

Minutiae Matching Algorithm For Partial Fingerprints

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Abstract: A fingerprint is an impression of ridges left behind on the surface of an object when they are touched or handled. Each person has own fingerprints with the permanent uniqueness. Because of this reason fingerprints are considered to be the excellent way of personal identification for criminal investigation purposes. The fingerprints encountered at crime scenes called partial fingerprints plays an important role in identifying criminals. Partial fingerprint matching also plays an important role in identifying suspects and criminals. In this paper we have proposed a minutiae matching algorithm to improve the performance of matching and reduces the time for matching. The proposed work reconstructs the orientation field of partials and iteratively matches the minutiae of partials and list of rolled and plain candidates that are initially matched. The main purpose of minutiae matching algorithm is to improve the matching rate and reduce the computational time in matching minutiae and also reduces the fault ratio.

Keywords – Partial fingerprints; Partial fingerprint matching; Minutiae matching algorithm

and plain impressions (collectively called rolled and plains), acquired under expert supervision.

I. INTRODUCTION

A fingerprint (fig. 1) is an impression of ridges left behind on the surface of an object when they are touched or handled. Fingerprint patterns are stable throughout one’s life-time, unique, and easily analyzed and compared. Fingerprints comprises of ridges, dark area of fingerprint and valleys, white area that exist between ridges. Minutiae are major features of a fingerprint, using which matching is performed. Minutiae mainly include: ridge termination which means the point at which ridge terminates; and ridge bifurcation which means a point at which two ridges meet. Minutiae are very important in the analysis of fingerprints since no two fingers have been shown to be identical.

Based on the acquisition process[1], fingerprints (fig. 2) can be classified into three types: (i) *Rolled fingerprints* which contain almost all of the ridge details and are captured by rolling a finger from nail to nail, (ii) *Plain fingerprints* which are acquired by pressing the finger on a flat surface, and (iii) *Partial fingerprints* which are partial impressions of the finger inadvertently left behind on the surface of objects when they are touched or handled. Partial prints, in particular, are of critical value in forensic applications because they are usually encountered at crime scenes and serve as crucial evidence in a court of law. Rolled



Figure 1: Fingerprint Image

Fingerprints have been widely used to determine the identity of an individual or to verify his claimed identity in both civilian and law enforcement applications. The main civilian applications of fingerprints are: banking security, information system security, Government benefits distribution, and National ID systems (Indian Aadhar Card).

Partial fingerprints are partial impressions of the finger inadvertently left behind on the surface of objects when

they are touched or handled. They left on a surface by deposits of oils and/or perspiration from the finger. It is not usually visible to the naked eye but may be detected with some chemical and physical methods. Physical methods generally involve powder dusting procedures which are used to enhance the prints. Clear adhesive tape is used to lift the print from the evidence. In chemical methods, partial prints are made visible by applying a substance that causes a chemical reaction with one of the components of partial prints. Another chemical method is the super-glue fuming technique where heat is applied to superglue in a sealed enclosure containing the evidence. The superglue vapours settle on the evidence and react with components in the partial print, forming a visible white outline of the fingerprint. The visibility of partial prints developed using either chemical or physical methods can be enhanced for photographing using the instrumental methods.

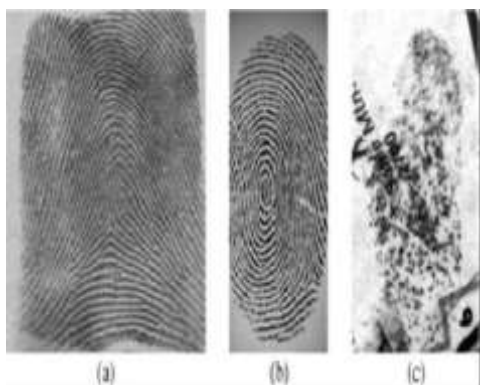


Figure 2: Three types of fingerprint images. (a) rolled, (b) plain and (c) partial fingerprints

Partial fingerprint matching means matching the partial image with a set of rolled and plain prints to find the appropriate match of rolled and plain prints. Partial prints are typically of poor quality with complex background noise which makes feature extraction and matching of partial prints a significantly challenging problem.

In this paper, a minutiae matching algorithm is proposed in feedback[1][4] mechanism to reconstruct the minutiae from orientation field and the reconstructed partial image is iteratively matched with the initially retrieved candidate list after matching with rolled and plain prints. The minutiae matching algorithm produces accurate results and it helps the investigators to identify the suspects and criminals. The proposed algorithm helps to improve the matching rate and reduce the computational time in matching minutiae.

The remaining paper is organized as follows: Section 2 discuss about the ACE-V[9] and certain techniques such as used for automatic partial fingerprint matching. In Section 3, the proposed system has been described which includes system architecture and minutiae matching algorithm. Section 4 summarizes the contents of this paper.

II. RELATED WORKS

There exist a number of techniques to match the partial fingerprint with rolled and plain fingerprints by manually and automatically. The automatic partial fingerprint matching techniques are enhancing, pre-processing, aligning and segmentation.

In manual matching of partial prints, partial fingerprint examiners usually follow the Analysis, Comparison, Evaluation and Verification (ACE-V) methodology [4]. This basically, is a four step process:-

Analysis: The preliminary step involves analyzing the partial image to ascertain if the partial is of sufficient value for processing and manually marking features such as minutiae, orientation field and ridge frequency. This is usually done by observing the partial image in isolation.

Comparison: This consists of comparing the partial image to the rolled and plain image in terms of their features, and assessing the degree of similarity/dissimilarity between partial and rolled and plain.

Evaluation: The partial examiner determines the strength of the evidence between the partial and rolled and plain based on the assessed degree of similarity/dissimilarity between the partial and rolled and plain in the comparison step.

Verification: A second partial examiner independently evaluates the partial - rolled and plain pair to validate the results of the first partial examiner.

The ACE-V procedure is a tedious and time consuming process for the partial examiner. The ACE-V procedure is a tedious and time consuming process for the latent examiner as it may involve a large number of fingerprint comparisons between different rolled and plain fingerprint pairs. This results in one of the following five outcomes: as suggested in [1] [4]

- 1) The latent examiner correctly matches the latent fingerprint to its true mated rolled and plain from the candidate list.
- 2) The examiner erroneously matches the latent fingerprint to rolled and plain fingerprint from the candidate list (which is not the true mate).
- 3) The examiner correctly excludes an rolled and plain fingerprint from the candidate list (which is not the true mate) to be the possible mate of the latent fingerprint.
- 4) The examiner erroneously excludes the true mated rolled and plain fingerprint of the latent fingerprint from the candidate list to be the possible mate of the latent.
- 5) The examiner deems the matching result to be inconclusive because he is unable to find any candidate rolled and plain that is sufficiently similar to the latent print. Note that while outcome 2) is an erroneous match and outcome 4) an erroneous exclusion, outcome 5) is a reject in the sense that the true mate does not exist in the background database[1].

The automatic partial segmentation[6] and enhancement algorithm based on image decomposition and coarse to fine ridge structure dictionaries. Here, a dictionary-based approach is proposed for automatic partial segmentation

and enhancement towards the goal of achieving “lights-out” partial identification systems. The segmentation algorithm consists of an off-line dictionary learning stage and on-line stage for segmentation and enhancement. The ridge structure dictionary is a set of high quality ridge patches, is then used to restore ridge structure in these partial patches. The ridge quality of a patch which is used for partial segmentation is defined as the structural similarity between the patch and its reconstruction. The proposed algorithm outperforms the state of the art segmentation and enhancement algorithms and boosts the performance of a state of the art commercial partial matcher.

The robust alignment algorithm, Descriptor-Based Hough Transform[2] to align fingerprints and measures similarity between fingerprints by considering both minutiae and orientation field information. Alignment between a partial and a rolled print is difficult problem because partials often contain a small number of minutiae and undergo large skin distortion. For overcome these problems they proposed the Descriptor-Based Hough transforms (DBHT), which is a combination of the generalized Hough transform and a local minutiae descriptor, called Minutia Cylinder Code (MCC). The assumption here is that true mated minutiae pairs will vote for very similar sets of alignment parameters, while non-mated minutiae pairs will vote randomly throughout the parameters. As a result, the set of parameters that presents the highest evidence is considered the best one.

A robust orientation field estimation[10] algorithm to process poor quality fingerprints, especially partials. The algorithm draws an analogy between fingerprint orientation field and a sentence in a natural language. A sentence is comprised of words which are further comprised of letters. Similarly, a fingerprint orientation field is comprised of orientation patches which are further comprised of orientation elements. Hence, a fingerprint orientation field can be viewed as a sentence, an orientation patch can be viewed as a word, and an orientation element can be viewed as a letter. Here, first builds a dictionary of reference orientation patches using a set of orientation fields extracted from real fingerprints. Given an input fingerprint, then estimate an initial orientation field using traditional orientation field estimation approaches. For poor quality fingerprints, such as most partials, the initial orientation fields are very noisy. Errors in the initial orientation field need to be corrected using dictionary as well as context information.

From the previous works, our proposed system uses a feedback technique to reconstructs the orientation field and minutiae and proposed a new minutiae matching algorithm to improve the matching accuracy and reduce the fault ratio.

III. PROPOSED SYSTEM

The proposed paradigm uses feedback in the matching stage to refine the features extracted from the partial images. This feedback is particularly useful because features extracted from the partial are often unreliable due to their poor quality. Matching partial images after reconstructing orientation and minutiae fields using minutiae matching algorithm improves the matching accuracy and reduces the computational time.

A) System Architecture

Fig. 3 depicts the system architecture. For the purpose of automatic partial fingerprint matching, good quality rolled and plain prints are collected and partial prints too. The manually marked minutiae in the partial image and automatically extracted minutiae from the rolled and plain image are fed as input to the partial matcher to obtain a list of candidates. The partial is then aligned[2] to the rolled and plain images using the scaling, rotation and translation parameters. Using the initial partial matcher generate an initial match score between the partial and rolled and plain, then a candidate list (*top K* candidates) is generated based on the alignment technique.

In partial image, the ridge orientation and frequency features are very difficult to extract because of the presence of structured noise in the background. So Fourier domain is used to extract the partial features. For refining partial features feedback[1][4] mechanism is used. The feedback is obtained by the orientation differences of each overlapping block between the rolled and plain and partial prints. The extracted features within each block are then refined based on the feedback from features extracted in the corresponding rolled and plain block. Feedback consists of orientation differences between each extracted partial ridge orientation closest to the rolled and plain orientation and partial ridge frequency corresponding to the selected orientation.

For reconstructing minutiae features, estimate phase offset $P(x,y)$ and reconstructs the continuous phase by following method. Starting with a queue containing the top left-most block (assume $P(x,y)$ to be 0), in each iteration a block is obtained from the queue and each of its connected neighbours is checked to see if it has been reconstructed ($P(x,y)$ has been estimated). If one of the connected neighbouring blocks has not been reconstructed, that block's phase offset is estimated and put in the queue. This method is continued until the queue becomes null (i.e. for all the blocks phase has been reconstructed). A subsidiary image is used to record the reconstructed blocks. After the reconstruction of continuous phase, the reconstructed fingerprint can be obtained by fusing the continuous phase and twist phase. The reconstructed partial fingerprint is overlay on the skeleton image of the each top k candidate list. The reconstructed fingerprint image matches with the candidate list fingerprint images to find out the highly accurate matching fingerprint

image.

IV. CONCLUSION

The partials are partial impressions of the finger, and thus have relatively smaller area containing friction ridge patterns. They generally exhibit poor quality in terms of ridge clarity due to the presence of complex background noise and have large non-linear distortions due to variations in the finger pressure. The idea of feedback in partial fingerprint matching is to incorporate a data flow between the matching module and feature extraction module and reconstructs the orientation field and minutiae. After reconstruction, the partial image and the set of rolled and plain prints candidate list undergoes minutiae matching to improve the matching rate and reduce the fault ratio.

V. ACKNOWLEDGEMENT

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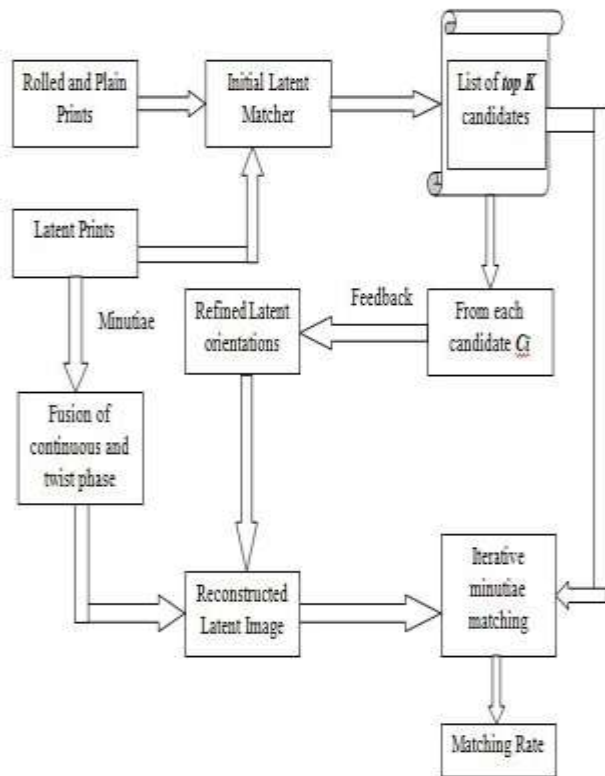


Figure 3: System Architectural Diagram Representation

After reconstruction of partial image, the minutiae matching [16] algorithm is used for computing the match rate of each candidates present in the *top K* list. The candidate list is resorted based on the match rate between the partial and the rolled and plain.

B. Minutiae Matching Algorithm

The proposed minutiae matching algorithm enhances the reconstructed partial image based on Fast Fourier transform and align the partial image and minutiae matching are performed. The algorithm as follows: -

Step1: Read the image.

Step2: Compute the size of image in a variable, i.e. $size = length * breadth$

Step 3: Normalize the image.

Step 4: Binarize the image by setting $r=0$ and $v=1$, where r means ridges and v means valleys.

Step 5: $Bin = zeros(size)$, where number of zeros is calculated from the size of image.

Step 6: Calculate the core point.

Step 7: $a = fftshift(fft(fft(Bin) * fft(y)))$

Step 8: Enhanced the image with Fast Fourier transform.

Step 9: Estimate the translation and rotation parameters between the ridge associated with the reconstructed partial image minutiae and the ridge associated with *top K* candidate list minutiae and align the two minutiae patterns according to the estimated parameters.

Step 10: Compute match rate and resort the candidate list

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