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Digital Enhancement of Bullet Striation Mark by Image Processing Techniques

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Abstract: ***In forensic ballistics, the examination of bullet striation mark is very important because it contains unique fingerprint striation pattern for matching. In automated PC based firearm identification system, generally Integrated Ballistics Identification System (IBIS) is used by forensic science laboratories. The functioning of IBIS is based on the databases comparison, this database preparation requires a defect free image of ballistics specimens to reduce false acceptance rate for positive identification and in feature extraction as well. In this paper brief description of digital enhancement of bullet striation mark by image processing using different type of filters for corrective action like noise reduction, colour balance and histogram equalization techniques using "Corel Paint Shop Pro Photo X2". It is observed that the digitally enhanced bullet striation mark image shows appreciable level of minute information for feature extraction and identification.***

Keywords: ***Ballistics Specimen, Integrated Ballistics Identification System, Corel Paint Shop Pro Photo X2, Image Processing, Histogram Equalization, Bullet Striation Mark and Filter.***

I. INTRODUCTION

When a firearm is discharged, the gun barrel leaves striation mark on the surface of the bullet and the gun's firing pin, breech face, and ejector imprint the bullet casing with distinct markings. These markings comprise a "bullet signature" and a "casing signature" that are considered unique to each firearm. The difficulties associated with traditional imaging of ballistics specimens are numerous, and include the smaller sample sizes, the nature of the surfaces and shapes of the bullet/ projectiles.

The forensic examination of ballistics specimens relies on the detection, recognition and ultimate matching of markings on the surfaces of cartridges and projectiles made by the firearms [1]. Traditional methods for the comparison of these marks are based on incident light microscopy. The image formed from the oblique illumination of the mark gives are presentation of the surface of the specimen in the region of the mark [2]. This representation is critically dependent on the material of the surface, on which the marks have been made, and the geometry and intensity of the illumination system. The assessment by the ballistic expert of the similarity between comparable marks on respective ballistics specimens from crime scenes and test firings will be based on the expertise and experience of the technologist. Thus the traditional method of matching markings has inherent difficulties, while maintaining an element of subjectivity [3].

The identification of the ballistics specimen from the crime scene with the test specimen is traditionally conducted by mapping the marks by visual images from a low-powered optical microscope. The selection of features within the identifying mark is chosen for their apparent uniqueness in an attempt to match both crime scene and test specimens. A decision is made whether the same firearm was responsible for making the marks under examination on the crime scene and test ballistics

specimens. The selection of the mark or set of marks for examination and comparison is a critical step in the identification process, and has the capacity to influence subsequent stages in the comparison process [4].

The difficulties associated with conventional imaging of forensic ballistics specimens are numerous, and include the smaller sample sizes, the nature of the surfaces for the bullet/projectiles where features have low contrast, the cylindrical shape of the bullet/projectiles, and the distorted shapes of the projectiles (after striking objects). Traditional ballistics identification using conventional low powered comparator microscopy examinations of forensic ballistics specimens is a labour intensive activity with several weeks of time being devoted to a single analysis and comparison. Digital image processing systems not only have the potential to reduce this period for identification to several hours but it also ascertain the better visualization of the specimen for positive identification with a great precision. A well established imaging system will both quickly pay for its research and development costs, and also provides rapid response by police at a crime scene incidence.

A few systems for firearm identification have been developed around world. These includes DRUGFIRE [5], developed by Federal Bureau of Investigation, USA, IBIS[6], developed by Forensic Technology, a division of the Walsh Group, and The Fireball Firearm Identification System developed after the initial research conducted by Smith and Cross [7] and Smith (1997) [8], and later by an ECU software team [9].

These systems integrate digital imaging, database and networking technologies to enhance the capabilities of the forensic firearm examiner. When a firearm is loaded and fired, the mechanisms and parts of the firearm that comes into contact with the cartridge case or projectile cause striations and impressions that are considered as a ballistics signature. Studies have shown that no two firearms, even those of the same make and model, will produce the same unique signatures on fired bullets and cartridge cases [8]. The measurement of these features allows precise ballistics metrics to be obtained for the identification of the make and model of the firearm.

The IBIS-BRASSTRAX-3D provides a number of quality control features such as an automated acquisition tray, automated imaging for breech face and firing pin impressions, and automated lighting, focus, and system calibration [10]. The positive identification of Exhibits/ballistics specimens from imaging systems is an important application of technology in criminal investigation. While the image capture methodology for person and specimens is similar, the process of identification for each is dependent upon the level of certainty required for the identification and interpretation.

II. Material and Methods

The bullet striation mark image is taken by the image acquisition system of Integrated Ballistics Identification which consists of a CCD camera, microscope, and ring light source that provides the condition for image formation. Illumination is always a crucial aspect regarding image quality of image acquisition.

The experimental setup comprises of the following items- bullet striation mark original image taken by Integrated Ballistics Identification System (IBIS), Image processing tool box “Corel Paint Shop Pro Photo X2” and computer with graphical user interface enabled.

Pre-processing of the Digital Image

The bullet striation mark image will undergo for pre-processing with different type of filters in a sequential manner to reduce the noise, enhance color adjustment, histogram equalization and contour detection.

(A) Noise Reduction

The term “noise” in photography refers to unwanted single pixels or groups of pixels that do not belong in the photo. The noise can be caused various factors. Usually, the problems are either introduced electronically by the camera itself or caused by file formats such as JPEG. Noise appears as colored specks within the photo. One can display the noise best by zooming. Ideally, the uniform grey image should have all of the pixels with the same exact value, corresponding to the scene brightness.

In actually, the histogram will show a peak that has a finite width, and shape similar to the Gaussian or normal curve. The width of the peak is a measure of the noise content of the image.

(B) Tonal/Colour Balance:

One can often improve a photo dramatically by adjusting the colors. Different types of lighting, cameras and the processing that occurs inside the camera can cause incorrect coloring in photos. Scanned images may have unnatural color casts.

To enhance colors and remove any color cast in your image, one can use the various color-balancing commands in Corel Paint Shop Pro Photo X2. By applying the commands to a selection or an entire image, the following process are used during tonal/colour adjustment:

- Tonally balance a photo's colors without affecting the luminance of the photo.
- Increase or decrease the red, blue, or green color channel by a percentage of the given channel.
- Restore color and contrast to faded/over focused photos.
- Create a photographic negative by replacing each pixel color with its opposite (for example, replace blue with yellow, black with white, yellow with blue, white with black, and so on).
- Adjust the amount of red, green, and blue in your image as a way to make color corrections by changing the overall color cast.

(C) Use of Filters

Median Filter

A fundamentally different method of dealing with pixels within a neighborhood is based on rank ordering. Instead of multiplying all of the pixels values in the neighborhood time's weight values, rank ordering lists the pixel values in order of brightness. Median filtering is a superior noise reduction method, because it does not blur or shift edges. The adjustable parameter for the median filter is the size of neighborhood used. As the radius is increased, the degree of noise reduction is increased.

High Pass, Minimum and Maximum Filter

Retains edge details in the specified radius where sharp color transitions occur and suppresses the rest of the image. (A radius of 0.1 pixels keeps only edge pixels.) The filter removes low-frequency detail in an image and has an effect opposite to that of the Gaussian Blur filter. It is helpful to apply the High Pass filter to a continuous-tone image before using the Threshold command or converting the image to Bitmap mode. The filter is useful for extracting line art and large black-and-white areas from scanned images.

The Minimum filter has the effect of applying a spread spreading out black areas and shrinking white areas. The Maximum filter has the effect of applying a choke spreading out white areas and choking in black areas. As does the Median filter, the *Maximum and Minimum filters* look at individual pixels in a selection. Within a specified radius, the *Maximum and Minimum filters* replace the current pixel's brightness value with the greatest or least brightness value of the surrounding pixels.

Histogram Equalization

A histogram illustrates how pixels in an image are distributed by graphing the number of pixels at each color intensity level. The histogram also gives a quick picture of the tonal range of the image, or the image key type. A low-key image has detail concentrated in the shadows, a high-key image has detail concentrated in the highlights; and an average-key image has detail concentrated in the mid tones. An image with full tonal range has a high number of pixels in all areas. Identifying the tonal range helps determine appropriate tonal corrections.

Contour Detection

Contours are distinguished from edges as follows. Edges are variations in intensity level in a gray level image whereas contours are salient coarse edges that belong to objects and region boundaries in the image. In general, a contour map is an efficient representation of an image since it retains only salient information and hence is more valuable for high level computer vision tasks. The design of a detector that can extract all contours from a wide range of images is therefore of interest. The key to extracting contours appears, from the ground truth, to be the ability to assess what is relevant and what is not in local neighborhoods.

III. Results and Discussion

The algorithms used for enhancement of bullet striation mark image, improves the clarity and reduce noise by blending the brightness of pixels using the application of Image processing tool box "Corel Paint Shop Pro Photo X2". The filter searches the radius of a pixel selection for pixels of similar brightness, discarding pixels that differ too much from adjacent pixels, and replaces the center pixel with the median brightness value of the searched pixels. This filter is useful for eliminating or reducing the effect of motion/noise on an image. The adjustable parameter for the median filter is the size of the neighborhood used. Noise reduction depends upon the use of neighborhood size which is small enough to retain real details, and to repeat the operation several times. The median filter value 1.0 to 2.0 produce good noise free results **(Fig.1)**. Image after tonal adjustment like brightness and contrast in RGB channel (Red, Green & Blue) at the increment value of 38% brightness and 71 % contrast contain more fine details.

Histogram equalization is a technique for adjusting image intensities to enhance contrast of bullet striation mark contains sufficient details like striation mark/firing pin mark in comparison to the original image. The histogram equalization is normally improving the visibility of details in bright or dark areas by adjusting the brightness, contrast, and gamma values. The best result found in gamma value at 1, **(Fig.2)**. The high band pass filter removes low-frequency detail in an image and has an effect opposite to that of the Gaussian Blur filter. Radius values of 47.7 pixels keeps only edge pixels and retains edge details in the specified radius where sharpen color transitions occur and suppress the rest of the image **(Fig.3)**.

The contour detection technique is used in pattern recognition for getting the outline margin of the image in respect to its surrounding **(Fig.4)**. It helps in computerized recognition system of the object with database matching. The contour detection of the bullet striation mark image show number of detail which can be classified for pattern recognition.

IV. Conclusion

The Image processing tool box "Corel Paint Shop Pro Photo X2" is a state of art tool having very effective enhancement algorithms for bullet striation mark images. Its applications like median filters for noise removal by minimizing the pixel value neighborhood pixel, allow making the image clear and distinguished boundaries. The histogram equalization at provides the details information of the dark area of firing pin mark by adjusting the brightness and contrast at different channel of RGB. High band pass removes the area having low frequency without increasing the radius of the pixel and have great detail of the image edges and line. The contour detection technique is alternative technique for edge detection used to characterize the images at different levels according to its region and boundaries for the purpose of automated identification. The edge/contour detection technique provides a very distinguish and well defined edges of bullet striation mark boundaries for the feature extraction and automated examination. The digitally enhanced image of bullet striation mark images improves the accuracy and positive identification with great potential.

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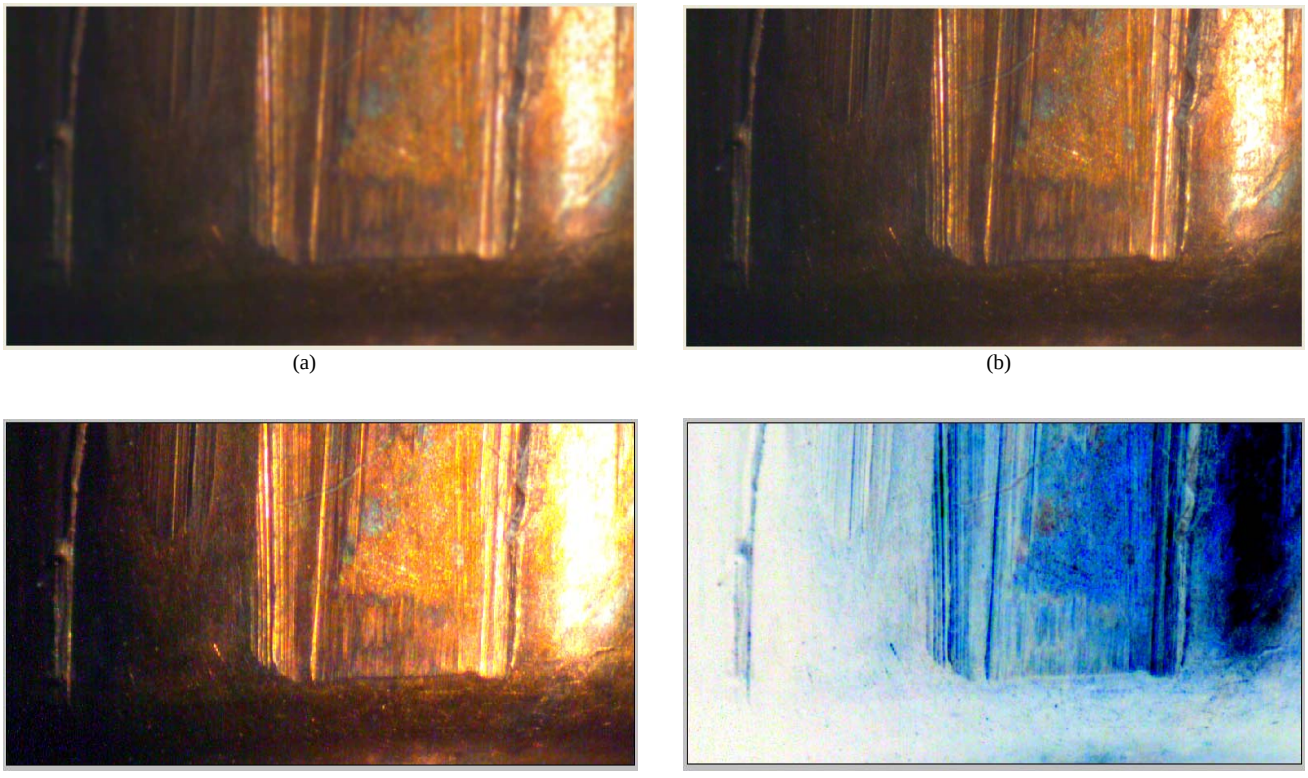
Legends to Figures

Figure 1: (a) Original Image (b) After Noise Reduction (c) Image after tonal adjustment like brightness and contrast and (d) Image after tonal adjustment in blue channel.

Figure 2A & 2B: Image before and after Histogram equalization; on Gamma value at 1, high and low key value at 70 and 114 respectively.

Figure 3: Image after high pass filter.

Figure 4: Contour Detection at different level.



(a) (b)

(c) (d)

Figure: 1

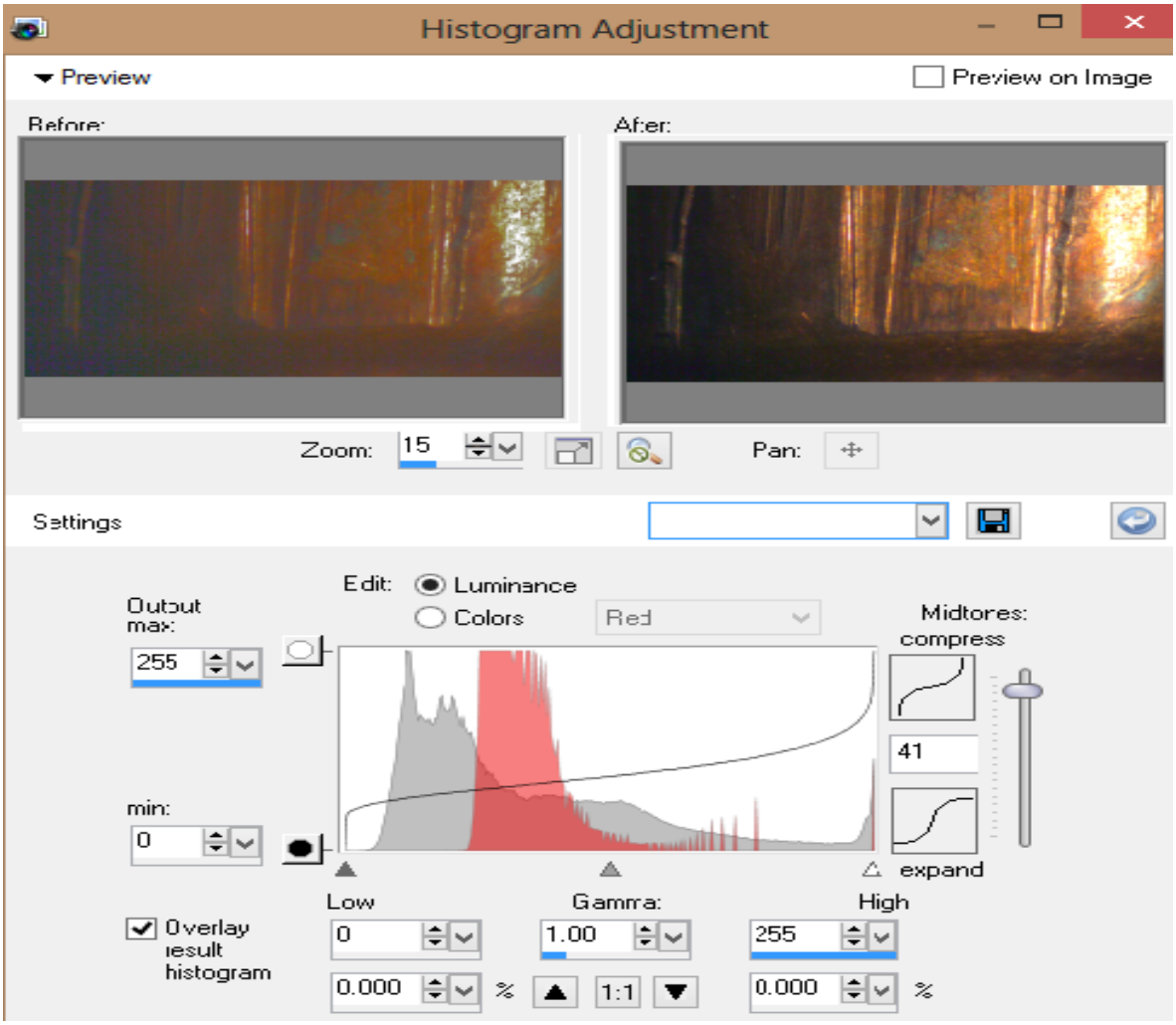


Figure: 2

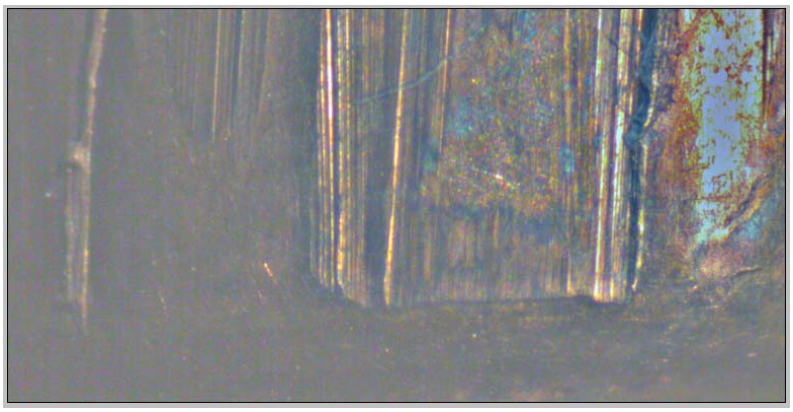


Figure: 3

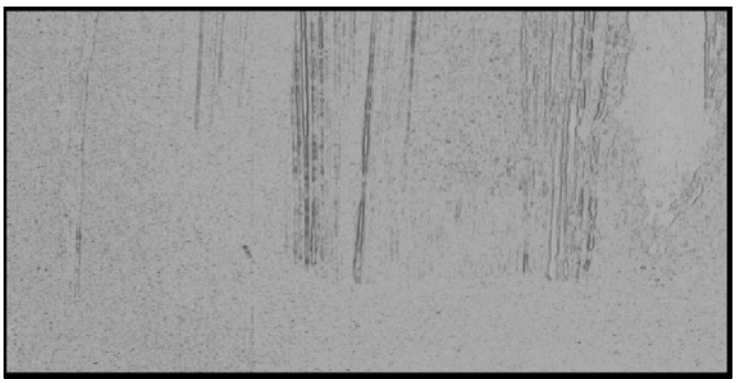


Figure (4)