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Application of the VSC-1/Atari 1040ST Image-Processing System to Forensic Document Problems

REFERENCE: Wenderoth, M., **"Application of the VSC-1/Atari 1040ST Image-Processing System to Forensic Document Problems,"** *Journal of Forensic Sciences*, JFSCA, Vol. 35, No. 2, March 1990, pp. 439–446.

ABSTRACT: In 1987, Foster and Freeman introduced a software package for image processing using the Atari 1040ST computer. The software and computer are interfaced with their video spectral comparator (VSC) to form a complete processing system. There are five basic image-processing functions and several display operations that permit the enhancement of images with this system. These image enhancement capabilities have direct application to problems encountered by forensic document examiners. Three such problems are set forth to demonstrate the direct application of these processing functions. The techniques used in these problems will also be presented.

KEYWORDS: questioned documents, computers, image enhancement system

Digital image-processing techniques are used today in a variety of technical fields including the space program, medicine, physics, geology, and biology. In almost any area that deals with problems involving enhancement of pictorial information, image-processing techniques have found useful applications. This includes the field of forensic science and, more specifically, forensic document examination.

Forensic document problems cover a variety of areas from handwriting and typewriting identifications to ink and paper analysis. Document examiners may also analyze documents to decipher obliterations and erasures that are present. They work with various problems involving photocopiers, rubber stamps, printing processes, and watermarks. Their examinations involve all aspects of the questioned document and the materials that went into producing that document. A certain number of these examinations could be aided by image enhancement capabilities.

To date, there are few commercially available image enhancement software packages designed primarily for forensic document applications. Most of the image enhancement software available today is designed for other purposes, such as medicine. Consequently, existing software has to be adapted for forensic document work.

In 1987, Foster and Freeman introduced a software package for image processing, specifically designed for forensic document applications, using the Atari 1040ST computer. It was updated in January 1989, and the program is currently in the process of adding colorizing capabilities.

To use the Foster and Freeman software package, the software and computer are

Presented at the 41st Annual Meeting of the American Academy of Forensic Sciences, Las Vegas, NV, 20–25 Feb. 1989. Received for publication 3 April 1989; revised manuscript received 22 May 1989; accepted for publication 23 May 1989.

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interfaced with their video spectral comparator (VSC) to form a complete processing system. There are five basic image processing functions and several display operations that permit the enhancement of images with this system. This paper will examine the direct application of this processing system to forensic document problems.

The VSC-1/Atari 1040ST Image Processing System

The VSC/Atari 1040ST processing system consists of four major components: the VSC-1, the DIPS video framestore, the Atari 1040ST computer with software and interface, and the 9-in. (23-cm) monochrome television (TV) monitor.

The VSC-1 is a versatile instrument used to perform video examinations of questioned documents. It is capable of being used with a variety of both internal and external lighting sources. Internal lighting sources include infrared (IR) incandescent, ultraviolet (UV) light, and a tungsten halogen lamp to provide illumination for far red and IR excitation, which is fitted with a blue-green filter. Three filters combinations are also available covering a range from 455 to 1000 nm.

The video image to be processed through this system is provided by the VSC-1. Any initial manipulation of the image is performed with this instrument. Through the use of the various lighting sources, filter combinations, and zoom features, an optimum image of the desired subject is obtained.

The second component of this processing system is the video framestore. The video framestore captures, stores, and displays the individual frame of video information. The video information is accepted as video input by the framestore unit. It is the VSC's video camera which provides the video input for this system. The video input is digitized and stored in the video framestore.

Digitizing is the process by which the image is stored into memory by the framestore unit. This is done by scanning a continuous image and breaking it into an array of digital intensity values called pixels, or picture elements. In other words, digitizing transforms the signal from the VSC video camera into a pixel array. This pixel array is then stored by the framestore unit as a matrix of 512 by 512 pixels, having any of 64 possible gray levels.

The third component of the system, the Atari 1040ST computer, processes the pixels using any number of selectable functions such as: Contrast, Hi-Pass, Mix, and Invert. The Atari computer is supplied in three main parts: the computer, incorporating the keyboard and disc drive, the video display unit (monitor), and the mouse (cursor control device). The Atari 1040ST uses a 68000 microprocessor.

The software for image processing is supplied on one 3.5-in. (9-cm) floppy disc. The particular software used, for purposes of this paper is the updated version, introduced in January 1989. This version has no colorizing capabilities. The processing software package performs numerous processing functions, all of which are based on the manipulation of pixels.

These processed pixels are then converted back into spatially organized image intensities. The images are displayed on the final component of this system, a 9-in. (23-cm) standard monochrome TV monitor, provided with the VSC-1.

Thus, as with all image-processing systems, the VSC/Atari system consists of an image-acquisition device (VSC), an image memory (framestore), a computer that can access this memory (Atari 1040ST), and a device that displays the contents of memory (monitor) [*1*].

Functions of This System

Image processing is the method by which the visual quality of digital pictures is improved or enhanced. This is achieved by any combination or series of processing functions. These functions are based on step-by-step procedures. Algorithms, the general term for these procedures, are the underlying structure of each processing function. To reach a processing goal, you should know which algorithms (procedures) to apply and in what order.

The outcome of any image-processing operation is directly dependent on the individual images supplied. Thus, there are no hard and fast rules as to what will work each time in each situation. Trial and error produces the best results. Because these processing functions are quite time-consuming, patience is also required when seeking to arrive at a set processing goal.

The VSC-Atari system has five basic image-processing functions: Average, Binarize, Contrast, Hi-Pass Filter (Edge), and Median. There is a second category of operations: Compress, Expand, Invert, and Profile, which are not technically image-processing functions, but do nonetheless change the appearance of the video information. These operations can play an important role in achieving certain processing goals. There are also several display operations that prove quite useful: Mixed, Strobe, and Gate.

This author has found that certain functions are more effective than others on the types of document problems commonly encountered. These include: Contrast, Hi-Pass, Mix, and Invert. Certain combinations of these functions also provide further capabilities. For example, Mix and Invert can be effectively combined to accomplish a subtraction, making otherwise illegible parts of an image legible.

What follows is a brief description of these more commonly used processing functions. These functions were the ones used to achieve the results demonstrated by the three examples set forth in the following section. An explanation of these functions will hopefully lead to a better understanding of how the various results were obtained.

Contrast

This function increases the contrast of an image by redistributing the original range of gray levels over the full 64 gray level scale. It is most useful for images that have a very narrow range of gray levels. The contrast enhancement broadens that narrow gray range and makes the image sharper.

The original range of gray levels is first calculated. The contrast stretch is then performed to broaden this original level so that it covers the complete scale. The gray levels are then rescaled to the original range of 0 to 63. After the operation is completed, a dialogue box appears to allow the gray level distribution to be altered (that is, increase or decrease white or black intensities in the image).

Hi-Pass

This function enhances the edge detail in an image. It selectively filters out low-intensity gray levels by emphasizing high-frequency components in the image. This in turn sharpens unfocused or blurred edge features.

The first step involves the selection of a particular filter or mask size. There are four choices of filter size, ranging from 3 by 3 to 15 by 15. These filter sizes designate the pixel area to be processed. For example, a choice of 3 by 3 will process a square area of three pixels by three pixels.

In this operation, the chosen area is processed to detect any changes in gray level intensities from one pixel to the next. A radical change would indicate the presence of an edge in the image. If an edge is detected, the high-intensity gray levels of the edge would be emphasized, while the low intensities in the area would be filtered out. This sharpens the edge detail in the image.

Invert

This operation rewrites the frame in inverse video, by turning black to white and white to black. All intermediate gray levels are converted accordingly. Only an area of 256 by 256 can be inverted. This area is selected by placement of the cursor. (Note: by operating from the keypad, which was originally obtained with the VSC-DIPS package, an entire frame (512 by 512) can be inverted.)

Mixed

This operation displays both live and stored images superimposed. The intensity balance between the two images can be adjusted with the Mix control knob. The Live image can be shifted horizontally with the Shift control knob.

Applications of These Processing Functions

The application of image-processing functions to forensic document problems has been reported on by Bouffard [*2*], Noblett [*3*], and Baier [*4*]. In fact, the applications demonstrated in this paper are much the same as those presented by Bouffard. One significant difference is that he used the 1982 DIPS keyboard processing system, while this author used the updated software package and computer to achieve the noted results. Noblett reported on subtraction capabilities of image processing as an aid to examining obliterated writing. A case using a similar technique is demonstrated in this paper.

Example 1: Faint Signature on Carbonless Copy

This example involves a borrower's copy (pink copy) of a loan agreement containing a faint signature of the debtor. A series of processing functions were undertaken to enhance this image and demonstrate the results obtainable with this type of document problem (Fig. 1).

1. Using the VSC-1, a *live* video image was obtained. The faint signature was luminescent under the high intensity blue-green light source which then was fitted with a filter (665 nm). This *live* image was *stored* by loading the image into the framestore unit.
2. The Contrast function was applied. After this operation was completed, a dialogue box appeared to allow the gray level distribution to be altered. This author chose to increase the *white* intensity of the image as a means of further enhancing it.
3. The image was *inverted* so as to produce a dark signature on a black background. (This was done at the discretion of the examiner. The image can be processed in either form.)
4. To increase the edge detail of the image, the Hi-Pass operation was next applied. A mask size of 5 by 5 was chosen.

Example 2: Handwriting Obscured by Typewriting (Subtraction)

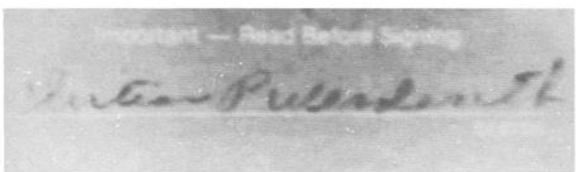
This example depicts the subtraction process, in which parts of two images which are the same cancel one another out, leaving that which is found in only one of the images visible. A handwritten telephone number in this case was obscured by typewriting found on the same document (Fig. 2).

1. Using the VSC-1, a *live* image of the first image was obtained. For the subtraction to be effective using this system, one image should contain the obliteration to be deciphered, while the second one should not. In this case, the first image contained

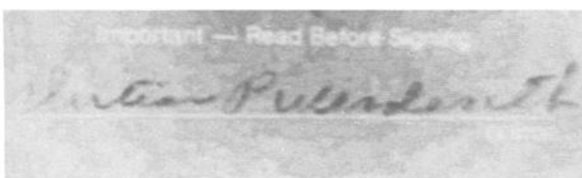
FIG. 1—*Example 1—faint signaure on carbonless copy.*

1. *Stored*

2. *Contrast*



3. *Inverted*

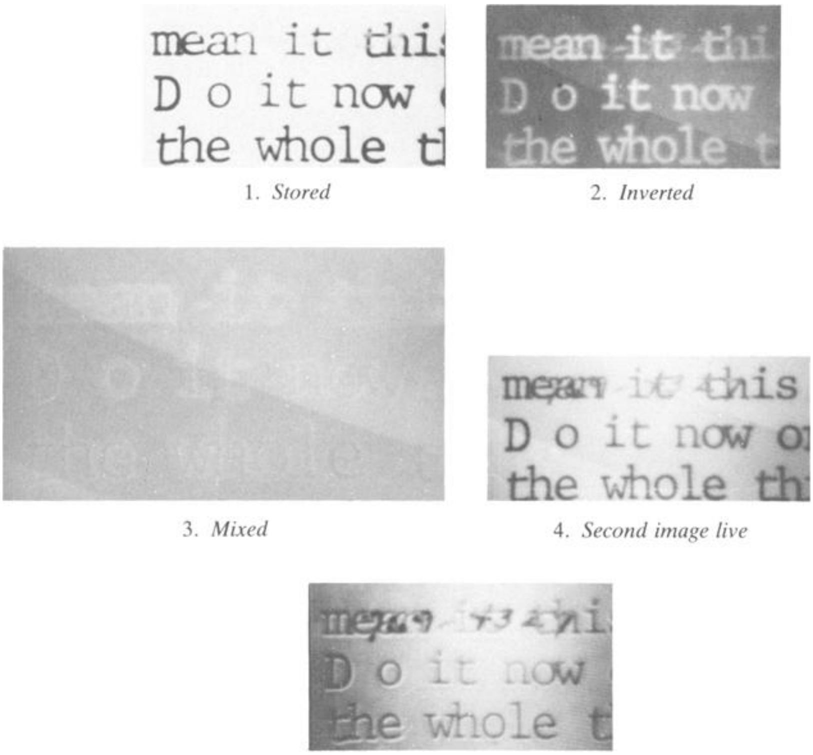


4. *Hi-Pass*

only a faint impression of the handwritten numbers, yet the typewriting remained dark and visible. This was accomplished by viewing the document with IR/Vis light source, fitted with a filter (665 nm). The *live* image was *stored*.

2. The *stored* image was then *inverted*, using the Invert function. This first image then appears as a negative.
3. The next function used in this series was Mixed. As described earlier, this function allows for the superimposition of live and stored images. With this function there is a knob which controls the variable intensity of both live and stored images.
4. Using the intensity knob, the *live* image, which appears as a positive, was viewed once again with IR/Vis lighting. This time, however, the filter was changed to LP1 to make the handwritten numbers visible. This live image was focused to account for the change in wavelength.
5. The two images were then *mixed* by adjusting the variable intensity knob. This was done until the optimum superimposition of the two images was achieved so as to nearly eliminate what was duplicated in both images. Once this was accomplished,

FIG. 2—*Example 2—handwriting obscured by typewriting.*



1. *Stored* 2. *Inverted* 3. *Mixed* 4. *Second image live* 5. *Both images mixed*

that which was not duplicated in both images becomes visible. In this case, the handwritten telephone number (769-4327) became visible, and the clarity of it was adjusted using the Shift knob found on the keypad.

Example 3: Faint Pencil Impression

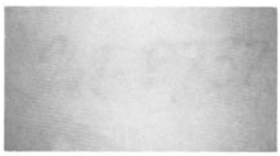
This example involves a faint pencil impression found on yellow paper. This was a very gray intense image. A series of processing functions were undertaken in much the same way as Example 1 to enhance this image and demonstrate the results obtainable with this type of document problem (Fig. 3).

1. Using the VSC-1, a *live* video image was obtained. The faint impression was viewed under IR/Vis lighting with the LP1 filter.
2. The *live* image was *stored* by loading the image into the framestore unit.
3. The Contrast function was applied. After this operation was completed, a dialogue box appeared to allow the gray level distribution to be altered.
4. This author chose to increase the *black* intensity of the image as a means of further enhancing it.
5. To increase the edge detail of the image, the Hi-Pass operation was next applied. A mask size of 5 by 5 was chosen.

FIG. 3—*Example 3—faint pencil impression.*

1. *Live*

2. *Stored*



3. *Contrast*

4. *Increase black*

5. *Hi-Pass*

Conclusion

The three examples set forth in this paper attempt to demonstrate some of the applications of image processing to forensic document problems. There are countless other document problems such as blurred rubber stamp impressions, poor quality photocopies or electrostatic detection apparatus (ESDA) prints, white-out cases, and obliterated writings whose analysis would be aided by image enhancement capabilities.

As stated by Gonzales, "When an image is processed for visual interpretation, the viewer is the ultimate judge of how well a particular method works" [5]. Gonzales goes on to say that the visual evaluation of image quality is a highly subjective process. Thus, there are no hard and fast rules in image processing as to what will work each time in each situation. It is up to the individual document examiner to determine subjectively which functions work well to achieve the examiner's processing goals and which do not.

Acknowledgment

Thanks given to Mr. Charles Sikora, Scientific Examiner, Cleveland Police Forensic Laboratory, whose technical support and gracious cooperation were greatly appreciated by this author.

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