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An American National Standard

Standard Guide for Forensic Digital Image Processing[1]

This standard is issued under the fixed designation E2825; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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.

1.3 *This standard cannot replace knowledge, skills, or abilities acquired through education, training, and experience, and is to be used in conjunction with professional judgment by individuals with such discipline-specific knowledge, skills, and abilities.*

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E1732 Terminology Relating to Forensic Science

E2916 Terminology for Digital and Multimedia Evidence Examination

2.2 *ISO/IEC Standard:*[3]

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))

3. Terminology

3.1 *Definitions*—For definitions of terms relating to this standard, refer to Terminologies E1732 and E2916.

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.

[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] 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.

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

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 brightness and contrast adjustments 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 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.

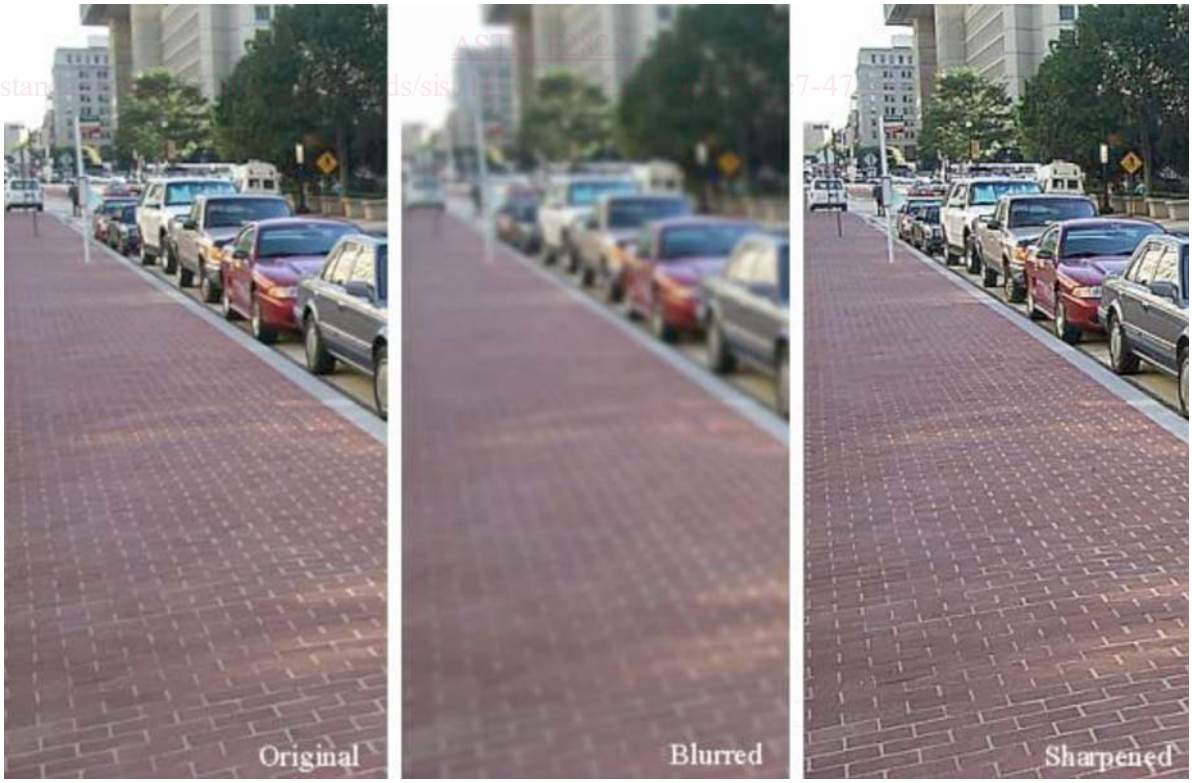

FIG. 1 This Example Illustrates the Effects of Linear Filtering—Left: Original Image, Middle: Blurred Image, and Right: Sharpened Image

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

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 replaced. Often partial blur removal can be successful even when total blur removal is impossible.

7.3.2 Use color balancing to render the colors in the scene more accurately. Color balancing is the extension of grayscale linearization to a color image and the adjustment of the color components of an image. For example, a color test target having known colors can be placed in the scene before recording the image. Then a grayscale transformation (nonlinear contrast stretch) can be designed for each color channel (red, green, and blue) to place the different colors on the test target in their proper relationship. This should reproduce the other objects in the scene in their proper relationship.

7.3.2.1 Improper color balance can render colors inaccurately causing objects to appear to have the wrong color.

7.3.3 Use grayscale linearization to render faithfully the different brightness values in the scene. This adjusts the brightness relationships among the objects in a scene. For example, a monochrome test target having known gray values can be placed in the scene before recording the image. Then a grayscale transformation (nonlinear contrast stretch) can be designed to place the different gray values on the test target in their proper relationship. This should put the other objects in the scene in their proper brightness relationship as well.

7.3.3.1 Improper grayscale linearization can render brightness values inaccurately so that objects may appear brighter or darker than they actually appeared when the image was recorded.

7.3.4 Use geometric restoration to restore the proper spatial relationships among the objects in the scene. This restoration removes geometric distortion from an image. It can be used for the removal of geometric distortion, such as that introduced by a curved mirror or a fish-eye lens.

7.3.4.1 Geometric restoration differs from image warping in that the geometric transformation is designed specifically for the process that distorted the particular image under examination.

7.3.4.2 The degree to which geometric distortion can be successfully restored is limited by the accuracy with which the actual distortion process can be described mathematically and the fact that information that has been totally lost (for example, hidden behind another object or obscured from the camera) cannot be replaced. Often, partial geometric restoration can be successful even when exact geometric restoration is impossible.

8. Image Compression

8.1 Digital images produce a large amount of data to be stored. Image compression techniques reduce the storage requirements by making image data files smaller.

8.2 *Compression Processes:*

8.2.1 Lossless compression reduces file size by removing redundant information. Because the redundant information can be retrieved to display the image, lossless compression results in no loss of information. Lossless compression does not alter the content of an image when it is decompressed.

8.2.2 Lossy compression achieves greater reduction in file size by removing both redundant information and data deemed expendable by the compression algorithm. Because the expendable data cannot be retrieved upon reconstruction of an image for display, compression results in some loss of image content as well as the introduction of artifacts.

8.2.2.1 Degradation occurs each time the image is compressed using a lossy process, such as saving to a compressed format.

8.2.2.2 Higher compression ratios result in the loss of more information. Normally, the degree of compression can be specified.

8.2.2.3 Depending upon the application, lossy compression may render an image less useful.

8.2.3 The Joint Photographic Experts Group developed an image compression standard known as JPEG (ISO/IEC 10918-1:1994). This compression algorithm is applied to the image in 8 by 8-pixel blocks. Normally, it is used as a lossy compression scheme in which the degree of compression can be specified before storing the image. However, JPEG can also be used as a lossless compression scheme. At high-compression ratios, JPEG could remove important image detail and introduce blocking artifacts as the block boundaries become visible (see Fig. 3). JPEG is but one of many compression algorithms.

8.2.3.1 Compression should be used with care to avoid material degradation of the image.

8.2.3.2 The compression settings used by one camera or software program may not be the same as the compression settings used by another camera or software program.

FIG. 3 Left: Original Image, Middle: the Result of JPEG Compression (Compression Ratio = 15:1), and Right: the Result of Edge Enhancement after Compression