

Background Subtraction Through Exhibit Substitution

Brian Dalrymple

*Brian Dalrymple & Associates
Orilla, ON, Canada*

Abstract: Previous articles have described a process for the elimination of background from fingerprint and other images by subtracting the background. Two options, filtration and erasure, have been discussed. Channel subtraction, either in RGB (Red, Green, Blue) or HSI (Hue, Saturation, Intensity) mode, can also be effected with variable results. There exists a fourth option: substituting another item of the same type in exact register to obtain a substitute background image for purposes of the subtraction.

Equipment

All images were captured with a Nikon Coolpix 995 digital camera on a copy stand. The images depicted herein were captured in JPEG format as 24 bit RGB images, for ease of transmission and publication, although TIFF is used for operational procedures. It is suggested that images be converted to gray scale after the subtraction has been done, although both options may be exercised to determine the optimum result in each case.

All images were processed with the subtraction function of ImagePro (Version 4.5.1). This process is dependent on the user's ability to accurately register the substitution image. Any software with this capability may be used.

Method

A fingerprint was placed on a \$20 Canadian bill (Figure 1). This surface exhibits obstructive background and is frequently encountered as an exhibit in a variety of investigations. Currency poses a particular challenge in obtaining optimum fingerprint images for the following reasons:

- The background is highly complex and is often randomly varied, making it, on many occasions, a less than suitable candidate for Fast Fourier Transform.
- The inks in currency are difficult to filter in a spatial approach to background suppression and may vary frequently in hue across the printed surface. Consequently, the use of a color filter may actually increase the strength of part of the obstruction.

However, currency offers an ideal surface for exhibit substitution because of the high quality and dependability of the engraving. Accurate, pinpoint locations for registration are easily located.

An image of the fingerprint was digitally captured.

Another similar piece of currency in excellent condition was used to obtain a background pattern image. On a different day, the same general area of the pattern obstructing the fingerprint on the previous bill was captured (Figure 2). The focus, alignment, and image size of the original capture were not preserved on the camera, but were emulated for the second capture. The normal copy lighting had also not been changed. Although the size of the two images was similar, the images were not identical.

Using the registration function in ImagePro, the second image was brought into register with the first image (Figure 3).

The registered background image was then subtracted from the first image (Figure 4).

Procedure

- Open both images in ImagePro Plus. When the registration feature is opened, four registration marks, numbered 1 through 4, will appear on each image.
- Move each registration mark on each image to the general location of a selected identifier in the background. The identifier should be extremely specific and easy to locate in both images.
- Enlarge each image with the Zoom function to approximately 10 times original size, centering on the registration mark 1 and the first selected identifier.
- Position the registration mark as exactly as possible on the selected identifier on each image.
- Return both images to their original size.
- Repeat the process for registration marks 2, 3, and 4 on each image.
- On the opened Registration window, select the option to transform the image of the background into the image bearing the fingerprint.
- Press “Register”.
- Save the resulting image under a new name.
- Open the Subtraction window and subtract the newly registered background image from the one bearing the fingerprint, or vice versa.
- Save the subtracted image.

Observations

The background interference clearly evident in the first image has been reduced significantly, as have the printed words that run into the fingerprint area. The fingerprint detail is consequently easier to examine.

Channel Subtraction

One other subtraction option may be exercised in ImagePro or Adobe Photoshop. The RGB or HSI channels may be displayed and subtracted, one from the other, in any combination desired. This option offers both advantages and limitations: The procedure is accomplished quickly and requires only one image. Also, it can be done after the fact, without prior anticipation and preparation. The image need only be captured as a digital image file. If, however, the desired signal (fingerprint, shoeprint) and the obstructing background both consist of complex colors, a gain in clarity of the fingerprint detail by subtracting the channels may not be realized.

Conclusions

Four options exist for optimizing clarity of digital images through background subtraction. Only one (erasure) is invasive and requires the destruction of the evidence impression.

1. The filtration option may be exercised when the desirable feature of the image is capable of being removed by a filter, as in the case of a ninhydrin impression. It will yield the best results if the background is not multicolored, but rather is comprised predominantly of one color.
2. The erasure option may be the only option if the desired image feature (e.g., shoeprint) is composed of black, gray, or white, rather than a hue, which may be filtered.
3. Channel subtraction may be attempted when the desired feature and the obstructing background are comprised of dominant, but complimentary, hues or can otherwise be isolated in specific channels. In any case, nothing is lost in the attempt.
4. The substitution option may be the best option and a noninvasive alternative to erasure when the desired image feature is black, gray, or white; the background is multi-colored; and the background pattern is high-resolution and a virtually indistinguishable substitute

can be obtained, as is the case with currency. In order to achieve optimum results, the following must be true:

- a. The background detail of the substitute exhibit must offer locations for exact registration and must be virtually indistinguishable from detail in the original exhibit.
- b. When recording the substitute image, every effort must be taken to emulate the lighting, camera position, and image size of the original capture.

Although the images in this study were processed in ImagePro Plus, filtration, erasure, and channel subtraction may also be completed successfully in Photoshop. The key with exhibit substitution is precision registration, an operation conducted easily in ImagePro. If registration of similar accuracy can be completed in other software options, the subsequent subtraction can be done equally successfully.

For further information, please contact:

Brian Dalrymple
Brian Dalrymple & Associates
PO Box 296
Orillia, ON L3V 6J6
Canada
info@briandalrymple.com

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Figure 1
Image of fingerprint on currency.

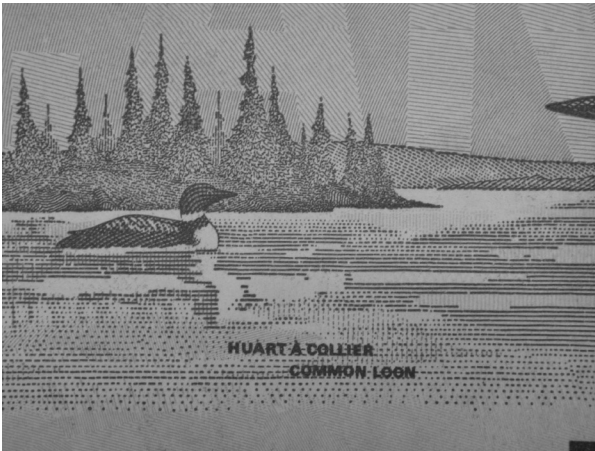


Figure 2
Image of background captured on substitute currency.

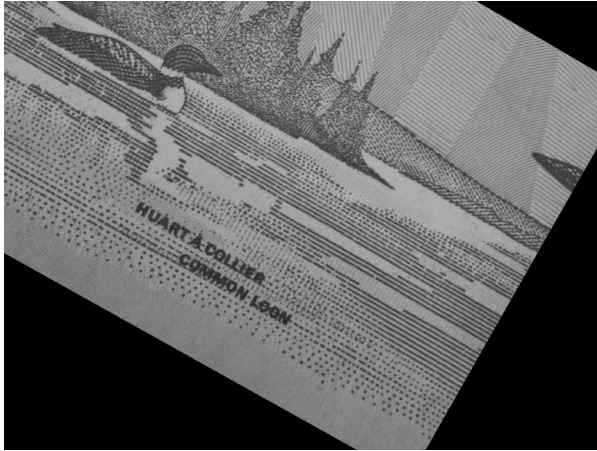


Figure 3
Background image after registration.



Figure 4
Image of fingerprint after subtraction.