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Removal of Artefact from Shoe Print Image

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ABSTRACT: *Shoe marks at the place of crime provide valuable forensic evidence. Many different artefacts can occur during processing of shoe print images. This paper proposed a methodology to remove the artefacts from shoe print images. The proposed methodology is very simple with the combination of statistical and computational geometric approach. Statistical methods like standard deviation are used to calculate the global threshold to binarize the image and computational geometry like convex hull is used to produce final output. It is possible to remove artefacts if it is present either in front side of the image or rear of the image.*

Keywords: *Artefact. Standard Deviation. Global Thresholdina. and Convex Hull.*

I. INTRODUCTION

Locard [1] believed that no matter what a perpetrator does or where he goes ,by coming in contact with things at or around a crimescene he can leave all sorts of evidence , including DNA, fingerprints, footprints, hair , skin cells, blood, body fluids, pieces ofclothing fibers and more[1]. While the criminal leaves something at the crime scene he is also expected to take something awayfrom the scene with him[1]. On a very loose connect it might be said that when killing an individual with a hammer hit thecriminal might take away the murder weapon with him but at the same time he might end up leaving behind bloody stains of theblood bearing hammer at the crime scene . 'A bloodstain resulting from contact between a blood-bearing surface and anothersurface' has been termed as 'Transfer Stain' by the International Association of Bloodstain Pattern Analysts (IABPA)[2-4]. Thusthis work is particularly directed at studying hammer transfer stain patterns at a crime scene.Many image processing techniques have been developed over the past two decades to help forensicscientist in detection of footprint image boundary. Most studies conducted have proven that measurementof parameters may help detection of crime scenario. In this paper we present initially pre-processing offootprint image after digitization and then find out the artefacts present. Segmentation of Region of Interest (ROI) is used. Further we useDivide and Conquer Homogeneity algorithm, followed by edge detection. We obtain the image boundaryby using our proposed algorithm. A RGB image taken as an input, but here the methodsdeals with grayimage, thus input RGB image converted intogray image first. Binarization is very effective preprocessingmethodsfor most of the segmentation. Due to largevariation on background and foreground ofshoe print imagesmaximum binarization fails but here a binarization methodhas been proposed and a globalthreshold value has beenselected by standard deviation of the image. Globalthresholding using standarddeviation gives very goodresults and binarize each component of the image.Shoeprint is the mark made by the outside surface of the soleof a shoe (consist of distinctive geometric patterns) found atcrime scenes. Shoe marks can be broadly classified into twoclasses: 1) shoe impressions which contain 3-dimensionalinformation (e.g. shoe impression at the beach) and 2) shoeprints which contain 2-dimensional information (e.g.shoeprint on a floor). Probability of occurrence of shoe marksat the place of crime is higher than that of fingerprints since ahigh proportion of burglars wear gloves [1]. In severaljurisdictions of Switzerland it was revealed that 35 percent ofcrime scenes had shoeprints usable in forensic science, andfound that 30 percent of all burglaries provide usableshoeprints [2, 3]. It is known that majority of the crimes arecommitted by repeat offenders. It is common for burglars tocommit a number of offences on the same day. As it would beunusual for offenders to discard their footwear betweencommitting different crimes [4]; timely identification andmatching of shoeprints helps in linking various crime scenes.

Often it is the case when number of crimes has beencommitted; the investigating officers have an idea of who hascommitted the crime(s). Indeed, they have suspect in custodywhose modus operandi fits the crime.

II. BRIEF REVIEW

In the IABPA Conference held in Tucson, Arizona, 2004, Peter Lamb presented the investigation report of the late night assault of a young man who was intoxicated at the time of attack and could only recollect part of the savagery that he had been subjected to[5]. Due to rain drop that had soaked the garment at the time of the assault it was difficult to examine the bloodstains on the soaked garment and shoe print image on the floor[5]. However there was evidence of kicking and stomping[5]. Based on the evidence the case finally proceeded for trial and the accused was proved guilty and hence imprisoned [5]. In his review of the Windsor city homicide case Scott Lamont pointed out that barefoot transfer impressions and footwear transfer impressions were found on the floor[6]. Foot morphology confirmed that the prints were left by the suspect who was wearing boots[6]. In the words of LeeAnnSingley, in the murder case of 2 women (74 year old mother and her 48 year old daughter) in their holiday home in a small town in Pennsylvania, while DNA evidence answered 'who ?' in identifying the perpetrator at the trial, the bloodstain pattern evidence proved to be valuable to the jury in answering the 'how?'[7]. To add to the list, in the case of Regina vs. Sion Jenkins, expirated and other bloodstains on clothing were used as relevant evidence within the legal setting to acquit Sion Jenkins of the murder of his 13 year old daughter Billie Jo[8]. In the case presented by Paul Treudson, at a particular crime scene bloody transfer impressions of an apparent right hand holding a knife was found on top of a sheet that lay at the foot of the bed [9]. The impressions included knuckles and a blade [9]. As Erin Sims puts it, for one particular case the evidence particularly the bloodstain pattern evidence was the only honest teller of the course of events that had led to the victim's injury[10]. Initially, the Birkett system of coding shoeprint patterns wasdevised by John Birkett of the metropolitan Police ForensicScience Laboratory by allocating alphanumerical values tovarious pattern elements. This system failed uniquely toidentify a pattern because of the multitude of new patternsfrom manufacturers in the late 1980s. The major problemwith the Birkett system was the volume of new patterns, whichthen addressed by prefixing the coding elements with twonumerical digits for the year and a 3 digit numerical suffix in1993. Again, as per the Federal Bureau of Investigation (FBI) Chart reports each year more people are killed by hammer, club or blunt ended object hit as compared to the number of people killed wt rifle or shotgun[11]. In this respect it might be interesting to mention that, in a case reviewed by Stuart H. James at the 2008 IABPA Annual Training conference, he reiterated that bodies of 4 Mexican construction workers were found in a rented apartment at Ohio [12]. The bodies of the victims remained undiscovered for almost a week [12]. When examined the victims were found to have suffered blunt and sharp force injuries [12-14]. The highlight of the case review were the interesting bloodstain patterns found at the crime scene which were studied in conjunction with the wounds suffered/sustained by the victims[12]. In their study, the authors came across many such cases where victims suffered blunt force injuries. Given the large possibility of instruments that can be easily obtained and hence deliver blunt force injuries to the human skull, the authors decided to particularly focus on the possible Transfer and Saturation stain patterns formed at a crime scene as a result of assault particularly with blunt ended objects.

III. METHODOLOGY USED

A statistical method i.e.standarddeviation is used to calculate the threshold value. In this processing statistical descriptions separate foreground images and background images. A digitized image I[m,n] and *h* is the intensity of each pixel of the gray image. Here Quickhull Algorithm for Convex Hulls is used. Quickhull Algorithm for Convex Hulls runs faster when the input contains non-extreme points and it uses merged facets to guarantee that the output is clearly convex.

IV. ALGORITHM (PSEUDO CODE)

Step 1. Grayscale shoe print image is taken as input.
Step 2. Threshold value of the image is calculated using the standard deviation technique described above.
Step 3. The image is binarized using the threshold value. i.e. pixels having value greater than the threshold is set to 1 and pixels less than the threshold are set to 0.

```
/* [A B]=size(I);
BI =zeros(a,b);
STD = std2(I);
FORi = 1 to A DO
FOR j=1 to B DO
IF I(i,j) > STD THEN
Set BI(i,j)=1
END IF
END FOR
END FOR*/
```

Step 4. The binarized image is labelled and areas of connected components are calculated using equivalence classes.
Step 5. The connected component with the maximum area and the connected component with the second highest area are found out.

Step 6. The ratio of the maximumarea to that of second maximum area are calculated if the ratio is high and if ratio is low

Step 7. On the basis of the ratio if ratio is high only the component with highest area is kept and all others are removed otherwise if ratio is low the component with the highest and second highest area are kept and all others are removed.

Step 8. A convex hull is calculated for the one pixel in the image and all regions within the convexhull are set to one.

Step 9.Now the above obtained image matrix is multiplied to the original image matrix to obtain an image consisting of only shoe print without any artefact.

V. CORRECTNESS

Loop invariant: At start of every iteration of outer loop, each row of image i = 1, 2, ... , A and inner loop , each column j = 1, 2, ... , B; in the end of the iteration it follows same process.

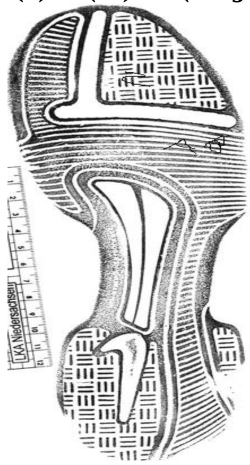
Initialization: Since i = 1 i.e. it is at first row of the image before the first iteration of the outer loop, so, the invariant is initially true and is same for the inner loop; some variable are initialize with the image size and dimension which is finite.

Maintenance: In each successive iteration loop invariant moves to next row by incrementing loop variable. Loop works by moving Image [i + 1][j], Image [i + 2][j], Image [i + 3][j] and so on.

Termination: The outer loop ends when outer loop >height, i.e. all the row of the image is already traversed.

Complexity Analysis

Assuming the height = width =n, the running time for both for loop is $O(n \times n)$ for all cases;At each level of the recursion, partitioning requires $O(n)$ time. If *partitions* were guaranteed to havea size equal to a fixed portion, and this held at each level, the worst case time would be $O(n \log n)$. However, those criteria do not apply; Partitions may have size in $O(n)$ (they are not balanced). Hence the worst case running time is $O(n2)$. Thus if we consider worst case time: $O(n\ 2)$ and expected time: $O(n \log n)$. To calculate the area of each component it requires $O(n \times n)$ running time.**T(n)**= $O(n2) + O(n \log n) + O(n2) = O(n2)$.



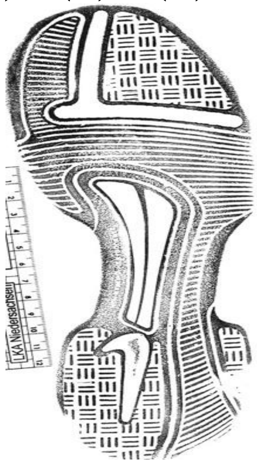
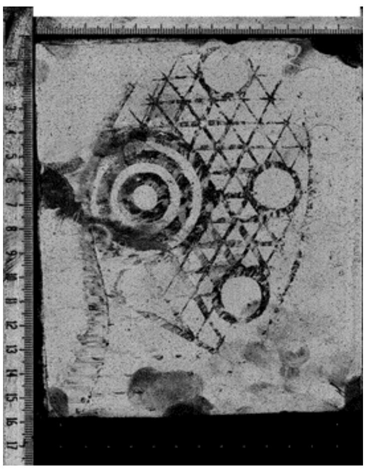


Figure 1(a) Shoe Print with artefact **Figure 1(b) Shoe Print without artefact**



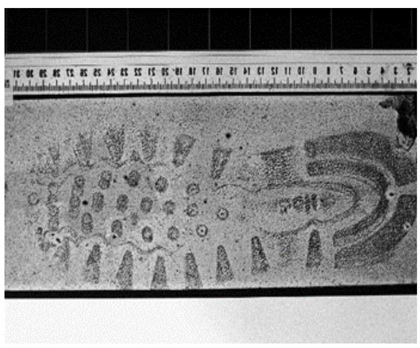


Figure 2(a) Shoe Print with artefact **Figure 2(b) Shoe Print without artefact(45 Degree rotation)**

VI. CONCLUSIONS

Removing artefact by calculating each component and the binarized output is shown in figure1 (b) and 2 (b). Maximum number of artefacts (mainly letter) removed from this step but if any metal or Gibbs artefact are present then those are removed by applying Quickhull convex hull and shown in figure 2(b). In figure 1(b) no artefact present i.e. all artefacts are removed by proposed algorithms. Artefact removal from shoe print is a pre-processing step. Here intelligence system for artefact removal on shoe print has been implemented. The automated system remove artefact using low time complexity. Proposed methods are based on a combination of statistical and geometric methods and it give very good results for different kinds of shoe print images.

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