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# Standard Practice/Guide for Image Processing to Improve Automated Facial Recognition Search Performance

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## 27 1. Scope.

28 1.1 The purpose of this document is to provide guidelines for processing a probe  
29 image in order to increase the likelihood that a potential candidate will be  
30 included among the search result set returned following a facial recognition  
31 system (FRS) search. "This process is not suitable for developing source  
32 conclusions regarding an image. The guideline does not address the necessary  
33 steps and processes for that type of examination."

## 34 2. Referenced Documents

### 35 2.1 ASTM Standards<sup>1</sup>:

36 E2916 Terminology for Digital and Multimedia Evidence Examination

37 E2825 Standard Guide for Forensic Digital Image Processing

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<sup>1</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

38 2.2 Other Standards:

39 ANSI/NIST- ITL-1-2011 Data Format for the Interchange of Fingerprint, Facial &  
40 Other Biometric Information<sup>2</sup>

41 **3. Terminology**

42 3.1 Definitions: See ASTM E2916 Terminology for digital and multimedia evidence  
43 examination terms.

44 3.1.1 Lossy compression—compression in which data are lost and cannot be  
45 retrieved in their original form

46 3.1.2 Lossless compression— a method of data compression in which the size  
47 of the file is reduced without sacrificing image quality.

48 3.1.3 Pixel aspect ratio— is a mathematical ratio that describes how the width of  
49 a pixel in a digital image compares to the height of that pixel.

50 3.2 Acronyms

51 FRS—Facial Recognition Systems

52 **4. Summary of Guide**

53 The image processing steps presented in this document are limited to the manual  
54 processing of images intended to be submitted as probe images for FRS searches.

55 Internal image processing applied by the FRS and issues associated with still image

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<sup>2</sup> For referenced NIST standards, visit the NIST website, [www.nist.gov/programs-projects/ansinist-itl-standard](http://www.nist.gov/programs-projects/ansinist-itl-standard)

56 extraction from video, scanning of printed imagery, and the use of forensic sketches,  
57 reconstructions, and composites are beyond the scope of this document.

## 58 **5. Significance and Use**

### 59 **5.1 Introduction**

60 Images that meet agreed upon international standards (such as ISO/IEC 19794-  
61 5: Face Image Data<sup>3</sup>) can normally be submitted to an FRS for searching with  
62 little or no operator intervention. Many FRS also include intrinsic mechanisms  
63 for correcting minor deviations in subject pose, image size, or vendor specific  
64 adjustments to the image. Manual processing may be beneficial for sub-optimal  
65 images (e.g. low resolution, heavily compressed or where the subject's pose,  
66 illumination, or expression is non-neutral). The image processing techniques  
67 presented in this document may be applied over an entire image or in localized  
68 areas of an image.

69 The image processing topics presented in this document are not intended to  
70 override recommendations for maintaining the forensic quality of images  
71 intended for one-to-one comparison. These processes specifically apply to the  
72 preparation of a facial image for the purpose of submitting it as a probe into an  
73 automated FRS search to maximize the likelihood that a potential candidate will

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<sup>3</sup> Available from <https://www.iso.org/standard/38749.html>

74 be returned in the search result set. These processes are not to be used for  
75 identification purposes.

## 76 5.2 Important Notes

77 5.2.1 The goal of any image processing should be to optimize the image for  
78 searching by the FRS, not to create an aesthetically pleasing image. An  
79 image that looks 'good' is not necessarily the same as one that is  
80 optimized for use by an FRS due to image processing done within the  
81 vendor specific algorithms.

82 5.2.2 The effect of any manual image processing will vary with different FRS  
83 and in some cases may degrade performance rather than improve it.

84 5.2.3 Image processing to the probe image before an FRS search is different  
85 from the operational processes performed for the purpose of a one-to-  
86 one manual comparison.

87 5.2.4 Any decision regarding whether or not a candidate returned from an FRS  
88 search is from a common source as the probe image must be made  
89 based on a comparison with the original (unedited) image and NOT the  
90 processed image.

91 5.2.5 Agency specific or mandated notes and audit trails shall be done at all  
92 times. Document and preserve processed images regardless of search  
93 results.

94 5.3 The following sections of this document describe a progression (minimal to  
95 complex) for the manual processing of probe images of less than optimal quality

96 for an FRS. They are intended to maximize the likelihood of returning a  
97 potential candidate from a search result set while minimizing the amount of  
98 processing of the probe image. Guidelines presented in this document may be  
99 adapted for agency specific policies and standard operating procedures.

## 100 **6. Procedure**

### 101 **6.1 Initial Steps**

102 The initial steps for the management of probe imagery include, but are not  
103 limited to, the following:

#### 104 **6.1.1 Save original**

105 A read-only copy shall be made of the original probe image(s). No  
106 enhancements or modifications shall be made to these original probe  
107 image(s). When making any final comparisons, always use a working  
108 copy of the original probe image(s).

#### 109 **6.1.2 Make lossless working copies**

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

#### 111 **6.1.3 Understanding the compatibility of image file formats for an FRS is critical**

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

## 117 6.2 Generalized Search Steps

118 For the purpose of this document, “pass” refers to an assumption that following  
119 each progression of image processing, an FRS search will take place and the  
120 resulting candidates will be assessed. It may not be prudent to run the probe  
121 image through an FRS search until it has been processed to a certain degree.  
122 In all examples of “passes” presented in this document it is assumed that for  
123 every sequential “pass”, the following steps shall be undertaken in every FRS  
124 search of a probe image. See Figure 1 **Simplified Image Processing Flow**  
125 **Chart.**

126 6.2.1 Verify eyes can be found. This step can also be described as “localizing  
127 the face in the image”. This is critical to determine if the facial imagery  
128 utilized has limitations or systemic image conditions, which may cause a  
129 problem when submitting to the proprietary technology within an FRS.

130 6.2.2 Save interim image sets – All processed images used for searching shall  
131 be saved according to agency policy. Searching images with different  
132 enhancements (e.g. cropped, black and white, or grayscale) may result in  
133 different candidate sets.

134 6.2.3 Search and review results – FRS results shall be compared against the  
135 original probe image(s). If no potential candidates are returned in the  
136 search result set, the recommendation is to re-evaluate the image that  
137 was used in searching and apply further processing.

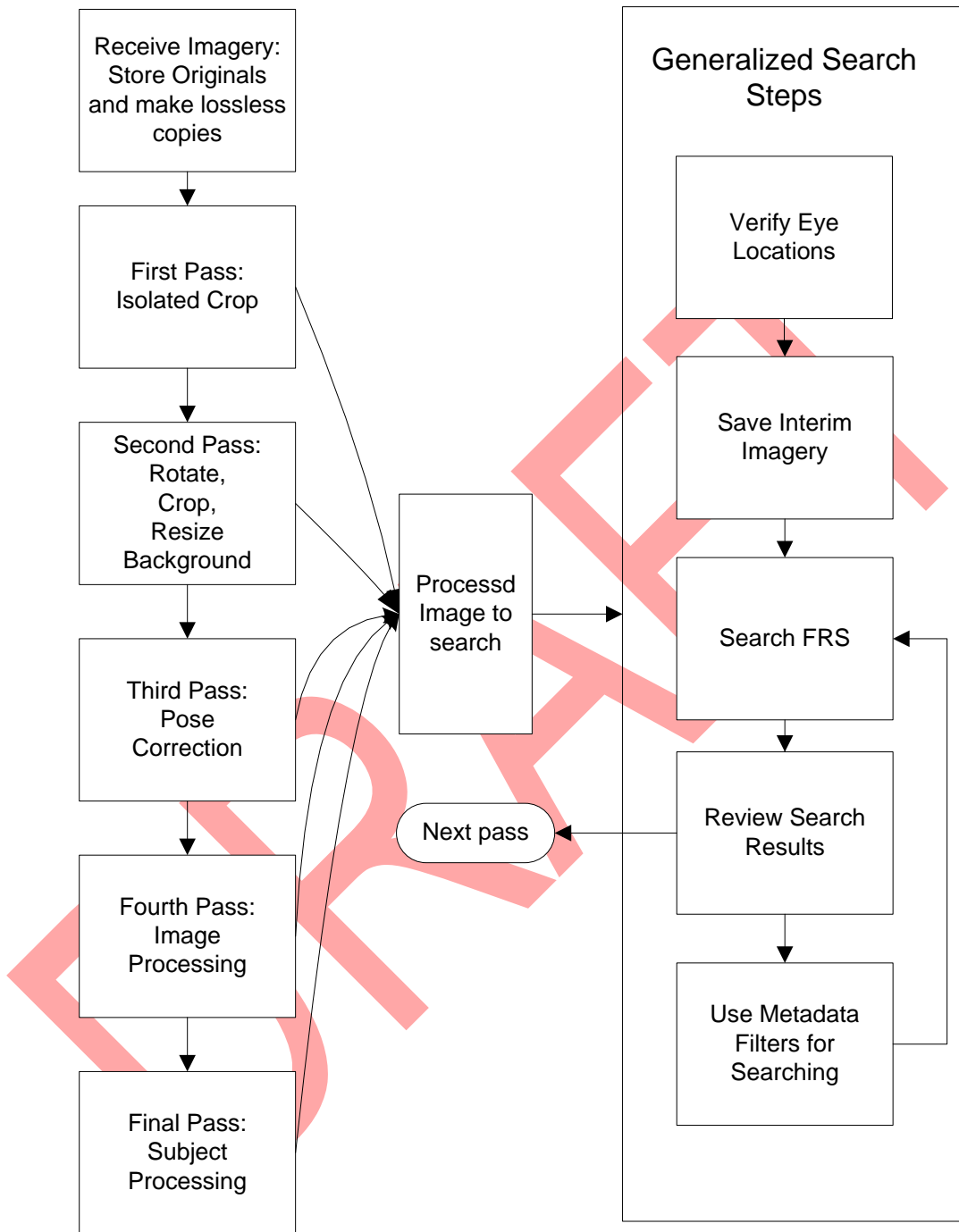
138 6.2.4 If available within the FRS, consider using metadata binning. The FISWG  
139 document *Facial Recognition Systems Metadata Usage*<sup>4</sup> should be  
140 referenced where metadata is accessible which refines searches through  
141 reducing the logical size of the search database.

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<sup>4</sup> Available from: [www.fiswg.org/document/viewDocuments](http://www.fiswg.org/document/viewDocuments)





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**Figure 1: Simplified Image Processing Flow Chart**

### 144 6.3 First Pass: Original Image Search

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

### 149 6.4 Second Pass: Isolated Face

150 A Second Pass would be initiated when no potential candidates are found  
151 during the First Pass or when the nature of the image warrants minimal  
152 processing to yield additional candidates.

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

158 6.4.1 Rotate – The image may be rotated around the roll axis to make the eye  
159 positions appear horizontally aligned.

160 6.4.2 Secondary Crop – The image processing steps done in this pass may  
161 require a secondary crop of the image. The goal of this crop is to  
162 produce an image that is more in accordance with the ANSI/NIST- ITL-1-  
163 2011 or ISO specifications.

164 6.4.3 Resize – Modify the size of the image to achieve a recommended  
165 interpupillary distance. This distance should be agency defined and

166 based on FRS vendor recommendations (e.g. 90 pixels). Resizing of the  
167 images should be done in even multiples of the original image size while  
168 preserving the original image aspect ratio.

169 6.4.4 Blur background – This is performed where the probe image has a non-  
170 neutral or busy background. The blurring process creates a consistent  
171 background preventing an FR engine from detecting items in the  
172 background. Examples include:

173 6.4.4.1 Surveillance photo with people or items in background;

174 6.4.4.2 An image captured with a background that varies in color and  
175 content.

176 6.4.5 Horizontal flip – This should be utilized if the probe image submitted may  
177 have been taken as a reflection, captured incorrectly, or been flipped  
178 left/right or right/left in transmission.

179 6.4.6 Aspect ratio correction – mitigates the impact of an image that looks  
180 unnaturally stretched in the horizontal or vertical direction.

## 181 **6.5 Third Pass: Pose Correction**

182 FRS algorithms have varying sensitivities to non-frontal facial imagery. Claims  
183 of performance degradations will vary, but it is broadly accepted that any non-  
184 frontal pose movements could negatively affect FRS performance.

185 The standard definitions of pose angles are defined in **NIST Special Publication**  
186 **500-290 Edition 3 (2015)** and **ANSI/NIST-ITL 1-2011 Update: 2015 Data**

187 **Format for the Interchange of Fingerprint, Facial, & Other Biometric**

188 **Information**<sup>5</sup> as referenced in Figure 2:

189

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

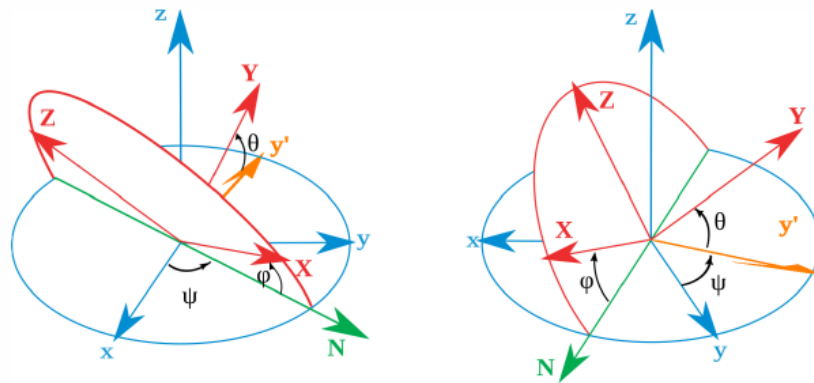


Figure 26: Tait-Bryan angles statically defined with the Z-X'-Y'' convention

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 ( $x$ ) axis.

**Pitch angle:** rotation about the horizontal back to front ( $z$ ) axis.

<sup>5</sup> Available from: [nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.500-290e3.pdf](http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.500-290e3.pdf)

ANSI/NIST-ITL 1-2011: UPDATE 2015

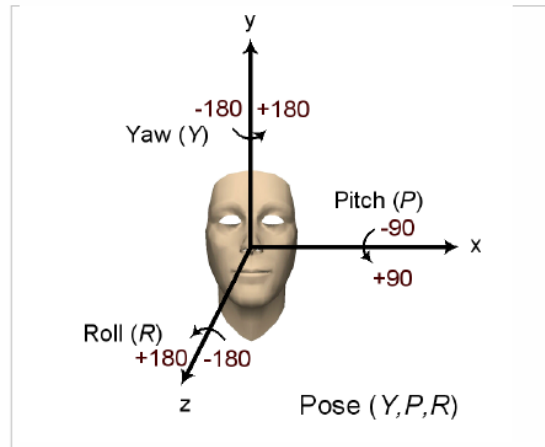


Figure 27: Pose angle set is with respect to the frontal view of the subject

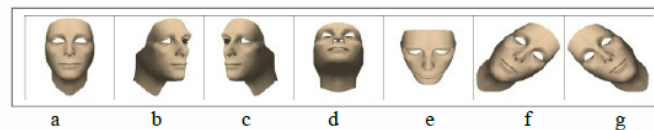


Figure 28: Examples of pose angles and their encodings.

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.

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

191

6.5.1 Software for pose correction is **dependent** on policy or vendor

192

recommendations. Any pose which varies more than 10 degrees in any

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direction from  $(0, 0, 0)$  could be considered a candidate for pose

194

correction.

195 6.5.2 When pose correction is done, consideration shall be given to the following

196 areas:

197 6.5.2.1 If available select the proper gender and race

198 6.5.2.2 Select any symmetric fill option

199 6.5.2.3 Place appropriate facial landmarks as needed

200 6.5.2.4 Select the number of poses to generate

201 6.5.2.4.1 Frontal

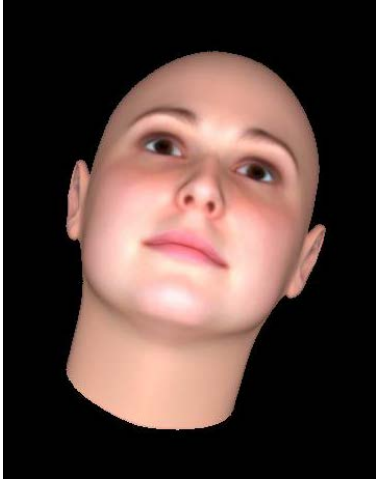
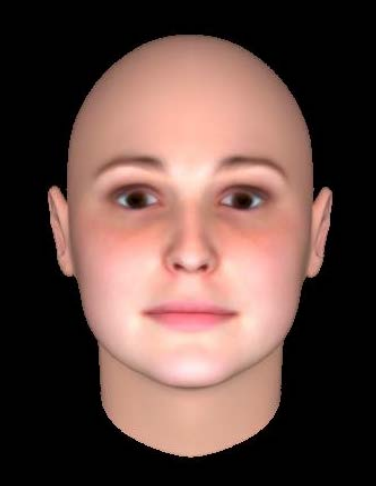
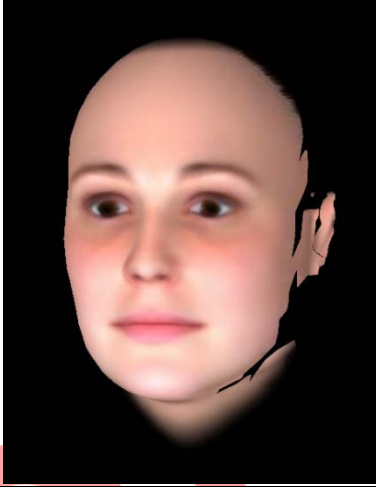


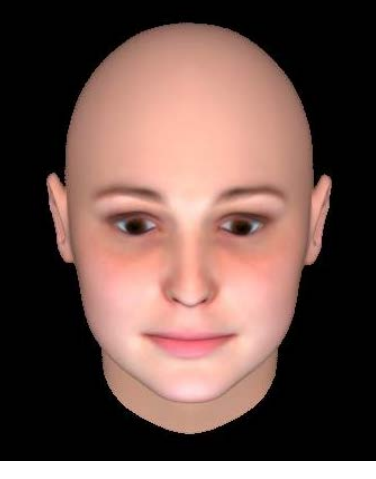
202 6.5.2.4.2 Slight left and right pose (e.g. +/- 15 degrees yaw)

203 6.5.2.4.3 Slight up and down pose (e.g. +/- 15 degrees pitch)

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Pose	Example Image	Pose	Example Image
Original Image		Pose corrected frontal	
Yaw -15 degrees		Yaw +15 degrees	
Pitch +15degrees		Pitch -15 degrees	

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Figure 3: Pose Examples

207 6.5.3 When multiple poses are generated, searching each pose as individual  
208 probe images within unique searches may allow for pose variations within  
209 the gallery. Some FRS supplied search clients allow group searching  
210 where groups of related imagery can be searched and reviewed in bulk.

## 211 6.6 Fourth Pass: Image Processing

212 6.6.1 During the Fourth Pass, image processing may be applied to a working  
213 copy of the original image or an image resulting from any of the previous  
214 passes to attempt to produce a different candidate search result set.

215 6.6.2 Image processing may be performed externally of the FRS using widely  
216 available image editors (e.g. Adobe Photoshop and GNU Image  
217 Manipulation Program [GIMP]) with the resulting probe image being  
218 submitted for an FRS search. The image processing listed below may be  
219 applied to the entire image or to selected regions within the image and  
220 may include, but are not limited to:

221 6.6.2.1 Histogram equalization

222 6.6.2.2 Color/tint corrections

223 6.6.2.3 De-blurring or sharpening

224 6.6.2.4 Lens distortion correction

225 6.6.2.4.1 Some images, such as those from smart phones,  
226 automated teller machines (ATM's) and Body Worn  
227 Video cameras that use wide-angle lenses typically  
228 exhibit perspective ('barrel') distortion. Image



229 processing software or manufacturers' provided lens  
230 correction data should be used to correct this prior to  
231 searching.

232 6.6.2.5 Grayscale conversion

233 6.6.2.6 Noise reduction

234 6.6.2.7 Brightness or contrast adjustment

235 6.6.2.8 Red eye reduction

## 236 6.7 Advanced Topic: Subject Processing

237 6.7.1 After previous passes have been completed (or rejected due to the nature  
238 of the image) additional processing steps targeted at the subject in the  
239 image may be used.

240 6.7.2 This type of processing may introduce external elements to the subject in  
241 the image. Agency procedures shall be followed to determine whether  
242 these measures can be applied to improve the likelihood of locating a  
243 potential candidate from an image returned in the candidate search result  
244 set from an FRS search.

**Reminder: Any decision on whether a particular candidate from a search is from a common source as the probe image shall be made using the original (unedited) image.**

245 6.7.3 Circumstances warranting this type of image processing include, but are  
246 not limited to, the following:

247 6.7.3.1 Facial landmarks obstructed by head coverings, accessories  
248 (e.g., jewelry or eyewear), hair, image artifacts, etc.

249 6.7.3.2 Missing or obstructed facial landmarks due to extreme pose or  
250 expression (including closed eyes)

251 6.7.3.3 Intentional alterations of the subject's face (e.g., excessive make-  
252 up)

253 6.7.3.4 Trauma (e.g., lacerations, blood, bruising), evidence of medical  
254 intervention (e.g., bandages, endotracheal tube, neck brace), or  
255 post mortem.

256 6.7.4 Examples of subject image processing include, but are not limited to, the  
257 following:

258 6.7.4.1 Replace or create missing facial landmarks on the subject.

259 6.7.4.2 Mirroring the probe image on the center line of the half face.

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FISWG documents can be found at: [www.fiswg.org](http://www.fiswg.org)