A NIST Type 10 Transaction Update Proposal

The Type 10 Ad-Hoc Working Group

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1 Introduction

This document contains proposed revisions and additions to the Type-10 facial & SMT image record described in ANSI/NIST-ITL-2000 [1]. The changes are designed to be enhancements and clarifications of the existing record.

- Existing records can be converted to this new format with no loss of data. There are no dropped fields or lost information

- The revisions maintain the existing record fields. Changes are made by adding new fields as opposed to deleting or significantly modifying existing fields, in order to minimize the changes required to existing software.

- The new record format contains compliance levels, which serve as application profiles. Users can select which level of compliance they need for their applications.

- The new format does not change the encoding scheme of the record, as defined by Section 17.1 of [1]. Fields are still encoded using ASCII text, and the record separators remain the same.

- The new format allows for the interchange of data with existing face image standards, such as ISO 19794-5. This data includes text data such as eye color.

The table below denotes the major additions to the record type, and the Section in which this addition is discussed in detail.

Item	Section
Addition of JPEG2000 as an allowed image format	3, 4
An increase of the maximum length of the source agency (SRC) text field	2
Inclusion of a set of facial mugshot capture requirements. These requirements are called out in new face application profiles	5, 6
Face capture application profiles, from non-mugshot photo capture to advanced mugshot application profiles. Includes in certain cases the requirement to adhere to mugshot best practices for capture and compression limits.	5, 6
Allow for the encoding of face image quality in the record	10
The encoding of the photo acquisition type, e.g. digital photo or video.	9
Allow for the encoding of 3D pose angles for each face photo	11
Addition of the encoding of Face Image Attributes such as blinking and major expression changes.	12, 13, 14
Addition of feature points to mark points of interest on the face.	15

The sections below, in this document, are intended to either replace existing sections or contain new text for new sections. That is, the proposed text below is intended to be placed directly into a new standard. Note however, that for brevity, this document does not contain the text in the existing type-10 record that is not to be changed when a new standard is issued. If existing fields included in the existing type-10 document are not discussed below, then the intent is to include these fields and their descriptions verbatim in the new standard.

2   The Record Layout

Table 1 below is the proposed updated version of Table 9 in ANSI/NIST-ITL 1-2000 [1]. Modifications are highlighted with shaded background. Note that this table includes all proposed changes.

The existing fields 10.004 and 10.999 have their maximum field sizes increased. Existing field 10.022 has revised text in its description. Existing fields 10.011, 10.012, and 10.020 have new field code additions. The entirely new fields, 10.013, and 10.023 – 10.029 are allocated from previously reserved field codes.

Table 1 – Type-10 facial and SMT record layout.

Ident	Cond code	Field Number	Field Name	IMG	Char type	Field size per occurrence		Occur count		Max byte count
						min	max	min	max	
LEN	M	10.001	LOGICAL RECORD LENGTH		N	4	8	1	1	15
IDC	M	10.002	IMAGE DESIGNATION CHARACTER		N	2	5	1	1	12
IMT	M	10.003	IMAGE TYPE		A	5	7	1	1	14
SRC	M	10.004	SOURCE AGENCY /ORI		AN	10	36	1	1	43
PHD	M	10.005	PHOTO DATE		N	9	9	1	1	16
HLL	M	10.006	HORIZONTAL LINE LENGTH		N	4	5	1	1	12
VLL	M	10.007	VERTICAL LINE LENGTH		N	4	5	1	1	12
SLC	M	10.008	SCALE UNITS		N	2	2	1	1	9
HPS	M	10.009	HORIZONTAL PIXEL SCALE		N	2	5	1	1	12
VPS	M	10.010	VERTICAL PIXEL SCALE		N	2	5	1	1	12
CGA	M	10.011	COMPRESSION ALGORITHM		A	4	6	1	1	13
CSP	M	10.012	COLOR SPACE		A	4	5	1	1	12
SAP	C1[1]	10.013	SUBJECT ACQUISITION PROFILE	FAC	N	2	4	1	1	11
RSV	-	10.014 10.019	RESERVED FOR FUTURE INCLUSION		--	--	--	--	--	--
POS	O	10.020	SUBJECT POSE	FAC	A	2	2	0	1	9
POA	O	10.021	POSE OFFSET ANGLE	FAC	N	2	5	0	1	12
PXS	O	10.022	PHOTO DESCRIPTION	FAC	A	4	21	0	9	196
PAS	C2[2]	10.023	PHOTO ACQUISITION SOURCE		A	7	15	0	1	22
SQS	O	10.024	SUBJECT QUALITY SCORE	FAC	N	10	35	0	9	322
SPA	C2	10.025	SUBJECT POSE ANGLES	FAC	N	9	23	0	1	30
SXS	C	10.026	SUBJECT FACIAL DESCRIPTION	FAC	A	6	21	0	50	1057
SEC	C2	10.027	SUBJECT EYE COLOR	FAC	A	5	14	0	1	21
SHC	C2	10.028	SUBJECT HAIR COLOR	FAC	A	5	12	0	2	31
SFP	O	10.029	SUBJECT FEATURE POINTS	FAC	N	10	18	0	88	1584
RSV	-	10.030 10.039	RESERVED FOR FUTURE INCLUSION		--	--	--	--	--	--
SMT	M	10.040	NCIC DESIGNATION CODE	SMT	A	4	11	1	3	40
SMS	O	10.041	SCAR/MARK TATTO SIZE	SMT	N	4	6	0	1	13
SMD	O	10.042	SMT DESCRIPTORS	SMT	AN	16	51	0	9	466
COL	O	10.043	COLORS PRESENT	SMT	A	4	21	0	9	196
RSV	-	10.044 10.199	RESERVED FOR FUTURE INCLUSION		--	--	--	--	--	--
UDF	O	10.200 10.998	USER-DEFINED FIELDS		--	--	--	--	--	--
DAT	M	10.999	IMAGE DATA		B	2	6*HLL*VLL +1[3]	1	1	6*HLL*VLL+8

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[1] The Subject Acquisition Profile (SAP) is a mandatory ASCII text field when field 10.003 has code "SAC" (and therefore the transaction contains a facial image).

[2] The Condition Code "C2" refers to fields that are mandatory if the SAP (field 10.013) has a numeric value 40 or above. Otherwise, these fields are optional.

Key for character type: N = Numeric; A = Alphabetic; AN = Alphanumeric; B = Binary

3   Modified field 10.011: Compression algorithm (CGA)

This mandatory ASCII field shall specify the algorithm used to compress the color or grayscale image. An entry of *"NONE"* in this field indicates that the data contained in this record is uncompressed. For those images that are to be compressed, the method for the compression of facial and SMT images is specified by the baseline mode of the JPEG algorithm or JPEG2000.

An entry of *"JPEGB"* indicates that the scanned or captured image was compressed using baseline JPEG. An entry of *"JPEGL"* indicates that the lossless mode of the JPEG algorithm was used to compress the image. If the image is captured in grayscale, then only the luminance component will be compressed and transmitted. For JPEG, the data shall be formatted in accordance with the JPEG File Interchange Format, Version 1.02 (JFIF)[4].

An entry of *"JP2"* indicates that the scanned or captured image was compressed using lossy JPEG2000 (Compliance with ISO 15444-1 is provided through part 4 of the standard, ISO 15444-4 "Conformance Testing".) An entry of *"JP2L"* indicates that the lossless mode of the JPEG 2000 algorithm was used to compress the image. For JPEG 2000, the data shall be formatted in compliance with JP2 format as described in ISO 15444-1 [11].

Where JPEG2000 is used, the following specifications/options of the compression algorithm shall be supported:

- Filters: The 9-7 irreversible filters [11] should be used for lossy mode; however for handheld devices (fixed point processors), the 5-3 reversible filters may be used instead. The 5-3 reversible filters shall be used for lossless mode. A compliant decoder shall be able to decode code streams created through both filters.

- Number of resolution levels: The image shall be encoded using enough resolution levels to ensure that a thumbnail with max(width, height) <= 64 is available in the image.   Example: a 640x480 image shall be encoded with 5 resolution levels, which enables sub-resolution decodes of 320x240, 160x120, 80x60, and 40x30.

- Resolution as the dominant progression: JPEG2000 allows five progression orders - LRCP, RLCP, RPCL, PCRL and CPRL. The RLCP progression order (resolution, layer, component, position) shall be used since it best facilitates decode and display of lower resolution derivative images by remote networked devices. Through the RLPC progression order, the code stream shall be formatted so that the resolution information of the image is the first data made available to a decoder in a streaming mode of operation.

- Bits per Channel: The number of bits per channel for encoders and decoders shall be 8-16 bits.

- Single tile images: Facial images shall be encoded using only single tile to avoid tiling artifacts.

- JPEG200 quality layers: The image shall be encoded using at least 10 quality layers to enable quality progressive decoding or sub-quality image extraction.

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[4] Developed by C-Cube Microsystems, 1778 McCarthy Blvd., Milpitas, CA 95035.

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Region of Interest Encoding is allowed: This encoding method is a useful way to compress a facial image to a small size, while retaining sufficient image quality within the specified ROI to perform either human or automated identification.

An example transaction for JPEG2000 is "10.011:JP2 [GS]".

4   Modified field 10.012: Color space (CSP)

4.1   Introduction and backwards compatibility

This mandatory ASCII field shall contain the color space used to exchange the image data.

In previous versions of this standard [1], the term "color space" referred to device-dependent color information with a particular sequence and range for the three color channels. The choice was either RGB or an RGB-derivative space known as YCC. Neither space provides an objective definition of a particular color or relates to the way in which humans perceive color.

Moreover, in the previous version of this standard [1], it was stated that "the preferred color space for compressed images using baseline JPEG and JFIF is YCbCr to be coded as 'YCC'," while the color space for uncompressed color images was to be labeled RGB.   Therefore, for backwards compatibility purposes, new systems must accommodate JPEG images that have been labeled in Field 10.012 as using the YCC color space. Specifically, systems compliant with this standard must accept an entry of YCC and interpret it as meaning a (device-dependent) RGB color space.

4.2   The color space sRGB

To ensure that color images exchanged between differing systems can be correctly displayed or printed, images should be converted to the device-independent color space, sRGB [12], before compression or transmission to another system. sRGB, as defined by IEC 61966-2-1 [12], is a non-linear display profile that accommodates the voltage-to-color response characteristics of most high quality CRT monitors. The colors of the red, green, and blue phosphors (primaries) and the white point setting of an sRGB-compliant monitor are specified in the IEC document.

The relationship between sRGB and a linear RGB space having the IEC-defined primaries and white point is as follows:

$$value_{sRGB} = \begin{cases} 12.92 value_{lin}, & \text{for } value_{lin} \leq 0.0031308 \\ 1.055 value_{lin}^{(1/2.4)} - 0.055, & \text{for } value_{lin} > 0.0031308 \end{cases}$$

$\qquad$ where $value_{lin}$ is an R, G, or B value in linear RGB space

$\qquad$ (with a range of 0 to 1) and $value_{sRGB}$ is the corresponding

$\qquad$ R, G, or B value in non-linear $sRGB$ space (also with a

$\qquad$ range of 0 to 1). To convert from/to the range of 0 to 255,

$\qquad$ divide/multiply by 255.

Typically, modern digital cameras, desktop scanners, LCD monitors, and printers, although they don't inherently operate in sRGB space, are designed with circuitry or software to produce sRGB output or to accommodate sRGB as an input space. If an image acquisition device's color space is unknown, sRGB is usually a reasonable choice. If an acquisition device and its software cannot provide sRGB output, various color management products are available commercially that use its color profile, often available from its manufacturer, to convert images in its native color space to sRGB.

4.3   Field code entries

If the color space for an RGB image cannot be determined, an entry of "RGB" shall be used for field 10.012.

JPEG: For JPEG-compressed color image files (stored using the JFIF file format), the preferred (external) color space is sRGB and an entry of "SRGB" shall be used for Field 10.012. For all grayscale (monochrome) images, an entry of "GRAY" shall be used for Field 10.012.

JPEG2000: For JPEG2000 images stored using the JP2 file format, the available enumerated color spaces are sRGB, sYCC, and grayscale, to be entered, respectively, as "SRGB", "SYCC", and "GRAY" in Field 10.012. The preferred (external) color space for color images is sRGB. If a photo acquisition device uses another ICC color profile, the acquisition system must convert the image data to one of these enumerated color spaces before the JP2 file may be embedded in a Type 10 record.

Uncompressed color images: For uncompressed color images containing non- interleaved red, green, and blue pixels in that order, the preferred color space is sRGB and an entry of "SRGB" shall be used for Field 10.012.

Note that the field codes do not determine if the image data is JPEG, JPEG2000, or uncompressed color images. The header in the image data itself will need to be examined to make that determination.

An example transaction for an image in the sRGB color space is "10.012:SRGB GS".

5 New field 10.013: Subject Acquisition Profile (SAP)

5.1 Introduction

The Subject Acquisition Profile (SAP) is a mandatory ASCII text field when field 10.003 has code "FACE" (and therefore the transaction contains a facial image).

When included, this field shall contain an ASCII character code selected from Table 2 to indicate the numeric value of the acquisition profile. Typically, the higher the value, the stronger the acquisition requirements become. Therefore, in the text below, the SAP value will also be denoted as a "level".

Table 2: Subject Acquisition Profiles

Subject acquisition profile attribute	Attribute code
Unknown profile	0
Latent facial image	1
Driver's license image (AAMVA)	10
ANSI Full Frotal facial image (ANSI 385)	11
ANSI Token facial image (ANSI 385)	12
ISO Full Frontal facial image (ISO/IEC 19794-5)	13
ISO Token facial image (ISO/IEC 19794-5)	14
PIV facial image (NIST SP 800-76)	15
Legacy Mugshot	20
BPR Mugshot	30
EBPR Facial Image (Head and Shoulders)	40
Forensic Facial Images (Head and Shoulders)	50
Forensic Facial Images (Head only)	51

An example transaction for SAP of value 40 is "10.013:40 ^{GS}".

5.2 Level 0 (Unknown profile)

This level denotes any case when the Subject Acquisition Profile is unknown. This value can be used to alert systems that the profile of the face image needs to be determined manually or via advanced face image quality evaluation techniques.

5.3 Level 1 (Latent facial image)

This SAP denotes a latent facial image: a face image captured without specific regard to scene, photographic, or digital requirements. For example, an image of a face from commonly available surveillance video equipment is generally considered a latent facial image. Typically latent facial images are of relatively poor quality compared to mugshots, including significant pose angle from frontal, poor image resolution, poor image contrast, etc.

5.4 Levels 10-15 (Other application profiles)

Levels 10-15 shall denote transaction associated with capture under the guidance of other facial standards or application profiles as defined below.

- Level 10 denotes a driver license facial portrait described in AAMVA DL/ID-2000 [5].

- Level 11 denotes an ANSI facial image which meets requirements of the Full Frontal Image type defined in ANSI/INCITS 385-2004 [10].

- Level 12 denotes an ANSI facial image which meets requirements of the Token Face Image type defined in ANSI/INCITS 385-2004 [10].

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- Level 13 denotes an ISO facial image that meets the requirements of the Full Frontal Image defined in International standard ISO/IEC 19794-5 [4].

- Level 14 denotes an ISO facial image that meets the requirements of the Token Face Image type defined in International standard ISO/IEC 19794-5 [4].

- Level 15 denotes a PIV facial image which meets requirements of Biometric Data Specification for Personal Identity Verification [3].

Note that the facial images of Levels 13 and 14 may come from travel documents as described in "Deployment of Machine Readable Travel Documents'', ICAO Technical Report, version 2.0 [4a, 6].

5.5   Level 20 (Legacy facial mugshot)

A transaction conforming to this application profile level shall be a mugshot captured according to ANSI/NIST-ITL 2000 [1], but not necessarily or known to be conforming to the best practice requirements given in profile 30 below. The subject pose(s) can be Frontal, Profile, or Angled.

5.6   Level 30 (Best Practice Recommendation (BPR) mugshot)

A transaction conforming to a level 30 application profile shall include at least one mugshot record conforming to all best practice requirements (BPR) of reference [2]. These mugshots adhere to strict background, lighting, and resolution requirements as specified in [2]. In particular, the background is 18% gray, the lighting is three-point, and the resolution is at least 480x600 with and aspect ratio of 1:1.25.

5.7   Level 40 (Enhanced Best Practice Recommendation (EBPR) facial image)

5.7.1   Face image capture requirements

A transaction conforming to a level 40 application profile shall include frontal face images conforming to the "face image capture requirements" of Section 6. At least one frontal face image shall be included in the transaction.

5.7.2   Scene requirements

Level 40 facial images shall conform to the "head and shoulders" composition requirements of Section 6.2.1.

5.7.3   Digital Requirements

5.7.3.1   Minimum number of pixels

The minimum number of pixels in the electronic digital image shall be 768 pixels in the horizontal direction by 1024 pixels in the vertical direction.

The composition shall conform to a "head and shoulders photo" (see Section 6.2.1), which can be captured with an off-the-shelf 1 mega pixel camera.

It should be noted that the image quality of the captured facial images will be improved as the number of pixels in both directions are increased. However, as images are captured with an increased number of pixels, the 3:4 (Width:Height) aspect ratio shall be maintained.

5.8 Requirements of Level 50 and Level 51 (Forensic facial images)

5.8.1 Face image capture requirements

A transaction conforming to a level 50 and 51 application profiles shall include face images conforming to the "face image capture requirements" of Section 6.

These profile levels are intended to allow for examination of up to forensic-level (0.1 millimeter) detail on a subject's face. Approximately 1700 pixels wide by 2515 pixels high on the face are needed for the 99th percentile male in the U.S. population [13].

With the width of the head taking 50% of the image width, this corresponds to an image width of 3400 pixels and this composition corresponds to a "head and shoulders photo" which can be capture with of-the-shelf 15 (or more) mega pixel digital cameras. Alternatively, with the width of the head taking 70% of the image width, this corresponds to an image width of roughly 2400 pixels and this composition corresponds to a "head photo" which can captured with of-the-shelf 8 mega pixel digital cameras.

5.8.2 Scene requirements

Level 50 shall conform to the "head and shoulders" composition requirements of Section 6.2.1.

Level 51 shall conform to the "head only " composition requirements of Section 6.2.2.

5.8.3 Digital requirements

5.8.3.1 Minimum number of pixels

•   Level 50 (head and shoulders): The minimum number of pixels in the electronic digital image shall be 3300 pixels in the horizontal direction by 4400 pixels in the vertical direction.

•   Level 51 (head only): The minimum number of pixels in the electronic digital image shall be 2400 pixels in the horizontal direction by 3200 pixels in the vertical direction.

It should be noted that the image quality of the captured facial images will be improved as the number of pixels in both directions are increased. However, as images are captured with an increased number of pixels, the 3:4 (Width:Height) aspect ratio shall be maintained.
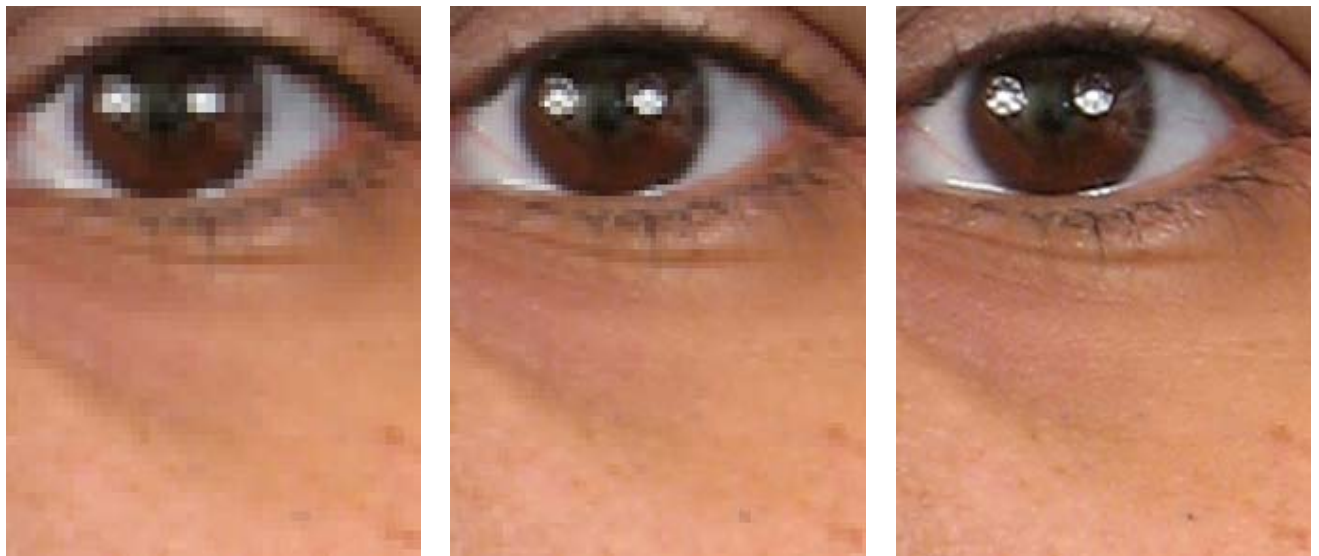
| **a. Level 30** | **b. Level 40** | **c. Levels 50 and 51** |

Figure 2 – Examples of resolution for levels 30, 40, 50, and 51.

5.8.3.2 Compression algorithm requirements

Non-frontal facial images shall be compressed using JPEG 2000 (JPEG is not allowed) meeting the maximum compression limits specified in Section 6.4.5.

Frontal facial images shall be compressed only using lossless JPEG 2000 compression.

5.8.4 Format Requirements

5.8.4.1 Number of photographs

Level 50 and 51 records shall include at least five photographs of the subject: frontal, left and right profile, and left and right ¾ profile.

A ¾ profile view consists of a face with a Yaw pose angle of ± 67.5 degrees, and with Pitch and Roll angles of zero (see Section 11, "New field 10.025: Subject pose angle (SPA)"). Note that the pose of the head is rotated to ¾ profile, and care should be taken to prevent the subject from keeping the head fixed while changing only the gaze. In ¾ profile photographs, both eyes must be visible in the image.
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6 Face image capture requirements for SAP levels 40, 50, and 51

6.1 Introduction

This set of "enhanced best practice recommendation" (EBPR) clauses is a set of constraints similar to those given in references [2, 4]. These constraints can be categorized into four types of requirements: scene, photographic, digital, and format. Scene requirements refer to the content, subject and background in the image. Photographic requirements refer to lighting, focus and other constraints required for photo capture. Digital requirements refer to the conversion of the captured image into a digital record. Finally, format requirements refer to additional or conditional required fields and in a Type-10 record or NIST transaction.

Note that the set of requirements in the remainder of Section 6 below applies to all poses of a subject.

6.2 Scene Requirements

6.2.1 The "Head and Shoulders" photo composition

The composition consists of a subject's head, partial shoulders, and plain background. For a frontal-facing pose, the width of the subject's head shall occupy approximately 50% of the width of the captured image. This width shall be the horizontal distance between the mid-points of two imaginary vertical lines. Each imaginary line shall be drawn between the upper and lower lobes of each ear and shall be positioned where the external ear connects to the head. A template and an example is shown in figure 3. For other poses, the composition shall be rotated about an imaginary axis extending from the top of the head though the base of the neck.

This composition is applied to SAP levels 30, 40, and 50.
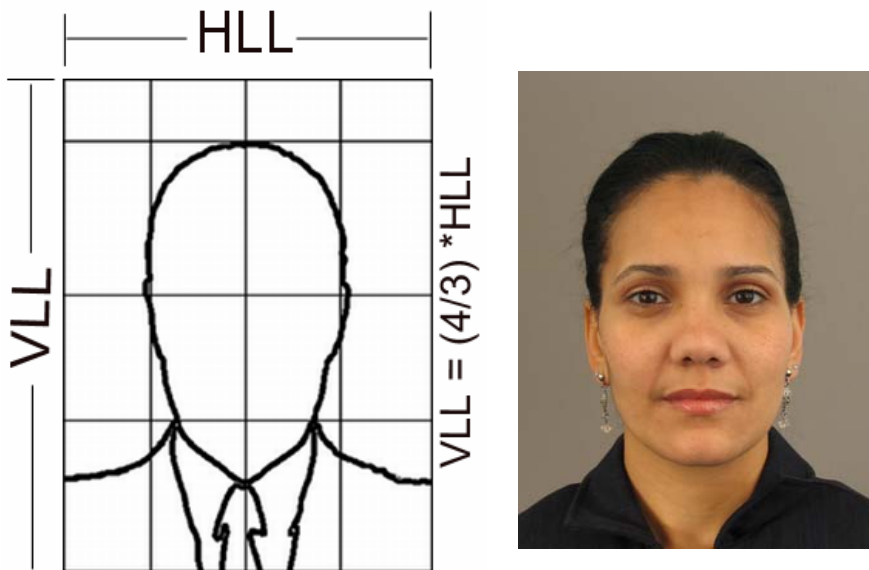
| a. A template of the "head and shoulders" photo. The width of the head is ½ the width of the photo. | b. An example "head and shoulders" photo. |

Figure 3 – A facial image template and an example image that meets "Head and Shoulders" (levels 40 and 50) scene constraints.

6.2.2 The "Head Only" photo composition

The composition consists of a subject's head, and a plain background. For a frontal-facing pose, the width of the subject's head shall occupy approximately 70% of the width of the captured image. This width shall be the horizontal distance between the mid-points of two imaginary vertical lines. Each imaginary line shall be drawn between the upper and lower lobes of each ear and shall be positioned where the external ear connects to the head. An example is shown in figure 3b. For other poses, the composition shall be rotated about an imaginary axis extending from the top of the head though the base of the neck.
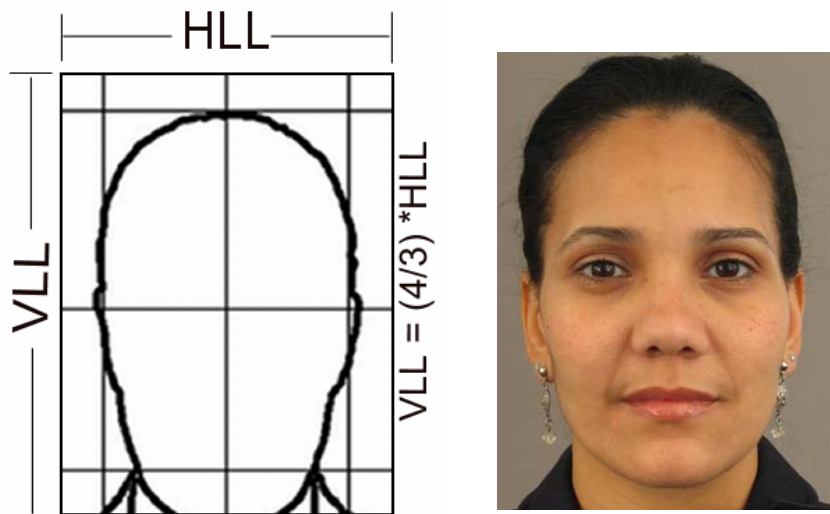
This composition is applied to SAP level 51.

| a. A template of the "head only" photo. The width of the head is 7/10th the width of the photo. | b. An example "head only" photo. |

Figure 4 – A facial image template and an example image that meets "Head and Only" (level 51) scene constraints.

6.2.3   Head centering

For the frontal pose, the face shall be positioned to satisfy all of the following conditions:

- The approximate horizontal mid-points of the mouth and of the bridge of the nose shall lie on an imaginary vertical straight line positioned at the horizontal center of the image.

- An imaginary horizontal line through the center of the subject's eyes shall be located at approximately the 55% point of the vertical distance up from the bottom edge of the captured image.

For non-frontal pose, the subject shall satisfy these conditions when the head is rotated about an axis though the head and torso from the current pose back to center (zero angles) pose.

6.2.4 Visibility of Ears

The ear(s) shall be visible in frontal, profile and angled views for both "Head and Shoulders" and "Head Only" scene compositions. The hair shall be pushed back or tied behind the ears when appropriate.

Move all other subsections down one subsection.

6.2.5 Facial expression

The expression should be neutral (non-smiling) with both eyes open normally (i.e. not wide-open), and mouth closed. Every effort should be made to have supplied images comply with this specification. A smile with closed jaw is not recommended.

6.2.6 Eyeglasses

For subjects who normally wear eyeglasses, every effort should be made to capture the mugshots with the glasses on. If significant glare in the glasses is evident in the photograph, then a second frontal mugshot image should be captured of the subject without glasses. Specification of eyeglasses in the SXS field is required.

6.2.7 Eye patches

The wearing of eye patches is allowed only for medical reasons. In these cases, the specification of the patch, in the SXS field is required.

6.2.8 Background

The subject whose image is being captured shall be positioned in front of a background which is 18% gray with a plain smooth flat surface. A Kodak or other neutral gray card or densitometer shall be used to verify this 18% gray reflectance requirement.

The boundary between the head and the background should be clearly identifiable about the entire subject (very large volume hair excepted). There should be no shadows visible on the background behind the face image.

6.3 Photographic Requirements

6.3.1 Depth of field

The subject's captured facial image shall always be in focus from the nose to the ears. Although this may result in the background behind the subject being out of focus, this is not a problem[5]. It is recommended that auto-focus on the central part of face be used with digital camera photography.

6.3.2 Subject lighting

Lighting shall be equally distributed on the face. There shall be no significant direction of the light from the point of view of the photographer.

The region of the face, from the crown to the base of the chin, and from ear-to-ear, shall be clearly visible and free of shadows.   In particular, there shall be no dark shadows in the eye-sockets due to the brow and the iris and pupil of the eyes shall be clearly visible.

Subject illumination can be accomplished using three point balanced illumination sources. An example is discussed in [2].   A single bare "point" light source, such as a camera flash, is not acceptable for imaging.

Appropriate diffusion techniques shall be employed to eliminate hot spots on the facial image. These hot spots usually appear on reflective areas such as cheeks and foreheads.

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[5] For optimum quality of the captured mugshot, the f-stop of the lens should be set at two f-stops below the maximum aperture opening when possible.

6.3.3 Background lighting

Proper lighting shall contribute to the uniformity of illumination of the background, and the background shall be free of shadows.

6.3.4 Exposure calibration

The exposure shall be keyed to the background. Several areas of the recorded 18% gray background shall be used to verify the proper exposure. The averages of the 8-bit Red, Green, and Blue (RGB) components within each area shall be calculated. Each of the RGB means shall fall between 105 and 125 with a standard deviation of plus or minus 10. Furthermore, for every area examined, the maximum difference between the means of any two of the RGB components shall not exceed 10.

6.3.5 No saturation

For each patch of skin on the person's face, the gradations in textures shall be clearly visible. In this sense, there will be no saturation (over or under exposure) on the face.

6.3.6 No unnatural color or "red-eye"

Unnaturally colored lighting (e.g. yellow, red) is not allowed. Care shall be taken to correct the "white balance" of image capture devices. The lighting shall produce a face image with natural looking flesh tones when viewed in typical examination environments. "Red-eye" is not acceptable.

6.3.7 No color or grayscale enhancement

A process that overexposes or under-develops a color or grayscale image for purposes of beauty enhancement or artistic pleasure is not allowed. The full spectrum shall be represented on the face image where appropriate. Teeth and whites of eyes shall be clearly light or white (when appropriate) and dark hair or features (when appropriate) shall be clearly dark.

6.3.8 No unnatural radial distortion of the camera lens

Fish eye effect, a type of distortion where central objects of the image erroneously appear closer than those at the edge, typically resulting in what appear to be unusually large noses in the image, is not allowed. While some distortion is almost always present during portrait photography, that distortion should not be noticeable by human examination.

For a typical photo capture system with a subject 1.5 to 2.5 meters from the camera, the focal length of the camera lens should be that of a medium telephoto lens. For 35 mm photography this means that the focal length should be between 90 mm and 130 mm. For other negative formats/sensors the recommended focal length is 2 to 3 times the diagonal of the negative/sensor

6.4 Digital Requirements

6.4.1 Pixel aspect ratio

Digital cameras and scanners used to capture facial images shall use square pixels with a pixel aspect ratio of 1:1

6.4.2 Image aspect ratio

The Width:Height (i.e., HLL:VLL) aspect ratio of the captured image shall be 3:4. This corresponds to commonly used format sizes such as 600 x 800, 768x1024, etc., allowing for a COTS digital camera to be used for capture.

6.4.3 No interlacing

Interlaced video frames are not allowed and all interlacing must be absent (not simply removed, but absent).

6.4.4 No digital zoom

The use of digital zoom (interpolation) to achieve specified resolution associated with Subject Application Profiles that point to Section 6 as normative is not allowed.

6.4.5 Image Compression

The maximum compression ratio for both JPEG and JPEG2000 of a rectangular region containing any exposed skin of the face, from crown to chin and ear to ear, shall be at most 15:1. This requirement is derived from studies of face algorithm matching at high and low resolutions. The non-facial portion of the mugshot, as well as the SMT Type-10 record, can be compressed up to a ratio of 120:1.

For JPEG, reference [14] provides source code to implement compression with both ROI and fixed compression ratios. For JPEG2000, these capabilities are built into the implementation.

For both JPEG and JPEG2000, care must be taken to account for automatic compression by camera hardware. Multiple compression stages can damage the quality of photographic data. When possible, minimum compression (highest resolutions) should be applied at the camera level when external software performs the final (15:1 or less) compression stage.

Note that SAP levels 50 and 51 include additional constraints on compression for the frontal pose facial image.

6.4.6 Allowed colorspace

A full color image shall be captured. To ensure that color images exchanged between differing systems can be correctly displayed or printed, images shall be converted to the device-independent color space, *sRGB* [12]. See Section 4 above (field 10.012) for further discussion of color spaces.

6.5 Format Requirements

6.5.1 Subject Pose (POS) and Subject pose angles (SPA)

One of either the POS or SPA fields shall be used to denote pose angles.

The POS field code values "F", "R", and "L" can be used for images in which the Pitch and Roll angles are 0 and the Yaw angle is 0, 90, and -90 respectively. (The sign of the Yaw angle in the previous sentence corresponds to the field 10.020 convention where a right profile is when the subject turns to the left).

The SPA field 10.025 can be used for the above poses and shall be used for all other angled poses. The POS field 10.020 shall then be of type code "D", for determined 3D pose, instructing the user to use 10.025 as the reference for pose angles.

In all cases, the uncertainty in the Yaw pose angle determination shall be less than 5 degrees of the frontal photograph, and 10 degrees in the non-frontal photographs. The uncertainty in the Pitch and Roll angles shall be less than 5 degrees.

6.5.2 Subject facial description (SXS)

The Subject facial description field shall be present in the transaction when one or more of the facial attributes given by the type codes of 10.026 is present in the image.

6.5.3 Subject hair color (SHC)

The Subject hair color field shall be present in the transaction. The code "UNKNOWN" for this field is not allowed.

6.5.4 Subject eye color (SEC)

The Subject eye color field shall be present in the transaction. The code "UNKNOWN" for this field is not allowed.

7 Modified field 10.020: Subject pose (POS)

This optional field is to be used for the exchange of facial image data. When included, this field shall contain one ASCII character code selected from Table 4 to describe the pose of the subject. For the angled pose entry "A", Field 10.021 shall contain the offset angle from the full face orientation. For the determined 3D pose entry "D", Field 10.025 shall contain a set of determined 3D pose angles (i.e., Yaw, Pitch, and Roll angles) away from the full frontal face orientation. Note that the offset angle in Field 10.021 is opposite from the yaw angle in Field 10.025 by a minus sign.

Table 4: Subject pose

Pose description	Pose code
Full-Face, Frontal	F
Right Profile (90 degree)	R
Left Profile (90 degree)	L
Angled Pose	A
Determined 3D Pose	D

An example transaction for determined 3D pose is "10.020:D ^{GS}".

8 Modified field 10.022: Photo description (PXS)

This optional ASCII field, retained for legacy systems, is used for the exchange of facial image data. When present, it shall consist of one or more subfields and shall describe special attributes of the captured facial image. Attributes associated with the facial image may be selected from Table 5 and entered in this field or subfield as one or two information items and a "US" separator character between the items. The attribute code listed in Table 5 shall be listed as the first information item.

Table 5: Photo descriptors

Facial image attribute	Attribute code
Subject Wearing Glasses	GLASSES
Subject Wearing Hat	HAT
Subject Wearing Scarf	SCARF
Physical Characteristics	PHYSICAL
Other Characteristics	OTHER

Physical characteristics, such as "FRECKLES" may be entered as a subfield consisting of two information items. The first is "PHYSICAL" followed by the "US" separator, followed by the characteristic as listed in Part 4 Section 13 of the Eighth (or current) Edition of the NCIC Code Manual, July 14, 1999. The "OTHER" category is used to enter unlisted or miscellaneous attributes of the facial image. This information shall be entered as a two-information item subfield. The first is "OTHER" followed by the "US" separator, followed by the unformatted text used to describe the attribute. Multiple attributes and subfields may be listed but must be separated by the "RS" character.

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Note: The Subject facial description (SXS), field 26, is intended as a replacement for this PXS field. Table 5 entries are now duplicated in Table 7.

An example transaction for subject wearing glasses is "10.022:GLASSES ^{GS}".

9   New field 10.023: Photo acquisition source (PAS)

This optional field shall specify the classification of the source of the image contained in this record. When included, this field shall contain an ASCII character code selected from Table 6 to describe the source of captured image data.

Table 6 – Acquisition source type codes

Acquisition source type attribute	Attribute code
Unspecified	UNSPECIFIED
Static photograph from an unknown source	UNKNOWN PHOTO
Static photograph from a digital still-image camera	DIGITAL CAMERA
Static photograph from a scanner	SCANNER
Single video frame from an unknown source	UNKNOWN VIDEO
Single video frame from an analogue video camera	ANALOGUE VIDEO
Single video frame from a digital video camera	DIGITAL VIDEO
Unknown	UNKNOWN
Vendor Specific source	VENDOR

The *"VENDOR"* category is used to enter unlisted or miscellaneous source attributes of the facial image. This information shall be entered as a two-information item subfield. The first is *"VENDOR"* followed by the *"US"* separator, followed by the unformatted text used to describe the attribute.

An example transaction for static photograph from a digital still-image camera is "10.024:DIGITAL CAMERA ^{GS}".

10 New field 10.024: Subject quality score (SQS)

This optional ASCII field shall specify quality score data for facial images stored in this record. Each subfield shall contain four information items. They identify a quality score and the algorithm used to create the quality score, and should be present if known. This information is useful to enable the recipient of the quality score to differentiate between quality scores generated by different algorithms and adjust for any differences in processing or analysis as necessary.

1.   The first information item shall be a quantitative expression of the predicted matching performance of the biometric sample. This item contains the ASCII representation of the integer image quality score between 1 and 100 assigned to the image data by a quality algorithm. Higher values indicate better quality.   An entry of "-1" shall indicate a failed attempt to calculate a quality score. The use of additional values to convey other information should be harmonized with ISO/IEC 19794 [4] standards.

2.   The second information item shall specify the alphanumeric ID value of the vendor of the quality algorithm used to calculate the quality score. NIST will maintain a Vendor Registry that will map the values in this field to registered quality algorithm vendors. The Vendor ID shall be composed of ASCII printable characters up to 16 characters in length.

3.   The third information item shall specify a numeric product code assigned by the vendor of the quality algorithm. It indicates which of the vendor's algorithms was used in the calculation of the quality score. This field contains the ASCII representation of the integer product code and should be within the range 1 to 65535.

4. The fourth item shall specify the version number of the quality algorithm used. The version number shall include a major number and minor number separated by a period. The major number and minor numbers should each be the ASCII representation of integer values in the range 0 to 255.

An example transaction for a quality score of 100 generated using a quality algorithm with a product code of 65530, version 255.255, by a vendor with a Vendor ID of "NIST" is "10.023:100 ^{US}NIST ^{US}65530 ^{US}255.255 ^{GS}".

11 New field 10.025: Subject pose angles (SPA)

This optional ASCII field shall only be used when Field 10.020 (POS) is not present or contains an *"D"* to indicate a set of determined 3D pose angles of the same subject. If the entry in the POS Field is an *"F", "L"*, or *"R"*, the contents of this field are ignored. When present, this information shall be entered as three or six information items.

The first is the Yaw angle followed by the "*US*" separator, followed by the Pitch angle, followed by the "*US*" separator, followed by the Roll angle. The fourth, fifth and sixth information items denote the uncertainty in the Yaw, Pitch, and Roll angles respectively.   If the second triple of angles is not present, then the uncertainty in the angles is not determined, but the additional three "US" separators shall still be included.

The first three items specify the pose of the subject estimated or measured at constrained possible orientations within a sphere (See Figure 5). Each angle value shall be to the nearest integer degree.

If both field 10.021 and this field are present, the Yaw angle of this field shall supersede the offset angle contained in Field 10.021. Note that the Yaw angle of this field has the opposite sign of the offset angle contained in Field 10.021.

11.1 The definition and range of pose angles

The Yaw and Roll angles shall be measured from the full face pose position and have a range of values from -180 degrees to +180 degrees. The Pitch angle shall have a range of values from -90 degrees to +90 degrees. The pose angle set is given by Tait-Bryan angles.
- Yaw angle: rotation about the vertical (y) axis. A positive Yaw angle is used to express the angular offset as the subject rotates from a full-face pose to their left (approaching a right profile). A negative Yaw angle is used to express the angular offset as the subject rotates from a full-face pose to their right (approaching a left profile).
- Pitch angle: rotation about the horizontal side-to-side (x) horizontal axis.
- Roll angle: rotation about the horizontal back to front (z) axis.

The angles are defined relative to the frontal view of the subject, which has angles (0, 0, 0) as shown in Figure 5. Examples are shown in Figure 6.
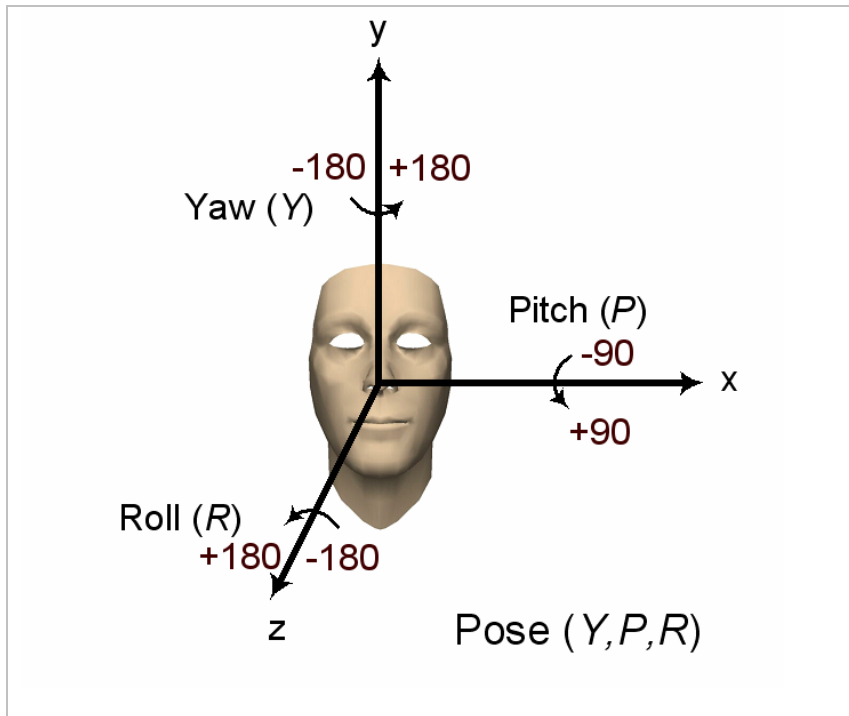
Figure 5 – The definition of pose angle set is with respect to the frontal view of the subject.
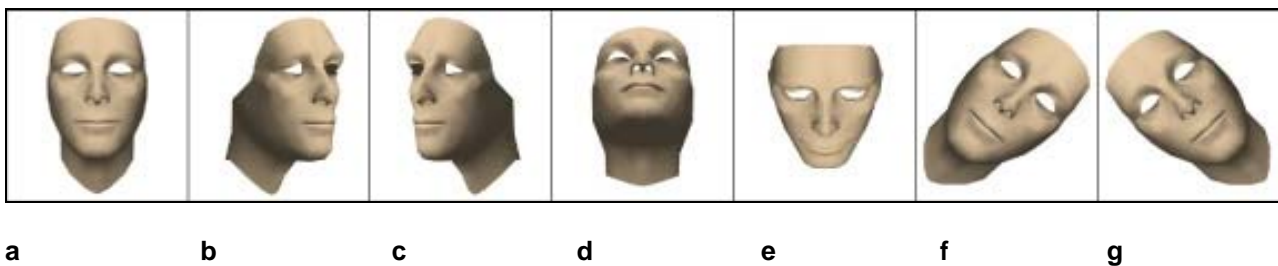

| a | b | c | d | e | f | g |

Figure 6 – Examples of pose angles and their encodings. The pose angles (Y, P, R) of Figures (a) – (g) are given by (0, 0, 0), (+45, 0, 0), (-45, 0, 0), (0, -45, 0), (0, +45, 0), (0, 0, -45), and (0, 0, +45), respectively.

The uncertainty in the pose angles is given by the range 0 to 90 inclusive. It shall denote approximately a maximum value of possible deviation in the measurement of the pose. This shall correspond to a two standard deviation confidence interval.

The encoding of angles is in ASCII format, with the minus sign "-" used to denote a negative value and the plus "+" sign optionally used to denote a positive value. Pose angle uncertainty angles always are positive.

For example, the optional ASCII field of the pose angle set (PAS) for the subject in Figure 5(b) is "10.025:+45^{US}0^{US}0^{GS}".

11.2 The order of rotation through pose angles

As order of the successive rotation around the different axes does matter, the encoded rotation angle shall correspond to an order of execution starting from the frontal view. This order shall be given by Roll (about the front axis), then Pitch (about the horizontal axis) and finally Yaw (about the vertical axis). The (first executed) Roll transformation will therefore always be in the image (x, y) plane. Examples are shown in Figure 7.

From the point of view of executing a transformation from the observed view to a frontal view, the transformation order will therefore be Yaw, Pitch, and then Roll. Note however that the encoded angle is from the frontal view to the observed view.

(Y, P, R)=(0, 0, +45)	(Y, P, R)=(0,-30, +45)	(Y, P, R)=(-45, -30, +45)
a	b	c

(Y, P, R)=(0, 0, -30)	(Y, P, R)=(0, +20, -30)	(Y, P, R)=(-30, +20, -30)
d	e	F

Figure 7 – Examples of the order of rotation through pose angles with an origin of coordinate system at the nose tip. Figures (a)-(c) show three successive rotation steps to achieve the pose angles (Y, P, R) of (-45, -30, +45). Figures (d)-(f) show three successive rotation steps to achieve the pose angles (Y, P, R) of (-30, +20, -30).

12 New field 10.026: Subject facial description (SXS)

This optional ASCII field shall be used for the exchange of facial image data. When present, it shall describe the facial expression of the subject and other attributes associated with the subject's captured facial image. This field may have one or more subfields each containing a single information item. Attributes associated with the facial image may be selected from Table 7 and entered in this field. For "Physical Characteristic", enter a characteristic as listed in Part 4 Section 13 of the Eighth (or current) Edition of the NCIC Code Manual, July 14, 1999. For the "Other Characteristic" enter unlisted or miscellaneous attributes as unformatted text used to describe the attribute. Multiple attributes may be listed but must be separated by the *"RS"* character.

Table 7: Subject facial description codes

Facial description attribute	Attribute code
Expression unspecified	UNKNOWN
Neutral (non-smiling) with both eyes open and mouth closed)	NEUTRAL
Smiling where the inside of the mouth and/or teeth is not exposed (closed jaw).	SMILE
Subject Having Mouth open	MOUTH OPEN
Having Teeth visible	TEETH VISIBLE
Raising eyebrows	RAISED BROWS
Frowning	FROWNING
Looking away from the camera	EYES AWAY
Squinting	SQUINTING
Subject Wearing Left Eye Patch	LEFT EYE PATCH
Subject Wearing Right Eye Patch	RIGHT EYE PATCH
Subject Wearing Clear Glasses	CLEAR GLASSES
Subject Wearing Dark or Visible Colored Glasses (medical)	DARK GLASSES
head covering/hat	HAT
Wearing Scarf	SCARF
Having Moustache	MOUSTACHE
Having Beard	BEARD
Ear(s) obscured by hair	NO EAR
Blinking (either or both eyes closed)	BLINK
Having Distorting Medical Condition impacting Feature Point detection	DISTORTING CONDITION
Physical Characteristics	<From NCIC Code Manual>
Other Characteristics	<Unformatted Text>

Note: This field is intended to replace the photo description field (PXS) and to enhance the content with additional descriptive information. As such, photo descriptors found in Table 5 also appear in Table 7.

An example transaction for subject having teeth visible is "10.026:TEETH VISIBLE[GS]".

13 New field 10.027: Subject eye color (SEC)

This optional ASCII field shall be used for the exchange of facial image data. When present, it shall describe the eye color of the subject as seen in the photograph. If unusual or unnatural such as may be the case when colored contact lenses are present and the "real" eye color cannot be ascertained, then the color should be labeled as "UNKNOWN".

Table 8 – Eye Color codes

Eye color attribute	Attribute code
Unspecified	UNSPECIFIED
Black	BLACK
Blue	BLUE
Brown	BROWN
Gray	GRAY
Green	GREEN
Multi-Colored	MULTI-COLORED
Pink	PINK
Unknown (e.g. can not be determined from image, monochrome image)	UNKNOWN

An example transaction for subject blue eyes is "10.027:BLUE[GS]".

14 New field 10.028: Subject hair color (SHC)

This optional ASCII field shall be used for the exchange of facial image data. When present, it shall describe the hair color of the subject as seen in the photograph. If unusual or unnatural color such as blue or orange is present and the "real" color cannot be ascertained, then the color should be labeled as "UNKNOWN"

If the subject is completely bald, or has a completely shaved head, then the hair color shall be labeled as "BALD". When the subject is predominantly bald, but hair color is discernable, then the appropriate hair color attribute code shall follow "BALD" (separated by the *"RS"* character).

Table 9 – Hair Color codes

Hair color attribute	Attribute code
Unspecified	UNSPECIFIED
Bald	BALD
Black	BLACK
Blonde	BLONDE
Brown	BROWN
Gray	GRAY
White	WHITE
Red	RED
Unknown	UNKNOWN

An example transaction for subject is bald and having gray hair is "10.028:BALD^{RS}GRAY^{GS}".

15 New field 10.029: Subject feature points (SFP)

The optional ASCII field shall be used for the exchange of facial image data. When present, it shall describe special attributes of manually or automatically detected facial feature points of the captured facial image. This information shall be entered as four information items described in Table 10. The first is Feature Point Type, followed by the "*US*" separator character. The second is Feature Point Code, followed by the "*US*" separator character. The third is the *X* coordinate of a Feature Point, followed by the "*US*" separator character. The fourth and final item is the *Y* coordinate of a Feature Point in the facial image. Multiple facial points may be listed but must be separated by the "RS" separator character. The maximum number of feature points shall be 88, with the use of 84 MPEG4 feature points and 4 additional center feature points.

Feature points shall be included in the record format if they have been accurately determined, thereby providing the option that that these parameters do not have to be re-determined when the image is processed for face recognition tasks. Note that feature points of eye centers are coded with feature point codes 12.1 and 12.2 as shown in in Figure 9.

Typically a computer algorithm will either accurately determine the position of the feature point or completely fail and provide either clearly erroneous or no landmark information. Therefore, a method for accurate determination is the use of computer-automated feature point determination followed by human verification and potential override of the computer determined feature points.

Table 10 – The Subject Feature Point Field

Item	Size	Value	Notes
Feature Point Type	1 character	1	Denotes a 2D Feature Point. All other values are reserved.
Feature Point Code	5 characters	A.B in ASCII text A and B are specified in Section 15.2.	The maximum values of A and B are 15.
X coordinate	1-4 characters	Horizontal pixel count from upper left pixel.	Count starts at 0.
Y coordinate	1-4 characters	Vertical pixel count from upper left pixel.	Count starts at 0.

The four information items are described as follows.

15.1 Subject feature point type

The Subject Feature Point Type item represents the type of the Feature Point stored in the Feature Point block. This field shall be set to "1" to denote the version 1 of feature point type that the position of the Feature Point is represented by the coordinate of the image. All other field values are reserved for future definition of Feature Point types.

15.2 Subject feature point code

15.2.1 MPEG4 Feature Points

The Subject feature point code item shall specify the Feature Point that is stored in the Feature Point block. The codes of the Feature Points in Section 15.2.1, taken from the MPEG4 standard and defined as MPEG4 Feature Points, or the additional eye and nostril Feature Points in Section 15.2.2 shall be stored in this field. Each Feature Point code is represented by a notation A.B using a major (A) and a minor (B) value. The encoding of the Feature Point code is given by the numeric ASCII representation of the value of A.B.

Figure 8 denotes the Feature Point codes associated with Feature Points as given by Annex C of ISO/IEC 14496-2.
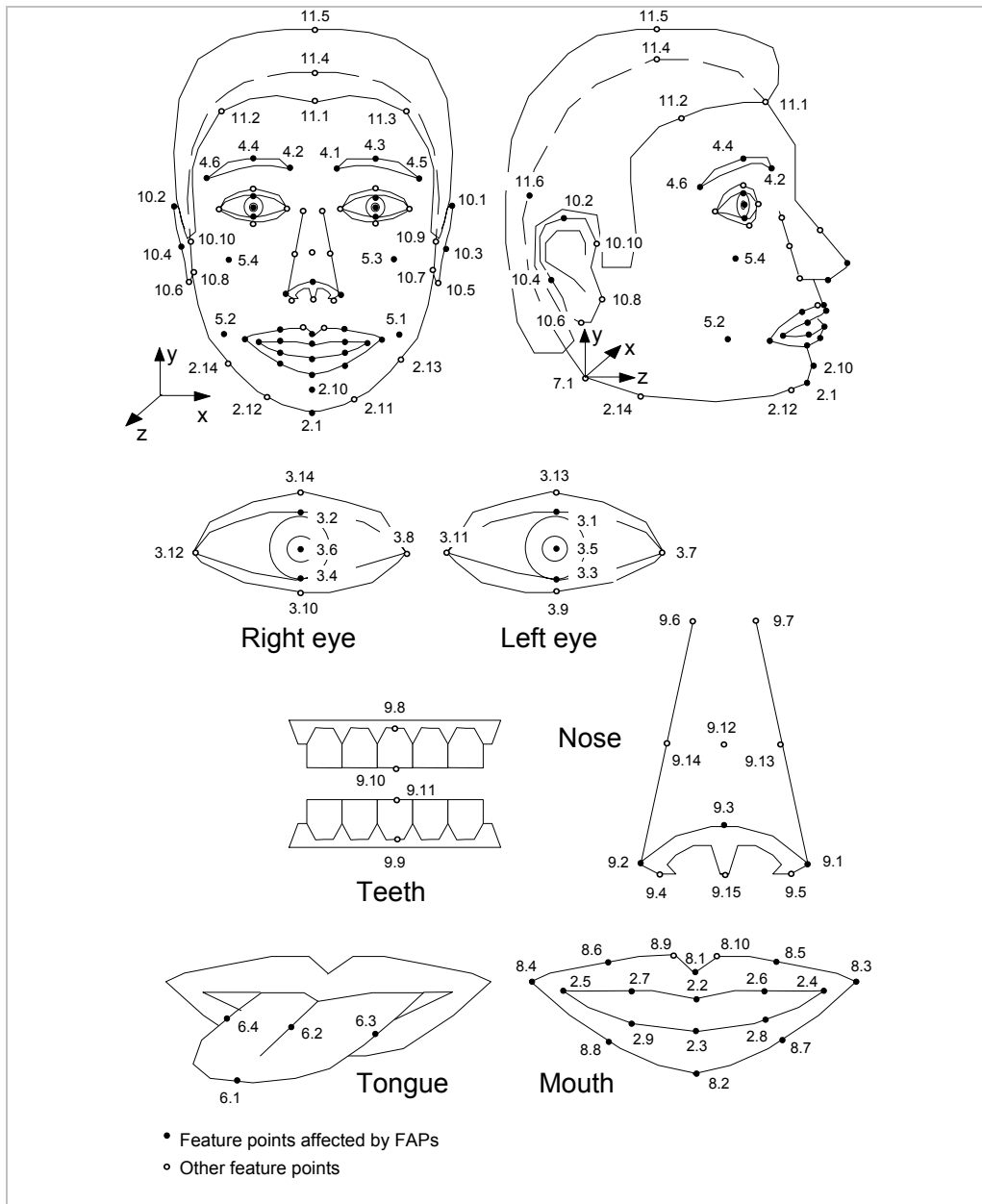
Figure 8 – The Feature Point codes defined in ISO/IEC 14496-2.

Each Feature Point code in Figure 8 is given by major value A and minor value B. For example, the code for the left corner of the left eye is given by major value 3 and minor value 7.

15.2.2 Eye and nostril centre Feature Points

The eye center Feature Points 12.1 (left) and 12.2 (right) are defined to be the horizontal and vertical midpoints of the eye corners (3.7, 3.11) and (3.8, 3.12) respectively. The left nostril center Feature Point 12.3 is defined to be the midpoint of the nose Feature Points (9.1, 9.15) in the horizontal direction and (9.3, 9.15) in the vertical direction. Similarly, the right nostril center Feature Point 12.4 is defined to be the midpoint of the nose Feature Points (9.2, 9.15) in the horizontal direction and (9.3, 9.15) in the vertical direction. Both the eye center and nostril center Feature Points are shown in Figure 9 and values given in Table 11.
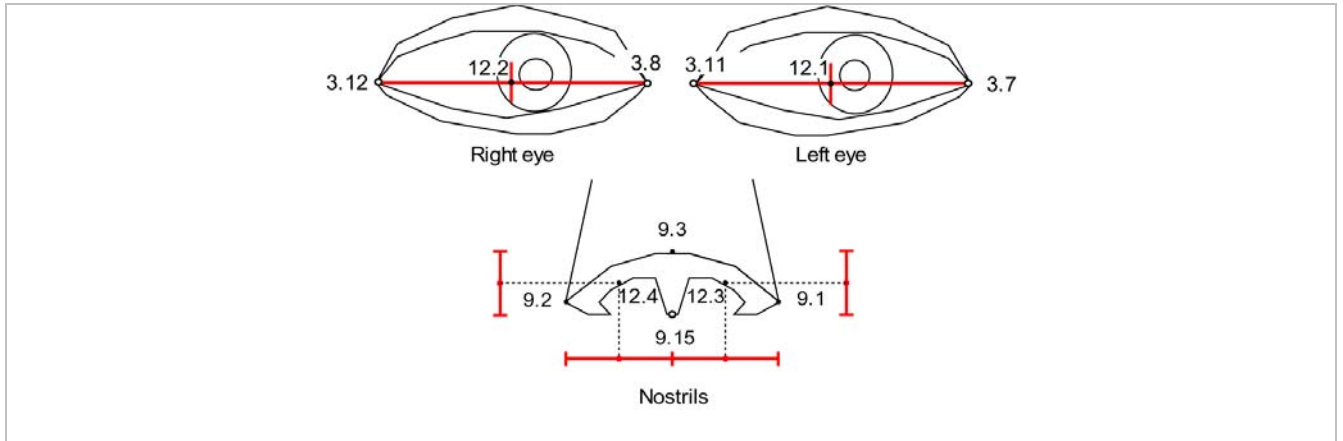
Figure 9 – The eye and nostril center Feature Points are defined by midpoints of MPEG4 Feature Points.

Table 11 – Eye and nostril center Feature Point codes

Center Feature Point	Midpoint of Feature Points		Feature Point code
Left Eye	3.7, 3.11		12.1
Right Eye	3.8, 3.12		12.2
Left Nostril	Horizontal	Vertical	12.3
	9.1, 9.15	9.3,9.15	
Right Nostril	Horizontal	Vertical	12.4
	9.2, 9.15	9.3,9.15	

An example transaction for representing two feature points of eye centers is "10.029:1^{US}12.2^{US}120^{US}130 ^{RS}1^{US}12.1^{US}240^{US}129^{GS}".

16 Example Transaction

e-10 Transaction Record (New or Modified fields)

COMPRESSION ALGORITHM (CGA) 10.011:JP2^{GS}

COLOR SPACE (CSP) 10.012:YCC^{GS}

SUBJECT ACQUISITION PROFILE (SAP) 10.013:40^{GS}

SUBJECT POSE (POS) 10.020:D^{GS}

PHOTO DESCRIPTION (PXS) 10.022:GLASSES^{GS}

PHOTO ACQUISITION SOURCE (PAS) 10.023:DIGITAL CAMERA^{GS}

SUBJECT QUALITY SCORE (SQS) 10.024:100^{US}NIST^{US}65535^{US}255.255^{GS}

SUBJECT POSE ANGLE (SPA) 10.025:-45^{US}0^{US}0^{USUSUSGS}

SUBJECT FACIAL DESCRIPTION (SXS) 10.026:OPEN MOUTH^{GS}

SUBJECT EYE COLOR (SEC) 10.027:BLUE^{GS}

SUBJECT HAIR COLOR (SHC) 10.028:BALD^{RS}GRAY^{GS}

FACIAL FEATURE POINT (FFP) 10.029:1^{US}12.2^{US}120^{US}130^{RS}1^{US}12.1^{US}240^{US}129^{GS}

(Example for describing two feature points of eye centers)

References

[1] R.M. McCabe, "ANSI/NIST-ITL 1-2000 Data Format for the Interchange of Fingerprint, Facial, and Scar Mark & Tattoo (SMT) Information," < ftp://sequoyah.nist.gov/pub/nist_internal_reports/sp500-245-a16.pdf >

[2] R.M. McCabe, "Best Practice Recommendation for the Capture of Mugshots,'' Version 2.0, Sept. 1997. < http://www.itl.nist.gov/iad/894.03/face/bpr_mug3.html >

[3] NIST DRAFT Special Publication 800-76, ``*Biometric Data Specification for Personal Identity Verification,''* January 24, 2005. < *http://csrc.nist.gov/piv-program/fips201-support-docs/SP800-76-Draft.pdf* >

[4] ISO/IEC 19794-5 (published version), Information technology — Biometric data interchange formats — Part 5: Face image data, June, 2005.

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[5] ``AAMVA National Standard for the Driver License/Identification Card,'' American Association of Motor Vehicle Administrators, June 30, 2000.
<http://www.aamva.org/Documents/stdAAMVADLIDStandrd000630.pdf >

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[7]   Biometrics Deployment of Machine Readable Travel Documents, Annex A: ``Guidelines for Taking Photographs to Maximize Facial Recognition Results.'' < http://www.icao.int/mrtd/download/documents/Annex%20A%20-%20Photograph%20Guidelines.pdf >

[8]   Biometrics Deployment of Machine Readable Travel Documents, Annex D: ``Facial Image Format for Interoperable Data Interchange.'' < http://isotc.iso.org/livelink/livelink/fetch/2000/2122/327993/2262372/2263034/2300191/JTC001-SC37-N-506.pdf?nodeid=3924597&vernum=0 >

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[10] ANSI/INCITS 385-2004 Information Technology - ``Face Recognition Format for Data Interchange,'' InterNational Committee for Information Technology Standards, May 2004. < http://webstore.ansi.org/ansidocstore/product.asp?sku=ANSI+INCITS+385%2D2004 >

[11] ISO/IEC 15444-1:2000. ``Information technology -- JPEG 2000 image coding system -- Part 1: Core coding system,'' 2000. < http://webstore.ansi.org/ansidocstore/product.asp?sku=INCITS%2FISO%2FIEC+15444-1-2000 >

[12] For information on *sRGB*, see http://www.w3.org/Graphics/Color/sRGB or many of the white papers available at http://www.color.org.

[13] Approximately 1700 pixels wide by 2515 pixels high on the face are needed for the 99th percentile male in the U.S. population, Richard W. Vorder Bruegge, FBI-OTD, Forensic Audio, Video and Image Analysis Unit, Building 27958A, Quantico, VA.

[14] JROI Project, a publicly available source of JPEG Region of Interest Compression for Face Recognition, at SourceForge.net http://sourceforge.net/projects/jroi.