TECHNICAL NOTE

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Image Enhancement for Document Examination Using the Personal Computer

REFERENCE: Houde, J., **"Image Enhancement for Document Examination Using the Personal Computer,"** *Journal of Forensic Sciences,* JFSCA, Vol. 38, No. 1, January 1993, pp. 143–146.

ABSTRACT: In a recent case involving the restoration of an obliterated message, an IBM compatible personal computer, a hand scanner, and commonly available software was used. The document was scanned, and the text was restored to readability by performing image manipulations such as gray-scale equalization and contrast enhancement.

KEYWORDS: questioned documents, criminalistics, obliterated writing, personal computers

This laboratory received a one-page letter written in pencil by a jail inmate who had subsequently erased his message. It was requested that we use any nondestructive means to restore the text to readability. Attempts at restoration by traditional photographic methods including infrared, ultraviolet, and oblique lighting were only partially successful, and it was suggested that computer image enhancement techniques be employed.

The hardware selected for the task was a 386 IBM PS/2 Model 80 computer, and a Logitech 256 ScanMan hand scanner. Printing was done on an Agfa Pro-set 9800 Imagesetter (Agfa, Wilmington, MA). The software included Logitech's Ansel (Logitech, Fremont, CA), running under Microsoft Windows 3.0 (Microsoft, Redmond, WA).

The questioned page was scanned in three separate passes, as the hand scanner's maximum scan width is only 10.1 cm (4 in). The resolution of the scanner is adjustable from 40 dots per cm (100 dots per inch) to about 160 (400 dpi). Higher resolution is desirable, because it allows for greater magnification on-screen, but the files created by anything more than 80 dots per cm (200 dpi) proved to be too big to copy onto even a high-density floppy disk, which has a maximum capacity of 1.44 megabytes, and thus could not be shared easily by other computers. Therefore, 80 dots per cm (200 dpi) was selected as an adequate compromise. A steady hand is required, as some skewing of the image may occur while the scanner is drawn along the page. The computer activates a red warning light on the scanner itself if the scanning speed exceeds its ability to keep up with the incoming data.

Once the document was digitized, a printout of the original unprocessed file was made, a portion of which is reproduced in Fig. 1. Enhancement was them attempted using a

Received for publication 29 Feb. 1992; revised manuscript received 1 May 1992; accepted for publication 4 May 1992.

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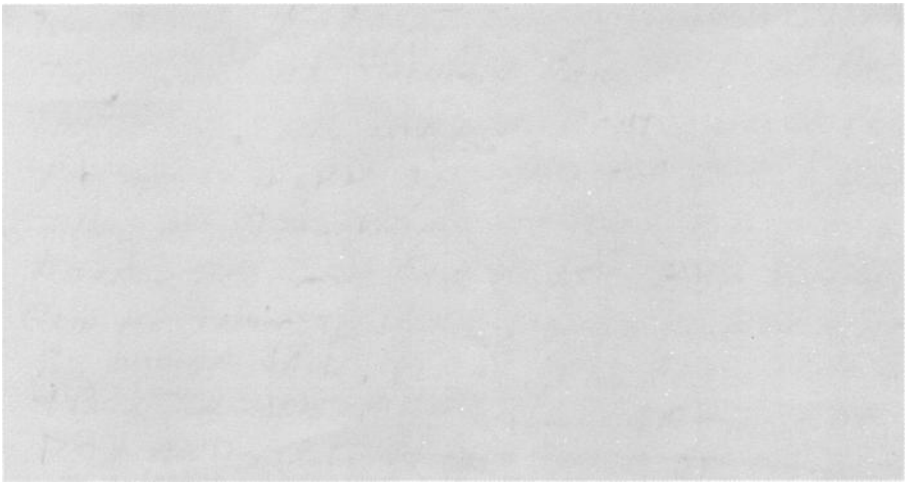

FIG. 1—*Unmodified image of upper left portion of scanned document. It is important to save a copy of the "raw" image before any enhancements are made, as different methods of enhancement will be tried.*

gray-scale equalization algorithm, which more evenly distributes the digitized gray shades in a document's image file across the entire spectrum. The human eye can distinguish only between 16 and 32 shades of gray [*1*], but the scanner can sense 256. This means that there are likely to be subtle differences between shades, which if made more pronounced, would become recognizable as images by the observer. The scanner digitizes the document's image into individual units of light intensity, or "pixels," each one of which can be stored as numerical data on a computer disk. The algorithm used in our software converts the lightest pixels to white, the darkest to black, and evenly distributes the remaining pixels in between. Sometimes the effect can be breathtaking, where a previously invisible image becomes quite apparent. Depending upon the condition of the original document, some adjustment of brightness or contrast may still be required. In this case, the image needed to be lightened up somewhat.

Next, the contrast of the image was enhanced using the sharpen algorithm. This is accomplished by increasing the difference between the gray level of neighboring pixels. This is not a true sharpening as that done by professional image enhancement software packages, where out-of-focus images are deblurred through complex calculations [*2*], but it does give the image an "edge," and a somewhat flat appearance, since the depth of gray levels has been reduced (Figs. 2 and 3).

The finished images were viewed on the monitor screen, which gives a more accurate rendering of gray levels than a printer, and then sent to a print shop for high resolution output. The software we used offers several choices of printing methods and each was tried on our own Hewlett-Packard Laserjet II printer, with the results being compared. Unfortunately, the Laserjet's maximum resolution, 120 dots per cm (300 dpi), makes it inadequate for rendering high-resolution images, because the maximum number of gray-shades is a function of the smallest dot a printer can produce. For good reproductions, an Agfa, Linotronic, or similar high resolution imagesetter should be used. Most print shops either have one in-house, or can provide access to one. These devices operate at four to eight times the resolution of a typical office laser printer. In this laboratory, we simply save our finished image onto a floppy disk, and deliver it to the print shop, who for a modest service charge will print it using any one of several page-layout programs.

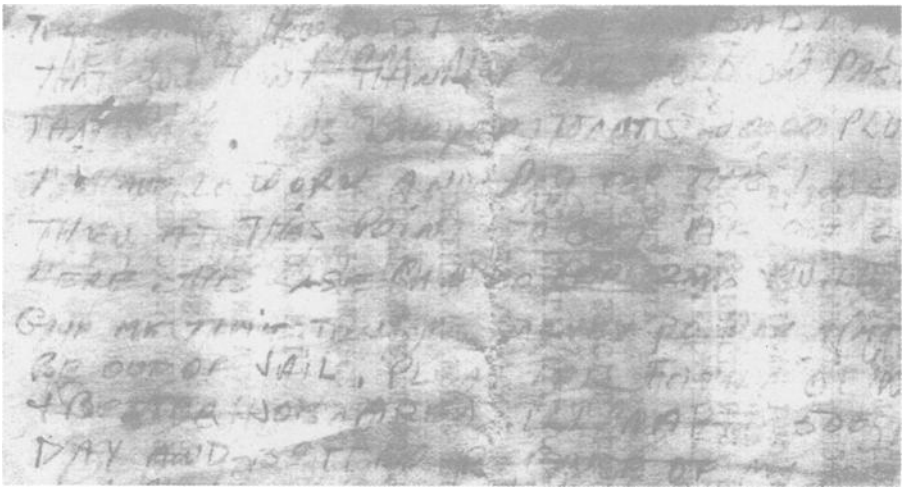

FIG. 2—*Same image as in Fig. 1, following gray-scale equalization and sharpening.*

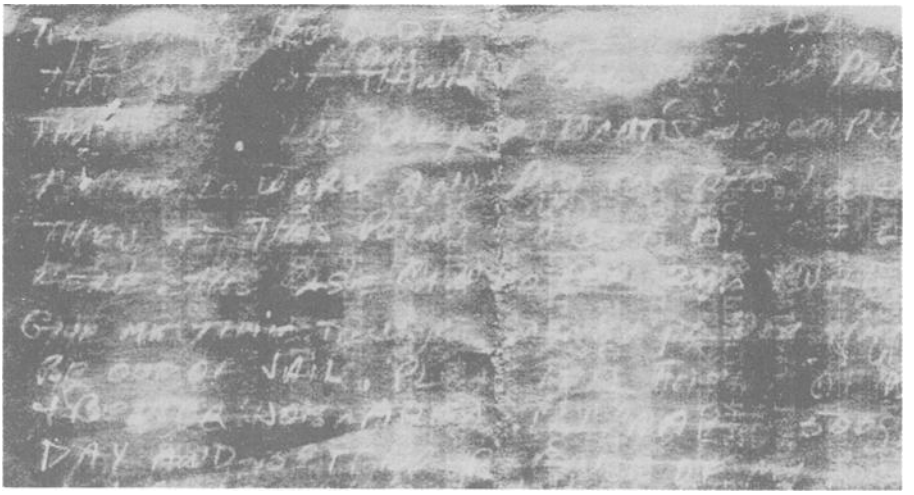

FIG. 3—*Same image as in Fig. 2, after the gray levels have been reversed.*

We have also applied the above technique to photographs of a variety of objects including ligature wounds, electrophoresis plates, bite marks, and faces with varying degrees of success. Much depends upon the quality of the original photo. Also, it should be noted that the scanner is most sensitive to the blue-green portion of the visible spectrum. This means it is practically blind to red, which is the opposite of most photocopiers. Color photographs containing reddish images should be copied onto black-and-white paper, such as Polaroid Type 667, before scanning.

Complete document imaging "systems" are available for the purposes described here [*3*]. However, there is no doubt that using inexpensive hardware, such as is found in many labs and offices, one could set up a rudimentary image enhancement program which would be certain to provide valuable information not otherwise obtainable.

References

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