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Information technology — Biometrics — Characterization and measurement of difficulty for fingerprint databases for technology evaluation

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee IST/44, Biometrics.

A list of organizations represented on this committee can be obtained on request to its secretary.

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ISBN 978 0 580 68454 8

ICS 35.040

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This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 December 2013.

Amendments issued since publication

Date	Text affected

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TECHNICAL REPORT

ISO/IEC TR 29198

First edition
2013-12-15

Information technology — Biometrics — Characterization and measurement of difficulty for fingerprint databases for technology evaluation

Technologies de l'information — Biométrie — Caractérisation et mesure de difficulté pour bases de données d'empreintes digitales pour évaluation de technologie

Reference number
ISO/IEC TR 29198:2013(E)

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

In exceptional circumstances, when the joint technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide to publish a Technical Report. A Technical Report is entirely informative in nature and shall be subject to review every five years in the same manner as an International Standard.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC TR 29198 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 37, *Biometrics*.

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Introduction

Recently, there have been worldwide increasing activities in testing and evaluating the performance of fingerprint recognition systems or algorithms. Testing activities occur in public sector, private sector, and academic entities, typically using datasets exclusive to a given entity. This complicates comparison of test results from different entities. Methodologies for assessing the level of difficulty of test datasets should improve the comparability of performance evaluation results over different fingerprint datasets.

ISO/IEC 19795-1:2006, 5.5.3[11] states:

"In a technology evaluation, testing of all algorithms is carried out on a standardized corpus, ideally collected by a "universal" sensor (i.e. a sensor that collects samples equally suitable for all algorithms tested). Nonetheless, performance against this corpus will depend on both the environment and the population in which it is collected."

Comparison of evaluation results based on testing against different corpora may be misleading. Further, policies for inclusion or removal of low-quality data in a corpus may vary from organization to organization, such that the same algorithm tested against the same corpus may generate different results. There are also certain difficulties when trying to compare multiple evaluation results derived from different corpora. Currently there is no established methodology for characterizing the level of difficulty of datasets used in performance evaluation. The ability to characterize a dataset's level of difficulty should support predictions of operational accuracy when processing data known to be of equivalent difficulty.

The purpose of this Technical Report is to provide guidance on predicting how "challenging" or "stressing" a fingerprint dataset is for recognition, based on factors such as relative sample quality, relative rotation, deformation, and overlap between impressions. The provided guidance can be used for characterizing and measuring the relative difficulty levels of fingerprint datasets used in technology evaluation.

Following the guidance in this Technical Report, users and system evaluators in different organizations will be able to compare and place into context the performance evaluation results of the other organizations according to the level of difficulty of its dataset.

This Technical Report proposes dataset generation methods based on analysis of comparison results or scores from multiple fingerprint recognition algorithms. These dataset generation methods support creation of datasets with specific levels of difficulty and creation of datasets for use in interoperability evaluations.

ISO/IEC TR 29794-4[16] defines methods for expressing the quality score of a *single* fingerprint image. Such quality scores are typically predictive of matching accuracy. This Technical Report, by contrast, is concerned with differences in rotation, deformation, and common area between reference and probe samples.

NOTE Other modalities can be considered in the future as more information becomes available about standardized quality measurements that are suitable for predicting the performance of other biometric systems.

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Information technology — Biometrics — Characterization and measurement of difficulty for fingerprint databases for technology evaluation

1 Scope

This Technical Report provides guidance on estimating how "challenging" or "stressing" is an evaluation dataset for fingerprint recognition, based on relative sample quality, relative rotation, deformation, and overlap between impressions. In addition, this Technical Report establishes a method for construction of datasets of different levels of difficulty. This Technical Report defines the relative level of difficulty of a fingerprint dataset used in technology evaluation of fingerprint recognition algorithms. Level of difficulty is based on differences between reference and probe samples in the aformentioned factors. This Technical Report addresses such issues as:

— characterizing level of difficulty attributable to differences between samples acquired from the same finger,

— developing statistical methodologies for representing the level of difficulty of a fingerprint dataset by aggregating influencing factors,

— comparing the level of difficulty of different fingerprint datasets,

— defining procedures for testing and reporting the level of difficulty of fingerprint datasets collected for technology evaluation,

— analysing mated pair data characteristics based on comparison scores,

— describing the archived data selection methodology for building a dataset for evaluation.

This Technical Report provides guidelines for comparing the relative level of difficulty of fingerprint datasets.

Outside the scope of this Technical Report are:

— defining the quality of individual fingerprint images,

— defining the methodologies or explicit measures for evaluating or predicting the performance of fingerprint recognition algorithms.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
raw biometric sample
information obtained from a biometric sensor, either directly or after further processing

2.2
biometric reference
<template, model> one or more stored biometric samples, biometric templates or biometric models attributed to a biometric data subject and used as the object of comparison

EXAMPLE Face image stored digitally on a passport; Fingerprint minutiae template on a National ID card; Gaussian Mixture Model for speaker recognition, in a dataset.

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Note 1 to entry: A biometric reference may be created with implicit or explicit use of auxiliary data, such as Universal Background Models.

Note 2 to entry: The subject/object labelling in a comparison might be arbitrary. In some comparisons a biometric reference might be used as the subject of the comparison with other biometric references or incoming samples used as the objects of the comparisons. For example, in a duplicate enrolment check a biometric reference will be used as the subject for comparison against all other biometric references in the dataset.

2.3
biometric probe
biometric data input to an algorithm for comparison to a biometric reference(s)

2.4
technology evaluation
offline evaluation of one or more algorithms for the same biometric modality using a pre-existing or specially collected corpus of samples

2.5
failure-to-enrol rate
FTE
proportion of the population for whom the system fails to complete the enrolment process

Note 1 to entry: The observed failure-to-enrol rate is measured on test crew enrolments. The predicted/expected failure-to-enrol rate will apply to the entire target population.

2.6
failure-to-acquire rate
FTA
proportion of verification or identification attempts for which the system fails to capture or locate an image or signal of sufficient quality

Note 1 to entry: The observed failure-to-acquire rate is distinct from the predicted/expected failure-to-acquire rate (the former may be used to estimate the latter).

2.7
false non-match rate
FNMR
proportion of genuine attempt samples falsely declared not to match the biometric reference of the same characteristic from the same subject supplying the sample

2.8
false match rate
FMR
proportion of zero-effort impostor attempt samples falsely declared to match the compared non-self template

Note 1 to entry: The measured/observed false match rate is distinct from the predicted/expected false match rate (the former may be used to estimate the latter).

2.9
false reject rate
FRR
proportion of verification transactions with truthful claims of identity that are incorrectly denied

2.10
false accept rate
FAR
proportion of verification transactions with wrongful claims of identity that are incorrectly confirmed

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2.11
receiver operating characteristic curve
ROC curve
plot of the rate of false positives (i.e. impostor attempts accepted) on the x-axis against the corresponding rate of true positives (i.e. genuine attempts accepted) on the y-axis plotted parametrically as a function of the decision threshold

2.12
detection error trade-off curve
DET curve
modified ROC curve which plots error rates on both axes (false positives on the x-axis and false negatives on the y-axis)

2.13
performance
capability in terms of error rates and throughput rates

2.14
quality
degree to which a biometric sample fulfils specified requirements for a targeted application

Note 1 to entry: Specified quality requirements may address aspects of quality such as focus, resolution, etc. Implicit quality requirements address the likelihood of achieving a correct matching result.

2.15
quality score
quantitative expression of quality

2.16
matchability
degree to which two mated fingerprint samples can be successfully compared through multiple comparison algorithms

2.17
mated pair
set of two samples of the same biometric characteristics captured from the same source, where one is used for the reference and the other used for the test

2.18
level of difficulty
measure of a biometric dataset which represents how 'challenging' or 'stressing' the fingerprint dataset is for recognition relative to other datasets

Note 1 to entry: Fingerprint dataset "A" is more difficult than dataset "B" with respect to chosen fingerprint comparison algorithms if the performance of these algorithms is significantly lower for dataset "A" than dataset "B". For how to assess the performance of given comparison algorithms, see ISO/IEC 19795-2.[12]

Note 2 to entry: For estimating the level of difficulty of a fingerprint dataset before testing the performance of fingerprint comparison algorithms against this and other datasets, this Technical Report defines measures that predict level of difficulty.

Note 3 to entry: This Technical Report addresses the level of difficulty for fingerprint corpora only.

2.19
singular point
either core point or delta point in fingerprint

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2.20
alignment point
either a singular point or a certain minutia point which is used to align a mated pair of fingerprints

Note 1 to entry: Since each alignment point has position and orientation, the alignment process based on a pair of corresponding alignment points from a mated pair will compensate the rotation and the translation between the two fingerprints.

3 Symbols and abbreviated terms

AP alignment point

CA common area

DF relative deformation

LOD level of difficulty

RSQ relative sample quality

SP singular point

4 Differential factors in fingerprint samples

4.1 General

As described in ISO/IEC TR 19795-3,[13] the following properties of a fingerprint dataset have influence on the performance of fingerprint recognition:

— Sensor type (e.g. total internal reflection, capacitance, thermal, swipe, touchless, ultrasonic, etc)

— Impression type (e.g. flat, rolled, segmented slap, scanned ink-print, etc)

— Image resolution

— Environmental conditions (e.g. temperature, humidity, etc)

— Demographics (e.g. age, gender, occupation, etc)

— Finger position (e.g. thumb, index, etc)

— Template ageing

— Biological condition (e.g. skin moisture)

— Subject motivation, habituation etc.

When the dataset is homogeneous in the aspects of sensor type and impression type, the rest of the properties can be represented and quantified by a fingerprint sample quality score.

As defined in ISO/IEC 29794-1,[15] the quality of a biometric sample is the degree to which a biometric sample fulfils specified requirements for a targeted application and the quality score is a quantitative expression of the quality. However, the quality score is associated with each individual biometric sample. As such it does not incorporate differences between reference and probe samples.

As pointed out by Hicklin and Reedy,[1] the ability to match fingerprints is dependent on three characteristics: (i) number of fingers (in the case of ten-print identification), (ii) correspondence between reference and probe images, and (iii) quality of both reference and probe images. Correspondence between the two fingerprints is a function of the degree of overlap and distortion between the reference

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