

Digital Imaging Technology In The Modern Crime Lab

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Abstract

The modern forensics laboratory utilizes extensive imaging of evidence, including crime scene documentation, fingerprints, tool marks, medical images, imaging of handwriting and questioned documents, and ballistics. The traditional workload for imaging has been with silver halide based film. However, with the advent of digital imaging technology, in the form of professional SLR digital cameras, flatbed scanners, film scanners, and imaging computer workstations, digital photography represents and new era for the crime lab. This paper describes a recent project conducted by the Indiana University Institute for Forensic Imaging to develop and install state-of-the-art digital darkrooms in several State of Indiana forensic laboratories.

Introduction

Modern criminal investigations utilize a great deal of images to accomplish evaluations such as, but by no means limited to:

- fingerprint searches and comparisons
- tool mark comparisons
- medical examinations
- analyses of questioned documents
- ballistics and weapons comparisons

Currently, the most common practice is to use conventional photography and/or instant-film photography to facilitate the imaging work. While these approaches are effective, they consume costly materials and/or involve a considerable amount of both investigator and analyst time. Also, in the case of traditional photography, there is a required break in the analysis to allow for processing of film. Recently, a new technology has become available, digital photography. With a digital camera, images are immediately available, as is the case with video and instant film, but the images are recorded on magnetic disc or flash cards, and if they are not saved, consume no materials. In addition, the images are immediately available to an image processing computer workstation, where image enhancements, such as elimination of backgrounds from latent prints, or analyses, such as measurements, can be accomplished in seconds. This allows investigators to pursue advanced analyses in minutes, such as the overlay of a series of images of suspected weapons on top of properly sized and positioned images of wounds to see if any can be matched. To assure integrity of evidence, images that are to be kept can be recorded promptly on writable compact discs (CD's), which provide excellent means to archive records of images. Properly designed digital imaging systems can also work with video and film originals as well.

Under a State of Indiana grant to Indiana University, the Institute for Forensic Imaging (IFI) recently conducted a development and installation project to place digital imaging darkrooms in several Indiana law enforcement crime labs located throughout the state. Site installations included Indiana State Police crime laboratories at Lowell, Ft. Wayne, Evansville, and Indianapolis, Indiana. Additional systems were installed at the Indianapolis-Marion County Forensics Services Agency lab in Indianapolis, and the forensic pathology laboratory, IU School of Medicine. To date, approximately fifteen personnel from the Indiana State Police-Laboratory Division, Indianapolis/Marion County crime lab, and IU School of Medicine-Forensic Pathology Group have been trained and certified in the application of these modern image capture and enhancement stations for forensic analysis.

Digital Darkroom for the Forensic Laboratory

Input Image Capture Requirements

Imaging of evidence can take many forms. Images from the crime scene itself, taken by a professional crime scene technician, are usually in the form of 35mm color negative film. At the crime lab, forensic examiners may use 35mm, medium format, or large format negative film to generate working images of latent prints, handwriting, or other physical evidence. Most crime labs have a least one conventional wet chemistry darkroom to support conventional film processing. The design of a digital darkroom should support the current practice of lab technicians and examiners, and leverage on their existing expertise in professional photography. To this end, one popular digital capture device to enter the modern crime lab has been the professional SLR digital camera.

Figure 1 illustrates one popular digital SLR digital camera model, the Kodak™ DCS 420, which has been acquired by many law enforcement agencies throughout the USA and the world since it's introduction in the early 1990's. The DCS 420 is a modified Nikon N90s. The film back has been replaced with a 1524 × 1012 progressive scan CCD array. The camera is available in an IR, color-IR, color, or monochromic model. The N90s body design can be used with an array of professional lens, filters, and lighting, allowing the photographer, in many cases, to use existing tried and proven conventional camera imaging techniques. A high resolution 3000 × 2000 pixel version of also available, known as the DCS 460. Also, both resolution models are available utilizing a Canon™ EOS 1n body.

Figure 1: Kodak™ DCS 420 Professional SLR Digital Camera

Although these cameras offer excellent opportunities to conduct digital image capturing, the resolution and CCD image area size represent limitations. For example, if the desired image is larger than approximately 4cm, higher resolution per cm is possible with a flatbed scanner than with the 420 digital camera. The flatbed scanner is especially useful to forensic document examiners, who routinely deal with large images such as checks and legal size paper.

If image evidence was originally captured with conventional film, such as 35mm negatives from a crime scene, utilizing a film scanner to digitize the image insures that maximum resolution, as thus image information, is preserved in the digital image.

Finally, if the crime lab is responsible for analysis of video surveillance tapes, a real-time 30fps video capture adapter should be part of the digital darkroom.

Output Image Requirements

Chain of custody and archiving/storage of digital images used as evidence, or part of evidence analysis, which may be used in the courtroom, is critical. Due to the typical large file size of high-resolution digital images, output devices must have significant capacity. One popular storage medium is the CD-Writer. Additional media include ZIP™ and JAZZ™ drives.

For hard copy production of digital images, a dye-sublimation printer can produce excellent results. However, these printers tend to be expensive, and unit image cost is high when compared to conventional film prints. Photographic quality inkjet technology is improving rapidly, which offers significant cost reduction in both capital expenses of the printer and unit image cost.

System Integration

Figure 2 shows a current digital darkroom design developed at IFI. Components illustrated in the image, from left to right, include:

- 21” 1280 × 1024 @ 90Hz Video Monitor
- Computer Platform:
  - Intel™ Pentium™ Pro Motherboard
  - 64MB RAM
  - 32-bit 8MB VRAM Video Adapter
  - 4GB Fast SCSI-II Hard Disk Drive
  - CD-Writer
  - CD-Reader (CD-to-CD copy)
  - Internal 100MB ZIP™ Drive
  - Internal 1GB JAZZ™ Drive
  - Internal Nikon™ 35mm Film Scanner
  - PCI Fast SCSI-II I/O Controllers
- HP ScanJet™ 6100C Flatbed Scanner
- HP PhotoSmart™ Inkjet Photographic Printer
- Kodak™ DS8650 Dye-Sublimation Printer

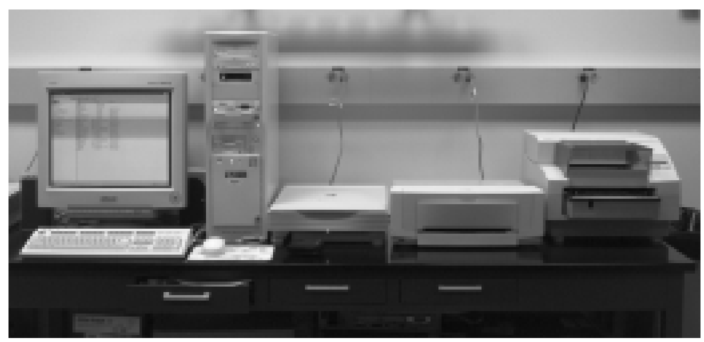

Figure 2. Prototype Forensic Digital Darkroom

Forensic Imaging Enhancements

One of the primary functions of a forensic digital darkroom is to enhance an image in some way that will assist the examiner in their analysis. Over the past two years, IFI has developed several software routines and Standard Operating Procedure (SOP) profiles in this area. Many of the enhancement routines have been incorporated into the darkroom host image processing package, Adobe PhotoShop™. as filters. Figure 3 illustrates a recent IFI enhance list, with include:

- Fast Forward Fourier Transform (FFT)
- Inverse Fast Fourier Transform (IFFT)
- Mask and IFFT
- Analyze (Microdensitometer)
- Sizing (Scale Calibration)
- Grid

Application of the Fourier Transform to an image to reduce background interference of latent prints has been recently documented[1-3]. Figure 4 shows the resultant FFT of a typical latent print superimposed on a halftone background such as found in newsprint. The spikes in the image represent the strong high frequency signature of the halftone background pattern. The fingerprint signature can be seen as a narrow low frequency ring near the center (zero frequency). Using a visual low pass filter masking technique on the FFT image, the desired elements of the image, i.e. the fingerprint, can be separated from the high frequency background. Performing an inverse FFT on the masked/filtered FFT image returns the desired image to spatial space.

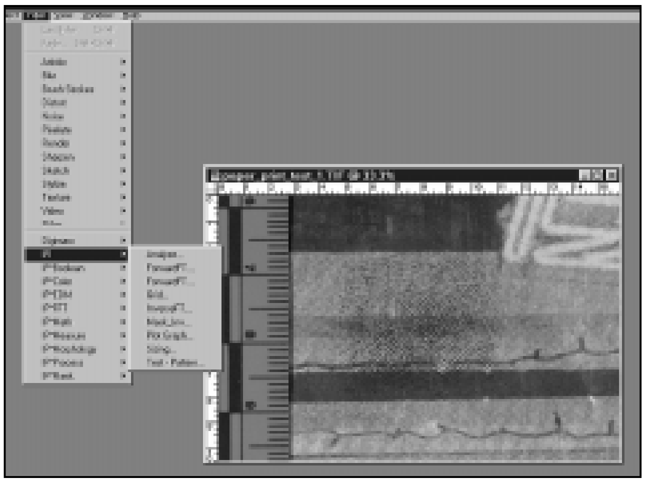

Figure 3: IFI Forensic Filter Enhancements to PhotoShop™

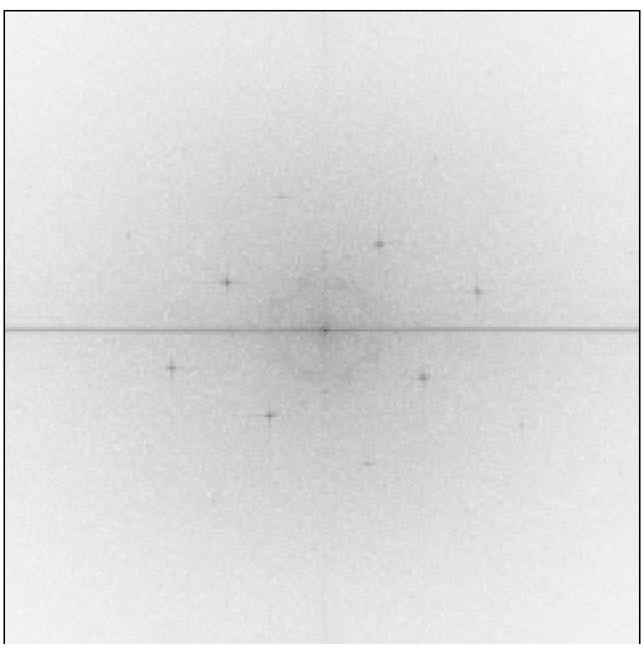

Figure 4: FFT Signature of Latent Print with High Frequency Halftone Background

Figure 5 illustrates the Analyze/Microdensitometer filter. Utilization of this filter assist's laboratory technicians in characterizing the modulation transfer function of imaging systems, and developing signatures of DNA gels for analyses by forensic DNA experts.

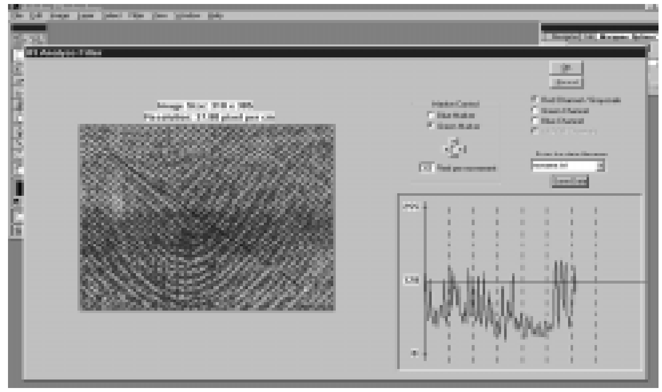

Figure 5: IFI Analyze Filter

Figure 6 illustrates the Sizing filter. This filter is use to calibrate the unit distance measure of an image based on a known dimension in the image, such as a ruler. The user can select any value of magnification, such as 1X, 2X, etc.

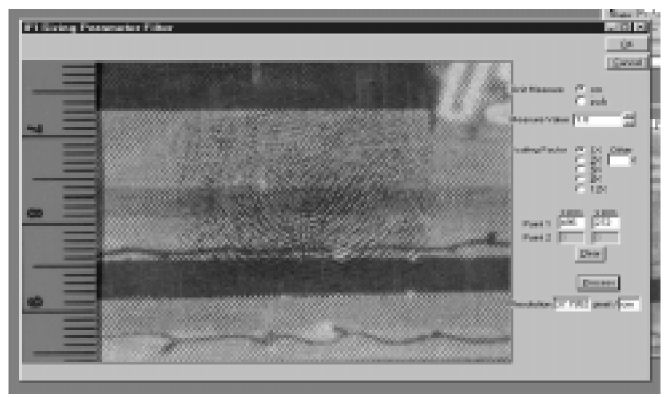

Figure 6: IFI Sizing Filter

A common practice in forensic document examination is to check the alignment of type on a document. This is done to determine if text on the document was generated on two separate occasions. Figure 7 illustrates the Grid filter, which allows the examiner to generate an electronic grid overlay on a given image with control of both the horizontal and vertical lines.

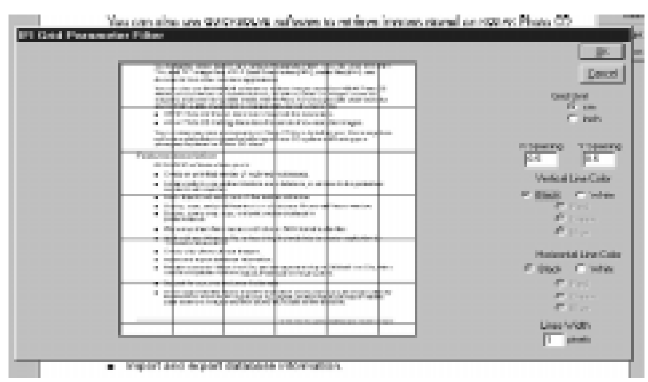

Figure 7: IFI Grid Filter

Summary

The digital capture and processing of images is becoming a technically attractive and cost effective alternative to conventional photography for the forensics laboratory. The trend toward utilization of digital image technology in the crime lab will only increase as digital input capture devices, digital image output devices, and imaging workstations become more powerful and affordable.

References

1. W. J. Watling, *Journal of Forensic Sciences*, **Vol. 43, No. 6**, 573-584, 1993.
2. S. K. Bramble, G. R. Jackson, *Journal of Forensic Sciences*, **Vol. 39, No. 4**, 920-932, 1994.
3. S. K. Bramble, P. M. Fabrizi, *SPIE Proceedings*, **Vol. 2567**, 138-144, 1995.