

Technical Notes

Digital Analysis, Comparison, and Projection of Fingerprints: A New Digital Device for Crime Scene Investigation

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Abstract: Since the mid-1990s, the forensic science community and law enforcement agencies have been using electronic/digital imaging devices such as video cameras, digital cameras, scanners, Power Point, and Adobe Photoshop software in crime scene recording. This paper introduces the Digital Imager in analyzing, comparing, and projecting fingerprint evidence. The portable device (software is included) can provide some unique functions: a larger field of view, longer zooming range, image dividing, and special viewings modes (of emboss, negative, edge, and grayscale effects). It is highly recommended that the new digital imaging device be utilized in fingerprint elimination and identification for crime scene investigation and courtroom presentation due to its multiple functions in one digital device.

Key Words: Fingerprints, Digital Imager, Crime Scene Comparison and Elimination, Digital Analysis of Fingerprints, Courtroom Presentation, Digital Forensics

Introduction

Electronic and digital technology has promoted great changes in almost every walk of modern life. Since the mid-1990s, several digital imaging devices such as digital cameras, color laser printers, scanners, and Adobe Photoshop have been utilized in forensic analysis, comparison, and presentation of fingerprints and in fingerprint enhancement [1, 2]. As a new trend, digital imaging technology has been able to transform the image of a specimen into a digital record and then reconstruct that image onto a computer screen or a projected screen for quicker, larger, and better visualization.

Based on the author's recent experiments on a friction ridge analysis in the lab, this paper introduces a new digital imaging device for fingerprint analysis, comparison, and projection using the Digital Imager (UF-80 DX). The greatest advantage of the new device is that it allows an examiner to conduct the three main tasks (analysis, comparison, and projection) in one device all at the same time.

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Background for Technical Evolution

The use of photographs by law enforcement dates back to 1841, when the Paris Police Department took pictures of criminals--the first primary mug shot files [3]. The following 150 years have witnessed many technological advances and breakthroughs in law enforcement and forensic science communities. Since the late 1980s, crime labs in law enforcement agencies have recognized the value of digital imaging technology in criminal investigation, lab analysis, and court presentation. Specifically, three types of digital devices are commonly used by crime labs in the field of digital imaging: digital cameras, flatbed scanners, and film scanners.

Several great advantages of digital technology lie in its speed, access, and ease of control of the digital information [4]. Digital cameras store images on a memory card rather than on film. Digital photographs are composed of pixels or picture elements. Digital cameras can control the number of pixels in each individual picture. In terms of image resolution, the more pixels utilized for an image, the more details can be recorded and visualized. Digital cameras require electrical or battery power, while traditional cameras are mostly mechanically handled (some may have digitalized bodies). Digital zooming offers a much longer zoom range than that of a traditional camera lens, which creates better enlargements. However, a digital image can (only?) be enlarged to a certain level without sacrificing image resolution. As a result, digital cameras are somewhat limited in their use in crime scene recording, but not in analysis and comparison.

Wertherim introduced the use of Adobe Photoshop and demonstrated the uniqueness of latent prints, stating that the use of the software is both obvious and challenging [5]. Unfortunately, Adobe Photoshop software is expensive and a large percentage of the program's capacities are not applicable to latent print examination. As a matter of fact, many of the filters and functions would never be used to create demonstrative exhibit evidence. Adobe Photoshop software relies heavily on the quality of the fingerprint picture taken by a scanner or a digital camera. To do an analysis or a comparison, two different images have to be taken by the same digital device using the same settings, e.g. resolution, distance, and dimension. Therefore, it is relatively difficult in reality to compare two lifted latent prints at a crime scene. Further, the size of a multi-layered color file in the Adobe Photoshop can quickly incapacitate a system. Finally, Wertherim [5] stated, "There is currently no software program that I am aware of that incorporates all of these demonstrative elements into one program without the other portion of the software that does not apply to forensic examination of image."

The Digital Imager introduced in this paper includes its software and offers many desired capacities and new features that other electronic or digital imaging devices do not have. These features allow an examiner to analyze, compare, and project unique image details by one device simultaneously while the examiner can still follow the required Analysis, Comparison, and Evaluation/Verification (ACE-V) procedure. The digital process does not change the original image or the fingerprint, nor does it destroy the evidence image or the fingerprint. Most

importantly, the Digital Imager, if connected to a laptop and a projector, can be used by an examiner to take pictures, conduct analyses, make comparisons, and create a live presentation all at the same time.

General Features of the Digital Imager

Four technical aspects of the Digital Imager must be first understood: computer system requirements, general specifications, methods of operation, and special features.

A. Computer System Requirements

To install the software (included in the device) for the Digital Imager, the computer or laptop must have at least the following system configurations which most of the PS (PCs?) or laptops have in the current market:

- 1) IBM or IBM-compatible computer with a Pentium II 350 Mhz or higher processor. A Pentium 4 or higher is necessary when using USB 2.0.
- 2) Windows 98 or later version. Windows 2000 pro or higher is required when using USB 2.0.
- 3) Screen display requires XGA 1024 x 768 as maximum, or 65536 color or higher.
- 4) USB 2.0/1.1 interface connector. On-board type USB chipset is required if using USB 2.0.
- 5) 64MB or higher RAM is the minimum requirement. 128 MB or higher is required if using USB 2.0.

B. General Specifications

The Digital Imager has the following general specifications.

- 1) Field of View: The Digital Imager has a larger field-of-view (shooting area) from 298 to 221 mm, which also allows taking pictures of a partial crime scene directly.
- 2) Working Distance: A varying working distance is available, ranging from 65 mm to 10 mm, depending on the size of the item and the degree of detail needed. At a normal working distance, the Digital Imager can still catch a clear view at 10 mm.
- 3) TMP: The total magnification power (zooming) allows for reduction or enlargement of the image size using two components: the 14X magnification power lens and the

- digital lens with 3X magnification can create a total magnification power (TMP) of 42X.
- 4) **Illumination:** There is a fluorescent light attached to the arm of the main unit. The BRIGHT button can be used as a control to lighten or darken the overall image. A prevention sheet option is provided for a shiny surface. On certain models, a light box is built-in on the examination stage for shooting a reflective surface and reducing defined reflection.
 - 5) **Electrical Input:** The unit is operated at DC 12V. The adaptor input ranges from AC 100V to 240V free voltages with 50/60 Hz, and the output is 12V with 3.5A. Thus, the device can be used worldwide without a converter.
 - 6) **Physical Dimension:** The overall dimensions of this Digital Imager measure 404 mm (W) x 488 mm (H) x 504 mm (D) when the device is in use. The height can be reduced to 206 mm (H) when the unit is in storage, making it a portable device for a crime scene investigation. The total weight is about 5 kilograms (11 pounds).

C. Methods of Operation

The Digital Imager can provide several unique operational methods: Connection Setup, Control Setup, Digital Lens Setup, and Optical Setup. The following is a brief discussion of each function:

- 1) **Connection Setup:** Once the supplied software is installed, five connection configurations can be utilized, depending on the purpose of the examination.
 - a. **The Imager-Laptop/PC Connection:** The Digital Imager can be connected to a laptop or desktop PC using a USB connection. The captured image from the Digital Imager can be viewed directly on the computer monitor. It is possible to view the details of the fingerprint evidence on the computer monitor. This connection is especially useful for analyses at crime scenes.
 - b. **Imager-Projector Connection:** Using the VGA output connection, the Digital Imager is connected to a projector for a live demonstration without a laptop or desktop PC. This connection also provides a drawing feature using a mouse control.
 - c. **Imager-Laptop/PC-Projector Connection:** This is a combined connection of a and b. The Digital Imager is connected to a laptop/PC

using a USB connection and the laptop/PC is then linked to a projector with a VGA cable. The computer should be equipped with an XGA, SXGA, or UXGA graphics card. **This connection is recommended for two reasons.** This connection is ideal for presentations and live demonstrations. Using this connection, any image captured by the Digital Imager can be viewed on the computer monitor and the projector screen simultaneously. This connection is especially useful when making a court presentation as the examiner is able to demonstrate the process of the analysis and comparison. If a portable projector and a section of white wall are available, this connection allows for a live examination and projection at the crime scene, in a DA's office or in the courtroom.

- d. For an advanced use, the digital imager can be connected to a DVD player or recorder for display.
- e. For an advanced use, the laptop or desktop can be connected to a flat panel (plasma) TV through a RS-232C cable for a high quality display.

2) Control Setup: The Digital Imager has five control setups for performing various functions.

- a. The Digital Imager has a stage control panel for basic feature controls. This panel is used to control basic or mini-functions if connected directly to a projector as described in the Imager-Projector Connection.

- b. Once connected, the selecting feature can be controlled from the computer screen either from a quarter screen (256 x 192) or a half screen (512 x 384). The control panel is the main control and has a complete selection of all the features.

- c. When selecting a full size or screen full (1024 x 768), an on-screen mini control panel with limited features has to be used.

- d. One can also connect a PS/2 mouse control provided by the manufacturer to the Digital Imager and use the mouse control to adjust the image. The mouse connection also has a special function—it can be used for drawing for GUI purpose (Graphic User Interface). More details will be provided under Digital Drawing in a later section.

- e. When conducting a presentation for an analytical meeting or a courtroom presentation, a remote control is provided by the manufacturer to function as the control panel. The remote control allows the presenter to walk around while controlling the Digital Imager and the laptop/PC.

- 3) Digital Lens Setup: The Digital Imager contains a digital camera lens on a folded arm and an examination stage by a stage control panel. The digital camera lens can be set in three positions: a vertical position, a horizontal position, and any adjustable position (the lens can be swiveled).
 - a. The Vertical Position: The digital lens is set up at 90 degrees toward the object. In other words, the lens is directly facing down the specimen. This position should be commonly used for analysis, comparison, and projection at crime scenes. The Horizontal Position: The imager lens can also be setup paralleling with the examination stage. This lens position allows shooting a larger object sideways within the required working distance. For example, the Digital Imager can be placed to shoot tattoos on a person's body, a bullet hole in the wall, or the toolmarks on a door-lock at crime scenes.
 - b. The Adjustable Position: The imager lens can be moved to any angle in a 360 degree position. Additionally, the arm can be swung from a higher to a lower position, allowing for more lens positions. This capacity makes the Digital Imager extremely useful for crime scene processing and none of the other similar devices in the market have this unique function.
- 4) Optical Setup: After the steps for connection, control, and lens setups are finished, lifted fingerprint cards are placed on the examination board. Next, a series of optical setups start using the control panel on the laptop screen.
 - a. Lens Focus: The lens focus includes: Wide View (F=1.5) and Tele View (F=2.1), ranging from 0 to 1904 zoom value. The two focus modes, Auto Focus (AF) and Manual Focus (MF) can be activated at any time using any of the controls (control panel, mini control panel, remote control, or mouse control). Also, Near/Far Focuses can be used to further adjust the focus point. The lens focus on the testing fingerprint was adjusted to 1750 zoom value for the examination.
 - b. Screen Size: There are four screen sizes available from a computer screen. The size chosen depends on the size of the specimen being studied. The four sizes are quarter size (256 x 192), half size (512 X 384), full size (1024 x 768), and screen full (1024 x 768). While the control panel is used for quarter and half sizes, the mini control panel is used for the full size and the screen full. Although the full size and the screen full have the same size numbers (1024 x 768), the screen full

opens up to a complete full screen without any original computer desktop icons in the background.

- c. Iris: The iris function can be Auto (AWC) or Manual with fine-level adjustment in terms of color (increase or decrease blue or red color). This function is important when the background is colorful.
- d. Specimen Selection: There are two more functions on the stage control panel and remote control. While the TXT selection is designed for word or text based materials, the IMG is for image materials.
- e. Resolution: The imager's resolution is set at 1/3 " 850,000 pixels PS CCD/ 1034 (H) x 779 (V). The VGA output is set at 1,024 x 768 (XGA) RGB color.
- f. Rotation: Images can be rotated at 90, 180, and/or 270 degree increments.

D. Special Features

The Digital Imager also has special functions called Digital Image Effect Processing (DIP) using the control panel or the mini control panel. DIP can produce impressionistic effects on an object/specimen by displaying pixels in different ways and highlighting the contrast in an image. Using DIP, the details of the specimen surface can be viewed with the influence of different optical effects. The DIP image can be reflected on the laptop/PC screen while the original image remains unchanged. Such special digital viewing is very useful when analyzing and comparing fingerprint evidence.

- 1) Emboss Image: The emboss function can scan the surface of an object with the original fill color so that any raised or stamped portion on the object can be viewed in a three-dimensional manner. The emboss feature converts the original color into a gray color, thus displaying a lifted fingerprint in a 3D image.
- 2) Edge Detection: Edge detection can identify any outline of the edge of any raised areas, allowing for clearer viewing of the edge of a fingerprint. This function emphasizes the edges using the Prewitt mask, a unique function for examining a partial fingerprint.
- 3) Negative Image: This function converts an image into a negative view. This function is very useful for overcoming the so-called "fingerprint reversal effect", e.g., converting fingerprints on human skin (live or dead) into a negative image, which is identical to an inked fingerprint card.

- 4) Grayscale: The grayscale function can be used to convert colorful images into gray tones and enhance readability or legibility of the image even with a colorful background. Therefore, developed fingerprints on a colorful magazine cover do not have any interfering contrast in the background during an examination.
- 5) Mosaic Effect: The Digital Imager can also display Mosaic Effect on a certain portion of the image and make it illegible. With this function, an examiner can focus on a certain portion of a fingerprint.
- 6) Scanning Capture: Installed separately, a Twain driver application program allows the Digital Imager to scan and capture full-size images (1024 x 768) of a fingerprint in a full size or a screen full mode. In other words, the scanning capture function opens a new potential possibility: connecting the Digital Imager with existing portable AFIS or IAFIS systems.

Digital Comparison for Elimination and Identification

Since the Digital Imager employs digital technology, several modes of comparison can be utilized for elimination and identification depending on the purpose of the task.

A. Direct Comparison

The Digital Imager has a relatively larger field of view, it is possible to place a known (exemplar) print and an unknown print side-by-side on the examination stage for a direct comparison. Using the Wide or Tele adjustment function, two lifted fingerprints can be viewed side-by-side. For example, hinge tape cards (2" x 2") are used to lift two fingerprints at a crime scene. The left print was developed from the wood floor using the Liquid Lifter and the right print was lifted from a kitchen tile using the black magnetic powder. Now the two fingerprint cards can be placed side by side on the examination stage for analysis and comparison for the detail characteristics on the two fingerprints.

B. Dividing Comparison

The image dividing function allows for a side-by-side comparison of one image (e.g an exemplar) from its pre-stored image memory or database and another image from the crime scene (an unknown print) through either the Control Panel or the Mouse Control.

C. Digital Drawing

The Digital Imager has another function useful for fingerprint analysis and comparison. Digital drawing can be displayed on the computer or projection screens. The drawing can be saved or deleted as desired. The drawing capacity can be accessed via the Mouse Control (the GUI menu) or Control Panel. There are four types of drawing tools available: Straight Line,

Freehand Line, Rectangular, and Eraser. These functions can be done using the icons, dragging the cursor, and releasing the cursor. These functions allow for the examiner to quickly and easily draw lines or areas of interest on a fingerprint image.

D. Digital Projection/Presentation

Traditional courtroom presentations have consisted of enlarged pictures, charts, diagrams, and illustrations. Since the mid-1990s, various electronic technologies such as Power Point or Adobe Photoshop have been introduced. However, neither Power Point nor Adobe Photoshop is designed for a live presentation of an analysis and/or comparison. The Digital Imager allows an examiner to simultaneously analyze, compare and project the fingerprint evidence from a crime scene in a police meeting room, a crime lab, a DA's office or even a courtroom. In addition, the following three types of presentation can be conducted to project other types of evidence (bullets, casings, or shoeprint) using the Control Panel, Mini Control Panel, Stage Control Panel, Mouse Control, or Remote Control.

- 1) Original Documents: The Digital Imager has a larger field of view and adjustable zoom for actual evidence, for example, a ten fingerprint card, counterfeit money, a fake driver's license, paint chips, or glass fragments.
- 2) Recorded Images: Using a USB connection, captured digital images from examinations can be stored to a computer hard drive and then forwarded to a thumb-drive, memory card (SD), external drive, or portable database. Digital images can be printed from a laser color printer. In addition, the pre-recorded or stored images can be viewed and presented directly using the Digital Imager.
- 3) Live Presentation: The most unique function of the Digital Imager is the live presentation to demonstrate an analysis and comparison process. This function is especially important when dealing with adversarial questions or challenges on any steps in the fingerprint elimination and identification.

Discussion

While the application of digital image technology in law enforcement and forensic science examination shows great promise, it is not without concern. There are three common arguments regarding digital imaging use for forensic purposes.

First, digital images are more subject to manipulation than film images, and thus, less reliable. However, the Digital Imager can duplicate, verify, and demonstrate all steps in the analysis and comparison process to answer any questions or challenges from a judge or counsel. In addition, the duplication process can be conducted in a live manner during cross-examination in the court room.

Second, it is commonly believed that digital image quality is not as good as that of traditional film. This argument was true about 10 years ago (or around the year 2000), but current digital image technology has been greatly improved for image quality. The Digital Imager can provide an image with up to 2 megapixels, which is much better than that of traditional film. In the near future, the Digital Imager will probably reach 5 megapixels, providing a crystal-clear picture since a digital camera with 16 megapixels is available in the current market.

Although the admission of digital images in court is still under discussion due to the Daubert requirements for admissibility and reliability, the fact remains quite clear that the digital image technology is well-accepted by the forensic science community and the general science community. As a matter of fact, many courts have accepted digital images under the Daubert criteria. Coppock [4] predicts that there is no doubt that eventually digital photography will completely replace traditional photography.

While the Digital Imager offers many useful and unique functions, the chain of custody, storage management, and proper operational protocols must be emphasized and followed. Two leading professional guidelines should be considered. The Scientific Working Group on Imaging Technologies [6] offers its guidelines, facilitating the interpretation of imaging technologies and systems within the criminal justice system by providing definitions and recommendations for the capture, storage, processing, analysis, transmission, and output of images. Another official document being adopted by the IAI, SWGFAST [7] for Quality Assurance Guidelines for Latent Print Examiners recommends updated guidelines for friction ridge examination.

Conclusion

This study has proven to allow for the observation of four advantages of the Digital Imager. First, when compared with Adobe Photoshop technology, the Digital Imager is much easier to use. Within a few minutes, the examiner can simultaneously start an analysis, conduct a comparison, and make a presentation. Second, the Digital Imager has a digital camera with its software to connect to a projector and make a live presentation. It can also be connected to a laptop or PC for the purpose of a detailed analysis and comparison. Third, the original image of the fingerprint is not affected at all by the digital processing. Digital processing was not detrimental to the fingerprint evidence. Finally, the Digital Imager has several advantages for crime scene investigation: 1) Digital recording allows instant review of a recorded image; 2) Digital images can be easily processed with other applications, such as enhancement or special effects for details; 3) Digital images can be easily filed, stored, and transferred between locations; and 4) Digital images can be easily duplicated for other uses--department mug shot files, digital photo line-ups, and gang tattoos. It is predicted that the Digital Imager will gradually gain acceptance and merits for crime scene investigation, crime lab analysis, and courtroom presentation and eventually become a practical and useful tool for forensic investigation.

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