Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2016, 3(2):24-33**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Foot Boundary Detection in a Crime Scene

Madhulina Das, Samir Kumar Bandyopadhyay

Department of Computer Science and Engineering

Abstract Crime scene investigation is the meeting point of science, logic and law. Processing a crime scene is a long, tedious process that involves purposeful documentation of the conditions at the scene and the collection of any physical evidence that could possibly illuminate what happened and point to who did it. There is no typical crime scene, there is no typical body of evidence and there is no typical investigative approach. At any given crime scene, investigators might collect dried blood from a windowpane -- without letting his arm brush the glass in case there are any latent fingerprints there, lift hair off a victim's jacket using tweezers so he doesn't disturb the fabric enough to shake off any of the white powder (which may or may not be cocaine) in the folds of the sleeve, and use a sledge hammer to break through a wall that seems to be the point of origin for a terrible smell.

Among the numerous biometric techniques used for human identification, foot biometry has been largely neglected so far. Even though the human foot has been extensively studied in medical and forensic research and obviously bears similar distinctive properties like the human hand, its use in commercial biometric systems is considered complicated. In this paper foot print boundary analysis is made and proposed method is illustrated.

Keywords Footprints, Identification, Shoeprints

Introduction

Crime scene investigation is the meeting point of science, logic and law. Processing a crime scene is a long, tedious process that involves purposeful documentation of the conditions at the scene and the collection of any physical evidence that could possibly illuminate what happened and point to who did it. There is no typical crime scene, there is no typical body of evidence and there is no typical investigative approach. At any given crime scene, a CSI might collect dried blood from a windowpane -- without letting his arm brush the glass in case there are any latent fingerprints there, lift hair off a victim's jacket using tweezers so he doesn't disturb the fabric enough to shake off any of the white powder (which may or may not be cocaine) in the folds of the sleeve, and use a sledge hammer to break through a wall that seems to be the point of origin for a terrible smell.

Among the numerous biometric techniques used for human identification, foot biometry has been largely neglected so far. Even though the human foot has been extensively studied in medical and forensic research [1] and obviously bears similar distinctive properties like the human hand, its use in commercial biometric systems is considered complicated. Reasons include a non-habituated environment, user-unfriendly data acquisition (due to the practice of wearing shoes) and, last, uncomfortable associations at the acquisition step. By tradition in Arab countries, it is considered offensive to show someone the sole of your foot. Most access control systems rely on face, fingerprint, hand geometry, iris, palm print and signature features [2]. While some biometric features are not secret and may be generated out of publicly available data, it is in each user's interest that private biometric features such as retina or even fingerprints are not compromised. However, precisely because foot biometry is not and probably will never be a suitable authentication mechanism for high-security applications, storage of foot biometric features does not necessarily imply security threats. If the environment allows user-friendly data acquisition, e.g., thermal baths, or security issues demand uncritical features, foot biometry may be considered as a useful alternative. Within special environments, foot biometry might even be implemented as a covert system in contrast to hand biometric techniques. Therefore, the image acquisition step used in this work is inherently simple, and it does not employ any special illumination, nor does it use pegs to cause any further inconvenience. The first footprint-based recognition dates back to Kennedy [1] in the late 1980s, who used inked bare- foot impressions to extract 38 local geometrical features, such as length between heel and tips of toes, optical centers of heel and toes or width of ball and heel. While Kennedy's work concentrated on forensic applications, the first scheme concentrating on footprint-based authentication using simple Euclidian distance between foot-prints was introduced by Nakajima et al [3]. Operating on pressure distribution data and simple Euclidian distance, recognition rates of 85% could be achieved. Further work concentrates on static and dynamic foot print based recognition using hidden Markov models [4, 5] with recognition rates of about 80 to 97.8% dependent on feature selection and database size. Since neither taking ink-based impressions in the first case nor recognition rates of 80 to 85% are suitable for commercial security applications, we investigate more elaborate approaches to foot biometrics. While the idea of using shape and skin texture information of the human hand is not new and numerous biometric features are described in detail in [6-8], it will be more specific for identification the application of some of these features are used in foot biometrics. Traditional hand biometric features are most likely to be applicable to foot biometrics; thus, we investigate theirdiscriminative properties. However, techniques also used in face recognition (e.g. Eigen faces as described in [9]) can be successfully implemented. Second, a goal of this project is the introduction of a prototype footprint verification system. Thus if following biometric measurements can be used for identification:

- Shape and geometrical information focusing on characteristics such as length, shape and area of the silhouette curve, local foot widths, lengths of toes, and angles of inter-toe valleys;
- soleprint features analogous to palm print-based verification extracting texture-based information of the sole of the foot;
- minutiae-based ball print features employing different techniques used in fingerprint verification systems;
- Eigen feet feature (corresponding to Eigen faces in traditional face recognition) in the principal component subspace for recognition of both shape and textural information.

The images of this project are on blood stain and the image of foot may not be in complete form and the quality is not so good to implement all of the above parameter for identification. Therefore the identification will be enough tough. In the next section the related previous works have been discussed, In the subsequent section the proposed work has been discussed. Then the experimental results are shown. Finally modification or addition to the system will be discussed.

Literature Survey

Pre-processing is important for reliable foot recognition. Nakajima et al. [3] could improve their Euclidian-distance-based footprint recognition method on raw images from roughly 30% to 85% by just achieving normalization in direction and position. While for unconstrained hand images a re-alignment of individual fingers using texture blending [7] is promising, an adaption to foot biometrics is considered complicated due to close-fitting toes and has not yet been implemented. How-ever, a successful alignment of toes could further increase recognition rates of global features. Andreas Uhl and Peter Wild [10] has pre prosed the following steps:

1. Binarization using Canny edge detection [11] and thresholding.
2. Rotational alignment using statistical moments.
3. Displacement alignment restricting the image to the bounding box of the footprint.
4. Background pixels are masked and the processed footprint is scaled to provide each of feature extractors with appropriate resolution input.

In the case of hand recognitionthere also need of image pre-processing. The hand images are first pre-processed in order to extract the hand silhouette and eliminate artifacts such as the guidance pins, user rings, overlapping cuffs or creases around the contour due to too light or too heavy hand pressing. The pre-processing step can range from simple image thresholding [12] and filtering to sophisticate gray-level segmentation or edge detection. Possible dents at the artifact location are smoothed by linear interpolation and/or morphologic operators [12] or are simply not used in the feature extraction process.

In the case of image of blood stain the pre-processing will be different. There are very few work on blood stain.

Common hand biometric systems and therefore foot biometric systems can be classified in analogous manner as follows [7]:

- Schemes relying on geometric features comprising silhouette shape and the lengths and widths of fingers,

among others;
- Palm print-based verification systems extracting palm curves;
- Hybrid approaches (such as [6]) employing fusion at the feature extraction, matching-score, or decision level to improve error rates.

Additionally, a lot of systems concentrating on fingerprint verification exist (such as the NFIS2 minutiae-matching software from NIST [13]). However, fingerprint matching results are fused with hand geometry in multiple biometric schemes [14] rather than combined employing a single sensor [15]. A reason for this might be that usually, fingerprint matching requires special hardware for image acquisition and does not work on low-resolution input. Nevertheless, when ridge structures can successfully be extracted from the captured scans of palms or feet, system performance can be increased using fusion without the cost of additional sensors or further inconvenience caused by multiple-step data acquisition.

In the next few paragraphs, I introduce possible foot biometric features and how they can be derived from their hand biometric counterparts. Furthermore, point out problems concerning feature extraction due to anatomical differences between hand and foot and analyze possible resorts.

Geometric measurements are frequently employed in hand biometric systems due to their robustness to environmental conditions, and a large number of possible features fall into this category. Considering the sole of the foot to be prone to injuries, shape-based features seem also well suited for the foot verification task.. One reason for this is that many hand recognition schemes rely on a robust identification of finger tips and finger valleys. When inter finger valleys cannot be detected reliably, a normalization, i.e., correct placement of individual fingers, is hard to achieve. The extraction of these characteristic landmarks is often facilitated by pegs [16], while more advanced schemes like [8] are peg-free but demand high contrast between background and palm. Since an introduction of pegs is unacceptable for the image acquisition step, and spread toes are not the default case, the reliable detection of inter toe valleys deserves closer attention in foot biometrics. Regardless the expected weak performance of shape features, it is better to map both global features (focusing on palm width, length or hand area) and local features (representing, e.g., finger lengths and widths at various positions) to their counterparts in foot biometrics.

While the shape of the human wrist is often neglected in biometric systems, the actual shape of the foot is characterized by its local widths and bending. The next feature is an approach that takes this fact into account. After aspect ratio preserving normalization of the footprint in order to achieve predefined rotation and size, the foot is divided into N vertical slices with equal dimensions. The y-monotone polygon is now used to compute the average width of the foot per slice, i.e. the average width. Significant problem concerning foot shape mentioned in [3].

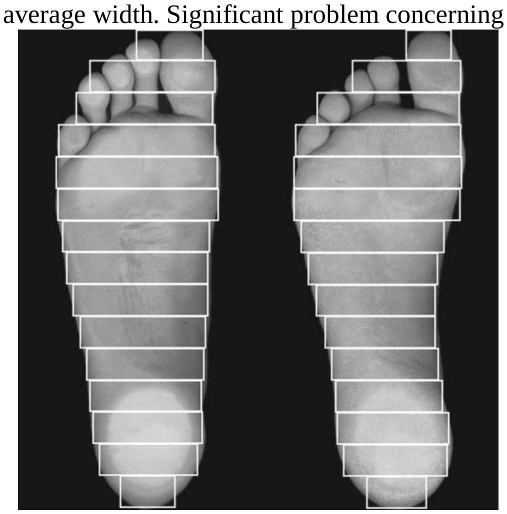


Figure 1: Shape

Hand extremities, i.e., the finger tips and the finger valleys, are typically exploited using a binary representation of the input image and deriving a different number of features. Kumar et. al. [6] for example, use 12 hand extremity features including 4 finger lengths, 8 finger widths (2 widths per finger). Sanchez-Reillo *et al.*, [16] use even more local finger widths, namely 25 features. More recent schemes [8] employ an extraction of contour shape information for individual fingers and incorporate principal component analysis and/or independent component analysis for the construction of the feature vector. Mapping hand extremity features to toes in foot biometrics is promising, but a crucial problem is that in unstrained pose, toes are close to each other. Thus a simple binary

thresholding using Otsu's Method, as in [6], will not suffice in general. Instead, Andreas Uhl and Peter Wild [10] employ both binarization and a Canny Edge detection [11] algorithm to first find candidate points for toe valleys by detecting the entrance between two toes. Then candidate points are improved by following the edge separating two toes within a cone centered in the center of mass of the binary foot image. Andreas Uhl and Peter Wild [10] then extract 9 toe extremity values, comprising the 5 toe lengths and the 4 intertoe angles.
An interesting convenience having extracted the length of the big toe and its neighbouring one is a pre classification of feet. Just as fingerprints can be separated into basic pattern-level classes known as arch, left loop, right loop, scar, tented arch, and whorl [13], it is possible to classify feet according to the differences in length of hallux and second toe into Egyptian (hallux longer than second toe), Greek (second toe longer than hallux) and square (both toes have almost the same length) feet. Orthopaedic surgeon Morton [17] was the first to describe this phenomenon of the second toe (also called Morton's toe) being longer than the great toe as a part of Morton's syndrome.

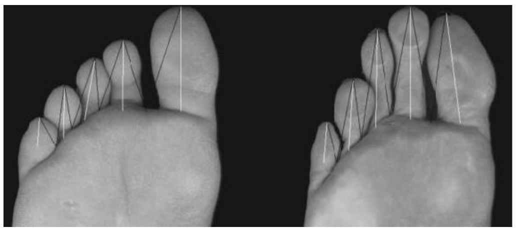


Figure 2: Toe Length

Figure 3: Different types of foot

Skin-texture-based identification on palm prints involves the challenge of extracting line structures. Using feet instead of hands a new problem arises, since typical principal lines are not present. Instead a comb-like pattern is visible, which seems to be sensitive to different pressure distributions. For this reason, in many cases for foot identificationwe apply a simpler generic but robust method [6] to extract texture-based patterns. While line information is extracted at lower resolution using directional Prewitt edge detection, typical ridge structure is also present in the footprint at high resolutions even if no special ridge extraction device such as a fingerprint scanner is used. For this reason, Andreas Uhl and Peter Wild [10] incorporate a minutiae based feature extraction step developed for fingerprint matching [13] estimating local ridge structure on a specified part of the 600dpi input image. Last, both shape and texture information are processed using principal component analysis [9] at lowest resolution rate.
Minutiae-based ballprint features employing different techniques used in fingerprint verification systems [10]. Andreas Uhl and Peter Wild [10] use the NFIS2 [13] minutiae extraction and matching software MINDTCT and BOZORTH3 to extract minutiae information out of the ballprint region under the big toe.

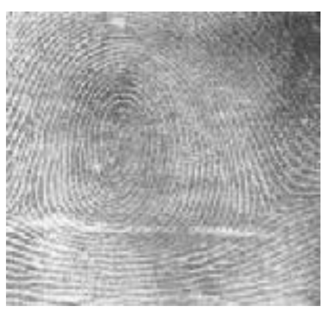


Figure 4: Minutiae

Proposed Method
The proposed method is described by the following steps.
Step1: For pre-processing of image, the image the RGB image first of all is converted into gray scale image which makes the process much easier, because here we need not to maintain three matrixes. There is another reason for converting; the input foot print image is on the blood stain.

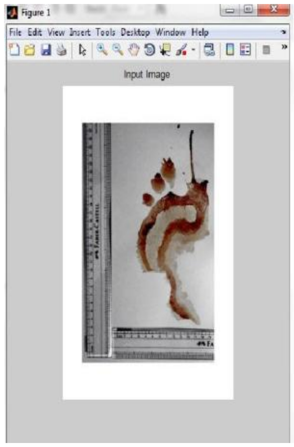


Figure 5: Input Image

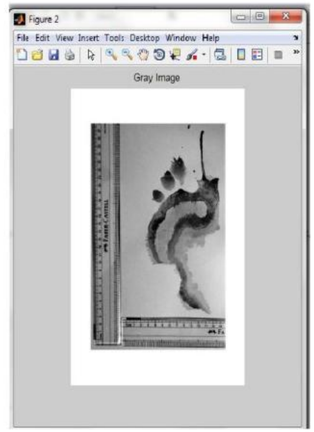


Figure 6: Gray Scale Image

Step 2: Next I have adjusted the contrast of the image. As it is not the scanned image therefore the lighting of the image may not be proper. For this reason this step is necessary.

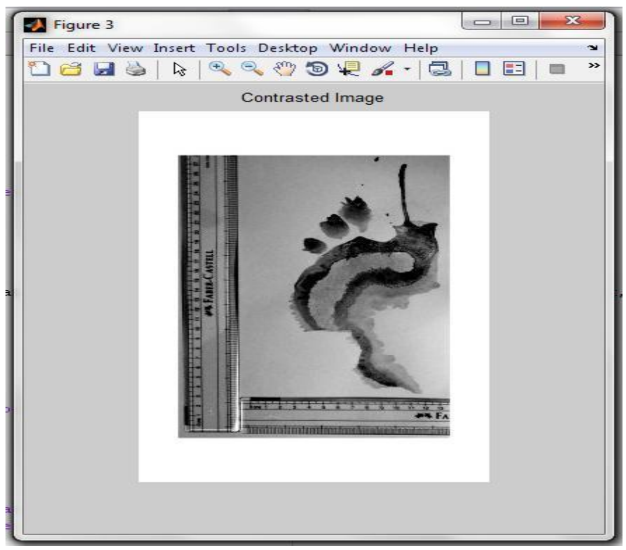


Figure 7: Contrasted Image

Step 3: Then applied the Canny Edge detection algorithm [11] to find the edges of the image and also the output image in the form of binary. Although this image is not used for the next steps. It will be used for further biometric identification.

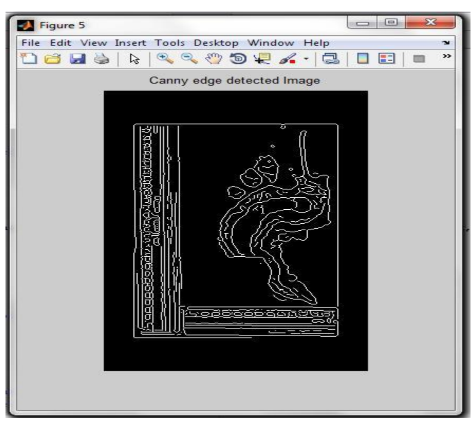


Figure 8: Canny Edge Detected

Step 4: Next convert the gray scale image in to binary image. At the same time create another binary image using thresolding value. In the next step add these two images to get more specific image for further processing.

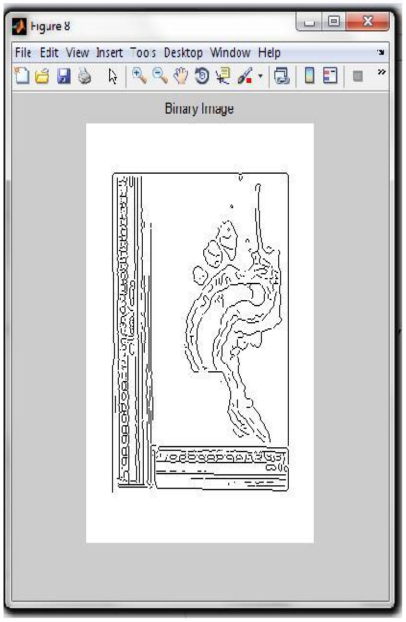


Figure 9: Binary Image

Figure 10: threshold binary image

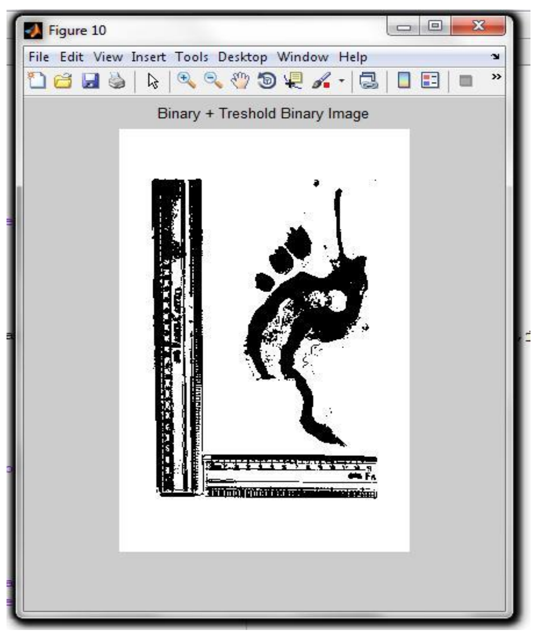
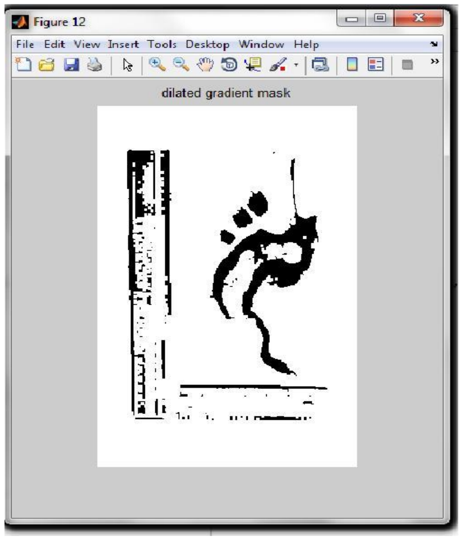


Figure 11: Added image

Step 5: To get more filled image apply necessary function. Here I have drawn smalllines to fill the image. Next apply canny edge detection algorithm [11].



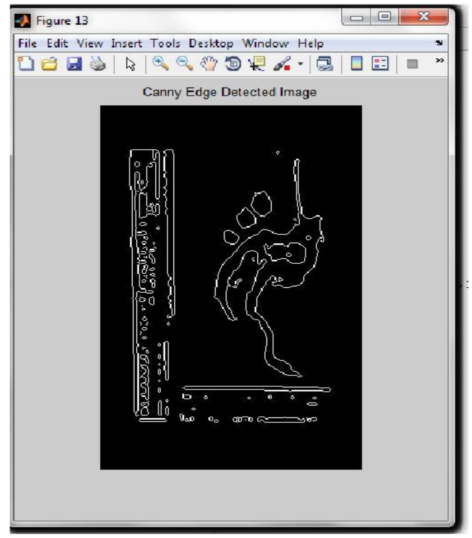


Figure 12: Gradient mask *Figure 13: Canny Edge Detected*

This system only identifies the left or right foot-print. To detect this, the current processed image is compared to the database image. These database images are processed in the same manner. To get output in short time I have stored these images in database, otherwise processing time will be high. The maximum matches with the database images are checked for identification.

Figure 14: left Foot (Database Image) *Figure 15 Right Foot (Database Image)*

The foot measurements are important in forensic field as they can be used as body height predictors for an individual. The morphology of human feet shows the variations. Determination of personal identity is the first and the most important step in forensic investigations and medicolegal practices. In anthropological cases, forensic identification is generally carried out through examination of the body or the remains (or prints) from the body. Thus, the feet and footprints become extremely significant, especially when a body is incomplete or unavailable. The finger print recognition, face recognition, hand geometry, irisrecognition, voice scan, signature, retina scan and several other biometric patterns are being used for recognition of an individual. Human footprint is one of the relatively new physiological biometrics due to its stable and unique characteristics. The texture and foot shape information of footprint offers one of the powerful means in personal recognition.

Figure 16 : GUI

Results

The proposed GUI interface with the content will be displayed in the following

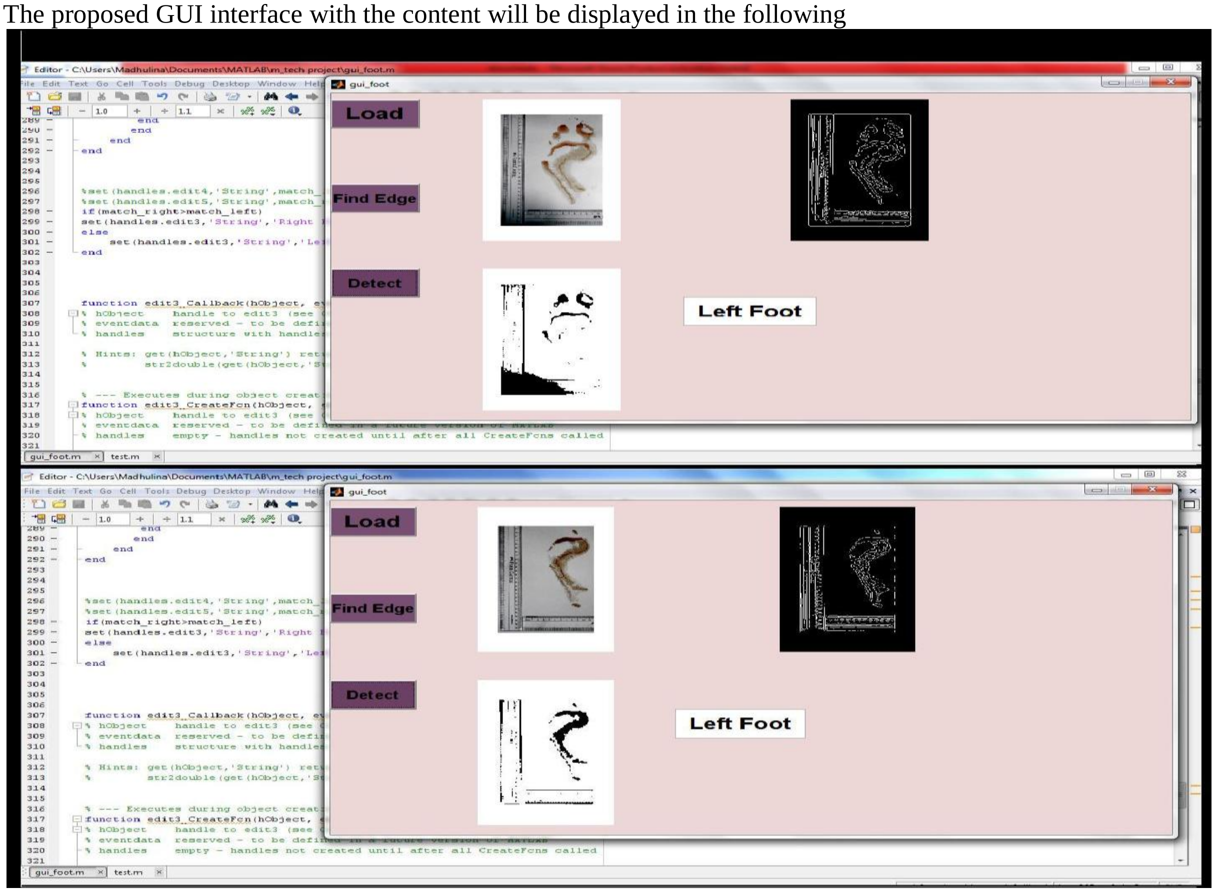


Figure: 17

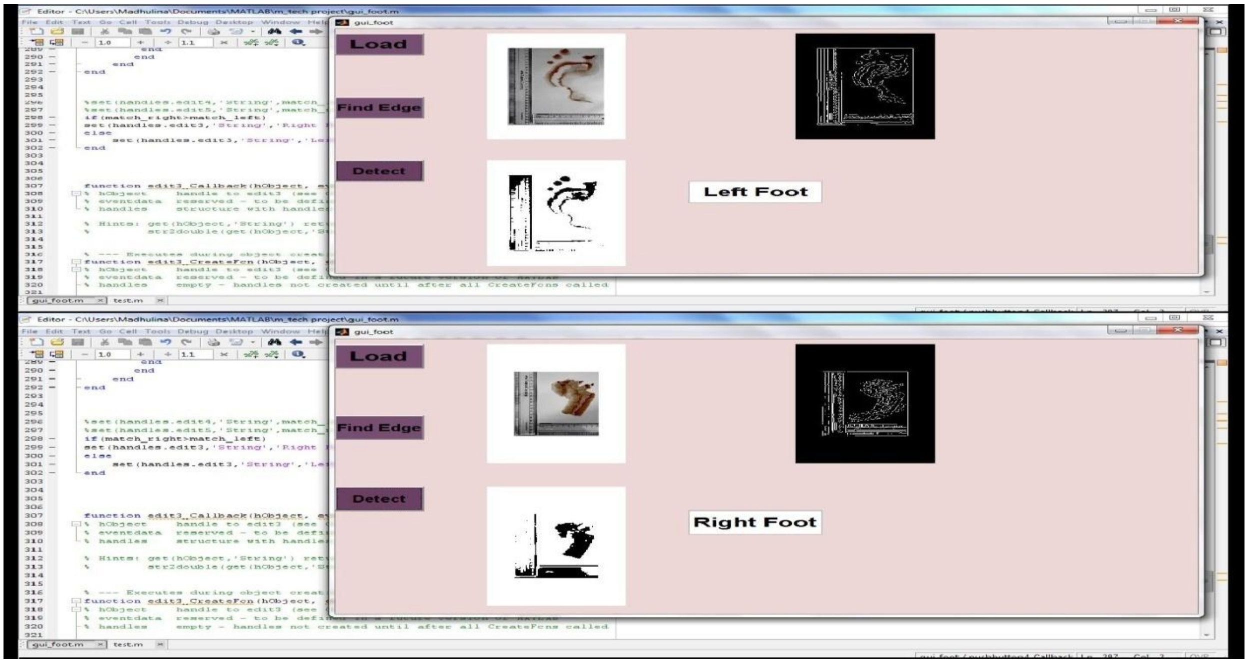


Figure: 18

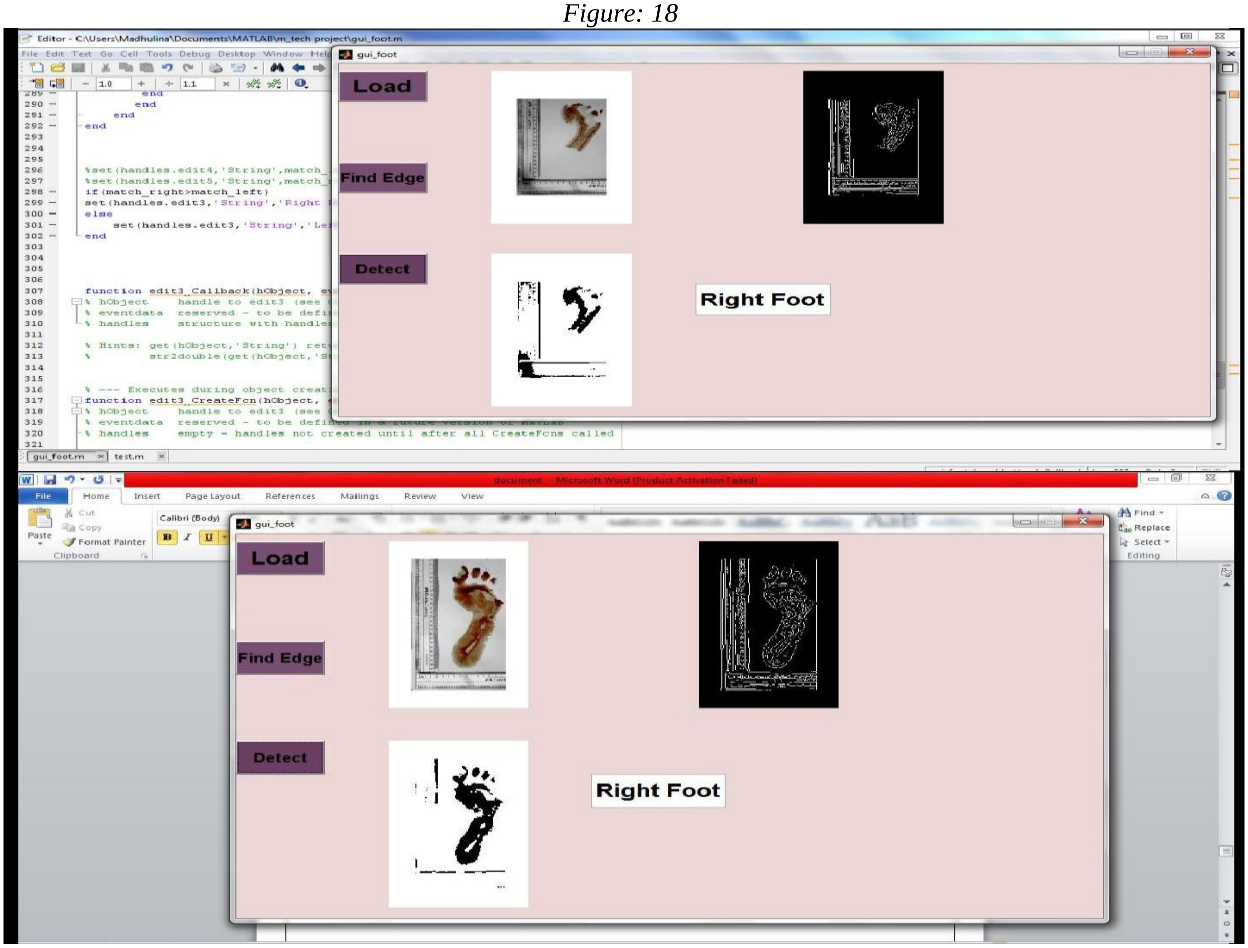


Figure: 19

As the images on blood stain, therefore the biometric identification as mentioned previous is very tough. For crime scene analysis the detection of walk, detection of foot (left or right) and also detection of male or female foot print will be enough helpful. Therefore detection of male or female will be added. Next if possible the biometric identification will also be added.

Conclusions

The images for the analysis of crime scene should be taken by the professionals because the quality and the alignment of the image should be proper.

References

[1]. Kennedy, R. B. (1996). Uniqueness of bare feet and its use as a possible means of identification. *Forensic science international*, *82*(1), 81-87.

[2]. Jain, A. K., Ross, A., & Prabhakar, S. (2004). An introduction to biometric recognition. *Circuits and Systems for Video Technology, IEEE Transactions on*, *14*(1), 4-20.

[3]. Nakajima, K., Mizukami, Y., Tanaka, K., & Tamura, T. (2000). Footprint-based personal recognition. *Biomedical Engineering, IEEE Transactions on*, *47*(11), 1534-1537.

[4]. Bien, Z. (2002). Unconstrained Person Recognition Mtehod using Static and Dynamic Footprint. In Proceedings of the 18th Hungarian-Korean Seminar, pages 129-137, 2002.

[5]. Jung, J. W., Sato, T., & Bien, Z. (2004). Dynamic footprint-based person recognition method using a hidden markov model and a neural network. *International journal of intelligent systems*, *19*(11), 1127-1141.

[6]. Kumar, A., Wong, D. C., Shen, H. C., & Jain, A. K. (2003, June). Personal verification using palmprint and hand geometry biometric. In *Audio-and Video-Based Biometric Person Authentication* (pp. 668-678). Springer Berlin Heidelberg.

[7]. Yörük, E., Dutağaci, H., & Sankur, B. (2006). Hand biometrics. *Image and Vision Computing*, *24*(5), 483-497.

[8]. Yoruk, E., Konukoglu, E., Sankur, B., & Darbon, J. (2006). Shape-based hand recognition. *Image Processing, IEEE Transactions on*, *15*(7), 1803-1815.

[9]. Turk, M., & Pentland, A. (1991). Eigenfaces for recognition. *Journal of cognitive neuroscience*, *3*(1), 71-86.

[10]. Uhl, A., & Wild, P. (2008). Footprint-based biometric verification. *Journal of Electronic Imaging*, *17*(1), 011016-011016.

[11]. Canny, J. (1986). A computational approach to edge detection. *Pattern Analysis and Machine Intelligence, IEEE Transactions on*, (6), 679-698.

[12]. Amayeh, G., Bebis, G., Erol, A., & Nicolescu, M. (2006, June). Peg-free hand shape verification using high order Zernike moments. In *Computer Vision and Pattern Recognition Workshop, 2006. CVPRW'06. Conference on* (pp. 40-40). IEEE.

[13]. National Institute of Standards and Technology.Fingerprint Image Software 2, 2006. http://_ngerprint.nist.gov/NFIS.

[14]. Ross, A., & Jain, A. (2003). Information fusion in biometrics. *Pattern recognition letters*, *24*(13), 2115-2125.

[15]. Kumar, A., & Zhang, D. (2006, August). Combining fingerprint, palmprint and hand-shape for user authentication. In *Pattern Recognition, 2006. ICPR 2006. 18th International Conference on* (Vol. 4, pp. 549-552). IEEE.

[16]. Sanchez-Reillo, R., Sanchez-Avila, C., & Gonzalez-Marcos, A. (2000). Biometric identification through hand geometry measurements. *Pattern Analysis and Machine Intelligence, IEEE Transactions on*, *22*(10), 1168-1171.

[17]. MORTON, D. J. (1927). Metatarsus atavicus: the identification of a distinct type of foot disorder. *The Journal of Bone & Joint Surgery*, *9*(3), 531-544.