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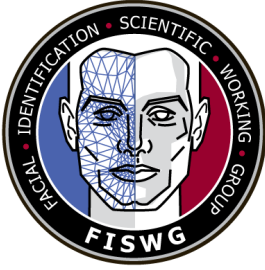
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Visual Image Manipulation Detection in Facial Images

1. Scope

1.1 The purpose of this document is to raise awareness of manipulation of facial images through the description of manipulation types, the detection of manipulations, and considerations when manipulations are encountered.

1.2 This document does not discuss nor describe to what extent a practitioner should be able to perform digital forensic tasks. Digital image experts should, when possible, perform the digital analysis for detection of potential manipulation.

1.2.1 It is worthwhile to point out that not all facial practitioner roles include being a digital image expert. Therefore, the purpose and goal of this document is to provide information to the facial practitioner.

1.3 This document does not address the impact to the image that occurs during capture, transmission, or storage.

2. Referenced Documents

2.1 ASTM Standards¹:

E2916 Terminology for Digital and Multimedia Evidence Examination²

E3445 Standard Practice for Image Processing to Improve Automated Facial Recognition Search Performance

2.2 FISWG standards³

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

² This guide is under the jurisdiction of ASTM Committee E30 on Forensic Sciences and is the direct responsibility of Subcommittee E30.12 on Digital and Multimedia Evidence.

³ Available from Facial Identification Scientific Working Group <https://fiswg.org/>

FISWG Guidelines for Image Processing Techniques in Facial Image Comparison

FISWG Image Factors to Consider in Facial Image Comparison

FISWG Guide for Facial Image Comparison Training of Examiners to Competency

2.3 Other standards and references documents.

ENFSI Best Practice Manual for Digital Image Authentication⁴

3. Terminology

3.1 Definitions:

3.1.1 *Image processing, n*—in image analysis, any activity that transforms an input image into an output image.

3.1.2 *Original image, n*—an accurate and complete replica of the primary image, irrespective of media.

DISCUSSION—For film and analog video, the primary image is the original image.

3.1.3 *Original submitted image, n*—the initial image provided by the requesting authority for a specific purpose, such as analysis, processing, documentation, or verification

3.1.4 *Post-processing, v*—Any process applied to an image after it has been captured to enhance for further use.

DISCUSSION— Post-processing can include cropping, exposure adjustments, brightness corrections, etc.

3.2 Acronyms:

3.2.1 *AI, n*—Artificial Intelligence

3.2.2 *FR, n*—Facial Recognition

4. Significance and Use

4.1 The quality and realism of manipulated facial images have increased significantly in recent years representing a challenge to all agencies and organizations,

⁴ Available from https://enfsi.eu/wp-content/uploads/2021/10/BPM_Image-Authentication_ENFSI-BPM-DI-003-1.pdf

which adopt facial images as identity credentials used for FR searches and facial image comparison.

4.2 Detection of image manipulation has become increasingly difficult in recent years. Furthermore, increased use of post-processing by photography and messaging applications, social media platforms and modern compression algorithms typically weaken signs of manipulations which would otherwise have been apparent. Thus, it is important for practitioners to be aware of these changing circumstances and limitations when looking for visible indications of manipulation, as previously discriminative features and artifacts may be less apparent and useful than they have been before.

4.3 Practitioners should have basic knowledge of how images can be altered through manipulation and when image features indicate potential manipulation. Image processing tools exist that could assist in the detection of manipulated content but is beyond the scope of this document.

4.4 When possible and applicable, practitioners shall refer images to a digital image expert for evaluation or ask for the original image(s) whenever manipulation is suspected.

4.4.1 It is of significance to highlight that not all facial practitioners are digital image experts. Therefore, the purpose and goal of this document is to provide information to the facial practitioner on visual detection of potential image manipulation. It is not the expectation nor the intention to juxtapose the facial practitioner with a digital image expert. On the contrary, a practitioner should not make statements or express opinion on matters which are not within their field of expertise.

5. Image Manipulation

5.1 Manipulation of facial images is considered the process of digitally modifying image content by adding, removing, or altering features in the image. It can be, but is not limited to, beautification, filters, morphing, re-touching, and composing.

5.1.1 Image manipulation can be performed manually, applying traditional image processing tools, or by utilizing Artificial Intelligence (AI). Manipulated images can be easily produced and difficult to detect. Manipulation may create artifacts on the image(s).

5.2 Image Manipulation Techniques

5.2.1 Insert/remove facial features (such as cut-and-paste or copy-move): Replacing one or more facial features from one image to the other, e.g., nasal features, eyes, marks, or scars.

5.2.2 Smoothing: A technique that reduces and suppresses texture in images.

5.2.3 Duplication: Copy and paste parts of an image on another part of the image

5.2.4 Morphing: Combining elements from two (2) or more images into one (1) image.

5.2.5 Attribute Manipulation (face retouching): The modification of some facial or demographic attributes, such as hair color, age, sex, facial pose, and inclusion of face adornments (e.g., glasses). Examples are filters from social media applications, or cameras, which automatically smooth skin texture, enlarge eyes, or slim the face.

6. Image Manipulation Detection

6.1 When looking for visible signs of image manipulation, practitioners should be aware that improved image editing and synthesis techniques, as well as increased use of post-processing by photography, messaging, and social media applications have resulted in artifacts of image manipulations being less apparent in general. Context clues suggesting manipulation may be identified by reviewing the image content outside of the face where applicable.

6.2 Visual image content analysis covers optical inconsistencies, perspective and geometrical inconsistencies, and artifacts, including but not limited to:

6.2.1 Inconsistencies in the relative size of objects in the image.

6.2.2 Information given about the scene and objects in the scene such as buildings, sightings, and people to evaluate whether contextual information provided with the image aligns with the information in the image.

6.2.3 Inconsistencies in shadows and light

6.2.3.1 Length and shape of shadows related to different objects within the image, verifying consistency within the image and in relation to the direction of light source.

6.2.3.2 The direction and number of light sources within the image, e.g., reflections in irises indicate the direction of the light source(s), inconsistencies in iris reflections could indicate potential image manipulation.

6.2.3.3 Inconsistency of exposure across the image.

6.2.4 Inconsistencies in transparent object(s) such as windows, glasses, plastic or glass containers, etc.

6.2.4.1 In the presence of a transparent object, information visible through the object and its alignment with expectations of the given scene should be considered.

6.2.5 Presence of reflective object(s) such as a mirror, water, metallic surface, etc.

6.2.5.1 In the presence of a reflective object, information present in the reflection and its alignment with the expectations of the given scene should be considered.

6.2.6 Sharpness in image

6.2.6.1 Inconsistencies in sharpness within the image may be visible. These inconsistencies can indicate different resolutions (e.g., different sized pixels) present within the same image. This can be due to objects inserted or removed or other alterations made to the original image. The lack of sharpness (from using a smoothing tool) could affect the skin details (texture and tonality) or be seen as the feathering of edges of an object/person.

6.2.7 Artifacts

6.2.7.1 Artifacts can be caused by applying manipulation. This includes, but is not limited to, double representation of lines, edges and un-sharp areas, inconsistencies in sharpness; hair, vein, and scar patterns; irregular color patterns; and indication of regional compression differences.

7. Additional Considerations

7.1 If additional images are available of the subject, compare details between the images, to check for inconsistencies and to verify observations.

7.1.1 If additional images are not available, check to see if new, supplementary images can be captured.

7.2 If manipulation is suspected, the practitioner shall do the following:

7.2.1 Consider contacting the submitter for the original image(s), verify if they are aware of the potential manipulation, and chain of custody. Consider referring the images to a digital image expert for evaluation.

7.2.2 Document the observations.

7.3 If manipulation is suspected (and no additional images can be obtained) or if manipulation is confirmed, the practitioner shall document the rationale to proceed with the comparison.

FISWG documents can be found at www.fiswg.org