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Information technology — A study of the differential impact of demographic factors in biometric recognition system performance

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Foreword

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

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Introduction

Automated systems (including biometrics) are increasingly used in decision-making processes. In recent years, systemic performance differentials reflected in several automated decision systems have been reported and hotly debated. In the context of this report, an algorithm exhibiting performance differentials produces statistically different outcomes or decisions for different groups of individuals, for example, based on gender, age and race/ethnicity. In the context of biometric recognition, this means that probabilities of false positives and/or false negatives can differ among the demographic groups. The impacts of such performance differentials on the affected individuals can range from mere inconvenience in cooperative access control systems, to consequential harms such as varying arrest rates for certain demographic groups based on decisions produced by facial recognition systems.

Although such systems are almost certainly not designed to be explicitly differential against any group, implicit differences can occur independently of the intentions of the system designers. They can be exhibited and propagated at many stages of the decision-making pipeline, including but not limited to training data itself as well as the data processing. Due to the scalability of such systems, a higher quantity of erroneous or inaccurate decisions can be generated than in the typical, human-based processes. Consequently, in recent years, measuring and ensuring the fairness (i.e. lack of differential performance) of such systems has often been discussed in the media and political circles, with research and commercial interest increasing accordingly. With increasing deployments of the technology, it is important to consider whether it performs similarly for all users. This document helps to identify where recognition performance differences related to demographic factors can exist in biometric systems.

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Information technology — A study of the differential impact of demographic factors in biometric recognition system performance

1 Scope

This document introduces the effects of population demographics on biometric functions. It:

— establishes terms and definitions relevant to the study of demographic factors in biometric recognition system performance;

— identifies areas where biometric systems can exhibit different performances based on different demographic factors of the individuals submitting the biometric samples;

— explains how different demographic factors can influence the biometric characteristics captured by different biometric modalities and how these influences can affect biometric performance measures;

— presents a case study on existing scientific material that explores the impact of demographic factors on biometric system performance. Only biometric modalities where quantitative information is available on the impact of demographic factors are considered.

Outside of the scope of this document are:

— effects of disease and injury on biometric performance; and

— how religious and cultural norms can affect biometric operations.

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*

3 Terms, definitions, symbols and abbreviated terms

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

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

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

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

3.1
age
length of time an individual has lived

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3.2
ageing
natural progression of an individual's characteristics over time

Note 1 to entry: The impact of ageing will vary at different ages.

3.3
categorical demographic variable
demographic characteristic that is nominally or ordinally described

EXAMPLE Gender categories consist of "Male", "Female", or "Other".

3.4
detection error trade-off
DET
relationship between false positive and false negative errors of a binary classification system as the discrimination threshold varies

3.5
differential performance
differences in system variables or system processing between different demographic groups

EXAMPLE Differences in comparison scores, feature-level fusion, and/or image-level fusion.

3.6
differential outcomes
difference in system results between different demographic groups

EXAMPLE Differences in match rate.

3.7
ethnicity
state of belonging to a group with a common origin, set of customs or traditions

Note 1 to entry: Scientifically, race can be defined as a group of humans that share biological features related to genetic ancestry. Practically, race is primarily a social construct, i.e. not related to biology but instead related to self-identity. Ethnicity is frequently used as a proxy for self-reported "race". In the context of this report, "ethnicity" and "race" are considered interchangeable and can both be taken to mean a social identity that was reported or assigned to a particular subject. These reported values can, but do not always, correlate with underlying genetic features.

3.8
failure-to-acquire
FTA
failure-to-accept for subsequent comparison the output of a biometric capture process, a biometric sample of the biometric characteristic of interest

3.9
failure-to-enrol
FTE
failure-to-create and store a biometric enrolment data record for an eligible biometric capture subject in accordance with a biometric enrolment policy

3.10
false accept rate
FAR
proportion of transactions with false biometric claims erroneously accepted

3.11
false match rate
FMR
proportion of the completed biometric non-mated comparison trials that result in a false match

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3.12
false negative differential
tendency for mated biometric samples from subjects in one demographic group not to match relative to another demographic group

3.13
false non-match rate
FNMR
proportion of the completed biometric mated comparison trials that result in a false non-match

3.14
false positive differential
tendency for non-mated biometric samples from one demographic group to falsely match relative to another demographic group or a tendency for this effect to occur across demographic groups

3.15
false reject rate
FRR
proportion of biometric transactions with true biometric claims erroneously rejected

3.16
gender
classification as male, female or another category based on social, cultural, or behavioural factors

Note 1 to entry: Gender is generally determined through self-declaration or self-presentation and can change over time.

Note 2 to entry: Depending on jurisdiction recognition, it is possible that gender will or will not require assessment by a third party.

3.17
phenotypic demographic variable
observable demographic characteristic of an individual resulting from the interaction of that individual's genotype and the environment

EXAMPLE An individual's skin reflectance.

3.18
sex
state of being male or female as it relates to biological factors such as DNA, anatomy and physiology

4 Understanding demographic factors in biometric systems

4.1 Introduction

Demographic factors include any characteristics or attributes that apply to a specific group within a population[1]. There are potentially an infinite number of different demographic factors that can be considered in terms of how they impact biometric systems. In order to maintain a manageable scope for this document, the demographic factors considered are limited to those where at least some research is available to evaluate the impact on biometric comparison performance, quality score, failure-to-enrol rate or other performance metrics[1]. The state-of-the-art of biometric system performance can change rapidly, and performance can improve by an order of magnitude over the course of just a few years. Therefore, performance results observed in this report can be overcome or obviated by more recent studies. It is valuable to continuously monitor for publications that provide new insights into aspects of differential performance. Specifically, this document considers the following demographic factors that have been shown to impact the performance of biometric systems (see Clause 3 for definitions):

— Age and ageing

— Ethnicity

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