A Hybrid Partial Fingerprint Matching Algorithm for estimation of Equal Error Rate

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***Abstract*— In Biometric fingerprints are most promising technology for identification and verification in various applications. The general fingerprint matching algorithms perform poorly in case of partial prints and may discard these prints during matching. The major problems with partial prints is the lack of level 1 and level 2 features which makes them distinguishable. Therefore, we can utilize level 3 features such as pores corresponding LBP ectraction in combination with level 2 features based radon transform. Pores are one of the discriminative level 3 feature and with the advancement in the technology they can be successively employed using Automatic Fingerprint (AFIS) identification systems. In this paper, Our main aim is to provide a method to increase accuracy of partial fingerprint matching in order to estimate Equal error rate(ERR) based on False Acceptance Rate and False Rejection Rate. In proposed method, score level fusion of minutiae based radon transform and pores based LBP matching is performed.This method can surpasses the results of other matching approach which uses single matching sceme.The performance can be evaluated by calculating ERR based on False Acceptance Rate (FAR) and False Rejection Rate (FRR).**

Keywords—Partial fingerprint, Minutiae extraction, Radon transform, Pores features, Local Binary Pattern, Score level fusion, FAR, FRR

I. INTRODUCTION

Biometrics uses physical and behavioral characteristics to identify a person in a much more reliable way. There are two types of biometric approaches i.e. behavioral and physiological. Physiological approaches includes iris and retina scans, palm prints, fingerprints, face recognition, DNA, hand veins, nail bed recognition etc. Behavioral approaches includes voice recognition, keystroke dynamics, signature recognition etc[1] .Among all ,fingerprints are most propound biometric because of their uniqueness and consistency over time.

Fingerprint Identification system become very popular technology in forensics and many security applications. Due to the large intraclass variation (variation in biometric feature set of an individual) and interclass similarity (similarity between feature set of two different individual) fingerprint matching is a difficult problem[2]. Intraclass variation occurs because of imprudent sensing condition or small overlap between fingerprint and sensor which results in partial fingerprints. Partial fingerprint frequently appears in fingerprint recognition

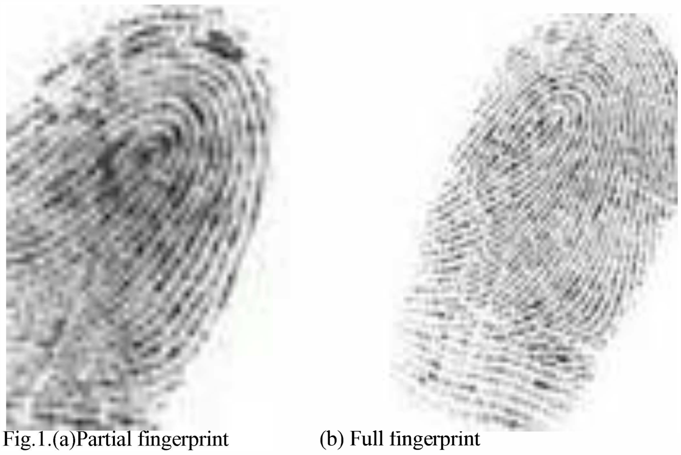

Fig.1.(a)Partial fingerprint (b) Full fingerprint

Due to imperfect scanning or latent prints. Therefore, improvement in partial prints matching is still a challenge.[3].Fig.1 shows partial fingerprint images and its mated full fingerprint image. From the survey on partial fingerprint recognition [3] it is found that area of partial fingerprint play a key role in their identification. Some conclusions are drawn- decrease in fingerprint area downgrades the performance of partial fingerprint recognition and decreases the match score and fingerprint with less than 20,000 pixels is considered as very poor to be used for recognition.

Fingerprint comparison is done based on ridge flows (level 1 features), the presence or absence of minutiae (level 2 features) and the sophisticated details of single ridge (level 3 features). General fingerprint matching algorithm do not perform well on partial prints because-(1) Less number of minutiae are their (2) absence of singular points such as core and delta. In case of partial fingerprints where sufficient level 1 and level 2 features cannot be establish, higher level features such as sweat pores can be utilized. Minutiae based matching is most widely used fingerprint matching. The two majorly used minutiae points are ridge endings and bifurcation and then descriptors (compensate for local distortions and broken ridges) are used for matching.

Many descriptors are defined for fingerprint matching such as Generalized Hough transform, SIFT (Scale Invariant Feature Transform)[4][5], Radon transform[6], DAISY, Descriptor Based Hough Transform(DBHT)[7]. In poor quality images, SIFT and SURF descriptors are affected by local distortions. Therefore, Weak projection based radon

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transform is used to capture abstract structural information in a given neighborhood of extracted minutiae. Based on only minutiae points, Fragmentary fingerprint matching with corresponding full fingerprints is quite difficult. Many researchers have given importance to extended feature set, working on partial fingerprints. Pores are extracted from partial prints which acts as anchor points using AFRS(Automatic fingerprint recognition system) because of advancement in sensing technology and then Pores corresponding Local Binary Patterns(LBP) [10] are used for Partial fingerprint matching.

In the literature, different levels of fusion are identified i.e. score level, rank level, feature level[12].There are two types rank level methods- Highest rank and Borda count. It can be observed that highest rank method is much better than Borda count. In feature level fusion, extracted feature points from enrolled fingerprints are combined and new higher dimensionality feature set is obtained[12]. In score level fusion, matching scores which are numerical values are fused to show the performance of the system. Five score level fusion rules are defined: min, max, sum, product and boosted max.[12].It is observed that all score level fusion method results in improved performance except for min method.

In this paper, Our main aim is to provide a method for reducing Equal error rate (ERR) based on False Acceptance Rate and False Rejection Rate. EER can be calculated by plotting Receiver Operator Curve (ROC) between False acceptance rate and false rejection rate.

The paper is organized as : section II gives brief description of related work; section III describes proposed methodology which includes score level fusion of minutiae based radon transform and pores based LBP extraction and performance evaluation based on ERR; and section IV finally concludes the paper and suggest some future work.

II. RELATED WORK

In forensics and many security application, matching partial fingerprints is still a challenge. Partial prints found at crime scenes are of poor quality and have small usable area. Partial fingerprints are even more vulnerable to false positives. Therefore, to work with partial prints is quite difficult .Many researchers have given different methodologies to deal with partial prints in order to improve matching accuracy.

Brief overview of different approaches given by many authors in the literature is given below-

[4] In this paper, the author proposes a new approach to aligning high resolution partial fingerprints based on pores, which is fingerprint fine ridge features that are abundant on even small fingerprint areas. First pores are extracted from the fingerprint images by using a difference of Gaussian filtering approach. After detection of pores, a novel pore–valley descriptor (PVD) is proposed to characterize pores based on their locations and orientations, and also the ridge orientation fields and valley structures around them. To locate pore correspondences, PVD-based coarse-to-fine pore matching algorithm is developed . The experimental results show that the PVD-based method is much better.

[5] The author presents an approach that uses localized secondary features derived from relative minutiae information. To obtain one-to-one correspondence of secondary features, a flow network-based matching technique is introduced. A two-hidden-layer fully connected neural network is trained to generate the final similarity score based on minutiae matched in the overlapping areas. This method balances the tradeoffs between maximizing the number of matches and minimizing total feature distance between query and reference fingerprints.

[6] In this paper, the author has presented a novel approach for partial fingerprint matching scheme based on SIFT (Scale Invariant Feature Transform) features and matching is achieved using a modified point matching process. This method results in improved performance when matching partial fingerprints with full fingerprints.

[7] This paper proposes a novel fuzzy logic method for matching partial fingerprints. The inputs of the proposed fuzzy logic algorithm are the correlation degree and the relative surface of the input fingerprint. This method combines the temporal performances of the minutiae-based algorithms with the reliability of the correlation-based ones.

[8] In this study, author proposed two new algorithms. The first one, called the Spaced Frequency Transformation Algorithm (SFTA), is based on taking the Fast Fourier Transform of the images. The next algorithm, called the Line Scan Algorithm (LSA),was developed to compare partial fingerprints and reduce the time taken to compare full fingerprints. Combination of LSA and SFTA provides a very efficient recognition technique.

[9] In this paper, the author proposed an algorithm to extract two major level 3 features types, Dots and Incipients , based on local phase symmetry and demonstrate their effectiveness in partial fingerprints.

[10] In this paper , suitable technique for partial fingerprint matching based on pores corresponding their Local Binary Pattern (LBP) features is defined. The first step involves extracting the pores from the partial image. These pores used as anchor points and sub window of (32*32) are formed surrounding the pores. After this, rotation invariant LBP histograms are obtained from the surrounding window. Finally Chi-square formula is used to calculate the minimum distance between two histograms to find best matching score.

[11] In this paper, the author proposes a weak descriptor to capture local structures at a higher abstract level. The aim here is to mine a large set of initial correspondence through weak description and then rely on robust estimator scheme to prune false matches. Weak local descriptor is coupled with robust estimator to minimize the affect of broken ridge patterns and also obtains a dense set of matches for a given pair. This paper also evaluate the performance of the proposed method against SIFT as per the Fingerprint Verification Competition guidelines.

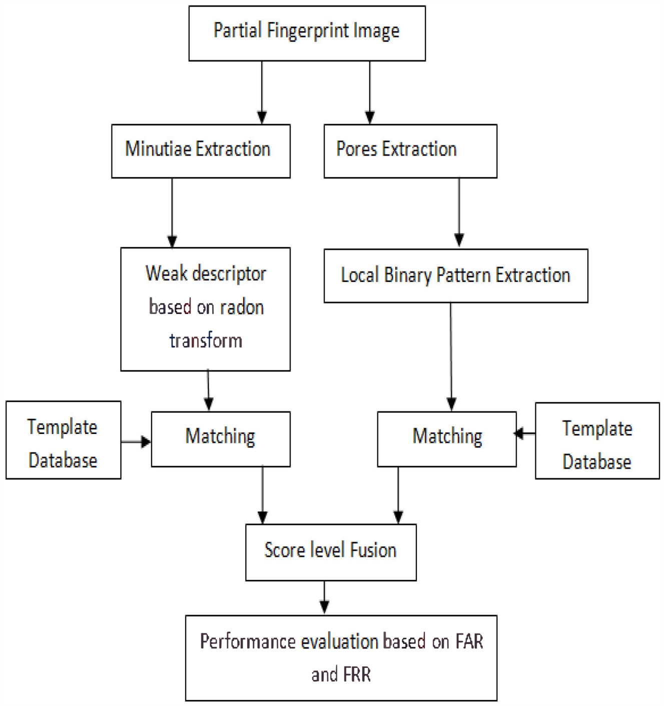

Fig2. Proposed Methodology for Partial fingerprint matching

III. Proposed Methodology For Partial Fingerprint Matching

Partial fingerprints are sub image of full image, having small number of features. Matching partial fingerprint with full image is a major challenge because of absence of level 1 and level 2 features. This result in false matches and increase in error rate. The proposed matching strategy starts with two separate matching strategy which results in similarity scores and at the end fused the matching scores from both the methods and provide better decision. For performance evaluation FAR and FRR is used. Fig.2 shows the working of proposed methodology.

1. Using Minutiae extraction in combination with radon transform-

The proposed method results in similarity score between sample image and database image. For processing, minutiae are extracted using well known Jain.et.al approach.Fig.3 represents the steps followed for minutiae features extraction. Extracted minutiae are act as interest point and then weak descriptor based radon transform is used around these interest points to get local structural information. The descriptor is used to deal with distortions and in continuous ridges. Two way matching method is used i.e. forward and backward matching. In forward matching query image is mapped on template image and for backward matching template image is mapped on query image. Then to reduce the matched set, robust estimator i.e. MLESAC (Maximum Likelihood Estimation Sample Consensus)[11] is used which removes the false matches. Based on threshold, match or non match is determined.

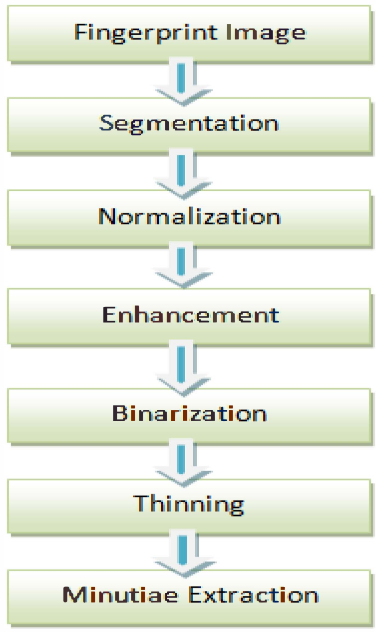

Fig.3.Steps for Minutiae Extraction

Following algorithm is used for this process-

Algorithm1-

1. Take sample image from input vector.
2. Find Region of Interest (ROI) using segmentation.
3. Perform normalization on segmented image.
4. Enhance image quality.
5. Perform binarization using recursive OTSU method.
6. Perform thinning of binarized image using Central line thinning algorithm .
7. Calculate Roto-Translation parameters for identification phase.
8. Minutiae act as interest point and perform Radon transform using the following formula-

$$g(s,\theta) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} R(x,y)\delta(xcos\theta + ysin\theta - s)\,dx\,dy$$

with $-\infty<s<\infty$,$0\leq\theta<\pi$ where s is the distance from the origin and θ is the angle of projection.

9. Employ Bilateral strategy for matching.
10. Use MLESAC (Maximum Likelihood Estimation Sample Consensus) algorithm for removing false matches.

2. Using Pores based LBP extraction-

The first step is to extract the pores using Watershed segmentation method proposed by S.Malathi[13].Markers are created using Morphological image reconstruction. Gradient fingerprint image is used and its Watershed Transform is calculated.

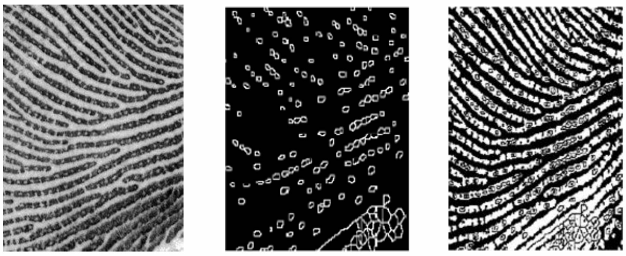

Fig.4 (a) Original image (b) Marker image (c) Extracted pores

After superimposing the watershed ridgelines on the original fingerprint image, a much improved pore extraction is obtained. Extracted pores are used as anchor points and then Local binary patterns are constructed around the anchor points. LBP operator is applied on windows around pores and histograms are constructed. Then LBP histograms are used for matching between query image and full fingerprint image.

Algorithm2-

1. Take grey scale images for further processing.
2. Use canny edge detector algorithm, and develop gradient image.
3. Use the gradient image and finds its watershed transform without performing any other processing.
4. Obtain forward markers by calculating regional minima and then superimpose foreground markers on binarized image.
5. Use edge reconstruction algorithm to clean the edge of the markers.
6. Compute the background markers
7. Compute the watershed transform of the function
8. Use extracted pores as anchor points and apply LBP operator to obtain LBP histogram.
9. Use Chi square formula to determine distance between two corresponding histograms S, M-

$$x^2(S,M) = \sum_{i-1}^{n} \frac{(Si - Mi)^2}{Si + Mi}$$

Where n=Number of elements in histogram.

3. Score level Fusion-

Different types of fusion levels are in place [] but for this paper score level fusion is used. In multimodal system, scores from different matchers are combining to get discriminative information used to identify genuine or imposter match. Fusion of scores requires normalization because individual matcher differs in magnitude. Generated scores can be similarity scores or distance scores. For this paper, similarity scores are used i.e. Summation based fusion algorithm[15]. The procedure used to perform fusion of scores resulting from different matchers is as follows-

Algorithm3-

1. Get the normalized scores(x_1 ...xm)
   Where index i=1...m represents biometric matcher.
2. Fused score fs, is calculated using-
   $f_s = w_1 x_1 + \ldots + w_m x_m$
   Where w_i = weights assigned to matcher i, i=1 to m

Weights can be calculated based on preliminary results. Here equal weights are considered. So, above equation can be simplified to-

$f_s = x_1 + \ldots + x_m$

3. Compare f_s with prespecified threshold t,
   if (f_s>t)
   Genuine match
   else
   Imposter match.

4. Performance Evaluation-

The performance of proposed methodology can be evaluated based on FAR and FRR. False acceptance rate (FAR), the fraction of access attempts by an unenrolled individual that are nevertheless deemed a match. False rejection rate (FRR), the fraction of access attempts by a legitimately enrolled individual that are nevertheless rejected [1].Therefore for accuracy, FAR and FRR must be low. The point at which FAR and FRR intersects, that value is called Equal Error Rate (ERR)[14]. EER of any system gives system performance independent of threshold. Therefore, lower the ERR, better the system performance. ERR can be represented by plotting a Receiver operator curve (ROC) between FAR and FRR. Following formula are used for FAR and FRR calculation [13]-

$$FAR = \frac{Number\ of\ false\ acceptances}{\text{Number of identification attempts}}$$

$$FRR = \frac{Number\ of\ false\ rejections}{Number\ of\ identification\ attempts}$$

IV. Conclusion and Future Work

Fingerprints are one of the dominant biometric trait because of its proven performance in law enforcement and civilian applications. Small number of minutiae in partial fingerprint is still a challenge for matching which results in false matches. In this paper, Score level fusion of minutiae based weak descriptor and pores based LBP method is used in order to reduce EER.For score level fusion summation based method is used which fuses the results from individual matcher. Our approach concentrates on increase in accuracy so as to estimate false matches or error rate. This study uses two features i.e. minutiae and pores, number of other extended features can be used in combination with other method to provide efficient method for latent fingerprint matching. In future, we can implement the proposed approach to simulate the results and compare them with existing methods. We aim to give more efficient method to speed up the process and verify the process with large dataset to approximate the error rate. We can integrate our approach with other feature set to improve latent identification.

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