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Section Two

Face Biometric Standards and Conformance

This article discussed currently available face biometric standards. We focused on ISO standards 19794-5 Biometric Data Interchange Formats - Face Image Data as it has significant impact on both government and civilian biometric implementation such as E-passport, personal identity documents and access control systems. The four main requirements in ISO 19794-5 are photographic, scene, digital and format specifications. Being compliance to the standard implies that the captured face image has reliable quality as it contains sufficient information for face authentication with minimal contamination from over-exposure, shadow and etc. On the other hand, systems conforming to the standard are interoperable on one another. It is also possible for biometric sample tracing to be done based on the included information. This results in the boosting of user's confidence level. Biometric Technical Committee (BTC) of Singapore will continue to contribute in the revision and promotion of this standard. BTC has also developed automated conformance testing suite for 19794-5 as a service to the industry.

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1 SHORT HISTORY OF FACE BIOMETRIC

While most may be familiar with what a face recognition system can do, it is interesting to know that the very first semi-automated face recognition system was invented not earlier than 50 years ago. It was developed by Woodrow W. Bledsoe, under a contract to the US Government. However, it was not fully-automated as it required a system administrator to locate useful features such as the eyes, ears, nose and mouth on the photographs. In 1971, Goldstein, Harmon and Lesk published their work on face recognition systems. Their system used 21 specific subjective markers such as hair color and lip thickness. However, as the invention still required measurements and locations to be manually captured [1], it was not recognised as the first fully-automated face recognition system.

It was until 20 years later that Kirby and Sirovich first applied principle component analysis, a standard linear algebra technique, to the face recognition problem [2]. With this, they had set the major direction for the face biometric research. They showed that less than one hundred values were required to approximate a suitably aligned and normalised face image. Based on this milestone, Turk and Pentland pioneered their research in this area, which eventually led to a real-time automated face recognition system through the use of residual error in the recognition of the face [3]. From this discovery, a large amount of interest was sparked in the area of face recognition development.

2 FACE STANDARDS

Comparing face biometric technology, face biometric standards took slightly different evolution paths. The main motivation behind face biometric standardisation was to effectively perform border control with application like E-passport etc. Thus, most clauses in the face-related standards are catering for manual identification and verification. Today, we have the following relevant face standards:

2.1 ICAO 9303

The International Civil Aviation Organization (ICAO) was established during a conference held in Chicago in the months of November and December 1944. There are currently 190 contracting states with a total of 36 members in the council. The ICAO works to achieve its vision of safe, secure and sustainable development of civil aviation through cooperation amongst its member States. As the results of five years of work, under the New Orleans Resolution, face biometric was concluded as the biometric to be used for global interoperability. The issuers of the travel documents may optionally use fingerprint and/or iris scans, but only in addition to face recognition. The ICAO 9303 covers capture, storage and transmission of a 2D face image and defines the requirements for Machine Readable Travel Documents.

Under ICAO 9303, a compliant photograph requires either:

- On-site photography at enrolment centres; or
- Proper use of image quality software at off-site photographers.

2.2 ISO/IEC 19794-5:2005 Biometric Data Interchange Format - Face Image Data

Published in 2005 as an international standard, ISO/IEC 19794-5 specifies scene, photographic, digitisation and format requirements for images of faces. This includes not only the context of human verification, but computer automated recognition. The approach to specifying scene and photographic requirements in this format is to carefully describe constraints on how a photograph should appear rather than to dictate how the photograph should be taken. Being the most comprehensive face biometric standard which supports both manual and automated face authentication, it is worthwhile for face biometric vendor to be compliant with the standard. This article will discuss 19794-5 in detail.

2.3 ANSI – ANSI INCITS 385:2004

ANSI INCITS 385 is the US Standard for digital image formats for use with Face biometric. This standard specifies definitions of photographic (environment, subject pose, focus, etc.) properties, digital image attributes and a face interchange format for relevant applications, including human examination and computer automated face recognition.

3 TYPES OF FACE IMAGES IN ISO/IEC 19794-5

The standard defines four face image types: basic, frontal, full frontal and token frontal.

- Basic: This is the fundamental face image type which specifies a record format including header and image data. There are no mandatory scenic, photographic and digital requirements for this image type.

- Frontal: A basic face image type that adheres to additional requirements appropriate for frontal face recognition and/or human examination. Examples of the requirements are, the limitation on head rotation angle, shadows over the face, subject lighting, scene lighting and so on.

- Full Frontal: A face image type which specifies frontal images with sufficient resolution for human examination as well as reliable automated face recognition. Full frontal image includes the full head including all hair in most cases, as well as the neck and shoulders. This type of image is intended for permanent storage of facial information or for personal documents.

- Token Frontal: A Face Image Type which specifies frontal images with a specific geometric size and eye positioning based on the width and height of the image. This type of image minimises the storage requirements on automated face recognition.

Figure 1 shows the properties inheritance relationship among the four image types.

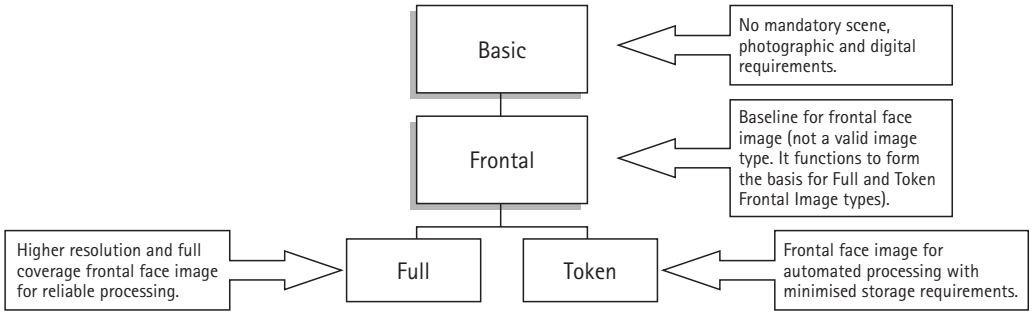


Figure 1: Face Image Types

For a face biometric vendor to conform to the standard under basic image type, the system needs to be compliant with both the record format as well as inheritance requirements for the basic image type. On the other hand, the system would need to be compliant with the record format, basic image requirements, frontal image requirements, as well as full frontal image requirements to conform to the full frontal image type. The same practices applied for token frontal image.

4 WHICH IMAGE TYPE TO CHOOSE

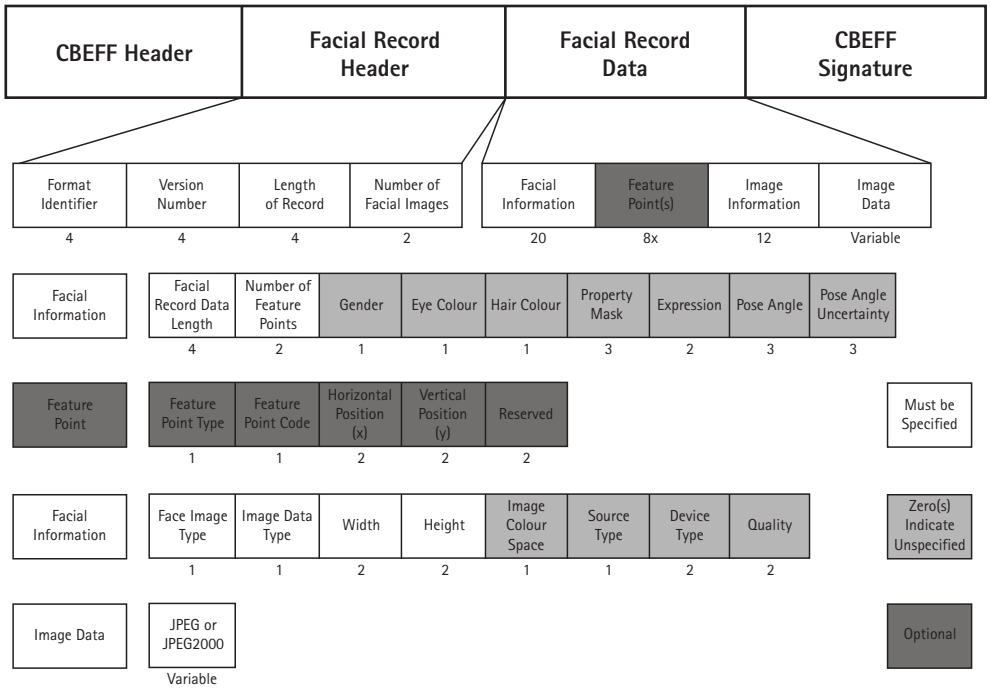
While the minimum compliance requirements for 19794-5 were to conform to record format as well as the basic image requirements, vendor should carefully choose the image type that is most suitable to their application. Some recommendations on the appropriate image type were given below. Do note that frontal image type is not a valid image type as it functions only to describe the common specifications for Full Frontal and Token Frontal Image types.

Characteristics	Sample Applications	Recommended Image Type
• Face visibility is not mandatory. • No requirement for automated face recognition.	• User registration for trivial applications. • Applications where face registration is not mandatory.	Basic
• Manual and automated face recognition in mind. • Reasonable number of users with no resource constraint on biometric data record size.	• Generic facial access control system for companies/buildings.	Full Frontal Image
• Manual and automated face recognition in mind. • Potentially large number of users with optimal size of individual biometric data record, yet maintaining system reliability.	• Checkpoints/Immigrations	Token Frontal Image

Table 1: Recommendations on the appropriate image type

5 RECORD FORMAT

The record format specified in ISO/IEC 19794-5 is compatible with Common Biometric Exchange File Format (CBEFF), developed by NIST and BioAPI consortium. The detailed implementation of the record format is summarised by the diagram shown in Figure 2 (extracted from [4]).



The length value of each field in bytes is shown below the field. White boxes indicate fields or blocks that shall be specified, light grey boxes indicate that zero values are used to indicate an unspecified value, and dark grey boxes indicate optional fields [4].

Figure 2: The Face Image Record Format

6 SUMMARISED NORMATIVE REQUIREMENTS FOR BASIC IMAGE TYPE

- Image to be encoded in either JPEG or JPEG2000 format.
- Facial header, facial information and image information to be intact.

7 SUMMARISED NORMATIVE REQUIREMENTS FOR FRONTAL IMAGE TYPE

- Rotation of the head shall be less than +/- 5 degrees from frontal in every direction.
- Only one face allowed in frontal image.
- Shoulders shall be "square on" to the camera.
- Lighting to be equally distributed on face.
- The region from crown to the chin shall be clear visible and shadow-free.
- There shall be no dark shadows in the eye-sockets due to the brow.
- Diffused, balanced light sources shall be used.
- Only clear glasses allowed.
- Additional photographic requirements e.g. no over or under exposure.
- Only pixel aspect ratio of 1.1 is allowed.
- The images shall be represented as 24-bit RGB, 8-bit monochrome or YUV 422 colour space.

8 SUMMARISED NORMATIVE REQUIREMENTS FOR FULL FRONTAL IMAGE TYPE

- Face image is horizontally centred.
- Requirements to ensure that the face is properly vertically positioned with proper length.
- Minimum face image width to be at least 5/7 of the full image width.
- The resolution of the full images shall be at least 180 pixels of resolution for the width of the head, or roughly 90 pixels from eye centre to eye centre.

9 SUMMARISED NORMATIVE REQUIREMENTS FOR TOKEN FRONTAL IMAGE TYPE

- Geometrical Requirements (See Table 2)
- The minimum required image width is 240 pixels. The distance from eye to eye (inclusive) in this case is therefore 60 pixels.

Feature or Parameter	Value
Image Width	W
Image Height	W/0.75
Y coordinate of Eyes	0.6 * W
X coordinate of First (right) Eye	0.375 * W
X coordinate of Second (left) Eye=0.625 * W	(0.625 * W) - 1
Width from eye to eye (inclusive)	0.25 * W

Table 2: Geometrical Requirements

10 CONFORMANCE FOR FACE BIOMETRIC VENDOR

For face biometric algorithm vendors to conform to ISO/IEC 19794-5, all that is required is to ensure that the face image record is compliant with the specified record format in part 4. On top of that, the face image provider shall ensure that the normative requirements for the chosen image type are met. While face image captured is normally handled by third party, it is logical for the biometric system integrator or biometric solution provider to implement automated conformance testing of ISO/IEC 19794-5 to ensure that input face images are compliant with the respective requirements of face image types from section five to section eight of this document.

11 APPLICATION OF 19794-5

19794-5 is widely referred in both government and civilian applications. Examples of standard application can be found below:

11.1 National Science & Technology Council's (NSTC) Subcommittee on Biometrics and Identity Management, USA

- Full Frontal or Token image type should be used for storage of digital images personal identity credentials.
- Full Frontal or Token image type, with at least 90 pixels between the eyes from all subjects should be used for capture and storage (i.e. enrolment or registration processes) for which end-to-end subject capture times above 120 seconds are tolerable.
- Basic type only for non-cooperative or uncooperative capture and storage of images.
- Basic, Full Frontal or Token image type for all other capture, storage or exchange applications of 2D face images.

11.2 UK The Identity and Passport Service

- 19794-5 as guidelines for photographers.

11.3 EU Passport Specifications

- Compliant with 19794-5.

11.4 Products from Companies like Cognitec, NEC and so on

12 BENEFITS FROM 19794-5 CONFORMANCE

On top of the application of standard listed in Section 11 above, there are many other applications of 19794-5. There are three main advantages from the conformance:

12.1 Image Quality

19794-5 requests face image to be captured with appropriate scene as well as photographic requirements. This ensures that the face image captured contains useful information presented for both manual and automated face authentication. Thus, the quality of the face image captured is guaranteed. As an example, the scene requirements from the standard specifies proper lighting while the photographic requirements proper positioning of the face in the photo. The resulting face image would then be free from shadow and partial face capture, which can degrade the performance in the authentication process. Conformance to 19794-5 can be seen as the tool to safeguard the image captured as a good representation of the subject. On top of that, 19794-5 record format has included a quality field to specify the sample quality for the face image.

12.2 Interoperability

19794-5 requires face image to be stored as JPEG/JPEG2000 image with proper CBEFF compatible format. This allows devices and applications from different vendors, conforming to the same standard, to work together. One example would be for face image to be captured by one vendor, passing the image to the other vendor for feature extraction, subsequently to be processed by face matcher from another vendor.

12.3 Traceability

The standard allows biometric sample tracing by the inclusion of capture device and image source information.

13 BIOMETRIC TECHNICAL COMMITTEE (BTC) OF SINGAPORE AND 19794-5 CONFORMANCE TESTING

BTC has been continually participating in the revision of 19794-5 at ISO level since year 2005. Several amendments e.g. relaxation of the maximum head rotation angle allowed as well as the inclusion of 3D face image specifications were proposed in the standard revision.

BTC has highlighted the lack of automated conformance testing mechanism to be one of the potential gaps in making this standard a success. In other words, while vendors can claim that they have conformed to the standard, there is no automated and unbiased mechanism to verify if this is really the case. BTC has worked with Temasek Polytechnic to develop a conformance testing suite for 19794-5 to bridge this gap. The conformance testing suite reads in a biometric data interchange record (BDIR) and field by filed the BDIR is analysed. A final report is generated with any non-conformance reported. The testing suite was demonstrated during Governmentware 2008.

14 CONCLUSION

This article discussed currently available face biometric standards. We focused on ISO standards 19794-5 Biometric Data Interchange Formats - Face Image Data as it has significant impact on both government and civilian biometric implementation such as E-passport, personal identity documents and access control systems. The four main requirements in ISO 19794-5 are photographic, scene, digital and format specifications. Being compliance to the standard implies that the captured face image has reliable quality as it contains sufficient information for face authentication with minimal contamination from over-exposure, shadow and etc. On the other hand, systems conforming to the standard are interoperable on one another. It is also possible for biometric sample tracing to be done based on the included information. This results in the boosting of user's confidence level. Biometric Technical Committee (BTC) of Singapore will continue to contribute in the revision and promotion of this standard. BTC has also developed automated conformance testing suite for 19794-5 as a service to the industry.

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Lim Eyung is a lecturer from Temasek Polytechnic/Cyber and Digital Security. He served as the senior officer of Biometrics Enabled Mobile Commerce (BEAM) Consortium from 2001 to 2002. He represented Singapore in Biometrics Consortium Meeting in Japan (2002 and 2009), ISO SC 37 meeting in France (2004), New Zealand (2007), Germany (2007), Korea (2008) and USA (2009). His main research area is in biometrics and image processing. He is appointed as the secretary of Biometric Technical Committee (BTC) of Singapore. He is also serving the International Standards Organization (ISO) as a project Co-Editor for project 29109-4 on conformance testing.

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Brandon Lum Jia Jun is currently a student pursuing a diploma in Cyber and Digital Security/Temasek Informatics & IT School. Despite only becoming part of the IT industry in 2007, he has been an active member of the security community in Singapore. As a security enthusiast and firm believer in Open Source technologies, he has helped organise security and open source seminars and events over the past two years. In addition, Brandon is part of the team that emerged champion and top offensive team at a security based competition, Syscan '09 CTF (Capture the Flag).

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