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## Additional Applications of Digital Image Processing to Forensic Document Examinations

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**ABSTRACT:** Two experimental applications of digital image processing to the examination of questioned documents are evaluated. First is a comparison of digital image processing, electrostatic detection apparatus (ESDA) processing, side lighting, and photography in the decipherment of indented writing. Best results are achieved by first utilizing the ESDA, then digitally enhancing the ESDA lift using a high-pass sharpening filter. The second application is the use of image processing equipment to make fracture match comparisons to associate carbon film typewriter ribbons with questioned typescript. Split-screen images and image overlays are found to be very effective techniques for this kind of examination.

Wenderoth [1] and Baier et al. [2] have reported on image processing as it relates to questioned document examination.

**KEYWORDS:** questioned documents, digital image processing, electrostatic detection apparatus (ESDA), image enhancement, photography, side-lighting, questioned document, carbon film ribbon, edge fracture match

Image processing is the manipulation of image information to make that information more useful. Digital image processing is image processing done with a computer. Applications of digital image processing to questioned document examination are being explored at the U.S. Army Criminal Investigation Laboratory, Fort Gillem, Georgia and at other crime laboratories. This paper deals with two applications of digital image processing to the examination of questioned documents.

The first application is a comparison of digital image processing, electrostatic detection apparatus (ESDA) processing, side lighting, and photography in the decipherment of indented writing. The second application pertains to the use of image processing equipment in making fracture match identifications to associate carbon film typewriter ribbons with questioned typescript. An analog digital image processing system (ADIPS), marketed as the Hunter Graphics Identification System, was used for this research. The system consists of two high-resolution black-and-white analog cameras coupled through a video-mixing device to a digital image grabbing (capture) board that is in an IBM AT computer. The image is displayed on a color monitor. The graphic format has a resolution of 512 by 480 pixels. The graphics card is able to distinguish between 256 shades of gray.

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The computer has 640 kilobytes of random access memory, a 30-megabyte internal hard disk, and a double-sided high-density floppy disk drive. The digital image processing software used with this system is the Image-Pro II, published by Media Cybernetics, Silver Springs, Maryland. Dr. Halo is the graphics software used with the system.

### Visual Examination of Indented Writing by Digital Image Processing Compared with the ESDA, Side Lighting, and Photography

A short paragraph (Fig. 1) was written on an 8½-by-11-in. tablet containing lined, white paper. A blue ballpoint pen was used to create the sample text and the writer was cautioned against applying excessive pen pressure. The five pieces of paper under the sample text were removed from the tablet for examination. The five sheets of tablet paper will be referred to as ST 1 through ST 5 in the remainder of this paper.

Attempts to decipher the indented writing on ST 1 through ST 5 were made using photography, ESDA processing, and digital image processing.

#### Photography

ST 1 through ST 5 were photographed with a Polaroid MP-4 copy camera using Kodak CPO film and Ilford HP-5 film. Side and copy lighting at various angles were applied to ST 1 through ST 5. The indented writing could be read from the photographs of ST 1 and ST 2 (Figs. 2a and 2b). Certain angles and directions of lighting achieved better results than others. The shadows of the stars in the lower right-hand portions of the photographs indicate the direction of the lighting for each photograph. Although some indentations in the paper of ST 3 through ST 5 were visible, the text could not be read.

#### ESDA

ST 1 through ST 5 were processed using the ESDA. ESDA processing was more successful than photography. ESDA lifts of ST 1 through ST 3 (Figs. 3a through 3c)

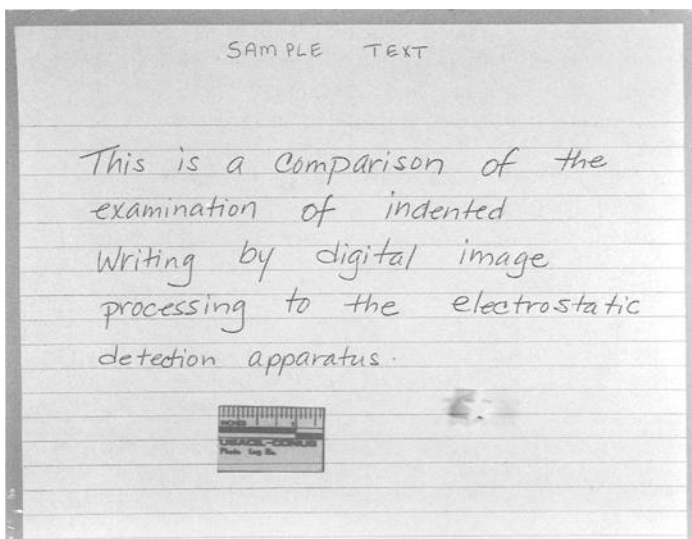


FIG. 1—Sample text.

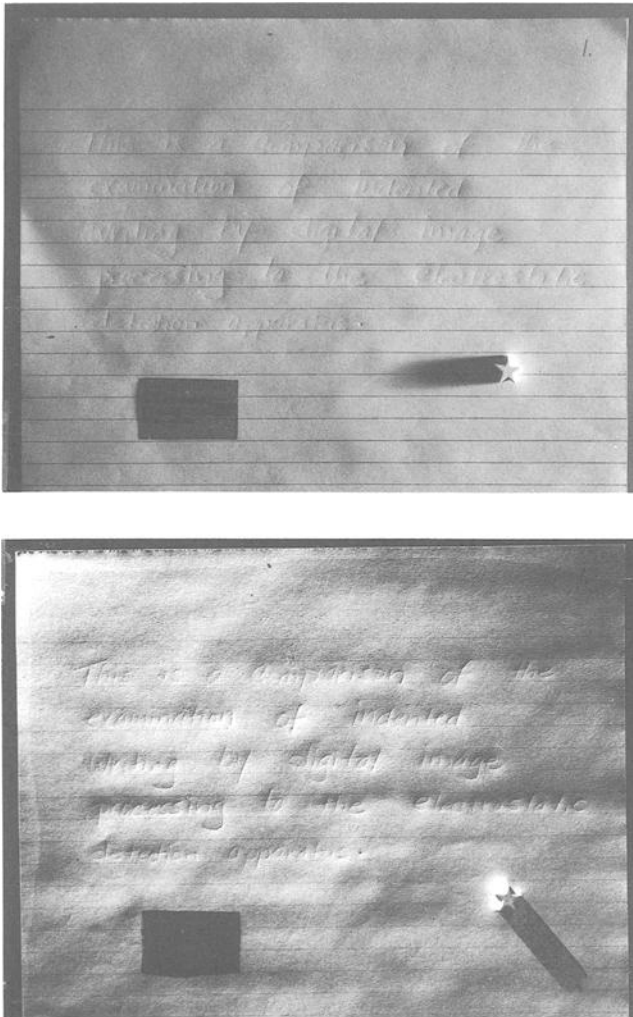


FIG. 2a—Photographs of ST 1 using two different directions of side lighting.

could be deciphered while only the photographs of ST 1 and ST 2 could be deciphered. Indentations were visible and parts of the indentations could be read in ESDA lifts of ST 4 and ST 5.

### ADIPS

ST 1 through ST 5 were placed under one of the cameras of the ADIPS and were illuminated with side lighting. The live image was captured as a digital image and was displayed on the ADIPS screen. Indented writing on ST 1 and ST 2 could be read as a digital image without enhancement. (NOTE: The entire document could not be captured on the ADIPS screen at one time. The camera was moved away to enable larger areas of the document to be captured at one time, but some image detail was sacrificed.) Some indentations were visible in ST 3, but they could not be read.

It was learned that care must be taken when applying side lighting to a document to

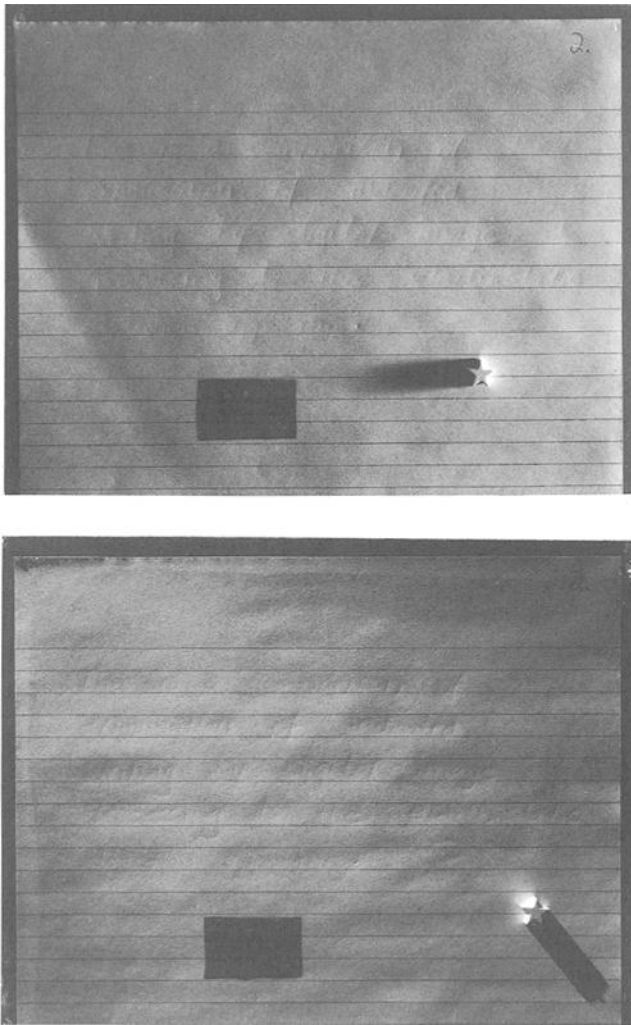


FIG. 2b—Photographs of ST 2 using two different directions of side lighting.

be digitized for enhancement. Having more light cast on one side of the document than the other affects the operator's ability to apply enhancement routines to the entire image.

Digital image enhancement was applied to images of ST 1 through ST 3 using a high-pass sharpening filter. This enhancement sharpened and cleared the writing on ST 1 and ST 2 (Figs. 4a and 4b) so that they could be read more easily. Digital enhancement did not make ST 3 readable nor did it aid in deciphering the text. ST 4 and ST 5 were not legible with or without digital enhancement.

Additional ADIPS functions were performed in an effort to enhance the texts. These included blurring routines, vertical and horizontal edge detection routines, and a range of contrasting routines. Enhancement with the routines alone and with the routines performed in combination with each other were attempted. Routines attempted after the high-pass sharpening filter did not enhance the images. Some routines made the images

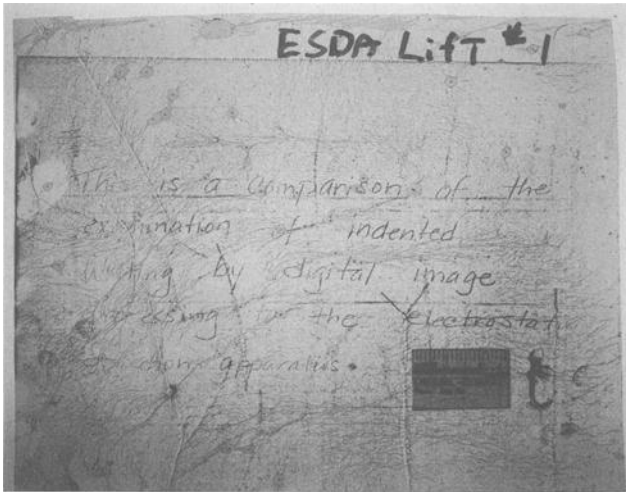


FIG. 3a—Photograph of ESDA lift of ST 1.

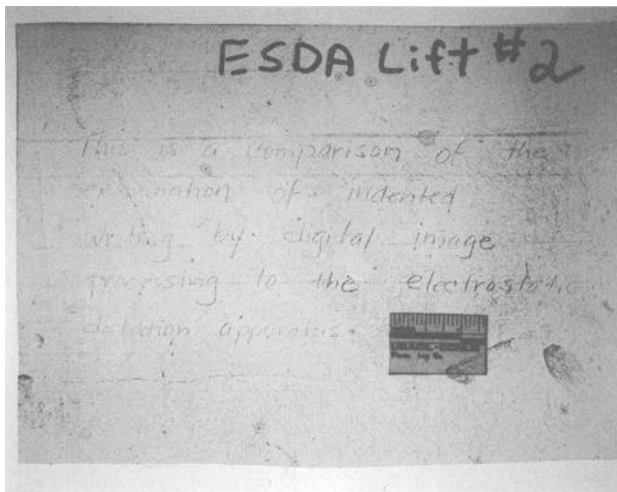


FIG. 3b—Photograph of ESDA lift of ST 2.

harder to read and some totally blacked out the image. This did no harm because the original image was saved on a disk and could be recalled for additional work.

#### *Digital Enhancement of the ESDA Lifts*

Digital enhancement improved the readability of the ESDA lifts of ST 1 through ST 3. The readability of portions of the ESDA lift of ST 4 was enhanced. Enhancement did not improve the readability of the ESDA lift of ST 5. Again, the high-pass sharpening filter provided the only improvement. The best results were obtained when the ESDA

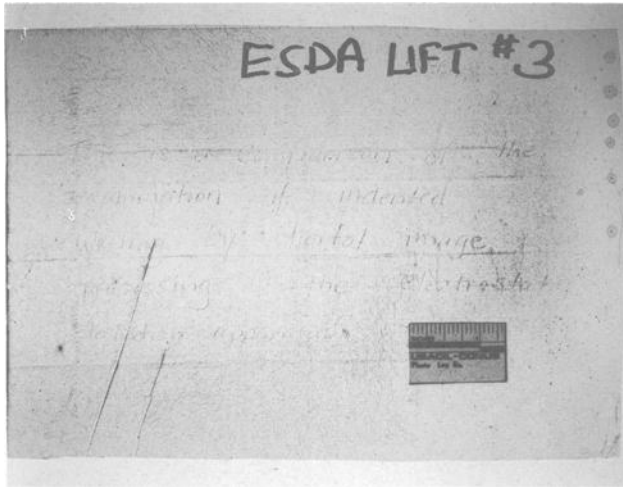


FIG. 3c—*Photograph of ESDA lift of ST 3.*

lifts were placed on a transmitted light box for illumination. Figure 5 is a photograph of the ESDA lift of ST 3 after enhancement.

### *Conclusion*

As a single procedure, neither the ADIPS nor photography produced images as readable as the ESDA. Both the ADIPS and photography produced “cleaner” images than the ESDA, because the background of the ESDA image is darkened with gray toner.

The best overall results were achieved by the digital enhancement of the ESDA lifts as depicted in Fig. 5. By enhancing the ESDA lifts, the examiner is taking the most readable product (the ESDA lift) and enhancing it to create a more readable image.

The ADIPS is a handy tool for screening large numbers of questioned documents to determine if they contain indented writing. Documents can be screened much faster with the ADIPS than they can be processed with the ESDA. It is just a matter of placing a document under the camera, checking the monitor, then going on to the next. If indentations are detected, the image can be digitally enhanced at that moment for a clearer look at the writing. This procedure is not recommended as a substitute for the ESDA, but in some cases an adequately clear image obtained on the ADIPS may preclude the need for further processing of the indented writing by the ESDA.

### **Image Processing Equipment for Fracture Match Identification to Associate Carbon Film Typewriter Ribbons with Questioned Typescript**

Non-enhanced digital image processing proved to be very helpful in the identification of carbon film ribbons used to prepare questioned documents. The following procedure can be used by any crime laboratory possessing image enhancement equipment. Two cameras and the ability of the computer to display the images from each camera simultaneously on the monitor (screen) are required for this procedure. The questioned document is placed under one camera and the carbon film ribbon containing the text of the questioned document is placed under the second camera. The questioned document is illuminated with a light source from above. It is preferable that the document be illu-



FIG. 4a—Photographs of ST 1 through ADIPS. (A) is ST 1 viewed through ADIPS camera with side lighting alone. (B) is enhanced image.

minated from two sides simultaneously. The carbon film ribbon is placed under the second camera and illuminated with transmitted light. A piece of clear, clean glass should be placed on both the questioned document and the carbon film ribbon to keep them flat. The two images are then captured as a live image and displayed on the monitor. Most image processing hardware should have the capability of split-screen display so that the document and the ribbon each occupy about half of the monitor. Both cameras should then be moved very close to the document and to the ribbon. This is done to enlarge a desired letter on the document and the corresponding letter on the ribbon so that the details of the fractured edges become more visible, and so each letter will fill about one half of the monitor.

If done properly, the fracture matches along the edge of the letter from the document and the ribbon should be clearly visible. Lighting can then be adjusted to enhance the edge

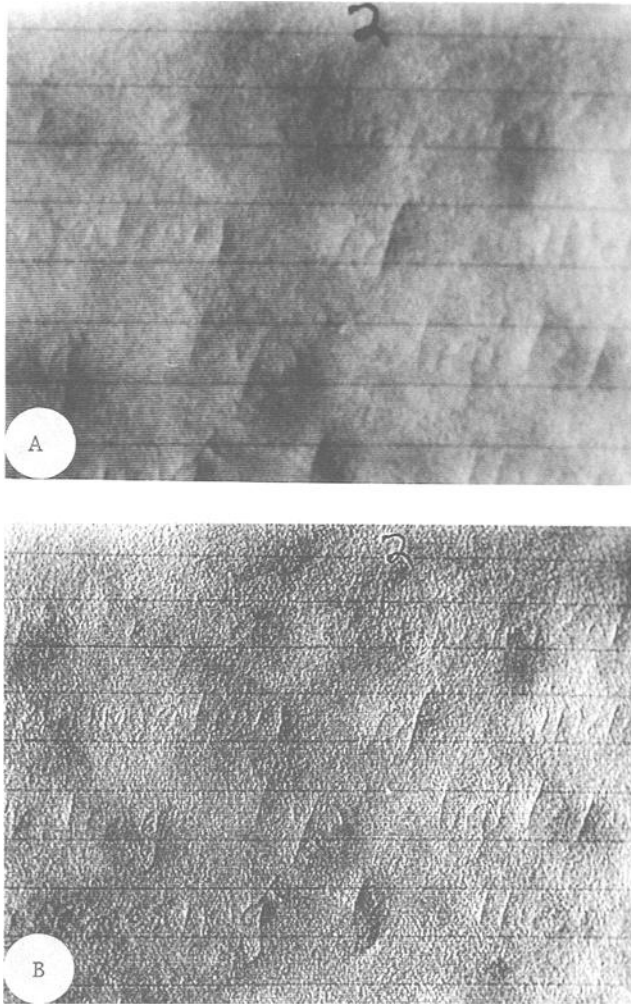


FIG. 4b—Photographs of ST 2 through ADIPS. (A) is ST 2 viewed through the ADIPS camera with side lighting alone. (B) is enhanced image.

detail of the letters. The cameras should be about the same distance away from the letter on the document and the ribbon so that they will appear the same size on the monitor. The fractured edges can be compared for similarities or dissimilarities (Fig. 6). This figure displays two letters. The light one is the absence of the letter from the carbon film ribbon and the dark one is the letter that has been transferred to the document. By following along on the outside of the letters, many fracture matches will be visible.

The two images can be superimposed, one on top of the other, if the system hardware permits (Fig. 7). In this figure, the dark letter from the document is on the bottom and the absence of the letter from the film ribbon is on top. Following along the outside edge of the letter, the fracture match can be seen quite nicely. The top image can be offset to the right or left (Fig. 8) to enable the two edges to be compared more easily. Thus, what appears to be a shadow along the edge of the character on the ribbon is actually the edge of the printed character on the document.



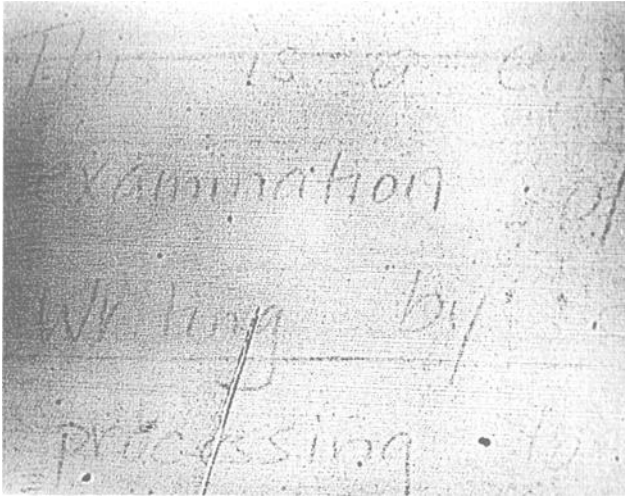


FIG. 5—*Photograph of ESDA lift of ST 3 after digital enhancement.*

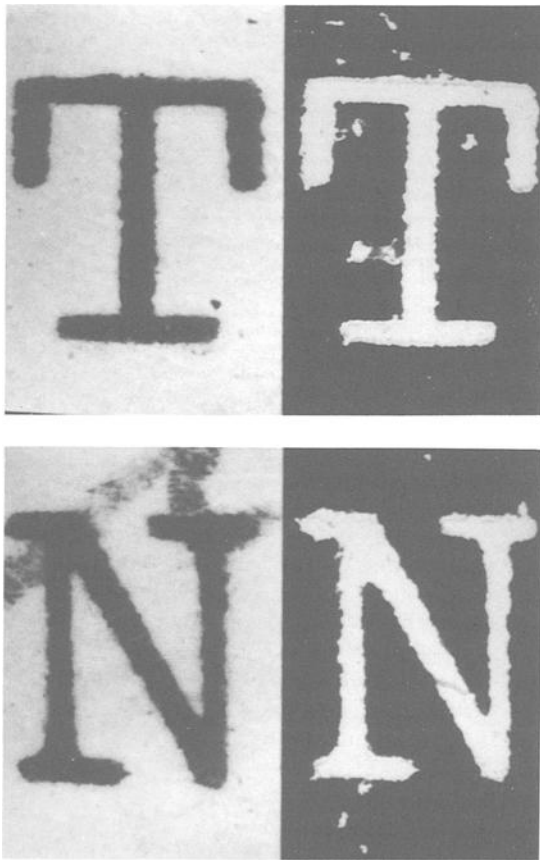


FIG. 6—*Two letters of side-by-side edge fracture matches.*

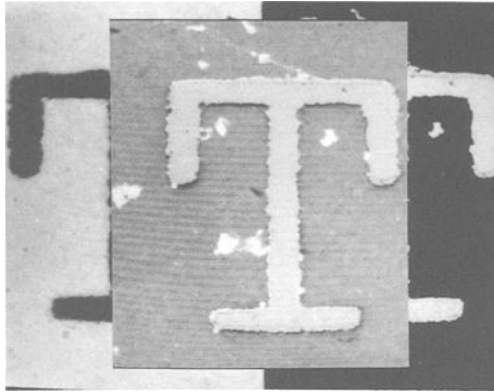


FIG. 7—*Superimposition of film ribbon over the typed letter on document.*



FIG. 8—*Superimposition of film ribbon over typed letter, set off to the side.*

### *Conclusion*

This procedure for fracture match identification has proven as effective as the use of the comparison microscope. A benefit of this system of identification is that large numbers of documents and letters can be examined simply by removing one and placing another under the camera. The system is also less stressful on the eyes than the comparison microscope. If a printer is a part of the image enhancement hardware, a printed picture can be made of the match for case file notes and courtroom demonstration. The image can also be saved on a disk for future use.

### *Acknowledgment*

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**References**

- [1] Wenderoth, M., "Application of the VSC-1/Atari 1040ST Image Processing System to Forensic Document Problems," *Journal of Forensic Sciences*, Vol. 35, No. 2, March 1990, pp. 439–446.
- [2] Baier, P. E., Teder, W., and Hussong, J., "ESDA-Improvements by Computer Assistance," paper presented at the American Society of Questioned Document Examiners Meeting, Sept. 1988.

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