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Automated Processing of Shoeprint Images for Use in Forensic Science

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Abstract: Shoe mark at the place of crime scene provides a vital forensic clue for catching the criminal. The implementation of a system automatically sorting a database of shoeprint images based on the sole pattern in comparison of the reference shoeprint image. Shoeprint database is generated by inviting the participants to tread on an inkpad and then stamp on a piece of paper. The performance of the system further increases for partial shoeprints.

Keywords: Forensic Science, Discrete Fourier Transform (DFT), Shoeprint Image, Gabor Transform, Radon Transform.

I. INTRODUCTION

Shoeprint recognition has never given much attention as a forensic clue, but since the Serious Organized Police Act (2005) gave it the same legal status as of DNA and fingerprint evidence .In the past shoeprint obtained at the crime scene used photographic techniques or processed manually against a database. The user uses the guides to identify features present on the sole of the shoes and would then be presented with candidates which match this description till the match is actually found. This method has some limitation such as time consumption and less reliable than automated methods. As new shoes are produced with different features on the sole these modes of description will have to be updated dynamically. The mark produced by a piece of footwear can lead to three identification ,sole of increasing accuracy, sole of certain size, sole of a specific pattern. A high quality image shows defects and shape differences specific to an individual shoes is very rare and the fact that there will be one sample of any specific shoe means the chance of classification is low. The most common type of recognition will be that of the shoes make a model, due to availability of this data the number of samples and the ability to classify according to the different features. Shoe marks are broadly classified into two types types :1)shoe impression which contain 3-dimensional information (shoeprint found on beaches) and 2)shoe impression which contain 2-dimensional information(shoeprint on flat floor).The probability of occurrence of shoeprint is more than that of fingerprint at the crime scene. A number of semiautomatic methods have been proposed to assist the forensic investigations making the database comparison. In all methods an operator uses a palette of basic shapes to build a model of shoeprint pattern. For each type of geometric shape the two dimensional Discrete Fourier Transform (DFT) was used to determine the spatial frequency of the shapes. The main advantage the DFT is that it is invariant to translations.

II. PROPOSED SYSTEM

A diagrammatic representation of shoeprint analysis system developed in this study is shown in the figure below. The system processes a sample shoeprint image and treats it as reference image and produces transformed image. The transformed image is then compared with the transformed database image and a measure of similarity is checked. The similarity of the reference image to each pattern category is determined. On the basis of similarity measures the database categories are sorted so that categories are most likely have identical pattern to the reference shoeprint image that appear at the start of the sorted list. The expert then reviews the sorted category that matches the pattern of referenced shoeprint image. If the matching is found then then the associated database fields can provide shoe manufacturer style information about the input shoeprint image. The pattern found can then be matched with the frequencies of the images in the database to found the average age of the wearer. The transformation used for the sorting is Fourier Transform as it is having translation and rotation properties in it.Assume that the rotated and translated image be I2 which is the replica of I1 with rotation θ an translation (x0.y0), then

$$I2(x, y) = I1(x \cos \theta + y \sin \theta - x0, x \sin \theta + y \cos \theta - y0) \quad ---(1)$$

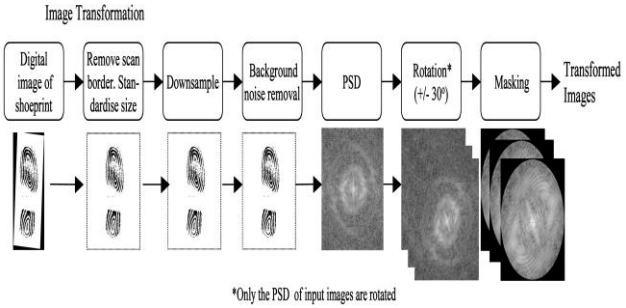

Fig.1. Image Transformation

Where mean (I) is the average pixel value of image I, standard deviation is given by std (I) of pixel value of

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image I and the size of image is P ×.P pixels. The advantage of similarity measure is that it is invariant to the average and standard deviation of pixel value of the image. When we compare the two PSD with the calculated similarity measure the comparison will be invariant to the average gray scale values of the two original prints and also invariant to the contrast between highlights and shadows of prints. In order to calculate the measure of similarity in the two images one present in the database and the referenced image, the correlation coefficient of the PSD of the database image is calculated. The measure of similarity and the maximum value of individual correlations.

The proposed shoeprint matching system is clearly understood by the figure given below

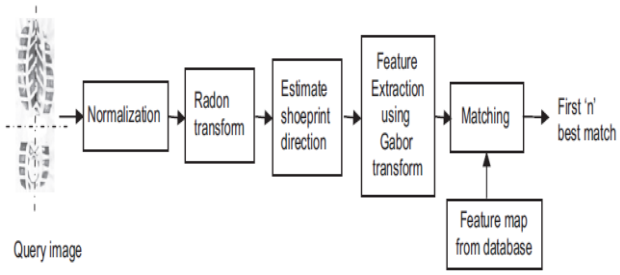

Fig.2.Proposed Shoeprint Matching System.

Forensic image databases serve two potential goals: identification or recognition. Recognition aims at distinguishing a particular individual from a limited number of people whose data are known. Identification is much more difficult to achieve than recognition, because false positives are unacceptable.

Shoeprint database has been generated by inviting participants to tread on an inkpad (only once) and then stamp on an 11.69'' x 8.27'' paper. Further the shoeprint images were digitized using a flatbed scanner of 300 dpi resolution and 256 level gray-scale mapping or webcam.

Applications of Proposed System:

Footwear impressions are routinely used to prove that a suspect was present at a crime scene. This type of evidence is very valuable and frequently used in homicides, assaults, robberies, rapes, burglaries, and similar crimes where the proof of an individual's presence is incriminating. . Footwear evidence can:

1. Help identify or eliminate a suspect.
2. Determine the brand of a shoe by comparison with a database.
3. Determine shoe size.
4. Help determine gait characteristics.
5. Determine the number of perpetrators.
6. Positively identify a shoe by its unique characteristics.
7. Prove an individual's presence at a crime scene.
8. Aid in reconstructing a crime scene.
9. Show the number of perpetrators involved.
10. Help prove involvement in a crime.
11. Reveal the time frame when the impression was made.
12. Reveal a sequence of events.
13. Prove or disprove an alibi.
14. Forensic application such as corpse identification, criminal investigation, terrorist identification, missing children, etc.

Advantages of Proposed System:

1. Faster
2. Provides objective matching, removing level of subjectivity in matching prints.
3. More accurate.
4. Full automatic matching, removing necessity to code up a shoeprint image from icons.
5. Ease of use, low level of training required.
6. The Gabor filter method gives both Benefits of Fourier Transform and Locality.
7. It allows study of the spatial distribution of texture.
8. It is useful for segmentation and local/pixel wise classification.
9. It enables analysis of "texture in image" .e. g. Gradual changes of texture, Texture variations, and Appearance models.

Innovative Aspects of Proposed System:

1. Fully automatic system requiring minimal user set-up/intervention.
2. Returns ranked list of possible matches.

III. MEASURING SYSTEM PERFORMANCE

The system is basically used to sort different categories of shoeprint images against the referenced image and to present images of sorted categories before the user to accurately identify the criminal shoeprint image. A system which is having the higher performance will present fewer number of matching categories than a system with a lower performance.

IV. SHOEPRINT DATABASE

Forensic analysis requires comparison of reference image against database images. These databases include:

1) Database of marks made by shoes currently and previously available in the market

2) Database of shoe mark found at the crime scene.

The database of the shoeprint images can be generated manually by inviting the participants to give their shoeprint impression on an inkpad and then stamp on a piece of paper. The information regarding the shoe including manufacturer, style, size and age of the shoe wearer has been recorded with each shoeprint. The identity of the wearer is not recorded. The shoeprint were of variable quality with some prints clearly showing the full detail of tread pattern and others only captured part of footprint.

V. CONCLUSIONS

This study tries to give a better solution by providing the technique for automatic matching for shoeprint by using some transform such as Radon transform present in Matlab. Shoeprint images can be an input into the system by using

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a scanner or a digital camera. The various transforms that exist in Matlab is used to extract the textural features of the shoeprint. On the basis of this textural features the sample shoeprint images is matched with the referenced shoeprint images present in the database and the best match is found. This study developed a system that automatically sorts a database of shoeprint pattern categories in response to a reference shoeprint image. The system was also able to successfully sort database images in response to reference partial prints. The system has translational and rotational invariance so that the positioning of pixels in the referenced shoeprint images and the database shoeprint image need not to correspond with each other. Gabor transform is used for feature extraction and Radon Transform is used for developing the system which is invariant to intensity and rotation features of the image. The simplified data entry of this system makes it a lower cost system to develop and maintain, as well as offering clients significant personnel cost savings.

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BIOGRAPHIES

Mahmood Ahmed Khan received his B.E. degree in Information Technology from Dr.Babasaheb Ambedkar Marathwada University.Aurangabad(MH).His research area includes development of Automated Shoeprint Matching Technique for use in Forensic Science.

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