SHOEPRINT IMAGE ENHANCEMENT USING ADOBE® PHOTOSHOP® AS AN AID DURING FORENSIC COMPARISON

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ABSTRACT: Recovery of shoeprints from crime scenes could provide useful information during forensic investigation, especially linking a suspect to a crime. Unfortunately, many shoeprints might appear faint as opposed to various backgrounds thus limit the possible matching between questioned prints and the known prints or suspect's shoes. Additionally, conventional physical and chemical enhancement techniques often destruct the integrity of shoeprints at a crime scene. Therefore, this study is aimed to explore the utilisation of commercially available image processing software Adobe® Photoshop® CC for forensic enhancement of shoeprints. Five shoeprints made using black ink from stamp pad as residue on different surfaces, namely newspaper, rubber mat and carpets were photographed using a Canon EOS 40D Digital Single Lens Reflect (DSLR) camera. The shoeprint images were then digitally enhanced using the software through the application of adjustment and filter tools of the image processing software. This study demonstrated the successfully enhancement of shoeprint images by either fully or partially reducing background noise to contrast the patterned area of the prints from the backgrounds in a non-destructive manner. The isolation of the shoeprints from the background has improved the clarity of the shoeprints thereby aiding in further forensic comparison and identification.

Keywords: forensic science, Adobe® Photoshop®, image enhancement, shoeprint.

Introduction

Locard's exchange principle states that every contact leaves its trace. When a criminal with footwear enter and/or exit a crime scene, he/she would leave traces of shoeprints [1]. Therefore, the presence of shoeprints with distinctive characteristics can decisively link a suspect with a crime scene. Additionally, such evidence can also provide other useful information for forensic investigation, including the number of people involved as well as their respective movements in a particular incident scene [2]. In view of this, successfully recovery of these prints is of great importance during forensic investigation, particularly for the establishment of positive identification through the matching of questioned prints with the known suspect items [3,4].

Depending on the nature of the surface, shoeprints can appear as plastic, latent or visible prints. A plastic shoeprint is formed when footwear is stepped into soft surface materials, such as mud or sand to create a three-dimensional impression. This print is normally casted after being photographed. A latent shoeprint, as its name implies, is not readily visible under unaided eye. Nonetheless, it can be made visible using suitable enhancement chemical or light source prior to photography. On the contrary, materials such as soil, blood or even dust can be transferred from the sole of the footwear and deposited onto a surface to form a visible print. In certain instances, subsequent chemical enhancement may be needed if it is faint. Electrostatic lifting could be applied if the prints are in dust. Although visible prints are readily seen, the background surface where they deposited on frequently restricted the forensic comparison of the questioned and reference shoeprints. In this study, visible shoeprints which appeared to be faint or unclear as opposed to various backgrounds were examined and enhanced digitally to reveal greater details of the shoeprints prior to the application of subsequent analyses.

Several researchers have attempted to enhance scanned fingermarks [5], fingermarks and shoeprints [6,7] using digital software. This study utilised commercially available Adobe® Photoshop® CC software with the latest image

adjustment tools, filters, repair and restoration techniques for image enhancement [8,9]. The availability of history log in the software is essentially a useful feature in forensic application to help maintaining the chain of every adjustment which can be saved automatically to the metadata of the image, text file or both [7]. Additionally, specific workflow option based on adjustment analysis can also be created [9] rendering it a useful forensic tool, especially where maintaining the chain of custody is crucial. The aid in correcting shoeprint images deliberately taken at certain angles determines also their evidential values [10].

This study is aimed to provide field-specific contribution in demonstrating the applicability of simple digital image enhancement, and thereby breaking through the current limitation of forensic shoeprint investigation. Without destructing the evidence as could have occurred in the conventional physical and chemical approaches, shoeprint images that simulated real crime scene scenario were captured and subsequently processed digitally in this study. The various workflow options for image enhancement of photographed shoeprints at common background materials, commonly encountered during crime scene investigation were also explored.

Material and method

The outsole of a shoe (Power®, UK size 6) was painted evenly with black ink from a stamp pad. Shoeprints were then deposited onto five different types of surfaces, namely white A4 paper as positive control, newspaper, red coloured carpet, dark brown and black stripes carpet, and also multi-coloured rubber mat. Each shoeprint was photographed (in close-up range and at the same range of length with fired flash) using Canon EOS 40D digital Single Lens Reflect (SLR) camera with a Canon macro lens EF 100 mm USM. All images were saved in raw file format.

The original images were copied without any alteration and used for enhancement process based on different techniques using Adobe® Photoshop® CC software [9]. Camera Raw Filter was used together with other adjustment and filter tools including histogram equalisation, colour adjustments and sharpen filters [11].

Digital enhancement was initiated by duplicating the selected shoeprint image. The background layer was then unlocked and a layer was added to the duplicate image so that the enhancement process could be carried out without altering the image permanently. Next, the histogram, colours such as greyscale mode, hue/saturation, brightness and contrast, and filters were adjusted to obtain a clear image with no disruption of the background image. All images captured on different surfaces were enhanced in similar way. All processed images were saved in the Tagged Image File Format (TIFF). Figure 1 summarises the general flow of image enhancement in this study.

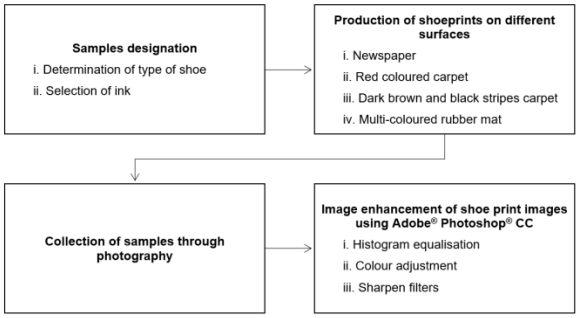

Figure 1: Methods of enhancement of shoeprint images.

Results

Digital enhancement on shoeprint images could have revealed further details of forensic information, including the class and individual characteristics of shoeprints. The comparison of shoeprint images before and after digital enhancement is depicted in Figure 2 to Figure 5, as described in the following section.

Shoeprint on Newspaper

Image was converted to Grayscale to facilitate the removal of background as there was only a small coloured portion of the newspaper. Radial Filter of Camera Raw Filter was then selected to remove the background of the black and white image. The background image was successfully removed without altering the shoeprints, Figure 2.

Shoeprint on Red Coloured Carpet

Unsharp Mask was applied onto the shoeprint image. The image was further enhanced using Black and White adjustment tool. The shoeprint image on the red coloured carpet was successfully enhanced. It is worth noting that the black portion of the carpet could not be fully removed as it would affect the black shoeprint. Nonetheless, the outline of the print could still be clearly observed, Figure 3.

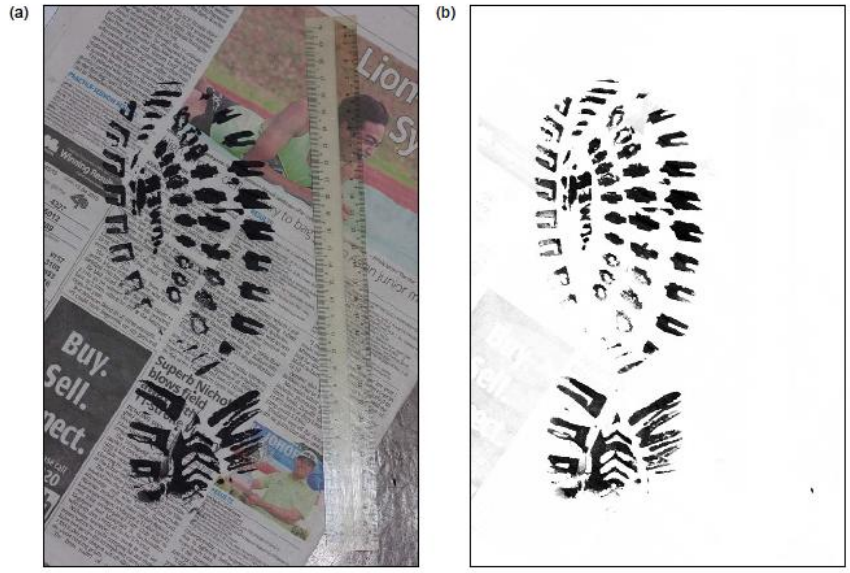

Figure 2: Shoeprint on newspaper; (a) original image; (b) enhanced image.

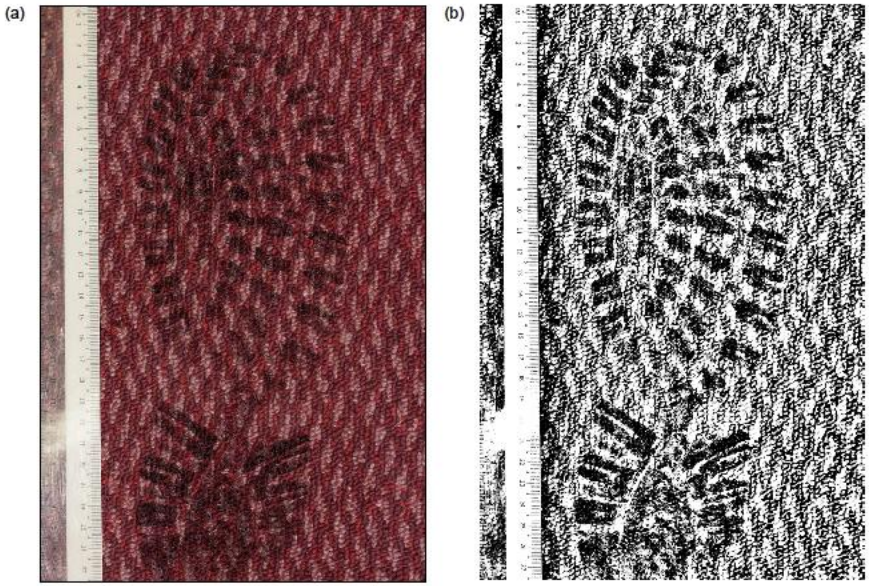

Figure 3: Shoeprint on red coloured carpet; (a) original image; (b) enhanced image.

Shoeprint on Dark Brown and Black Stripes Carpet

The process of enhancement was initiated by applying the Camera Raw Filter. Exposure, Contrast, Highlights, Shadows and Clarity, Sharpness Level and the Noise Reduction were adjusted accordingly. The Reds and Oranges of the Saturation and Luminance were changed, followed by the adjustment of Exposure and Image Contrast. The image of the shoeprint on the dark brown and black carpet was partially enhanced to reveal the shoeprint characteristics, Figure 4. The presence of black stripes on the carpet was found to have restricted further enhancement.

Shoeprint on Multi-Coloured Rubber Mat

Due to the multi-coloured background, Channel Mixer adjustment, Brightness and Contrast, Levels adjustment, Colour Lookup, Invert tool, and Selective colour adjustment were applied onto this shoeprint image. Individual adjustment of the print was performed using Polygon Lasso tool, Selective Colour adjustment and Replace Colour tool to avoid the removal of the black shoeprint. Adjustment of the Selective Colour was focused on the colour correction of the Whites, Neutrals and Blacks. The details of the print could be clearly observed with targeted enhancement, Figure 5.

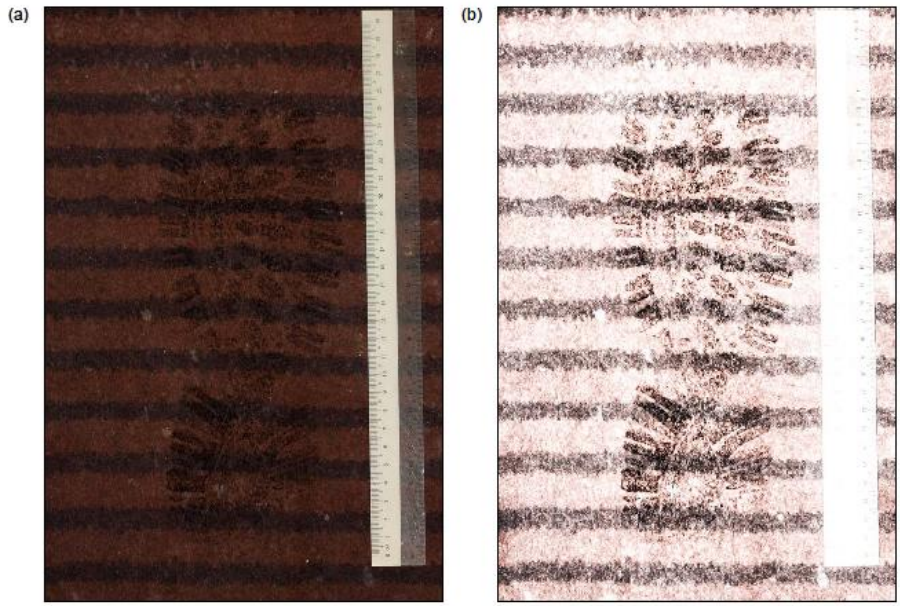

Figure 4: Shoeprint on dark brown and black stripes carpet; (a) original image; (b) enhanced image.

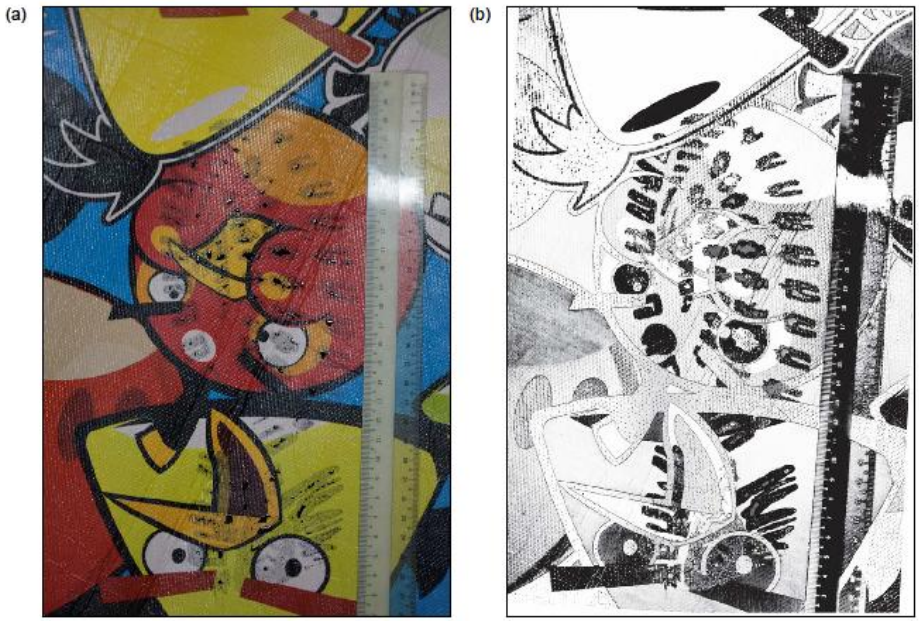

Figure 5: Shoeprint on multi-coloured rubber mat; (a) original image; (b) enhanced image.

Through the application of colour adjustments and filters, shoeprint images were enhanced with the removal or reduction of the noise backgrounds as demonstrated in the images used in this study. The quality of the images was greatly increased allowing the physical examination of morphological features on the shoeprints. In this study, shoeprint images were successfully enhanced by either full or partial reduction of the background noise to better contrast the prints from their backgrounds. This is an essential step during crime scene investigation prior to the application of destructive strategies. Our results show that a dark background where a shoeprint deposited was also found to have restricted the enhancement process due to the lacking in contrast between the print and the background. This could serve as useful information for crime scene officers to consider alternative strategies for image enhancement.

In brief, utilisation of digital enhancement software has successfully enabled the isolation of shoeprints from the backgrounds and greatly improved the clarity of shoeprints. This non-contact step could guide the forensic scientists in making decision for subsequent forensic comparison and identification analysis. The studies on workflow for image enhancement images left by biological stains and fingermarks, upon chemical enhancement are being investigated by our research group.

Conclusion

Adobe® Photoshop® software was successfully utilised in digital forensic enhancement of shoeprint images. The application of colour adjustments and filters in the latest version of the software has enhanced the shoeprint images by removing the noise backgrounds. Darker colour backgrounds may give slight difficulties in the enhancement work and this has to be taken note by forensic scientists. Besides, different types of surfaces and the deposited materials may affect the development of the shoeprint, and therefore their characteristics and enhancement strategies should be familiarised by forensic investigators. With the demonstration on the applicability of simple and non-destructive image enhancement, this study could augment the establishment of linkage between questioned and reference shoeprints for forensic investigation.

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