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CURRENT AND FUTURE USE OF IMAGE PROCESSING

Alan L. McRoberts
Los Angeles County Sheriff's Department
Los Angeles, California

In July of 1983, a housewife was killed in a homicide in a Los Angeles suburb. There were 327 other homicides in Los Angeles County that year, but this homicide introduced image processing to the Los Angeles County Sheriff's Department criminal laboratory.

The female victim was discovered lying in her garage next to an open tool box. A ladder was lying on its side next to the body. The husband, who notified the Sheriff's Department, offered the theory that his wife had fallen from the ladder and struck her throat against the open tool box. Investigators, upon examining the scene, observed faint fingerprints on a bloodstained area on the tool box lid. The husband denied having touched anything after the "accidental fall."

The tool box was taken as evidence and transported to the laboratory for latent print processing and blood analysis. The evidence was processed with cyanoacrylate fumes and fingerprint powder. A print of marginal quality was developed, photographed and lifted. Both the lift and the photograph revealed that the tool box had a surface texture that interfered with the visual comparison of the print detail. Photographic filters, misfocusing and lighting techniques were employed in an attempt to eliminate the problem but without success. Despite the visual interference, a comparison against the husband's fingerprint exemplar was attempted. Several minute details, or characteristics, were observed in the evidence print that matched the husband's exemplar. These few characteristics, however, were insufficient for the examiners to make a positive identification.

Our homicide investigators were aware that Infrascan, a Canadian Electronics Company, was marketing an analog-digital image processing system. We sent a fingerprint expert to Canada with the evidence. Through the use of this system, enough detail was observed in the tool box print to effect a positive identification.

The techniques used to enhance the fingerprint detail were either analog or video processes. Slightly misfocusing the image reduced the interference of the surface texture. It is recognized that this technique also can be applied photographically. Direct, on-screen viewing of the effect, however, allows for more precise control. The use of the video "offset edge enhancement" provided better subject to background separation and additional contrast. This enhancement is the electronic superimposing of a positive and negative of the image with a slight offset to create an artificial highlight.

In this examination, the digitization of the latent print image was used to facilitate the orientation of the two prints being examined, but because of the limited resolution of the digitized image with the original Infrascan system, only the video-enhanced image was used in the final comparison.

Through the use of the analog-digital image processing system, the evidence print was successfully examined and identified. The case proceeded into the court system but came to an abrupt halt when the suspect committed suicide before the preliminary hearing.

The success of the tool box case and the obvious advantage of this technology prompted the Los Angeles County Sheriff's Department to purchase the Infrascan system. Identification Unit personnel (latent print examiners) of the Scientific Services Bureau have been the principal operators of the system since its acquisition and delivery in late 1984.

The system has been beneficial as a comparator device, far superior to conventional apparatuses. The use of video cameras and monitors to control brightness and contrast is often useful in making difficult comparisons. It occasionally makes the difference in whether or not a fingerprint identification can be made. During examinations of latent prints, where the contrast can be improved photographically, the examiner has the ability to control the density and degree of contrast instantly instead of waiting hours or days for the photographer or laboratory technician to modify those factors. The system has also been valuable with fingerprints on surfaces that normally would be very difficult to photograph. When misfocusing and/or difficult lighting arrangements are necessary, this system is more convenient and often superior to conventional photographic methods.

In October of 1985, the Identification Unit personnel took delivery of the Department's first laser, a Cooper-Lasersonics, 13-watt, double-ended, copper-vapor laser. The laser is another one of the technical advances benefiting the forensic sciences and specifically latent prints. The use of the image processing system to view and evaluate laser prints is extremely
effective. Through examination of the enlarged fingerprint on the television monitor, latent prints of insufficient quality for comparisons can be eliminated without being photographed.

The video portion of the system consists of two matched commercial-grade monochrome video cameras (with 1-inch Newvicon tubes) adapted to a standard 35mm camera lens mount. Having dual cameras allows the operator to view two live images for comparison. The Newvicon tube provides spectral resolution similar to that of the human eye and is not as subject to image burn as are many other types of camera tubes. The Infrascan system uses a video switcher for overlays of one signal on the other or for various split-screen applications. A special effects generator provides the video enhancement processed, such as the edge enhancement or image polarity reversals. A video recorder documents examinations for later reference. A selector on the side of each camera offers the operator image position control such as mirror imaging. This left-to-right transposition of the image is sometimes necessary when prints are viewed directly from a finger or through the surface on which the print is found, such as the underside of cellophane tape or a print on the inside of a drinking glass.

Our original system was equipped with two monitors, a monochrome monitor for menu or program display and an R.G.B. color monitor for image examination. After using the system for a short time, we added a second color monitor. The new monitor displays the main camera's unprocessed image, and the R.G.B. monitor displays the images of either camera and any processed or enhanced images.

The Infrascan system presently in use at our laboratory is configured with the Apple II computer system. This system has some shortcomings in the area of resolution (only 256 × 192 with single-bit quantization). The laboratory plans to upgrade the system based on the IBM AT computer.

The IBM computer system supports an analog-digital converter with a digital resolution of 512 × 512 picture elements with 8-bit quantization. This should be considered a minimum standard for all future installations.

This minimum standard affords the complete digital storage and retrieval of an image obtained through the video system. With a complete image captured digitally, the door is open for true digital image enhancement.

There are numerous image processing techniques, but for those of us in fingerprint identification, the end result is most important. In latent print examinations, contrast manipulation or variation is of great value because the computer is better than the human eye at making distinctions between gray tones. A continuous-tone black and white photograph can render approximately 40 shades (tones) of gray, whereas the human eye can distinguish only between 16 and 32. A computer with 8-bit quantization can discern and record 256 different shades. When prints that are too dense or too thin are examined, a histogram of that image can depict high concentrations within small tonal ranges of the histogram. By varying the gray tones represented by the histogram, one can spread them out so that the individual shades are more discernible. The ability to control arbitrarily the contrast in real-time so that the effects can be evaluated immediately is of great benefit. Edge enhancement or edge sharpening using digital image processing rather than video techniques is also beneficial in latent print comparisons; because it creates a more distinct separation between image detail and background, the detail is more readily recognizable.

False, or pseudo, color assignment also can be employed to discern different gray tones. Even though the human eye can discern only approximately 30 shades of gray, it can distinguish several thousand different colors. By assigning arbitrary colors to represent various gray tones, the human eye is more capable of distinguishing between those tones.

Geometric transformation (rubber sheeting) can be used to provide modified view perspectives. Latent prints are often distorted because of excessive pressure or slippage. These distortions, however, can be corrected by a geometric transformation technique. In some instances, the corrected view may help to make a better exhibit of a badly distorted fingerprint.

Two other aspects of digital image processing are beyond the scope of this paper other than for reference. These are Automated Fingerprint Identification Systems (AFIs), a computer system capable of searching an inked exemplar against a database to identify the subject, and Automated Latent Print Systems (ALPs), a computer search system that can identify latent prints developed at a crime scene. Because of these automated systems, the science of fingerprints is now receiving more recognition than it did a decade ago when it was only through a television writer's pen that a single partial print at a crime scene could identify an unknown suspect. Now, however, through automated searching techniques and equipment, it has become a reality. To maximize those benefits, we must obtain more and better latent prints for automated searching. Image enhancement of latent prints can be
used to improve the quality of some prints previously unacceptable for automated search.

Image processing is also used for image restoration to improve or clarify photographs. Two techniques of image restoration are deblurring and image averaging. The benefits of these are obvious in the processing of surveillance photographs, where the contrast levels are frequently low and the image is occasionally blurred. Bank-type security videotaped images can be improved through the use of image restoration and enhancement techniques.

Latent print examiners across the country react differently when image enhancement of latent prints is discussed. Often, the initial reaction is one of disapproval. The concern is that nonexistent detail is added to the latent print. This skeptical attitude can be eliminated only through education. Image enhancement techniques are not designed to create detail but to differentiate or improve detail already contained within an image. Just as photographic techniques assist us in seeing various spectral ranges (for example, infrared) and microscopes help us to see extremely small items, image enhancement techniques can help us to discern slight tonal differences in an image (Figure 1).

Will digital image processing be acceptable in court? As of this date, the author is aware of only one criminal case in which digital image processing was used to enhance a latent print and effect an identification. This identification subsequently proceeded to the point of obtaining a judicial decision with regard to acceptability. Unfortunately, this particular case, in the early 1970's, did not receive a favorable court ruling and the evidence was not permitted. The court's ruling stated that the new techniques used must have general acceptance in that particular field. With the increased awareness and interest in image processing, as demonstrated by this symposium, common acceptance is soon to come.

Analog-digital image processing has already proved its laboratory value to the Los Angeles County Sheriff's Department Identification Unit in several cases. With upgraded capabilities and expanded uses for this technology, we are anxiously looking forward to its future.

Figure 1. (a) The unenhanced digital image of a latent print. (b) The results of one enhancement technique used on the digital image. The technique, contrast manipulation, varies the different gray tones for improved acuity. Both photographs were taken with a 35mm camera. The photographs were taken of images depicted on the R.G.B. monitor of the Infrascan IBM AT image processing system.