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Standard Guide for Forensic Digital Image Processing[1]

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1. Scope

1.1 This guide provides digital image processing guidelines to ensure the production of quality forensic imagery for use as evidence in a court of law.

1.2 This guide briefly describes advantages, disadvantages, and potential limitations of each major process.

2. Referenced Documents

2.1 *ISO/IEC Standard:*[2]

ISO/IEC 10918-1:1994 Information technology—Digital compression and coding of continuous-tone still images: Requirements and guidelines (JPEG) (also published as CCITT Recommendation T.81 (1992))

2.2 *SWGIT Material:*[3]

SWGDE/SWGIT Glossary SWGDE and SWGIT Digital & Multimedia Evidence Glossary, updated June 8, 2012

3. Terminology

3.1 *Definitions:*

3.1.1 *artifact, n*—visual/aural aberration in an image, video, or audio recording resulting from a technical or operational limitation. **SWGDE/SWGIT Glossary**

3.1.1.1 *Discussion*—Examples include speckles in a scanned picture or "blocking" in images compressed using the JPEG standard.

3.1.2 *compression, n*—process of reducing the size of a data file (see *lossy compression* and *lossless compression*). **SWGDE/SWGIT Glossary**

3.1.3 *grayscale image, n*—continuous tone image that has only one component. **ISO/IEC 10918-1:1994**

3.1.4 *grayscale transformation, n*—operation that modifies a single channel or component of image data (for example, a single color).

3.1.5 *image, n*—imitation or representation of a person or thing, drawn, painted, photographed, and so forth. **SWGDE/SWGIT Glossary**

3.1.6 *image enhancement, n*—any process intended to improve the visual appearance of an image or specific features within an image. **SWGDE/SWGIT Glossary**

3.1.7 *lossless, adv*—descriptive term for encoding and decoding processes and procedures in which the output of the decoding procedure(s) is identical to the input to the encoding procedure(s). **ISO/IEC 10918-1:1994**

3.1.8 *lossless coding, n*—mode of operation that refers to any one of the coding processes defined in this guide in which all of the procedures are lossless. **ISO/IEC 10918-1:1994**

3.1.9 *lossless compression, n*—compression in which no data are lost and all data can be retrieved in their original form. **SWGDE/SWGIT Glossary**

3.1.10 *lossy, adv*—descriptive term for encoding and decoding processes that are not lossless. **ISO/IEC 10918-1:1994**

3.1.11 *lossy compression, n*—compression in which data are lost and cannot be retrieved in their original form. **SWGDE/SWGIT Glossary**

3.1.12 *noise, n*—variations or disturbances in brightness or color information in an image that do not arise from the scene. **SWGDE/SWGIT Glossary**

3.1.12.1 *Discussion*—Sources of noise include film grain, electronic variations in the input device sensor and circuitry, and stray electromagnetic fields in the signal pathway. It frequently refers to visible artifacts in an image.

3.1.13 *original image, n*—accurate and complete replica of the primary image, irrespective of media. **SWGDE/SWGIT Glossary**

3.1.13.1 *Discussion*—For film and analog video, the primary image is the original image.

3.1.14 *primary image, n*—first instance in which an image is recorded onto any media that is a separate, identifiable object. **SWGDE/SWGIT Glossary**

3.1.14.1 *Discussion*—Examples include a digital image recorded on a flash card or a digital image downloaded from the internet.

[1] 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.

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[2] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[3] Available from Scientific Working Group on Imaging Technology (SWGIT), http://www.swgit.org.

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3.1.15 *restoration, n*—any process applied to an image that has been degraded by a known cause (for example, defocus or motion blur) to remove partially or totally the effects of that degradation. **SWGDE/SWGIT Glossary**

4. Summary of Practice

4.1 The original image shall be preserved. Any image processing should be applied only to a working copy of the image.

4.2 Any changes made through image processing shall meet the following criteria:

4.2.1 Processing steps are documented in a manner sufficient to permit a comparably trained person to understand the steps taken, the techniques used, and extract comparable information from the image; and

4.2.2 The end result is presented as a processed or working copy of the image.

4.3 Avoid the introduction of artifacts that add misleading information to the image or the loss of image detail that could lead to an erroneous interpretation.

5. Significance and Use

5.1 Processed images are used for many purposes by the forensic science community. They can yield information not readily apparent in the original image, which can assist an expert in drawing a conclusion that might not otherwise be reached.

5.2 This guide addresses image processing and related legal considerations in the following three categories:

5.2.1 Image enhancement,

5.2.2 Image restoration, and

5.2.3 Image compression.

6. Image Enhancement

6.1 Image enhancement is any process intended to improve the visual appearance of an image.

6.1.1 Use brightness adjustment when the image is too bright or too dark. If the image is made too bright, there is a risk of loss of detail in light areas. If the image is made too dark, there is a risk of loss of detail in the dark areas.

6.1.2 Use color processing to modify the color characteristics of objects within an image. This includes color space transformations, pseudocoloring, and hue and saturation adjustments.

6.1.2.1 Application of these techniques can compromise the color fidelity of the image.

6.1.3 Use contrast adjustment when the image lacks sufficient contrast. If the image contrast is increased too much, there is a risk of loss of detail in both light and dark areas.

6.1.4 Use cropping to remove that portion of the image that is outside the area of interest.

6.1.5 Use dodging and burning to adjust brightness in localized areas.

6.1.6 Use linear filtering techniques (see Fig. 1) to increase the contrast of small detail in an image. These include sharpening, blur removal, edge enhancement, and deconvolution. If a low degree of enhancement is used, the image will remain an accurate representation of the scene. If a high degree of enhancement is used, the image may no longer be an

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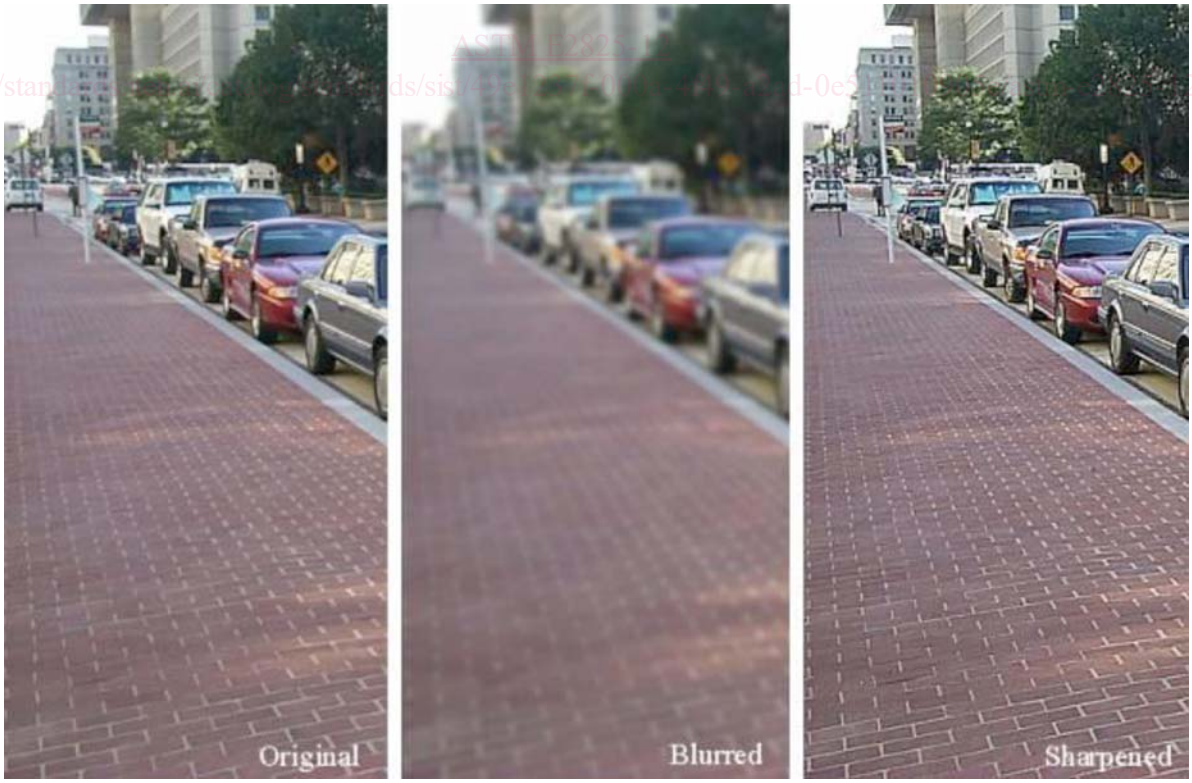

FIG. 1 This Example Illustrates the Effects of Linear Filtering—Left: Original Image, Middle: Blurred Image, and Right: Sharpened Image

accurate representation of the overall scene, though it still may be useful as an adjunct for interpretation of small details.

6.1.6.1 A high degree of enhancement can also increase the visibility of existing noise and artifacts; examples of noise include film grain, snow appearing on a television screen, or random color dots.

6.1.7 Use nonlinear contrast adjustments to adjust the contrast in selected brightness ranges within the image. These include gamma correction, grayscale transformation, and the use of curves or look-up tables, or both.

6.1.7.1 A nonlinear contrast adjustment can be used to bring out details in the shadow areas of an image without affecting the highlight areas.

6.1.7.2 A severe adjustment can cause loss of detail, color reversal, or the introduction of artifacts, or a combination thereof. (See Fig. 2.)

6.1.8 Use pattern noise reduction filters to identify repeating patterns in an image and selectively remove them. This type of filter can be used to remove patterns such as fabric weaves, window screens, security patterns, and halftone dots.

6.1.8.1 Overuse of this technique will remove material image detail.

6.1.9 Use random noise reduction techniques to reduce the contrast of small detail in the image to suppress random noise. These include such filters as low-pass filtering, Gaussian blurring, median filtering, and speckle removing.

6.1.9.1 Overuse of this technique will remove material image detail.

6.1.10 Use warping to change the spatial relationships among the objects in an image. It is analogous to printing a photograph on a rubber sheet, then stretching the sheet in different directions, and then tacking it down. Warping can be used, for example, to remove perspective from an image or to "unroll" a poster that was wrapped around a pole.

6.1.10.1 Used improperly, warping can distort the natural appearance of the objects in a scene.

7. Image Restoration

7.1 Image restoration is any process applied to an image that has been degraded by a known cause (for example, defocus or motion blur) to remove the effects of that degradation partially or totally.

7.2 Information that has been totally lost in the image during the original imaging process cannot be replaced through restoration. However, partial restoration can be successful even when total restoration is impossible.

7.3 *Restoration Techniques:*

7.3.1 Use blur removal to remove partially or completely an image blur imposed by a known cause.

7.3.1.1 Blur removal differs from the image enhancement filtering processes because the blur removal filter is designed specifically for the process that blurred the particular image under examination. Examples include defocus and motion blur, since these phenomena can be described mathematically. Thus, a specific filter can be designed to compensate for each blur. The degree to which a blur can be successfully removed is limited by noise in the image, the accuracy with which the actual blurring process can be described mathematically, and the fact that information that has been totally lost cannot be

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FIG. 2 This Example Shows Nonlinear Contrast Adjustments—Left: Original Image, Middle: Enhancement of Shadow and Highlight Areas at the Expense of Midrange Tones, and Right: Enhancement of Midrange Tones at the Expense of Shadow and Highlight Areas