# TECHNICAL REPORT

# ISO/IEC TR 29794-5

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## Information technology — Biometric sample quality —

## Part 5: Face image data

*Technologies de l'information — Qualité d'échantillon biométrique —*

*Partie 5: Données d'image de face*



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# Foreword

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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, the joint technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;



— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;



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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 29794-5, which is a Technical Report of type 2, was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 37, *Biometrics*.

ISO/IEC 29794 consists of the following parts, under the general title *Information technology — Biometric sample quality*:

— *Part 1: Framework*

— *Part 4: Finger image data* [Technical Report]

— *Part 5: Face image data* [Technical Report]

## Introduction

The purpose of this part of ISO/IEC 29794 is to define and specify methodologies for computation of objective, quantitative quality scores for facial images. Furthermore, the purpose, intent, and interpretation of face quality scores are defined.

ISO/IEC 19794-5, *Information technology — Biometric data interchange formats — Part 5: Face image data*, already gives some specifications that are related to

— scene constraints of the facial images,

— photographic properties of the facial images, and

— digital image attributes of the facial images.

Within this part of ISO/IEC 29794, a sample of a classification scheme of facial quality is exemplified and approaches for the determination of certain aspects of quality are introduced.



 

# Information technology — Biometric sample quality —

## Part 5: Face image data

## 1 Scope

For aspects of quality specific to facial images, this part of ISO/IEC 29794:

— specifies terms and definitions that are useful in the specification, use and testing of face image quality metrics;

— defines the purpose, intent, and interpretation of face image quality scores.

Performance assessment of quality algorithms and standardization of quality algorithms are outside the scope of this part of ISO/IEC 29794.



## 2 Normative references



The following referenced documents are indispensable for the application 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 29794-1, *Information technology — Biometric sample quality — Part 1: Framework*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 29794-1 and the following apply.

**3.1**
**comparison score**
numerical value (or set of values) resulting from a comparison

**3.2**
**face quality assessment algorithm**
algorithm that computes a quality score for a given face image sample

**3.3**
**facial image**
electronic image-based representation of the portrait of a person

## 4 Abbreviated terms

CCD Charge-coupled device

DCT Discrete Cosine Transform

 

GCF Global Contrast Factor

FQAA Face Quality Assessment Algorithm

QS Quality Score

FQS Face Quality Score

QSN Quality Score Normalization

## 5 Approaches to Face Image Quality

Face Image Quality can be defined in many ways, depending on the application. For the purpose of this part of ISO/IEC 29794 standard Face Image Quality is defined in relation to the use of facial images with automated face recognition systems. The performance of an automated face recognition system is affected by the amount of defect or the degree of imperfection present in the face image. The knowledge of quality can, and is currently being used to, process face images differently, by either invoking some image enhancement or normalization methods prior to feature extraction, invoking different matchers based on quality, or simply changing the threshold. The use of face image quality assessment to enhance the overall performance of the system is increasing [3, 4, 5].

A very important application of real-time quality analysis of faces is Face Recognition in Video, also referred to as Face in a Crowd, Recognition on the move, or Face at a Distance, e.g [21].

This part of ISO/IEC 29794 shows some approaches for estimating Face Image Quality. The aim is to give the reader examples of assessment algorithms. Note, that these algorithms have pros and cons and no one algorithm is likely to be suitable for all facial images. Standardization of these algorithms is out of scope of this part of ISO/IEC 29794.



The following related work is being done in ISO/IEC JTC1 SC37 [1, 2]:



- ISO/IEC 29794-1 suggests the use of Quality Algorithm Identification (QAID), or Quality Score Percentile Rank upon standardization of a Quality Score Normalization Dataset (QSND).

This part of ISO/IEC 29794 adopts the following approach for face sample quality description:

- Specifying characterization of the facial quality and possible defects of face biometric samples in categorized aspects.
- Showing how FQAAs can be used to derive face quality scores (FQSs) related to specific characteristics and associated possible defects. An FQAA typically analyzes a face sample locally at the pixel or feature level and fuses the local analysis results over a global region. An FQS evaluates one or more characteristics and associated potential defects, and provides an indicator of the quality.

A typical approach of a system for generation of quality scores for facial images then takes the atomic FQSs generated by the FQAAs and combines them to a final quality score. The final quality score must predict performance metrics such as either false match or false non-match of an automatic facial image recognition.

## 6 Categorization of Facial Quality

Different factors affect the quality of the facial image with respect to biometric systems' performance. A successful recognition will be based on the biometric characteristics of the subject and a number of factors that influence these characteristics such as variations (e.g. due to ageing) and the environmental conditions in the acquisition process:

- Influence of subjects characteristics on biometric performance,
- Influence of the acquisition process (including the capturing device) on biometric performance.

 

This classification is not sufficient, as it does not distinguish between static and dynamic characteristics and properties:

- static subjects characteristics are related to anatomical characteristics of the subject,
- dynamic subject characteristics are related to subjects behaviour during the acquisition process,
- static properties of the acquisition process are related to physical properties of the capturing device and effects caused by the sample processing chain,
- dynamic properties of the acquisition process are related to environmental conditions during the capturing process.

Table 1 shows a classification scheme that differentiates between the dynamic versus static properties as well as the subject versus the acquisition process characteristics affecting facial quality.

**Table 1 — Characterization of Facial Quality**

| | **Subject characteristics** | **Acquisition process** |
|---|---|---|
| **Static** | Biological characteristics, like<br>- anatomical characteristics (e.g. head dimensions, eye positions)<br>- injuries and scars<br>- ethnic group<br>- impairment<br><br>Other static characteristics<br>- Heavy facial wears, such as thick or dark glasses<br>- Makeup<br>- Permanent jewellery | Acquisition process and capture device properties, like<br>- image enhancement and data reduction process<br>- physical properties (e.g. image resolution and contrast)<br>- optical distortions<br>- static properties of the background, e.g. wallpaper<br>- camera characteristics<br>  o sensor resolution<br>- scene characteristics<br>  o geometric distortion |
| **Dynamic** | Subject characteristics and behaviour, like<br>- closed eyes<br>- (exaggerated) expression<br>- hair across the eye<br>- head pose<br>- subject posing (frontal / non frontal to camera) | Scenery, like<br>- dynamic characteristics of the background like moving objects<br>- variation in lightning and related potential defects as<br>  o deviation from the symmetric lighting<br>  o uneven lighting on the face area<br>  o Extreme strong or weak illumination<br>- subject posing , e.g.<br>  o too far (face too small), or too near (face too big)<br>  o out of focus (low sharpness)<br>  o partial occlusion of the face<br>- Acquisition process and capture device properties, such as<br>  o camera characteristics<br>  o dynamic range (response to weak and strong lighting) |

The classification scheme (as all other content of this part of ISO/IEC 29794) is given for informative purposes only. The proposed classification scheme is certainly not the only possible scheme, but it is very useful since it separates design from character, i.e. it can be used to guide quality by design and hence performance improvement.

This characterization and the related categories of defects, degradations and interferences affect the performance of an automated facial recognition system. What is not considered in this part of ISO/IEC 29794 are the effects of printing on the given facial images (e.g. in a passport production process), which likely introduces further distortions especially with respect to image appearance and noise.

## 7 Facial Image Quality Analysis

Different aspects have to be considered in a facial image quality analysis. Some of them are already defined in related standardization documents. Different categories can be identified:

1. image properties like the size of the image or its resolution,
2. image appearance characteristics like the exposure or noise,
3. scenery characteristics like lighting or background,
4. characteristics like the consistency between the skin colour on the image and the skin colour of the subject,
5. the behaviour of the subject.



For some of these properties and characteristics metrics already exist. Some properties and characteristics, however, are much harder to be assessed and evaluated like the consistency of the skin colour on the image and the skin colour of the subject.



Furthermore, for some properties and characteristics, like the eye distance (in pixels), requirements are defined in ISO/IEC 19794-5 [37]. Their evaluation requires more complex algorithms and technologies from computer vision and image understanding. Therefore, a simple metric can not be given without considering the implementation that is needed to extract the corresponding features. In addition to this, different core concepts might be possible, e.g. different principles exist to automatically determine the eye positions in facial images. It may be possible to derive normalized quality scores as described in ISO/IEC 29794-1 (QSND). For some metrics, the variation between the enrolled images and that of the query images plays a bigger role in predicting performance than does the absolute metric applied to a single image. For instance [38] shows that performance is more affected by the relationship between the resolution of enrolled images and the query images than by absolute measure of resolution applied to each of them.

An FQAA can examine the image without a segmentation of the facial area (e.g. to assess static characteristics of the acquisition process like the compression rate and resulting compression artefacts, sensor resolution when measuring the size of an image) or perform an analysis on the facial area only (e.g. when estimating the pose of a subject). Local structures of a face may be defined by pixel values (raw or processed) within local regions; they may be fused globally to give a single quality score. Various FQAA can be developed, for different quality aspects related to environment, of camera, and/or subject showing different performance on different data sets. It is out of scope of this part of ISO/IEC 29794 to rate or rank the different approaches.

For some of the quality measures it is assumed that the face has been detected, and the facial area is normalized properly in geometry according to some landmarks such as the eye positions. Only the cropped face region is used for the analysis in this case.

 

## 7.1 Dynamic Subject Characteristics

### 7.1.1 Subject's Behaviour

Typical characteristics that are related to the subject's behaviour include:

- closed or open eyes,
- closed or open mouth,
- any kind of expression, e.g. smiling or neutral,
- head pose, e.g. frontal or rotated in any direction.

Similar to the scenery properties or the characteristics, the quantification of these parameters requires the recognition of background, faces and facial characteristics.

Again, different core algorithms can be implemented and their performance values can be used. A reduction in complexity can be achieved by selecting algorithms or concepts that are most commonly applied if this information is available.

### 7.1.2 Analysis Based on Statistical Differences of the Left and Right Half of the Face

#### 7.1.2.1 Lighting Symmetry



The following approaches are based on the assumption that the images being analyzed are 2D portrait style images such as those specified in ISO/IEC 19794-5:2005/Amd.1, *Information technology — Biometric data interchange formats — Face image data — Amendment 1: Conditions for taking photographs for face image data*. This relates to facial and environment semantics. Left-right symmetry can be used to evaluate quality of lighting and pose [36]. The face region is divided into left and right halves at the mid-line of the eyes (Figure 1).The symmetry analysis below examines differences between the corresponding left-right locations. The difference value indicates the degree of asymmetry in some local image properties, e.g., raw pixel value, or locally-filtered pixels value. The local image filter can be Gabor filter [9,10], Local Binary Pattern (LBP) filter [11-13], Ordinal filter [14-17], or any other suitable local filter. The left-right difference value provides a quality score for the lighting (i.e. how symmetric the lighting is), or the pose quality (i.e. how frontal the pose is). Although the majority of faces seem to be left –right symmetric some faces could have significant deviation, e.g. caused by marks, discoloration etc. that would affect symmetry based quality analysis metrics Images are taken from Yale face image database [18].

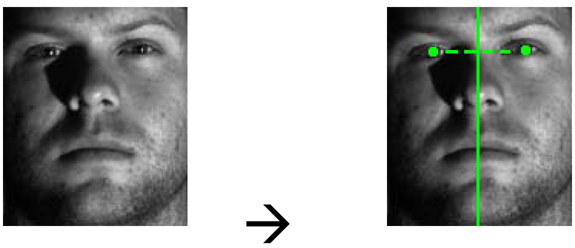

**Figure 1 — Division of a face into left and right half regions at the mid-line of the eyes**

The difference can be based on histograms $H^{L}_{m*n}$ and $H^{R}_{m*n}$ of some local features in the left and right half regions where *m* is the dimensionality of the feature vector, and *n* is the number of bins in the histogram. A histogram difference can be calculated as follows:

$$D_i = \left| H^{L}_{m*n} - H^{R}_{m*n} \right|$$