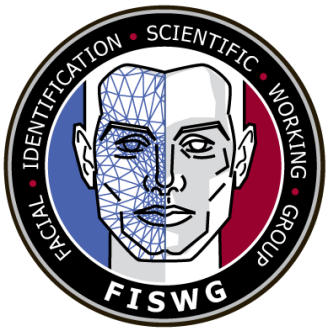

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Version 2.1 2025.06.06

Standard Guide for Image Processing to Improve Facial Recognition Search Performance

1. Scope

1.1 The purpose of this document is to provide guidelines for processing a probe image in order to increase the likelihood that a potential candidate will be included among the search result set returned following a facial recognition system (FRS) search.

1.1.1 This process is not suitable for developing source opinions regarding an image.

1.1.2 The guideline does not address the necessary steps and processes for that type of examination.

2. Referenced Documents

2.1 *ASTM Standards*:

E2916 Terminology for Digital and Multimedia Evidence Examination[1]

E2825 Standard Guide for Forensic Digital Image Processing

2.2 *Other Standards*:

ANSI/NIST- ITL-1-2011 Data Format for the Interchange of Fingerprint, Facial & Other Biometric Information[2]

FISWG Facial Recognition Systems Metadata Usage[3]

[1] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@asstm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

[2] For referenced ANSI/NIST documents, visit https://www.nist.gov/programs-projects/ansinist-itl-standard

[3] For referenced FISWG documents, visit https://fiswg.org/documents.html

3. Terminology

3.1 *Definitions:*

3.1.1 *Lossy compression, n*—data reduction process that is not completely reversible, and some original data is irretrievably lost.

3.1.2 *Lossless compression, n*—a data reduction process that is completely reversible, such that all of the original data can be retrieved in the original form.

3.1.3 *Pixel aspect ratio, n*—the ratio of the width to the height of a rectangle, such as an image, a pixel, or an active video frame.

3.2 *Acronyms:*

3.2.1 *FRS, n*—Facial Recognition Systems

4. Summary of Guide

4.1 The image processing steps presented in this document are limited to the manual processing of images intended to be submitted as probe images for FRS searches. Internal image processing applied by the FRS and issues associated with still image extraction from video, scanning of printed imagery, and the use of forensic sketches, reconstructions, and composites are beyond the scope of this document.

5. Significance and Use

5.1 Introduction

5.1.1 Images that meet agreed upon international standards (such as ISO/IEC 19794-5: Face Image Data[4]) can normally be submitted to an FRS for searching with little or no operator intervention. Many FRS also include intrinsic mechanisms for correcting minor deviations in subject pose, image size, or vendor specific adjustments to the image. Manual processing may be beneficial for sub-optimal images (e.g. low resolution, heavily compressed or where the subject's pose, illumination, or expression is non-neutral). The image processing techniques presented in this document may be applied over an entire image or in localized areas of an image.

5.1.2 The image processing topics presented in this document are not intended to override recommendations for maintaining the quality of images intended for one-to-one comparison. These processes specifically apply to the preparation of a facial image for the purpose of submitting it as a probe into an automated FRS search to maximize the

[4] Available from https://www.iso.org/standard/38749.html

likelihood that a potential candidate will be returned in the search result set. These processes are not to be used for identification purposes.

5.2 Important Notes

5.2.1 The goal of any image processing should be to optimize the image for searching by the FRS, not to create an aesthetically pleasing image. An image that looks ‘good’ is not necessarily the same as one that is optimized for use by an FRS due to image processing done within the vendor specific algorithms.

5.2.2 The effect of any manual image processing will vary with different FRS and in some cases may degrade performance rather than improve it.

5.2.3 Image processing to the probe image before an FRS search is different from the operational processes performed for the purpose of a one-to-one manual comparison.

5.2.4 Any decision regarding whether or not a candidate returned from an FRS search is from a possible common source as the subject in the probe image must be made based on a comparison with the original (unedited) image and NOT the processed image.

5.2.5 Agency specific or mandated notes and audit trails shall be done at all times. Document and preserve processed images regardless of search results.

5.2.6 The following sections of this document describe a series of steps with varying complexity for the manual processing of probe images of less-than-optimal quality for an FRS. They are intended to maximize the likelihood of returning a potential candidate from a search result set while minimizing the amount of processing of the probe image. The guidelines presented in this document may be adapted for agency specific policies and standard operating procedures.

6. Image File Management

6.1 **Initial Steps –** The initial steps for the management of probe imagery include, but are not limited to, the following:

6.1.1 Save original

6.1.1.1 The original untouched probe image should be kept in all cases. A read-only copy shall be made of the original probe image(s). No enhancements or modifications shall be made to these original probe image(s). When making any final comparisons, always use a working copy of the original probe image(s).

6.1.2 Make lossless working copies

6.1.2.1 All image processing steps should be done using a lossless file format.

6.1.2.2 Understanding the compatibility of image file formats for an FRS is critical because the original image(s) may be received in a variety of file formats. If a probe image is not in an FRS compatible format, follow the vendor's recommendations for conversion to a supported compatible format. This conversion (if needed) should be done as a last step from the lossless images being processed, prior to searching.

6.2 **Generalize Search Steps –** For the purpose of this document, "pass" refers to an assumption that following each progression of image processing, an FRS search will take place, and the resulting candidates will be assessed. It may not be prudent to run the probe image through an FRS search until it has been processed to a certain degree. In all examples of "passes" presented in this document it is assumed that for every sequential "pass", the following steps shall be undertaken in every FRS search of a probe image. See Figure 1 below: **Simplified Image Processing Flow Chart**.

6.2.1 Verify eyes can be found.

6.2.1.1 This step can also be described as "localizing the face in the image". This is critical to determine if the facial imagery utilized has limitations or systemic image conditions, which may cause a problem when submitting to the proprietary technology within an FRS.

6.2.2 Save interim image sets

6.2.2.1 All processed images used for searching shall be saved according to agency policy. Searching images with different enhancements (e.g., cropped, black and white, or grayscale) may result in different candidate sets.

6.2.3 Search and review results

6.2.3.1 FRS results shall be compared against the original probe image(s). If no potential candidates are returned in the search result set, the recommendation is to re-evaluate the image that was used in searching and apply further processing.

6.2.4 If available within the FRS, consider using metadata binning.

6.2.4.1 The FISWG document ***Facial Recognition Systems Metadata Usage***[5] should be referenced where metadata is accessible which refines searches through reducing the logical size of the search database.

[5] Available from: https://www.fiswg.org/documents.html

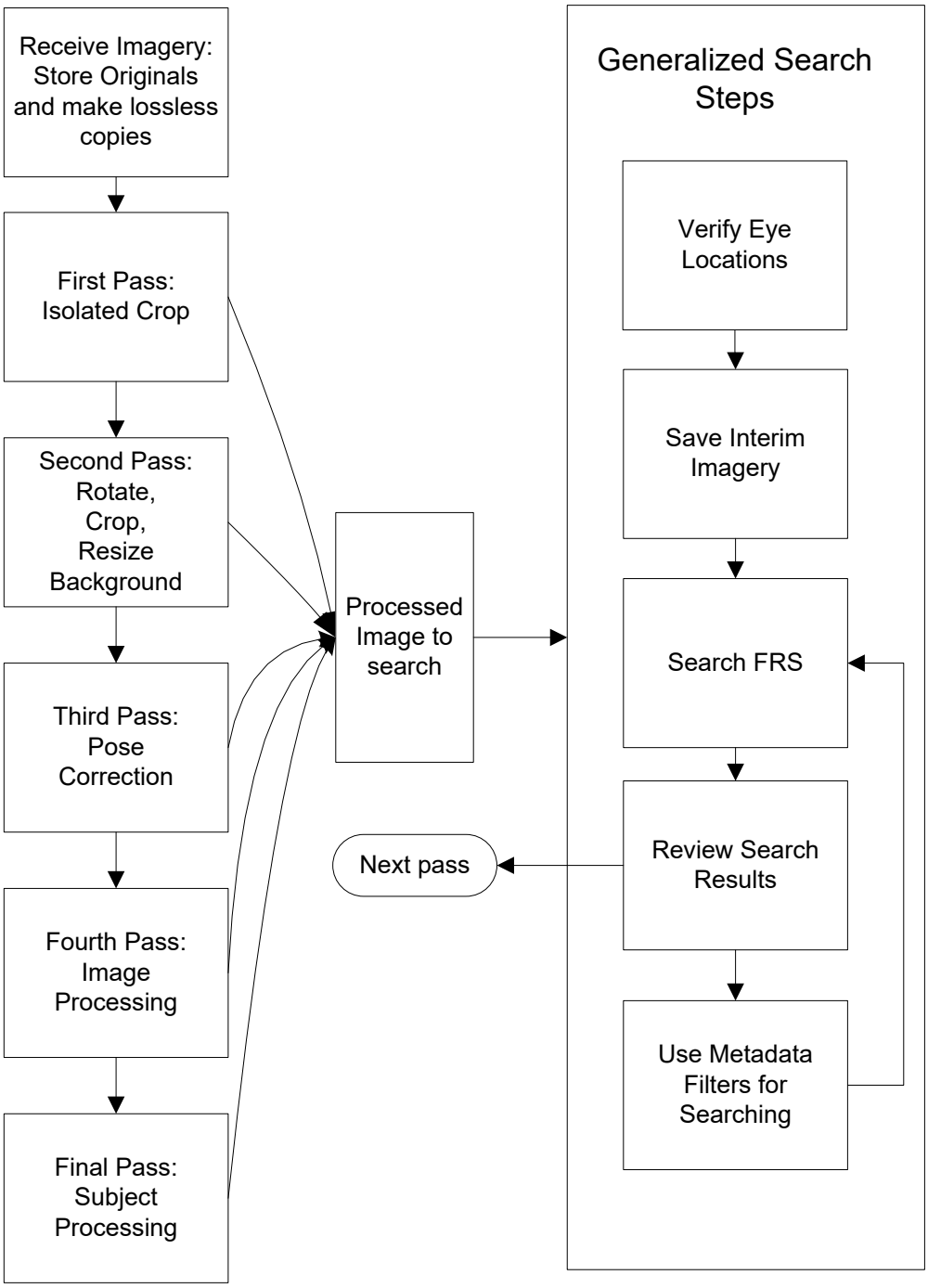


Figure 1: Simplified Image Processing Flow Chart

7. First Pass: Isolated Crop

7.1 The first pass should be initiated with the original image. The relevant face(s) should be cropped, if not undertaken automatically by the FRS. When cropping, ensure that the aspect ratio is maintained and aim to produce an image that is in accordance with ANSI/NIST- ITL-1-2011or ISO specifications.

8. Second Pass: Rotate, Crop, Resize, Background

8.1 The second pass would be initiated when no potential candidates are found during the First Pass or when the nature of the image warrants minimal processing to yield additional candidates.

8.2 The second pass may include the tasks below, all of which are not necessarily required; however, if more than one is applied, they should be performed one at a time. When processing images, care should be taken to not remove or alter portions of the subject's head (e.g. portions of the ear, crown of the head, or portions of the neck).

8.3 Rotate **–** The image may be rotated around the roll axis to make the eye positions appear horizontally aligned.

8.4 Secondary Crop – The image processing steps done in this pass may require a secondary crop of the image. The goal of this crop is to produce an image that is more in accordance with the ANSI/NIST- ITL-1-2011or ISO specifications.

8.5 Resize – Modify the size of the image to achieve a recommended interpupillary distance. This distance should be agency defined and based on FRS vendor recommendations (e.g. 90 pixels). Resizing of the images should be done in even multiples of the original image size while preserving the original image aspect ratio. For example: 90x120 pixels to 180x240 pixels to 270x360 pixels, etc.

8.6 Blur background – This is performed where the probe image has a non-neutral or busy background. The blurring process creates a consistent background preventing an FR engine from detecting items in the background. Examples include:

8.6.1 Surveillance photo with people or items in background.

8.6.2 An image captured with a background that varies in color and content.

8.7 Horizontal flip – This should be utilized if the probe image submitted may have been taken as a reflection, captured incorrectly, or been flipped left/right or right/left in transmission.

8.8 Aspect ratio correction – Mitigates the impact of an image that looks unnaturally stretched in the horizontal or vertical direction.

9. Third Pass: Pose Correction

9.1 Some legacy FRS algorithms have varying sensitivities to non-frontal facial imagery. Claims of performance degradations will vary, but it is broadly accepted that any non-frontal pose movements could negatively affect FRS performance. If the FRS algorithm has been tested and is proven to be pose invariant, then this step may not be needed. Check with the facial algorithm provider to verify this.

9.2 The standard definitions of pose angles are defined in: **NIST Special Publication 500-290 Edition 3 (2015)** and **ANSI/NIST-ITL 1-2011 Update: 2015 Data Format for the Interchange of Fingerprint, Facial, & Other Biometric Information**[6] as referenced in Figure 2:

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 as shown in Figure 26.

ANSI/NIST-ITL 1-2011: UPDATE 2015

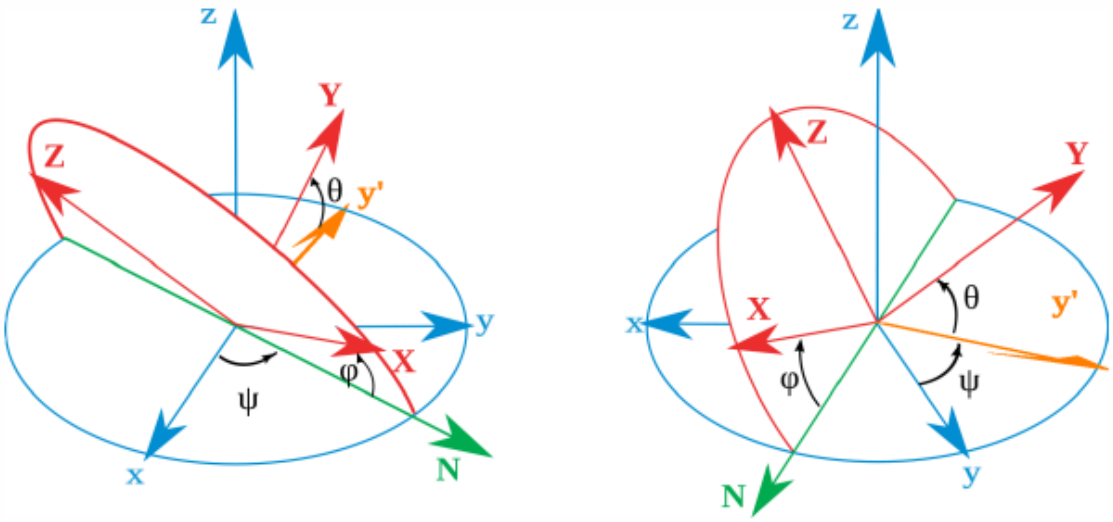


Figure 26: Tait-Bryan angles statically defined with the Z-X'-Y'' convention

[6] Available from: http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.500-290e3.pdf

The angles are defined relative to the frontal view of the subject, which has angles (0, 0, 0). Examples are shown in Figure 27.

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 his or her 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 his or her right (approaching a left profile).

Roll angle: rotation about the horizontal side-to-side (z) axis.

Pitch angle: rotation about the horizontal back to front (x) axis.

ANSI/NIST-ITL 1-2011: UPDATE 2015

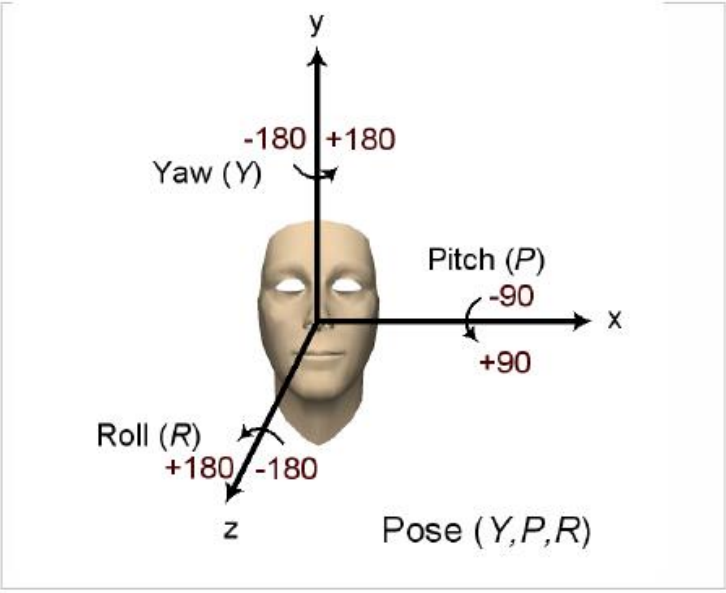


Figure 27: Pose angle set is with respect to the frontal view of the subject

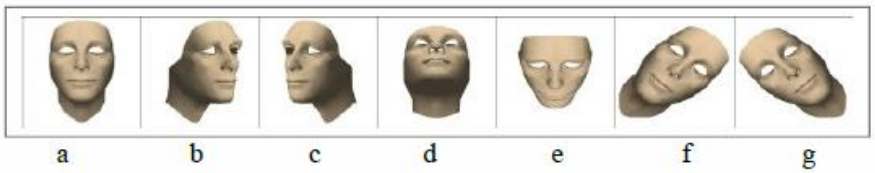


Figure 28: Examples of pose angles and their encodings.

The pose angles (Y, P, R) of (a) – (g) in Figure 28 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 are always positive.

Figure 2: NIST Special Publication 500-290 Edition 3 (2015)

9.3 Software for pose correction is dependent on policy or vendor recommendations. Any pose which varies more than 10 degrees in any direction from (0, 0, 0) could be considered a candidate for pose correction.

9.4 When pose correction is done, consideration shall be given to the following areas:

9.4.1 If available, select the proper gender and race.

9.4.2 Select any symmetric fill option.

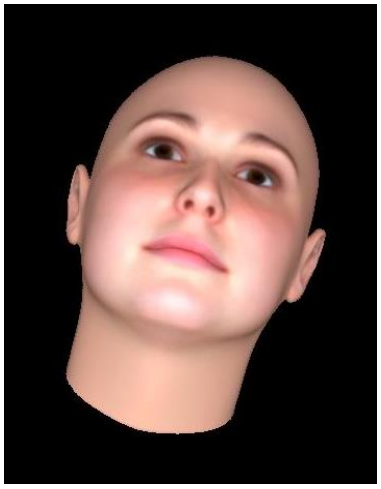
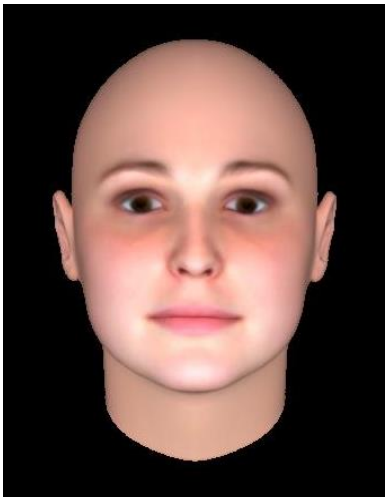
9.4.3 Place appropriate facial landmarks as needed.

9.4.4 Select the number of poses to generate.

9.4.4.1 Frontal

9.4.4.2 Slight left and right pose (e.g., +/- 15 degrees yaw)

9.4.4.3 Slight up and down pose (e.g., +/- 15 degrees pitch)

Pose	**Example Image**	**Pose**	**Example Image**
Original Image		Pose corrected frontal	

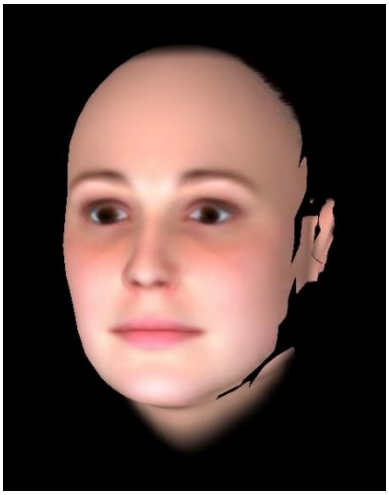
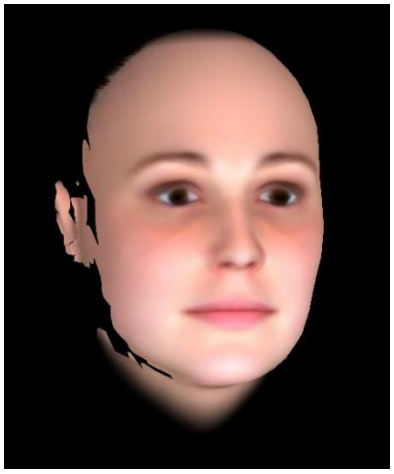
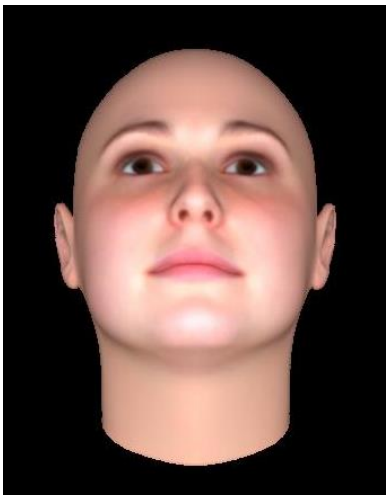
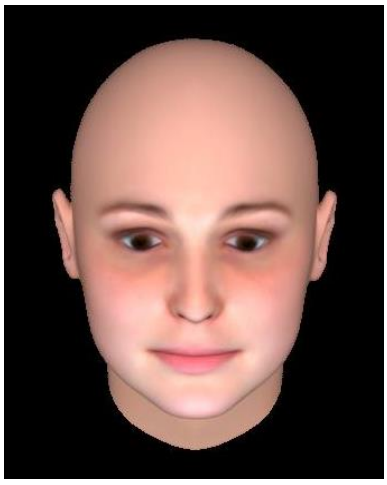
Yaw -15 degrees		Yaw +15 degrees	
Pitch +15degrees		Pitch -15 degrees	

Figure 3: Pose Examples

9.4.5 When multiple poses are generated, searching each pose as individual probe images within unique searches may allow for pose variations within the gallery. Some FRS supplied search clients allow group searching where groups of related imagery can be searched and reviewed in bulk.

10. Fourth Pass: Image Processing

10.1 During the Fourth Pass, image processing may be applied to a working copy of the original image or an image resulting from any of the previous passes to attempt to produce a different candidate search result set.

10.2 Image processing may be performed externally of the FRS using widely available image editors (e.g. Adobe Photoshop and GNU Image Manipulation Program [GIMP]) with the resulting probe image being submitted for an FRS search. The image processing listed below may be applied to the entire image or to selected regions within the image and may include, but are not limited to:

10.2.1 Histogram equalization

10.2.2 Color/tint corrections

10.2.3 De-blurring or sharpening

10.2.4 Lens distortion correction

10.2.4.1 Some images, such as those from smart phones, automated teller machines (ATM's) and Body Worn Video cameras that use wide-angle lenses typically exhibit perspective ('barrel') distortion. Image processing software or manufacturers' provided lens correction data should be used to correct this prior to searching.

10.2.5 Grayscale conversion

10.2.6 Noise reduction

10.2.7 Brightness or contrast adjustment

10.2.8 Red eye reduction

11. Advanced Topic: Subject Processing

11.1 After previous passes have been completed (or rejected due to the nature of the image) additional processing steps targeted at the subject in the image may be used.

11.2 This type of processing may introduce external elements to the subject in the image. Agency procedures shall be followed to determine whether these measures can be applied to improve the likelihood of locating a potential candidate from an image returned in the candidate search result set from an FRS search.

11.3 Circumstances warranting this type of image processing include, but are not limited to, the following:

11.3.1 Facial landmarks obstructed by head coverings, accessories (e.g., jewelry or eyewear), hair, image artifacts, etc.,

11.3.2 Missing or obstructed facial landmarks due to extreme pose or expression (including closed eyes),

11.3.3 Intentional alterations of the subject's face (e.g., excessive make-up), or

11.3.4 Trauma (e.g., lacerations, blood, bruising), evidence of medical intervention (e.g., bandages, endotracheal tube, neck brace), or postmortem.

11.4 Examples of subject image processing include, but are not limited to, the following:

11.4.1 Replace or create missing facial landmarks on the subject.

11.4.2 Mirroring the probe image on the center line of the half face.

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