterns would constitute a PAIS.

EXAMPLE 2 A specific type of alteration made to the fingerprints of several test subjects would constitute a PAIS.

Note 1 to entry: The term “recipe” is often used to refer to how to make a PAIS.

Note 2 to entry: PAIs of the same species can have different success rates due to variability in the production process or in the PAI source.

3.1.7
PAI series
class of presentation attack instruments (PAIs) created using a common production method and based on the same biometric characteristics

EXAMPLE A set of fake fingerprints all made in the same way with the same materials and with the same friction ridge pattern.

Note 1 to entry: Depending on the experimental goals, an evaluation can potentially utilize multiple series, each with different production methods or sources. While tests involving several biometric sources can demonstrate generality of a PAI species, they add variation associated with individual human traits.

3.1.8
target of evaluation
TOE
IT product that is the subject of the evaluation within the context of the Common Criteria

Note 1 to entry: The TOE is the equivalent of the "item under test" (IUT) in Common Criteria evaluations.

3.1.9
attack potential
measure of the capability to attack a target of evaluation (TOE) given the attacker’s knowledge, proficiency, resources and motivation

3.2 Metrics

3.2.1
attack presentation classification error rate
APCER
proportion of attack presentations using the same presentation attack instrument (PAI) species incorrectly classified as bona fide presentations by a presentation attack detection (PAD) subsystem in a specific scenario

3.2.2
attack presentation classification error rate at the given attack potential
$APCER_{AP}$
attack presentation classification error rate (APCER) of the most successful presentation attack instrument (PAI) species within a given attack potential

3.2.3
bona fide presentation classification error rate
BPCER
proportion of bona fide presentations incorrectly classified as presentation attacks in a specific scenario

3.2.4
attack presentation acquisition rate
APAR
proportion of attack presentations using the same presentation attack instrument (PAI) species from which the data capture subsystem acquires a biometric sample of sufficient quality

3.2.5
attack presentation non-response rate
APNRR
proportion of attack presentations using the same presentation attack instrument (PAI) species that cause no response at the presentation attack detection (PAD) subsystem or data capture subsystem

EXAMPLE A fingerprint system can potentially not register or react to the presentation of a PAI due to the PAI's lack of realism.

3.2.6
bona fide presentation non-response rate
BPNRR
proportion of bona fide presentations that cause no response at the presentation attack detection (PAD) subsystem or data capture subsystem

3.2.7
impostor attack presentation accept rate
IAPAR
in a full-system evaluation of a verification system, proportion of impostor attack presentations using the same presentation attack instrument (PAI) species that result in accept

3.2.8
impostor attack presentation accept rate at the given attack potential
$IAPAR_{AP}$
in a full-system evaluation of a verification system, proportion of impostor attack presentations of the most successful presentation attack instrument (PAI) species at the given attack potential that result in accept

3.2.9
concealer attack presentation reject rate
CAPRR
in a full-system evaluation of a verification system, proportion of concealer attack presentations using the same presentation attack instrument (PAI) species that result in a reject decision

Note 1 to entry: CAPRR is transactional and involves both biometric comparison and presentation attack detection (PAD), whereas non-match rates are attributed to the comparison algorithm.

Note 2 to entry: A biometric concealer compelled to unlock a device might want to be rejected. In this case, they might use a PAI to obscure their biometric characteristic, leading to a rejection.

3.2.10
impostor attack presentation identification rate
IAPIR
in a full-system evaluation of an identification system, proportion of impostor attack presentations using the same presentation attack instrument (PAI) species in which the targeted reference identifier is among the identifiers returned, or, depending on the intended use case, at least one identifier is returned by the system,

Note 1 to entry: An attacker might be both an impostor (trying to match an existing non-self enrollee) and a concealer (obscuring their real biometric sample with a PAI).

3.2.11
concealer attack presentation non-identification rate
CAPNIR
in a full-system evaluation of an identification system, proportion of concealer presentation attacks using the same presentation attack instrument (PAI) species in which the reference identifier of the concealer is not among the identifiers returned, or, depending on the intended use case, in which no identifiers are returned

Note 1 to entry: In a negative identification system, such as a block-list, the concealer could intend that no identifiers are returned to avoid scrutiny by a human operator.

Note 2 to entry: CAPNIR is transactional and involves both biometric comparison and presentation attack detection (PAD) whereas false negative identification rates are attributed to the comparison algorithm.

3.2.12
relative impostor attack presentation accept rate
RIAPAR
sum of impostor attack presentation identification rate (IAPAR) and false reject rate (FRR) at a fixed decision threshold

3.2.13
PAD subsystem processing duration
PS-PD
duration required for the presentation attack detection (PAD) subsystem to classify PAD data

3.2.14
data capture subsystem processing duration
DCS-PD
duration required for the data capture subsystem to acquire a sample, inclusive of the presentation attack detection (PAD) subsystem processing duration (if applicable)

3.2.15
full system processing duration
FS-PD
duration required for the data capture subsystem and comparison subsystem to acquire and process a sample, inclusive of the presentation attack detection (PAD) subsystem processing duration (if applicable)

3.3 Test roles

3.3.1
biometric impostor
subversive biometric capture subject who performs a biometric impostor attack

Note 1 to entry: Biometric impostors include capture subjects using PAIs and capture subjects presenting intentionally damaged or altered characteristics.

[SOURCE: ISO/IEC 2382-37:2022, 37.07.13, modified — Original notes to entry deleted; new Note 1 to entry added.]

3.3.2
biometric concealer
subversive biometric capture subject who performs a biometric concealment attack

Note 1 to entry: Biometric concealers include capture subjects using PAIs and capture subjects presenting intentionally damaged characteristics.

[SOURCE: ISO/IEC 2382-37:2022, 37.07.21, modified — Note 1 to entry added.]