Applying Specific Digital Enhancement Techniques To ESDA-Developed Impressions

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The ESDA (Electrostatic Detection Apparatus), IMEDD (Indentation Materializer Electrostatic Document Device) and other instruments and techniques are employed routinely by Forensic Document Examiners (FDEs) in an effort to locate, decipher and preserve indented writings or impressions. The impressions developed on the polymer film sheet using the ESDA or IMEDD, regardless of technique, will frequently be less than optimum and defy successful decipherment and/or poor legibility. A study was conducted to determine whether the use of specific digital enhancement techniques significantly improved the legibility and decipherment of impressions developed by the ESDA on polymer film. The results of this study will be presented as well as the specific techniques that were utilized.

INTRODUCTION

Forensic Document Examiners (FDEs) continue to explore and utilize digital imaging as a tool in their examinations. One area of exploration involves the application of digital imaging and image processing on ESDA or IMEDD-developed indented writings preserved on polymer film. Whether specific digital image processing techniques significantly improve the legibility or aid in the enhancement of ESDA impressions are the questions posed in this limited study.

The usefulness of imaging software and techniques have been described by Nelson (1993), Hart (1992) and Hicks (1995). Hicks' article specifically describes the use of several digital image enhancement techniques on ESDA-developed impressions.

This study dealt with a combination of techniques involving digital capture and enhancement of ESDA images on polymer film from both a global and character-specific perspective. Global digital enhancement involves the application of a particular technique across the entire digitized ESDA image, whereas character-specific enhancement would focus on the enhancement of a particular area of interest (AOI) or character(s). The questions to be addressed through the evaluation of these techniques are:

- Does the technique or method improve the legibility of the ESDA impression for either presentation or decipherment purposes?
- Does the technique or method sacrifice or alter substantive detail within the ESDA impression?
- Is the technique or method repeatable and demonstrative?
- Is the technique or method costly in terms of time and materials?
- Is the technique or method easily learned?

Methods and Materials

The following equipment and materials were utilized in the acquisition and digital enhancement of ESDA-developed impressions.

- Umax PowerLook III flatbed scanner
- PhotoShop 5.0 and 5.5 (PC versions)
- Personal computer with 256mb RAM
- Two ESDA instruments and numerous ESDA lifts

Various writing instruments were utilized to create the original writings and/or non-textual entries and several techniques utilizing the ESDA were employed to develop the latent impressions. The emphasis of this project was not the development of impressions utilizing the ESDA, but rather digital enhancement techniques applied to the developed impressions.

Various methods of digital capture and enhancement were employed on all and/or specific portions of the ESDA lifts. For the most part, the techniques utilized in this study focus on adjusting the brightness values of specific pixels or averaging groups of pixels. Each step of the process may be recorded manually or automatically through the history palette. The techniques utilized are totally dependent on the type of image problem presented in the ESDA impression. The settings utilized in arriving at the image results discussed in this paper may not be appropriate for other image enhancement problems.

General Techniques

Certain procedures and techniques were utilized universally and include:

- Digital (reflected) capture by scanner at 400ppi (pixels per inch) resolution, in gray scale.
- Some image enhancement (contrast/brightness) was accomplished during the "preview" scan mode. Although dependent on a scanner's default settings, some enhancement in the preview scan mode should be made, if possible, to secure a more workable image.
- Original scanned images were archived. All enhancements were made and saved to working images of the original. (A working image is a duplicate of the original or primary image.)

Method 1

Utilizing a working image of the original image (Figure 1A) the following enhancements were undertaken:

- Dust and Scratches filter [filter -> noise-> dust and scratches] at a radius of 2 utilized to reduce background "noise." Levels (brightness/contrast) adjusted (Figure 1B).
- Close up of effect of dust and scratches filter before (Figure 1B-i) and after (Figure 1B-ii) filter application.
- Burn tool applied with brush to Shadows at an exposure setting of 30. Dodge tool applied with brush to Highlights at an exposure setting of 25. (Figure 1C)

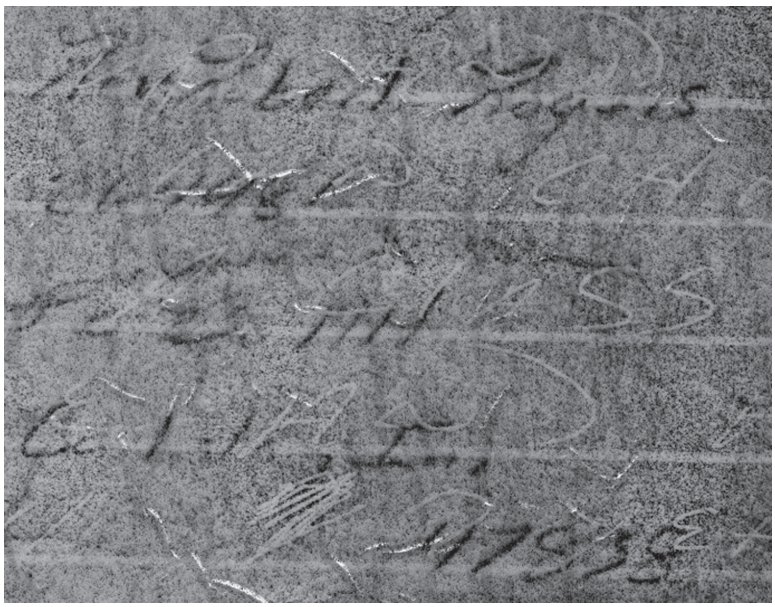

Figure 1A

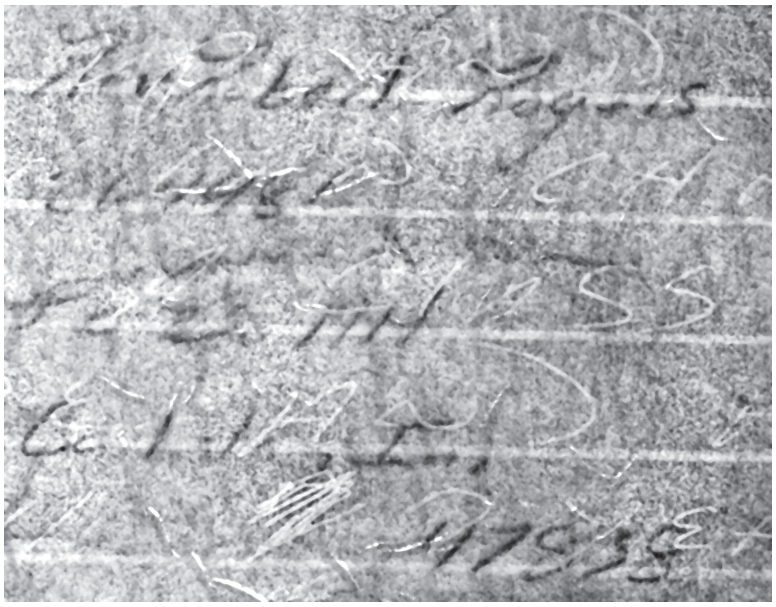

Figure 1B

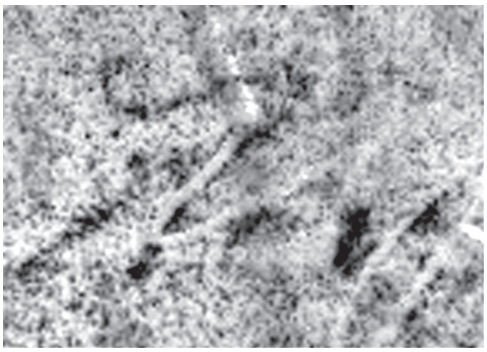

Figure 1B-i

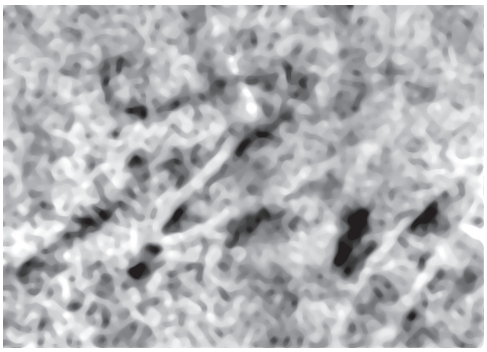

Figure 1B-ii

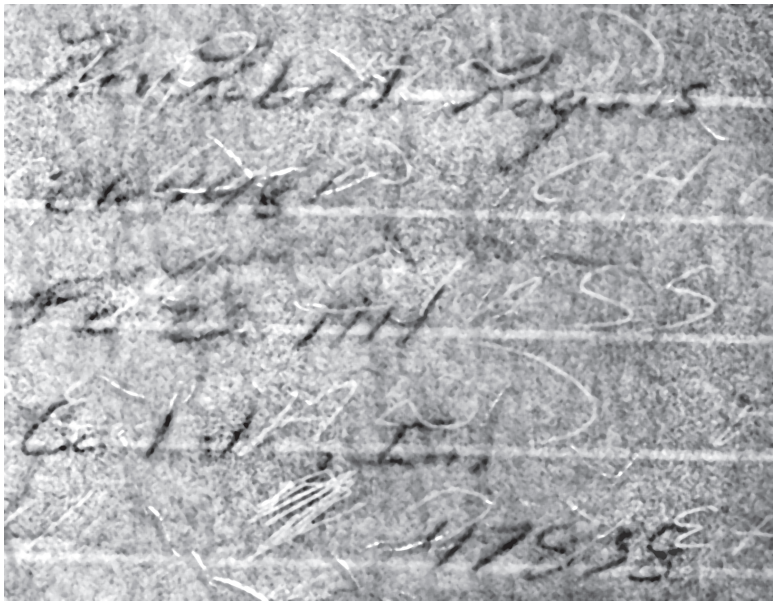

Figure 1C

- Changed image to RGB [image -> mode -> RGB] added a new layer [layer-> new-> layer -> normal/100%] and filled [edit -> fill ->] with selected color. Opacity adjusted on layer menu bar to allow blending of layers (Figure 1D).

Method II

Using a working image of the original image (Figure 2a) the following enhancements of a single impression appear below with magnification to illustrate the effects of the processes:

- Adjusted brightness and contrast in Shadows, Mid-tones and Highlights with Level Adjustment [image -> adjust -> levels] (Figure 2B).

- Sharpened image [filter -> sharpen -> unsharp mask], applied dust and scratches filter, utilized dodge and burn technique with soft brush selection (Figure 2C).

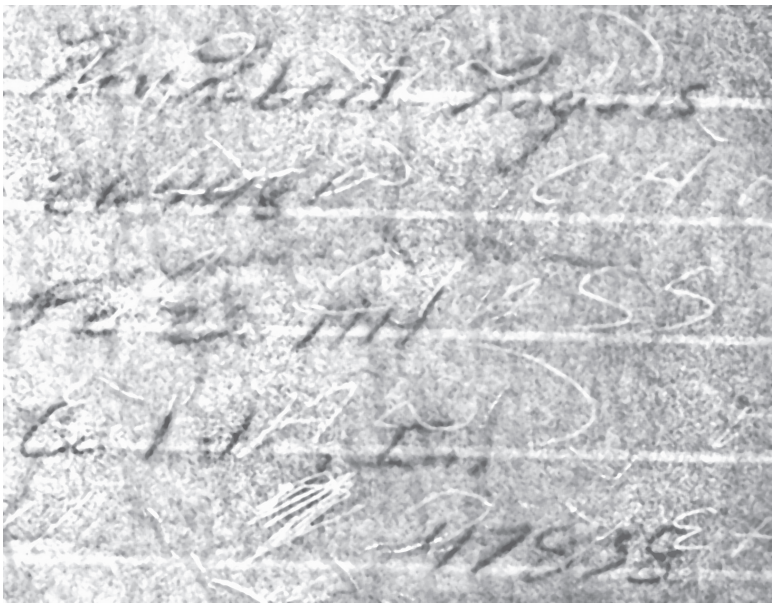

Figure 1D

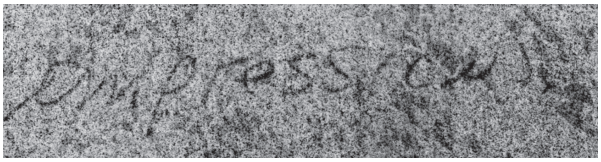

Figure 2A

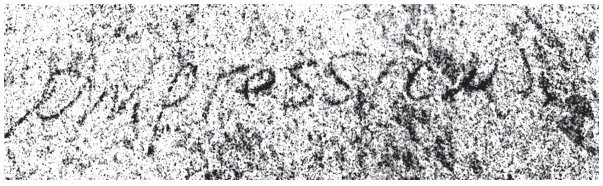

Figure 2B

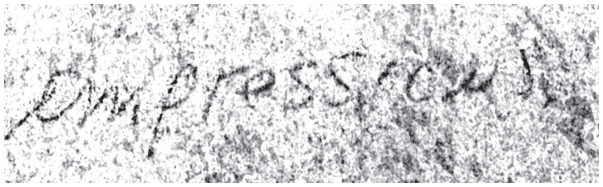

Figure 2C

Method III

Utilizing a working image of the original image (Figure 3A), unevenly developed image impressions were enhanced utilizing the following techniques:

- Lighter and darker areas of interest were selected and individually processed (brightness/contrast) utilizing the layers adjustment to facilitate maximum balance within specific areas of low contrast. A dust and scratches filter was subsequently applied to the entire image to reduce background noise (see Figure 3B).

- Changed image mode to RGB, added new layer, filled new layer (normal blend) with selected foreground color, opacity adjusted to reach desired contrast (Figure 3C).

- Used the burn tool on shadows with a hard brush and an exposure of 35 to enhance the image (text) areas. Used the dodge tool on highlights and mid-tones with minimal (10) exposure and a soft brush to bring out contrast (Figure 3D).

- Applied unsharp mask filter [filter -> sharpen -> unsharp mask] using a maximum radius (250) (Figure 3E).

- Desaturated (removed color) image and adjusted levels (brightness/contrast) (Figure 3F).

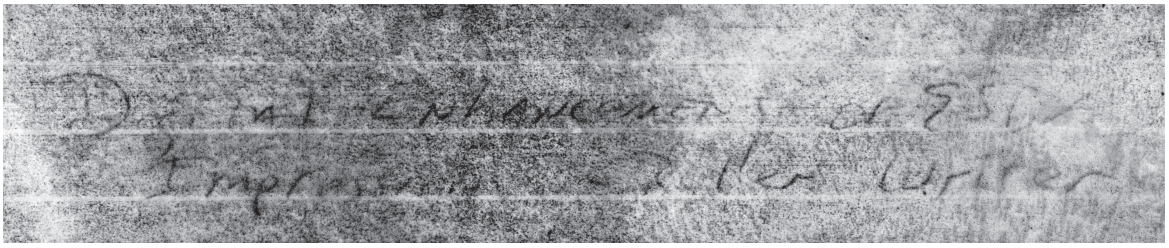

Figure 3A

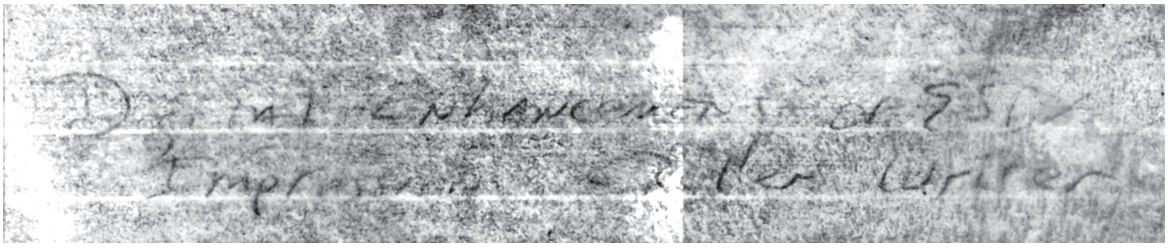

Figure 3B

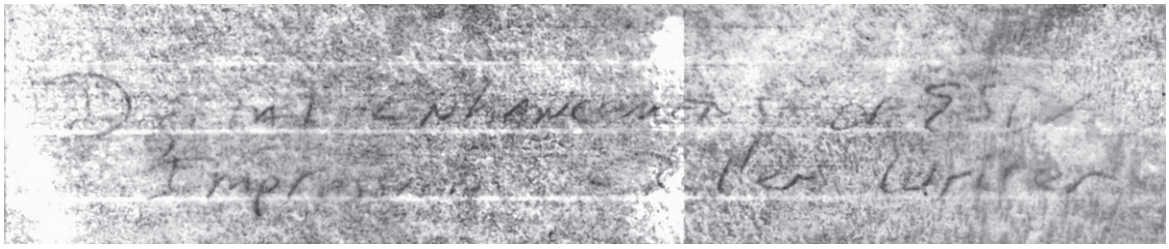

Figure 3C

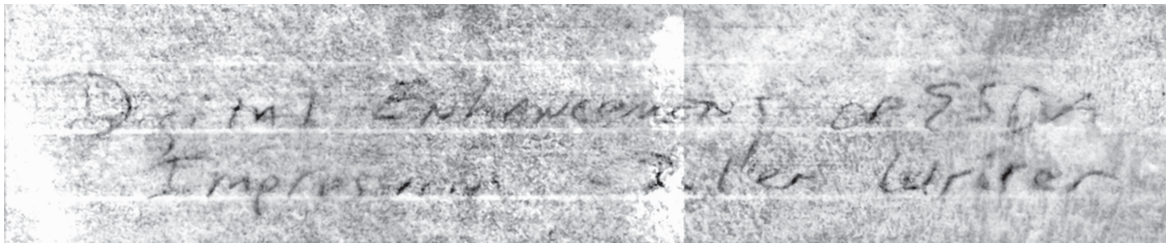

Figure 3D

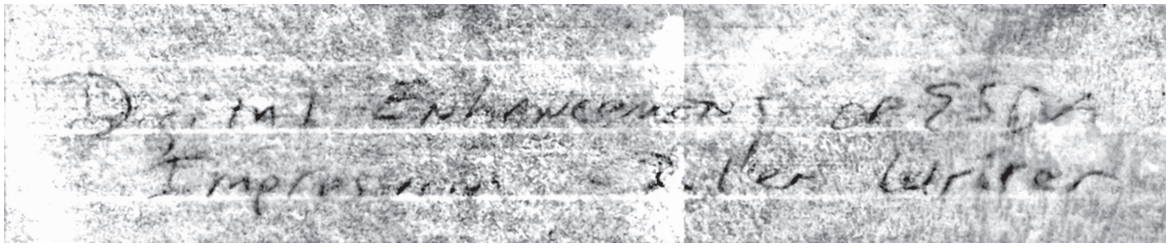

Figure 3E

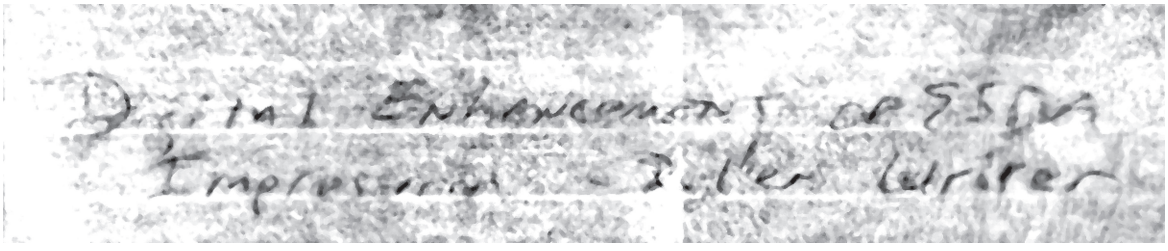

Figure 3F

Method IV

Utilizing a working image of the original image (Figure 4A), a contrast adjustment was made [image -> adjust -> contrast/brightness]; an additional adjustment was made utilizing curves [image -> adjust -> curves]. Changed image mode to RGB, added new layer, filled new layer (normal blend) with selected foreground color, opacity adjusted to reach desired contrast. The burn tool set on shadows was utilized to darken the image area (Fig 4B).

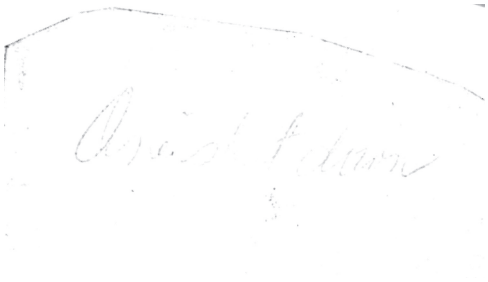

Figure 4A

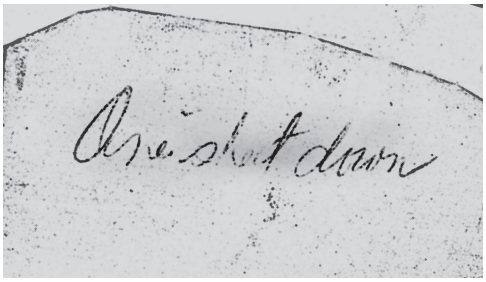

Figure 4B

Discussion and Results

Experimenting with the techniques detailed in this research have provided for an assessment of their viability as a tool for the FDE. The results as they relate to the viability standards expressed earlier are provided below.

- The methods utilized improved the legibility of the ESDA-developed image for presentation purposes, thereby enabling the client or fact finder to decipher the developed impressions with less FDE interpretation. This was particularly found to be true in instances where varying levels of legibility were apparent within the ESDA lift. By selecting and enhancing specific AOI within the working image and utilizing the methods outlined, the ability to enhance selected areas without impacting the remainder of the image improved the legibility of the overall image based on the cumulative processing techniques employed.
- The methods and techniques tested generally enhanced the substantive detail within the ESDA lift. However, this was accomplished in some instances by reducing the random "noise" (toner splatter) through the use of blurring filters (Gaussian or Dust and Scratches). The end result was enhanced legibility through a fuzzier, yet easier to read image as a result of removing (averaging) the high frequency information. The sequence of order with respect to each step within a technique generally had no effect. However, when extensive noise (toner splatter) was present there was a benefit to applying the "Dust and Scratches" or Gaussian filter ahead of any dodge and burn application. The reduction of background information (toner splatter) provided for greater legibility of the developed impressions and facilitated the application of the dodge and/or burn technique.

- The individual steps used in these techniques are tracked within the History palette [Window -> Show History] as they are implemented. These steps may be recorded for playback to demonstrate the reproducibility of these techniques through the Action palette [Window-> Action]. Each enhancement step may be deleted individually (through the History palette) at any point prior to saving the image, allowing one to view the image excluding that step. Snapshots of the image at a particular point may be made through the History palette, allowing one to experiment with different techniques on a snapshot of the image made at a particular step. Each step, whether recorded in the case notes or through the Action palette, provides the ability to repeat the process for demonstrative purposes. Although PhotoShop will record most processing steps through the Action palette (e.g. brush size, pressure setting, etc.), it is strongly recommended that the FDE record the individual settings in the case notes.

- The techniques utilized and the time required to complete will vary with the individual image problem. One of the primary advantages of digital enhancement is the ability to experiment quickly with any technique and immediately view the result. The PhotoShop™ program varies in price depending on the vendor. Many manufacturers of flatbed scanners will include the full version of PhotoShop with their scanners at a greatly reduced price. A computer with a minimum of 128mb of RAM and a processor of 300mhz or faster is recommended.

- Whether the techniques discussed are easily learned and implemented in PhotoShop™ depends on the user's familiarity with Windows and PhotoShop™. Assuming the individual knows little about PhotoShop™, the tutorial accompanying the program and its "help" features will greatly expedite the learning process. The techniques themselves are easily applied and experience may be acquired through practice and experimentation with simulated problems or from actual working images.

Comments

Other software applications will facilitate the same or similar techniques as detailed in this paper. Prior to utilizing software applications, the FDE should consider whether the scientific community has relied on the applicable techniques utilized, and whether the software has proven reliable and acceptable by the judicial system.

Written procedures for digital image capture, processing and output should be included in the operating procedures and guidelines of any forensic laboratory utilizing digital imaging.

References

Behnen, A. P. and Nelson, L. K. (1992). Additional Applications of Digital Image Processing to Forensic Document Examinations, *Journal of Forensic Sciences,* Vol. 37, No. 3, pp. 797-807.

Hart, L. J. (1992). Computer Imaging of Questioned Documents,Southeastern Association of Forensic Document Examiners conference, Atlanta, GA.

Hicks, A. F. (1995). Computer Imaging for Questioned Document Examiners I: The Benefits, *Journal of Forensic Sciences*, Vol. 40, No. 6, pp. 1045-1051.

Nelson, L. K. (1993). Explorations in Digital Imaging, Southeastern Association of Forensic Document Examiners conference, Atlanta, GA.